Improving inventory management through ERP implementation

BSc thesis Industrial Engineering and Management

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27-07-2020

UNIVERSITY OF TWENTE.

matco INTERNATIONAL

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Management summary

Problem definition

This research took place at Matco International in Deventer and Waalwijk. Matco International is specialized in the assembly and sales of pallet wrappers. Currently, Matco International uses two ERP systems for performing and documenting business processes. Moreover, there are inventory problems concerning obsolete inventory and incorrect inventory numbers which are not identified in time, since inventory is monitored through experience and observations. Thus, Matco International decided to implement AFAS for both Deventer and Waalwijk. Therefore, a problem identification is carried out and a problem statement is constructed:

"How can Matco International gain insight into the performance of their inventory management for Deventer and Waalwijk through the implementation of AFAS?"

The scope for this research concerns inventory management in combination with the order management module in AFAS.

Methodology

The research cycle by Heerkens and Van Winden (2017) offers a structured method to answer research questions. A theoretical framework is created to gain insight into the implementation of ERP systems and into measuring inventory performance. The theoretical framework describes an ERP implementation framework (Panayiotou et al., 2015), a requirements engineering framework (Sommerville, 2005), a top ten of CSFs concerning ERP implementation (Ahmad et al., 2013) and finally, an inventory performance framework presenting KPIs (Van Heck et al., 2010).

Results

First, the ERP implementation framework is assessed for the situation of Matco International. The creation of the AS-IS situation and the TO-BE situation steps should be revisited. The other steps, except for the ERP selection, should be carried out completely. Moreover, the top ten CSFs are assessed resulting in six insufficient CSFs. Thus, successful implementation is not guarded when these CSFs do not improve.

Then, the first two steps of the ERP implementation framework are revisited. The AS-IS situation is analysed using BPMN. The AS-IS situation represents the current situation of Matco International's inventory-related processes. Then, the TO-BE situation is analysed using the requirements engineering cycle. The TO-BE situation represents requirements for the processes after the implementation of AFAS. Moreover, requirements regarding inventory performance management are set.

Next, AFAS is analysed. Process structures within the ERP system are identified for AFAS's order management module. Moreover, AFAS's business intelligence options are described. Many KPIs are available in AFAS and unique KPIs could be generated if the data is stored in AFAS using GetConnectors.

Finally, the AS-IS situation, the TO-BE situation and the analysis of AFAS are used as input for business process re-engineering. First, it is assessed whether the KPI requirements concerning inventory performance management are available in AFAS and if not, how KPIs could be retrieved.

Then, the two selected AS-IS processes were re-engineered and validated with a demonstration in AFAS. The selection is made according to the constructed requirements for the TO-BE analysis. These selected processes are: the planning and assembly of semi-automatic pallet wrappers and the purchasing and issuing of spare parts. Both processes should work fluently in AFAS. Otherwise, monitoring processes and inventory would not be as effective since the documentation of the processes does not present the required data.

Conclusion

Matco International could manage its inventory by business intelligence since the KPI requirements could be fulfilled in AFAS. Thus, the core problem is solved since inventory performance could be managed through experience and observations as well as using business intelligence. Additionally, the requirements regarding the selected business processes could also be fulfilled in AFAS, except for one since pick orders cannot be generated without booking out sold items. Although, this constraint does not have a major impact on Matco International's business processes. Thus, the business processes of Matco International fit AFAS, which is important for implementing AFAS.

Finally, the core problem can only be solved when AFAS is implemented successfully. Therefore, it is advised that Matco International invests time in the insufficient CSFs to ensure appropriate implementation.

Preface

Dear reader,

In front of you lies my bachelor thesis. This thesis is executed at Matco International in Deventer and Waalwijk. I've worked often at the location in Deventer. Moreover, I've visited the location Waalwijk a handful of times to gather more information and to involve my colleagues in Waalwijk in the research. I enjoyed the period and gained much experience. The working environment at Matco International is very friendly and ambitious at the same time. The company aims to develop rapidly. Therefore, the process of bringing theory to practice is embraced by Matco. This resulted in a great environment to carry out the thesis and to gain experience. Moreover, the colleagues at Matco International provided me with extrinsic motivation and with information whenever I requested it, for which I am grateful.

