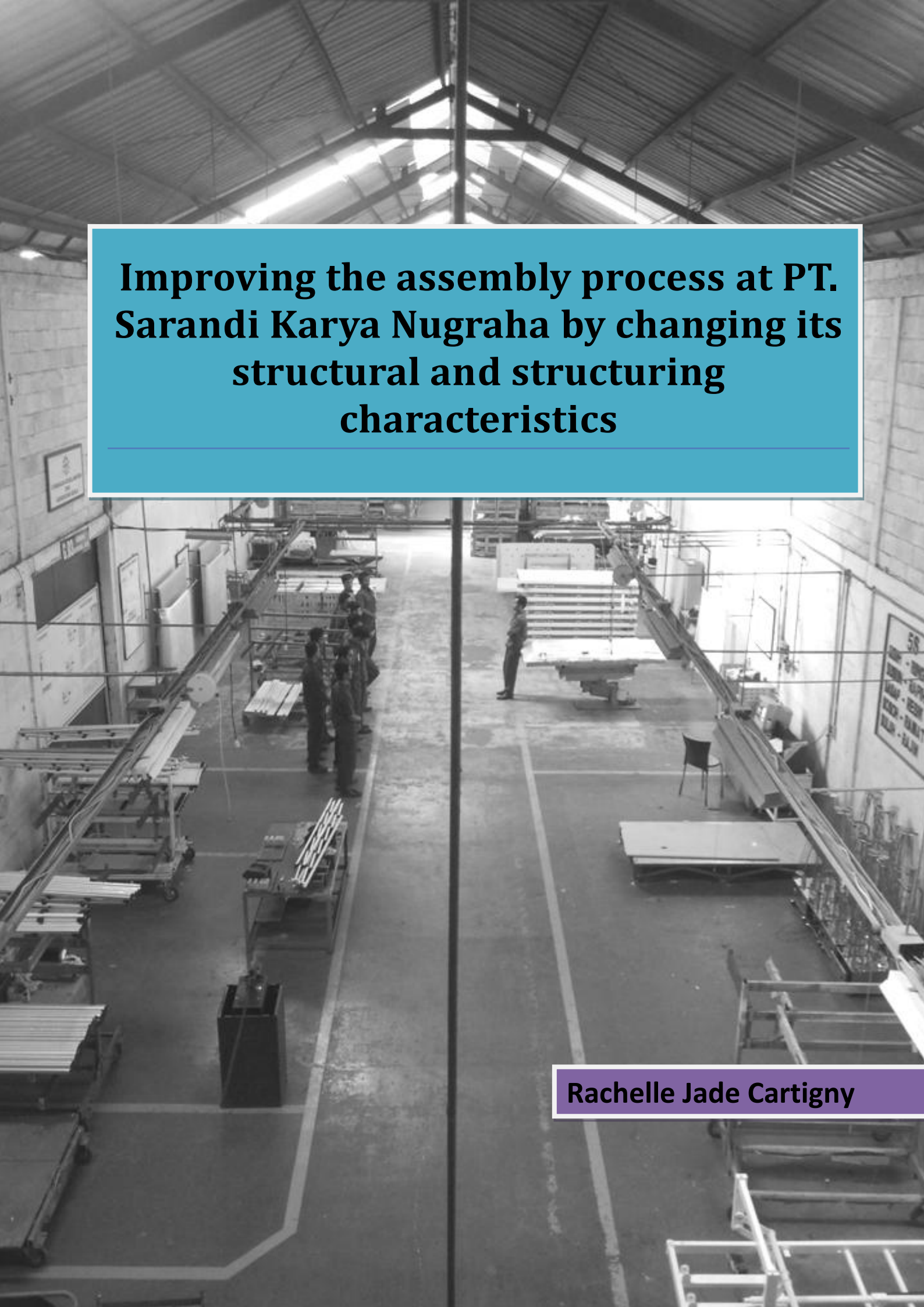

Improving the assembly process at PT. Sarandi Karya Nugraha by changing its structural and structuring characteristics

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Improving the assembly process at PT. Sarandi Karya Nugraha by changing its structural and structuring characteristics

Bachelor thesis

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Management summary

PT. Sarandi Karya Nugraha, a hospital equipment producing company, wants to improve the efficiency of, and control on their assembly department by implementing a conveyor system. The lack of structure, mostly due to a lack of standard procedures and insufficiently equipped working places, causes the department to be hard to control and causes inefficiencies throughout the whole assembly process. This research looks for a way to improve this situation by restructuring the department. Therefore the following research question was formulated:

"How should the assembly department of PT. Sarandi Karya Nugraha be structured to improve its control and efficiency?"

To answer this question a theoretical framework, providing an overview on all important elements and their relationships, was constructed. The main elements were: 1) the improvement goals, being control and efficiency, 2) the structural characteristics, being physical traits such as layout and the conveyor system and 3) the structuring characteristics, being the characteristics of activities and/or policies, such as standardization, formalization, simplification and specialization. The current situation of the department has been analyzed using observations, measures and interviews. From knowing the current situation, the improvement goals and the relationships of all important elements, information followed on what needed to be changed.

From analyzing the current situation of the department we found that little was defined on what procedure needed to be executed, where, by whom, when and in how much time. The working spaces were not always equipped with tools and materials in a sufficient and orderly way. Furthermore, employees seemed to waste a lot of time looking for materials and tools, and looking for what to do next. The balancing loss of the current layout, which is a measure of its efficiency, was found to be relatively high: around 12,5%.

This research provides Sarandi with extensive information on how to change the assembly department's structure. It includes a new layout plan and a detailed design of a new conveyor system with all its supporting equipment, such as trolleys and working tables. It also provides information on how to work with the new system through manuals and exact task allocations to the new stations. And finally, it provides information on what other effects, apart from better control and efficiency, can be expected.

The most important conclusions and recommendations this report makes in its search for the ideal structure for Sarandi's assembly department are the following:

- The assembly department of Sarandi needs to better structure its department by raising the levels of standardization, formalization, simplification and specialization (called structuring mechanisms).
- The implementation of a conveyor system with its appropriate layout and support materials will provide the right structural characteristics to initiate and further the levels of these mechanisms.
- The arrangement of stations should be changed from being short and fat to long and thin. A long thin arrangement has the quality of providing better control on material flow. It will also reduce the balancing loss from 12,5% to 4,94%.
- The efficiency will improve because of the smaller balancing loss, a smaller time loss from material handling and a higher level of the structuring mechanisms.
- The validity and reliability of the control measures will increase through a better definition of the preconditions of the department, which allows supervisors to have better insight into what happens at their department, providing them with better opportunity of control.

Preface

To finish my bachelor and for the final project of the minor Sustainable Development in Developing Countries I chose to go abroad to Indonesia. In this country I have some family roots and on top of that it is one of the most fast developing countries in the world, and therefore very interesting for a Business Administration student like me. After asking around and sending several application letters I came in contact with Sarandi. This company, that made hospital beds and other hospital equipment, was looking for a student that could help them improve their production process. After some correspondence back and forward we came to the agreement that I would focus on the possibilities of implementing a conveyor system.

This project provided me with a great opportunity to learn, see and experience the real practice of working life which I ambience when I have finished my study. For the company of Sarandi, which provided me with the best support possible I hope to make a sizeable contribution in making the work at the assembly more efficient, less costly and more easy for everyone involved.

For the implementation of the conveyor system I had the fortune of working with a team consisting of Mr. Diar Ruslani, Mr. Tri Sugeri Gumilar Permana, Mr. Rian Ahmad Nurdiansyah, Mr. Aries Febryan and Mr. Razali Bin Abdul Ghani. I like to thank all of them for making this project a success and I especially would like to thank Mr. Razali Bin Abdul Ghani for his guidance throughout my stay.
I also like to thank Mrs. Yeni Marlina Mustikadi, Mr. Arief Rahman, and Mr. Isep Gojali from Sarandi Karya Nugraha for making my stay in Indonesia so pleasant and giving me the best conditions for writing this Bsc Assignment. And finally I like to thank Dr. Jasper Veldman and Prof. Dr. Celeste WIlderom from the University of Twente for supporting this Bsc Assignment.

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Chapter 1 Introduction

This report describes and analyzes the project process and results of the implementation of a conveyor system at PT. Sarandi Karya Nugraha, a hospital equipment producing company located in Sukabumi, Indonesia. The company was already executing several projects, like a better utilization of the robot welding, the implementation of a pull-system and several software, and was planning on implementing a conveyor system in the assembly department. This conveyor system would be used to transport its main product, namely hospital beds, through the assembly department. This would reduce the amount of time and effort the employees had to make to transport the heavy hospital beds and make it possible to mainly move the hospital bed frame instead of all materials that needed to be attached to the hospital bed frame. These effects quite naturally follow the implementation of a conveyor system. However, the main incentive for the management of Sarandi to implement a conveyor system was their desire to improve their control on the department and to improve the department's efficiency. The research on how this objective could be reached by the implementation of a conveyor system together with the more practical element of actually redesigning the assembly department seemed a very interesting experience for me and provided an interesting research for my Bachelor assignment.

This report will give the new design for the assembly department. The correct implementation of the conveyor system will change the whole organizational structure of the department, meaning that it will affect the structural characteristics, being physical traits, as well as the structuring characteristics, being activities and/or policies (Campbell, Bownas, Peterson, & Dunnette, 1974). The structural characteristics consists of all physical traits, thus not only the conveyor system but also the necessary supporting materials like working tables and trolleys. It will even include an appropriate layout change in order to make the conveyor system effective. Furthermore an implementation of a conveyor is expected to have the three-S effects on the structuring characteristics. These three effects are the higher levels of standardization, specialization and simplification (Makino & Arai, 1994).

This research will look into all these characteristics and will look for the manner in which they provide the best structure for the assembly department. This report will provide information on how the department is currently structured and it will give the design on how the assembly process should look like to work satisficing. By this the implementation of the conveyor system will thrive for meeting the Sarandi's management requirements of getting better control and efficiency at the assembly department.

1.1 Country study

Indonesia is with its estimated 220 million inhabitants the fourth largest country in the world and the biggest archipelago of the world. Indonesia also has the biggest Muslim society of the world with a percentage of 86,1% being Muslim. It consists of 17.508 islands of which 6.000 are inhabited and of which Java, Sumatra, Borneo and New Guinea are the biggest ones (CIA, 2000). Java and Sumatra are densely populated and especially Java is a very important or even the most important island of Indonesia. Much of Indonesia's economic activities evolve around the enormous capital Jakarta which also has the biggest political power. Jakarta also is the most easily accessible since it has an enormous international airport and harbor.

Interesting about Indonesia for a Business Administration student is its fast growing economic development. Despite the economic world crisis they had a GDP real growth rate of 4,6% in 2009, of 6,1% in 2010 and even of 6,4% in 2011 (CIA, 2000). On the other hand there still are big problems concerning equalities in the distribution of wealth and recourses. Although the Indonesian government already made a lot of structural changes concerning their financial policy, they still struggle with a

country that has a bad infrastructure, has a difficult geographical position, and that deals with a lot of corruption.

Sukabumi, the city where Sarandi is situated is just 113 kilometers from Jakarta and has the advantage of having employees which are a lot cheaper than when Sarandi would be situated in Jakarta. The official language of Indonesia is Bahasa Indonesia. The local language used by people living at Sukabumi is Sundanees.

1.2 Company information on P.T. Sarandi Karya Nugraha

PT. Sarandi Karya Nugraha is a manufacturing company established at November 12th 1997 and is located in Sukabumi, Indonesia. Since a couple of years they also have a marketing office at Jakarta. Sarandi's main products are hospital beds and they also produce some other kinds of medical equipment. The company has been steadily growing over the years and currently consists out of 267 employees and is thus a medium-sized company. Though the company has been doing well, competition has increased and therefore Sarandi has been improving a lot in their production process.

Sarandi is an ambitious company striving for excellent, innovative and reliable medical products. The official vision of Sarandi states: "*Emerging as a bona fide innovative leading company in hospital equipment.*" Their bona fide, or in good intention, focus can be recognized in their ambition for being a 'Green Company', for which they have been awarded by ASTRA International. Another aspect that reflects the importance of good intention can be found in Sarandi's Kaizen policies. Kaizen emphasizes the good intention, and the process of improvement instead of emphasis on the end result (Imai, 1997). A focus that is more common in most western orientated companies. Sarandi has been rewarded many times for different areas, for example they also have been rewarded the Upakarti honor award for Indonesian entrepreneurs by the President Susilo Bambang Yudhoyono in 2010 and have been chosen as a role model for other small and medium sized Indonesian companies (Gojali, 2012; Sarandi 2012).

The organization of Sarandi according to the sources provided by Sarandi is quite decentralized with multiple directors and with a bottom-up policy (Gojali, 2012; Sarandi, 2012). However according to the Bachelor report of Van Stek (2012) the director still is the dominant power when implementing new projects, as according to him, the director is the gatekeeper, the project champion, the organizational sponsor and the team leader. My experience in Sarandi suggests that this is an exaggerated vision, since I experienced multiple people throughout the organization taking initiatives and having new ideas and suggestions. Management also seems to stimulate this by organizing employee committees and by rewarding good ideas of employees with awards. For a further elaboration on the structure of Sarandi the organizational chart can be found in appendix A.

1.3 Previous research

Through the years, several students came to Sarandi and studied different aspects of the company and all made their own contribution to the company. Here I will give a short overview of some of the main topics these students covered. In 2005 G.J.H. Meutstege and R.G.A. Golbach did a research concerning the planning and control system of the company. Their main contribution is the recognition of the need for Sarandi to formalize and standardize its production process more in order to cope with the growth and development the company is going through. For this they needed to improve the planning system and reduce the complexity of the production. For example by simplifying the design or by reducing the number of products. In 2006 M. Bieze and J. Jongejan did research on the poor interdepartmental communication, the cash flow problem and the performance recording system. In 2007 M. van Vliegen and G. van den Brandt focused their research on the excessive number of job cards, insufficient inherent process quality and inadequate performance measurement. In 2009 two students from the University of Twente did two separate reports on Sarandi, W. Mulder mapped all the problems of Sarandi and looked

into the overall process, R. Westrik looked into the HRM area and looked for ways of improving employees motivation. Useful information from these previous researches will be incorporated in this research.

1.4 Problem definition

This paragraph will explain the main practical issues of the assembly department. These issues have been found by observing the assembly department, by meeting with several supervisors and managers, by using information found from the employee questionnaire (appendix E) and by looking into the cause-effect diagram of previous research at Sarandi (Westrik, 2010). We will go through these issues by explaining the problem analysis as given below in figure one.

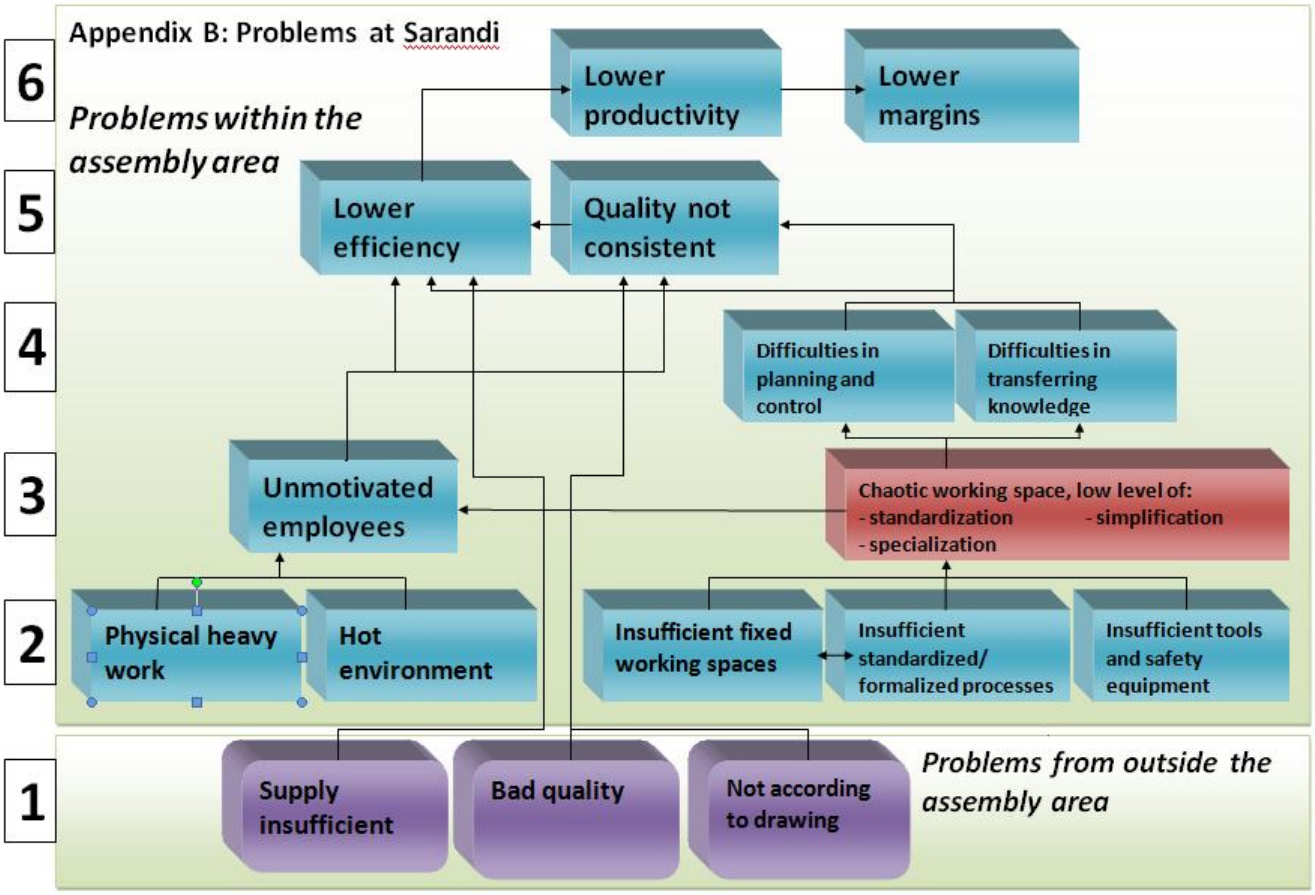


Figure 1: Cause-effect diagram of the problems at Sarandi

The problem analysis is separated into different levels which are numbered from one to six. Level one represents some main problems caused by other departments but which are encountered by the assembly department (supply insufficient, bad quality and not according to drawing). Level two represents some of the main more practical problems caused within the assembly area, of which the physical heavy workload and the hot environment cause the unmotivated employees. This is one of the problems at the third level which are a bit more complicated since these problems are more abstract. These problems are caused by other problems and also cause further problems. The insufficient fixed working spaces and insufficient standardized/formalized processes from level two have a interrelated relationship since these two reinforce each other. Together with the insufficient tools and safety equipment these problems at the second level cause the chaotic working space. The chaotic working space at the third level is being characterized by the low level of standardization, simplification and specialization. This creates difficulties in planning and control and difficulties in transferring knowledge

at the fourth level. These problems more clearly are consequences caused by the earlier discussed problems of the assembly department, and thus are symptoms which need to be addressed by handling the real causes in the lower levels. The levels five and six give an even further elaboration on what further consequences the earlier discussed problems will have on the performance of the assembly department in terms of quality, efficiency, productivity and margins. The problems at these levels also have their effects on the whole company since for example the lower margins effect the whole company.

Since the problems of levels four to six rather can be defined as being symptoms, or being classified as being caused by the previous levels, these problems are no core problems but rather improvement goals. This is in accordance with the demands of the management which also wanted to improve the control and efficiency, two problems which can be found in level four and five.

Since level one only covers problems from outside the department these are outside the working area of this project. The core problem thus lies in the levels two and three. Since unmotivated employees and its underlying causes do not seem to have an immediate effect on the goal of better control, this also will not be seen as being the core problem. This leaves us with remaining problems at level two and three. The chaotic working space has a lot of effect (either direct or indirect) on almost all other problems and therefore is being classified as the core problem (Imai, 1997). The smaller more practical problems at level two causing the chaotic working space thus also have to be resolved to solve the core problem but are too small to be handled as being the core problem.

In practice the chaotic working space means that different working stations are always partly occupied because employees are moving to other working stations when they need certain parts or tools. This leads to supply and tools laying spread all over the assembly work floor and employees working inefficient because of the time loss from walking around, searching equipment or tasks to do. In correspondence with the chaotic workplace the job descriptions of employees are vague and they therefore have difficulties instructing new employees. For the management of Sarandi the chaotic working place means they have no insight in the production process. This problem causes difficulties for the management to evaluate the work. The indirect main reason causing this is that there are no official or written down standard procedures that need to be followed. Supervisors and management cannot evaluate the work performance of the whole department and neither for individual products, because they don’t know how much standard time it takes to make the product and they can also not evaluate the performance of individual employees because they have no insight in his or her contribution to the whole process. The lack of an evaluation system therefore makes it very hard for the management to make improvements or changes.

Sarandi wants to improve the chaotic workplace by implementing a conveyor system. Currently they tried to improve the chaotic workplace by using the Kaizen philosophy, a philosophy that is born from several important theories of which the scientific management of Taylor (1911) can be recognized as a significant influence. Taylor, as Kaizen, recognized bureaucracy as a method of dealing with problems of evaluation, planning and control. In following chapters we will discuss and research why those techniques were insufficient in the case of the assembly department of Sarandi. Furthermore the necessity of the implementation of the conveyor system will be addressed.

