UNIVERSITY OF TWENTE.

Performance management of company X

“How can the performance management of company X be improved based on the needs of the company?

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5-7-2019

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Preface

This thesis describes the research on the performance management of company X. Upon completion of this research, I am finishing the bachelor Industrial Engineering and Management at the University of Twente. During the three years of the bachelor I gained a lot of knowledge and I improved my professional skills.

First of all I would like to thank Dr. Adina Aldea from the University of Twente for all the guidance and feedback from the start of this thesis. This guidance was the basis for this research. Besides Dr. Adina Aldea, I would also like to thank Prof. Dr. M.E. Iacob of the University of Twente for the assessment of this thesis.

I would like to thank my external supervisor for this opportunity at company X and the great feedback on the thesis. Our conversations provided me with a lot of practical knowledge and experiences which I experienced as being very useful. Besides, I also would like to thank my colleagues with whom I shared the office for the last three months. During this research I had access to all the information that I needed, and I could always ask questions.

At last, I can not forget to thank Ruben Wienk, a fellow student Industrial Engineering and Management. During the setup and actual execution of this research, we had discussions on the content of our research projects.

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5-7-2019

Management summary

The performance management of the production environment of company X was an unclear process according to the production manager. There were doubts whether the current KPIs were defined and calculated right. Moreover, the management was not sure whether the current KPIs were the right ones according to the needs of the company. Furthermore, the communication and the availability of the KPIs had to be assessed.

To get a clear overview of the current performance management process, an overview diagram with all the different reports, Excel files, actions, and codes was made. This diagram made it possible to list all the current KPIs used in the process. The KPIs which were used daily were defined and compared with literature.

Based on the overview diagram of the process, a KPI tree which contained all the KPIs available was made. This KPI tree was linked to the mission and vision of the company to show the relation between the KPIs and the needs of the company. It showed that especially safety and quality are highly valued in the company but almost no quality KPIs were available. To finalize the KPI tree, a survey was performed on the preferred KPIs by the employees of the company.

The finalized KPI tree with its link to the mission and vision made it possible to choose the selection of KPIs that the company should use. Of this final selection, it was defined which data is needed to calculate these and whether this data is available.

The link between the mission and vision and the KPI tree made it possible to make an overall design of a daily report. This daily report should show the selection of KPIs. Based on the values in this report, a potential weekly report can be defined. Creating both these reports will decrease the complexity of the performance management process of company X a lot.

But before this daily report can be implemented, some steps with regard to the calculations and definitions of KPIs and goals should be performed namely:

- Small simplification of the registration done by the shift leaders
- Make sure that the distinction between work orders and work products is clear
- Define the losses in the production process
- Discuss the goal of the yield for work orders and shifts

To be able to evaluate the final design of the daily report, an example version was made with real data. The overall reaction of the employees was quite positive and with the insights of this evaluation the design was finalized. The employees of the company want to implement the finalized design of the dashboard on short notice.

Besides the daily report, the company has a morning meeting in which the performance of the process of the last day is discussed. This daily meeting was observed during the problem identification phase to be able to choose appropriate literature to improve this meeting. The Daily Scrum Meeting was chosen to do literature research on, and later this theory was discussed for the situation in company X. Based on the final selection of KPIs and the improved daily report, an improved structure of the daily meeting was defined.

The conclusion of this research is that the performance management of company X can be improved based on the needs of the company by using the KPI tree, implementing the proposed dashboard, and improving the morning meeting. But before the dashboard can be implemented, several steps

have to be completed. Besides that the process of the morning meeting is improved. This research is a good start for continuous improvement of this meeting. Further research that should follow after this thesis is on creating a weekly dashboard and whether Tableau can connect to the ERP system of the company.

List of abbreviations

- OEE: Overall Equipment Effectiveness
- BSC: Balanced scorecard
- BPMN: Business Process Model and Notation
- WO: Work order; order in which production is scheduled
- WP: Work product; used to report changeovers and corrective maintenance
- ERP system: Enterprise Resource Planning system
- AS400: The ERP system used by company X
- Queries: Codes used to extract data from AS400
- KPI: Key Performance Indicator
- MPSM: Managerial Problem-Solving Method
- DSM: Daily Scrum Meeting
- FTR: First Time Right

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1. Introduction

1.1 The original reason for starting the project

The production environment of company X consists of three production lines of which the performance has to be measured.

The reason to start this assignment was because the production manager of company X doubted whether their performance management is as effective as it could be. This was stated as: “can you examine our performance management and compare it with our needs.” This had to be assessed at aspects like are the goals of the organization properly communicated to the work floor and is it possible for everyone to manage people at all levels, are the current KPIs the right ones and are these communicated properly to the employees responsible to influence the process and do these KPIs actually help them.

Another question which could be answered after solving the problem mentioned above. Is whether the results of the process in the company were available soon enough to be able to anticipate on it. It was observed during the first weeks that only the daily and shift values of the OEE are noted during the day. These value are then discussed during a daily meeting in the morning. The production manager doubted whether it was better to have the OEE (or other KPIs/values) real time available. If the values are real time available, the process might be steered better during a shift, and not only after a shift.

The data of a shift is filled in the system at the end of every shift. It happened quite some times in the past that shift leaders forgot to put in this data. This resulted in bad reports for the management but this is something that the company has been working on for quite some time. So this is not something that is improved in this thesis, but it is described how the data is put in the system.

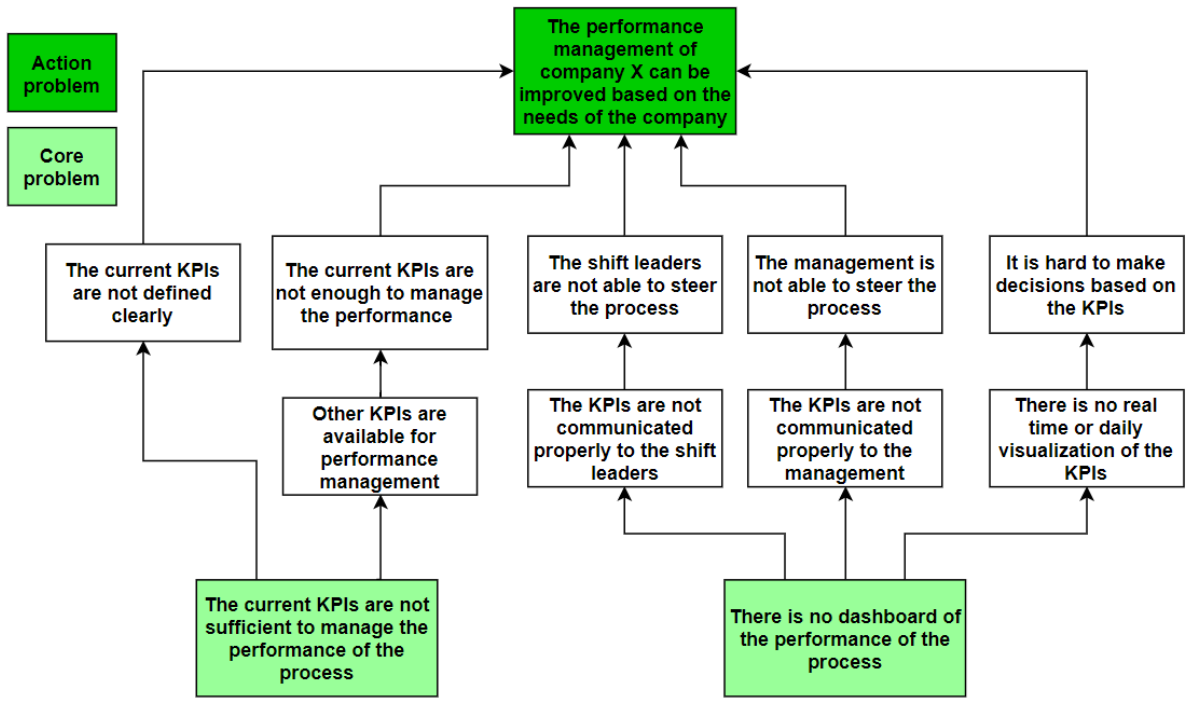
1.2 Problem identification

To manage the three production lines, every morning at 10 am three meetings takes place while standing around a whiteboard. In these meetings many different aspects of the production are discussed and noted on the whiteboards. Every production line has its own whiteboard in the factory where the line's meeting is held. At the start of the meeting, the quality and safety are indicated as good or bad. Secondly the percentages of the OEE and the waste are discussed. These values are copied from AS400. Subsequently, everything that went wrong during one of the shifts is discussed. This is divided in the morning, afternoon, and night shift. Stops in the process are also discussed at this moment and the time of the stops is noted in minutes. At last, problems or particularities which are present for a longer time are discussed.

To manage the process, a lot of different Excel sheets with data are used. Some sheets of data are extracted from AS400 with certain queries, others are filled in manually. Every different department of the company uses different queries and different Excel files to analyze the data. Most of the input for the system happens at the work floor. Before every morning meeting, a small production report is sent to the management of the company. In this report, the amount of boxes planned, the actual amount of boxes produced, the deviation in percentages, the amount produced in kg, and the stops with their reasons are noted.

1.2.1 Problem cluster

In the parts original reason for starting this project and the problem context, several different problems are stated. To structure these problems, a list of non-overlapping problems is defined in appendix 1. The pneumonia rule of Hans Heerkens was taken into account here because it is not important how company X ended up with the current way of working. This is the case since it will not help with solving the problem. To find the core problem out of all the problems, a problem cluster is made. All the different problems are linked based on causality. This means that the arrows point from cause to effect, which is an aspect of the problem cluster based on the MPSM. This also gives the result that the core problems are the problems with the longest chain. The action problem and core problems are given a specific color which is indicated in the legend. With performance management, the ability to manage the performance of the production process in the whole factory is meant.



1.2.2 Core problem

The core problem consists of two parts which basically describe the needs of company X. The needs of the company consists of sufficient KPIs and a dashboard for the management of the process. For the KPIs, it is first important that these are defined and calculated properly. Secondly it had to be assessed whether the current selection of KPIs was enough to manage the performance or that other KPIs should be included in this selection. At last, for the KPIs, it was important that these were communicated properly bottom-up and bottom-down in the organization. This is important because both the shift leaders and the management have to steer the process based on the KPIs. A dashboard of the performance of the process is needed to give real time or daily visualization of KPIs. A dashboard would enable the management to make better decisions regarding the performance of the process. KPIs can be described as values providing a way to measure how well companies are performing in relation to their strategic goals and objectives. But the primary value of KPIs is not in measurement per se, but in enabling rich data-driven performance conversations and better decision making.(Marr, 2018)

1.2.3 Motivation

The management of the company makes decisions about the process based on the current KPIs. The company uses a continuous process and this process is really expensive. The factory and the machines are quite new. AS400, the ERP system, is relatively old and the KPIs are calculated with the use of many different Excel sheets. It is important that the values of the KPIs are correct and that the calculations do not take too much time. This is one of the reasons why a dashboard is important. A dashboard can save a lot of time every day since the KPIs can be visualized automatically. Besides this, a dashboard gives more insight in the process than just numbers.

1.2.4 Scope

In this thesis, both the core problems are worked out to improve the performance management of the company. The core problem of the KPIs is first divided in the research questions. After working out these questions, a clear and precise overview of the KPIs was provided to the company. Based on the selection of KPIs, a dashboard is designed for the production process of company X.

1.3 The problem solving approach

In this thesis, the steps of the MPSM are used. The steps of the regulative cycle are used to find a solution on the problem as it was stated by the production manager of company X. Chapter one of this thesis describes the first three steps of the cycle which are the problem identification, planning of the problem-solving approach, and the problem analysis. This can also be called the project plan. The second chapter describes the theoretical framework used in the thesis. The next chapters contain the remaining steps which are designing and assessing possible solutions, choosing a solution, implementing the solution, and evaluating the solution. The research questions are defined based on these steps. In the part of the research questions is indicated which research question is answered in which part of the MPSM. After the last step of the MPSM a conclusion chapter follows.

During different steps, it was the case that extra information was needed. This is done by going one or more steps back in the cycle. The research cycle is a part of the MPSM and is a method to solve a knowledge problem. The cycle consists of 8 steps namely: research aim, problem statement, research question, research design, operationalization, measuring, analysis, and conclusions. This cycle could have been used in every phase of the MPSM except phase 5 but the research cycle is not used in this thesis. This cycle is not used since going a few steps back in the cycle was sufficient to find all the needed data. Furthermore, a systematic literature review was performed when the research cycle could also have been used. But a systematic literature review was more appropriate for this problem.

Data collection

In this project, four ways of acquiring information are used namely, interviewing, observing, literature study, and going through available data. Interviewing is done using checklists. This way, the interviews did not take that much time and the answers could be summarized easily. Observing was done during the morning meetings, the process and the conversations were observed while making notes. The literature study consists of both normal literature study and a systematic literature review. The fourth way of acquiring information, going through available data, was performed by assessing all the Excel files and used calculations.

The theoretical perspective used in this project is both technical and social. The technical parts consists of the calculations and data files that are used in the company and the social part is about the way of working. The way of working includes certain procedures how the management does performance management at this moment.

1.3.1 Stakeholders

The stakeholders of this project contain of several layers in the organization. The first is the management of the company, these people use the daily report which show the KPIs every day. Decisions can be made based on certain KPI values. The people actually calculating the production KPIs every day are also affected by this project. Their way of working changed a bit and they are asked for information. The third layer that this project effected, consists of the people working in the production environment. Of this layer, this project mostly effected the shift leaders. The shift leaders make decisions based on KPI values and they also attend the morning meeting, where the KPIs are discussed.

1.3.2 Descriptive research

The primary purpose of this research was to describe the current situation and come up with improvements. The overall design is rigid and focuses on reliability, this is especially the case with the definition of current and potential KPIs. The research process is structured and the design for analysis is planned beforehand. Thus the research is descriptive.

1.3.3 Main research question

How can the performance management of company X be improved based on the needs of the company?

To answer the main research question, first research is performed to answer the question "what is performance management?" This research can be found in the theory chapter. Then the following sub questions are answered. Based on the answers to these questions, the main research question is answered. The sub questions are made based on the MPSM. Below, the steps of the MPSM are indicated and it is stated which research questions are answered in which step.

The fourth step is the solution generation. This step consists of the first two research questions out of which improvements of the current way of working come forward.

1.3.4 Sub questions

Solution generation

1. Are the current KPIs for the performance management of the production process of company X defined the same as in literature?

To answer this question, first the current KPIs used in the performance management of the company are described. The process from putting in the values in the ERP system on the work floor till the calculations in Excel is checked. This is done by actually going to the work floor and defining how the shift leaders put values in the system. This action is performed multiple times and with different shift leaders. Assessing the calculations in Excel is partly done by interviewing employees to find out their way of working and for the other part by going through the Excel files. Of this process, an overview diagram is made. The company gave permission to talk with the shift leaders and necessary Excel files are acquired. At last, the definitions of the current KPIs were compared with definitions in literature. The answer of this question consists of a diagram of the current process and a discussion of the KPIs in comparison with literature.

2. Which KPIs are needed for the performance management process of company X?

To be able to answer this question, first literature research is performed to find out which KPIs are available to manage the performance of a production process. Four different sources are used to find as many KPIs as possible. The result of this literature research is noted in chapter two. Then, based on the overview of the process that is created in the first research question, a KPI tree is made. This is why research is performed on KPI trees and its benefits. The KPI tree is linked to the mission and vision of the company. This made it possible to see whether the current KPIs fit with the mission and vision. It is also assessed whether the KPIs are available in the right time span. Of the list of possible KPIs, a list with potential KPIs for company X is chosen, and a questionnaire for employees is made. With the results of this questionnaire, the KPI tree is finalized.

Solution choice

Based on the questionnaire and the link between the KPI tree and the mission and vision statement, it was possible to choose which KPIs are needed for the performance management of company X. The selection of KPIs, the design for the dashboard, the choice of software application, and the improvements for the morning meeting are all part of the solution choice which is the fifth step of the MPSM. But the two questions about the morning meeting will be answered after the evaluation. This is done because the answers on these questions depend on the result of the implementation and evaluation.

3. What data is needed to calculate the final selection of KPIs?

To extract data from AS400, different employees use different queries to get Excel sheets with a lot of data. There are already a lot of different queries available in the system and it is even possible to

create a new one. To calculate the KPIs it was important to find out which data is needed for this. This is done by defining the required data for the KPIs of the final selection.

4. How can a dashboard for the performance management of company X be built?

To be able to design a dashboard, some overall design guidelines are defined first. This is done with the use of a literature search and the results can be found in chapter two. Then the actual design of the dashboard and the way how the final selection of KPIs should be visualized is made. The time frame in which the dashboard has to be updated depends on the selection of KPIs with the required time frames which is set in the KPI tree.

5. Which software applications can be used to build a dashboard?

To find the answer on this question a systematic literature review is performed. Three software applications are chosen after a short research. Then, these three software applications are described with their pros and cons to be able to choose which is the best one. With the use of this information, and further necessary information from the company the most appropriate software application for the company is chosen. The systematic literature review can be found in chapter two and the final recommendation for company X is answered in the question: Which software application is recommended for company X?

Implementation
The implementation consists of several steps which the company has to perform. The steps are ordered starting with the most important one. This is the sixth step of the MPSM.

Evaluation
The seventh and last step of the MPSM is the evaluation. First an example design of a dashboard is evaluated with the production manager. This evaluation made it possible to make an example dashboard with real data of a certain day which could be evaluated with several employees.

6. Is the current methodology of the morning meetings the same as a meeting described in literature about Daily Scrum Meetings?

To answer this question, the morning meetings are observed for a while to be able to define the process. The reason that the Daily Scrum Meeting is chosen for the comparison is due to the observations done in the problem identification. Literature research is performed in chapter two to describe DSMs. The answer of this research question consists of a discussion of the theory in comparison with the observations.

7. How can the current morning meeting be improved?

Based on the selection of KPIs and the time frame when these should be available, the needs of the morning meeting are defined. Besides setting the needs for the morning meeting, which might improve the efficiency, some general guidelines are made. These guidelines are made based on the discussion of the theory in sub question six.

Conclusion
At last a conclusion chapter follows. This chapter consists of an overall conclusion, recommendations, future research, discussion, limitations, and the contributions to theory.

1.4 Problem analysis

Based on the formulated research questions, some extra research is performed about the barriers to solutions, the norm and reality, the validity, and the reliability.

1.4.1 Barriers to solutions

The reason that the company works the way that it does, is that the ERP system used in the company is the same as in the headquarters. Besides the ERP system, the company acquired partly the way of working. Furthermore, the employees in the company are quite busy what also makes it hard to change the way of working. But the overall cause of the problem, is the adopted way of working. This cause is irrelevant for solving the problem.

1.4.2 Norm and reality

Before this project was started, the management had doubts about the current KPIs used to manage the performance of the process. The process in the company is called a continuous process since it involves an ongoing production of end products. In theory, the process can keep going on 24-hours a day. The norm of the management of the company, is that there are no doubts about the current KPIs. These should be described clearly and the calculations should be precise. The calculations of these KPIs every morning should be automated with the use of a dashboard. This dashboard can be used by the management to get a quick overview of the process. The frequency with which the dashboard is updated depends on the capabilities of the ERP system and the needs of the company.

1.4.3 Validity

Validity is important for every research. Hans Heerkens defines three types of validity, namely: internal, construct, and external validity. For all the three types of validity it is important that the research takes this into account as much as possible, that is also why potential threats are defined. It was not possible to eliminate all the threats of validity, but being aware of the threats already helped a lot.

The first type of validity is internal validity, which means: do you measure what you want to measure? The measurement in this research consists of interviewing, observing, literature study, and going through available data. The threats for interviewing and observing the shift leaders were the possibility that they worked more precise while an observer was present or that they were not honest about own mistakes. It might be that shift leaders did not want to look bad in the eyes of the observer/interviewer. The management is interviewed and different results came out of this because of their different interests in the process. But this was not a problem since the information on a dashboard had to be tailored specifically to the requirements of a given person, group, or function; otherwise it won't serve its purpose.(Stephen Few, 2006)

Literature study is a part of the construct validity which is the second type of validity. It is important that literature is used correct. The biggest threat here is the fact that the concept of dashboards in organizations is relatively new and changed a lot over the last years. This is why the most recent literature is used. The last measurement in this research, going through available data, did not have big threats.

The third type of validity is external validity, which can also be called generalizability. The result of this research is unique for this company, but the approach of the research can be used by another company to increase their performance management.

1.4.4 Reliability

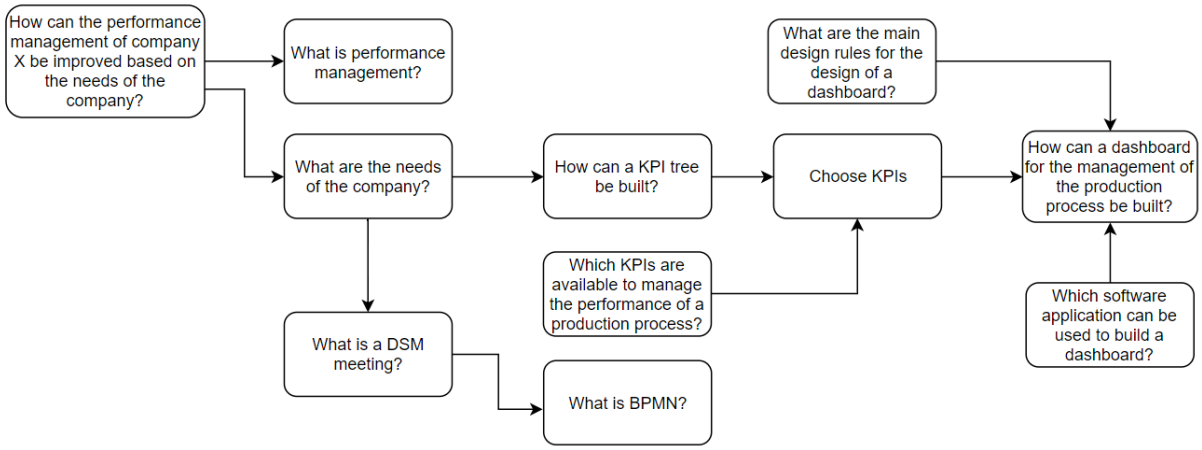
Reliability refers to the consistency of the results in research.(Psychology blog, n.d.) Therefore, in order for research to be considered reliable it should produce the same (or similar) results if repeated. That is why for the main inputs of this research, reliability is discussed below.

