Finding & analysing weaknesses in the setup of Completely Knocked-Down Production

MAN Truck & Bus AG

Stefan Tjeerdsma – S1583581

Bachelor – industrial Engineering and Management

s.tjeerdsma@student.utwente.nl

Bachelor Thesis

Public summary

Coach at MAN: Markus Loferer
Production Central – Planning Brand
xKD-Network - Global Support (PCWXS)

Supervisor: DR. J.M.G. Heerkens

Second supervisor: DR.IR. A. Al Hanbali

Faculty of Behavioural Management and Sciences

UNIVERSITY OF TWENTE.

The present thesis

"Finding & analysing weaknesses in the setup of Completely Knocked-Down Production"

contains internal, confidential information of the participating company MAN Truck & Bus AG. This document provides a public summary and therefore focusses on the approach and way of working during the research. Actual findings are confidential and will therefore not be included in this summary.

Permission for the confidentiality of the thesis was granted by the Examination Board Management Sciences at the 11th of July 2017.

PREFACE

This bachelor thesis report is the result of my graduation assignment at MAN Truck & Bus AG in Germany. The graduation assignment is part of the Bachelor of Science Industrial Engineering and Management at the University of Twente. The assignment was provided by the Production Central Global Support department (PCWXS).

I would like to thank MAN and my supervisor at MAN, Markus Loferer, for giving me the opportunity to do my bachelor assignment at MAN and to support me in doing the assignment abroad. Mr. Loferer was always there to provide me with input and a critical view on my work. I would also like to thank all employees of PCWXS for their input and help during the entire duration of the assignment. The input and time of these employees were vital to get to the result presented in this report.

Furthermore, I would like to thank my supervisor at the University of Twente, Hans Heerkens. Mr. Heerkens provided extensive feedback and support throughout my bachelor assignment and helped me create this report as it is today. I also would like to thank Mr. Ahmad Al Hanbali for being my second supervisor at the University of Twente and for being involved with my thesis right from the start.

Stefan Tjeerdsma

Enschede, July 2017

CHAPTER 1: INTRODUCTION AND RESEARCH LAYOUT

In this paragraph, an introduction on the research is provided. Both the company at which the research took place and the research itself is introduced to make the reader acquainted with the subject at hand. The research is presented using a description of the assignment, the subsequent problem identification, the research approach and the goals and deliverables of the overall bachelor thesis. Lastly, the need for the research is explained.

1.1 COMPANY BACKGROUND

The research described in this thesis was conducted at MAN Truck & Bus in Munich, Germany. MAN Truck & Bus is a subdivision of the MAN group, which in turn is a subdivision of the commercial vehicle branch of the Volkswagen AG. Volkswagen AG itself is present in almost all automotive industries. The company structure is displayed in figure 1.

Figure 1 - Company structure of the Volkswagen AG (MAN company presentation, 2017)[1]

1.1.1 MAN DIVISIONS

MAN itself can be divided in four core divisions representing the main activities of the company being the production of trucks & busses, the production of trucks in Latin America and the production of (large) power plants. The divisions of MAN accompanied with their respective revenue in 2016 are displayed in figure 2.

Figure 2 - MAN divisions & revenue in 2016 (MAN company presentation, 2017)[1]

[1] Retrieved from MAN intranet, source not publicly available

1.1.2 COMPLETELY KNOCKED-DOWN PRODUCTION

The research for this bachelor thesis took place at the Truck and Bus division of MAN. More specifically, the research focusses on the Completely Knocked-Down production at MAN. Completely Knocked-Down (from now on: CKD) production is a production type in modular production systems. The concepts of knocked-down production are used to describe ways of producing products on a global scale using a certain knock down degree. There are several variations on the knocked-down systems:

1. CKD (Completely Knocked-Down) – The vehicle is completely knocked-down to smaller units or parts after production in the main production facility. Next, the parts are transported to an assembly plant at a location in a different market. Here, the knocked-down vehicle is reassembled and then sold to customers in that market.
2. SKD (Semi-Knocked-Down) – partially disassembled system which depends both on producer and customer. Compared to CKD production, the assembly kit now contains subassemblies such as a complete chassis. In general, the assembly kit is assembled to a higher degree compared to CKD production.
3. CBU (Completely Built Up) – The product is exported as a fully assembled product. In this case, no assembly plant is needed. This often leads to high transport costs and import tariffs. However, quality is assured due to centralized production. Moreover, economies of scale are obtainable due to higher production quantities at the centralized production site.