In line with the philosophy of Kaizen some of the goals the organization is striving for are: more standardization, better control over the production process and better stock control. Improvements that are made or are currently in process are: the introduction of a pull system, higher utilization of robot welding and better process control by using software. Finally the management of Sarandi wants to improve the assembly process by introducing a conveyor system. All these improvements together will ensure that Sarandi will get better process control and get higher efficiency. For this research I will concentrate on improving the control system by standardizing and formalizing the process at the

assembly department and by reinforcing this by the introduction of a conveyor system with its necessary complementary devices.

1.5 Stakeholders for the implementation of the conveyor line

The management of Sarandi came to me with the problem of not having any control on the assembly department and their plan to implement a conveyor system in an attempt to improve this. At first sight I would have said that management of Sarandi was the one having the problem. To get a better insight into the situation at the assembly department, we also made a questionnaire for the employees, asking about all important issues and elements they encountered (appendix D). Of course after some meetings, from observations and from results of the questionnaire (appendix E) the problem became more complex and the management of Sarandi turned out to be not the only one having problems with the current structure of the assembly department. Assembly supervisors indicated difficulties in training new employees, which took a lot of time, which put a lot of stress on the other employees, especially during the high season. From the employee questionnaire (appendix E) you can see that employees have physical complaints from the work, as it is too heavy to flip and carry the hospitals beds, and since safety requirements are not sufficiently looked after. The workload can be relieved by designing trolleys which can flip the hospital beds more easily and by the conveyor system which pulls the beds through the assembly department. By the design of new working tables and tools we try to make the work more easy and hopefully more safe. More problems can be recognized from the employee questionnaire but since the implementation of the conveyor system and moderation of the layout will not directly influence these problems, these problems are discussed with top and middle management from Sarandi, in the hope they will focus on these issues in the future. Thus, we can conclude that the management and the assembly employees of Sarandi have problems with the current structure of the assembly department which can be improved by the implementation of the conveyor system and the alteration of the layout.

There are already quite a lot of people involved in this project, all of which deal with the conveyor line. Since a successful implementation needs the support from the assembly employees who will need to work with it, these people are kept informed about the plans concerning their department. To do this in a correct way I visited the assembly department as much as possible and talked with employees who could speak a little English. Every assembly employee also filled in a questionnaire (English translation version available in appendix D) and after processing the results of these questionnaire we had a meeting to discuss the results and to inform them about the plans concerning the conveyor system and layout. The management directly involved in the assembly department also should be informed to enable them to comprehend the possibilities of the new conveyor system, also in relationship with the evaluation. The main supervisor of assembly, Mr. Diar Ruslani and the factory manager, Mr. Razali Bin Abdul Ghani who are most important for this are therefore highly involved and included in the project group. Their knowledge on the assembly process also is a critical factor for the success of the project. The last essential stakeholder in the case of the implementation of the conveyor line is the managing director, Isep Gosali, who will decide whether the conveyor line will be implemented or not.

Because of the broad perspective and the load of work needed for the correct implementation of a conveyor system a new layout and some supporting components like the trolleys, working tables and tools, this project is done by a team. The team consists out of; Mr. Razali Bin Abdul Ghani, who I mentioned before and who is my mentor during this project, Mr. Diar Ruslani who knows everything about the assembly process, Mr. Tri Sugeri Gumilar Permana, Mr. Aries Febryan and Mr. Rian Ahmad Nurdiansyah, three technical students doing an internship at Sarandi. Within this team my role was that of project leader, keeping track on what needed to be done and what progress was made. The project team had at least weekly meetings on the progress and to discuss problems encountered. The schedule for the project team tasks and deadlines are in appendix C.

1.6 Research question

The ultimate goal for this research is to improve the control system and the efficiency of the assembly department at Sarandi. The main problem with improving this is the chaotic workplace. The chaotic workplace is a result of a lack of structure. This we try to improve by implementing a conveyor system with its necessary complementary devices. These devices range from trolleys and working tables to tools. Also when implementing a new conveyor system it will be necessary to change the layout of the department to make implementation possible and make the system most efficient. By changing these structural factors we also expect structuring factors like the standardization to change (Ranson, Hinings, & Greenwood, 1980).
These structuring and structural factors are expected to reinforce each other. This research looks for the correct way to do this and by that improve the situation of the chaotic workplace, the core problem according to our problem analysis. By handling this core problem we try to deal with the improvement goals as set by the management of Sarandi, namely improve the control and efficiency of the assembly department. For the correct approach towards this all, the following research question has been formulated:

"How should the assembly department of PT. Sarandi Karya Nugraha be structured to improve its control and efficiency?"

This question implies several areas which have to be looked at more carefully. First, we will look for the relationships between all important factors in the next chapter and make a usable theoretical framework to have an overview on all factors and their relationships. Then, the current production process in the assembly department and all its structuring and structural characteristics need to be evaluated. The second sub question will describe the situation as required and desired by all people concerned. Factors considered will reach outside the main research targets of better control and better efficiency and will also look at human aspects and flexibility because these are very important aspects within a company and since a change in these aspects can be expected. Yoshimura (2010) recognized this, stating that more standardized processes and conveyor systems tend to be less flexible and make that employees get less or smaller tasks. Finally this chapter will also be devoted to discuss the concrete design of both the structuring as structural characteristics of assembly and what effects these structures will have on the control system and the overall performance of the assembly department.
The following sub-questions are formulated:

1. How is the assembly department currently structured?
2. What organizational structure is most suitable for the assembly department of Sarandi?

These sub questions will be covered in chapters four and five.

1.7 Objectives

This research' ultimate goal is to help Sarandi to improve its assembly department. Or more specifically help Sarandi's management to get better control over the assembly department and to improve the efficiency of the assembly department. The ultimate effect of both these goals will be that Sarandi will get better margins from its efforts and through that get a better position in its market. The more practical result from efforts from this report will be a new design for the assembly design This design will include all elements needed for the successful implementation of this system towards reaching its goals. The design will include technical requirements of the conveyor system, like motor requirements, the layout which is best suitable when implementing a conveyor, some devices like trolleys, and will also include manuals and descriptions on employee tasks which follow from the structural changes.

My personal objective is to get more working experience, to get better insight into actual working processes and to experience working in another country. Of course, my main incentive for this work were to really make a contribution to Sarandi, which was the best possible host for such a project and to successfully complete my Bachelor with this final report.

1.8 Relevance

We can separate the scientific and social relevance (Geurts, 1999). A scientific relevance, being the way in which this research is theoretically or methodologically relevant, is not established in this research. The research uses a model that has been formed by statements and models from established literature and will use this model to make a design for the assembly department of Sarandi, but the validity or reliability of this model will not be tested empirically.

The social relevance, thus the societal relevance or the relevance for the company, can be observed quite literally. Unlike most reports this research actually made an impact on the company other than having the results of a report. Its actual result will be the new design of the assembly department. Through this new design we tried to make the work less heavy and frustrating for the employees and more controllable and productive for the management.

Chapter 2 Theoretical framework

In chapter one we found that the ultimate goal of this research is to improve the control and efficiency and we found that the main underlying problem is the chaotic working space. In this chapter the main concepts are discussed and a theoretical framework will be set up. The main concepts can be divided into three groups being: 1) the **improvement goals** of a higher level efficiency and control, 2) the **three-S mechanisms** or the structuring mechanisms and 3) the **structural characteristics**. After introducing all these concepts we will discuss their relationships and the theoretical framework will be presented.

2.1 Improvement goals

The improvement goals were set out by the management of Sarandi. The first goal is to get better control on the department, they want to have better insight into the process to be able to make potential improvements and also to be better able to evaluate individual and overall performance. The second goal is to increase the department's efficiency, since they presume that this is far from satisficing. The following paragraphs will discuss the literature definitions and implications of these terms.

2.1.1 Control

Throughout literature the term 'control' has been defined in many different ways, with every definition having its own focus or problem area accompanying this term. One of the most common used definitions of control is by Henri Fayol who stated:

'*Control of an undertaking consists of seeing that everything is being carried out in accordance with the plan which has been adopted, the orders which have been given, and the principles which have been laid down. Its object is to point out mistakes in order that they may be rectified and prevented from recurring.'* (Fayol, 1949)

In accordance with this definition Weber (1947) also saw control as a way of creating and monitoring rules through a hierarchical authority system. Others saw control as a process of testing, measuring and providing feedback (Thompson, 1969). Slack, Chambers and Johnston (2007) emphasize the interrelatedness of planning and control and define it as being the reconciliation between what the market requires and what the operation's recourses can deliver. Planning according to them is a formalization of what is intended to happen, while control is the process of coping with changes.

The mechanisms used in a control system can be job descriptions, rules and standard operating procedures, budgets and performance appraisal systems (Flamholtz, 1996).
These mechanisms can be defied in three groups being (Ouchi, 1979):

- Market mechanisms; mechanisms who rely on market information or external information to make better decisions within the organization.
- Bureaucratic mechanisms; existing of a variety of explicit routines and policies which need to be followed, formulated in rules or standards. This mechanism is conform the bureaucratic model described by Weber (1947).
- Clan mechanisms; this can be best described as being the social mechanisms controlling people. It consists out of socialization processes, cultural norms and values.

Since by the implementation of a conveyor system there is no reason to expect any change in external information this research will not take market mechanisms into further account. The bureaucratic control mechanisms on the other hand are highly probable to change since the implementation of a conveyor system forces employees to work according to the conditions implied by the conveyor system as to where to be and how much time they have for certain procedures. Therefore two of the main control mechanisms, being standardization and formalization, will be used to improve the bureaucratic control and to make the implementation of the conveyor system possible. It is also possible that the clan mechanisms will change because of a diminishing flexibility and importance of implicit knowledge. These

mechanisms are very hard to manage and currently are appropriate (employee questionnaire, appendix E, question 7).

In practice businesses use an 'organizational control system', which can be defined as a synergy of mechanisms which increase the probability that people will behave in the desired way according to the organizational goals (Flamholtz, 1996). A control system can be divided in two parts: " (1) a set of conditions which govern the form of control to be used (..) and (2) the control system itself (..). The control system itself consists primarily of a process for monitoring and evaluating performance while the preconditions specify the reliability and validity with such comparisons made" (Ouchi, 1977, p. 96-97). These preconditions derive from the organizational structure, since the control system is embedded in its organizational structure (Terrien & Mills, 1955; Anderson & Warkov, 1961). Ouchi (1977) then recognized there are just 2 phenomena you can evaluate, being behavior and outcomes. Resulting in just 2 types of control, either behavior control or outcome control. For behavior control the observer needs extensive knowledge on the process through which the outputs are formed, for outcome control the observer just needs valid and reliable measure of outputs. Figure two gives a simplified overview on the understanding of an control system according to the theory just discussed.

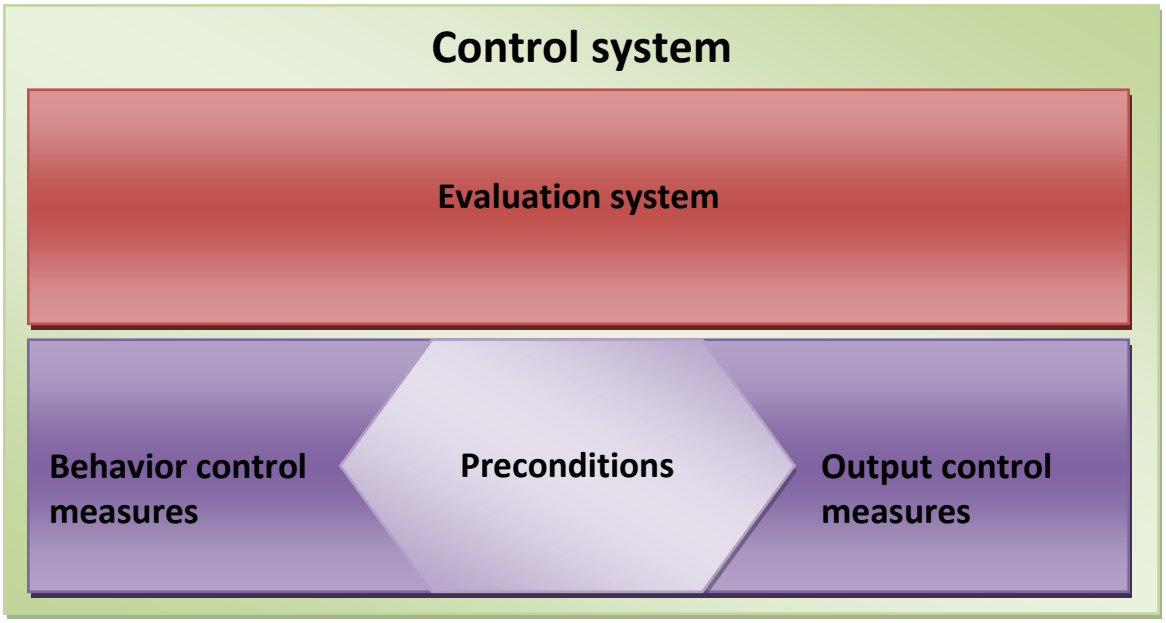


Figure 2: Overview of a control system

For this research we will look into improving the control system by improving the preconditions, which derive from the organizational structure. By revising the preconditions the reliability and validity of the measures of possibly both behavior control as output control can be improved. By that the overall evaluations from the control system will be more valid and reliable.

2.1.2 Efficiency

According to Slack et al. (2007) the efficiency of a process can be calculated using the following formula:

Efficiency = actual output/effective capacity

The actual output literally is how much output actually been produced. The effective capacity is "the useful capacity of a process or operation after maintenance, changeover and other stoppages and loading has been accounted for" (Slack, Chambers, & Johnston, 2007, p. 329). The difference between these measures determines the efficiency. The difference between these factors is caused by other

factors than the ones mentioned in the definition of effective capacity. For example the balancing loss caused by a imbalanced work distribution can cause a difference between these factors and therefore causes the efficiency to get smaller.

2.2 Structuring mechanisms

Manual assembly conveyor systems are said to have the following three S effects: simplification, specialization, and standardization (Makino & Arai, 1994, p. 501). We will explain each of these concepts in the following subparagraphs and present the model incorporating these mechanisms as the core needed to reach the goal of higher efficiency and better control. Subparagraph 2.2.1 will discuss standardization and the closely aligned formalization mechanism. Subparagraph 2.2.2 will discuss the closely aligned mechanisms specialization and simplification.

2.2.1 Standardization and formalization

From the problem analysis we discovered that the insufficient level of formalization and standardization was one of the main problems causing the chaotic work space. These mechanisms can be used to improve the layout and to implement the conveyor system. Because standardization and formalization are two main mechanisms for bureaucratic control these will have a big effect on the bureaucratic control and the organizational structure too. This is why standardization and formalization will get included in the model as shown in figure two. The relationships between all factors will be discussed in paragraph 2.4 and 2.5.

The first mechanism we will discuss is standardization. The definition of standardization can be described as being: *"*The degree to which processes, products or services are prevented from varying over time." (Slack, Chambers, & Johnston, 2007, p. 17)

As mentioned in the description you have different types of standardization, being process standardization, product and service standardization. For this research there will be a focus on process standardization since we want to modify the way the product is assembled. Standardization can lead to relatively lower costs (Slack, Chambers, & Johnston, 2007, p. 17). A survey among 707 companies confirmed this with the arguments that by making information more available and accessible transaction costs will be lower (Verlag, 2000). Also, standardization has a positive relation with the strategic potential, competitive advantage, potential for foreign markets, cost reduction, buying power over suppliers, formation of strategic alliances, safety and liability (Verlag, 2000).

The concept of formalization is defined by the number of codified jobs and the tolerated range of variation from these rules (Hage & Aiken, 1966). According to Pugh, Hickson, Hinnings, Macdonalds and Turner (1963, p. 303) formalization is a "statements of procedures, rules, roles and operation of procedures, which deal with (a) decision seeking (applications for capital, employment, and so on), (b) conveying of decisions and instructions (plans, minutes, requisitions and so on), and (c) conveying of information including feedback". In a similar, more practical way formalization is formulated as systematic behavior, assignment of responsibilities and documentation (Argouslidis & Baltas, 2007).

David and Greenstein (1990, p.4*)* wrote the following: *"*a 'standard' is (..) a set of technical specifications adhered to by a producer, either tacitly or as a result of a formal agreement". According to this definition formalization of the agreement about the process can be part of standardizing the process. Thus standardization and formalization have a interrelated relationship. Dalton (1978) also recognize the close alignment between these factors. According to him the difference can be defined as formalization stating what you should do, while standardization states how you should do it. He also stated that the effect of standardization and formalization is the diminishing of role ambiguity, which can lead to a positive effect in employee attitude and performance. However standardization and formalization can also lead to limited job scope, which results in boredom, job dissatisfaction and eventually into low output (Dalton, Fielding, Porter, Spendoli, & Todor, 1978).

Figure five gives the theoretical model of the main forces in the assembly contributing to the new control system as shown in figure two, these forces are structural qualities according to the definition of Campbell (1974) who made the distinction between structural and structuring characteristics of an organization. Structural characteristics referring to physical characteristics, while structuring characteristics refer to policies and/or activities which prescribe or restrict behavior of employees. Formalization and standardization are examples of structuring characteristics and are part of the organizational structure, therefore they stand close to the control system.

2.2.2 Specialization and simplification

Specialization refers to the task variation employees have. A company with a highly specialized workforce comprise that employees have one job and only do that job. A lower specialization degree means employees have more different tasks, thus have a higher variability of jobs to do (Olson & Chervany, 1980). This definition is a very general one. The term 'specialization' mostly is associated with knowledge companies, but this general term is also applicable for a production department.

Simplification can be applied to different aspects of the operation. First there is job simplification, job simplification 'pursues tasks efficiency by reducing the number of tasks a single person must do' (Daft & Marcic, 2006, p. 627). The principle is based on scientific management and industrial engineering. Tasks get more standardized, simple, repetitive and routine. This makes the training of new employees easier and workers thus more interchangeable (Daft & Marcic, 2006). The mechanisms job simplification and specialization according to these definitions, both encompass task variability and thus are exchangeable.

However product simplification is a very different mechanism. It can be done in two different ways, you can either reduce the number of different products made, or you can reduce the number of parts out of which the product exists (Lucchetta, Bariani, & Knight, 2005). A more hybrid form of this can be recognized in using more standardized components for different products. By using more standardized components you get more flexibility in production, costs can be minimized and you need less stock. We expect only to change the job simplification by changing the structure of the department. Product simplification should be handled in another project which would mainly concern the product design.

Finally Daft (2006, p.579) mentions the simplification of work cycles, which leads to shorter cycle times. According to him substantial improvement can be possible "by focusing on improved responsiveness and acceleration of activities into a shorter time".

2.3 Structural characteristics

The main structural characteristics we define are the conveyor system and the layout. The actual conveyor system, consisting of a motor and a chain dragging the trolley, on itself has little influence on the process without changing the necessary conditions. One of the main conditions is the layout and additional process flow. This we will discuss in paragraph 2.3.2. The other structural necessities like the trolley and the conveyor system will be discussed in paragraph 2.3.1.

2.3.1 The conveyor system

A conveyor system encompasses the whole system that transports materials, components or items (Oxford, 2012). It will be accompanied by, and in practice probably has the most effect through, the appropriate layout and some supporting materials like working tables and trolleys. The trolleys have to be able to ease the work of the employees since currently some employees have some complaints about this (employees questionnaire, appendix E). We also found from the questionnaire and observations that the lack of individual working spaces and the shortage of tools cause the employees to walk around, this is why we also will look into this. An advantage of the conveyor system is that it forces

people to work according the standard processes, on the predetermined place within the predetermined standard time. These predeterminations make it easier for the management to control the assembly process. “This conveyor system in manual assembly line is said to have the following three-S effects of rationalization; simplification, specialization and standardization. By these effects the manufacturer can reduce the cost of products” (Makino & Arai, 1994). This statement will be discussed in the following paragraph.

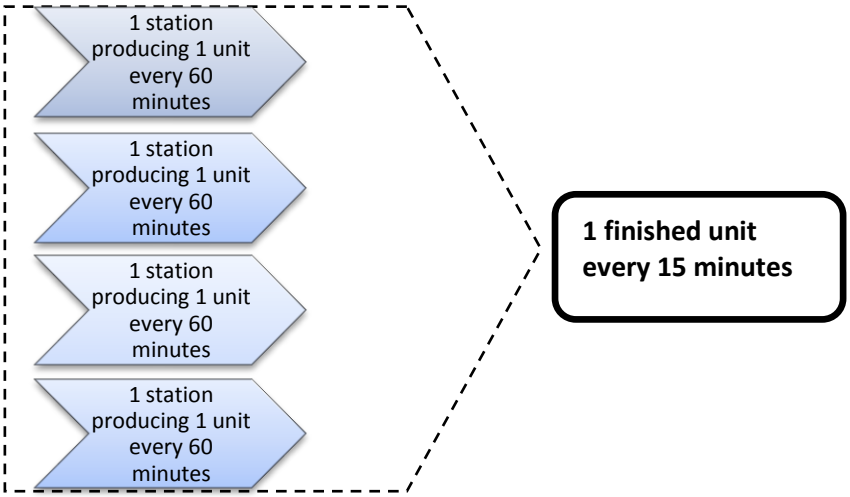
2.3.2 The layout

According to the needs from the production area the management can choose from different types of layout. The basic layout types are classified by Slack et al. (2007) as being:

- The fixed-position: with this layout the product or the service is mainly stationary, while transforming recourses are moved to and from the product/service.
- The functional layout: also called process layout, locates all similar resources or processes together.
- The cell layout: in this layout, the transformed resources will move to the ‘cell’ which meets their processing needs.
- The product layout: this layout locates it transforming resources entirely according to the transformed recourses needs. It involves the transformed resources to follow a certain route and is commonly used for processes like automobile assembly.