To define the current way of working in the company, a diagram is made starting with the ERP system in the middle. The ERP is used as a starting point since this contains the most information and it is used the most. If a similar research to the way of working would be done in another company, it is recommended to start with the ERP system in the middle. If the company does not have an ERP system, the most important file should be used as a starting point. Building the diagram is done by asking employees for information and going through the available data.

To find the final selection of KPIs that should be used in the company, a KPI tree is made. To build the KPI tree, the opinions of employees had to be taken into account. Lists are used to note the opinions of employees in a structured way. The lists are presented in a neutral way, so the results would not be influenced by the way of asking. The results are unique for this company but this is supposed to be the case. Because the selection of KPIs and the design of a dashboard have to be made based on the needs of the company according to literature.

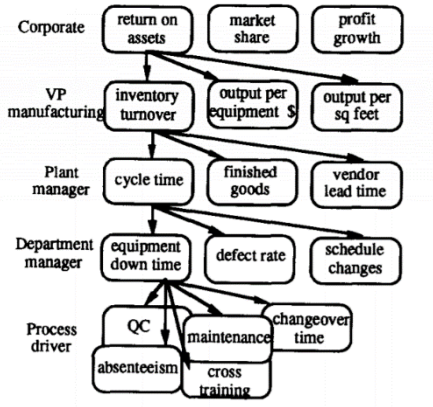
2. Literature research

Performance management had to be clear first to answer the main research question as can be seen in the diagram below. That is why literature research is performed on performance management and its different methods.



2.1 What is performance management?

Performance management creates the context for performance which is a way of defining where one wants to go.(Lebas, 1995) Performance of a manufacturing facility can be defined by different measures by each firm, defining it to match its strategy and vision. Understanding the process of performance will facilitate first of all the identification of measures, and secondly it allows for clear deployment of strategy at all levels of responsibility. A method to define performance management, is the causal model. This model shows for each level of responsibility the parameters that need to be measured. The illustration on the right shows how each of these parameters is broken down into more detailed measures at the lower levels of responsibility.



Another method for performance measurement is the balanced scorecard. This is a means to evaluate corporate performance from four different perspectives: the financial, the internal business process, the customer, and the learning and growth. (Kaplan & Norton, 2000) All the four different perspectives have their own measures which are connected to measures in other perspectives. The balanced scorecard links a vision to strategic measures. (Intrafocus, 2014) It balances financial measures with performance measures and objectives related to all other parts of the organization. This approach starts with setting objectives and then think about how these objectives can be measured.

A third method available for performance management is the KPI tree. This is essentially a tree diagram, on which KPIs are positioned in order that there is a clear structure amongst them. (Opex, 2010) To build a KPI tree the highest values in the company should be decided on first. Then, to build the different branches, the KPIs below should move progressively down into more detailed levels of KPIs. The different levels of KPIs make it possible to make decisions at strategic, tactical, and operational level. (Ante, Facchini, Mossa, & Digiesi, 2018)

All of the three methods explained above focus on finding the right measurements to focus on. A KPI is a measurable value that demonstrates how effective a company is in achieving key business objectives. (Neely, Richards, Mills, Platts, & Bourne, 1997) Thus a measurement can be called a KPI if it is chosen correct, which is also the objective of the methods. The definition of performance management and the different methods make it clear that in order to find the right KPIs to focus on, the highest objective in the company should be broken down into more detailed ones.

To be able to define the current KPIs and the potential KPIs in company X, all the possible KPIs are defined below.

2.2 Which KPIs are available in a production process according to literature?

In appendix 8, four lists of KPIs for the performance management of a production process are made out of four different sources. The definitions of all the KPIs are stated as they are in the sources. A table with all the KPIs is made to visualize which KPIs overlap in the different articles. Every row in the table is a possible KPI for the performance management of the production process. That is why, the KPIs of all the rows are listed below. The definitions of these KPIs are mostly the same as the definitions used in the four sources. If it was necessary, definitions were taken from other sources.

- **Actual production:** Number of products produced in a work order or shift
- **Rate:** Production speed in products per hours
- **Target output:** Target value per shift or work order
- **Manufacturing cycle time:** Time planned for a work order in hours
- **Scrap:** Amount of dough that is left over after a shift
- **Downtime:** Any reason why the process has to stop, indicated in minutes; Stops are basically inactions that adds cost to a product being produced for a customer(Christina Gay, 2016).
- **Throughput:** Time to finish one product
- **Behind plan:** Percentage of actual production that is less than the expected quantity
- **Corrective maintenance:** Amount of corrective maintenance in hours
- **WIP:** Amount of work in progress in kilo's
- **Overtime:** Total amount of overtime in hours
- **Absenteeism:** Total amount of absence in percentages
- **Health, safety and environment**
- **Reject ratio %:** Percentage of products that is rejected; is also waste:
- The 8 wastes of lean manufacturing include(Christina Gay, 2016): Defects, excess processing, overproduction, waiting, inventory, moving, motion, and non-utilized talent.
- **On-time delivery:** Amount of on time deliveries
- **Storage days:** Amount of days that finished products are stored at the production facility
- **OEE:** is the gold standard for measuring manufacturing productivity. (Vorne, 2002) and is calculated as Availability x Performance x Quality
- **Availability:** Takes into account all events that stop planned production long enough where it makes sense to track a reason for being down.
- **Performance:** Takes into account anything that causes the manufacturing process to run at less than the maximum possible speed when it is running.
- **Quality:** Takes into account manufactured products that do not meet quality standards.

For the OEE, Availability, Performance, and Quality several formulas are available since there are several authors. Nakajima (1988) was the original author of OEE and De Groote (1995) is one of several later authors (Jonsson & Lesshammar, 2014) who use different formulas. These different formulas are stated in appendix 3.

2.3 What method for performance management is suitable for company X?

The production manager asked whether a KPI tree could be made for company X. The three different methods for performance management mentioned earlier are all built using the same logic. But the first method, the causal model, uses different KPIs for different functions. This model is too complex for the situation of the company since different layers in the organization steer on the same KPIs. The second method, the balanced scorecard could be used but the focus of this research is only on the production process and not on other perspectives. That is why after some further research on KPI trees, this method is chosen. The research consists of how to build a KPI tree and its benefits.

A KPI tree can be built using three different relations between KPIs namely: (Bernie Smith, 2016)

- Cause and effect: One activity directly influences another for example: “Consumption of free salty snacks” causes “Increase in drink sales”
- Conflict: One activity conflicts with another for example: “Minimize performance rewards” conflicts with “Increase staff motivation”
- Companion: One measure is a subset of the other, or there is a significant overlap for example: “Weight” is a companion measure to “Body Mass Index”.

There are a number of benefits that come from using KPI trees (Bernie Smith, 2016).

- A KPI tree can sum up a complex situation with just a few indicators
- Help build agreement: Companies can have dominant employees who steer a company towards a set of measures. A KPI tree prevents this because it gives a visible output that anyone can challenge and question.
- Easy to explain: It can cost quite some time to build a KPI tree but it is possible to explain a group how to read one in about five minutes.
- Keep in step with changes in strategy: The KPI tree visualizes what impact changes in the strategy will have on measures.
- Understand how measures interact: The relations between the KPIs are explained in the previous question.

The possible connections that can be used building a KPI tree and the benefits of a KPI tree are discussed in section 3.2.1.

After defining the selection of KPIs for company X, the next step was to define how these should be visualized. That is why research on the design of a dashboard and software applications is performed below.

2.4 What are the main guidelines for the design of a dashboard?

A dashboard is a single-screen display that shows important information about a company so that the whole situation, for example in a factory or on a production line, can quickly be understood. (Tokola, Gröger, Järvenpää, & Niemi, 2016) Dashboards give more insight than Excel files which is why it is likely that dashboards will become more common in manufacturing systems. The article "Designing Manufacturing Dashboards on the basis of a key Performance Indicator Survey" gives several design principles for dashboards which are:

Single-screen; so no scrollbars or multiple windows
Mainly a static display
The top left and center should contain the most important information
Graphs reduce the information overload when compared to tabular information

Besides the design principles, it states that three different dashboards for three different levels in the organization can be designed. These are: an operational dashboard for workers which shows the statuses of the factory floor and job queue, a tactical dashboard for managers which is normally available daily to weekly, and a strategy dashboard for executives which is normally available monthly to yearly. In the illustration below, the idea of the three dashboards is visualized. In appendix 12 some more information about the different dashboards can be found. For this research it is important to take into account which levels of the organization will work with the dashboard of this project.

To get more bullet points about the design of a dashboard, the article "key performance indicator analysis and dashboard visualization in a logistics company" is used. In appendix 13 an overview of all the points mentioned is noted in three sections. These sections are design, layout and navigation, and characteristics of a dashboard – S.M.A.R.T. Some of the points are pretty straightforward so these are not included in the list of most relevant points below.

Design

- The different chart types should be designed before designing the dashboard
- Charts must be linked and user drilldown must be allowed

Layout and navigation

- Graphs that present relative changes are often higher valued than just the raw values
- Bar charts and column charts are used to emphasize individual values

Characteristics of a dashboard – S.M.A.R.T.

- Synergetic: ergonomically and visually effective
- Monitoring KPIs: must display critical KPIs for decision making
- Accurate information: Examined information must be entirely accurate in order to get user's full confidence and to be sure of the data's validity
- Responsiveness: A dashboard must respond to predefined thresholds by showing different kinds of user alerts
- Timely: information must be on real-time or right-time

2.5 Which software applications can be used to build a dashboard?

Nowadays there are a lot of different software applications to build dashboards. That is why a systematic literature review is performed on different software applications. A systematic literature review is a way of finding information in a very structured way. Normally, to find extra information, the research cycle of the MPSM is used. But a systematic literature review is performed because this is a reliable way of finding information using literature. The review consists of seven steps which are all worked out in appendix 11. Below only the findings are stated.

For the scope of this systematic literature review, the needs and resources of the company had to be taken into consideration. This is because a lot of software applications require a lot of coding which is a resource that the company does not possess. This is why the focus of this systematic literature review is on the following three software applications.

- Excel
- Qlik sense
- Tableau

For the different software applications, several criteria are placed in a table. For every criteria is indicated which application "wins" the criteria. The winner is indicated with a one, the second and third place are indicated with a 2 and 3 respectively.

	Microsoft Excel	Tableau	Qlik Sense
Amount of coding	3	1	2
Quality of the dashboard	3	1	2
Costs	1	3	2
Process capability	3	1	2
Data manipulations	2	3	1
Multidimensional analysis	3	1	2
Total	15	10	11

The question: Which software applications can be used to build a dashboard? Is answered using the table above. Tableau has the overall highest score. That is why this software application is chosen as the best one. But Tableau scores lowest on costs, that is why it has to be assessed whether the application is worth the money. This depends on the requirements of the dashboard. The answer of the question: "Which software application is recommended for company X?" explains which software application is recommended to the company taking information about the company and the dashboard into account. This question is section 4.4.

After defining the dashboard design and the proper software application to build this in, it was important to assess the process of discussing the performance. Below, first the DSM process is described, and secondly the BPMN.

2.6 What is a DSM?

A daily scrum meeting is a meeting where a group discusses the process until the recent day and potential problems for the current day. This happens preferably standing around a whiteboard. A lot of people might be under the impression that scrum can only be used in the software development field, which is not true as it is capable of adding value to other fields as well. (Ian Haines, 2017) Information that is shared in DSMs is supposed to be relevant for the production environments progress. Organizations should be aware of the factors that may affect the attitude towards DSMs and should consider recommendations and guidelines to make this agile practice as valuable as possible.(Stray, Sjøberg, & Dybå, 2016) This is because a great amount of meeting time is perceived as ineffective, and it even affects an employee's productivity beyond the meeting. Furthermore participants of the meetings all have their own work, and talking about solutions for others might not be interesting. This confirms a study that found that over time, as employee's roles became increasingly specialized, the extent of shared communication decreased. (Levesque, Wilson, & Wholey, 2001)

Stray, Sjøberg, and Dybå described four characteristics that affect the DSM process, namely: use of board, use of video, number of participants, and proportion of team standing.

- The use of board has a positive effect on the DSM process because people could relate to what participants said.
- With the use of video is meant that the team members are not at the same place. Which is not relevant for this research.
- A low number of participants positively affects the DSM process because then the participants find the information that is shared more relevant and thus pay more attention to what is said. The general recommendation is that the number of participants in a group should be as low as possible, but high enough to represent many viewpoints.
- Standing during the meeting reduces the duration of a meeting.

It is important that the meetings do not become a reporting process to a manager. The people attending the meeting are then only busy with the report of their own work. The time will be spent useful if participants are supported in identifying, avoiding and solving problems. Back-up behavior is a term used here which means that employees help each other to solve problems. Four characteristics negatively affect DSM attitude namely: too high frequency, having the meeting at a disruptive time, not starting promptly, and too long duration. The first, too high frequency also depends on the communication outside the meetings. If people communicate everything also outside the meetings, then the meetings will not give new insights. Overall it depends on the work whether the daily meetings are necessary or not. The time of the meeting might be more disruptive at a later or earlier time. But this differs for every employee. The recommendation is that the DSM meeting is scheduled in the morning. (Mountain Software, 2016) The third characteristic, that the meeting should start promptly is because people feel like they are wasting their time if they have to wait for others. Whether a meeting feels to be too long depends on the meeting and employee. Scrum meetings are strictly time-boxed to 15 minutes.(Mountain Software, 2016) The time limit of 15 minutes is set because people seem to appreciate meetings better when these are short.
(Ian Haines, 2017) describes bad habits about daily meetings:

- Waiting around: Ensure that meetings start at the same time, even if not everyone is present yet.

- No rambling: Ensuring that every piece of information communicated is valuable to everyone in the room will already minimize this.
- Stand-Ups are not the only form of team communication: It is not the case that people should wait for the next meeting to bring up challenges.

2.7 What is the Business Process Model and Notation?

Business process modelling is the activity of representing processes in a company, so that the current process may be analyzed and improved in the future. (Chinosi & Trombetta, 2012) The goal of BPMN is to provide a notation that is understandable to all users in the business. Besides this, the intention of the designers of BPMN was that the modelling language can equally well be applied to many different business modeling activities. (Zur Muehlen & Recker, 2008) This way BPMN has established itself as the standard method to visualize business processes in the form of a diagram similar to a flowchart. The fact that the method has become the standard is the reason why it is used in this thesis. The method contains a great variety of modelling elements and it uses different lanes. The lanes make it possible that activities can be grouped in organizational departments.

In this thesis, only a few basic elements are used namely the start event, end event, exclusive gateway, and task. An exclusive gateway means that only one of the paths can be taken. In the BPMN visualizations, a legend with the four elements is shown. The BPMN models with the used methods are easy to understand for many employees.

At this moment, the company does not use BPMN to describe processes yet. But the process is easy to understand and it helps in defining improvements. Besides improvements in this thesis, the notation of the process like this gives a clear visualization. The company can use the improved visualization to further change the process of the morning meeting if necessary.

3. Designing and assessing possible solutions

The fourth step of the MPSM is designing and assessing possible solutions. This step consists of the first two research questions. In the answers of these questions, improvements of the current way of working come forward.

3.1 Are the current KPIs for the performance management of the production process of company X defined the same as in literature?

To answer this question, first research is performed on the current daily KPIs in the company. Secondly, the current KPIs are defined with their calculations. At last the used definitions of the KPIs in company X are compared with definitions in the theory chapter. This comparison is to make sure whether the current KPIs are correct or not. At the end of this research question, a conclusion based on the current KPIs follows.

3.1.1 Current KPIs

The KPIs used in the company are calculated in several different Excel files or copied from AS400. It is even the case that different Excel files with the same calculations or information exist. In the company, no clear overview of this is available and based on first observations it is not unlikely that employees are doing work double. Or it might even be the case that reports are made that are not even used anymore. That is why a visualization is made of all the files, queries, reports, calculations by hand, actions, and values that have to be copied by hand. This diagram can be seen in appendix 2. It is built starting with the ERP system in the middle and adding all the aspects which are found using interviews and going through the available data.

The diagram gives an overview of the performance management of company X. In the diagram the Excel files Registration and Resources calculation are used for the main input in the ERP system. In the file: Resources Calculation, the amount of Mix Fripanut, Flour, Yeast, Sunflower oil, water, and sugar used is calculated automatically. The amount of chocolate and scrap is calculated based on some more input like the amount of boxes produced, amount of products in a box, scrap test in one minute, and the scrap weight of a batch. All these resource calculations are performed, according to several shift leaders, because it is not possible to measure the amount of resources used precisely. It is important to note that the actual amount of resources used, can differ from the calculated amount because certain values are put in the system based on tests or estimations. The other resources, which consist mostly of toppings and fillings, are counted per bag or per tank. The calculated and counted values are all put in AS400 and are used in the calculations of the KPIs. Besides the input of resources, all the stops in minutes and waste in kg with their reasons are filled in. The following points are important to take into account:

- All the input is done by hand
- Overall, for the input, several different Excel files are used. That is why it is not unlikely that sometimes wrong values are used since most files are updated frequently
- Some calculations contain estimated values
- Some calculations are done by hand, so a mistake can easily be made

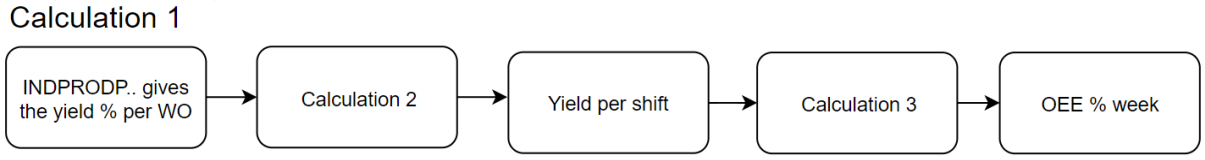
First the current KPIs that are used in the morning meeting are described and compared with definitions in the theory chapter. These are the OEE/Yield, waste, stops, and the differential waste.

Yield and OEE

In the system, the yield in % of the process is used to assess how well a shift went. The yield can be found in AS400, and this value is also written on the whiteboards in the production environment. It has to be clear that yield and OEE are not the same measures. This is why it was important to find out how the yield is calculated and assess whether it is the same as the OEE or not. No calculations of the yield were available in the company, this is why the formulas in appendix 3 were filled in for Work Orders of company X. These calculations are based on the OEE explanation as stated in the theory chapter. The actual calculation is explained below and can be found in the Excel file named Improved example dashboard.

Overview diagram

In the connection diagram below, the connection between the yield and the OEE is shown. A calculation based on the yields of one or more work orders, gives the yield per shift (Calculation 2). And a calculation using all the yields per shift and the available hours in a week gives the weekly OEE(Calculation 3).



Calculation 1. Yield of a Work Order

In Excel, the OEE is calculated for 300 different WOs. A work order is an order in which production is scheduled. Besides WOs, the company uses WPs which are used to indicate the gaps between different WOs. Things like setup time, very large breakdowns or startup time are reported in WPs. 300 calculations with the formula of the OEE gave the same result as the given yields. This is why it can be said that the Yield per WO is calculated based on the formula for the OEE. The calculation used is explained in appendix 4 and is based on the following formulas:

Availability = (Planned production time – Unplanned downtime) / Planned production time
Performance = Actual amount of production / Planned amount of production
Quality = (Actual amount of production – Non accepted amount) / Actual amount

The process waste is not a part of the calculation of the yield of company X. After some discussion with several employees, among which the supply chain manager. It became clear why this is the case. The process waste is not taken into account in the OEE calculations since this waste does not decrease the overall production. The process waste would not have been processed into for example donuts or croissants. This waste was never shaped as a product, thus it never took the space of an end product, so it does not affect the OEE. The definition for process waste is not clear since it is automatically calculated in the system. The company should find out how this is calculated via the headquarters.

Although the calculation for the yield in a work order is clear, in three different reports which contain the daily and weekly yields, the percentages differ. It can be that different calculations are used, or that employees report wrong. This is a problem which can be solved by creating a dashboard that replaces the three different reports. In this dashboard, the right calculation should be used and beforehand explained to the employees.

Calculation 2. Yield of a shift

The yield gives an indication of how well the production of a shift went during planned production time. This means that the yield of a shift does not take changeovers into account. The yield per shift is the average of the WOs in that shift. The yield per day is the average of the three shifts, and the

yield per week is the average of all the shifts in a week. It is important to note that the average is taken and not the weighted average.

Calculation 3. OEE
The actual OEE of the production lines is calculated based on the total available hours every week. The donut lines both have six whole days of production available and the croissant line has five whole days available. So that is 144 and 120 hours available respectively.