(D. Mežnar, 2012 and S. Wiesse, 2013, internal publications MAN) [2]

The implementation of CKD production at MAN is called Truck in the Box (TiB). This production system differs from CKD production in the sense that trucks are packed per unit instead of the more common packing per part. A TiB package contains one truck packed in production order, that is, parts that are needed first are packed in such a way that they can be unpacked first. Parts are already grouped in assembly groups to make the final assembly easier. The advantage of packing per truck is that there are no large inventories or difficult logistical processes at the assembly plant. Moreover, the pre-grouping of parts assures only limited technologies and knowledge is needed at the assembly location. An overview of the TiB concept is provided in figure 3.

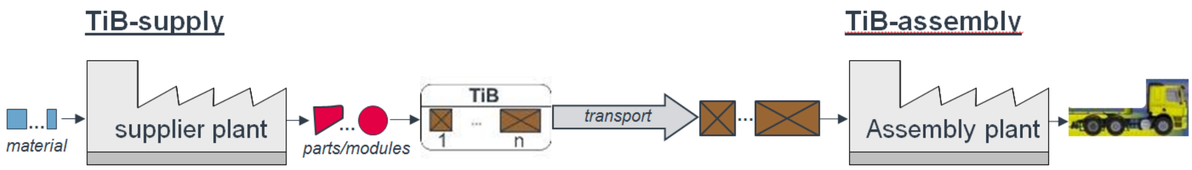

Figure 3 - Truck in the box concept (MTB's international xKD business, 2014)[2]

Note that throughout this thesis the assembly plant is referred to as either the customer or the assembler. The company or person that will buy the truck or bus and operate it in the end is referred to as the end customer.

[2] Retrieved from MAN intranet, source not publicly available

The CKD and SKD activities of MAN are spread around the world. The supply plants are the plants in Salzgitter (Germany), Pithampur (India) and Steyr (Austria). These plants serve a wide spread assembly network. The network is displayed in figure 4.

Figure 4 - MAN xKD network (xKD business MTB, 2014)[3]

1.1.3 XKD GLOBAL SUPPORT (PCWXS)

The bachelor thesis is written for the xKD Network Global Support (PCWXS) department of MAN. The official name of the department, PCWXS, is an abbreviation of "Production Central World-wide xKD Support". This implies that the department is concerned with production related issues and more specifically, the global xKD production facilities, where xKD represents both SKD and CKD production systems. The department is concerned with three main activities being:

1. The introduction of new CKD models. Existing models that are produced in the normal Completely Build Up fashion are transformed to CKD models that can be built in the assembly plants all over the world.
2. Assisting in the setup of new CKD plants. Together with other departments, PCWXS supports the process of expanding the xKD worldwide network.
3. Customer support services. Also in existing production programs, PCWXS is active to further improve the product quality and production efficiency. An example of this activity type is a Technical Product Validation (TPV) in which the quality of a product is validated and assured.

Although PCWXS is a department that is often involved in large projects with different aims and subjects, the above-named classification of activities is generally applicable. The focus of this research will be on the setup and introduction activities of the department. The customer support services are regarded as a continuous process that follows these two activities. In the analysis of the activities of the department, the support activities will therefore be regarded as a part of both the setup and introduction processes. PCWXS is a support department which is situated below the PCWX department in an organizational view on the company. The two departments are closely related and cooperate frequently. This thesis considers the perspective of both departments, since the communication between the departments is an essential building brick of successful operations. PCWX is generally the project management department of new xKD projects, whereas PCWXS provides support for these projects.