Of course in practice most layouts cannot be defined as being one of these layouts but rather as a mix. Deranged from this basic layout the process flow must be determined. This can be either long and thin or a short fat arrangement. A clarification on these principles is depictured in figure three. As can be seen in the figure the long thin arrangement has many sequential stages, all performing a small part of the total amount of tasks that needs to be executed. The short fat arrangement has relatively few sequential stages, meaning that also a relatively bigger part of the total work will be done at every stage.

Short fat arrangement



Long thin arrangement

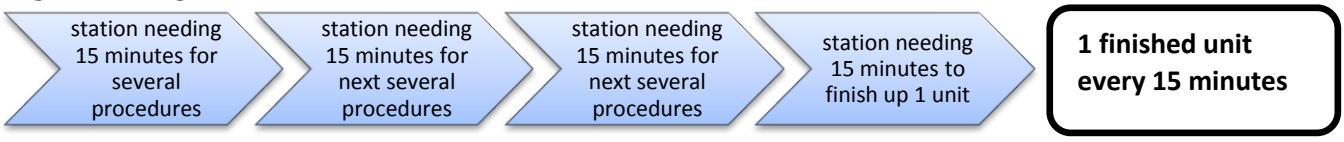


Figure 3: Arrangement of stages

The long thin arrangement has the advantage of being easy to control, has simple material handling, lower capital requirements and has the effect of a more efficient operation. The short fat arrangement however has a higher mix and volume flexibility, has higher robustness and makes the work less monotonous. The long thin arrangement also automatically encompasses a smaller variety of tasks, thus a higher level of simplification and specialization.

2.4 The relationship between the structuring characteristics and the structural characteristics

This paragraph will give an outline on the forces and influences the structuring characteristics will have on the main factors contributing to the new control system, being the layout, the conveyor system and the bureaucratic control mechanisms. As we also discussed in the prior paragraph the chaotic workplace caused by a lack of formalization and standardization is the main problem causing difficulties for management to control the assembly process. We will use the easy to use description of Dalton (1978), formalization is what to do, standardization is how to do it, to determine what formalization and standardization will mean in the case of each of the factors.

Formalizing the layout means determining and making rules about what job should be done in which place. Standardizing the layout entails giving standard procedures on how to do it in that place. Furthermore the responsibilities and job descriptions are given to employees according to where they are standing and what job is required at that place according to the layout. The other way around the fixed layout will thus also reinforce the standardization and formalization of the procedures. In short, formalizing and standardizing the layout will define where to do what procedure.

The implementation of the conveyor will have the three-S effects (Makino & Arai, 1994). However, this relation also has a divers effect because for the appropriate implementation of the conveyor system procedures will need to be formalized and standardized, tasks need to be simplified and people therefore get specialized in certain tasks. The necessity for this is the result of the diminishing flexibility that comes forth out of the implementation of the conveyor system. A tradeoff you have to make for the gain of efficiency, described by Thompson (1967) as being: The central paradox of administration coming forth out of bureaucracy. Furthermore the responsibilities and job descriptions for employees are determined by the conveyor system which is inflexible. It thus forces people to adapt to the conveyor system as defined by the formalization and standardization. Formalizing and standardizing by implementing a conveyor system will define how much time people have to do a procedure. It will also specify what people need in more concrete terms, in most cases by specializing and simplifying the tasks executed by one employee.

2.5 The effects of the structuring characteristics on control and efficiency

For the control system a further formalization implies more documented control mechanisms. Further standardization implies that a further specification on how the targets should be reached is given by the control mechanisms. This will thus lead to a more intensive control system including more procedures and more specifically defined procedures.
The gemba kaizen philosophy warns for the dangerous effects of standardization by a detached management. Managers ought to avoid an environment consisting out of too many rules, where the bureaucracy overshadows the actual process. This can be avoided by only providing what is required by the workplace (Imai, 1997).

The preconditions for the control system mainly consist of the organizational structure. The core structuring mechanisms discussed are an important part of the organizational structure and therefore define the preconditions for the control system. These factors will change and will have an influence on the whole organizational structure, of which they are also part of. “Organizational structure both

describes the prescribed frameworks and realized configurations of interaction, and the degrees to which they are mutually constituted and constituting" (Ranson, Hinings, & Greenwood, 1980, p. 3).

"For procedures to be verbalized, elements of them must be encoded in declarative memory, and those declarative elements, or "chunks," must be accessible to other production rules that have specific purpose of verbalizing thoughts (language productions)" (Alibali & Koedinger, 1999). The verbalization of the knowledge makes it explicit and information storage in the declarative or explicit memory has the advantage of enabling people to use the information in adapted situations and to better memorize it (Eichenbaum & Morris, 1990). The more direct advantage for management of more explicit knowledge is that this kind of information is better to control since the preconditions for the control system get better defined and more constant. The preconditions can both influence the reliability and validity of the measures of behavior control and output control. When there is perfect knowledge on the transformation process there is an opportunity for behavior control. By formalizing and standardizing the information on the assembly process, or in other words, by making it more explicit, the knowledge on the process increases and thus improves the possibilities for behavior control. When there is a high availability of output measures there is a possibility for output control (Ouchi, 1977). Figure 4 gives the matrix displaying this theory. The amount of output control is already pretty high at Sarandi. Also by formalizing and standardizing the process the amount of output control will not change. Therefore no change in output control is to be expected. At this moment Sarandi thus has a high availability of output measures and an imperfect knowledge on the transformation process, this implies that at this moment Sarandi uses output control. By increasing the standardization and formalization a high availability of output measures and a perfect knowledge on the transformation process can be expected, which implies that Sarandi can then choose between behavior control and output control. Since empirical research suggests that output control and behavior control have different functions rather than being alternative forms, Sarandi can choose the appropriate form by looking at its purpose. Output control is a sufficient control measurement for many companies, since it is easy to measure, its outcomes are easy to compare and it provides legitimate evidence of performance (Ouchi, 1975). Behavior control is more difficult but provides better opportunities for improving processes by finding the actual problems and causes. Behavior control thus better fits the kaizen strategy of Sarandi, while output control is better suitable because of its easier use.

		Knowledge of transformation process	
		Perfect	**Imperfect**
Availability of output measures	**High**	Behavior control or output control	Output control
	Low	Behavior control	Ritual

Figure 4: Control type and its antecedents conditions (Ouchi, 1977).

2.6 The theoretical model

Figure five shows the theoretical model used for this report. As can be seen it consists of three layers. The top layer portraits the improvement goals we want to reach by improving the overall structure of the assembly department. These are a better control system, or more precisely more reliable and valuable measures for the control system comprised from better preconditions and a higher efficiency level.

The bottom level displays the more practical structural characteristics which the management of Sarandi wants to implement to reach the mentioned goals. The figure displays the layout and the conveyor system, but also includes the other equipment like the trolleys.

The middle layer which in theory will connect these layers consists of the more abstract structuring characteristics. The two previous paragraphs already discussed the way the three-S mechanisms will be connected to both the improvement goals and the structural characteristics. This will be essential in linking the practical structure to the improvement goals.

The framework will be used to give a better overview on all these main factors to answer both sub question one, on the current situation, as sub question two, on the desired situation. In chapter four the answer on the first sub question will be organized by this framework and it will clarify the relations between all factors. Chapter five will provide the new design by looking at the current situation and how this differs from the situation which provides better control and efficiency. The model gives a good overview on how these improvement goals are connected to the structuring and structural characteristics and because of that, it will be used as a frame to direct all changes towards these goals. It will also provide an overview on what has been discussed about the most important elements at the end of both chapter four and five.

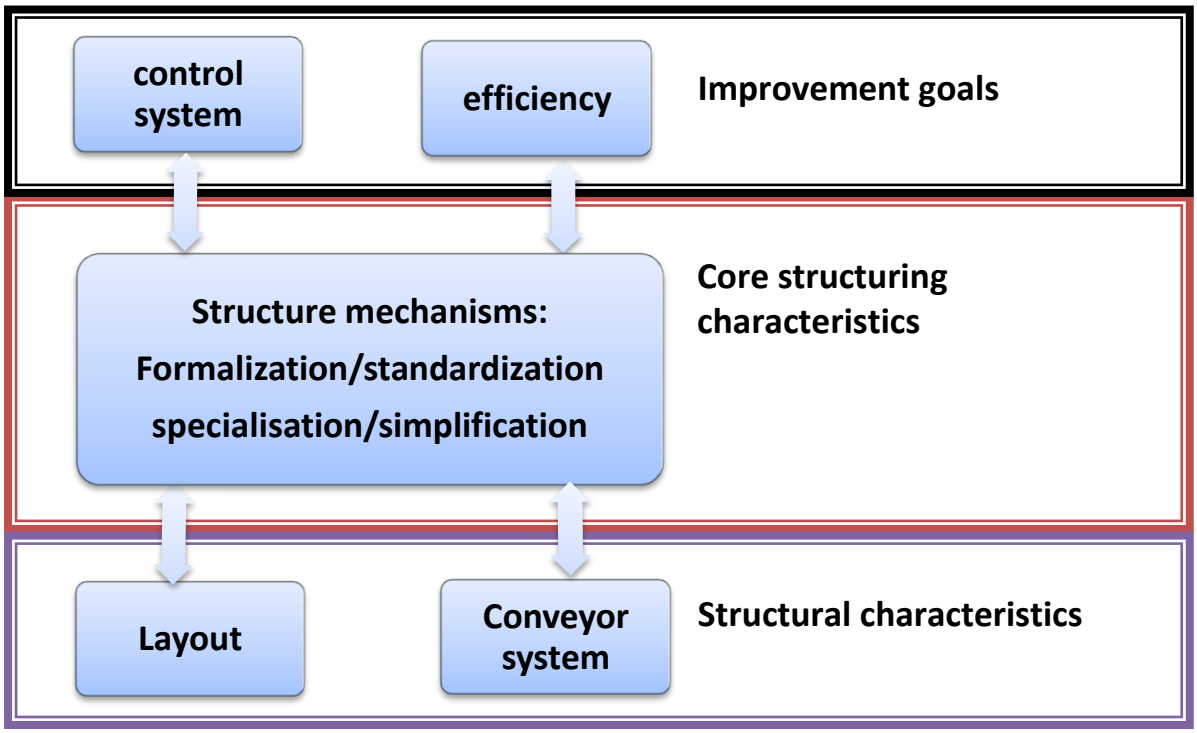


Figure 5: Model of the main forces contributing to the new control system and higher efficiency.

Chapter 3 Methodology

3.1 Introduction to MPSM and the work method throughout the report

The problem analyzed for this research can be defined as an 'action problem' meaning that there is a discrepancy between the observed reality by the observer and the desired norm (Heerkens & van Winden, 2012). The Management Problem Solving Method (MPSM) by Heerkens (2012) provides a general approach for Business Administrative action problems. The MPSM allows the researcher to be creative while having a structured approach to solve an action problem and therefore is a suitable approach for this research. The structure it provides by giving seven phases which need to be completed to get the best solution will be followed throughout the whole report. A complication for this problem, but a problem experienced in most researches, is that this problem does not only has a theoretical approach and solution, but it also has a practical approach and solution. The art is to balance the practical aspects with the theoretical aspects in an effort to get the best possible solution. Table one provides the phases imposed by MPSM and the chapter or the appendix in which these are covered. It also gives a brief description on the practical approach.

Phase in the MPSM	Chapter/appendix	Practical approach
1: The problem identification	Chapter 1.4, appendix B, D, E	Observations, meetings
2: Formulation of the problem approach	Chapter 3	Observations, meetings
3: Problem analyses	Chapter 2,4,5, appendix D,E,F,G	Observations, meetings
4: Formulation of alternative solutions	Chapter 5	Theoretical research
5: Choose the solution	Chapter 5, appendix H,I,J,K,L	Theoretical research, meetings
6: Implementation of the solution	-	Producing the conveyor system
7: Evaluation of the solution	Chapter 7, evaluation report	Questionnaires, meetings

Table 1: Phases of MPSM and the corresponding chapters or appendixes

To solve an action problem you always need to solve some 'knowledge problems', being problems of having a discrepancy between what the observer knows and what he needs to know. This research report focuses on the theoretical part of the project and thus focuses on the 'knowledge problem' we encounter when trying to implement a conveyor system in the best possible way to improve the control system. This 'knowledge problem' must be solved first by analyzing relevant theory and by analyzing the current situations.

3.2 Research design and instruments

This research tries to find the causalities between different factors which finally influence the control systems reliability and validity and the overall efficiency of the department. The research will analyze the current situation, look for the most ideal situation according to the goals as specified by the management of Sarandi and will make a concrete proposal on how the department should be structured. By doing this the research tries to contribute to the successful implementation of the conveyor system. It thus is a constructive research.

For this research we first wanted to research the relationship between different factors by comparing the situation before the implementation of the conveyor system with the situation after the implementation. This would be been done by using the model of a longitudinal study, which records the

same variable on two or more different times. However since the research has to be completed within three months while the production of the conveyor system will be done by Sarandi itself after the high season, which takes a couple of months, this was not possible. It is however possible to add this at a latter point in time by using the same questionnaires as used before implementation. So for now we use a cross sectional research model, which is very useful for observing a situation but less appropriate for explaining relations. Therefore we have to use explanations which already were provided by foregoing research.

The necessary information will be collected in different ways. The information required serves a couple of goals; first we need information on the current situation to properly make plans for the conveyor line. This will be done by a process and time study. Information needed for this are: standard times, descriptions on processes, knowledge on usage of tools, on problems occurring at the assembly and on current layout. From this information we can properly make plans on what requirements are needed for the design of the conveyor line and the supporting instruments and layout or in other words what the desired situation is. Second, we need information on the current situation, including exact descriptions on the control mechanisms and on more general information like human aspects and the production flexibility. And finally we will need information on what influence the conveyor line had combined with all its supporting equipment and higher level of standardization and formalization. So we need three kinds of information, namely (current situation) information to determine the requirements, information on the general current situation and information on the expected situation after the implementation of the plans. We use different sources of information which are summarized in table two. Table two also informs about the chapter or appendix where this information can be found and on what kinds of information we try to get from this source.

Information source	Information on	Corresponding chapter/appendix
Discuss issues and requirements with Isep Gojali (managing director)	Requirements, current situation	Chapter 1
Regular meetings with project group	Requirements, current situation	Appendix C
Experiences at the assembly	Requirements, current situation	Chapter 4
First questionnaire for assembly employees	Requirements, current situation	Appendix D and E
Meetings with assembly employees	Requirements, current situation	Appendix C
Informal conversations with employees throughout Sarandi	Requirements, current situation	Chapter 4 and 5
Information meeting with all department heads	Requirements, current situation	Chapter 4 and 5
Interview for supervisor and managers directly linked to the assembly department	Current situation	Chapter 4 and 6
Theoretical research	Expected new situation	Chapter 5 and 6

Table 2: Information sources and the corresponding chapters or appendixes

3.3 Operationalization

The first sub question on the current situation needs extensive information on the current status of the assembly process. That means that we will have to observe and measure what procedures are done, how they are done and how much time these procedures need. We will thus do a process and time study to map these processes. We also need to map all the main factors discussed in the previous chapter. Thus all the structuring and structural characteristics and the improvement goals. These are all variables at the conceptual level of understanding and are called conceptual variables or constructs (Schwab, 2005). These constructs need to be translated in measurable operational variables. The relationships between the different constructs and between different variables and the relationships

between indicators and constructs are depicted in figure six. In this figure (a) portraits the conceptual relationship between the constructs which get tested by empirically researching the relationship (c) between the operational variables. The constructs and their relationships were already depicted in the theoretical model of chapter two.

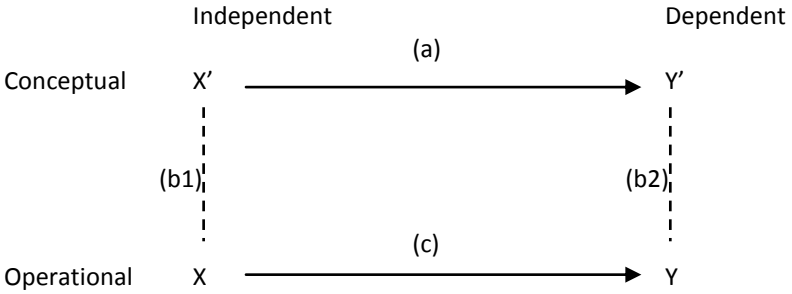


Figure 6: The empirical research model (Schwab, 2005)

Table three gives all the constructs of the main concepts and translates them to operational variables which can be translated into observation items. These observation items are investigated by using questionnaires for the main supervisor and manager (appendix F) and from observations. The information found on these constructs will be used in the theoretical model we discussed in chapter 2 to get a better overview on how the department is currently structured and how this can explain the current situation of control and efficiency.

Sub question two is on how the assembly should be structured and thus looks for the difference between how the department is currently structured and how it should be according to the requirements of management and literature. To answer this question we will thus use the information we found for sub question one and information from the theoretical framework.

Construct	Operational variable	Observation items	Instruments
Formalization/ standardization	❖ overall level of procedures on ass. process ❖ level of procedures derived from time specifications ❖ level of procedures derived from layout specifications ❖ task specification	❖ What is the number of formalized rules? ❖ How much of the procedures are connected to time limits? ❖ How much of the procedures are connected to the fixed layout? ❖ How much variability is possible within the timeframe? ❖ How much flexibility is possible within the fixed layout? ❖ How much task variability is possible within current conditions?	❖ Interview with supervisors and managers ❖ Observations
Specialization and simplification	❖ variation of tasks	❖ How many different procedures are executed by one employee? ❖ How long does one employee need to complete its tasks for one hospital bed?	❖ Interview with supervisors and managers ❖ Observations
Quality of output control	❖ number of output measures ❖ reliability and validity of output measures	❖ What output measures are kept? ❖ How many times are these measured? ❖ Do these measures give an accurate projection of the reality?	❖ Interview with supervisors and managers ❖ Observations
Quality of behavior	❖ number of behavior	❖ What behavior measures are	❖ Interview with

control	measures ❖ reliability and validity of output measures	kept? ❖ How many times are these measured/or on what occasions are these measured? ❖ Do these measures give an accurate projection of the reality?	supervisors and managers ❖ Observations
Efficiency	❖ number of outputs a day (with same number of employees)	❖ What is the number of hospital beds produced in one day? ❖ What causes losses in efficiency?	❖ Interview with supervisors and managers ❖ Observations
Overall performance	❖ Productivity level ❖ Instruction of new employees ❖ Flexibility ❖ Employee satisfaction ❖ managers satisfaction	❖ what is the average number of finished goods (with normal cast)? ❖ How long does it take to instruct new employees? ❖ How easy can the assembly adapt to new situations or problems? ❖ Do employees like working at assemble? What do they like? What not? ❖ Do managers/supervisors like working at the assemble department? What are advantages? What are disadvantages?	❖ Interview with supervisors and managers ❖ Observations

Table 3:Constructs with its operational variables, observation items and instruments

3.4 Limitations of the research design and methodology

As any research, this research and its research design has its limits. The external validity or the generalizability of this research may be classified as being irrelevant since the purpose of this research is to apply general literature on the specific conditions of the assembly department of Sarandi. This research thus doesn't aim to be externally valid. The external validity of the theoretical framework is possible but should be proved by an empirical research. The internal validity referring to whether or not the experimental results accurately reflect the reality is tried to be kept at a maximum by using multiple methods of research (observation and several questionnaires) and by using different observation items (employees, supervisors and the actual processes). The construct validity measuring whether the variables are related as can be expected within the theoretical framework is more complicated. The theoretical framework used is carefully constructed by using well established theories, but in total it is new. However the strong interrelated relationships and the way all pieces fit together suggest that it is correct. Whether all these relationships react as can be expected from the theoretical framework could be seen in practice when the implementation of the conveyor will go as expected.

Chapter 4 Current situation at the assembly department

This chapter we give a description on the current situation at the assembly department in an attempt to answer sub question one being:

"How is the assembly department currently structured?"

This chapter will provide all information on the current situation needed for the theoretical framework. The first paragraph will provide all information on the current structural characteristics and the current production process with elements like standard times and procedures, and has the function to inform the project team on what requirements there are for the conveyor system in order to make the best suitable design. This information area on the current situations structural characteristics will be accompanied by the description on how the current situation analysis has been done. Paragraph 4.2 describes the current structuring characteristics. Paragraph 4.3 covers the more general elements like the human aspects, the production, the flexibility, the control system and the efficiency. And finally, paragraph 4.4 will give some extra background information on how the people of Sarandi deal with the current situation.