In addition, this thesis would not have been possible without the help of my supervisors of the University of Twente and Matco International. Rogier Harmelink and Guido Bruinsma aided me in the name of the University of Twente and Ferry van Huffelen in the name of Matco International.

Thus, I want to thank Rogier Harmelink for his involvement. He showed great interest in my thesis and guided me in the right direction. Moreover, he is very flexible and thus, communication was pleasant. His feedback was critical and helpful.

Additionally, I would like to show my appreciation for the support of the external supervisor Ferry van Huffelen. Ferry helped me throughout my period at Matco International. He provided me with support and information. Moreover, he was critical to the delivered work and provided me with great feedback.

Finally, I am grateful for Guido Bruinsma for the time he took to proofread my thesis. He provided me with valuable feedback to improve my bachelor thesis. The feedback about readability was especially helpful.

Tobias Lansink

July 2020

Table of Contents

1 Introduction 1

1.1 Commissioning organisation 1

1.2 Research motivation 1

1.3 Problem identification 2

1.4 Methodology 3

1.5 Research goal 4

1.6 Problem statement 5

1.7 Research questions 5

1.8 Research design 6

1.9 Reading guide 7

2 Theoretical framework 8

2.1 Implementation of an ERP system 8

2.2 Monitoring inventory performance 15

3 Current situation 18

3.1 ERP implementation framework 18

3.2 As-Is situation 19

4 TO-BE situation 24

4.1 Elicitation 24

4.2 Analysis 24

4.3 Validation 27

4.4 Negotiation 27

4.5 Selection 27

5 AFAS software 29

5.1 Inventory management 29

5.2 Purchase proposals and production proposals. 30

5.3 Monitoring inventory management 33

6 Business process re-engineering 34

6.1 Inventory profiles 34

6.2 KPIs 35

6.3 Business process re-engineering 37

6.4 Demo 40

6.5 Conclusion 40

7 Conclusion, discussion and recommendations 41

7.1 Conclusion 41

7.2 Discussion 41
7.3 Recommendations 42
Bibliography 43
Appendix A: Assessment of the top ten CSFs 45
Appendix B: BPMN explanation with legend 48
Appendix C: Sales of semi- and fully-automatic pallet wrappers 50
Appendix D: Planning and assembly semi-automatic pallet wrappers 52
Appendix E: Production planning 53
Appendix F: Preparation outsourcing fully-automatic wrappers 54
Appendix G: Purchasing and issuing spare parts Waalwijk 56
Appendix H: Purchasing and issuing spare parts in Deventer. 57
Appendix I: Interview results 58
Appendix J: Analyses and reports 61
Appendix K: Dashboard graphs and figures 63
Appendix L: Overview of the KPIs 64
Appendix M: Purchasing and issuance of spare parts re-engineered 67
Appendix N: Planning and assembly of semi-automatics re-engineered 71
Appendix O: AFAS demo implementation steps 72
Appendix P: Demo 73