Waste
The waste % is calculated as: Waste total / (KG products + Waste total). The waste total contains the same four parts as indicated in the performance calculation. This waste consists of products that are taken off the production line but it does not include products that are rejected after production by quality. Quality tests products and is able to block pallets for further inspection. Pallets can be blocked because products do not meet the requirements of a customer. If this is the case, quality can either try to find a customer with lower requirements or the products can be scrapped.

Stops
In the query INDPRODP50 is the stop time in percentage indicated for every WO, the stops can be divided in three different parts:

- Planned stops
- Not planned stops
- Stop breakdown

Total stops = is the sum of the different parts

- Stops % = Total stops / Hours shift

It is important to note that for stops that are not significant enough to stop the whole production line, the products are thrown away as waste just before the defect in the production line. The reason for this, is that there is a proofer in every production line in which it takes 45 minutes for a product to get through. Stopping the whole production line because of a defect, would mean that all the products in the proofer result in waste. So for “small” defects, the production line is not stopped completely. If the input of the line has to be stopped, which basically means that the extruder at the start of the line stops. Then, this is indicated as a stop in the process. Such a stop will result in a gap on the production line.

Differential waste
Another KPI that is used is the differential waste. This KPI is used by planning to give an indication of how well a work order is reported. The differential waste is the difference between the input and the output of the system. The differential waste of a work order can be found in AS400 or can be calculated by hand.

The calculation of the differential waste has been found by adding all the input that could be found in a work order and subtracting all the output. This has been done for ten different work orders, then these values were compared with the values given in AS400.

Differential waste = Dough KG + scrap consumed – scrap generated – boxes kg (TAI) – waste process – waste total

The differential waste can be positive or negative. A negative differential waste means that a shift has more output than input which can most likely be explained by resources that are not filled in the system. A positive differential waste means that the output is lower than the input which can most likely be explained by waste that is not filled in the system.

In appendix 5 an example is shown of a work order with all its input, output, and the differential waste. This example shows a positive differential waste.

3.1.2 Comparison with literature

All the current KPIs used in the company are explained above, below these are compared with the definitions in the theory chapter.

Yield and OEE

The calculation of the yield is similar to the calculation of the OEE, that is why the definition of the OEE can be used for this value. Although several articles give calculations for the OEE which are based on multiplying the availability, performance, and quality. Which are explained in chapter two. These parts can be calculated using several different formulas. This is due to the fact that exact definitions of OEE differ between applications and authors. These different calculations result in the same percentage in the end. Due to this, it is not possible to give a single calculation for the OEE. So, the yield per WO in the company is calculated the same as how it is calculated in the articles.

But it is important to understand that this calculation is only based on the hours of a shift, changeovers or planned stops are not taken into account. This is why the yield is a good KPI for the employees in the production environment since this is what they can actually effect. The calculation for the yield of a shift is done using an average instead of a weighted average which is wrong.

Waste

At the production line of company X both defects and excess processing products are thrown away which are two parts of waste as indicated in chapter two. Defects are products of which the quality is too low and excess processing means that a product should for example be repaired. The products that are later blocked or scrapped by quality are not included in this waste calculation but this should be done. Both the products that are sent to another customer, and the scrapped products should be seen as waste and thus be subtracted from the OEE. But at company X is chosen not to do this. The OEE and yield calculation will be discussed with the management.

Stops

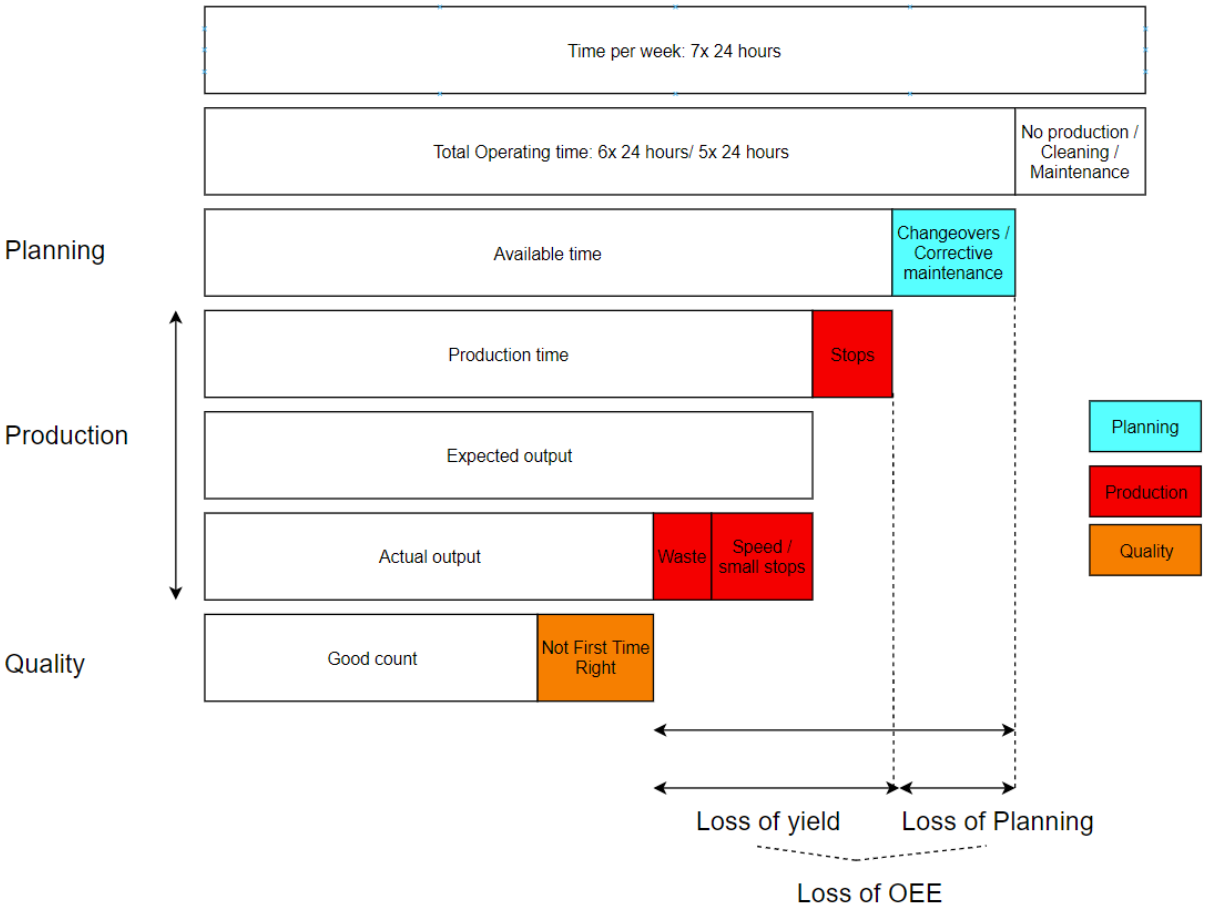
In the case of company X, stops mean that the production line is not moving. The production line with employees have a very high cost per hour. So costs increase while no products are being made. Waste in the company is seen as the products which have to be thrown away. The only remarkable point is the fact that some stops are reported as waste which is explained before. These should be reported both with the stop time and the amount of waste, then only one of these should be subtracted from the OEE / yield. The reason that both have to be reported is because the management has to assess the problem.

Differential waste

The differential waste KPI which is used in the company cannot be compared to a KPI in literature.

3.1.3 Conclusion based on the used calculations

The calculations of the different KPIs are clear, but how these connect is hard to understand without a visualization. That is why an illustration is made which can be seen below. At the top of the illustration, the total time in a week is shown as a bar of full length. The bars below show all the possible decreases. The first is not planned/cleaning which happens at Saturday at line 1 and 3, for line 2 this is two days a week. Not planned/cleaning is not a part of the OEE. This results in the total production time, which is the time over which the OEE should be calculated. The second decrease is due to planning which consists of maintenance stops and changeovers. The third, fourth, and fifth decrease are due to production. The production is responsible for the yield, in which the decreases are stops, waste, and speed. The last decrease is called quality in the illustration. The quality decrease consists of finished and packed products which are rejected based on specifications but this decrease is not taken in consideration in the OEE of company X. With the use of this illustration, the management is explained what the current situation is and it can be decided if it will be changed. Based on these decisions, the goal for the yield and the OEE should be assessed.



3.2 Which KPIs are needed for the performance management process of company X?

In the first sub question, a diagram was made in which everything used in the reporting process of the company is shown. The diagram of the process contains all the different reports used in the process. Based on these reports a KPI tree is made which contains all the current KPIs in the company and the time frame in which these are available. The KPI tree is linked to the mission and vision of the company. This made it possible to assess whether the current KPIs should be used according to the mission and vision and if these are available in the right time frame. At last the KPI tree is updated based on a questionnaire of a list of potential KPIs. This list of potential KPIs is made during the literature study. In the next chapter, this KPI tree is used to choose the right selection of KPIs for the company and the proper visualization will be explained.

3.2.1 KPI tree

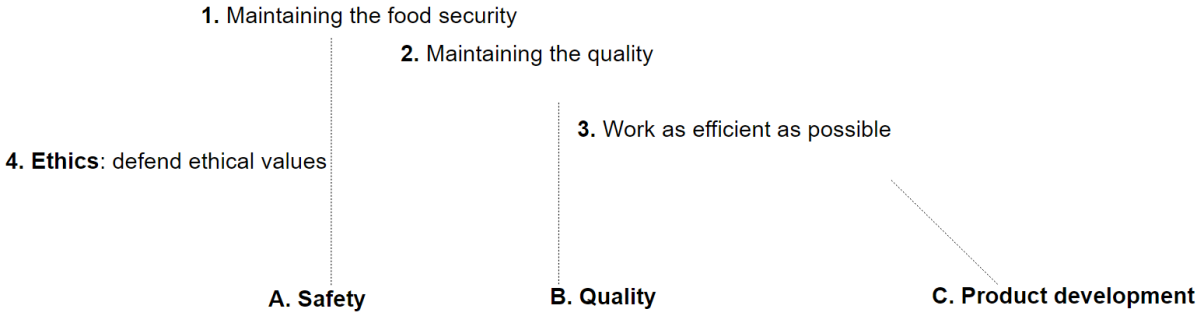
In the theory chapter it is stated that a KPI tree has five benefits. The first benefit is that a KPI tree can sum up a complex situation with just a few indicators. This is helpful in the case of company X since there are a lot of KPIs. The second benefit is that it helps to build agreement. Every employee in the company can easily see what the effect of their work is on achieving the mission and vision. This is also something that the production manager asked, as explained in the introduction. How is the communication bottom-up and top down in the company, which is improved by a KPI tree. The third benefit is that the approach can easily be explained, it might cost quite some time to build the KPI tree but understanding it might be done in only five minutes. This is relevant since there are a lot of employees in the company who might want to understand the KPI tree. The fourth benefit, is that a KPI tree helps to keep in step with changes in strategy and a change happened recently in the company. The last benefit stated in the theory chapter is that a KPI tree can help in choosing the right selection of KPIs.

In the theory chapter, three different connections between KPIs in the KPI tree are explained. For the KPI tree of company X, companion links are used which means that one measure is a subset of the other. Only one link type is used to make the KPI tree as easy to understand as possible. Three layers are shown in the KPI tree namely strategic, tactical, and operational. Normally, strategic is a monthly or yearly KPI and this is also the case here and is indicated with an orange color. Tactical is normally daily to weekly available, in this KPI tree it is weekly which is indicated with green. The operational KPIs are normally daily to real-time available and here it means daily which is indicated with blue.

Mission and vision

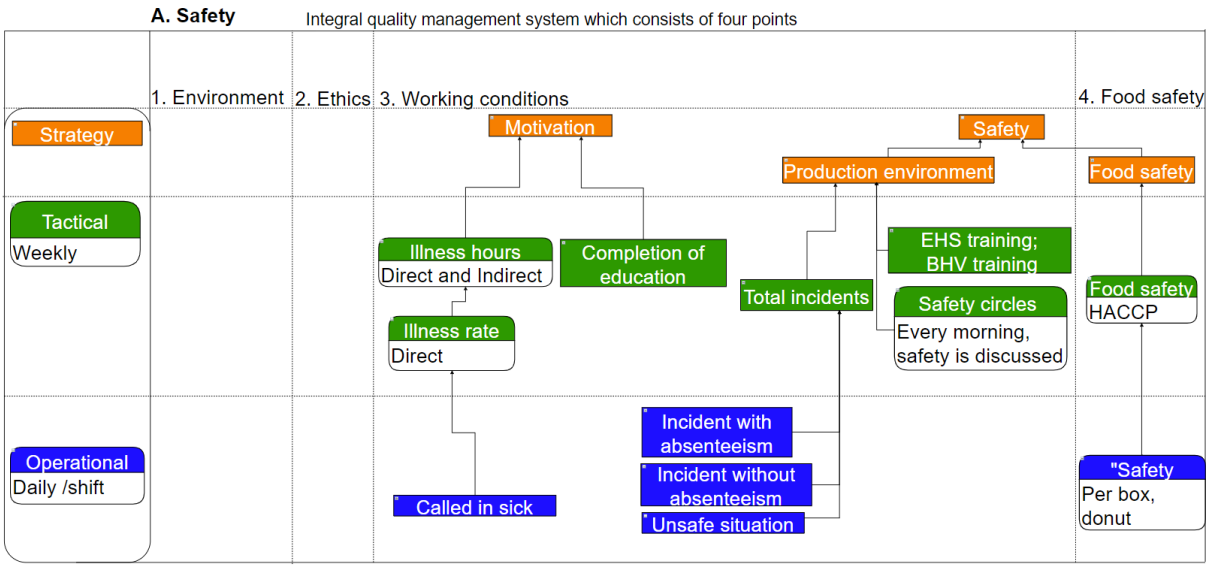
A first version of the KPI tree was made based on all the current KPIs with companion connections. This resulted in three parts namely safety, quality, and production which is the same division as can be seen on the production board. Then, the mission and vision of the company was connected at the top of the KPI tree, this gave some more divisions. The mission and vision is first divided in four parts, namely the safety, quality, product development, and ethics. To maintain the safety, the company created an integral quality management system which contains four points namely: food safety, ethics, environment, and working conditions. This means that ethics is indicated twice on the mission and vision board. In the KPI tree, ethics is set as a part of the integral quality management system, this is done since this is the primary objective of the company. The division of the mission and vision can be seen below.

Vision: Lead the market by developing new products with the speed the market demands.
Mission: The daily goal is to make bakery products and improve the results.



Safety

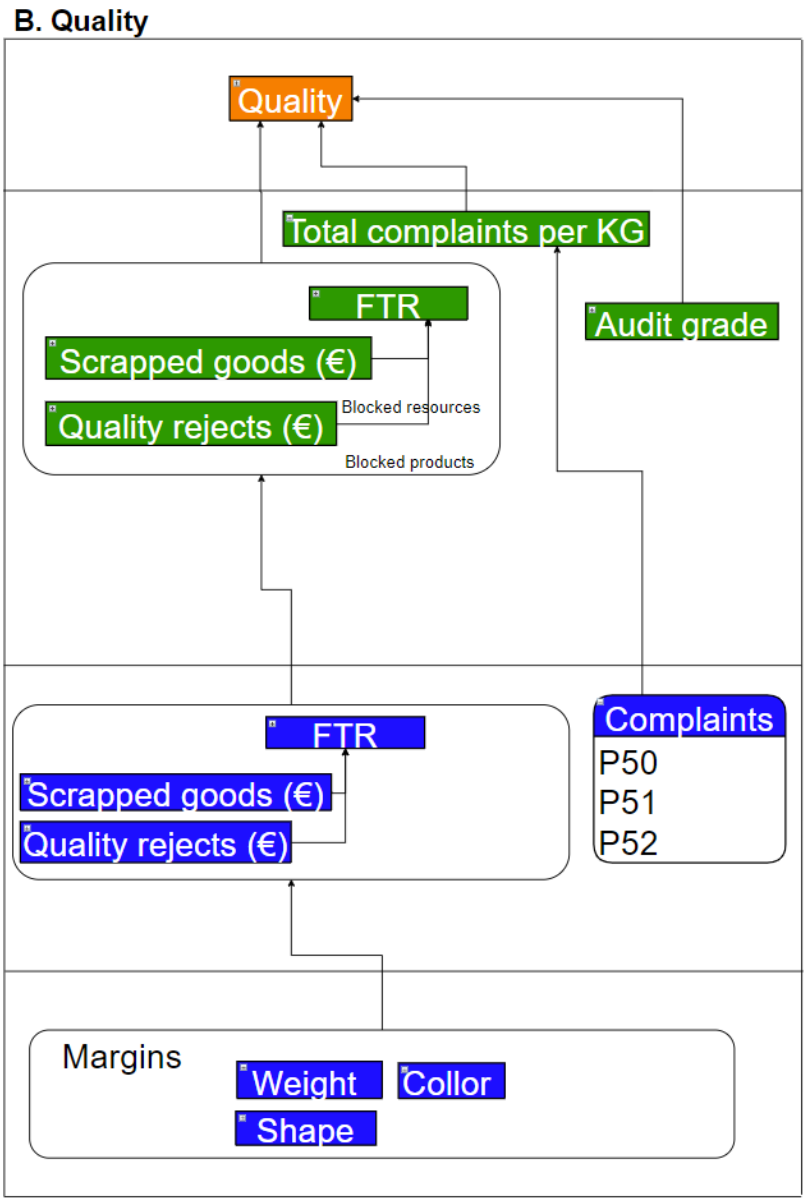
Safety with its four different divisions is the first part of the KPI tree of company X and can be seen below. This part is quite elaborate and this is in line with the mission and vision of the company. The daily KPIs are discussed every day during the morning meeting. If something regarding safety happens in the company, the employees know what to do because they have BHV training. Furthermore, situations regarding safety are handled directly.



Quality

The second part of the KPI tree is about the quality of which the first version can be seen in appendix 7.1. Quality is the second highest value in the company, but there are not a lot of KPIs used in the reporting process. Moreover, the KPIs that are used are only available on a weekly basis. So the quality KPI tree is not elaborate enough based on the value it has according to the mission and vision. So this KPI tree had to be improved.

There are several weekly KPIs with regard to quality but these are not specific enough. These weekly KPIs only show what amount of products is blocked or scrapped. Company X can not improve its process based on this, because no information is available why the products are blocked or scrapped. This was discussed with the production manager and the result was that the reasons should be included in the KPI tree. Products already have margins for quality so the different margins can be used as reasons. These are added in appendix 7.2.(not all since there are a lot and a selection should be discussed) But this way it is hard to get a KPI with a percentage, and margins are not available after a shift at this moment. That is why the KPI tree is expanded in the third version which can be seen below. But before this can be realized the company should define the margins of products very clear.



Product development

The third part of the KPI tree is called product development. The first part is about the planning/effectiveness and the second part is about the costs. This KPI tree is valued as third, but it is still quite important since it affects the company's profitability. This part has a lot of KPIs, so a selection has to be made on which the company should focus. All the KPIs are relevant since they affect costs, and this is why research is performed based on possible KPIs and the preferences of employees.

interviews

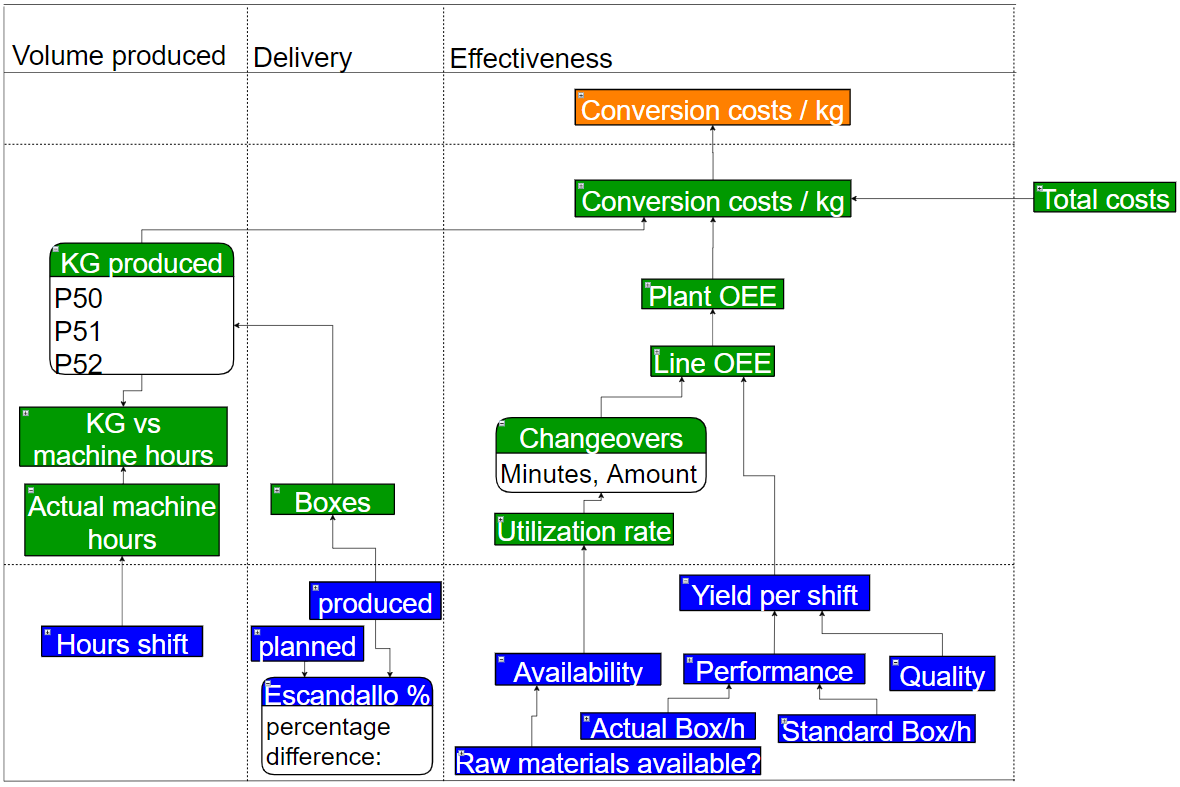
To find out which KPIs are preferred by employees, two lists with KPIs were made. The first list contains the current KPIs on the daily report and the second list contains the potential KPIs. The list of potential KPIs is a more compact version of the list with all possible KPIs as stated in chapter two. In the compact list, the focus is on the production process. Of both lists the employees were asked which KPIs they thought are useful. The following employees were asked about the KPIs:

Management: 5 employees, Shift leaders: 5 employees, Quality: 1 employee, Supply chain 1 employee, Planning 1 employee

The checklists are shown in appendix 9.1 and appendix 9.2 is a summary of the responses of all the employees. The current KPIs are all relevant except for the KG produced, that is why this KPI is not included in the KPI tree. The potential KPIs are all set as relevant that is why availability, performance, and quality are added in the KPI tree. The other potential KPIs were already available in the company but not in the daily report. Below, the KPI tree of the product development is shown in two parts namely: C1: planning and effectiveness, C2: Direct costs, Indirect costs, and Revenue. C1 and C2 are two parts of the same KPI tree of production.