4.1 Studying the current process and structural characteristics

Because of the fixed order in which the main products of Sarandi are made, the main assembly part therefore is according to a product layout. The assembly of some sub components is laid out in a functional layout. For the correct implementation of the conveyor system a process and time study is done. Product layout is concerned with 'what to place where', meaning that first locations will be decided upon by balancing the work load among all of the stations and then by allocating tasks to the stations (Slack, Chambers, & Johnston, 2007). This was done in the following phases, which will be discussed in the following subparagraphs:

- process study
- time study
- balanced time layout
- task allocation

4.1.1 Process study

The total work content of making one hospital bed will have to be broken down into separate processes, in order to make an efficient functional layout. Therefore we have to know every individual process. In a way the observation and description of all these processes is the first step of formalizing the process. For this research this will include a description on what tools are needed and on what materials, subcomponents and standard components are needed. By having all processes formalized, we can transform them into procedures and provide written down guidelines for the employees. However the main goal of doing this for now is to have a proper vision on what happens in the assembly and what requirements there will be for the conveyor system. This research studies the assembly of hospital beds since the conveyor line will only be used for hospital beds. This is because Sarandi wants to focus more on hospital beds and because the hospital beds by far already are the most important products they have with a last year's order of 2059. To compare, the following orders had a quantity of 1129, 1098 and 1010, and consisted out of products that are easy to assembly and light(infusion standard and bedside cabinet) and out of a product that is done by a subcontractor (mattress) (Sarandi Karya Nugraha, 2011). After these orders the quantity of orders for other types of equipment were dropping very quickly. Because of these numbers and because the hospital bed is one of the most difficult to assemble and heavy products Sarandi produces, the management of Sarandi first wants to implement a conveyor line focused on hospital beds. It is supposed to be flexible and should later on be possibly applicable for other products. Sarandi produces some different models of hospital beds, the trolley of the conveyor

line will be suitable for all common hospital beds. The exact description of all processes for now will only be done for the hospital bed that is ordered in a large quantity but is one of the more difficult to assemble products, hospital bed 13C. We chose to do this one first because this is the most difficult hospital bed we definitely want to do on the conveyor line, and because when the conveyor is suited for this it is also appropriate for the more simple models. With only some small changes to the description of hospital bed 13C, this description can be adapted to the most common hospital bed 12C. Exact descriptions of the assembly processes for other types of hospital beds which are less common will be done later because of the short time we have for this project.

In the current situation the assembly process is divided in two parts, namely the main assembly, which involves the attachment of components to the main frame and the sub assembly, which consists out of putting some more complicated sub components together and also involves one station where they prepare standard components like bolts. The main assembly process happens in two phases, occurring at two stations. In the first station some heavy subcomponents like the foot framework get attached to the hospital bed. The hospital bed has to flip a couple times so employees can be able to attach the parts either on the bottom or top side of the frame. After that, the hospital bed will go to phase two, which can be done at four similar stations, we call them station 2a to 2d.

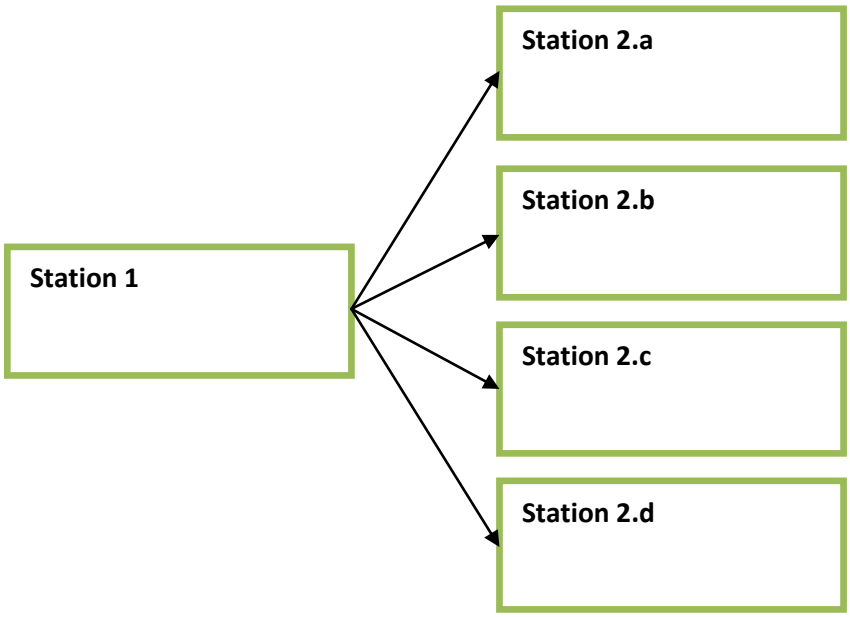


Figure 7:Current general workflow

The basic layout type Sarandi currently uses is a mix of a product and a cell layout. The sub assembly is done according a cell layout, the main assembly is done according a product layout. The arrangement of stations can be defined as being short and fat. The advantages of this type of layout are higher mix flexibility, higher volume flexibility, higher robustness and less monotonous work (Slack, Chambers, & Johnston, 2007, p. 214). One of the disadvantages of the current situation involves employees having to flip and carry the hospital bed manually without support of a devise or trolley, causing half of the employees to have some physical complaints about their waist and back (appendix E). Because there are four stations all doing the same they all need the same components. Every station has its own stack of small components, but for the bigger components they often have to walk to another station to get the part they need. The same thing goes for the tools. This has been mentioned by Slack et al. (2007) as being a need for higher capital requirements; having multiple stations, you will need to have more stock spread out through the assembly space, and you will need to have more tools in order to have employees walking around as little as possible. Also a short fat arrangement opposed to a long thin arrangement of stations has the tendency of being difficult to control the flow of materials and being inefficient partly because of its tendency of having more handling time waste. As mentioned we found

that the attachment of a lot of parts of the hospital beds need to be done in a fixed order. Sometimes because a part needs to be fixed to another part because otherwise the first part will be blocking the attachment of another part. This already limits the possibilities of layout options. The exact description of all processes is given in appendix G.

4.1.2 Time study

Time study is derived from the scientific management methods from Taylor (1911), who recognized the need of management to have proper documentation on what processes are executed and in what time frame in order to have a standard. This standard is essential for a proper revision. We broke the assembly process down in the main assembly processes and in the sub assembly processes. We then broke main assembly down in different phases and finally we broke it down to the individual attachments of different parts. This is what we will take the standard time for. Since employees have variable operation time this will cause time losses, also defined as system loss (Wild, 2004). Because of this system loss and the time lost while handling the materials and tools we gave an allowance of 5%. Meaning we take another 5% of time extra into account. By setting this as a standard we can look at how quick the employees actually finish all processes in a station. When this is quicker than anticipated we can reduce the standard time, when the time needed for the processes will be longer than anticipate we can look for causes and we know where to focus on when we try to improve the overall system. The current arrangement of procedures and the time these stations take can be found in appendix G. The standard times of every broken down process of the main assembly can be found in appendix H and I. The standard times for every broken down process in sub assembly can be found in appendix J.

For hospital bed 13C, all the procedures in phase one together take about 24 minutes. The second phase happens at another station. The procedures done at the second station take about one hour. The workflow with the process times of the stations is displayed in figure eight.

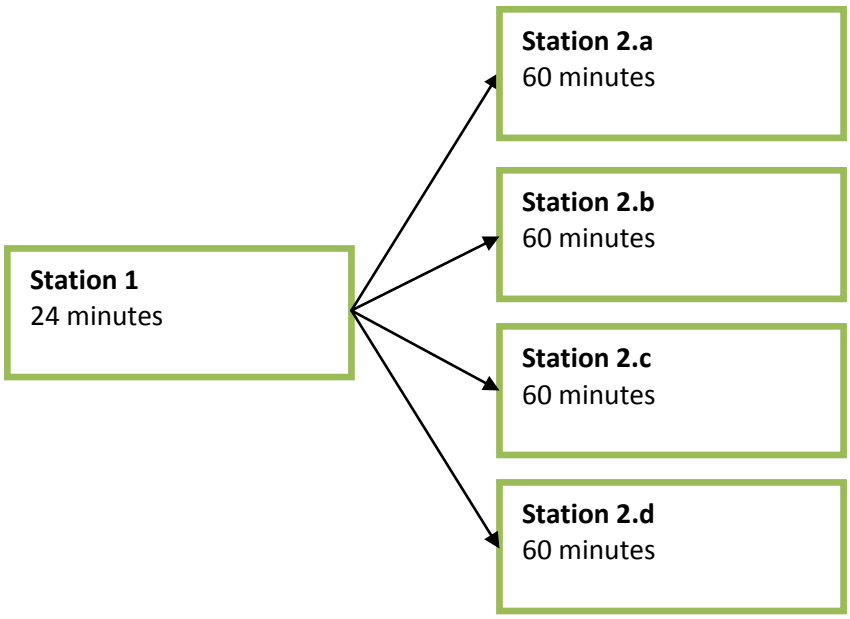


Figure 8: Current workflow with its station process times of hospital bed 13C

The employees usually do not stay at one station, but move with the hospital bed to the next station. When the station they want to go to already is occupied, they can try to keep their selves busy by helping others or by helping at the sub assembly. Since the station times cannot be matched the employees thus have to keep themselves busy. The employees switching jobs and working spots every hour or even more are hard to control for the supervisor and can lead to inefficiency.

For hospital bed 12C, the time needed for station one is approximately 18 minutes. This time differences is caused by the foot framework of hospital bed 12c which is much easier to attach. The second station still takes approximately 60 minutes.

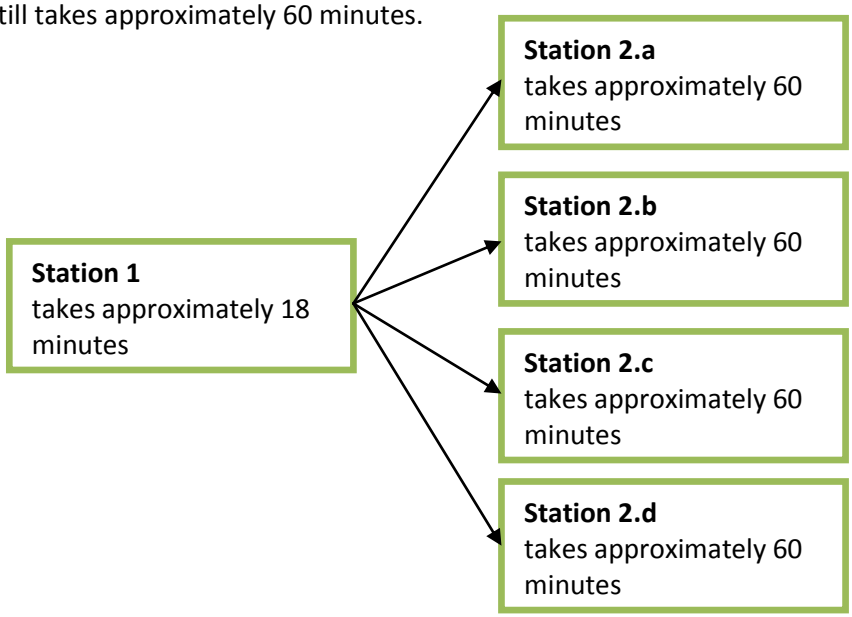


Figure 9: Current workflow with the station process times of hospital bed 12C

4.1.3 Balanced time layout

Through a calculation of the standard time and by knowing the fixed order of some of the parts we can arrange all processes to different phases which in the new layout will be coupled to new stations at the conveyor line. Balancing this processes means obtaining the same standard times for every station in order to prevent one station from having to wait for the other station to finish. The efficiency of this process is measured by balancing loss. Balancing loss is 'the quantification of the lack of balance in a production line defined as the percentage of time not used for productive purposes with the total time invested in making a product' (Slack, Chambers, & Johnston, 2007, p. 211). A similar statement from the management encyclopedia defines balancing loss as 'the quantification of the lack of balance in a production line, defined as the percentage of time not used for productive purposes with the total time invested in making a product' (Bennett, 2012). In order to calculate the balancing loss, we need to know the cycle time of the process, which is 'the average time between units of output emerging from a process' (Slack, Chambers, & Johnston, 2007, p. 209). This implies that the cycle time of the process depends on the station that takes the most time. Also, we need to know how much time all stations need to finish all tasks assigned to their stations. The total task time is the sum of the task time assigned to each individual station. By dividing the task times for all stations by the total throughput time (which equals the cycle time multiplied with the total number of stations), we obtain the percentage of time used to actually produce the product. By subtracting this percentage from a 100% you will get the balancing loss. In a situation of *n* stations, the formula for the balancing loss therefore is the following:

$$Balancing\ loss = \left(1 - \frac{\sum_{i=1}^{n} \text{time task i}}{\text{cycle time} \times \text{number of stations}}\right) \times 100\%$$

For hospital bed 13C we calculate the balancing loss when using station 2a to 2c (which can be interpreted as 3 sequential stations with a total task time of 60 minutes and a theoretical cycle time of 20 minutes). The total task time for all these stations is 24+60=84 minutes. The total throughput time is $24 \times 4 = 96$ minutes.

The balancing loss therefore is:

(1 - 84/96)*100% = 12,5%

The balancing loss for hospital bed 13c is thus 12,5%, but the work floor will also not be fully used.

For hospital bed 12C we calculate the balancing loss when using 2a to 2d (which can be interpreted as 4 sequential stations with a total task time of 60 minutes and a theoretical cycle time of 15 minutes). This will not cause a bigger balancing loss since the cycle time is smaller due to lower task time of station 1. The total task time needed to produce one hospital bed is 18+60=78 minutes. The throughput time is $18 \times 5 = 90$ minutes.

So, the balancing loss for hospital bed 12C is:

(1 - 78/90)*100% = 13,34%

The balancing loss for hospital bed 12C is thus a little higher than of 13C. However for hospital bed 13C the department's work floor is not fully utilized.

4.1.4 Task allocation

After configuring the new layout we make a new task allocation. The current layout involves two employees at every station who do all tasks together. The exact allocation of tasks is not provided, the employees will figure this out themselves. Employees like this element of their job, as two of them also mentioned the team work as a positive factor of their work. However this is another element that makes the evaluation of the work difficult for supervisors. Also while permanent employees are perfectly able to work with this system, it creates difficulties when training new employees or when working with temporary employees in the high season. New employees don't have any manual and are highly dependent on intensive supervision from more experienced employees. At this moment training a new employee will take about two months (appendix F)and needs extensive supervision. Supervisors thus have difficulties assigning jobs to new employees since almost all stations take about an hour and involve a large range of processes and therefore need a lot of supervision from experienced employees who do not have time since they have a lot of assignments during high season. This causes new employees to make mistakes, which either later need to be corrected or which cause the product not to be up to standard.

From observing the department I also noticed that the efficiency of the department was low because a lot of the time employees just don't know what to do. At an average at least two of the fourteen employees are walking around looking for something to do or are just sitting down waiting for someone who appoints them to something or until they can help with something. For example, from observing the quality checker of the department I saw that at an average he was working about ten minutes of every half hour at the task he was appointed to do. The rest of the time he was walking around, filled in a paper, talked to some people, looked at his mobile phone, sat down for a bit, and sometimes helped people with tasks, which to my judgment they were perfectly fine doing themselves. To me it seemed he was willing to work, since he was constantly looking around, was trying to help others and seemed restless (shaking his legs when sitting). When asking the supervisor about this he said this employee just does the quality check and currently has not much work because it still was low season. This particular employee is the most extreme example I could find but overall a lot of employees were not contributing efficiently since a lot of times they did not know what to do and just helped someone who did not really needed help (like moving small and light components on racks with wheels with two persons), looking at other peoples' work or discussing things. I also noticed that while the supervisors were very necessary to be available to instruct the other employees, having two of them walking around was not contributing to the assembly process. However when having multiple shifts you do need two supervisors.

On a very general level the layout of Sarandi is according to the 5S principles of kaizen; the overall work floor, the arrangement of departments, machines and other big devices are laid out according to 5S, thus in a effective and orderly fashion. However when you look more closely, the arrangement of sub components, tools and standard components are not arranged according to the 5S. For some departments this is a bigger problem than for others. The assembly department is one of the departments that still has some difficulties in upholding the 5S principles in several ways. Their layout is not sorted or straightened. The processes are not standardized or sustained. Since the execution of the 5S is not properly done at the assembly department they have difficulties in following the PDCA cycle. There is no 'plan' they can follow since there is no standard procedure which makes it difficult to set out objectives, 'doing' is possible but should be according to the plan, which is not well defined, this gives a lot of uncertainty during the process. Also, because of the unstructured and ineffective layout the 'doing' part could be made more efficient. 'Checking' gives difficulties, for the lack of standard provides no measure size which they have to uphold, also when they do find flaws, they cannot trace the responsibility or cause back to the source. Corrective 'actions' should be specifically directed towards improving severe changes between actual result and planned results. This is thus not possible, and therefore Kaizen's goal of constant improvement is not reachable.

4.2 The current structuring characteristics levels

The current situation of the structuring mechanisms which cause the chaotic working place have already been discussed quite extensively in the previous chapters. This paragraph will briefly summarize this since these factors are very important for this research.

The formalization and standardization levels on the production floor overall and especially on the assembly department are low. There are no standard procedures and no standard times for any of the assembly products. The supervisor and more experienced employees therefore fully rely on tacit knowledge and instructing a new employee takes a lot of supervision. The low level of standardization and formalization can also be recognized in the fact that the department needs a lot of supervision. The department has two supervisors for a department of fourteen persons and the questionnaire also mentioned that missing the supervisor caused problems. The main assembly of one hospital bed is done by teams of two persons. These teams fully distribute the tasks among each other as they see most suited unless the supervisor interferes. Individual performance is very hard to trace because of these low levels of standardization and formalization.

The simplification and specialization also have low levels in the assembly department. Except for some employees who sometimes do sub assembly, employees have to do a large variety of tasks since they put together a whole hospital bed and not just a part of it. They thus are not specialized in one certain task. Although indicated as not a good practice for Sarandi by various researches from interns before myself, the product standardization or simplification still is low. Customers have different demands for products and the marketing department keeps giving them the possibility of customizing the products like hospital beds. Also, the Research department of Sarandi keeps modifying all products. This makes it hard to simplify the production of the products. However the need to is been recognized and Sarandi now does try to implement the more hybrid form of product simplification by using more standard components for various products.

4.3 The current situation of human aspects, flexibility and the improvement goals

This paragraph will be divided into the sub paragraphs human aspects, flexibility, efficiency and control system. For each element the current situation with its advantages and disadvantages will be discussed, supported by employee surveys and experiences by supervisors and by own observations and experiences. The focus for the control system will be on the preconditions determining the reliability and validity of the measures since this research will focus on these aspects.

4.3.1 Current situation of human aspects

Human resource management is the business department "comprised with a broad range of practices covering all main aspects of the management of people in organizations" (Peccei, 2004, p. 2). According to Ehrnrooth (2002) these main elements are; an adequate selection processes, adequate socialization processes, adequate performance appraisal processes, adequate development processes, adequate communication processes, adequate compensation and benefits and adequate employment security. The emphasis on the right amount or well balanced aspects has the purpose of amplifying the relative difficulty of this branch of management to make these elements fit well with each other, the overall company's concerns and of course the well-being of the employees. For this research only the aspects of adequate performance appraisal processes, adequate development processes and adequate communication processes will be relevant since these elements can be effected by the introduction of the conveyor.

Starting with the adequate development process, the training of employees we already shortly discussed in the subparagraph 4.1.4 on task allocation. The current situation on training new employees is quite inefficient, it takes at least two months to fully train employees and it takes a lot of accompaniment of supervisors and other employees. This is partly caused by the stations which, except for one, have a number of processes in it which take an hour in total. This prevents the learning process of being step by step, and forces them to learn almost the whole process at once. The other cause for this derive from the implicit nature of the current knowledge. Procedures are not formally standardized which results in not having manuals for new or temporary employees.
The appraisal processes are done by the control system and will be discussed in subparagraph 4.2.3. Which just leaves us with the communication processes that we need to discus. As mentioned the current exchange of knowledge is challenging because of the implicit nature of the knowledge. Communications with the supervisor seems to be fine, since employees like their supervisor and like having him around for help (employee questionnaire, appendix E) . Communications with other departments like painting, machining and the warehouse, however sometimes do get frustrating to employees, since they have to wait for components and also have to deal with a lot of products that are not up to standard. Meaning that the components either have flaws or are not according to the design.

4.3.2 Current situation of flexibility

Overall the current layout of the assembly department is very flexible. The short flat layout caused by having 4 stations which all do the same processes has the quality of having higher mix flexibility and higher volume flexibility (Slack, Chambers, & Johnston, 2007, p. 214). Thus, the current layout provides opportunities for several types of products to be assembled and provides the possibility of shutting a station down when demand is low. The difficulties of training new employees is not only inefficient but also causes inflexibility since especially during the high season it is difficult to handle the sudden increased demand when the quantity of employees is inflexible.