[3] Retrieved from MAN intranet, source not publicly available

1.2 THE PROBLEM DESCRIPTION

The assignment provided by MAN, is to analyze the weaknesses in the existing CKD network and to find optimization potentials in the activities of the PCWXS team. This assignment was formulated because of the occurrence of problems in the field during the setup of CKD factories or the introduction of new CKD models.

MAN states that an optimization of the process is necessary to reduce the number of problems that occur during this setup and to increase employee satisfaction. An example of a problem that occurs in the network is the fact that sometimes pre-series are not build and as a result, the Bill of materials is incomplete or the number of parts in the packaging box is insufficient. In these cases, the parts sometimes must be sent via airmail to prevent production stagnation at the assembly plant. The occurrence of failures causes the department to be forced to turn back to a setup process that was supposed to be finished, which causes frustration at the team. The problems that occur are generally known to the department, however, there is no clear overview or documentation of these problems. It is therefore not clear where the CKD production network can be optimized or improved. The assignment exists out of creating this overview and proposing solutions for the most important problems found.

1.3 KNOWLEDGE PROBLEMS

In analyzing the core problem, certain knowledge deficiencies will arise. It is helpful to know what knowledge will be needed during the research that is conducted for this bachelor thesis. The following knowledge problems were found:

Which failures occur in the CKD setup process and how frequent do they occur?

To be able to answer this question the following research questions were formulated:

- What are the phases and activities of the completely knocked-down processes that are the responsibility of PCWXS?
- What is the exact layout of the completely knocked-down setup processes at MAN?
- How many failures arise in the setup of completely knocked-down processes at MAN?

What areas of improvement are most promising, that is, which areas have the highest expected potential and effect?

To be able to answer this question the following research questions were formulated:

- What is the impact of the found failures?
- What are the costs of improving these aspects? (How much effort is needed?)
- What is the expected impact of the proposed improvements?

These are knowledge problems that should be solved in this bachelor thesis report, this will help understand the problems that occur at PCWXS and support prioritization and proposing solutions for the found problems.

1.4 GOALS OF THE RESEARCH

In the bachelor thesis, we aim to solve the core problem described partially in section 1.2. Due to confidentiality, the full problem statement cannot be published. To solve the core problem, we determined the following goals:

- Create an overview of the activities of the PCWXS department and the cooperation with other departments. This overview can be used for problem localization.
- Create an overview of weaknesses in the setup process of completely knocked-down production plants and the setup of new completely knocked down models. The overview should display the phases the weaknesses belong to and the cause of the problem, to understand the problem environment of the problems that will be found.
- Provide a prioritization of the problems that can be used for selecting problems to solve in the future.
- Provide a recommendation on how to solve a selection of the found problems. (focus on 1 or 2 problems)

1.5 RESEARCH APPROACH

To work in a structured way during the research project, the Managerial Problem-Solving Method (Heerkens and Van Winden, 2012) will be used as an overall framework. Not all phases of the Managerial Problem-Solving Method (MPSM) will be executed due to the time constraints in this project. The focus will be on the first four phases of the MPSM, displayed in figure 5. An additional action is the estimation of the impact of alternatives. This will be done at the end of the project; however, it cannot be stated that evaluations will be executed as it is done in the full evaluation phase of the MPSM.