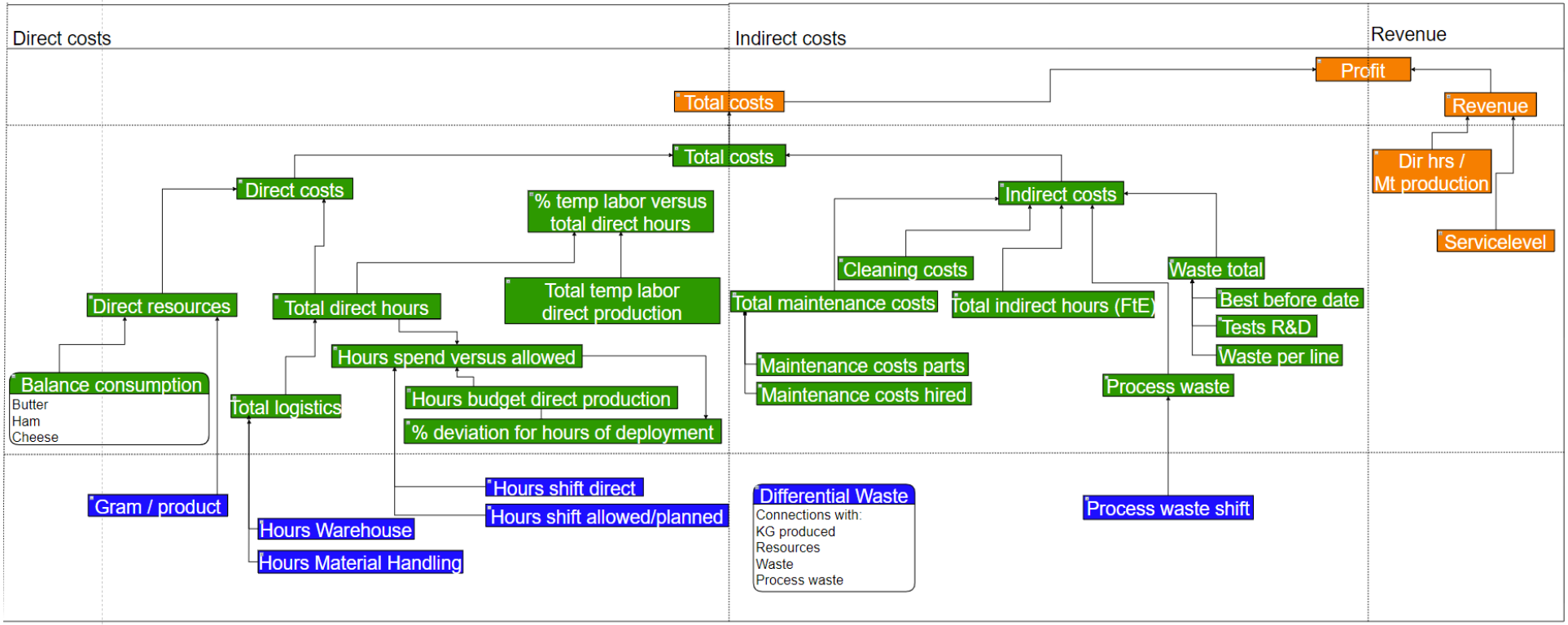
Volume produced, delivery, and effectiveness are connected in the highest KPI of these sections which is the conversion costs / kg. The total costs on the right is a part of KPI tree C2.

C1. Planning and effectiveness



C2: Direct costs, Indirect costs, and Revenue

The highest KPI is the profit of the company. Profit is first divided in revenue and total costs. This research focuses on the production process and not on the revenue of the company. That is why the total costs is worked out. The differential waste is not connected to other KPIs in the KPI tree but the calculation of the differential waste is explained earlier. The connections that the differential waste should have are noted. The reason that these connections are not shown is because this will make the KPI tree unclear and the differential waste also has connections with other parts of the KPI tree.



4. Choosing a solution

In this chapter, first the final selection of KPIs is stated. Secondly the data needed for these KPIs is defined. Third, guidelines for the morning meeting are made and the meeting are structured based on the needs of the company, which is based on the selection of KPIs. Fourth, a suitable software application is chosen in which a dashboard can be built. At last, the actual dashboard is designed.

4.1 selection of KPIs

Based on the KPI tree and the literature study in combination with the questionnaire, the final selection of KPIs is chosen and the way these should be visualized. The selection of KPIs are mostly the resulting daily KPIs in the KPI tree. According to the theory in chapter two, the way how KPIs should be visualized has to be decided before designing the dashboard. This is done separately for the three main objectives.

4.1.1 Safety

On the daily report, no safety KPI is present. The daily report should contain the same safety indication as is used on the production board in the factory. The three different ways of indicating safety can be seen in appendix 14. The three illustrations stand for: no accidents, accident without absenteeism, and accident with absenteeism.

4.1.2 Quality

The lowest part of the three is for hourly KPIs. The company should check quality every hour (or more) to be able to steer on quality. This way, every morning the amount of products which are first time right can be calculated, and this can be used in the daily meeting and reporting. Besides this, the amount of customer complaints should be reported. The FTR and amount of complaints can be shown as numbers. The FTR can be colored red or green to indicate whether the norm is met or not.

4.1.3 Product development

The highest KPI of the production is the conversion costs per KG. The conversion costs can be divided in three parts namely the planning, effectiveness, and the costs. Planning can never be optimal since changeovers have to be done, the effectiveness is always lower than 100%, and costs always occur. That is why these three parts are seen as losses. These three losses with their selection of daily KPIs are explained below.

Planning

The company has people working with a planning program which should make an optimal schedule. Assessing the planning is not a part of the project, but it is assumed that it is best to follow the schedule every day. That is why the planned hours of a shift, the actual hours of the shift, the boxes planned, and the actual amount of boxes are important in the daily report. This way it can easily be seen if production deviated from the planning, then it can be asked why. All the four values can be shown as numbers.

Effectiveness

The OEE is one of the highest KPIs of effectiveness which can be used as a weekly or monthly indication of the performance of the company. The company can already calculate this KPI and it is already used. To increase the OEE, the company has to focus on daily KPIs. Until now, the yield without its components is shown on the production board. To be able to steer on the yield, this KPI should be added on a daily report with its three components. The yield and its different parts can be shown as numbers but for every part, red or green can be used to indicate whether the norm is met or not. For the parts of the yield, the norm is not set yet.

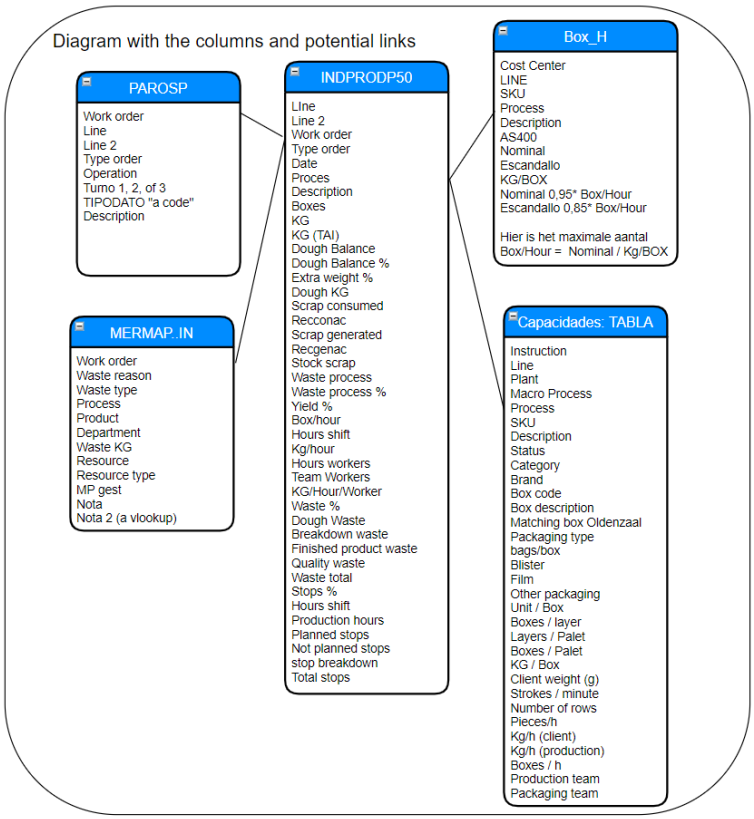
Costs

The costs are divided in two sorts of costs namely the direct costs and the indirect costs. The direct costs consists of the resources that are put in a product. The amount of resources that are put in a product can be seen in the margins which are discussed in the part of the improvements for the quality KPI tree. The second sort of costs is the indirect cost which consists of the process waste and the differential waste. Both these costs are already explained earlier. Also these KPIs, can be shown as numbers. Potential norms can be added if this is necessary. A norm for the process waste or differential waste can for example be a percentage of the total output of a shift.

Above, all the KPIs that the company should focus on are discussed. In appendix 10 a clear list of the selection of daily KPIs is made.

4.2 What data is needed to calculate the final selection of KPIs?

For the selection of KPIs, is stated in appendix 10 where the required data can be found. All the required data except for the improved quality part is available and this is used to create the example dashboard. Although safety and quality have to be reported somewhere before it can automatically be included in the daily report. In chapter 3 several calculations were performed in Excel. These files are used again to calculate most of the KPIs. Below, an overview of the Excel sheets is given which are used to create a daily report. The names of these sheets are also the names of the corresponding queries which are used to extract the Excel sheets. A relative simple improvement of the data queries needed for the daily report, would be creating a new query with only the necessary information. This way, only one sheet of data is needed for the daily report.



The weekly KPIs which are stated in appendix 10 can not all be calculated at this moment. Financial aspects of the production process have to be filled in and some more calculations have to be performed. But a weekly dashboard is a next step for the company in improving their performance management.

4.3 How can a dashboard for the performance management be built?

In the theory in chapter two, three different dashboards and guidelines for the design of a dashboard are discussed. Below, first the different types of dashboards are discussed, then the design principles are discussed for the case of company X.

In the theory chapter is stated that three different dashboards for three different levels in the organization can be designed. The first is an operational dashboard for workers, such a dashboard could be made somewhere in the production environment but this dashboard is not discussed further in this thesis.

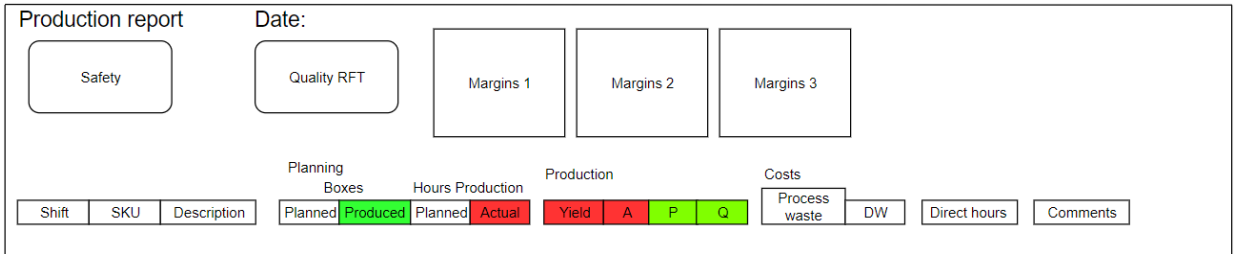
The second dashboard is the tactical dashboard for managers. In the case of company X, this is the daily dashboard. Below, the design and selection of KPIs for this dashboard are discussed.

The third dashboard is the strategic dashboard which could be a weekly dashboard in the case of company X. This dashboard is not designed completely for company X, but the requirements and design rules are set below.

Daily dashboard

The daily dashboard should be divided in the three main parts which are safety, quality and production since these are the three main objectives based on the mission and vision. Safety and quality are the most important parts so these should be placed top left and top center on the dashboard according to the guidelines in the theory chapter. The rest of the report can be filled with production KPIs. The visualization of the KPIs should be as stated in the previous section.

On the current daily report, the WOs are sorted based on the shift. The daily report could have different parts for every production line. Upon opening the daily report, the different lines with its problems can then be seen separately. The first design of the daily dashboard is still ordered based on the shifts. But it is asked whether employees think that ordering on shift or line is clearer. The fact that the first design is still ordered based on the shifts is because the focus is on the KPIs and the places of safety, quality, and production. The production KPIs can all be noted as numbers, it is not necessary to create for example graphs as stated in the previous chapter. The first design principle is shown below which made it possible to discuss the first design with the production manager.



Weekly dashboard:
The goal of this assignment was to design a dashboard for the performance management of the process. But the selection of daily KPIs can best be visualized as raw data. But the daily report can be used as a basis to build a weekly, monthly, or even yearly dashboard of the process. The connections in the KPI tree are companion connections which means that most KPIs can be counted for a weekly value. In the second part of appendix 10 are a lot of KPIs noted that could be placed in such a dashboard. To realize this, the company should report the daily data properly. Then, based on the daily data and some financial aspects that should be included, the dashboard can be built. This dashboard will replace several other reports that are used now. In appendix 2.2, the potential new overview of the process can be seen when such a weekly dashboard is implemented which is less complex than the current situation.

The overall design of the weekly dashboard should be similar to the daily dashboard. In the top left, the safety KPI should be placed. The top center and top right should contain quality and the rest of the dashboard can be filled with KPIs of the production process. For safety, the amount of incidents with and without absenteeism can be counted to get the weekly values. For quality the percentage FTR and the total amount of customer complaints can be placed on the weekly report.

4.4 Which software application is recommended for company X?

The daily report of company X can best be made at this moment using Excel. This is because the daily report does only contain raw values. The cost of Tableau or Qlik Sense is too much for the benefit it might have. Moreover, the employees of the company have knowledge of Excel and can create quite a lot in it. For Tableau, which is the best software application according to the literature review in chapter two, research about a connection with the ERP system should be performed before it can create extra value. The same is the case for a weekly report, not a lot of graphs have to be made and the amount of data is relatively low. But connecting Tableau to the ERP system would be a valuable possibility. Because it can save employees time to create a dashboard daily since a connection with the ERP system will enable Tableau to do this automatically.

5. Implementation

5.1 How can the performance management of company X be improved based on the needs of the company?

The main research question is answered in the last two chapters of this thesis. The company can decide to change their reporting process by using the KPI tree and create the proposed daily report. But before the company can decide on a daily report, several points should be discussed about the current KPIs. It is important that the current KPIs in the company are calculated right and are clear for everyone in the company before an improved daily report can be implemented. That is why an implementation plan with several steps is described below.

1. Simplify the registration for the shift leaders

This recommendation has the highest priority since it is a minor adjustment to the current process but it saves the shift leaders some work every day. This improvement is an automatization of a simple calculation performed by shift leaders. At the end of a shift, the shift leaders have to calculate the amount of hours workers by hand. This is done by multiplying the amount of workers by the production time. Then, the amount of workers, the production time, and the calculated amount of hours workers has to be filled in at AS400. But both these values are available in the query INDPRODP50, thus it can be automated in Excel. Although it has to be noted that this improvement is not necessary for the implementation of the improved daily report.

2. Define WP and WO

Define what should be reported in a WP or a WO. Keeping the WO as actual production and WP as changeovers or corrective maintenance is logical because it gives a clear division between actual production and gaps. But it has to be clear for everyone what this means. This division makes it possible to define the yield as: the effectiveness during the planned production time.

3. Define the losses of Planning, Production, and Quality (section 3.1.3)

<u>Planning:</u>

- Corrective maintenance / Changeovers: Which are the WPs

<u>Production</u>

Two kinds of losses: Which all occur in a WO

- Yield
    - Availability: Includes stops: Extruder stopped for 2 minutes or more. (2 minutes is an example)
    - Performance: Line speed lower/higher than the theoretical speed or stops below 2 minutes occurred that are not reported
    - Quality: Waste %; Division between process waste and waste % should be clear for everyone
- Costs
    - Process waste
    - Differential waste
    - Quality margins

Quality

- Quality should define the specifications when products are blocked. The amount of blocked / scrapped products should then be available every morning.
- This way the percentage FTR can be calculated and put on the daily report

4. Discuss the goal of the yield for a WO and a shift
It should be discussed whether the goal for the yield is correct. This goal will also be used in the daily report.

- If the steps above are performed, the losses with regard to the OEE are divided in two parts. Every part should then have a goal.
    - Planning
    - Yield: the different parts of the yield can also be given a goal

5. Start using the improved daily report
After a relative short time it should be possible to automatically create the improved daily report. But for two KPIs, the company has to agree who is responsible for these and where these are reported. This is the case for safety and quality.

6. Improve the daily morning meeting
The morning meeting in the company is the place where the performance of the last day is discussed. This meeting depends on the selection of KPIs and the final dashboard design. That is why the improvements of the daily meeting are discussed as last in this thesis. The recommendations for the morning meeting can be found in section 7.1 and 7.2.

7. Create a weekly, monthly, or yearly dashboard using Tableau
The last step is to continue working on improving the performance management of company X. The daily report is a good start to create a weekly, monthly, or yearly dashboard. The OEE values with the percentage stops and waste are weekly available. Creating a weekly report and comparing it with the weekly OEE values can be a valuable improvement of the current way of working.

6. Evaluation of the solution

In chapter 5, quite some recommendations are stated which should be discussed by the management of the company. Discussing all these points will not take that much time, and actually implementing changes can be done in a few weeks. After completing the steps regarding the KPIs, the daily report can be improved. Completing the steps will make sure that the KPIs are calculated and defined right. To evaluate the improved daily report, an example report is made

6.1 Creating the example daily report

The first design of the dashboard in section 4.3 made it possible to do a small evaluation with the production manager. The only comment was that the direct hours of employees should be added. Then it was possible to create an example dashboard with real data. It was important that this report was made at the start of a day to make it possible to interview employees with the most recent data. In chapter three, an Excel file was used to calculate the aspects of the yield. This file is used to calculate these for the daily data. An example dashboard was made on 13-6-2019 which included the data for the three shifts of 12-6-2019. This daily report can be seen below. The percentage difference between boxes produced and planned is not shown anymore, but it is indicated with red or green whether it was high enough. Besides this, the planned time for a shift and the actual time of the shift is noted. This shows whether the planned schedule is followed or not. The final selection of KPIs are calculated or copied from other files to create this daily report. But the process waste and differential waste could not be added yet. This is because the process waste is calculated automatically after a work order is closed. Closing a work order means that an employee has checked whether the data in the WO seems correct. The process waste is a part of the calculation of the differential waste, so the differential waste could also not be calculated yet. But the moment that the daily report is automated, the employees would be able to do this before 10 am.

Safety 12-6-2019 LINE 1 LINE 2 LINE 3 FTR FTR FTR

					Planning					Production				Costs				
					Boxes		Hours shift										Direct hours workers	
Day	Shift	Line	SKU	Description	Planned	Produced	Planned	Actual		Yield	A	P	Q	PW	DW			Actual
11/06/19	Night				4524	3960	8											
11/06/19	Morning				616	616	1,1											
11/06/19	Morning				2375	3464	2,2											
12/06/19	Morning				1191	673	4	2,32		87%	97%	97%	93%					56,84
12/06/19	Afternoon				1056	1080	3,1											
12/06/19	Afternoon				1363	704	3,5											
12/06/19	Afternoon				300	300	0,9											
12/06/19	Night				1810	1848	4											
12/06/19	Night				1810	1680	4											
11/06/19	Night				1018	720	8	8		64%	83%	87%	88%					136
12/06/19	Morning				1018	960	8	8		85%	93%	95%	96%					142,25
12/06/19	Afternoon				891	703	7	5,5		90%	99%	98%	93%					97,73
12/06/19	Night				1114	782	7											
11/06/19	Night				4362	5213	6,4	6,95		96%	96%	110%	90%					152,89
11/06/19	Night				600	600	0,9	0,8		96%	100%	101%	95%					17,6
12/06/19	Morning				4975	4592	7,3	6,58		91%	92%	105%	94%					134,89
12/06/19	Afternoon				1363	1124	4	4,22		68%	80%	101%	84%					97,06
12/06/19	Afternoon				1363	1042	4	3,77		68%	85%	96%	84%					
12/06/19	Night				2487	2658	7,3	7,42		92%	100%	95%	97%					133,54
12/06/19	Morning				1680	1954	8											

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6.2 Evaluation of the daily report

To evaluate this daily report a checklist is made with all the changes in comparison with the current daily report. Employees of different departments were questioned using this checklist. It is important to note that only “Escandallo” and KG produced are left of the improved report. The goal was to show the right information on the report without making it too large.