List of figures

Figure 1: Semi-automatic pallet wrapper (left), fully-automatic pallet wrapper (right) (source: Matco brochure) 1
Figure 2: Problem cluster 2
Figure 3: ERP implementation steps (Panayiotou et al., 2015) 4
Figure 4: Overview of the modules covered by AFAS (source: AFAS brochure) 4
Figure 5: An example of ERP modules in one ERP system (Shebab et al., 2004) 9
Figure 6: Requirements Engineering cycle (Sommerville, 2005) 11
Figure 7: Top ten CSFs (Ahmad et al., 2013) 13
Figure 8: Inventory management process 15
Figure 9: Inventory management framework (Van Heck et al., 2010) 16
Figure 10: Functions in order management (Productie - AFAS Help Center, n.d.) 20
Figure 11: Order management functions in inventory management 20
Figure 12: Link requirements and scope 28
Figure 13: inventory process structure AFAS (source: AFAS training) 29
Figure 14: Production, sales and purchasing overview (Productie - AFAS Help Center, n.d.) 32
Figure 15: Database with receipts (source: AFAS test environment) 36
Figure 16: inventory mutations per article (source: AFAS test environment) 37
Figure 17: an example of a BPMN flow-chart (White, 2008) 48
Figure 18: Bizagi BPMN legend 49
Figure 19: BPMN flow-chart of sales process 50
Figure 20: BPMN flow-chart of planning and assembly process 52
Figure 21: Excel production planning Matco International 53
Figure 22: BPMN flow-chart of preparation outsourcing process 54
Figure 23: BPMN flow-chart of spare parts process Waalwijk 56
Figure 24: BPMN flow-chart of spare parts process Deventer 57
Figure 25: Overview analyses (source: AFAS test environment) 61
Figure 26: Inventory cockpit (source: AFAS analysis tool) 62
Figure 27: Production cockpit (source: AFAS analysis tool) 62
Figure 28: Link sales and production (source: AFAS analysis tool) 63
Figure 29: Underlying parts production (source: AFAS analysis tool) 63
Figure 30: Overview reports (source: AFAS test environment) 63
Figure 31: Actual inventory dashboard graph (Dashboard Actuele voorraad - AFAS Help Center, n.d.) 67
Figure 32: Actual inventory dashboard graph (Dashboard Actuele voorraad - AFAS Help Center, n.d.) 67
Figure 33: Inventory dashboard graph (Dashboard Voorraad - AFAS Help Center, n.d.) 67
Figure 34: Sales revenue dashboard graph (Dashboard Verkoopomzet - AFAS Help Center, n.d.) 68
Figure 35: Sales dashboard (Dashboard Verkoop - AFAS Help Center, n.d.) 68
Figure 36: Purchasing dashboard (Dashboard Inkoop - AFAS Help Center, n.d.) 69
Figure 37: BPMN flow-chart spare parts process re-engineered 70
Figure 38: BPMN flow-chart of planning and assembly process re-engineered 71
Figure 39: AFAS home screen (source: AFAS test environment) 73
Figure 40: Sales order overview (source: AFAS test environment) 73
Figure 41: Sales order (source: AFAS test environment) 74
Figure 42: Link sales order and purchase proposal (source: AFAS test environment) 74
Figure 43: production proposal (source: AFAS test environment) 74
Figure 44: Production orders (source: AFAS test environment) 75
Figure 45: Purchase proposal (source: AFAS test environment) 75
Figure 46: Purchase orders (source: AFAS test environment) 75
Figure 47: Receipt (source: AFAS test environment) 76
Figure 48: Production bill (source: AFAS test environment) 76
Figure 49: Production bill lines (source: AFAS test environment) 76
Figure 50: Pick order (source: AFAS test environment) 76
Figure 51: Inventory overview (source: AFAS test environment) 76
Figure 52: Production planning (source: AFAS test environment) 76
Figure 53: Bookings-layout sales order (source: AFAS test environment) 76
Figure 54: Bookings-layout production order (source: AFAS test environment) 76
Figure 55: Generating serial numbers (source: AFAS test environment) 76
Figure 56: Bookings-layout production bill (source: AFAS test environment) 76
Figure 57: Production bill overview (source: AFAS test environment) 76

List of tables

Table 1: Research design 6
Table 2: INCOSE requirements (source: Requirement Working Group, 2012) 12
Table 3: Top ten CSFs 14
Table 4: Assessment of ERP implementation framework 18
Table 5: Top ten CSFs assessment 19
Table 6: Key tasks inventory process 23
Table 7: KPIs per requirement 26
Table 8: Inventory profiles (Voorraadprofiel voor controle artikel voorraad - AFAS Help Center, n.d.) 31
Table 9: KPI assessment 35
Table 10: Assessment of the top ten CSFs 45
Table 11: KPIs actual inventory dashboard 64
Table 12: KPIs inventory dashboard 64
Table 13: KPIs sales dashboard 65
Table 14: KPIs sales revenue dashboard 65
Table 15: KPIs purchasing dashboard 66