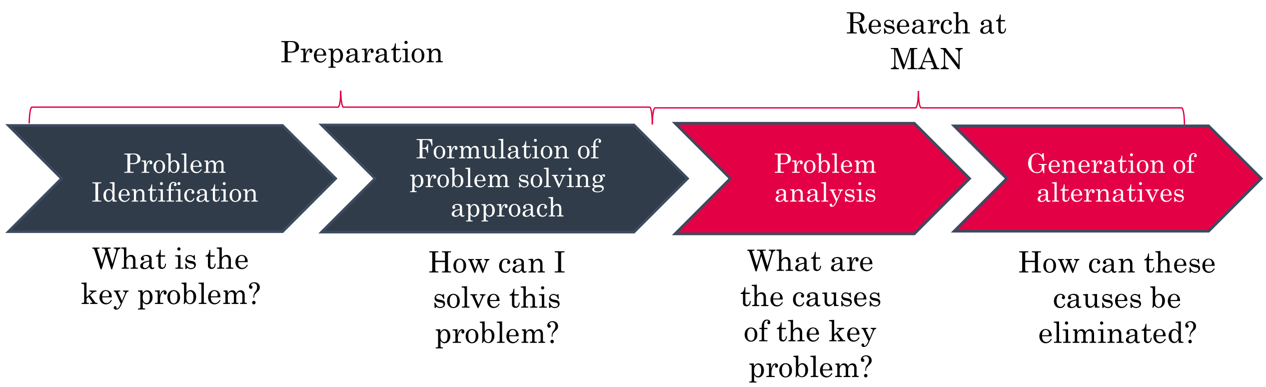

Figure 5 - Managerial Problem Solving Method phases

The second phase of the MPSM consists of formulating a problem solving approach that will be used during the rest of the research. The approach in the research project can be divided into four consecutive phases. The phases are displayed in figure 6.

Figure 6 - Problem solving approach phases

During the process analysis phase, an illustration of the process phases and the associated activities in the setup of new CKD models and plants will be created. This should help to understand the nature of the employment of PCWXS better. Moreover, the process analysis will be used to locate problems and to investigate their effect on other activities.

In the problem identification phase, problems are identified using interviews with PCWXS employees. These interviews provided a list of problems that are considered to be important for the employees. The problems are added to this list only if the problems turn out to be existing and structural. This is checked for every problem that is proposed by the employees.

In the problem selection phase, a selection of problems is made to investigate further. Not all problems can be solved due to the time available, only for those problems that turn out to have the highest priority can be taken into consideration for further analysis.

In the detailed analysis phase, the selected problems are analyzed more thoroughly. The precise cause of the problem is determined in this phase.
In the optimization proposals phase, a proposal for solving the selected problems is made on the basis of the previously conducted detailed analysis. Several proposals will be made, which is then assessed on their expected effect. The solution proposal will then be included in a final recommendation

1.6 DELIMITATION

The limitations of the research are mainly implied by the limited time available. This time restriction eventually causes some restrictions on the research itself:

1. The scope of the research is limited to the problems that occur in the daily operations of one department, namely the xKD Global support (PCWXS) department.
2. Mainly members of the global support team have been interviewed. Although there have been interviews with people that are closely involved with the activities of PCWXS, the interviews with members of this department are the red line in the research. This choice of perspective is important to take into consideration. Customers will not be interviewed due to the time limitations of this research and the size of the customer network. However, the interviews with employees provide a good insight in relevant problems for customers.
3. The research is based on existing data only (except the interviews). Due to the time restrictions, this thesis is based on existing reports and data. This data is carefully studied and approved. However, the data and reports are not established as a part of this research.
4. Only a selection of the observed problems that occur in the department are further analyzed. A solution proposal is only made for this selection of problems. Not all problems are solved. The remaining problems are prioritized and documented for the company to solve in future projects.

Although these limitations define the boundaries of the research and therefore assure feasibility, they do not necessarily limit the quality of the research when attention is paid to the fact that secondary data is used throughout the research, which will therefore be done.

1.7 VALIDITY AND RELIABILITY

There are some limitations on the validity of this report due to the limited time available for the thesis. The limitations mainly occur since secondary data will be used, data that was obtained from interviews and from existing internal reports and analysis. Obtaining all the data individually could possibly assure a higher validity. For example, if an interview results in the conclusion that spare parts are not replaced correctly, the highest validity could be achieved by observing this problem when it occurs. In this thesis, the actual observation of the occurrence of problems cannot be performed. Instead, to assure acceptable validity, the used secondary data will be crosschecked using at least one other source with care. This way, the accuracy of the data can be assured.