In appendix 15, a table is made which shows all the checklists of the different employees. It can be seen that all employees value including safety and quality on the daily report. The amount of boxes planned, boxes produced, and the indication whether the planned amount is met or not is clear this way. The production hours planned which can be seen beside the amount of actual production hours raised some questions. It was not clear that this was meant to show whether production happened as it was planned. Employees thought that this was an indication of the production hours and the stop time. The yield and its aspects are valued by most employees, but a shift leader mentioned that instead of the availability and quality, the stops in percentage and the waste in percentage is clearer. The process waste and differential waste were interesting according to the managers and planning even though the values were not available this day. Asking about the direct hours resulted in questions like: “what does this value indicate?” It became clear that employees only valued this KPI in comparison with the planned amount of hours. At last employees were asked whether they wanted to see the WOs in order of the shifts or per line. Almost all employees mentioned that per line would be better. A remark was that the KG produced could be interesting for comparison with KGs in the comments.

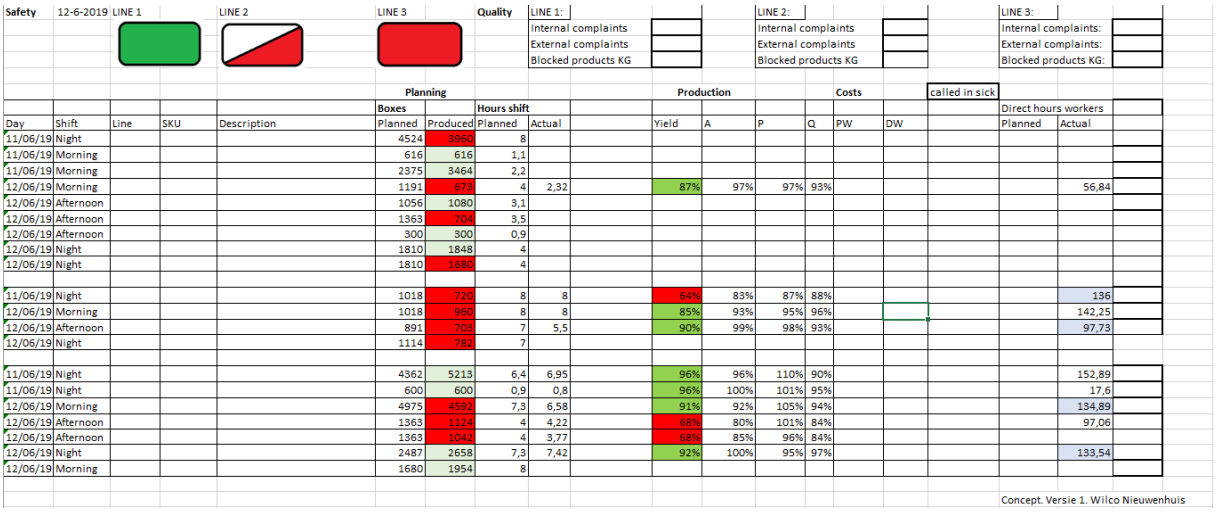
The quality manager mentioned that the daily report until now was never interesting for anyone of quality except for some comments. But safety is important for everyone in the company, and adding quality to the daily report would be a good improvement. But the manager did not think that it was possible to realize a first time right KPI on short notice. This is due the fact that a lot of margins are still based on opinions like when is the color right, or when is a donut oval? And these points are discussed by the management during the day. So it is not possible to put values of this on a daily report before 10 am.

That is why it was suggested to put three values for every production line on the daily report which are the internal complaints, external complaints, and the amount of blocked products in KG. Products which might not meet the quality standard can be blocked during all the shifts, and these blocked products are discussed in the management during the day. The amount of blocked products can also be noted on the production board, and after the management decides on for example colors, or shapes, the products can either be scrapped or released. These three KPIs were discussed with the production manager, and he thought that these are good for the daily report.

Besides the answers based on the checklists, all the employees gave their opinion about the dashboard. All the employees think that the dashboard is quite clear and asked when it will be implemented. The employee responsible for creating the daily report asked whether he had to start building the automatic version of this report. Overall the employees think that working with the improved dashboard has a lot of value and they want to implement it soon. Although the report contains more values than before, the employees mentioned that it is not too complex and it is easy to understand.

6.3 Final version of daily report

Based on the evaluation, some changes should be made to finalize the dashboard. Quality can be shown based on the three KPIs which were suggested by the quality manager although it is still recommended to the company to improve the Quality KPI tree. The WOs in the report should be ordered per line and the actual and planned production hours should be renamed in planned shift time and actual shift time. The yield will be stated with its aspects and not with the waste and stops in percentage. This is done since most employees preferred this. The last change in comparison with last version is that the planned hours of workers is added to the report. The final version of the report can be seen below. Since the calculations are already defined in Excel, the company can quite easily make an automatic version of the daily report.



Safety	12-6-2019	LINE 1		LINE 2	LINE 3		Quality	LINE 1:			LINE 2:			LINE 3:		
								Internal complaints			Internal complaints			Internal complaints:		
								External complaints			External complaints			External complaints:		
								Blocked products KG			Blocked products KG			Blocked products KG:		
					Planning					Production			Costs		called in sick	
					Boxes		Hours shift									Direct hours workers	
Day	Shift	Line	SKU	Description	Planned	Produced	Planned	Actual		Yield	A	P	Q	PW	DW	Planned	Actual
11/06/19	Night				4524	3960	8										
11/06/19	Morning				616	616	1,1										
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12/06/19	Morning				1018	960	8	8		85%	93%	95%	96%				142,25
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12/06/19	Morning				1680	1954	8										
																Concept. Versie 1. Wilco Nieuwenhuis	

After the evaluation with all the different employees, the final design was shown to the production manager. He had only two remarks and the first one is that he missed the amount of people that called in sick. That is why this KPI is added in the daily report. The second remark was that he missed the WPs. On an average day there are only a few WPs so these can be added on the daily report without making it larger than one page. This also enables the company to add all the WPs with its hours for a weekly overview.

Besides these two remarks, the opinion of the production manager was really positive. This is because he thinks that the daily report gives a lot of useful information, there is an opportunity to create a similar weekly dashboard, and the reporting process becomes a lot clearer. That is why the production manager mentioned that the improved report will actually be implemented. Furthermore, since the report can replace several other reports, the improved report will save quite some time daily.

7. The morning meeting

7.1 Is the current methodology of the morning meetings the same as a meeting described in literature about Daily Scrum Meetings?

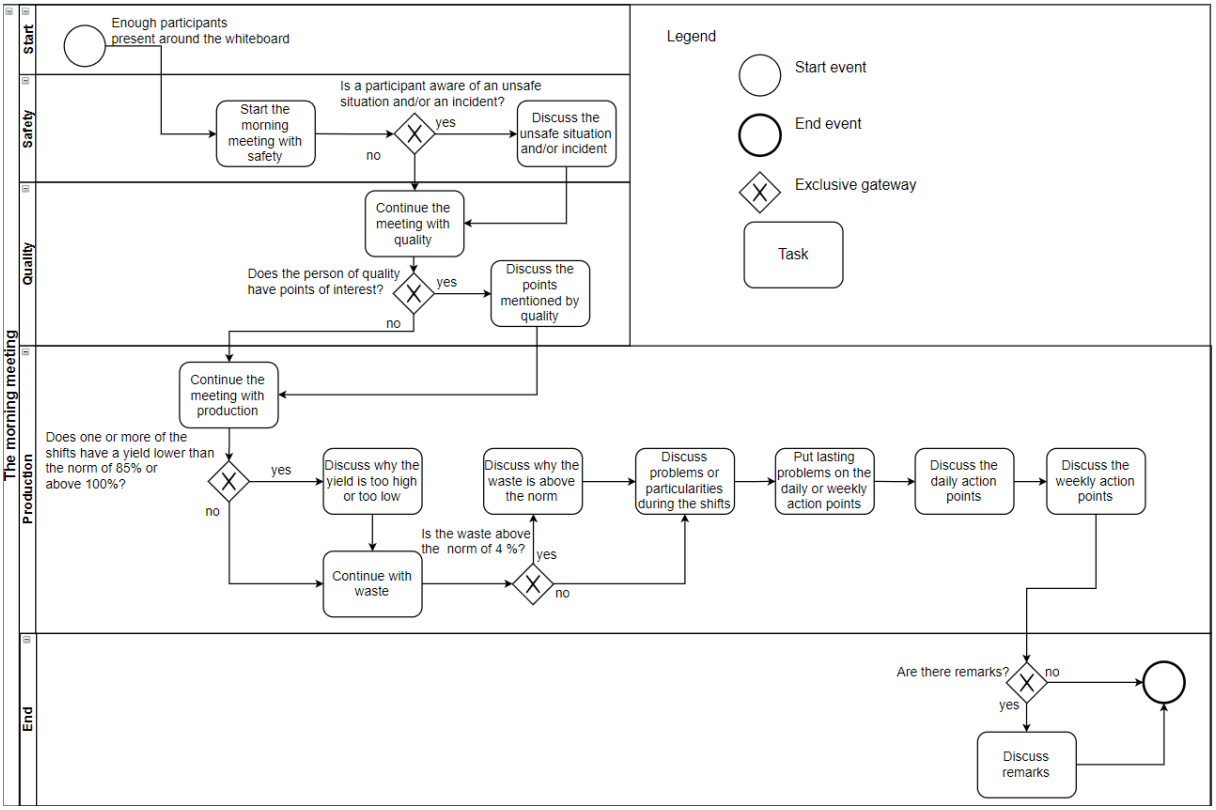
To answer this question, in theory chapter two the process of a daily scrum meeting with mistakes often made is described. To find out whether company X makes the same mistakes, observations are performed and the current situation is described. Based on the observations, a comparison with literature is made. After the comparison with literature follows a small conclusion.

Meetings now

Every morning, at every production line, a meeting takes place. These meetings happen while standing around a whiteboard, close to the particular line. Since the same employees attend all the three meetings, the meetings happen one after the other. The order is due to the fact that starting at the office, the lines are numbered 2 – 1 – 3. In the problem identification phase, it was already chosen to choose the Daily Scrum Meeting to compare this meeting to. The meeting was observed ten times and the main reason to choose DSM is because the participants stand around a whiteboard during the meeting. In total, the meetings were observed 40 times. The notes of these observations are stated in appendix 16. In the BPMN model below, the current process of the morning meeting is described. In the legend, the four used elements are shown.

The process of the morning meeting is divided in five different parts. The same participants are present during all the parts of the meeting, but the different parts are the different subjects discussed during the meeting. The different subjects during the meeting are important for employees of several divisions.

The current meeting starts when enough people seem to be present. For safety, there is not a certain person responsible for this. The second part of the meeting, quality, does not have clear KPIs that are reported. The third part of the meeting, production, consists of several KPIs.



Amount of people present.
A certain group of people attends all the three DSMs if they are able to. It could happen that for example a stop at a production line is more important at that moment for an employee, simply because stops cost a lot of money. The group attending all the meetings consists of: 3x management, 1x planning, 1x education, 2x technical, and 1x quality. Besides this group, at every different DSM the shift leader responsible for a certain production line attends his lines meeting so the total amount is around nine employees. But it was observed that that several times even 10 to 13 people attended the meeting.

7.1.1 Discussion of the theory based on the observations

In the theory chapter is stated that four characteristics negatively affect DSM attitude namely: too high frequency, having the meeting at a disruptive time, not starting promptly, and too long duration. Based on the observations of the meetings, it is discussed whether company X's way of working includes one or more of these characteristics.

Too high frequency
The first characteristic, too high frequency is not a problem at company X. Line meetings are only held if the line produced the day before the meeting. If this is the case, three shifts with their problems or particularities can be discussed, which is always relevant. Some points are already discussed outside the meetings, this is not a problem since meetings are not the only way of communication. It is even the case that employees should note some problems directly to for example the management and do not wait until the next meeting. This should be done if problems at a production line are hard to solve and may result in high costs.

Disruptive time
The second characteristic, having the meeting at a disruptive time, is not a problem either. It is advised in the theory chapter that the meeting is held in the morning which is the case. The meetings are always planned at 10 am and the employees plan other tasks around them. Employees could be interviewed to get a better understanding whether the time of the meeting is disruptive, but the fact that this is different every day makes this quite hard. Interviewing all these people is also not possible in the time frame of this project and it is also not the focus so this is not done.

Not starting promptly
For the third characteristic, not starting promptly, no rules exist at this moment. It is important to make guidelines for this since a lot of people have to wait if the meeting does not start promptly which happened several times. Besides this waste of time, employees might get frustrated because they have to wait. Frustration can also be caused because the overall time of the DSMs becomes too long, but this is discussed in the fourth characteristic.

Too long duration
The fourth characteristic, too long duration is a problem at company X. In the theory chapter is stated that a DSM meeting should take no more than 15 minutes. Multiplying this time of 15 minutes by three, since three meetings takes place every day, is not right. But a total of 15 minutes for three meetings is not possible since a lot of problems just have to be addressed. A maximum of 10 minutes for one meeting should be possible and the production manager thinks that this is possible. Less than ten minutes, if possible, would even be more ideal but this also depends on the amount of problems during the last three shifts.

Conclusion
First of all, the amount of people attending the meeting is often too much. Secondly, of the four characteristics above, both not starting promptly and too long duration are a problem at company X. That is why guidelines for these points are made in the next section.

7.2 How can the current way of working of the morning meeting be improved?

Based on the discussion of literature in the previous section a list of guidelines to improve the morning meetings is made. Then, based on the needs of the company, the needs for the morning meeting are defined. The needs for the morning meeting are basically the same as the final selection of KPIs. These needs indicate what should be discussed during the meeting. Until the end of the project, the morning meeting was observed whenever possible. This helped with finalizing the guidelines and it sometimes gave new insights.

Advice on the number of participants
Less people attending the meeting, can make the DSM more effective as stated in the theory chapter, and it reduces the total amount of hours put in the meeting. It can cost an employee 30 minutes to an hour every morning so guidelines should be made with regard to who participates. According to the theory in chapter two it has to be taken into account that all viewpoints in the company should be present. But the amount of people should be as low as possible. The sum of the people that should attend all the meetings is nine people. More or less than this amount should only happen with a reason. Based on the structure of the morning meeting which is made in 7.2.1. the amount of people present might be decreased.

Guidelines for the time of the meeting
To make it possible to spent no longer than 10 minutes, some guidelines are made:

- The daily report should be available before the DSM. That is why the data of the last three shifts has to be filled in before 9 am by the shift leaders. After that, the person responsible for creating the daily report has till 9.30 am to do this.
- Only points that are relevant for most people in the meeting should be discussed, other points can be discussed outside the meeting
- Only show pictures if these are necessary and clear for everyone
- In general, do not postpone meetings if someone is not present. Start at 10 am.
- Problems during the shift are discussed, but these should not be discussed in detail. Lasting problems can be addressed to a person and set on the daily or weekly tasks.
- The daily and weekly points should only be discussed if the date is of the present day. The discussion of the these points should not be in detail. If it is necessary to set a new date, do not do this too optimistically since this will result in discussing the same point every day. Some points should be set to a later day, this can be done with a short explanation or even without an explanation. Trust that employees are working on the points, not everyone needs to know every detail of every problem.

7.2.1 The needs of the morning meeting

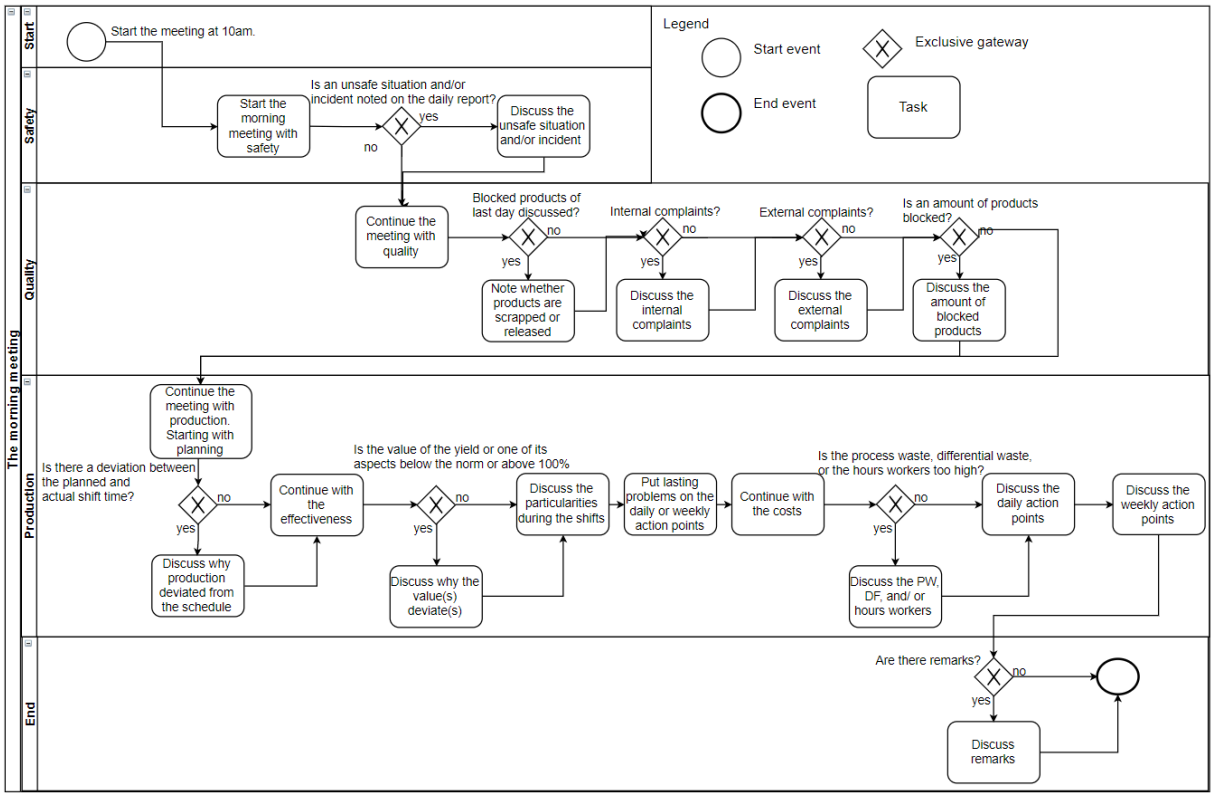
Based on the design of the dashboard with the selection of KPIs. An improved process for the morning meeting is made below.

The first change with the current situation is the starting time of the first meeting. The first meeting should start at 10 am and the second and third meeting should follow without waiting around. The second change is that safety is noted on the daily report which is possible after the company assigned who is responsible for this.

The third change is the quality part of the meeting, the three KPIs on the daily report can be discussed if these are reported correct every day. The internal complaints can be mentioned shortly, external complaints should be discussed but these almost never occur. The third part of quality, the blocked products, should be mentioned with the reason and written down on the production board. After the management has decided what to do with the blocked products, this can be discussed. The earliest moment for this, would be the next day if the management actually discussed the blocked products. That is why quality can be started with the blocked products of the previous day, if this was the case. Then, for the amount of blocked products of the previous day, it can be written down whether these are released or scrapped.

The production part of the process has several changes based on the selection of KPIs. Based on the values of the KPIs on the report, these KPIs can be discussed. The shift time, yield, and hours workers already have norms. But for the aspects of the yield, the process waste, and differential waste should be decided what the norm is.

The BPMN model gives insight in the process of the morning meeting. All the employees can easily understand the order of the meeting and the different steps. And this gives the possibility to discuss over time whether all the steps are still important enough to discuss.



8. Conclusion

Conclusion

The conclusion of this research is that the performance management of company X can be improved based on the needs of the company by using the KPI tree, implementing the proposed dashboard, and changing to process of the morning meeting. Furthermore, there are possibilities to increase the performance management even more.

Defining all the files used in the company, gave the first insights in the performance management. The KPI tree makes it possible to explain how the KPIs in the company are related. It can be explained to all employees which KPIs they can influence and what the effect of this is on achieving the mission and vision.

The designed dashboard shows the best possible selection of KPIs at this moment. The KPIs for quality are advised to be made even more specific, but the proposed three KPIs are already an improvement. The safety and production KPIs are valuable since these give more insight in the last three shifts. The company will actually implement the dashboard, which is possible since all the data and calculations are available.

Based on the discussion of the theory of DSMs and the KPI tree in combination with the final dashboard, the process of the morning meeting is improved. The discussion of theory resulted in a list of guidelines to reduce the duration of the morning meeting and the amount of people present. Both the current process and the improved process are described using BPMN.

The daily dashboard reduces the amount of files used in the company. Furthermore, the daily dashboard is a basis for a weekly, monthly, or even yearly dashboard if the data is reported correctly. This weekly dashboard will also decrease the amount of files used in the company. The decrease in the amount of files, which is the decrease in complexity can be seen in the difference between appendix 2.1 and 2.2. The BPMN model of the improved morning meeting gives the possibility to discuss the process with all employees present. This way the process can easily be explained and it can be discussed whether changes should be made. This research is the starting point to increase the performance management even more. The process is defined and the first improvements are stated.