Glossary

AFAS	AFAS is a company providing an ERP system. AFAS is an abbreviation of applications for administrative solution.
API	Application programming interface. APIs define interactions between software systems.
BOM	BOM is an abbreviation for bill of materials. The BOM represents the product structure.
BPMN	Business process modelling notation. BPMN is a notation to model business processes that are easily understandable from a non-technical perspective.
BPR	Business process re-engineering. BPR is the rethinking and redesigning business processes.
BSC	BSC stands for balanced scorecard. BSC is a performance measurement framework.
CIMO	CIMO is an abbreviation of context, intervention, mechanics and outcome. CIMO is a search strategy for finding literature.
CRM	Customer relationship management.
CSF	Critical success factor. CSFs are variables that influence the competitiveness of a company significantly.
ERP	ERP is an abbreviation of enterprise resource planning. An ERP system refers to an integrated and cross-functional system that helps in managing all operations of a company
INCOSE	International council on systems engineering. INCOSE is an organisation focussing on the application and development of systems engineering.
KPI	Key performance indicator. A KPI is a quantitative metric measuring performance.
MPSM	Managerial problem-solving method.
NPV	Net present value. The NPV measures financial performance quantitively.
REST	Representational state transfer. REST is a software architectural style to link web services to software programmes.
ROI	Return on investment. ROI is a quantitative metric measuring financial performance.
SCOR	SCOR is an abbreviation of supply chain reference model. SCOR is a performance measurement framework.
SMEs	SME stands for small and medium enterprise.

1 Introduction

This chapter will introduce the research. The first section, section 1.1 introduces Matco International, the commissioning organisation. Section 1.2 presents the motivation for this research. Then, a problem identification is presented in section 1.3. The methodology and the first stages of the methodology framework are presented in section 1.4 until section 1.8. Finally, a reading guide is shown in section 1.9.

1.1 Commissioning organisation

This thesis is performed at Matco International. Matco International is a company specialized in the assembly and delivery of semi-automatic and fully-automatic pallet wrappers as shown in Figure 1. Moreover, Matco International offers after-sales service for both types of wrappers. The company is located at multiple locations in multiple countries. Facilities are located in Deventer and Waalwijk in the Netherlands, in Hamme in Belgium, in Gevelsberg in Germany and in Cluj in Romania. The focus of this research is on the Dutch facilities located in Deventer and Waalwijk.

Figure 1: Semi-automatic pallet wrapper (left), fully-automatic pallet wrapper (right) (source: Matco brochure)

1.2 Research motivation

Matco International has locations in Deventer and Waalwijk. These locations were different companies in the past. The previous owner of the location in Waalwijk acquired the location Deventer. Therefore, both locations use different ERP systems. The location in Waalwijk uses Navision and the location in Deventer uses Isah. The usage of these ERP systems results in problems as shown in section 1.3. For instance, there are problems concerning obsolete inventory and incorrect stock positions. Both Deventer and Waalwijk removed obsolete spare part inventory costing €80.000,-, according to the management. The current ERP systems do not offer the information to prevent this. Moreover, the semi-automatic wrappers are not registered in the system properly. Therefore, the monthly stock counting for semi-automatic pallet wrappers results in differences. Sales staff sells combinations of turntables and columns, which are the components of a basic semi-automatic pallet wrapper as presented in Figure 1. It is possible that a column of one wrapper is sold in combination with the turntable of another wrapper. Then, the original wrapper combination of the column is booked out of the ERP system. Inventory differences occur since the incorrect turntable is booked out the inventory. The inventory differences result in unsaleable components since these are either not in the actual inventory or not in the ERP system. Thus, the management has decided to implement one ERP system for both locations. The choice for the ERP system is already made. The plan is to implement an EPR system named AFAS. This implementation offers the opportunity to improve the current situation concerning the use of the current ERP systems.

1.3 Problem identification

The research motivation presented a couple of problems that concern the use of ERP systems. A problem identification is executed to identify a core problem that could be solved. Multiple problems were identified during introductory conversations with the employees and management of Matco International. These problems are structured using a problem cluster. A problem cluster is a collection of problems that are linked to each other through causality. The overarching problem that is discovered during these conversations is the perception that Matco International's current growth is not in line with their potential growth. This problem has multiple causes, as shown in Figure 2:

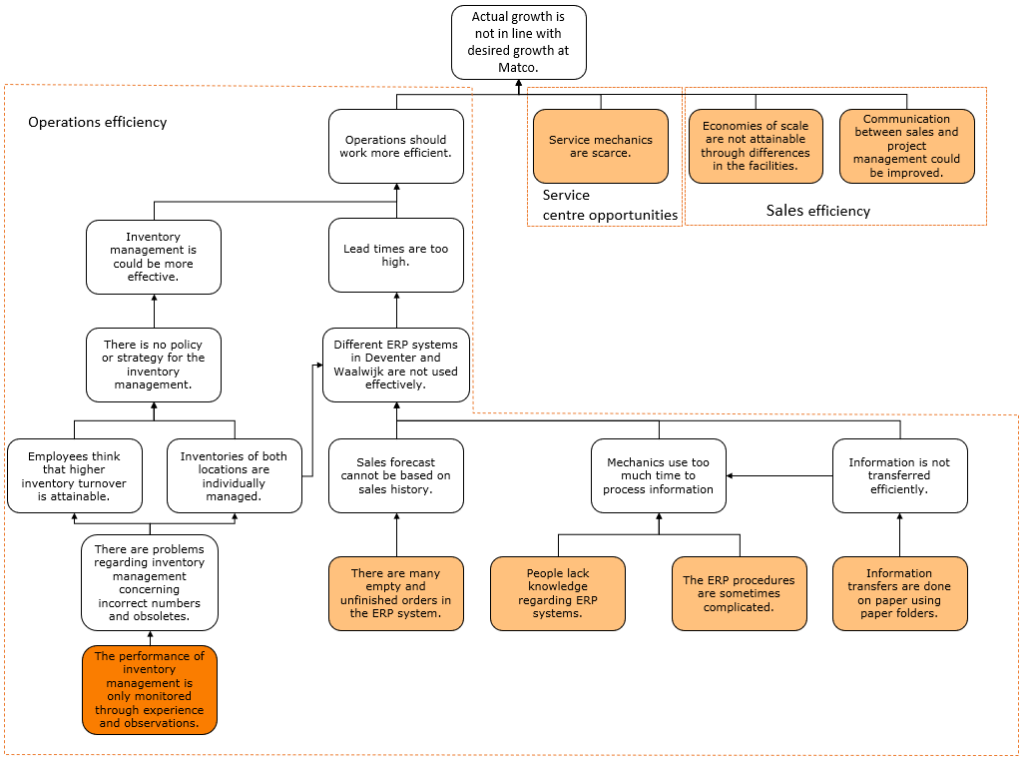

Figure 2: Problem cluster

There are multiple potential core problems. These are marked in orange. Heerkens & Van Winden (2017) mention that one core problem should be chosen based on the greatest impact at the lowest cost.

The problem cluster could be divided in three categories, namely: operations efficiency, service centre opportunities and sales efficiency. The categories sales efficiency and service centre opportunities are not within the scope of the ERP implementation since the role of the ERP systems within Matco International are mostly focused on operations. Solving one of the three core problems that influence the opportunities of the service centres and influence sales efficiency will not have the largest impact since these problems are harder to influence through ERP implementation than the problems influencing operations efficiency. Moreover, current problems regarding the usage of two ERP systems are part of the operations efficiency category. Therefore, solving an operations efficiency problem would result in the highest impact considering the implementation of AFAS.

There are five potential core problems linked to the operations efficiency category. It became clear during conversations with the management and employees that there are multiple improvement opportunities regarding inventory management. Growth could be realized by solving any of them.

At this point, there is no insight into the performance of inventory management. Observations and experience are the current means to come to strategic decisions. For instance, it is not based on performance indicators. Therefore, solving the problem related to the performance management of the inventory could improve the strategic decision-making process within Matco International. Moreover, solving this problem might also result in more coherent management for both locations, which would be helpful for the whole organisation. The other four potential core problems are related to the current ERP systems. Therefore, they might be solved when implementing a new system. Thus, the core problem that is most worth solving is the core problem described in the dark orange box:

"The performance of inventory management is monitored only through experience and observations."

This problem has the greatest impact at the lowest cost since business performance management could save a lot, while it is not very costly to solve given the opportunity of the ERP implementation. The ERP implementation itself is costly. Though, the choice has already been made to implement AFAS. Thus, the acquisition costs cannot be influenced by this research. Moreover, the two problems mentioned in the research motivation could be solved by proper inventory management using the ERP system. Potential obsolete spare parts could be identified in time and the inventory of semi-automatic components should be done properly using an ERP system. Solving these problems could impact business performance management greatly.