Reliability of the research is affected by the stability, equivalence and internal consistency of measurements (Cooper and Schindler, 2014). The reliability of this thesis is, again, mainly affected by the use of interviews as input. Stability in conducting the interviews is achieved through standard predetermined questions. This way, consistent results should be obtainable with repeated interviews with the same person. To assure equivalence in the interpretation of the interviews. The results have been discussed and evaluated in a group meeting in which concrete examples of the found problems were used to validate the interviews. Lastly, to test internal consistency, the found problems in the CKD process should be observable in the different supply chains for different countries. The separate countries form a control group that can be used to test whether problems occur structurally or only locally in one country.

CHAPTER 2: THEORETICAL FRAMEWORK

In this chapter, an overview of the theories and literature used in this bachelor thesis will be provided. The literature presented, will be used to solve the knowledge problems presented in the previous chapter. The theoretical framework provides a perspective for the research, attributes for the evaluation of supply chain partners, a modeling language and a problem prioritization method. The following questions will be answered in this chapter:

- Which perspective can be used to approach the CKD network?
- How can the quality of assembly partners be assessed?
- How can a business process be formally documented?
- How can problems be prioritized?

2.1 SUPPLY CHAIN PERSPECTIVE

The CKD network can be interpreted as a supply chain. A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves. A typical supply chain may involve the following stages: customers, retailers, wholesalers/distributors, manufacturers and component/raw material suppliers.

Each stage is connected through product, information and fund flow. The objective for a supply chain is to maximize overall generated value. (Chopra, S., & Meindl, P, 2013). Treating the CKD production chains as a supply chain is valuable for this research as there is extensive literature available on performance indicators and the phases in a supply chain. Treating CKD processes as a supply chain is a valid choice since the process consists of the typical supply chain activities. These activities include new product development, marketing, operations, distribution, finance and customer service (Chopra, S., & Meindl, P, 2013). A strongly simplified model of the CKD supply chain can be described using a few steps. Steps in the process are: production of parts, packaging of parts, transport of parts and assembly in the assembly plant respectively.

MAN can be viewed as a supplier of parts to the overseas manufacturer together with other smaller suppliers, whereas MAN itself is supplied by a large number of suppliers as well. To identify weaknesses and strengths splitting the supply chain into phases is helpful. The following phases/processes can be determined in a supply chain (Stewart, 1995):

- Plan, defines the planning activities involved in running the other three supply chain processes.
- Source, relates to processes on the supplier side and contains two sub-processes, material acquisition and the management of the sourcing infrastructure.
- Make/assemble process comprises production execution and the management of the infrastructure.
- Deliver consists of four management sub processes: order, warehouse, transportation and delivery.

This bachelor thesis focuses on the analysis of the planning and make/assemble phase of the CKD production supply chain at MAN. These two phases are the main responsibility of PCWXS, the department at which this bachelor assignment was executed.

2.2 SUPPLY CHAIN ALLIANCE EVALUATION

In a supply chain network, partners carefully select each other to achieve the most efficient value creation. To be able to select the right supply chain partner this partner must be assessed on relevant attributes. In chapter three and four, this assessment turns out to be problematic. Therefore, a theory presenting the most relevant attributes for assessment is presented here.

The attributes can be categorized into eight groups according to an extensive literature review (Lin, C., R., & Chen, H., S. (2004)). The groups are 1. finance, 2. human resource management, 3. industrial characteristics, 4. knowledge/technology acquiring and management, 5. marketing, 6. organizational competitiveness, 7. product development, production, logistics management and 8. relationship building and coordination.

For each of the assessment groups a list of attributes has been created by Lin & Chen. These attributes can be used to judge the performance of the potential supply chain partner and to identify weaknesses.

2.3 PROCESS MODELLING LANGUAGE

For the interviews that took place with the colleagues in the department, informal models of the activities were used. These models were constructed during the first exploratory conversations with both the supervisor at MAN and the involved colleagues. These informal models were useful for the conversations since they are understandable for all parties and are easy to use in tracing back causes of possible failures. For proper documentation, the informal models do not suffice. To document the processes in such a way that they are generally understandable for the scientific community a documentation standard should be used.