Recommendations for the company

Before the company can start using the KPI tree, the improved daily report, and the improved process for the morning meeting. Several steps have to be completed first.

Before the improved dashboard can be used, the following steps have to be performed.

- Make sure that the distinction between work orders and work products is clear
- Define the losses in the production process
- Discuss the goal of the yield for work orders and shifts
    - Discuss the goals for the aspects of the yield

After completing these steps, the improved daily dashboard can be used, and the company can improve the morning meeting. This consists of discussing the guidelines and structure the meeting as shown in the BPMN model.

The next step after improving the process of the morning meeting is working on a weekly, monthly or yearly report.

Future research
Based on the daily report, a weekly report can be designed. The overall design rules for this report are stated in section 4.3. But further research has to be performed on the selection of KPIs for the weekly report and the way these are visualized. The KPI tree can be used to choose the right selection of KPIs.

Another research that follows out of this thesis, is whether Tableau is suitable for the daily and weekly report. It might be possible to connect Tableau to the ERP system which would make it possible to always have the most recent dashboard available automatically.

Discussion
This research resulted in several conclusions about for example the measurement of quality. Even though that a KPI as real time as possible is advised, the company can not implement that in a relative short time. That is why, the final dashboard contains quality KPIs which are realistic in a short time span. This way, the company can actually use the result and work towards the recommended KPIs. Overall the recommendations follow as a logical conclusion from the research, but sometimes this had to be changed in order to provide practical value in a realistic time span.

It was hard to find proper articles and proper examples of KPI trees, although the production manager of the company mentioned that KPI trees are used widely. On internet, several companies provide classes to build KPI trees. If the production manager is right, it can be the case that other companies build KPI trees with the help of consulting companies. Further, examples online tend to place all kind of measurements or statements in KPI trees. This can be an easy way of improving your performance management, but this is not how it should be performed while performing scientific research.

The final design of a dashboard is not really a dashboard. An actual dashboard contains visualizations like graphs or diagrams. But for the selection of KPIs, it was not necessary to make these. An actual dashboard can be made for a potential weekly, monthly or yearly dashboard.

Limitations
The amount of time available for this research was a limitation. An evaluation of the dashboard was performed, but the dashboard had to be changed after that. This final dashboard design should have been evaluated and then implemented in the company. Although the company has the means to do this, these last steps are quite valuable.

The data implementation method for the morning meetings could have been more structured. Observations are performed in which notes are made. But this is not a structured method. If for example a list was made with different points that had to be observed, it would have been possible to quantify these points and conclude on that. This list could have been made based on theory of DSM in chapter two. Points for this research could have been for example: starting time, amount of people, and duration of the meetings.

Another limitation is the sample size of the interviews, managers and employees with different responsibilities are interviewed. But this resulted in interviewing only one person for quality, supply chain, and planning since these managers are the only ones working on these parts. So no comparison could be made between employees of the same department.

Furthermore, not all the shift leaders could be interviewed due to time constraints and their working times. The shift leaders work in three shifts which made it hard to interview all of them in a short time span. But a sample of five shift leaders is taken to assess their opinion. This seemed reasonable

because the shift leaders all have the same responsibilities and five is halve of the total amount of ten which is quite a lot.

Contributions to theory

This research structured an unclear performance management process by using a KPI tree. There are not a lot of studies available on KPI trees. This research proves that for the case of company X, this method is a clear way to structure KPIs. Theory in articles claimed that the KPI tree is easy to understand, which is confirmed in this research. Employees were able to understand the KPI tree with minimal explanation. Although it has to be noted that for the KPI tree of company X only one type of link is used.

If a company wants to structure their performance management, the approach of this research can be used. It can be started with defining all the reports that are made. Then finding all the KPIs and structure these in a KPI tree. Then based on the KPI tree, dashboards for the process can be defined.

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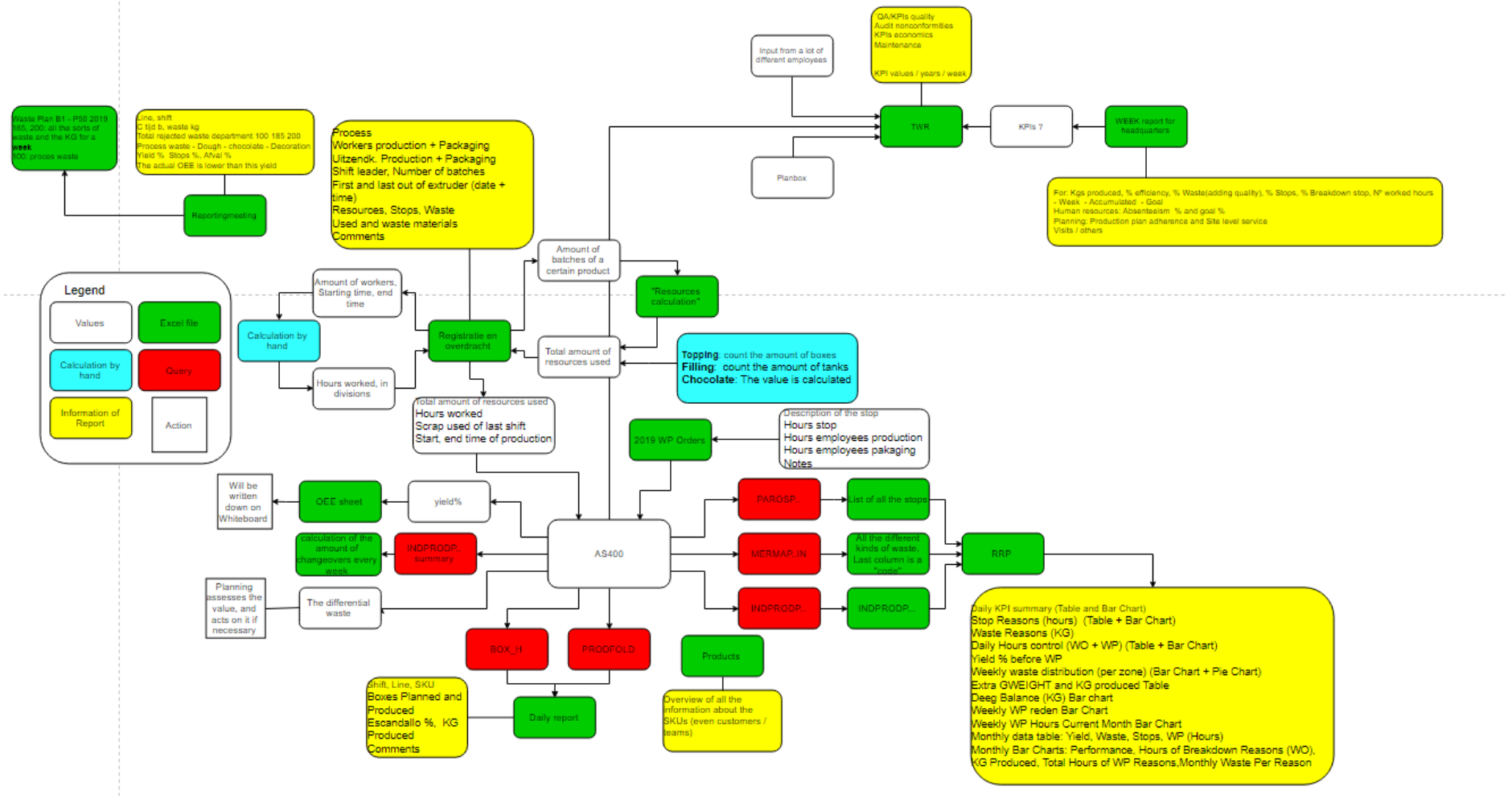
Appendix

Appendix 1. List of cleaned up problems

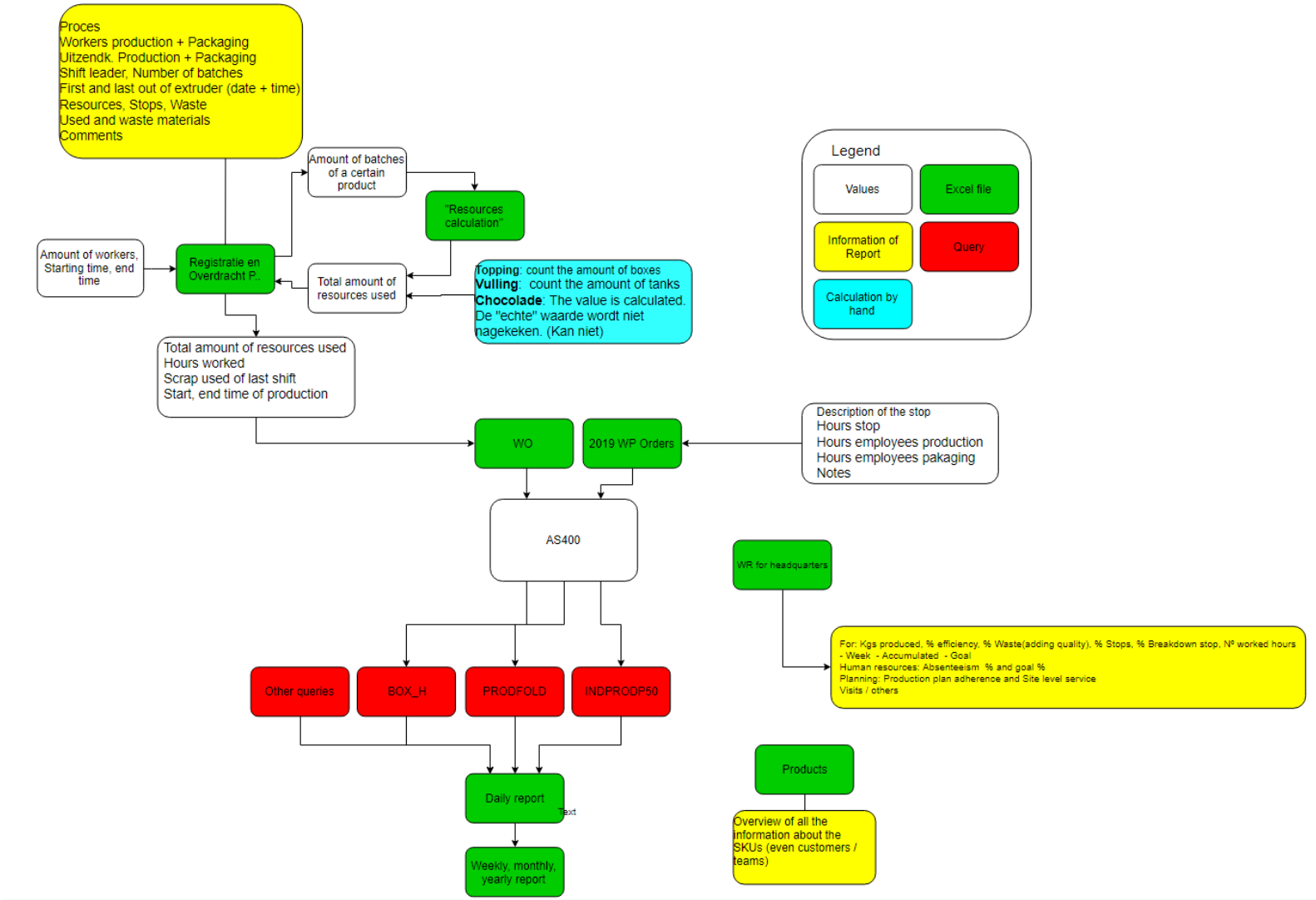
- Are the current KPIs to manage the performance of the production process defined clearly?
- Are the current KPIs enough to manage the performance of the production process?
- Can the shift leaders steer the production process based on the current KPIs?
- Can the management steer the production process based on the current KPIs?
- Is real time or daily visualization of the KPIs of the performance of the production process possible?

Appendix 2. Diagram of the process

2.1 Current process



2.2 Potential new process



Appendix 3. Formulas to calculate OEE, Availability, Quality, Performance

OEE

1. Availability x Performance x Quality
2. (Good count x Ideal cycle time) / Planned production time

Availability

1. Runtime / Planned production time
    - Runtime = Planned production time - Stop time
2. (Loading time – Downtime) / Loading time
3. (Planned production time – Unplanned downtime) / Planned production time

Performance

1. (Ideal cycle time x Total count) / Ideal run rate
2. (Ideal cycle time x Output) / Operating time
3. Actual amount of production / Planned amount of production

Quality

1. Good count / Total count
2. (Input – Volume of quality defects) / Input
3. (Actual amount of production – Non accepted amount) / Actual amount

Appendix 4. Calculation 1; Yield calculation for a Work Order

Yield % = Availability x Performance x Quality

Availability = (Planned production time – Unplanned downtime(stops)) / Planned production time
Performance = Boxes + (waste total / KG/box) / Planned amount of production

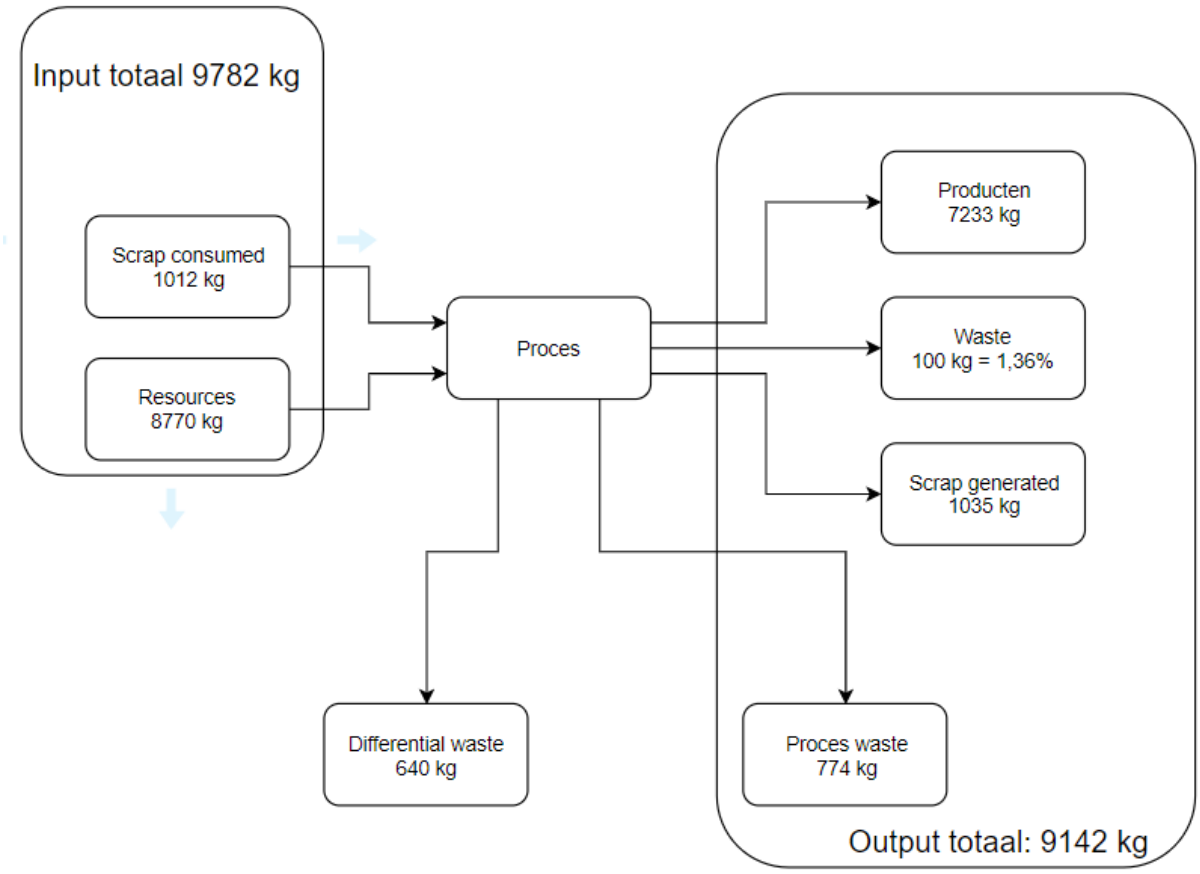
- Waste total:
    - Dough waste
    - Breakdown waste
    - Finished product waste
    - Quality waste

    - Planned amount of production = hours production x Box per hours max
    - KG/box = KG per hours / Box per hours

Quality: = (actual amount of production - non accepted amount)/ Actual amount of production

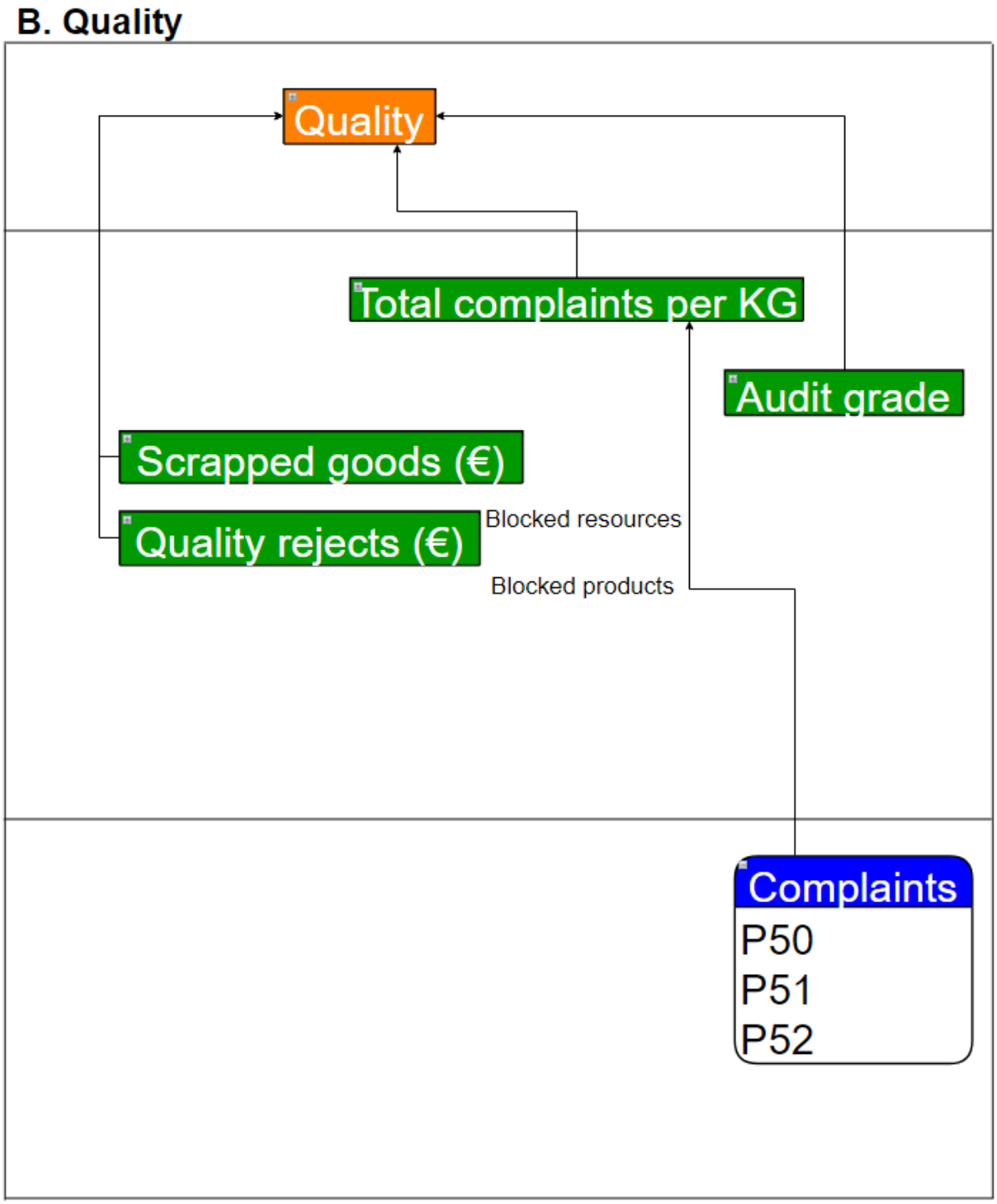
- Actual amount of production = KG + Waste total