1.4 Methodology

The literature of Heerkens & Van Winden (2017) offers two perspectives for the methodology. The first perspective is the Managerial Problem Solving Method (MPSM) and the second is the research cycle. The MPSM is used to solve action problems while the research cycle is used to solve knowledge problems. An action problem is described as a discrepancy between the norm and reality while a knowledge problem is a description of the research population, the variables and relations that need to be investigated (Heerkens & Winden, 2017). The core problem selected in section 1.3 does not have a measurable norm and reality. Though, inventory performance and its variables should be described. Thus, the core problem is a knowledge problem. Therefore, the research cycle will be used according to the following steps (Heerkens & Van Winden, 2017):

- Phase one: Formulate the research goal.
- Phase two: Formulate the problem statement.
- Phase three: Formulate the research questions.
- Phase four: Formulate the research design.
- Phase five: Perform the operationalisation.
- Phase six: Perform the measurements.
- Phase seven: Process the data.
- Phase eight: Draw conclusions (review the problem statement).

Moreover, another framework is identified throughout the literature review. This is the ERP implementation framework shown in Figure 3 by Panayiotou et al. (2015). This framework will identify the tasks necessary to implement an ERP system. This framework can identify what has to be operationalised and measured throughout this research.

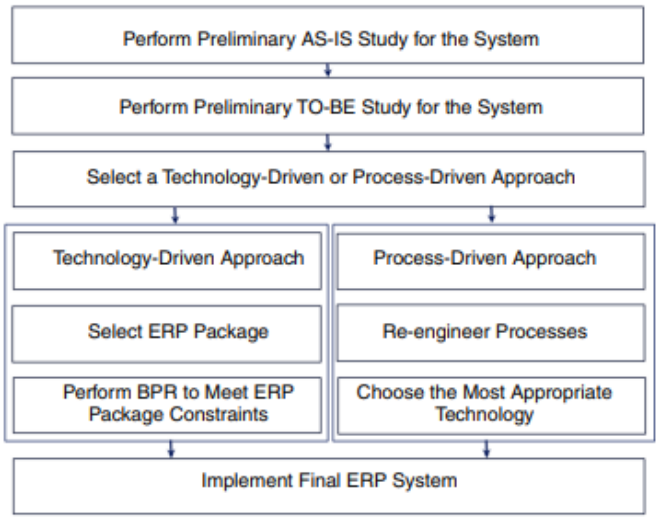

Figure 3: ERP implementation steps (Panayiotou et al., 2015)

1.5 Research goal

The first step of the research cycle is to determine the research goal. The research goal should state the reasoning why the selected core problem needs solving and include what knowledge is necessary to present a solution to the knowledge problem (Heerkens & Van Winden, 2017). The goal of this research is to present the management of Matco International how more insight into the performance of their inventory management can be gained through the implementation of AFAS. The knowledge necessary to answer this question is related to ERP implementation processes in general. Then, the performance measurement options for inventory management should be identified. Moreover, the current situation and the wishes of Matco International have to be taken into account. Finally, AFAS should be analysed. Figure 4 shows the modules of AFAS.

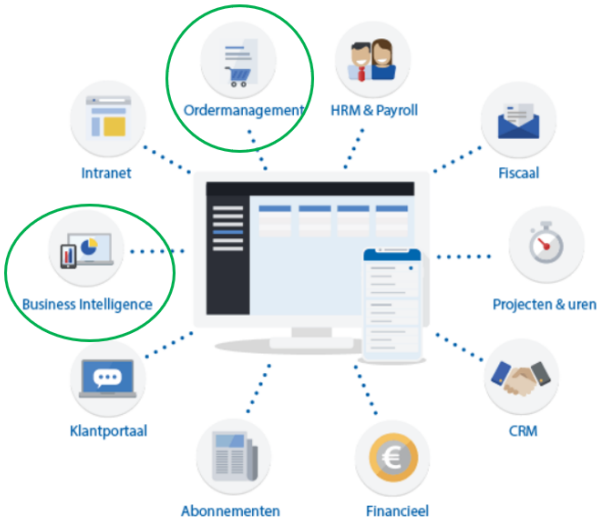

Figure 4: Overview of the modules covered by AFAS (source: AFAS brochure)

The order management module is circled. This is the module that will organize the inventory. The order management module focuses on orders and how it connects with the inventory. Therefore, the focus for this thesis will be on the order management module regarding the ERP implementation. Moreover, the business intelligence module is useful as well. The business intelligence module presents dashboards for every module. Thus, only the order management dashboards of the business intelligence module will be considered.