To formally model the processes analyzed in this thesis, a choice was made between a selection of suitable modelling languages. For modelling business processes, common languages are UML (unified modelling language), BPMN (Business process model and notation), IDEF0 (Integration definition for function) and BPEL (Business process execution language). These languages are selected because of their frequent use and their suitability for business related processes. In the following section the four languages are assessed on their application area and ease of use.

2.3.1 LANGUAGE CHARACTERISTICS

BPEL is a process language that is used to display software implementation of web services in business processes. This language is capable of modelling business processes, however it provides an IT related view on the process. BPEL can be used to model both executable and more abstract processes; its focus is on the behavior in certain processes (Oracle BPEL Process Manager, n.d.).

UML is a language that was originally developed for the description of software systems. UML, as well as BPEL has proven itself to be capable of modelling normal business processes as well. UML can be used to model structure, behavior and interaction diagrams. UML uses an object-oriented approach (What is UML, n.d).

IDEF0 can also be used to model business processes or a production process. IDEF0 differs from the previously mentioned modelling languages in the sense that the connections between activities all represent a certain input or output. That is, an arrow does not only represent a sequence flow, it also specifically describes what is used and what is produced in a certain activity. This characteristic allows for great detail concerning necessities and deliverables. However, in more complex processes it tends to cause the model to be unclear and hard to quickly understand (IDEFØ – Function Modeling Method, 2016, August 05)

BPMN is a frequently used business process modelling standard. It uses a graphical representation that represents the sequence flow in a process. The notation has been specifically developed to depict the sequence of processes and the messages that flow between departments or actors. The notation is aimed at high level business users though the essence of the notation is that it should also be readable for lower level users. (Business Process Model and Notation., n.d.)

2.3.2 CONCLUSION

The purpose of the models in this thesis is to clarify the activities that are conducted by the different departments. In order to do so, the modelling language should also support a simple and intuitive representation of the activities. IDEF0 is not suitable as it does not produce easy-to-read models because of its complex connections. BPEL is a language that is focused on modelling web services. This causes the interpretation of the model to be hard for users that are unfamiliar with software or IT systems.

Due to the object-oriented modelling style of UML, it is hard to express an intuitive sequence flow using this language. In UML, activities should be grouped per instance or actor that executes the activities. In the environment of this bachelor thesis and the high-level modelling approach that is used, one actor will execute several actions. Expressing the sequence of execution in an intuitive way is not possible using UML. BPMN is a modelling language that is suited to the application in this situation. It provides an intuitive sequential view on the process that is readable without much prior knowledge about the modelling language. Another advantage of using BPMN is that is a frequently used and well-known language. BPMN will therefore be used as the formal modelling language in this bachelor thesis. The language will now be explained.

2.4 BUSINES PROCES MODEL AND NOTATION

The BPMN uses several standard expressions and figures to illustrate process characteristics. Although the entire set of standards is an extensive set that outreaches the scope of this research, a selection of definitions that will be used in this bachelor thesis will now be described.

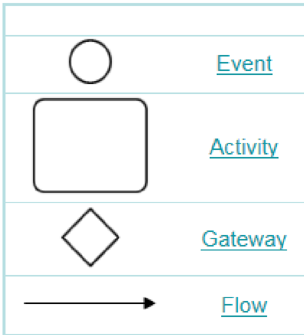

Figure 7 - BPMN basic elements (Business Process Model and Notation., n.d.)

The basic elements used in BPMN are events, activities, gateways and flows. These elements are generally displayed using the illustrations displayed in figure 7.

Events can be start events, intermediate events or end events. These three types occur in various forms. For the sake of simplicity, the models produced for this bachelor thesis only use the standard event forms.

Figure 8 - Flow types (Business Process Model and Notation., n.d.)