4.3.3 Current situation of efficiency

Currently the efficiency is not satisficing. According to the production planning inventory control (PPIC) and the supervisor of assembly the daily output for hospital bed 12C is about 20 a day. For hospital bed 13C the daily output is about 15 a day. However using the same amount of people as it does now and using the standard times we have from keeping record (including a 5% allowance) we find a cycle time, which also includes some balancing loss, of 16 minutes and 44 seconds. This means that in an average day of 8 hours the assembly department should be able to produce 28 hospital beds. The optimum which doesn't include any balancing loss actually is 30 hospital beds 13C. This is the double amount which currently is produced. We can thus conclude that the efficiency at this moment is low. Also the balancing loss with its 8,34% is a little high and should be reduced a little more. And finally the handling

time loss derived from walking around to get various equipment, materials and tools currently is a lot. The efficiency should benefit most from reducing this.

4.3.4 Current situation of the control system

At this moment Sarandi has a evaluation system that evaluates both output as behavior characteristics of the whole department and of individual employees. We first discuss the output measures and then the behavior measures. This research concentrates on the reliability and validity of the measures the control system uses to appraise performance of individual employees.

For now, the output measures kept are the number of outputs in one day for the whole department and the absence of individual employees. Every day the supervisor gets a target number of products the department has to produce. Through the day the supervisor keeps record on how many products are finished. At the end of the day the IT department and the assembly department itself can see whether they made the target. This output measure is very reliable and objective since it is easy to check and verify. However an objective appraisal process for now only is possible for the whole department and then only for the output measures, since the assembly supervisor only keeps record on how many products are made daily by the whole department, but cannot record output performance measures for individual employees. Since the processes are not formalized or standardized and since the work is done in teams who have joined responsibility the actual work individual employees put into the end product is hard to trace.
The absence is measured by letting employees check in and out every time they enter or leave the company, also during lunch. The check-in is done by a machine that registers when employees keep their individual employee card in front of the machine. All employees have to check in and out four times a day otherwise it will be registered as being late or absent. This will have strong consequences for their individual behavior evaluation. This we will discuss later.

Sarandi has two evaluation forms that mainly evaluate some behavior measures. The first is an evaluation form for individual employees performance which will be used when an employee's contract is at his end and the management will have to decide whether they want to rehire the employee. This actually is a very extensive evaluation that considers all important qualities of employees. The aspects that are considered are given in table four on the next page.

No.	Aspect
A	**Work attitude**
1.	Performance drive
2.	Initiative
3.	Acceptance for positive change
4.	Work standard
5.	Endurance
B	**Personal aspect**
1.	Emotional stability
2.	Withstand work under pressure
3.	Adaptability
4.	Social aspects
5.	Confidence
6.	Independence/responsibility
C.	**Social interaction aspect**
1.	Discipline
2.	Teamwork
3.	Positive impact/Trustfulness
4.	Communication
D.	**Performance**
1.	Work quality
2.	Work load
3.	Understands the work
4.	Ability to communicate
5.	Decision making
6.	Time management
7.	Work dependency
8.	Adapt to work and change
9.	Understand safety aspect
10.	Ability to analyze and recommend
11.	Ability to lead and manage

Table 4: Evaluation measures

However this evaluation form is purely based on the subjective judgment of one supervisor. The supervisors recognize this and seem careful in their judgment, their comment on this form also was that the scale was too big and that they rather would rate on a scale from 1 to 5 instead of 1 to 100.
The second evaluation form is done on an annual basis for employees with a fixed contract. It evaluates 3 areas; general performance, work attitude and discipline/character. The category of general performance includes measures like knowledge and rapidity to complete tasks. More specifically for the operators it also rates the skills with machines and tools and working according to safety standards. The category work attitude includes the measures like initiative, discipline to complete tasks and communication skills. And finally the category of discipline/character includes compliance, work ethic, dressing appropriate and willingness to improve. All of these measures can be rated on a scale from 1-100 of which in practice they only use 40-100. After getting the average of this they then extract penalty points being late or absence. For every absence without a legal reason like a doctor letter the average score will be reduced two points. For being late (also during a lunchbreak) the average score will be reduced half a point. The absence and lateness of employees thus greatly affects their average score. I also experienced that employees always arrived early at work while when meeting during free time they were always late. Another more negative side of their urge not to arrive late was that when they were

almost late they would not show up at work and just got a letter from their local doctor. The rating of the employee will be done by its direct supervisor and after that gets approved by the HRM director and another supervisor. When employees get a very high score the supervisor will recommend that the employee will get a raise or will be promoted which also involves a raise. This recommendation will have to be approved by the HRM department and by the managing director, Mr. Gojali.

Employees do not take these evaluations very serious because of the high level of subjectivity and the lack of foundation of this system. Management may have recognized this since there are no consequences attached to almost all evaluations. In practice, I saw that all evaluations had very moderate scores and from my experience with employees the scores sometimes also seemed to depend on what supervisor was rating him. Some supervisors generally gave higher scores than others. One supervisor even told me he always rates his colleagues a little higher to undo the effect of the distraction of points from absence and lateness. The only chance of a raise at this moment is by having a very good score and a recommendation of the supervisor which also needs to be approved by HRM and the managing director. Supervisors also seem very careful in giving a negative evaluation since in the last years only one employee has been laid off. This is extremely low for a company of more than 200 employees, even considering the fast employee flow and the fact that they first use a year contract. Striking about this one lay off also is that this was one of the directors which was directly supervised by the managing director. To me this gives me the impression that he is the only one who dares to make such judgments. After an appointment of a raise this will not be communicated to the department and the employee will be asked to keep it private, since management is afraid this will lead to dissatisfaction among the other employees. This seems strange since “a fair degree of internal dispersion in earnings” contributes to the well-being of employees (Peccei, 2004, p. 13). Employees can be motivated by the knowledge that they will be rewarded for their hard work. Little but fair difference between the salaries of employees should thus motivate them. However this only can be the case when the difference is fair and known by employees. The problem for Sarandi, and the reason they keep it quiet, lies in the part of “fair degree” since this cannot be evaluated through a system depending on reliable and valid measures.

4.4 Current policies

At Sarandi the knowledge of assembly is not formalized and is passed through by treating the information like it is tacit knowledge (Polanyi, 1966) also known as implicit knowledge. Tacit knowledge or implicit knowledge is highly personalized, not formalized and is therefore hard to communicate. This trait of difficulty in transferring the knowledge can be an advantage when trying to keep your competitor from getting your knowledge but it can be a big disadvantage when training new employees and it causes difficulties for management when trying to get insight in the process. When information is critical to the company and gives the company its strategic advantage it is a big advantage when this information is implicit knowledge because it will be more difficult to copy (Nonaka & Takeuchi, 1995). Because the knowledge is highly implicit, not formalized or standardized at a minimum level, management has difficulties keeping control and therefore also has difficulties planning.

Sarandi already recognized and tried to handle these problems. In an attempt for this they implemented the Kaizen principles. The concept of Kaizen states that management has two major functions, namely maintenance and improvement (Imai, 1997). It especially emphasizes the importance of continuous improvements by small changes according to a common sense approach. Improvements are done by following the plan-do-check-act (PDCA) cycle. The PDCA cycle assures continuity in pursuing a policy of maintaining and improving standards (Imai, 1997). Because Sarandi has an insufficient evaluation system and no standards for the assembly department it is impossible to follow the kaizen philosophy the way it was prescribed by its founding father.

Kaizen is born from several important theories of which the scientific management of Taylor (1911) can be recognized as a significant influence. Taylor, as Kaizen, recognized bureaucracy as a method of

dealing with problems of evaluation, planning and control. A further elaboration on kaizen, bureaucratic control and the connection with structural characteristics, physical characteristics like conveyor system which restrict and prescribe employees behavior, and structuring characteristics, activities and/or policies like standardization and formalization (Campbell, Bownas, Peterson, & Dunnette, 1974), is done in the theoretical framework.

The more specific theory deranged from the Kaizen which Sarandi especially tries to follow are the 5S principles (Imai, 1997), which stands for:

- Sort: Distinguish needed and unneeded items, and clear the unneeded items. At Sarandi this is done at a reasonable level, they are still trying to improve this by implementing a pull system, but in practice I noticed a couple of materials lying in the assembly department which were not used at that moment.
- Straighten: Needed items should be in the correct place which allows for easy and immediate retrieval. As mentioned before, you can see that the whole factory has been tried to be arranged according to this principle by a Japanese expert appointed by the Indonesian government to make Sarandi an example for small and medium sized companies. The floor and departments are arranged very organized and practical, with squares on the ground and signs everywhere indicating for example what machine should be where. However in practice the employees do not work according this principle, with leaving tools lying around everywhere and putting materials too far from their working places.
- Shine: Keep the working place neat and clean. This principle is done quite well at Sarandi. To ensure this is done every day, the last 10 minutes of the working day an alarm bell rings indicating they should stop working and clean their department for the next day. Every couple of months the best cleaned and neat department also wins a small price.
- Standardize: The method through which they make a habit of the sort, straighten an shine process. The shine process is very well imbedded in the daily procedures by devoting the last 10 minutes of every working day to this principle. The other 2 principles are less well imbedded, especially at the more detailed level. This is probably due to the fact that the responsibility for this is not clearly appointed to one or a small group of persons and there is no specific time planned for these principles.
- Sustain: Maintain the established procedures. Some of the procedures I saw where well maintained during the years. However from reports and interviews I learned that a lot of initiatives and ideas did not work because they lacked a good implementation or were not sustained.

4.5 Conclusion

The sub question covered in this chapter stated:

"How is the assembly department currently structured?"

Since the structural organization consists of structural as well as structuring characteristics these both are carefully analyzed. The current structural characteristics were observed by using a process and time study, by observing the department, and by having extensive meetings with the departments supervisor, who also was part of our project team. From these instruments we once again confirmed that the structure from the structural characteristics where at a minimum. The working spaces seemed almost improvisational with employees having to walk around for tools and materials a lot. The layout can be classified as being a cell layout combined with a product layout and its stations are arranged according the short and fat arrangement. The allocation of tasks to these stations has a balancing loss of at least 12,5%, which is relatively large. Because of this layout the employees also had relatively large variation of tasks.

The structuring characteristics were researched by interviewing the direct supervisor of the department and the factory manager. These interviews confirmed our first impressions on the structuring mechanisms, namely that the levels of standardization, simplification and specialization are low. The processes were not standardized or formalized at all, which made it hard to instruct new employees. The lack of standards also made it hard to measure individual as well as overall performances. And as mentioned just now, the employees had relatively large variation of tasks, hence low simplification and specialization. The interview also gave us insight on the current status of the improvement goals of better control and efficiency. Since there was no standard to compare measures with, the current control was mainly based on output control measures. Output control measures only give results and almost never clarify the causes which makes it hard to make improvements. The efficiency was low because processes were not standardized or written down at all, causing employees to do it the way they thought was fine, which not always is the most efficient way. The big variety of tasks also made it hard for employees to do every task efficiently and up to standard, this thus also drove efficiency down. And finally the relatively large balancing loss caused a loss in efficiency. Figure ten gives an overview on all main factors and causes of the structural and structuring characteristics and the improvement goals by using the theoretical model structure.

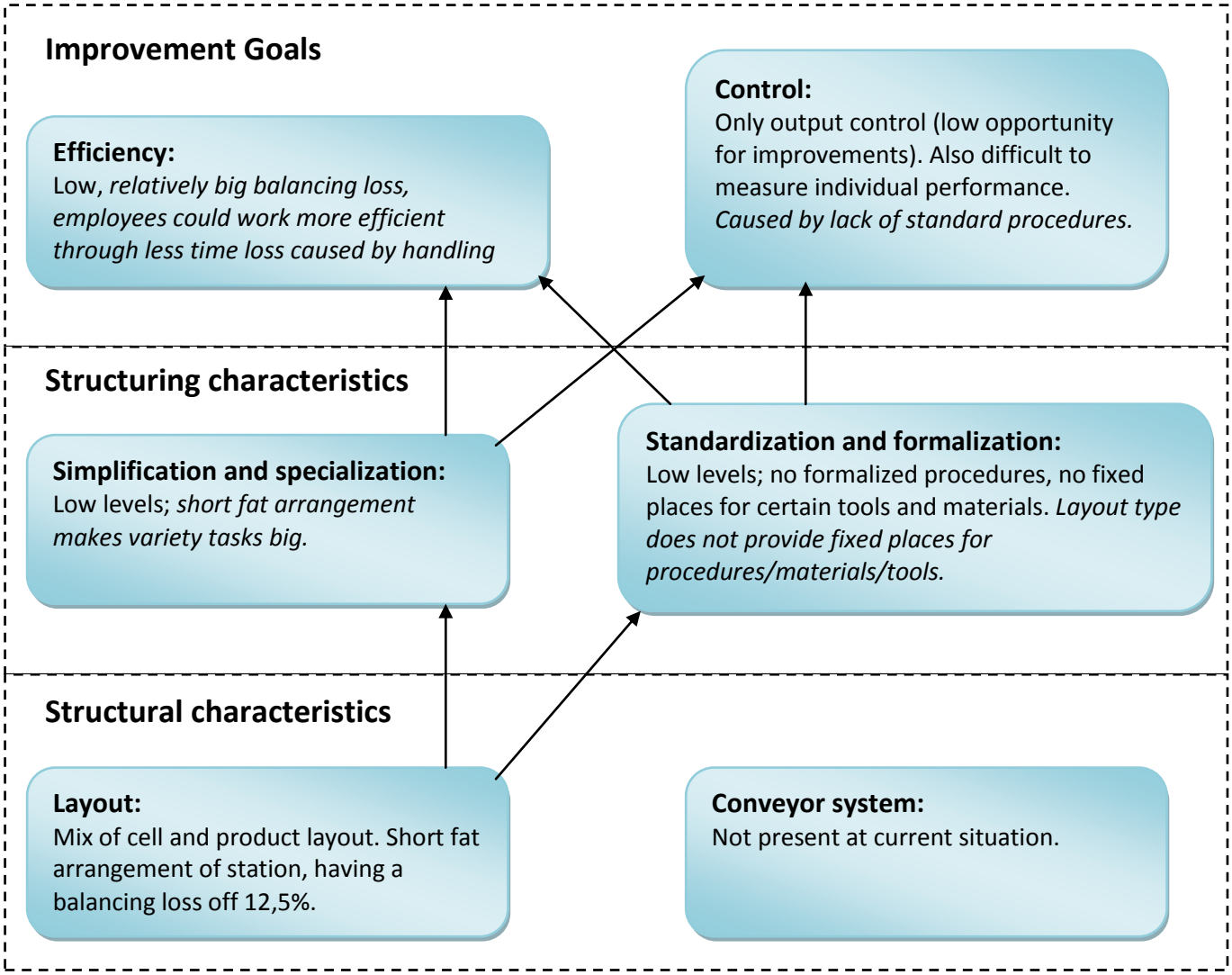


Figure 10: Overview of all important factors at the current situation using the theoretical model.

Chapter 5 The new design of the assembly department

This sub question is done to get the complete grasp of how to get the correct organizational structure through the modification of the structuring and structural characteristics in practice. It states:

"What is a good design of the assembly process at the assembly department of PT. Sarandi Karya Nugraha?"

In the previous chapter we once again concluded that the low levels of the three-S mechanisms were at the center of the problem area, and that by resolving the issues surrounding these mechanisms we could improve the control and efficiency of the department. However the standardization, formalization, simplification and specialization are all quite abstract constructs which need to be operationalized into practical plans for the department to reach its goals. This is why the concrete plans presented to the management will mainly concern the structural characteristics, which in their turn will affect the structuring characteristics.

This chapter presents the more practical and concrete approach of the implementation of the conveyor system with its appropriate layout and all its supporting equipment which has the ultimate goal of getting better control and efficiency. After the presentation of these elements we discuss how these modification should effect the three-S mechanisms and finally we will discuss how these mechanisms will influence the control and efficiency.

This chapter thus discusses our proposal on modifying the assembly department. For the correct implementation we will need a new layout, a conveyor system consisting out of a belt and a motor, a trolley and several support materials. These elements will be discussed in the paragraphs 5.1 to 5.3. Paragraphs 5.4 and 5.5 then further discuss the expected and required structuring characteristics and the implications of these structuring characteristics on our improvement goals of better control and efficiency.

5.1 The layout design

For the implementation of the conveyor we need to change the layout and we had to raise the level of the structuring mechanisms. The best possible balanced time layout was highly defined by the many fixed orders of processes of the main assembly, is done according to the time balancing process and considers all distances travelled by components. The time balancing together with the desired number of employees the management prescribed and the amount of space we could use, led to a layout with four stations for the main assembly with two employees working at every station. Unlike in most cases not the desired output but the number of employees and space were the most important limiting factors to our design. The schematic overview of the arrangements of the stations can be found in figure eleven.

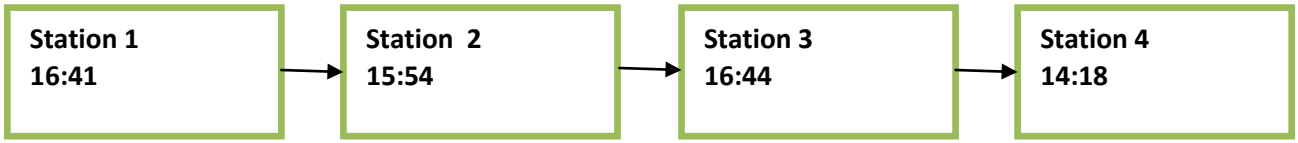


Figure 11: Schematic new arrangement of stations with their station times

This layout will be used during the low season from approximately February to August. A picture of the design can be found in appendix N. This layout uses the same number of permanent employees as before the implementation of the conveyor. As can be seen In figure eleven, the layout will become long and thin. Advantages of this kind of arrangements are the more easy to control flow of materials and a

higher efficiency due to less time waste caused by handling (Slack, Chambers, & Johnston, 2007). You can also see that the stations are not perfectly balanced since the fixed order of procedures and different standard times make it impossible to perfectly balance it out. Station four which involves quality control and packaging needs the least amount of time but has the biggest time fluctuation. The cycle time for this layout will be 16 minutes and 44 seconds, since this is the time needed for all processes in the longest station. The average time needed for all station is 15 minutes and 54 seconds. The balancing loss therefore is:

100% - (15,9/16,733)*100% = 4,94%

Compared with the current balancing loss of 12,5% this is an improvement of 7,56%. This improvement in efficiency is sole derived from the balancing loss. The improvement of handling is not even included in this.

The stations will need to be 2,6 by 1 meter. In between all stations is at least 2,8 meters to stall one hospital bed in the case one of the stations runs into trouble. It gives them time to get that time back over a couple of rounds. The room for stalling also provides some more flexibility needed because of natural fluctuation and to deal with system loss (Wild, 2004). The last station will need to be done outside the conveyor line since quality check and packing activities do not allow the hospital bed to be on some kind of trolley. With this layout the assembly department will produce one finished hospital bed 13C every 16 minutes and 44 seconds. The sub assembly is next to the conveyor line, located such, that it will be most close to the stations using the subcomponents. The sub assembly will be divided into two station (appendix J). The first station assembles the foot mover framework, the foot unit, patient board and bumpers. Assembling the necessary number of all these sub components for one hospital bed takes 13 minutes and 26 seconds. It thus can be done within the cycle time. In practice the employee at this station will make a small stock of each of these components and keeps this stock up to level. This is possible because the total time needed to assemble all parts necessary is less then the cycle time. The technical designers also designed special working tables and fixtures for this station, which will make the work a little more easy for the employee.

Sub assembly station two assembles the side guards. One hospital bed needs two side guard. Assembling one side guard takes 12 minutes and 24 seconds. In total one employee will thus need 24 minutes and 48 seconds to assemble the needed number of side guards. Since this is more then the cycle time, this station needs two employees. Making the average time needed to produce two side guards 12 minutes and 24 seconds. The project team also designed new working tables and even a new tool for this station. The expectation is that by using these new equipments the time needed will be reduced by a minute or two.

During the high season, from approximately August till January, the layout on the conveyor system will change from four stations to five stations, making room for more employees to work at the main assembly. Using five stations with nine employees this will mean that one hospital bed 13C will be finished every 13 minutes and 26 seconds (appendix I). The balancing loss we found for this arrangement is even lower. It only has a balancing loss of 4,37%. By making the number of processes at every station even less the temporary employees will need even less guidance from other employees. This makes that the hospital beds will mostly be assembled by temporary and new employees, leaving more time for the permanent employees to handle special/customized orders like operation tables and X-rays.

5.2 The conveyor system

The actual conveyor system itself only consists out of a belt, a motor that makes it running and a chain holder. The chain length will be 42 meters and the material diameter needed is 6,4 cm, this is

translatable in a working load of 420 kg/925 LB. The motor suitable for this conveyor system is the Mogor M-51K40N,, 40, with a gear ratio of 36. This motor can be set such that the speed of the trolleys on the conveyor will be 1 km/h and the maximum is 3 km/h. Thus the average walking speed is quicker. This was a requirement we wanted to assure the safety of employees. Table five gives a quick overview on what these minimum and maximum speed comprehend when you translate them to meter/second and how much time it will take for the trolley to get to the next station which is three meters further.