Appendix 5. Differential waste

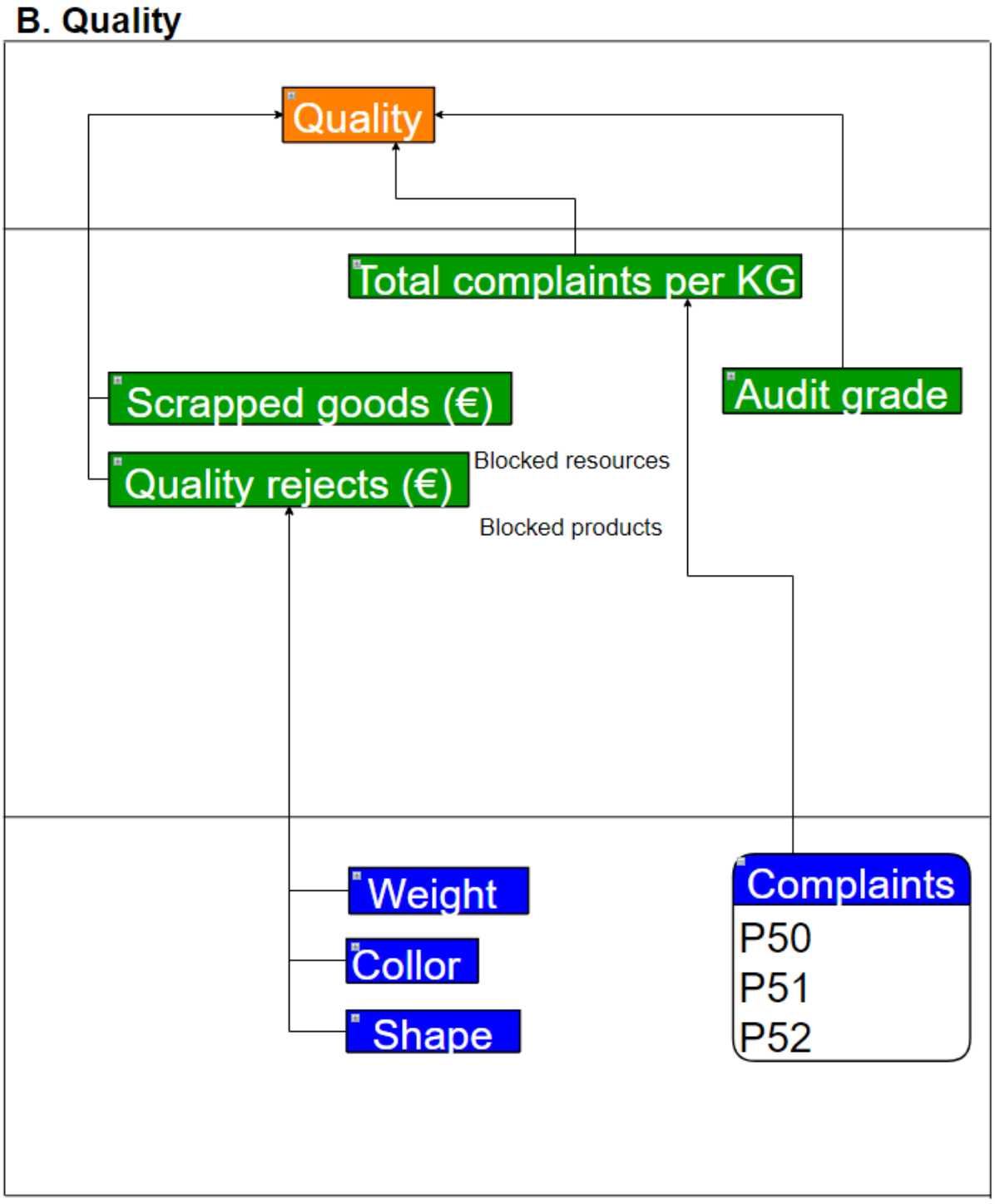


Appendix 7. KPI tree quality

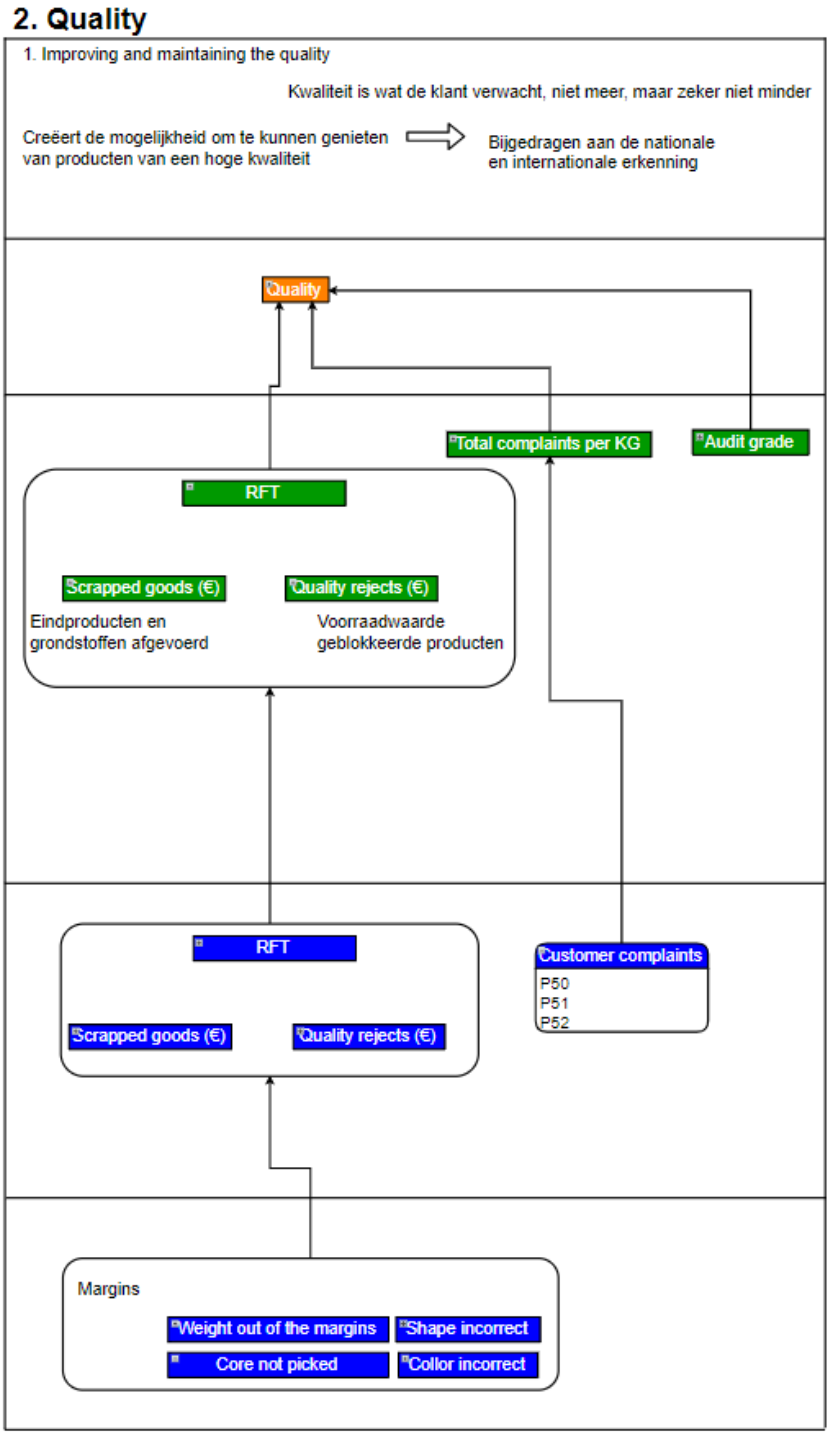
Appendix 7.1 Quality 1



Appendix 7.2 quality 2



Appendix 7.3 quality 3



Appendix 8. KPIs available to manage the performance of a production process

Below the three sources are worked out in three lists.

Seven common KPIs for production monitoring (RedLion, 2015) **A**

- Count (since last machine changeover, entire shift, or entire week)
- Reject ratio
- Rate (speed)
- Target (output, rate, quality)
- Takt time (cycle time of a task)
- OEE (a metric that multiplies availability by performance and quality to determine resource utilization
- Downtime (breakdown, machine changeover, anything)

KPIs in production and manufacturing (PLANETTOGETHER, n.d.) **B**

Five common KPIs in production and manufacturing

- Downtime (breakdown, maintenance, anything)
- Takt time (task fulfillment)
- Rate (production speed)
- Ratio rejection
- OEE; multiplying availability and performance, this determines the amount of resources that are being utilized effectively.

Nine important KPIs to measure on the production floor (Acharya Nikhil, 2018) **C**

- Goods count/Actual production
- Availability %; the ratio of operating time to planned production time
- Performance %; the percentage of actual output out of the expected outcome of the planned production
- Quality %; the percentage of goods count out of the actual production count for the products
- OEE; Availability x Performance x Quality
- Behind plan; what percentage of actual production is less than the expected quantity with this, a floor supervisor can monitor how much the floor is lagging in meeting their target
- Manufacturing cycle time
- Throughput
- Downtime

There are 16 metrics specific to the production area(José Roberto Ferro, 2018). No definitions are given in this source, that is why the KPIs are only stated in column **D** of the table below.

The KPIs of the different sources have some overlap. To make a complete list of all the different KPIs, a table is made. The columns A, B, C, and D indicate which column refers to which list above.

A	**B**	**C**	**D**
Count x		Goods count/actual production	Production volume
Reject ratio x	Ratio rejection	Quality (the percentage of goods count out of the actual production count)	Deliveries
Rate	Rate		Turnover
Target (output, quality) x			Cost
Takt time (cycle time) x	Takt time	Manufacturing cycle time	
OEE(availability x performance x quality) x	OEE (Availability x Performance); which is remarkable	OEE (Availability x Performance x Quality)	
Downtime x	Downtime	Downtime	Defects
		Throughput	
		Availability (the ratio of operating time to planned production time)	x
		Behind plan (what percentage of actual production is less than the expected quantity)	Delayed quantity
		Performance (percentage of actual output out of the expected outcome of the planned production)	x
			Scrap x
			Corrective maintenance

			Storage days
			WIP
			On-time delivery
			Stock outs
			Overtime x
			Absenteeism x
			Health, safety and environment x

Appendix 9. Checklists to find the preferred KPIs

Appendix 9.1 summary of the results

Table 1: Current KPIs:

"Group"	Boxes Planned	Boxes Produced	Escandallo %	Produced KG	Comments
Shift leaders	x	x	x	x	X This one seems to be the most important for them
Management	x	x			x
Quality					x
Supply chain	x	x	x		x

Appendix 12. Table 2: Potential KPIs

"Group"	Absenteeism	H, S, E (safety)	OEE	Availability	Performance	Quality	Waste %	Differential Waste KG
Shift leaders	x	x	x	x	x	x	x	
Management	x	x	x	x	x	x	x	
Quality								
Supply chain	x	x	x	x	x	x	x	x

9.2 The results

Current KPIs

Employee	Boxes Planned	Boxes Produced	Escandallo %	Produced KG	Comments
Production Manager	x	x			x
Packaging Manager	x	x	x		x
Line Manager					
Training coordinator					x
Planning:	x	x			x
SL:					x
SL:					
SL:	x	x			x
SL:	x	x	x	x	x
SL:	x	x	x		x
Quality manager					
Supply chain manager	x	x	x		x

SL = Shift leader

Potential KPIs:

Employee	Absenteeism	H, S, E (safety)	OEE	Availability	Performance	Quality	Waste %	Differential Waste KG
Production Manager	x	x	x	x	x	x	x	x
Packaging Manager	x	x	x	x	x	x	x	
Line Manager	planbox			x	x	x		
Training coordinator		x	x	x	x	x	x	
Planning:		safety	x		x	x	x	x
SL:		x	x	x	x	x	x	
SL:								
SL:	Observes own shift		evt	evt	evt	evt	x	
SL:			x	x	x	x	Zit bij quality in	x
SL:			x	x	x	x	x	
Quality manager								
Supply chain manager	x	x	x	x	x	x	x	X he cant see this one now.

SL = shift leader

Appendix 10. Selection of KPIs with the required data.

10.1 The list of KPIs for the daily report:

Safety: incident yes or no

- With or without absenteeism Production manager and or shift leader knows this

Metal detection performed properly? Quality checks this

Quality: FTR: in combination with margins of products Not available yet

Product development:

Planning These can all be found in the ERP system

- Hours production planned
- Hours production actual
- Boxes planned
- Boxes produced
- Escandallo % Can also be shown as a color, red = wrong green = good
    - The Escandallo column in the original daily report showed the percentage difference between the planned and the actual produced amount of boxes of a shift.
- Corrective maintenance / changeovers

Effectiveness

- Yield Available in INDPRODP50
    - Availability The three parts can be calculated
    - Performance
    - Quality

Costs

- Direct
    - Direct hours can be found in INDPRODP50
    - Margins which are same as quality
- Indirect
    - Process waste INDPRODP50
    - Differential waste AS400

10.2 The list of KPIs for a weekly report:
Safety:

- Total amount of incidents
    - With absenteeism
    - Without absenteeism
- Metal detection per box performed?

Quality: A weekly FTR

- Total amount of scrapped goods / quality rejects
    - Divided with its different reasons.
- Total complaints
- Audit grade

Product development:

Planning

- Actual machine hours: Sum of the hours shift
- KG produced: The KG produced could be reported. Is available in INDPRODP50
- Utilization rate: Calculate based on machine hours, WP orders, total time
- Line OEE Weekly calculations with the total time
- Plant OEE Weekly calculations with the total time
- Direct resources Can be reported by adding the resources of all the shifts
- Total logistics hours
- Hours allowed Can be added to a report
- Process waste Daily values can be added
- Differential waste Daily values can be added
- Changeovers Daily amounts can be added
- Waste total Daily amounts can be added
- Tests R&D Daily amounts can be added

All the KPIs above are important for production. The KPIs below can only be calculated if some financial numbers are added in the reporting.

- Conversion costs / kg
- KG production vs machine hours
- Actual machine hours
- Total indirect costs
- Total maintenance costs
- Maintenance costs parts
- Maintenance costs hired
- Cleaning costs
- Total indirect hours
- Illness hours
- Illness rate
- Material loss per line

Effectiveness

- Yield can be added for a weekly average
    - Availability
    - Performance
    - Quality

The weekly OEE can be calculated by the ERP system. But the FTR is not taken of that OEE.

Costs

- Direct
    - Direct hours
    - Margins which are same as quality
- Indirect
    - Process waste
    - Differential waste

Appendix 11. Systematic literature review

11.1 Which software applications can be used to build a dashboard?

Nowadays there are a lot of software applications to build dashboards. To give this systematic literature study a proper scope, some first research is done. The needs and resources of the company have to be taken into consideration. A lot of free software applications require a lot of coding which is something that has to be taken into account. Thus the first criteria for the application is that not a lot of code is required so that the company can actually use the result of this research. This is why the focus of this systematic literature research is on the following three software applications.

- Excel dashboard
- Qlik sense
- Tableau

11.2 Defining the inclusion and exclusion criteria

Inclusion criteria:

- The use of programs to build dashboards is a pretty recent development. That is why, if it is possible, only literature from 2014 till now will be used. Although Excel is a program in which dashboards are made for a relatively longer period.
- Only English articles

Exclusion criteria

- Reviews
- Editorials

11.3 The database Google Scholar

The UT library shows several databases, the database that will be used for this systematic literature review is google scholar.

11.4 The search terms and the used strategy

To find information about the three different programs to create a dashboard, articles about all the different programs will be searched for. A dashboard is a single-screen display that shows this important information about a company so that the whole situation, for example in a (Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013)(Jim Wright, 2013) factory or on a production line, can quickly be understood. Excel, tableau, and Qlik sense are all programs in which dashboards can be made. Every program has of course it specifications and pros/cons. These have to be assessed to find out which program is appropriate. In this review, only the technical aspects of the applications will be assessed.

Things like, who will use the program, does the program have to be updated by someone in the company, and how much data can be processed will be taken in consideration at the end of this project.

The first step of the strategy is that the articles are sorted on date. Out of all the articles, the ones which define the program and might give indications for pros and cons of the programs are viewed further. With this is meant that the abstract part of the article will be read, if the article still seems valuable, the text will be scanned for a view minutes. Articles that still seem interesting then, will be put in the list.

search terms:

1. Microsoft Excel dashboard
    - Excel dashboard
2. Tableau dashboard
    - Tableau dashboard software
    - Tableau dashboard application
3. Qlik sense dashboard
    - Qlik Sense dashboard software
    - Qlik Sense dashboard application

11.5 The final set of articles

a. http://www.tabpi.org/2012/htah1.pdf Dashboard your scorecard; how can you design a dashboard with minimal effort in Microsoft Excel.
b. file:///C:/Users/wilco%20nieuwenhuis/Downloads/1128-2692-1-PB.pdf Tableau vs D3.js (also says something about Qlik Sense)
c. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7460347 Is about several programs including Qlik sense and tableau. Ends with a Tableau example
d. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4816475/ Some general information about Tableau
e. https://uhdspace.uhasselt.be/dspace/bitstream/1942/19293/1/13358962014836.pdf Compares Tableau and Qlik sense
f. https://www.theseus.fi/bitstream/handle/10024/101838/QlikView_Thesis.pdf?sequence=1&isAllowed=y Information about Qlik Sense and the data that should be used

11.6 Concepts
Evaluation of quality of studies

1. This article is based on one case example in which a dashboard is made and it is not clear whether it this easy in other situations. Furthermore, this article is not based on other knowledge, which results in the conclusion that this is not a very strong study.
2. In this article, the proprietary tool Tableau and the open source tool D3.js are compared. A lot of references are used and the same experiment is done with the two different programs. Which makes it a quite strong article.
3. This article is built on the basis of a lot of information of the different programs that are compared. A lot of references are used for this. Which gives an indication of a quite strong article.
4. This is an article of Tableau itself, it states specifications of the program and it gives information about free and paid versions.
5. The article has a clear research objective and methodology, in which several theoretical approaches are used. What is negative about the article is that it is from 2014, a lot of changes happened with Qlik Sense and Tableau since then.
6. This article compares commonly known data management processes and compares them to QlikView which is a forerunner of Qlik Sense.

Tableau, Qlik Sense, and Excel

Proprietary tools like tableau and Qlik Sense offer customer support but tend to be expensive compared to open source tools. (Nair, Shetty, & Shetty, 2016) Another way to categorize tools is on the basis of whether they are drag and drop type or whether coding is required for creating visualizations. Most of the proprietary visualization tools are drag and drop type, which requires no

coding. Hence it is easy to learn and visualizations can be created in minutes, but the drawback is that out-of-box visualizations are not possible. In most of the open source tools, the coding is done in Java. Microsoft Excel is another sort of program, which has VBA as coding language. The Tableau method of importing data is more intuitive and easier to operate than the data load features in Qlik Sense.(Li, 2014)

Excel

Most enterprise systems provide dashboards that decision makers can easily customize to fit their specific needs. (Mark W.Lehman, Caral M.Lehman, & Jim Feazell, 2011) But at company X, this is not the case. A lot of data here is extracted from the ERP system and then processed using Excel. In the article "Dashboard Your Scorecard" it is explained how you can design your own dashboard with minimal time and effort. This process build on lists of data in Excel, which is set in a table. With the use of several functions it is explained how the data can be visualized in a dashboard. The last section of the article defines how the dashboard can be updated. The moment that new information is inserted, only a view clicks are needed to refresh the dashboard with the new data. Furthermore, performing visual analytics on big data involving millions of records is hard to achieve using traditional tools like Excel as the complexity of big data demands new visualization tools or enhancements in existing tools to handle the same data.(Nair et al., 2016)

Tableau

Tableau is a highly preferred tool with a drag and drop nature. It offers a wide variety of options with which informative dashboards can be created instantly from diverse datasets. It can connect with data stored in Excel, csv and text files and recognize fields and formats. Although it might be the case that data has to be connected. Tableau can handle millions of records where Excel fails. A con is that it can only do simple data manipulations with the usage of mathematical formulas like the ones used in Excel. Anyone can analyze data with Tableau's intuitive drag & drop products. (Gounder, Iyer, & Mazyad, 2016) Connecting and visualizing your data in minutes, Tableau is 10 to 100x faster than existing solutions which is why business analysts choose this tool. This is also why Tableau has grown so popular, the drag and drop interface is relatively simple to use; therefore, users without any programming knowledge can easily manipulate data to create a wide variety of interactive visualizations.(Elizabeth Connor, 2016) The two editions of Tableau, the professional and personal edition, both support Excel formats of data sources. In Excel it is possible to track counts over time, but with Tableau it is possible to make a robust chart which would allow to apply a variety of filters (such as time of day, or collection area) for deeper analysis. A feature of Tableau is the possibility to create an electronic presentation that enables readers to navigate through distinct views of the data presented. It is important to remember that for the free version, all files are saved to a user's profile on the Tableau Public website, where they are accessible to anyone with the uniform resource locator (URL).(Elizabeth Connor, 2016) Tableau has a very thoughtful and intuitive graphical user interface. Wrongly categorized variables can easily be changed and the program has strong capabilities in performing multidimensional analysis. Two kinds of sheets are available, worksheets and dashboards. In a worksheet an interactive table, chart or map can be designed and the dashboard sheet is meant to combine objects.

Qlik Sense

The drag and drop features of the interface is good for rapid building of dashboards, data visualization and reports.(Gounder et al., 2016) The program has three different versions. The first is Qlik Sense Desktop which targets the individual users for importing own data and visualizing on a personal computer. A pro of this is that this is a free version. The second version is Qlik Sense

Enterprise which is for enterprises that have large data sources with custom visualizations. The third version Qlik Sense Cloud supports cloud hosting of the data analysis and visualization. Qlik Sense was designed to generate business insights by accessing information from standard database applications such as Excel, CRM, ERP, ORACLE SAP, URL.(Li, 2014) Both the names QlikView and QlikSense are used in articles. QlikView is the original platform, and Qlik Sense is a newly released platform in the second half of 2014 which is officially an improved and extended version of QlikView. Since 2014, Qlik spent the most time on improving Qlik Sense, and this version is also easier to use. This is why Qlik Sense will be used from now on. Qlik Sense offers a free download Personal Edition, but it limits the connections to data sources. In Qlik Sense it is quite easy to find relationships between variables and data fields by means of its instantaneous selection filter. (Li, 2014) This is basically that when a user clicks on some data fields of a variable, the user's selections are highlighted in green.

Article	Microsoft Excel	Tableau	Qlik Sense
1	x		
2	x	x	x
3		x	x
4		x	
5		x	x
6			x

For the different software applications, several criteria are placed in a table. For every criteria is indicated which application "wins" the criteria. The winner is indicated with a one, the second and third place are indicated with a 2 and 3 respectively.