Flows are represented by arrows. In this report, two flows are used, a sequence flow and a message flow. Both types are displayed in figure 8. The sequence flow represents the sequence of execution of a model (in the direction of the arrow). The message flow represents a message flow between different actors in a process.

Activities represent the execution of an activity. Activities are represented by a rectangle with rounded corners. Again, there are several types of activities. Activities that occur in the produced models are at the department management level. These activates contain several sub activities that are of differentiating natures. Because of the high-level perspective, the type of activity will not be specified further in this report.

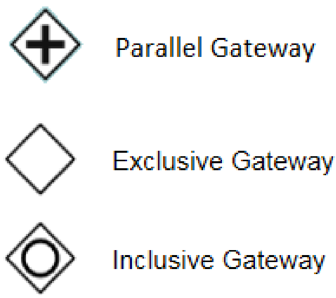

Figure 9 - Gateway types (Business Process Model and Notation., n.d.)

Gateways are used to split or join sequence flows. The different gateways are displayed in figure 9. In the parallel gateway split, the flow is split in two or more flows which are all executed. In a parallel gateway join, two or more flows are united in one new flow only when all previous processes have finished.

In an exclusive gateway split, the flow is split in two or more flows of which only one flow is executed. In an exclusive gateway join, two or more flows are reunited when one of the previous processes is finished. In an inclusive gateway split, the flow is split in two or more flows of which at least one is executed. In an inclusive gateway join, two or more flows are united in one flow when one or more of the previous processes are finished simultaneously.

Lastly, swimming lanes are used to make a distinction between activities of the various actors in the process. (Business Process Model and Notation., n.d.)

2.5 PRIORITIZING PROBLEMS

Once failures have been identified in the studied processes, a methodology for handling and prioritizing these failures is needed. The prioritization will take place using expert opinions on the severity of the problems. Moreover, the extent to which the problem is influenceable is of importance for choosing problems.

2.5.1 FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS

The methodology prescribes precise actions that should be undertaken to assess the importance of found failures in a process. The approach can be used in both high-level business processes, like the ones presented in this thesis, and in lower level production processes. A structured overview of the parts of the approach that will be used in this thesis is displayed in figure 10. This includes only the calcution of the Risk Priority Number, only a part of the full FMECA cycle.

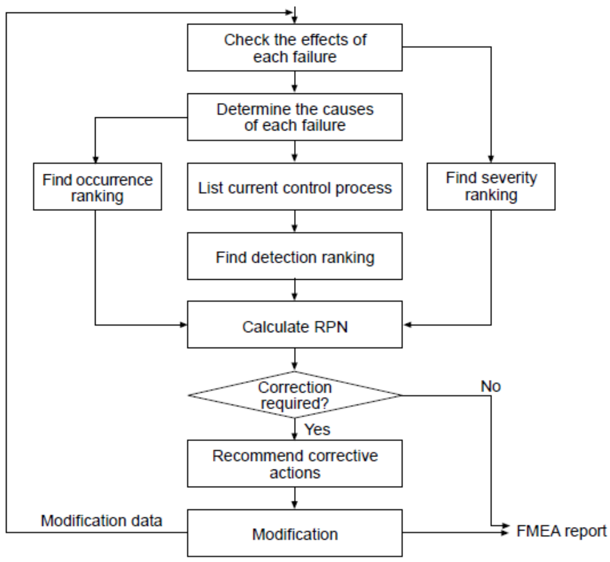

Figure 10 - FMEA cycle

FMECA ranks the found problems according to the product of the occurrence ranking (O), the severity ranking (S) and the detection ranking (D). The occurrence ranking is a numerical and subjective estimation of the frequency of occurrence of a failure mode. This factor is sometimes also referred to as likelihood. The severity ranking is a numerical and subjective estimation of how large the impact of the failure mode will be for the customer or end user. This factor thus describes the effect of a failure mode. The detection ranking refers to the extent to which a failure mode can be influenced or controlled before it reaches the customer. It assesses the effectiveness of available controls. All three factors should be assessed using a score ranging from one to ten.