	Kilometers/hour	meters/second	Time to get to the next station (3 meters further)
Minimum speed	1 km/h	0,278 m/s	10,8 seconds
Maximum speed	3 km/h	0,833 m/s	3,6 seconds

Table 5: Motor speed requirements and implications

5.3 The trolley and other equipment

An important aspect of the conveyor is the trolley. The trolley is designed to make the work for employees as comfortable as possible by using three main functions of the trolley. The first is the possibility to adjust the height of the trolley. The second, and most important one is the flipping function. Since the employees had back complaints from flipping over the bed to install different components the trolley is specially designed to keep the main frame stuck to the trolley while the employees flip it. This means that the employees still have to flip it but do not have to carry the full weight during the flip. The third function is the turning mechanism. This can be used by employees when they want to work at another side of the bed. This mechanism can also be used to stall more trolleys in between the stations since sideways the beds take half the space on the conveyor line. A picture of the design of the trolley can be found in appendix L.
Also while formalizing and standardizing all processes we make manuals for new employees so information will be available to them at all time. This manual just consists out of one page with all procedures in order and materials needed and with a small picture of the conveyor. Since we keep the team element in, thus working on one station with two employees, we make two manuals for each station so every employee will have its own procedures. Some of the procedures will be done together while some will be done by just one employee. The allocation of work tasks is done according to the time balancing between employees so they will be done at the same time. The manual layout as will be used for every station is exemplified in appendix M.

The conveyor line forces the employees to fixed position working spots. This can lead to boredom and dissatisfaction These working spots have working tables which provide space for 6 traces to put the different parts in and provides space for the tools and has a lower tray for materials that is not used at that moment. For bigger components racks will be set behind them. All materials are thus within an arm's reach which prevent them from walking around. A full lists of components necessary is provided in appendix J.

5.4 The ideal structuring mechanisms

Chapter 2 on the theoretical framework already discussed the implications the structural and structuring factors have on each other and on the organizational structure according to the scientific theories. The alteration of the structural characteristics were all working towards higher levels of standardization and formalization, simplification and specialization. This and the next paragraph work towards the satisficing organizational structure by concentrating on the goal of higher efficiency and better system control. The chapter integrates the earlier discussed theory and the current situation, and by that looks for the ideal situation. In other words, it couples the theory with the specific environment of Sarandi and by that looks for the best way of structuring the department of assembly.

This paragraph will give a quick overview on the ideal standardization and formalization, specialization and simplification levels in the new situation. From the implementation of the conveyor and other practical implementations we discussed in previous chapter, the three-S effect will arise. Thus all mechanisms we mentioned will reach a higher level. Procedures will be standardized and have standard times, employee tasks will be standardized, meaning that the way in which they do their job should be according to the standard and should be in an certain order. And the employees tasks will get simplified and specialized. The implications of these new mechanisms and how to deal with possible negative effects are far more interesting and will be discussed in the next paragraph.

5.5 Implications of the moderation of the structuring characteristics

First the higher level of standardization will have the effect that the preconditions for the control system are more constant and therefore can be compared over time and between different employees. Because the preconditions will be better known and constant, supervisors will get the opportunity of using behavior control measures, which can be very useful when problems occur. By getting a higher level of standardization the knowledge used in the assembly area will change from being mostly implicit to explicit, meaning it has the advantage of being easier to communicate and also has the effect of being more controllable. And by that, makes instructing employees easier by using manuals. Also, the better the insight in the assembly department the better the possibility to control and plan. We thus do expect to have a better possibility of getting behavioral control since knowledge increases. The output control already was on a good level which enables supervisors and management to choose between these two measures of control. Our suggestion is to use output control when the assembly is running smoothly. This kind of control is sufficient for that situation and takes less effort. When problems arise management or supervisors get the possibility of using behavioral control measures in an effort to trace the problem source. For example, when one station is slower than the others, this is easy to trace for the supervisor since the other stations must wait for this station. He already narrowed the problem area down to two employees doing just a few tasks. He can then look at which employee has problems with what task and can help reinstruct or help fix the problem. In the current situation this is a lot harder since employees assemble a whole hospital bed and problem areas they face get hidden by the other employee with whom they work or by making up time during other processes.

The other goal of getting a higher level of efficiency will be partly be reached by the better control possibilities of the management By standardizing the procedures and by having standard times we can calculate the best possible layout and procedures in order to make the assembly department most efficient. Together with higher level of simplification and specialization the efficiency loss from handling different materials, tools and products will be minimized. This is done by minimizing the balancing loss and by minimizing the distance materials, components and tools have to travel, or in other words, by minimizing the employees waste by walking around to do stuff other than procedures contributing to the assembly procedures. The effect from the specialization of the job is that they will get better in the tasks they have to do. Employees need less time to learn the smaller range of tasks and will get more routinized with the tasks. This also contributes to the bigger ease to instruct new employees. A downside of the higher specialization however will be that employees tend to be easier bored and dissatisfied with a smaller range of tasks (Daft, 2006). This can lead to sabotage, absenteeism and unionization. To prevent this while keeping the advantages from simplification and specialization we will implement job rotation.
‘Job rotation systematically moves employees from one job to another, thereby increasing the number of different tasks an employee performs without increasing the complexity of any one job’ (Daft, 2008). The definitions of these terms are being clarified in figure eleven. Our suggestion is to rotate jobs either every two or three hours or during the lunch break. The other element trying to prevent these negative effects is keeping the teamwork element in.

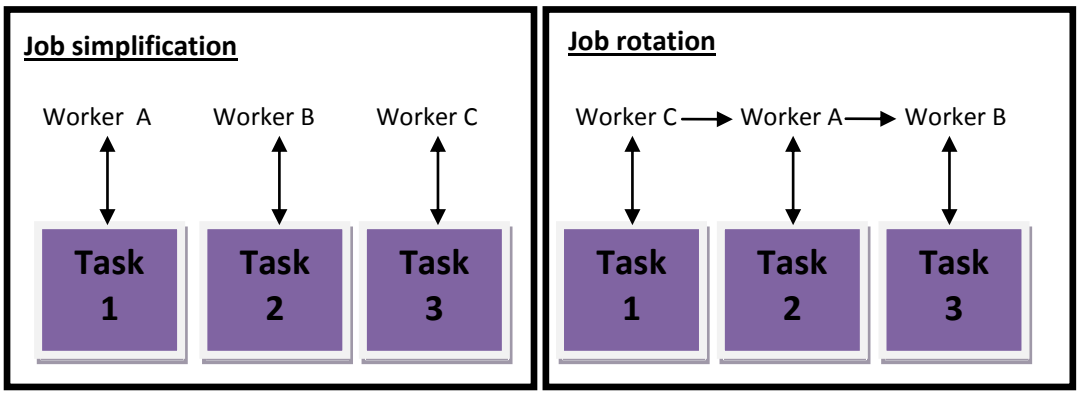


Figure 12 : Job simplification and rotation.

The other important elements of human aspects and flexibility are also likely to be affected by the new structure. For the level of flexibility we can expect a decrease. Procedures are standardized and routinized which can make it harder to adapt to potential changes from outside the department. To minimize the risk of this having effect on the procedures in the assembly department the supply and overall planning and control of other departments must be improved. These issues have been discussed with other department heads and we agreed on having a better information flow when problems arise, also the supply of some essential or problematic components will be done one day ahead, to have time to resolve any potential problems. On the other hand, by making the information of procedures more explicit the procedures are better understood by management and employees and therefore problems arising within the assembly department can be better handled (Eichenbaum & Morris, 1990).

We try to keep the human aspects affected by the new structure as positive as possible. As mentioned the new structure makes the task for employees more routine which makes the risk of boredom bigger. We try to keep this to a minimum by keeping communications with employees open and by job rotation when employees are experienced. The team element is kept in which is experienced as being positive and the fact that the work physically will get less heavy probably will be experienced as being positive since this was one of the complaints employees had. The fact that employees will be more structured will ensure that they will more effectively contribute to the overall process and better know what to do. From observations it seems employees would be fine with that, since they also sometimes seem frustrated with not knowing what to do while they do seem willing to work. The better possibilities to evaluate the work employees performance will make the supervisors more able to give an appropriate evaluation which will be experienced as being more fair by employees. This can also motivate the employees (Peccei, 2004).

5.6 Conclusion

As for chapter four we will give an overview (figure 13, on the next page) on the most important elements by using the theoretical framework. The overview for this chapter provides information on what would be the desired situation for the department. This desired situation can be reached by implementing the proposals done in this chapter and a lot of the appendixes (appendixes H,I,J,K,L,M) . The first big alteration is the implementation is the implementation of the conveyor system in the structural characteristics layer. The implementation of this system with all its supporting equipment like trolleys, working tables and material racks will make work less heavy for employees and will provide a more structured working place to tidy up the whole department. It will also reduce the amount of time employees spend on walking around to get materials/tools they need. The conveyor system only works when the layout is changed from short and fat to a long thin arrangement. This new arrangements also has the advantage of having a smaller balancing loss (4,94% instead of 12,5%). These structural changes will cause and reinforce the higher levels of the three-S mechanisms. In practical terms this will mean that; procedures will be standardized, manuals will be provided, individual responsibilities will be made

clear, tasks variability will get smaller. By defining how procedures should be executed, who should do what and where he should do it, the departments procedures will be more clear to both employees as supervisors. Thus, these more predictable and predefined situation will be easier to control for supervisors. When something goes wrong the availability of preconditions, will make it possible to know: where it went wrong, what material is not in place, which employee made a mistake or who works too slow. The department can thus also use behavior measures in the new situation. The efficiency will get higher because of different reasons. First, the balancing loss is reduced, meaning employees will spend less time waiting for a new task. Also the more clear work descriptions and the smaller range of tasks makes it possible for employees to be instructed quicker and to reach an higher level of specialization, which normally is accompanied with a higher level of productivity. And finally, because supervisors has better control, he will have better insight in what is the problem, making it possible to fix the problem beforehand or faster.

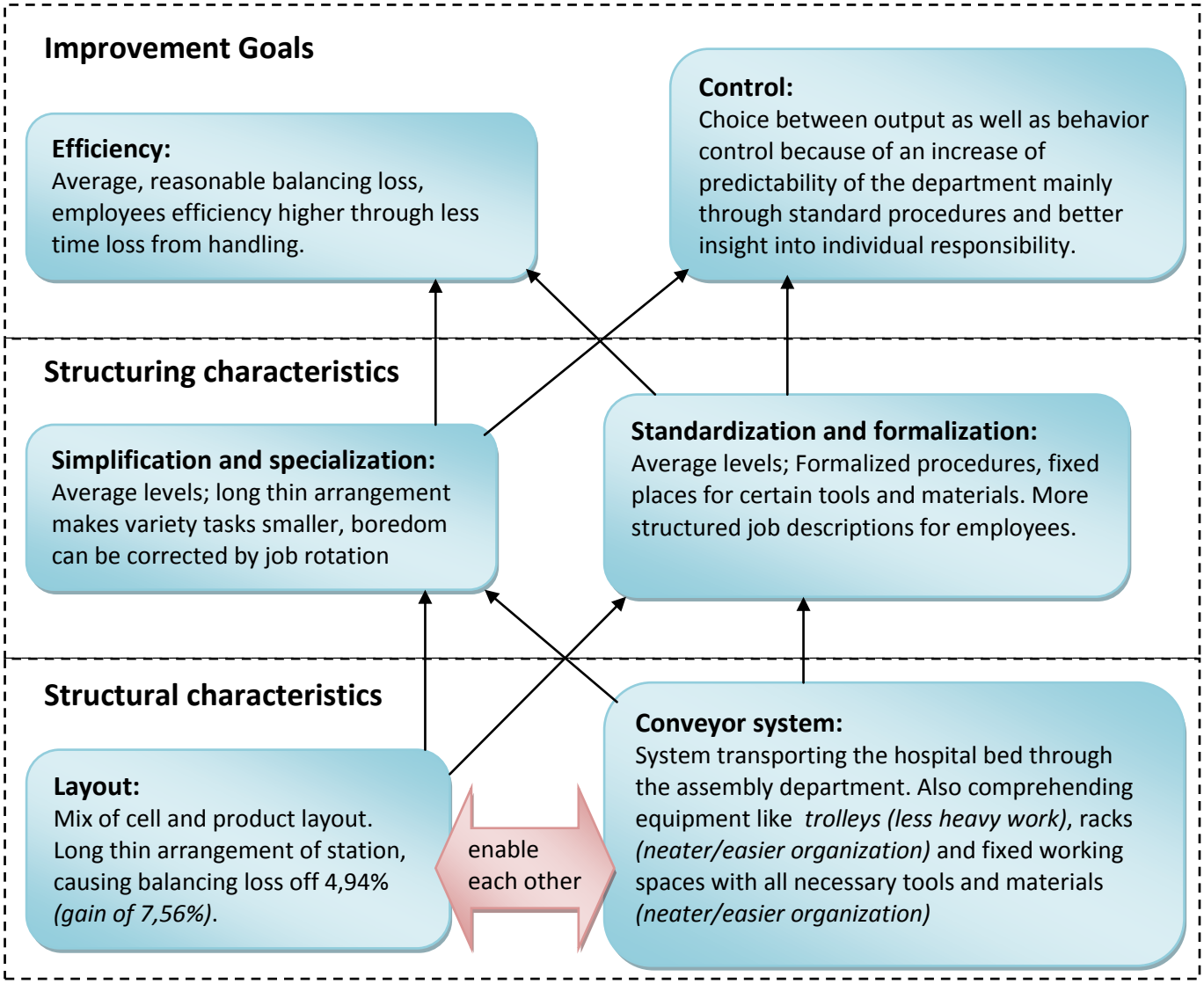


Figure 13: Overview of all important factors at the new situation using the theoretical model.

Chapter 6 Conclusion

6.1 Conclusion on research question

This research done for the assembly department of PT Sarandi Karya Nugraha looked into the project of restructuring and redesigning the assembly departments organizational structure. By this we thrived for the goals of achieving an higher level of validity and reliability for the control systems measures and also attempt to improve the overall efficiency of the department.
To reach these goals and to tackle problems we found occurring at the assembly department, the following research question was formulated:

"How should the assembly department of PT. Sarandi Karya Nugraha be structured to improve its control and efficiency?"

Looking at the current situation, it could be concluded that there was little structure. There were no standard procedures and the working places were not equipped and/or arranged appropriate to be able to reach a high level of efficiency. It was not defined what to do when, by whom, or where. The levels of standardization and formalization was thus very low. The employees assemble a whole hospital bed with two employees causing a low level of specialization and simplification. The supervisor has little insight in who does what and when. The lack of predefined conditions through standard procedures and predefined individual responsibilities made it very difficult for supervisors to have control on what exactly happens at the department. Therefore the department only uses output control. This type of control, unlike behavior control, does not provide inside in causes of any occurring situation, making it hard to solve any occurring problem.

To change this situation we thus had to raise the levels of standardization, formalization, simplification and specialization. To be able to do this the structural characteristics of the department had to reinforce the higher levels of these mechanisms. Implementing a conveyor is known to have the three-S effect, meaning it will raise the levels of these mechanisms. A conveyor system defines what procedure to happen at what place, and how much time this should take. Standard procedures thus have to be implemented for the conveyor to work. This results in a higher level of standardization and formalization. The layout also has to be changed for the conveyor system to be efficient. We changed the arrangement to a long thin arrangement. This had the effect of decreasing the balancing loss to 4,93%. It thus increased the efficiency. The conveyor system makes it possible for the materials to come to the employees. Employees therefore do not have to move the main frame to the next station. This makes a long thin arrangement with more stations possible. The employees stay at these stations for at least a couple hours, after which they can rotate jobs to avoid boredom. Because employees stay at one station, instead of staying with one hospital bed throughout all processes, the variety of tasks will decrease. This will make the level of simplification and specialization higher. Because of the higher level of standardization, formalization, simplification and specialization there will be better insight into who does what, when and where. Through this better knowledge on the preconditions, the measures of behavior control will get more reliable and valid.

The assembly department of Sarandi needs to better structure its department by raising the levels of standardization, formalization, simplification and specialization. The implementation of a conveyor system with its appropriate layout and support materials will provide the right structural characteristics to initiate and reinforce the raise of the levels of the three-S mechanisms. The efficiency will get higher through a smaller balancing loss, through a smaller time loss from material handling and from the higher levels of the structuring mechanisms. The validity and reliability of the behavior measures will increase through the more defined preconditions of the department. Also, the long thin arrangement has the quality of providing better control on material flow.

6.2 Recommendations

We recommend the management of department to raise the levels of standardization, formalization, specialization and simplification. We also recommend the implementation of a conveyor system as described throughout the report and more specifically in some appendixes. And finally we advice to change the layout by using a long thin arrangement. These recommendations, how to implement them and what effects they will, has been discussed throughout this report. This paragraph will just give some highlighted points and recommendations.

- The higher levels of standardization, formalization, simplification and specialization will make the preconditions of the department more constant and predictable, and by that, makes behavior control possible. However since behavior control is more time consuming as output control, the behavior control should only be used to solve problems that occur or to improve the situation. Under normal conditions output control should be sufficient.
- During high season we recommend the department to switch to the five stations design. The levels of specialization and simplification will increase even more with five stations, making instructing the new/temporarily employees even easier. Because the main assembly of the hospital bed has the relative high levels of simplification and specialization we recommend the temporary employees to do this work, so permanent employees have time to assemble other equipment like X-rays.
- The employees tasks will get more standardized and simplified and by that tend to get more boring, task rotation is been advised to prevent this from happening. Rotation of working stations can for example happen during the breaks. New employees should first learn to execute the processes at their current station perfectly before they are allowed to rotate.
- For the conveyor system to work, the supply of materials at the working tables needs to be sufficient. We therefore recommend that supply needs to be filled up to a standard level at the end of every day, so the stock at the working tables will be sufficient the next day.
- Employees complain about insufficient safety materials. The department should have masks, which are according to the safety requirements, safety shoes, glasses and gloves.

Chapter 7 Discussion

As mentioned in the methodology chapter the initial design for this research was longitudinal. The plan was to compare the situation as it was before the implementation of the conveyor system and further modifications, with the situation after the implementation and modifications. By using this construct we could find prove that the theoretical framework used was correct. However, because the conveyor will be produced after the high season which will take at least four more months, it was not possible to see the result of the implementation before finishing the research report. That is why we used a cross sectional research model. The theoretical framework we used was composed from information we found in literature. This model was filled in by using information from observations, meetings, measurements and interviews. The new design then was constructed by using all available information and assuming the correctness of the relations as displayed in the theoretical framework. The individual assumptions made for this model all have been empirically proved, however the reliability and validity of the model in total has not been empirically proved. When we would have used the longitudinal research we could have proved the correctness of the theoretical model. Because this was not possible, the theoretical model is the limiting factor of this research.

However, the empirical justification of the theoretical framework can also provide a new opportunity for a next research, either at Sarandi or somewhere else. A next student located at Sukabumi could help with the correct implementation of the conveyor and could research whether the effect of all implementations is as expected. By comparing the old situation with the new situation the actual outcome of the implementation and modifications can be observed. When the new situation develops as expected, through the implementation and modifications, the correctness of the theoretical model will be empirically proved for this particular case. To make the prove more valid and reliable the theoretical model should be empirically tested at a larger scale, thus it should be researched at multiple companies.