1.6 Problem statement

The research goal is identified, including the required knowledge. The next task is to formulate a problem statement that functions as a base for the research questions. The research goal is to increase insight into the performance of their inventory management. The constructed problem statement is:

How can Matco International gain insight into the performance of their inventory management for Deventer and Waalwijk through the implementation of AFAS?

The problem stated in the problem identification is transformed into a knowledge question, as Heerkens & Van Winden (2017) present. This knowledge question will be answered through different research questions presented in the next section.

1.7 Research questions

The problem statement presented in section 1.6 should be solved throughout this research. Research questions need to be created to divide the problem statement (Heerkens & Winden, 2017). This is the third step of the research cycle. The created research questions are the following:

1. **What steps are required to implement an ERP system?**
   First, the implementation of an ERP system should be analysed. A solution to the problem statement can only be carried out when AFAS is successfully implemented. ERP implementation steps should be presented to guarantee successful adoption.
2. **How can inventory performance be monitored?**
   A literature study should be carried out to identify performance measurement techniques regarding inventory management.
3. **What is the current state of the implementation process at Matco International?**
   Matco International's implementation process should be assessed given the researched literature presenting an answer to the first research question.
4. **What does Matco International require regarding the order management module in AFAS?**
   The requirements of Matco International have to be identified to create a clear overview of the requirements and expectations of the management and the employees. The research population knows the company and its processes well. Thus, it would be unwise to ignore their knowledge. Moreover, requirements engineering could provide a structural method for identifying the needs of a software system.
5. **What are the constraints and opportunities for Matco International's inventory management in AFAS?**
   AFAS is the ERP system that will be implemented at the facilities of Deventer and Waalwijk. The implementation of AFAS will come with constraints and opportunities for the processes of the facilities at Deventer and Waalwijk. The constraints and opportunities should be identified.
6. **Which requirements could be fulfilled through the implementation of AFAS?**
   All the data is gathered in the previous chapters. Therefore, the requirements presented by the requirements engineering cycle should be considered and solutions should be presented with a demo in AFAS.

Concluding, six questions should be answered to solve the core problem and thus, to apply a solution to the situation of Matco International.

1.8 Research design

The research design covers the methods to answer each research question according to the fourth phase of the research cycle. According to Cooper & Schindler (2014), there are multiple descriptors of the research design. The descriptors that will be included are the method of data collection and the purpose of the study (type of research). Moreover, the research population, the data processing and analysis method should be included. Table 1 shows the research design:

Table 1: Research design

Knowledge question	Subject	Type of research	Research population	Research strategy	Operationalization of key variables	Data gathering method	Data processing and analysis method
Number 1.	ERP implementation.	Descriptive.	Literary databases.	Qualitative.	Steps necessary to reach the successful implementation of an ERP module.	Literature study, use steps systematic literature review to gather sources.	Use the gathered sources to summarize information on ERP implementation.
Number 2.	Inventory management.	Descriptive.	Literary databases.	Qualitative.	KPIs to analyse inventory performance.	Literature study, use steps systematic literature review to gather sources.	Use the gathered sources to identify inventory management strategies.
Number 3.	Process visualisation.	Descriptive.	Matco's employees.	Qualitative.	BPMN process maps.	Observations and open unstructured interviews with employees.	Sketch the process. Visualise answers using BPMN flow charts.
Number 4.	Requirements of Matco regarding ERP implementation.	Descriptive.	Matco's employees.	Qualitative.	Requirements of Matco.	Execute semi-structured interviews. Record interviews.	Transcribe interviews, list the demands and wishes. Use requirement engineering.
Number 5.	AFAS analysis.	Descriptive.	The AFAS training sessions, help pages and test environment.	Qualitative.	Characteristics of the order management and BI module. These could either be constraints or opportunities.	Participate in implementation training sessions, use the test environment.	Write findings down and summarize the constraints and opportunities.
Number 6.	Process visualisation.	Descriptive.	Chapter 2 until chapter 5.	Qualitative.	BPMN process maps and a demo.	Data is already gathered in chapters 2 until 5.	Visualise data through BPMN flow charts. Construct a demo in the AFAS test environment.