The product of the previously explained factors (O x S x D) provides the risk priority number (RPN). Problems with the highest RPN should be solved first. As a result of the score ranges for each individual factor, the RPN varies between 1 and 1000, where a risk priority number of 1 represents the lowest priority and a risk priority number of 1000 represents the highest priority possible.

2.5.2 MOSCOW METHOD

The MOSCOW method exists out of a clarification of the items that are to be prioritized into five groups. These groups all contain items of the same or comparable importance. The theory is specifically useful for the development of products or services. The priority groups are:

- Must have; items that have highest priority and should be dealt with anyway. Neglecting these items will have catastrophic effects and is not an option.
- Should have, these items have a moderate importance. It would be good to take these items into consideration.
- Could have, these items are slightly less important compared to the should haves. Could haves are to be taken into account only if there are resources available for them at all.
- Won't have, this category is also known as the wish list. Although the items may still be an addition if taken care of, they will currently not be incorporated in the project.

An advantage of the MOSCOW method is its simplicity. The fact that several problems can be prioritized in the same category prevents mutual comparison of the priority of these problems. It is not clear which problem is more important within a priority group.

2.5.3 AHP METHOD

The Analytic Hierarchy process (AHP) is a well-known method to prioritization in multi criteria decision making processes. The method uses mutual comparison of criteria to determine a priority ranking. In every comparison, the user specifies the importance balance between the two items. A combination of all comparisons allows for calculating the relative importance of each item.

The AHP method is normally used in two steps. In the first step, the relative importance of the criteria is determined. In the second step, the alternatives are awarded point on these respective criteria. To allow for this decision-making structure, the selected problems would have to be scored according to several criteria. These criteria could be impact or frequency of occurrence for example. Introducing these criteria and using the AHP method would create a complicated set of comparisons that requires detailed specification and support of the scoring whereas this amount of detail cannot be provided at the high level of this bachelor thesis yet. The decision process would also cost a lot of time to explain and complete together with all colleagues.

2.5.4 CONCLUSION

In conclusion, the failure mode, effect and criticality analysis is the most applicable prioritization method since the method brings the right amount of precision in the decision process. Whereas the MOSCOW method lacks precision due to its equally prioritized classes, the AHP method will be a complicated tool that requires a lot of effort from the colleagues to use. The FMECA is a method that considers relevant characteristics of the problems at hand that can be easily determined in discussions with the PCWXS team members. The FMECA will therefore be used for the prioritization in this report.

Due to confidentiality of the found problems and solutions, the actual findings and execution of the previously described approach are not presented in this summary.

CHAPTER 3: RESULTS OF THE RESEARCH

The execution of the approach presented in chapter two, let to a problem listing based on the conducted process analysis. The process analysis helped to analyse the daily activities of the department together with the involved employees. We created an overview of the problems found and prioritized these problems using the FMECA procedure (see chapter 2). The factors used in the FMECA evaluation of the problems have been determined in cooperation with the head of the PCWXS team.

Based on the FMECA analysis of the problem list, a selection of problems was made that turned out to be of high priority to the company. Other factors that were considered are the relationship with the Industrial Engineering and Management discipline and the feasibility of proposing a well-documented solution for the problem due to the time restriction. This consideration let to the selection of two problems that are closely related to each other.

Now that we selected two problems, the background situation of the problems was investigated in more detail. Interviews and group sessions with the involved employees helped to create a good understanding of the cause of the selected problems. The group sessions also included a creative part that helped to come up with possible solutions for the problems.

Based on the suggestions for possible solutions for the selected problems, three potential solutions were proposed. These solutions were then evaluated on their costs, both in terms of money and effort required. Lastly the expected effect was estimated and considered. The evaluation of the proposed solutions let to a final recommendation on how to solve the selected problems.

The final products of the bachelor thesis exist out of both the recommendation on how to solve the selected problems and the extensive problem list that was created during the interviews conducted in the research. Both products are valuable starting points for MAN to further improve the daily operations of the PCWXS department.

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