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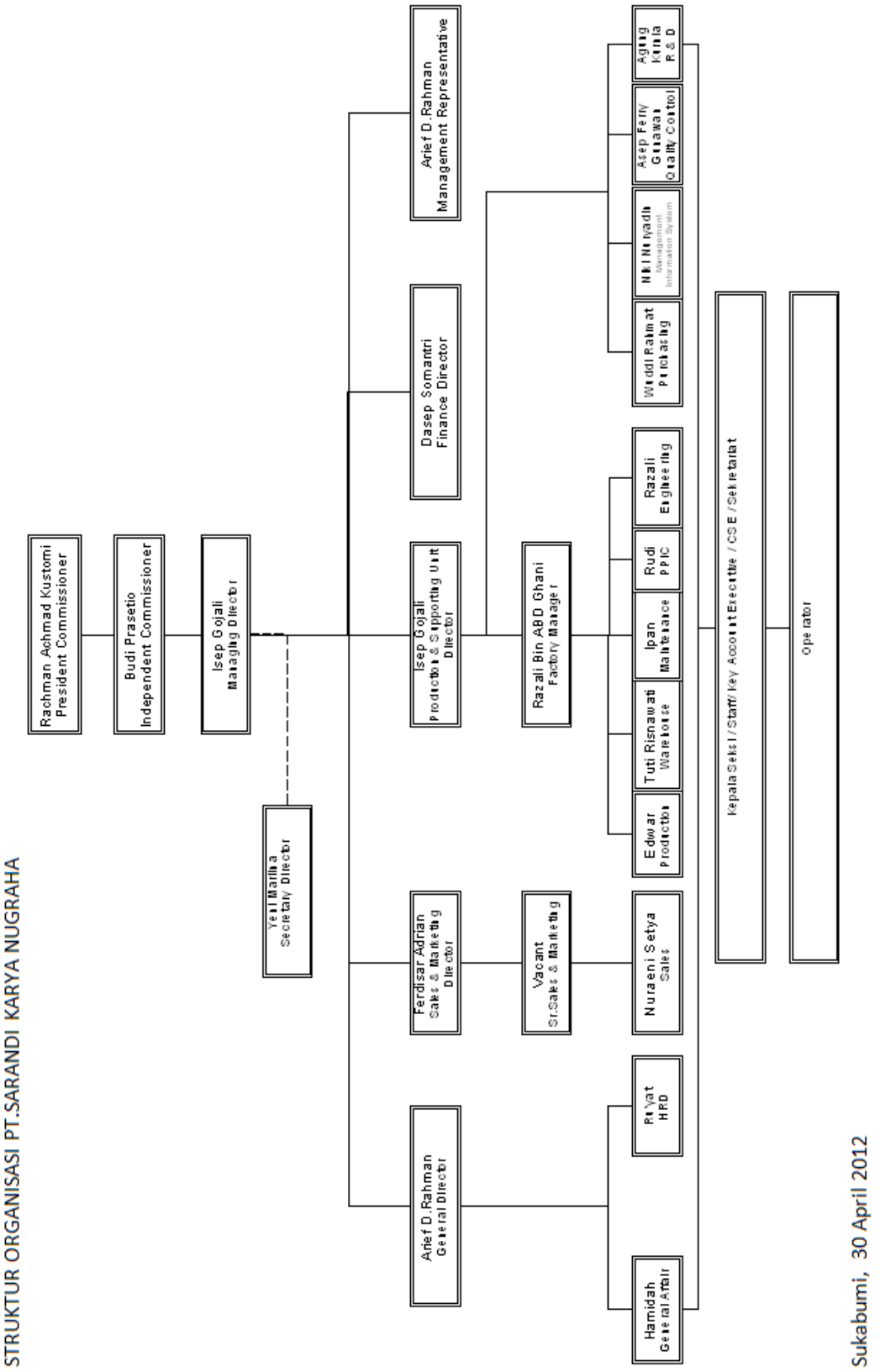
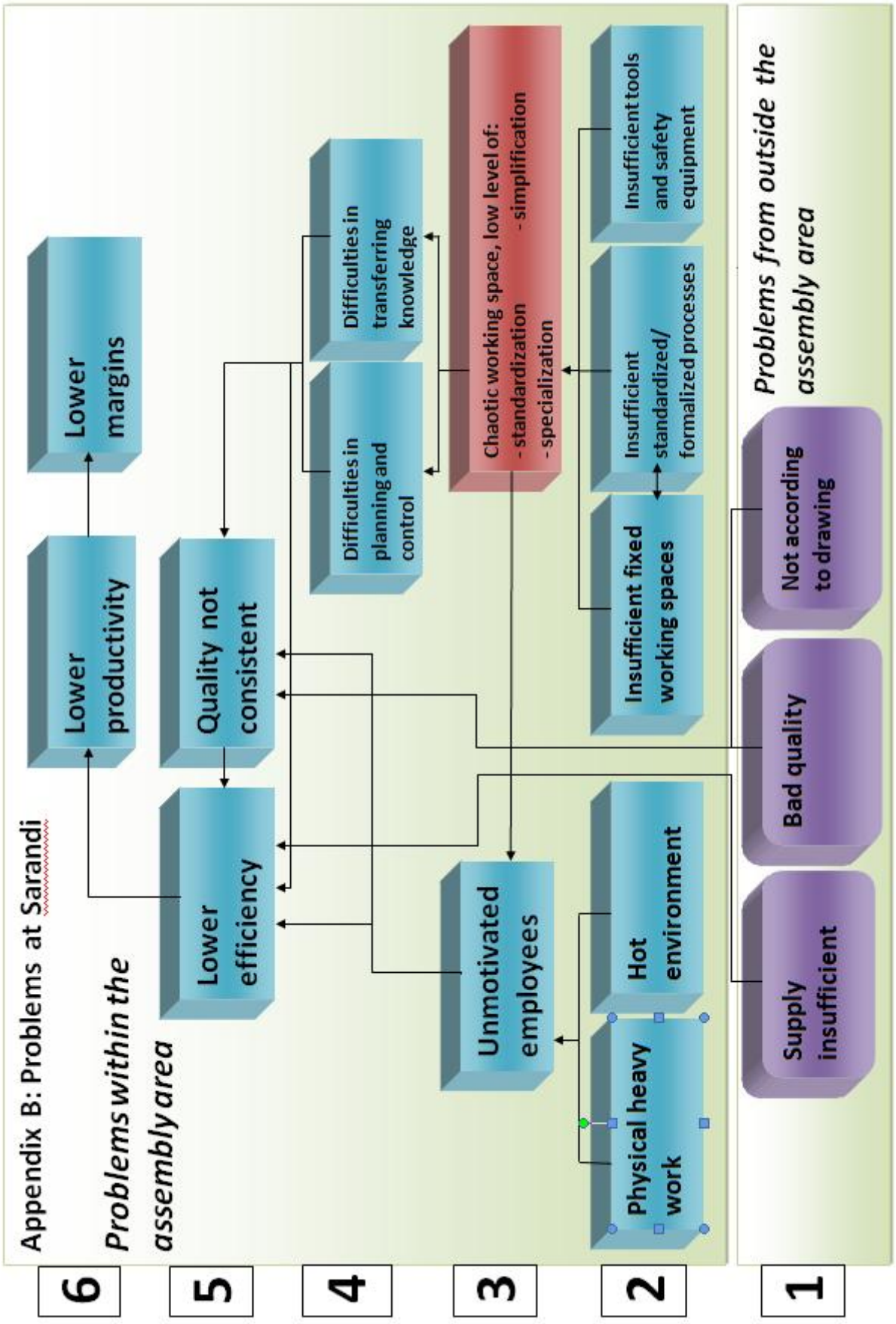
Appendix A: Organization structure



Appendix B: Cause-effect diagram of the problems at Sarandi



Appendix C: Time schedule

	Activity	PIC	timeline
1	Establish project team	Razali & Rachelle	4 May
2	Current process & time	Diar & Geri	8 May - 16 May
3	Discuss research proposal with Isep Gojali (Managing director)	Rachelle	10 May
4	Prepare and distribute questionnaire for assembly employees	Rachelle	15 May
5	Present results of the questionnaire with employees and managers and present the still rough plans for the new layout and conveyor system	Rachelle/Diar	18 May
6	Propose Process balancing	Rachelle/Geri/Diar	18 May - 23 May
7	Plan & Design for support equipment: trolley	Rian	21 May - 10 June
8	Plan & Design conveyor layout	Rachelle/Diar/Razali	24 May - 10 June
9	Allocate work task to workers	Rachelle/Diar	10 June - 15 June
10	Plan & Design for support equipment: working tables for main assembly	Rian	10 June - 20 June
11	Information to other departments	Rachelle & Razali	20 June
12	Plan & design for support equipment: working table sub assembly and additional tools	Rian	20 June - 30 June
13	Fabricate the supporting equipment	Rian	January
14	Fabricate the conveyor line	Maintenance/Aris	January/February
15	Test running	all project team	End of February/March
16	Ready to use	all the project	March

Appendix D: Questionnaire assembly employees

Questionnaire assembly employees

This questionnaire is made to get better insight in the employees wishes for the new conveyor system and the new layout for the assemblage department.

The information conducted by this questionnaire will be kept anonymous. The questionnaire will take about 5 minutes.

We thank you for cooperation. We will try to incorporate your wishes.

1. How long do you work at the assembly?
    - Less than a month
    - Less than 2 months
    - Less than six months
    - More than six months

2. Are you involved throughout the whole process of assessment or just in several parts?
    - Yes
    - No, I am just involved in……. (please fill in the box below)

3. Do you ever have pain in your back, arms or other parts of your body from working in assembly?
    - No
    - Yes, I sometimes have pain in my…….(please fill in the box below)

4. Did you ever got injured while working at assembly?
    - No
    - Yes, I got injured. Please describe what happened…..(please fill in the box below)

5. What safety equipment would you like to use while working?
    - Glasses
    - Gloves
    - Mask
    - Other suggestions……(please fill in the box below)

6. Do you ever have to wait for components to arrive to start working?
    - No
    - Yes, I waited for the following components…… (please fill in the box below)

7. What aspects of your work do you like?

8. What aspects of your work don't you like?

9. What problems do you encounter when working at the assembly?

10. What suggestions do you have for the improvement of the assembly process?

Thank you for your cooperation!

When you have more suggestions you like to share with me, you can always write me a note in Bahasa Indonesia which I will translate or you can come talk to me or Mr. Razali.

Greetings,

Rachelle Cartigny

Appendix E: results from employee questionnaire (Excel bestand)

		Question number					
Respondent number	1	more then six months	whole	arm twisted, eye splashed by glue	eye splash by glue, drill bit broken and hit eye	gloves and mask (must be according to safety rules)	shortage of standard component, component not always ok
	2	more then six months	whole	back pain*	hand cut and clothes pulled by grinding machine	mask (should be accoring to standard)	short supply of plastic matresses, not balance left and right
	3	more then six months	whole	back pain caused by carrying heavy things	cut by knife, because of not functioning knife handle	mask, safety Shoes*	always wait for incomplete components*
	4	more then six months	whole	arm twisted when lifting hosbed, hand cut by grinding machine, cut by knife	no	mask, safety shoes	shortage of backrest and crank
	5	more than six months	whole	back pain	finger injured by slipping drill	mask, safety shoes	standard components, components from subcontractor, components from earlier process
	6	more then six months	whole	feel pain at left-hand side shoulder	right hand get twisted, finger cut by knife	gloves, mask (should be according to health standard)	wait a lot because of shortage of components
	7	then six months	whole	Back pain	injured by drill bit	glasses, safety shoes	bolts
	8	more then six months	whole	no	no	mask	wait for repaired components
	9	more then six months	whole	back pain	arm got scretched by grinding machine	mask, safety shoes	wait for standard components from warehouse

	Question					
Responden d number ⇩	1	2	3	4	5	6
10	more then six months	whole	pain at arm joint and shoulder becauce of carrying heavy things	toe run over by trolley	glasses, mask, gloves, ear guard, safety shoes	sub-assembly components and sub-materials (rugs, thinner, plastic bag, carton)
11	more then six months	hospital bed	arm joint	finger cut by knife, finger stuck by crank unit	insufficient safety shoes	standard component en product component
12	more then six months	whole	back, arm joint	hand cut by sharp plate	insufficient safety shoes	yes, for example for sideguard bracket, step plate
13	less then six months	sideguard type G	no	no	glasses	no
14	less then two months	hosbed 12 C	no	no	mask	no

	Question number			
Respondend number ⇩	7	8	9	10
1	Superior instructions are good	when the superior is not available (on-leave), too many problems arise*	Component dimension not follow to drawing, repair from last process, standard components lost, tools not suitable for certain process	priority should be given to work facilities (tools, rack etc) clear work instruction, dimension must be according to drawing*
2	health aspects - clean environment, not noisy, easy work instructions, not to noisy. Social aspect - good communication, good relation with section head	employees are not cooperative when they must clean the workplace, less suport from sub assembly when I want to assembly a product	too little monitoring from the start which causes interrupted assembly process	sub-assembly must ensure smooth supply to main assembly
3	likes it when every components are completed and ready for use	small working area	insufficient tools	don't have specific area for a job, working table equiped with a hydraulic system to rise up and down*
4	clean environment and not smelly, friendly*	components always need to be repaired beforehand	components shortage, painting not good	fast supply of components to ease assembly
5	clean, healthy, tidy, teamwork	no comment	Always wait for components,components not follow standard, components not follow drawing, drawing mistake	standardise components, before assembly all components must be complete, tidy up drawings
6	environmnent is quite clean, overtime can increase income, friendly	high season, insufficient workplace & tools*	human mistake from earlier process, not standardised components, late supply of components from earlier process cause tight delivery schedule, rework/repair components	Increase facilities for earlier process so that prompt supply can be achieved. QC inspection must be improved at painting process and assembly assembly process, because problems are only encountered at assembly process not during the QC.
7	clean workplace, not dusty	nothing	always wait for components	additional tools*
8	when all components are available, work will complete earlier/faster	stress when urgent delivery and components need to be repaired	no	All components have to be checked on availability and function before they go to assembly
9	clean workplace	bad ventilation (hot environment)	insufficient standard components, BOM doesn't match actual usage	working table to repair and increase, tools need to be replaced, no rework of the product

	Question number			
Responend number ⇩	7	8	9	10
10	tools and components and	small assembly area makes working not convenient, too short process time, different person has different ability and not always in good condition	components not correct, such as no hole, wrong dimension from drawing, malfunction, painting not done properly and flatness problem	workers welfare should be take care of*
11	clean workplace,	no comment	late receive of components	not to have rework jobs or repair
12	the environment is	no comment	sometimes components are different and shortage of components*	ensure all components are completed before start to assembly
13	healthy	nothing	no comment	before assembling any product, ensure all components are redied
14	clean environment	no comment	no comment	no comment

*Some of the most common or most useful information which we either tried to incorporate in the new design or which we presented to the other departments or persons involved.

Appendix F: Interview with the direct supervisors of the assembly department and the factory manager

Interview with Diar and Razali.

Formalization/standardization

1. How much of the procedures assembly employees have to do are written down?

Only on a very general level.

2. Are there any manuals employees can follow?

We do have very general manuals, only including what materials are needed for what products, however they don't include the processes, process orders or how to do things.

3. Do employees have a fixed position?

No, they move with the bed through the assembly area.

4. Do they have all materials and tool they need at their stations? (What do they need to get, what do they have to walk around for?)

No, they sometimes have to walk for materials and tools. Quite many times small distances, and sometimes longer distances.

5. How much processes can be done at different places of assembly?

Some, like the patient board.

6. Do processes have standard times?

No.

7. Do the stations have a standard time?

We don't know exactly, but we know approximately.

8. Is there a high time fluctuation between employees to finish a station/process?

The fixed employees all need about the same times. The temporary employees fluctuate a lot, some temporary employees are even faster than some the fixed employees but most are slower. Thus fluctuations between temporary employees are a lot bigger.

9. Do employees who work at one station have their own fixed tasks?

Depends on the product they are producing, some products ask for a lot of teamwork. But tasks are never so far defined by the supervisor that they cannot decide for themselves what task they do.

10. Do employees have a say in what they want to do that day?

The supervisor says what they have to do.

11. Can employees vary their daily activities?

Yes, daily activities are flexible and are highly dependent on the product requested for that day.

Quality of output control measures (definition of output control will be explained)

1. What output measures are kept by the supervisor?

The output of finished goods in a day and the absence of employees.

2. How are output control measures observed/administrated?

For the absence we have a system consisting out of a machine and personnel cards for every employee. Every time an employee comes in at or leaves work he/she has to check in or out. The same goes for the lunch break. The output is measured by administrating how many beds are made in a day by the whole assembly department.

3. Do employees administrate their progress? (for example: number of beds made)

no, we tried to implement a system in which every employee had to register when they finished a product. However it didn't work since employees didn't do it. They always had excuses, like; I forgot. It is possible that they didn't waned to be evaluated, or that they didn't saw the point of doing so.

4. How is the progress at the assembly area administrated?

By registration of the finished goods

5. At what moments/for what timeframes are these output measures kept?

This will be kept during the day for one day. We have to make the target number of products for one day.

6. Do these output measures give an accurate projection of the reality?

Yes, I think so. However, we don't registrate how much half fabricates we produced for one day.

7. Do you think that the current methods of getting output measures are subjective?

No.

8. When products are not up to standard how will these be administrated?

They will not be registrated until they are finished and approved.

Quality of behavior control measures (definition of behavior control will be explained)

1. What behavior measures are kept by the supervisor?

The following aspects are rated by supervisors for their yearly evaluations on fixed employees. Employees can get a score from 1-100 for every aspect and the evaluation form also leaves room for comment.

No.	Aspect
A	**Work attitude**
1.	Performance drive
2.	Initiative
3.	Acceptance for positive change
4.	Work standard
5.	Endurance
B	**Personal aspect**
1.	Emotional stability
2.	Withstand work under pressure
3.	Adaptability
4.	Social aspects
5.	Confidence
6.	Independence/responsibility
C.	**Social interaction aspect**
1.	Discipline
2.	Teamwork
3.	Positive impact/Trustfulness
4.	Communication
D.	**Performance**
1.	Work quality
2.	Work load
3.	Understands the work
4.	Ability to communicate
5.	Decision making
6.	Time management
7.	Work dependency
8.	Adapt to work and change
9.	Understand safety aspect
10.	Ability to analyze and recommend
11.	Ability to lead and manage

2. How are behavior control measures observed/administrated?

By the supervisor, though experience and by watching.

3. When mistakes are made can the causes be traced?

No, but most of the times Diar knows where the cause lies when the mistake was made in the assembly area, not too long ago. When they find the flaw really late, the cause is not traceable, also not when it was caused in another department.

4. When mistakes are made can employees responsible be traced?

Depends, see previous question.

5. How easy is it to see what employee is most quick?

The direct supervisor most of the time knows its employees and their traits.

6. Can individual achievements of employees be traced?

Only when the supervisor experienced or saw it.

7. When/how many times do you observe/administrate behavior control measures?

The direct supervisor will observe the behavior of employees the whole time. The actual administration of his findings will be done when he does the evaluation. Which is done when a contrat expires (evaluation form 1) and every year for employees with a fixed contract.

8. Do these behavior measures give an accurate projection of the reality?

Diar thinks so. Razali has his doubts. They agree that it is very subjective.

9. Do you think that the current methods of getting behavior measures are subjective?

Yes.

Overall performance

1. What is the daily output for hospital bed 12C and 13C at this moment? (during low season)

12c: maybe, 15, 13c: maybe 10. high season: 12c 20-25, 13c 15 (maybe)

2. How much does this number fluctuate?

Quite a lot fluctuation between the high season output and the output of the low season. But little fluctuation between different days.

3. How long does it take before an employee knows all processes to put hospital bed 12C together?

2 Months (instructed by other employees)

4. How many products can be produced at the assembly area at one moment?

Many different types.

5. Do employees like working at the assemble department? What do they like? What not?

Clean/healthy/not noisy environment. Like their colleagues and their supervisor. (Also see the employee questionnaire, this confirms this). Don't like if they have to wait for components.

6. Do managers/supervisors like working at the assemble department? What do they like? What not?

Yes, better environment, good air, no noise, good team, flexible, likes conveyor when it increases output. Doesn't like the inefficiencies.

Appendix G: Current process for hospital bed 13C

Main Assy	Process (Include handling)	Qty
Station 1	1. Install foot mover framework	2
	2. Install support plate	4
	3. Install foot unit	2
	4. Install pipe mover	1
	5. Install center crank unit	1
	6. Install cover crank unit	1
	Total time used for station 1: **24 minutes**	
Station 2	1. Install Backrest	1
	2. Install Tighrest	1
	3. Install Legrest	1
	4. Install Oxygen rack	1
	5. Install sideguard holder	4
	6. Install sideguard	2
	7. Install bumper unit	4
	8. Install crank unit back rest	1
	9. Install crank unit leg rest	1
	10. Install support plate for foot framework	2
	11. Install cover crank unit	2
	11. Install ABS unit	4
	12. Install retainer matrass	2
	13. Install panel	2
	14. Install patient board	1
	15. Install Infussion stand	1
	16. Clean activity	1
	17. set the sticker	12
	18. Quality control	1
	19. packaging (cardboard box)	1
	Total time used for station 2: **60 minutes**	

Appendix H: Balanced process times for four stations

Main Assy	Process (Include handling)	Qty	total time (Qty x Time/unit)	allowance	Total time
Station 1	1. Install foot mover framework	2	0:04:00		
	2. Install support plate	4	0:04:32		
	3. Install pipe mover	1	0:04:16		
	4. Install center crank unit	1	0:02:25		
	5. Install cover crank unit	1	0:00:40		
	Total time for Station 1		**0:15:53**	**5%**	**0:16:41**
Station 2	1. Install foot unit	2	0:07:04		
	2. Install Backrest	1	0:01:10		
	3. Install Tighrest	1	0:01:10		
	4. Install Legrest	1	0:01:10		
	5. Install crank unit back rest	1	0:00:55		
	6. Install crank unit leg rest	1	0:01:00		
	7. Install cover crank unit	2	0:00:40		
	8. Install Oxygen rack	1	0:00:50		
	9. Install support plate for foot framework	2	0:01:10		
	Total time for Station 2		**0:15:09**	**5%**	**0:15:54**
Station 3	1. Install ABS unit	4	0:01:04		
	2. Install sideguard holder	4	0:01:30		
	3. Install sideguard	2	0:00:55		
	4. Install bumper unit	4	0:01:30		
	5. Set stickers	12	0:01:30		
	6. Install retainer matrass	2	0:00:32		
	7. Install panel	2	0:00:38		
	8. Install patient board	1	0:00:16		
	9. Install infussion stand	1	0:00:16		
	10. Bolt covers	16	0:02:30		
	11. Clean activity	1	0:05:15		
	Total time for Station 3		**0:15:56**	**5%**	**0:16:44**
station 4	1. Quality control	1	0:03:07		
	2. Packaging		0:10:30		
			0:13:37	**5%**	**0:14:18**
total time needed for all stations					**1:03:37**
average time needed for all stations					**0:15:54**
throughput time					**1:06:55**
cycle time					**0:16:44**
balancing loss					**4,94%**

*All stations have 2 employees working on them.