	Microsoft Excel	Tableau	Qlik Sense
Amount of coding	3	1	2
Quality of the dashboard	3	1	2
Costs	1	3	2
Process capability	3	1	2
Data manipulations	2	3	1
Multidimensional analysis	3	1	2
Total	15	10	11

11.7 Integration of theory
Conclusion

Tableau and Qlik Sense are both software applications which use drag and drop features. This makes it relatively easy to create dashboard. Excel requires more programming to create a dashboard. For the Excel dashboard it is also the case that the amount of data that can be processed is limited. This is not the case for Tableau and Qlik Sense. These software applications can both process a huge amount of data, but this also depends on the capabilities of the computers. Further in the project, the capabilities of data processing should be considered before starting to build a dashboard. Excel is not compared with the other software applications in the literature. What is stated in the literature is that Tableau is 10x to 100x times faster than currently existing methods. It seems reasonable to assume that both in Tableau and in Qlik Sense dashboards can be build faster than in Excel. This is why Excel is not chosen as the best software application and Tableau and Qlik Sense are the two candidates left.

Tableau and Qlik Sense are both software applications with a certain cost. These costs depend on several aspects like the amount of persons working with the software application. This will be taken in consideration later in this project. That is why for now the technical aspects like user friendliness and the visualization capabilities will be assessed. Below the pros and cons of both Tableau and Qlik Sense are noted.

Tableau:

Pros

- Tableau is very easy to use; anyone can analyze data with Tableau's intuitive drag and drop products
- No programming knowledge needed
- The program can handle millions of records
- Can create a wide variety of interactive visualizations
- Allows a variety of filters
- Possibility to create an electronic presentation
- Strong capabilities in performing multidimensional analysis

Cons

- Can only do simple data manipulations
- Dashboards made in the free version are accessible for everyone with the URL

Qlik Sense

Pros

- Drag and drop features for rapid building of dashboards
- Can use several databases
- Easy to use program
- No coding knowledge needed

11.8 Answer on knowledge problem

The question: Which software applications can be used to build a dashboard? Focusing on the three this can be answered shortly. All the three software applications can be used, but Excel takes by far the most time and the dashboard will be of a lower quality than with Tableau or Qlik Sense. Tableau and Qlik Sense can both be used to create a dashboard in a relatively short time and it gives high quality interactive dashboards. But Tableau is easier to use than Qlik Sense and it has more capabilities. So all the software applications can be used, but Tableau is the first option, then Qlik Sense, and at last Excel. In the last part of the project were the most suitable application is chosen, the costs have to be taken into consideration.

Appendix 12. How can you design a dashboard?

literature review about design principles of dashboards

- Single-screen; so no scrollbars or multiple windows
- Mainly a static display
- The top left and center should contain the most important information
- Graphs reduce the information overload when compared to tabular information

Three representative manufacturing dashboards are designed

In this paper, a survey was done which resulted in a list of KPIs preferred for different users and different updating times in manufacturing companies. Based on this survey, three representative manufacturing dashboards are designed.

- **Operational dashboard for workers**; details

Shows the status of the factory floor and job queue. The time period is minutes to an hour but the survey showed that some kinds of information are also important in near-real time. The focus is on the status of the machines and job queue. Colors can be used to show the status of machines.

- **Tactical dashboard for managers**; performance-related information

This dashboard shows utilization details, the OEE, the production lead time for jobs, delivery reliability, line efficiency and reclamations. The time period for this is a day to a week. The idea of this dashboard is to contain lots of information so that the user can also find out the details. An important note is that utilization and OEE are shown in tabular form.

- **Strategy dashboard for executives;** status of the company

This dashboard shows the forecast of on-time delivery, workers, lead time from an order, total productivity of lines, demand information, manufacturing costs and inventories. The time period of this dashboard is a month to a year.

Below a picture is shown of these different dashboards and the different layers.

Appendix 13. Key elements of visualization

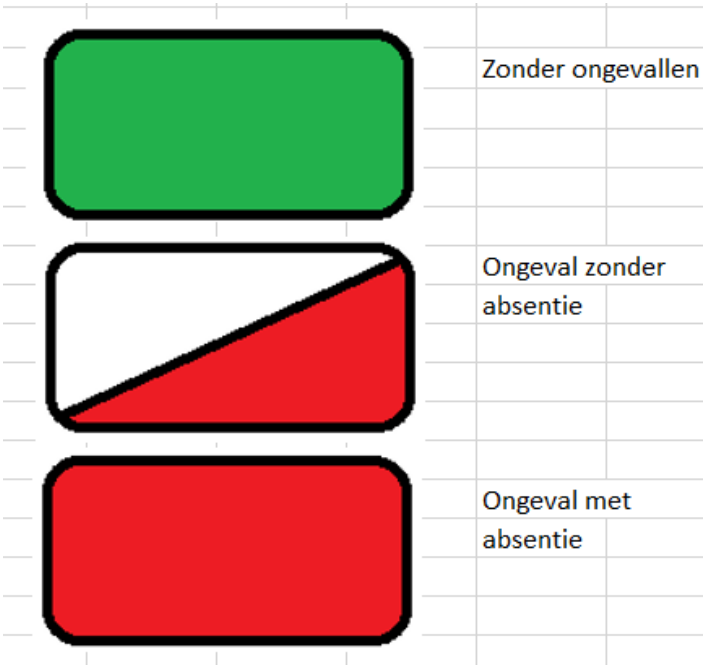
Design:

- Colors should not distract from the key message
- The different chart types should be designed before designing the dashboard
- Numbers of windows/frames, symmetry and proportions, screen resolutions
- Charts must be linked and user drilldown must be allowed
- Layout and navigation
- A line chart or line graph can display information as a series of data points which are connected by straight line segments and this way of visualization is common in many fields.
- When examining time-series of data, the ability of graphs that present relative changes is often valued high and the raw values are considered to be less important.
- Bar charts and column charts are used to emphasize individual values and not overall trends and it can be useful when comparing items.
- Histograms are a decent way to describe distributions

Characteristics of a dashboard - S.M.A.R.T.

- Synergetic: Ergonomically and visually effective for the user by synergizing the information to the single screen view
- Monitoring KPIs: A dashboard must display critical KPIs that are required for the decision making.
- Accurate information: Examined information must be entirely accurate in order to get user's full confidence and to be sure of the data validity.
- Responsiveness: A dashboard must respond to predefined thresholds by showing different kinds of user alerts
- Timely: The information that is examined must be on real-time or right-time, depending on the KPI what is necessary (as current as possible)

Appendix 14. Safety symbols



Appendix 15. Evaluation forms

First part

	safety	quality	Boxes planned	Boxes produced	escandallo	Production Hours planned	Production Hours actual
Supply chain manager	x	x	x	X	x	x	x
Production manager	x	x	x	x	x	x	x
Packaging manager	X	It is nice if the employees of production can see directly what is done with "their" products	x	x	x	x	x
Line manager	X	x					
Trainings coordinator	x	x	x	x	x	X	x
Planning: E	X	X	X	X	X	X	X
Planning: R	X	X	X	X	X	X	X
Shift L: Re	X	X	X	X	X	X	x
Shift L: M	X	X	X	X	X	X	x
Shift L: A	X	X	X	X	X	X	x
Quality Manager	x	x					

Second part

	yield	a	p	q	pw	dw	Direct hours crew	Per line, or shift
Supply chain manager	x	May make it unclear	same	same	x	x	x	x
Production Manager	x	x	x	x	x	x	x	x
Packaging manager	x	x	x	x	x	x	x	Per line
Line Manager	X	X	X	X	X		X	Per line
Trainings coordinator	X	X	X	X	X	x	Only useful in combination with the planned hours	Per line
Planning: E	x	x	x	x	x	x		Per line
Planning: R	X	X	X	X	X	x	Planned hours should also be available	Per line
Shift L: Re	x	Stops%		Waste%			Not (yes after planned)	Per line
Shift L: M	X	X	X	x			Yes	Per line
Shift L: A	x	x	x	x				Per line
Quality Manager								x

KG produced was taken of the report, but in combination with the comments it seems interesting some times. The supply chain manager said that other values may only be set on the daily report if this does not increase the reporting time in the company.

A: availability
P: performance
Q: quality

Appendix 16. Logbook daily morning meeting

Observing the morning meetings, no literature study done yet

7-3-2019 Thursday 1

- A lot of noise in the production environment
- At this moment it is not clear yet where agreements are noted. Is there more available than just email?
- Are more KPIs possible than the current selection
    - Speed of machines?
    - CO2 values
    - Reaction speed on breakdowns or other problems.
- An overview of the production board can be something nice to use during the poster market.
- Which employee has to do which tasks is indicated at the daily action plans.
- A shift leader thought that some points are personal against him. But this is not the case and that should be clear

8-3-2019 Friday 2

- Values of the fryer are a problem
- Temperatures of for example butter can differentiate a lot every day
- The speed of production lines probably differs for different products

14-3-2019 Thursday 3

- It seems like relationships between problems are not noted somewhere
- Again: it is sometimes hard to hear some people talking
- The problems are very diverse
- Some points are important for every production line or for example for every shift leader, this could also be communicated outside the meetings

15-3-2019 Friday 4

- The diverse problems in the production environment are not relevant for my research. It is important to focus on how the meetings can be improved

21-3-2019 Thursday 5

- One production board is placed somewhere else. This place is less noisy.
- The reporting which is done by the shift leaders in the morning, is sometimes not done correct. The planning is working on this.

22-3-2019 Friday 6

- Some problems are really interesting, shift leaders explain a lot in detail which also makes it possible for me to understand it
- The time of the meeting is quite long
- Standing for a long time is not that comfortable

28-3-2019 Thursday 7

- Hard to define a focus for myself
- It is hard to say how long the meetings should take, sometimes a lot of important points are addressed.

29-3-2019 Friday 8

- Same as 28-3.
- Busy with the project plan and the literature study besides observing the meetings
- This is also were the literature study for the meetings will be done.

4-4-2019 9

- Project plan almost done, literature study for morning meetings not yet
- Still hard to focus
- Interesting problems but it is hard to see improvements

5-4-2019 10

- Already quite far with literature study
- Observation partly focused on the literature study so far

Now I should observe the with the knowledge acquired from literature. Some focus during the meetings will help in defining an advice.

18-4-2019 Thursday 1

- At max there were 11 people present at the meeting.
- Three meetings, total time around 35 minutes: advice normally 15 minutes for a meeting, but 35 minutes is still quite long. Not sure yet what others think of the time.
- Quality showed some pictures on a phone, but this is not very clear if you are with a lot of people. This happened more often.
- Some points are really relevant for only 2-3 people, which result in a large amount of people "waiting".
- During a meeting, problems should be addressed, maybe solved, but a discussion with just a small part of the participants should not happen.

19-4-2019 Friday 2

- The meeting started before everyone was present. This seemed good because it prevented that a lot of people have to wait.
- Again pictures shown by quality on the phone, and one printed on a4. Which is a lot clearer.
- Sometimes discussions between just a few participants
- It is hard to define who has to be present during a meeting, this is also because there are three meetings in a row.
- People look like they think that the meeting took too long.

23-4-2019 Tuesday 3

- Started without everyone present, took a few minutes
- The head of the technical service was not present. Although a lot of points are addressed to him
- Overall the meetings were quite "short" 30-40 minutes

24-4-2019 Wednesday 4

- Only six participants
- Only one meeting since two lines did not produce
- We had to wait a few minutes for the shift leader.
- Quite fast meeting, only having one is quite nice.
- Only six people so a picture on a phone was quite clear.

25-4-2019 Thursday 5

- Around 8 participants
- The meetings took a regular time of +/- 15 min
- Important to note, that anyone can always say points at the end of a meeting.

26-4-2019 Friday 6

- Around 10 participants
- 40 minutes or more for the three meetings

29-4-2019 Monday 7

- The first two meetings were quite fast. Around seven people present. Although there were quite some diverse points during the second meeting.
- Third meeting, this was the first meeting like this for this shift leader, this was not a problem. TC explained beforehand (without others) how such a meeting is build up. And others could of course help during the meeting.
    - A point of interest here is that this shift leader explained everything in a way that everyone could understand. I thought that it was quite interesting, but this does not make the meeting more efficient. Problems can be solved in detail outside the meeting.

30-4-2019 Tuesday 8

- The first meeting was quite short, also because there were not a lot of problems during the shifts of this line.
- Second and third shift had a lot of daily and weekly points. These points are discussed in several meetings. Everyday all the points are assessed “short” but some could be skipped completely

1-5-2019 Wednesday 9

- Quite some people present, but two people are new and are will not participate always in the meeting. Maybe only this day. Else it will be stated in the notes of later days.
- First two meetings were quite long, discussions about how to solve certain problems
- Every day some action points are discussed, seems like some points are named like five times or more.
- One of the “new” guys would start working on this. Seems like a very good improvement for the process itself and for the meetings
- PM is probably aware of the time that the meetings take and that some things should be discussed somewhere else. But he does not have specific rules.
- OEE and Waste is sometimes a point, this can be seen in the other parts of the thesis

2-5-2019 Thursday 10

- During the first meeting, the daily actions were almost completely skipped, these would be discussed by PM and a “new guy”. This made the meeting a lot faster, which seemed to be a positive thing.
- Quality has some small points almost every day. This should not take to long or be unclear with the use of pictures
- The production manager was called during the meeting, the others continued so no time was lost. I think this was better than waiting for him.

3-5-2019 Friday 11

- Average meeting time like 35 - 40 minutes for three meetings.
- Daily actions did not take too long, it seems that it is possible to go over these actions quite fast instead of talking about every action
- The problems that occurred during the last three shifts is mainly what the meeting is about, so the focus should be on this. Then problems can be assigned to certain people.

6-5-2019 Monday 12

- 40 minutes for 2 meetings. This was partly due to the fact that there were a lot of problems during the shifts at the lines
- But also a lot of daily and weekly points.
- The person normally responsible for resources was not present at the meetings, but only one point was really for him. Someone would discuss that with him outside the meeting, so this was not a problem, and it did not took the resources person 40 minutes.

7-5-2019 Tuesday 13

- Quality has some small points which some people might think are irrelevant. This conclusion is based on people's reaction or talking after a meeting, or when walking to the next. But quality is very important in this company, so even the small things have to be noticed. Furthermore, this may also prevent bigger quality problems.
- "Action Plan daily" Packaging manager was not present. Things with his name were just skipped. This seems possible for more points but this is normally not the case.
- Planning had one point of attention: the shift leaders all made a certain mistake sometimes. This had to be addressed but it is not the case that he has to attend 40 minutes of meeting for this. Furthermore, he does not reach all the shift leaders this way.
- 2 meetings: 40 minutes.Frustrations:
    - LM: too long, a meeting should take 10 minutes
    - Quality: thinks that the meetings are frequently too long
    - Planning: Agreed with LM
    - This is not really academic research, but it gives an indication of people's opinions, besides the meeting should seem relevant to everyone. Interviewing everyone who attends the meeting in order to find points of improvement is not possible due to time constraints of this research and this is not the focus.

8-5-2019 Wednesday 14

- First meeting +/- 7 participants
- Second meeting +/- 11 participants
- Both meetings took +/- 20 minutes
- The first one seemed shorter, I think that most people just want to go further after a certain amount of time.
- Sometimes quality shows pictures, people look at it really shortly. It seems that most people do not really care about those points. But pointing these out is not weird since quality is a very important value for the company.

9-5-2019 Thursday 15

- First meeting "looks" shorter.
- Second meeting had a lot of daily and weekly points
- PM became a bit frustrated because of the amount of points and the time these take
- Another technical guy is now present which should lower the amount of points.
- The second meeting: +/- 13 persons
    - Although 2 interns
    - 2 shift leaders and someone of the shift who just observes mostly.

    - 2 technical persons.
- This amount of people is quite a lot, the circle becomes quite large and this decreases the effectiveness. Although it is the case that all viewpoints should be present, several persons of the same viewpoint gives a too detailed discussion.

10-5-2019 Friday 16

- +/- 8 participants
- Both meetings +/- 15 minutes
- Planning has to attend the meeting mostly because of mistakes made somewhere else
- Second meeting, no shift leader, did not seem to be a problem
- 2 persons of TD, maybe that one is enough

13-5-2019 Monday 17

- First meeting +/- 12 minutes
- Second meeting +/- 18 minutes
- Quality sometimes has very “small’ points, should everything be addressed during the meeting? It can be done faster
- Second meeting: yield 84 %, waste 3 %, “redenen van verlies” : process waste, the process waste does not decrease the yield, so something went wrong here.
    - “Process waste” is the waste at the start of the process that does not influence the OEE, does everybody know this?
- Weekly and daily points can be done faster

14-5-2019 Tuesday 18

- First meeting 12 minutes
- Second meeting 14 minutes
- Total amount of time is not that bad
- Line 2: again for the same shift: “redenen van verlies” : process waste
- For quality, the points addressed differ a lot.
    - Points like: clothing, or other stuff what still has to be cleaned up, is this something for the meeting or should this be said to the shift leader individual. For example
    - Cleaning points around the line because of small mistakes around the line, might be relevant, but shift leaders can assess the situation and define it as a problem for the meeting

15-5-2019 Wednesday 19

- In total for three meetings +/- 30 minutes
- PM and LM did not participate, so their points were skipped which made it a bit faster
- Second meeting was the longest, still a lot of points, points with another date than today should be skipped
    - Have some trust in your colleagues
- Quality had some points specifically for some people, maybe not relevant for all.
    - Maybe an idea to let quality address these points to the specific people personally, and that she personally checks at the end of the day whether this is done or not. If it is not done, then address it in the meeting
- Still thinking about the part of trust in your colleagues, maybe not really the way to say this, but if a task is assigned to someone. Only ask about it when the task has the current date.
- The first meeting did start promptly even though that PM and LM were not present. This seemed to be very good
- Total time around 30 minutes, this seems to be a good maximum time, it can even be shorter

16-5-2019 Thursday 20

- 2 meetings in total
- The first meeting around 12 minutes
- Second meeting around 20 minutes
- Quite a lot people present
- 4 shift leaders or operators at the second meeting, and 2 interns makes the group enormous
- Some points are “personal” but it just seems like the

17-5-2019 Friday 21

- The action points in most of the meetings were quite fast
- Not too many discussed
- It is important to note that there is always something to discuss
- Process waste is indicated a lot on the production board, but what is process waste>

20-5-2019 Monday 22

- Only six people present
- Trainings c. and PM did not participate
- Although the “important” people were not present. All the problems were discussed and addressed to persons. It seems like BK is doing a good job on the daily and weekly points
    - It is of course always a thing whether the problems are solved properly or not: or that for example PM knows something that changes the solution
- Although only six people were present, the meeting took 45 minutes
    - All the daily and weekly points were discussed, even the ones with a date in the future, it differs per shift leader whether this is done
    - And nobody is like: “conclusion about this point, up to the next”

21-5-2019 Tuesday 23

- A lot of problems
- A lot of people
- Three long meetings

22-5-2019 Wednesday 24

- The meetings took in total 37 minutes
- 4 to 5 people present at the beginning
- PM and Packaging manager not present
- Quote LM: “the daily and weekly points are for td”
- Maybe the daily and weekly points are not necessary to discuss during the morning meeting

23-5-2019 Thursday

- Missed the morning meeting, was busy giving a tour in the company

24-5-2019 Friday 25

- Not that many people present
- Around 40 minutes
- Still quite some problems, daily, weekly
- BK seems to do a good job
- Sometimes it can go a bit faster

27-5-2019 Monday

- Missed the morning meeting due to a meeting with supervisor

28-5-2019 Tuesday 26

- Meeting around 24 minutes for two lines
- First meeting started a bit late because some important people were not present. Some did not participate at all, so they had to wait for some. Overall meeting was quite good

3-6-2019 Monday 27

- Total of the meetings was an hour. This was due to the fact that there were a lot of problems.
- Not too many people present
- People can become frustrated because there are a lot of problems, not weird

4-6-2019 Tuesday 29

- Meeting took almost an hour
- Up to 12 people present
- Production manager not present
- Resources came to the last meeting with a problem, this resulted in a discussion between 3 people while 9 others had to wait
    - It took a while until someone noticed that such a problem could be discussed outside the meeting. The production manager was not present, otherwise he might have said this. What should have been said: who should participate in this discussion, what do we need, when do we do this?
- Shift leader answered a phone call while 12 people waited
- The first meeting was quite short, there was a lot of noise, not a lot of things discussed everybody just wanted to move to the next meeting

5-6-2019 Wednesday 29

- A lot of problems are set to the next day, although it has to be noted that some progress is made
- First meeting really short, problems at the line so a meeting was not really most important at that moment
- Production manager and line manager did not participate

6-6-2019 Thursday 30

- The production manager did not participate. This is because he works from 2 to 10 for a week. It is interesting to see the difference in the morning meeting when he is not present.
- Some people from another facility were present today to observe the reporting process of company X, which is similar to what I am doing.
- Some extra explanations during the meetings, but overall it took 30 to 40 minutes

7-6-2019 Friday 31

- First meeting, took a while to get started, shift leader was busy, problems with the start of the line
- First meeting, quality showed several graphs about last nights production. It seemed like nobody had a clue what it showed. But it could be the case that a large part of production will be blocked or scrapped
- Second meeting was quite fine
- Third meeting, quality showed a box with donuts which was produced two weeks ago. Quality was not sufficient, line manager said that this was already discussed.
- THIS: Quality is important for the company, there are protocols, but the way everything is presented now is not right. A whole shift of production can be thrown away, while people are focusing on the yield of that shift.

11-6-2019 Tuesday 32

- Overall the meetings took 40 minutes
- Several points were not discussed since some people were not present
- First meeting started 5 minutes later due to a stop at the line close to the production board.