Appendix I: Balanced process times for five stations

Main Assy	Process (Includes handling)	Qty	Total time (Qty x Time/unit)	allowance	Total time
Station 1 Station uses **2 employees** (time displayed is standard time for 2 persons, since processes are only possible with two persons)	1. Install foot mover framework	2	0:04:00		
	2. Install support plate	4	0:04:32		
	3. Install pipe mover	1	0:04:16		
	Total time for station 1		**0:12:48**	**5%**	**0:13:26**
Station 2 Station uses **2 employees** (time displayed is standard time for 2 persons, since processes are only possible with two persons)	1. Install foot unit	2	0:07:04		
	2. Install center crank unit	1	0:02:25		
	3. Install cover crank unit	1	0:00:40		
	4. Install Backrest	1	0:01:10		
	5. Install Tightrest	1	0:01:10		
	Total time for station 2		**0:12:29**	**5%**	**0:13:06**
Station 3 Station uses **2 employees** (time displayed is standard time for 1 person)	1. Install Legrest	1	0:01:10		
	2. Install crank unit back rest	1	0:01:50		
	3. Install crank unit leg rest	1	0:02:00		
	4. Install cover crank unit	2	0:01:20		
	5. Install support plate for foot framework	2	0:02:20		
	6. Install ABS unit	4	0:02:08		
	7. Install Oxygen rack	1	0:01:40		
	8. Install sideguard holder	4	0:03:00		
	9. Install sideguard	2	0:01:50		
	10. Install bumper unit	4	0:03:00		
	11. Set stickers	5	0:01:20		
	Total time for station 3		**0:21:38** **12 min 2 pers**	**5%**	**0:12:36**
station 4 Station uses **1 employee** (time displayed is standard time for 1 person)	1. Install retainer matrass	2	0:01:04		
	2. Install panel	2	0:01:16		
	3. Install patient board	1	0:00:32		
	4. Install Infussion stand	1	0:00:32		
	5. Clean activity	1	0:08:30		
	Total time for station 4		**0:11:54**	**5%**	**0:12:30**
station 5 Station uses **2 employees** (time displayed is standard time for 1 person)	1. set the sticker	7	0:01:50		
	2. clean activity	1	0:02:00		
	3. Quality control	1	0:06:14		
	4. packaging (cardboard box)	1	0:10:30		
	Total time for station 5		**0:20:34** **11 min 2 pers**	**5%**	**0:11:33**
total time needed for all stations					**1:04:14**
throughput time					**1:07:10**
cycle time					**0:13:26**
balancing loss					**4,37%**

Appendix J: Sub assembly processes

Sub assembly station 1

Sub - Assembly	Qty	Component (Include handling)	Qty	Tools	Total time (Qty x Time/unit)
Foot mover framework	2	Foot mover framework	2	Tap W 5/8"	
		Roda + rem D 5"	2	Tang promat	30 seconds
		Roda D 5"	2		30 seconds
		Ring per W 5/8"	4		20 seconds
		time for 1 foot mover framework	1		1 min 20 sec
		Total time for foot mover framework	**2**		**2 min 40 sec**
Foot unit	2	Dop nylon 30 x 60	4	Hammer	12 seconds
		Total time for foot unit	**2**		**24 seconds**
Bumper	4	Bumper plate	4	Tap M8	
		Bumper	4	Tap M6	12 seconds
		Bolt M8 x 15	4	screwdriver (+)	40 seconds
		Panhead bolt M6 x 15	4	pass wrench 13	40 seconds
		Plate ring M8	4		8 seconds
		Spring ring M8	4		8 seconds
		time for 1 bumper			1 min 48 sec
		Total time for bumper	**4**		**7 min 12 sec**
Patient board	1	patient board hanger	1	screwdriver (+)	20 seconds
		acrylic	1	drill bit D 6	18 seconds
		panhead bolt M6 x 15	2	wrench 10	40 seconds
		plate ring M6	4	hand drilling-	48 seconds
		Lock Nut M6	2	machine	24 seconds
					2 min 30 sec
		total time with 5% allowance			**13 min 26 sec**

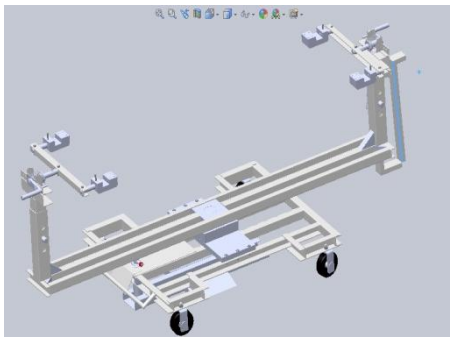
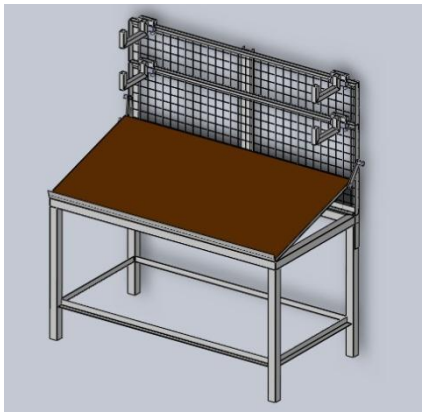
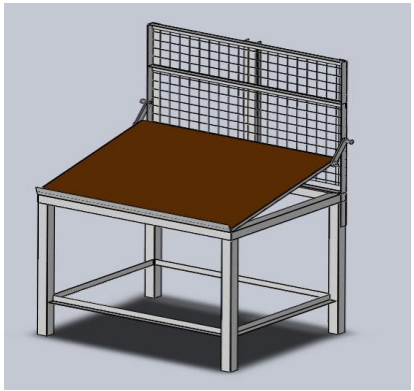
Sub assembly station 2

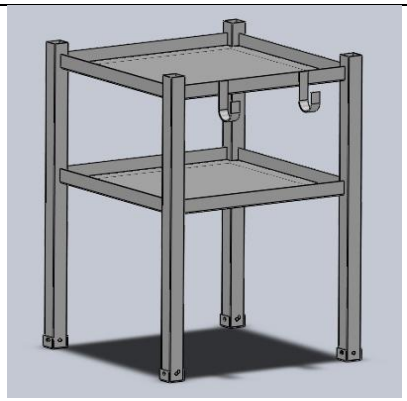
Sub Assembly	Qty	Component (Includes handling)	Qty	Tools	Time/unit	Total time (Qty x Time/unit)
Side guard	2	Top side guard pipe	2	hand drilling-machine eye drill D 4,2 ;5 ; 12	2 seconds	24 seconds
		Trellis	12		12 seconds	24 seconds
		Locker shaft	2		12 seconds	24 seconds
		Locker set	2		2 seconds	4 seconds
		Main pipe of side guard	2		2 seconds	20 seconds
		Spring ring M5	10		2 seconds	4 seconds
		Press Spring D 1,2 x 9 x	2		5 seconds	60 seconds
		rivet nail D 5 x 10	12		5 seconds	20 seconds
		rivet nail D 4 x 10	4		11 seconds	4 min 24 sec
		rivet D 5 x 40	24		5 seconds	50 seconds
		Flower Panhead bolt M	10		5 seconds	50 seconds
		Hexagonal moor M5	10		2 seconds	40 seconds
		Plate ring M5	20		7 seconds	14 seconds
		Slot holder	2		5 seconds	50 seconds
		Locker moor M5	10		2 seconds	24 seconds
		Folding hinge (engsel pelipat) 1	12		2 seconds	20 seconds
		Folding hinge (engsel pelipat) 2	10		3 seconds	26 seconds
		Dop profile SKN A Dop	2		3 seconds	26 seconds
		box pipe 25 x 25	2			12 min 24 sec
		time for 1 side guard				**24 min 48 sec***
		Total time for side guard	**2**			

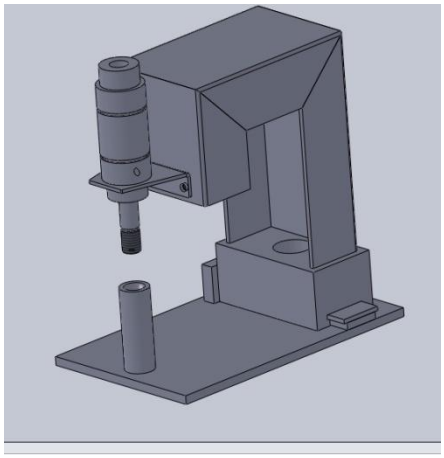
*Since the cycle time for 4 station is 16 minutes and 44 seconds and for 5 stations 13 minutes and 26 seconds. This station will need 2 employees to finish the required number of side guards within these cycle times. The average time to finish two side guards (required for one hospital bed) with two employees is 12 minutes and 24 seconds.

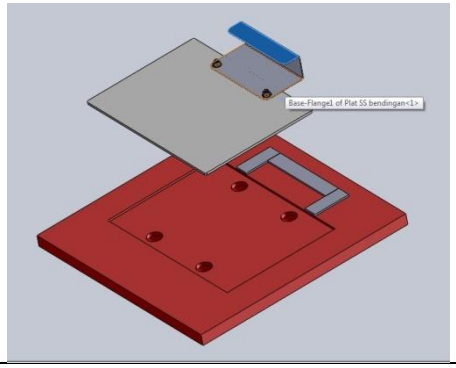
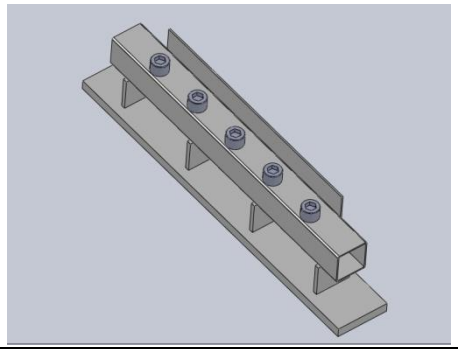
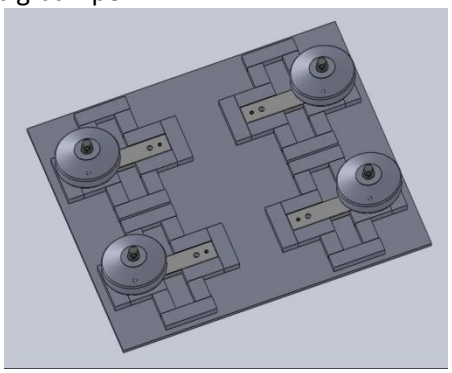
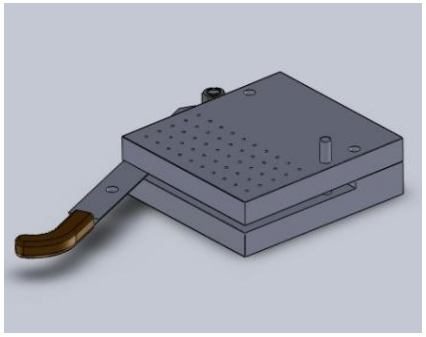
Appendix K: List of equipment for the conveyor system

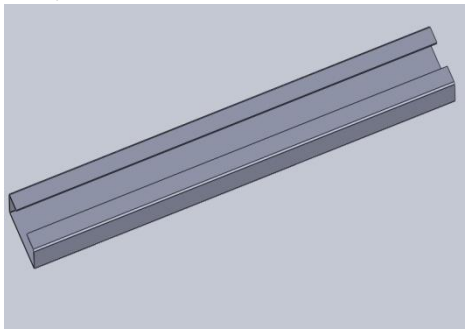
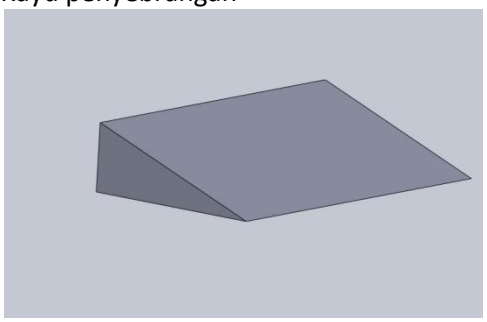
List of equipment needed for the conveyor system

No	List Kebutuhan	Specification/ Dimension (p x l x t)	Quantity	Notification
1.	Trolley 	2,6 m x 0,6 m x 1 m	6	1 spare
2.	Meja sub-assy Sideguard 	152 mm x 80 mm x 90 mm	2	No spare
3.	Meja sub-assy 	100 mm x 80 mm x 90 mm	3	No spare
4.	Rack for main assy	52 mm x 52 mm x 90 mm	7	No spare

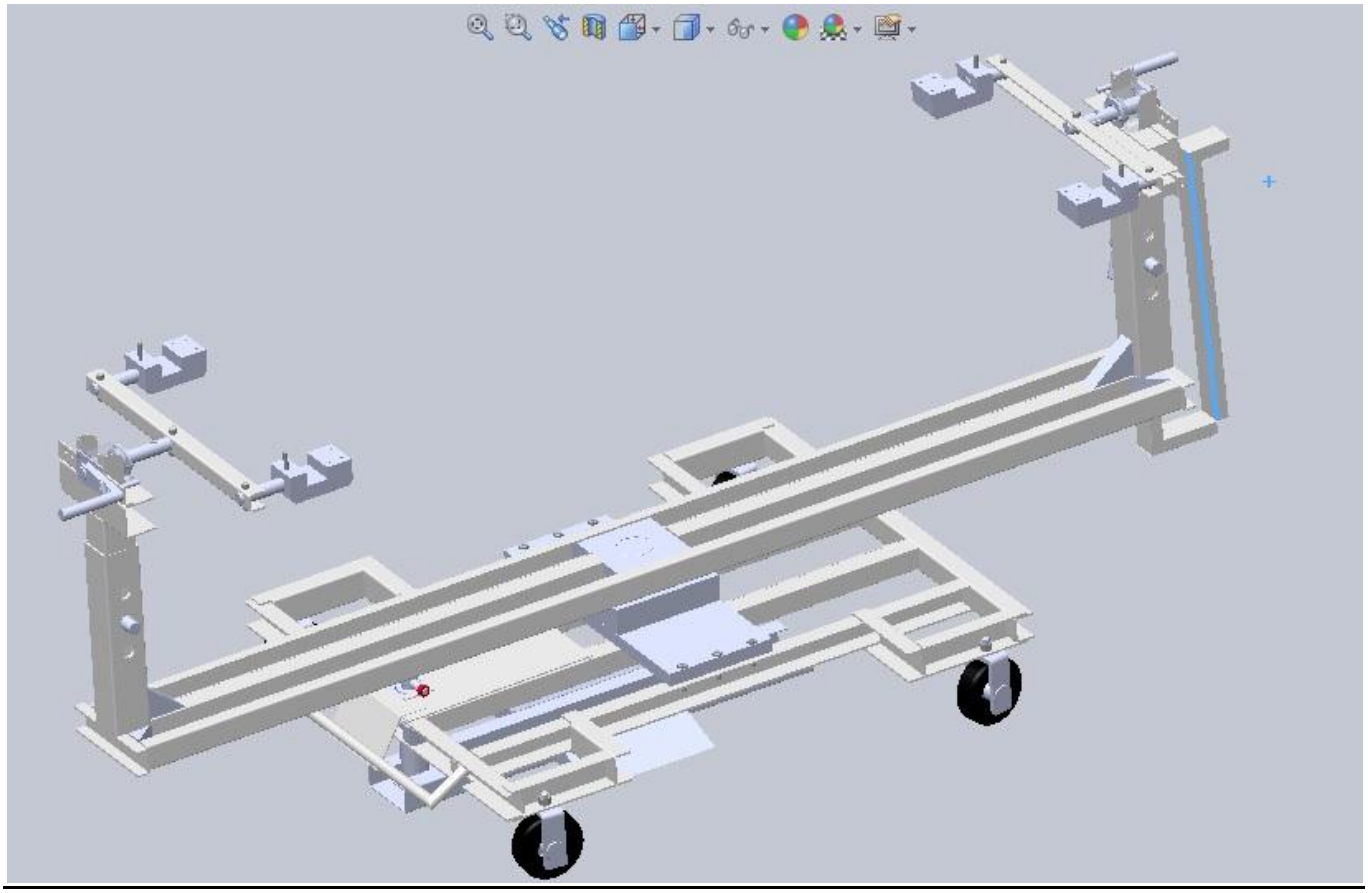
				
6.	Meja packing 	1,3 m x 1,4 m x 0,3 m	1	No spare
7.	Rantai/Chain 	Material diameter : 6,4 cm Working load : 420 kg/925 LB	1	
8.	Motor 	Moger M-51K40N ,, 40 W With gear ratio 36	1	

	Inverter Speed 	LG INVERTER SV015IG5A-4 (1, 5KW)	1	
9.	Rak komponen besar 	2 m x 1 m x 1,4 m	3	
10.	Tools box container (plastik) 	25 mm x 16 mm x 12 mm	56	Rack main assy = 36 Rack Sub assy = 20
11.	Jig paku keling/press tool 	195 mm x 120 mm x 195 mm	1	

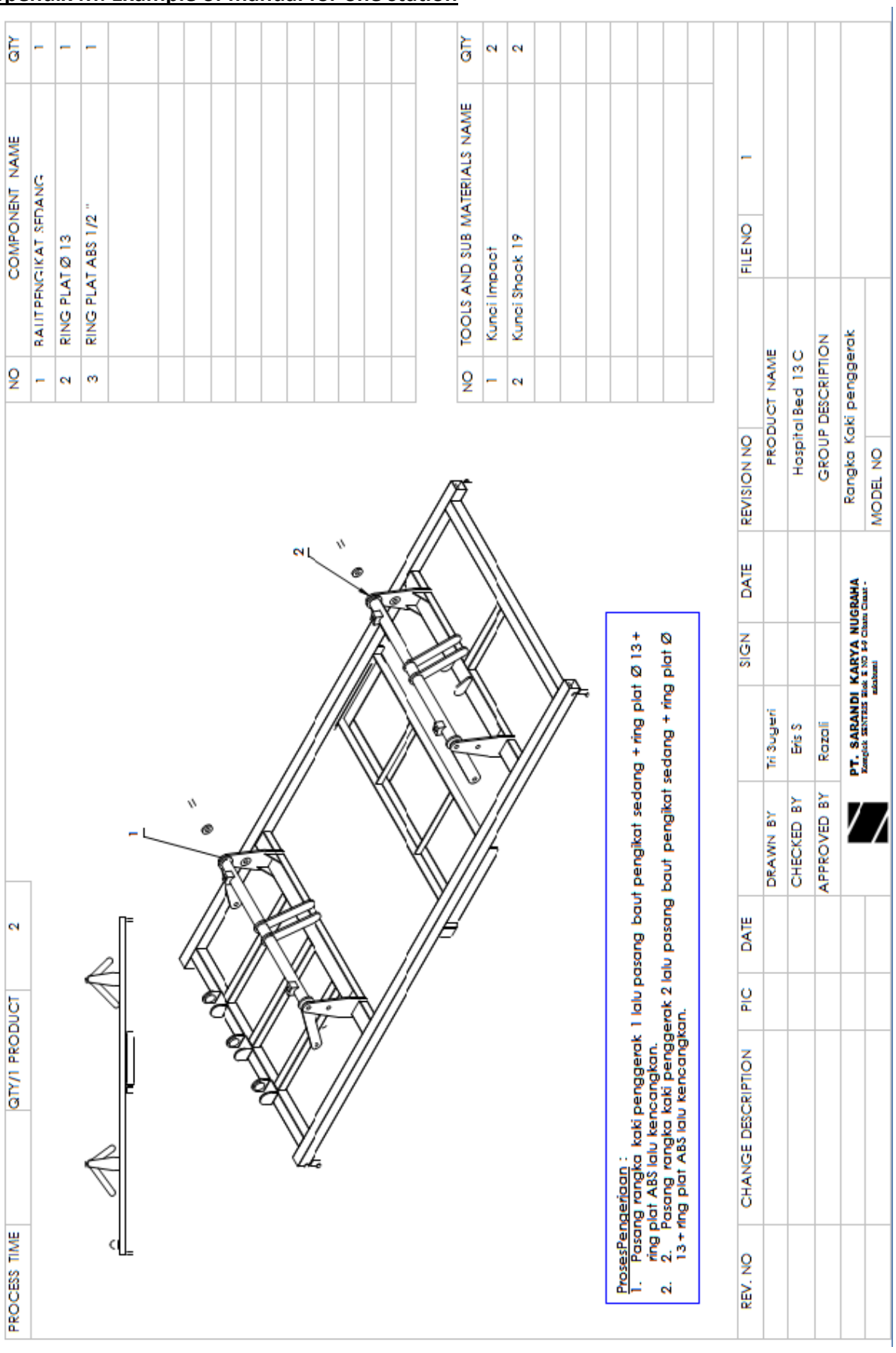
12.	Jig papan pasien 	400 mm x 400 mm x 10 mm	1	
13.	Jig engsel pelipat 	340 mm x 50 mm x 73 mm	2	
14.	Jig bumper 	500 mm x 500 mm x 3 mm	1	
15.	Jig pemotong paku rivet 	30 cm x 28 cm x 3 cm	1	

16.	Jalur/lintasan troli 	Panjang lintasan = 2,6 m ~ 2,7 m	1	
17.	Kayu penyebrangan 	300 mm x 150 mm x 55 mm	8	

Appendix L: Picture of the trolley design



Appendix M: Example of manual for one station



Appendix N: Layout design