The choice for the type of research and the research strategy will be explained according to definitions of Cooper & Schindler (2014); they state that descriptive studies are executed to describe or to define a subject. The answers on the final four questions will describe the current situation, the AFAS modules, requirements of Matco and an assessment of the gathered data to present a possible future situation. The literature studies are descriptive since they will describe inventory management KPIs and implementation steps. Moreover, Cooper & Schindler (2014) state that qualitative research is designed to tell the researcher how (process) and why (meaning) things happen as they do.

1.9 Reading guide

This section presents an overview of the structure of the thesis. The next chapter, chapter two, discusses the theoretical framework. The first and second research questions are answered. It covers the implementation of an ERP system and the monitoring of an ERP system. Subsequently, chapter three describes the current situation and presents an answer to the third research question. The state of the EPR implementation at Matco International is analysed. Moreover, current order management processes are modelled to represent the AS-IS situation. Then, chapter four discusses the TO-BE situation, which is the desired situation. Requirements engineering is used to construct requirements. The fourth research question is answered. Next, chapter five describes the constraints and opportunities of AFAS. The chapter presents an answer to the fifth research question. Chapter six processes the data presented in the previous chapters and answers the sixth research question. Business process models are re-engineered and a demo is presented. Finally, chapter seven concludes the research and reviews the problem statement. A conclusion, a discussion and recommendations are presented. Finally, the bibliography and appendices are shown at the end of the report.

2 Theoretical framework

This chapter answers two research questions that are fundamental to solve the core problem. This chapter is part of the fifth phase of the research cycle called operationalisation. Section 2.1 discusses the implementation of an ERP system. An ERP implementation is a good opportunity to redesign a process to generate the data necessary to monitor the performance of processes (Van Heck et al., 2010). The ERP implementation should be performed appropriately to use this opportunity. Hence, a literature study on ERP implementation is conducted. Then, section 2.2 provides literature on monitoring inventory management. This presents the possibilities to generate insight into their inventory performance management.

2.1 Implementation of an ERP system

ERP systems can be used to carry out business processes and to store data of these processes. Thus, the implementation should be executed appropriately to create valid and reliable data gathering. The research question that will be answered in this chapter is the following:

"What steps are required to implement an ERP system?"

The right steps or procedures should be identified to guide the implementation of AFAS. The first section discusses the definition of an ERP system. It must be clear what an ERP system is before the implementation of the system can be analysed. The second section discusses the necessary steps to implement an ERP system. The implementation process should be monitored. Therefore, critical success factors are identified to analyse the most important aspects of an ERP implementation. The critical success factors are explained in the third section.

2.1.1 ERP system

An ERP system refers to an integrated and cross-functional system that helps in managing all operations of a company (Talluri & Vasu Deva Reddy, 2019). ERP systems often consist of modules. These modules cluster functionalities that are necessary to execute a process creating integration and cross-functionality between business processes. Figure 5 has been included to illustrate an example of the modules that could be included in an ERP system. For example, the human resource management module could cover employee scheduling, employee reimbursements and application data amongst other functionalities (Figure 5). The ERP system can cover important aspects of the human resource management process and replaces a separate software system that would be solely responsible for the human resource management process. Other examples are finance modules, sales and distribution modules, materials management modules and production planning modules. Separate software systems could all be replaced by one single system, which might result in a major advantage.

Moreover, the modules that cover many processes within a company are linked to one single database. The integration attribute and cross-functional attribute are shown, one system is responsible for many processes and these processes are linked to each other through the same database (Shehab et al., 2004). The modules share and transfer information using the same databases resulting in data that is accessible for all the modules. Process data is visible and accessible through the integration. Analysing this data could result in a reliable overview of the performance of the organisation.

Concluding, ERP systems are essential to the competitiveness of a company. The correct use could lead to operation excellence (Panayiotou et al., 2015).

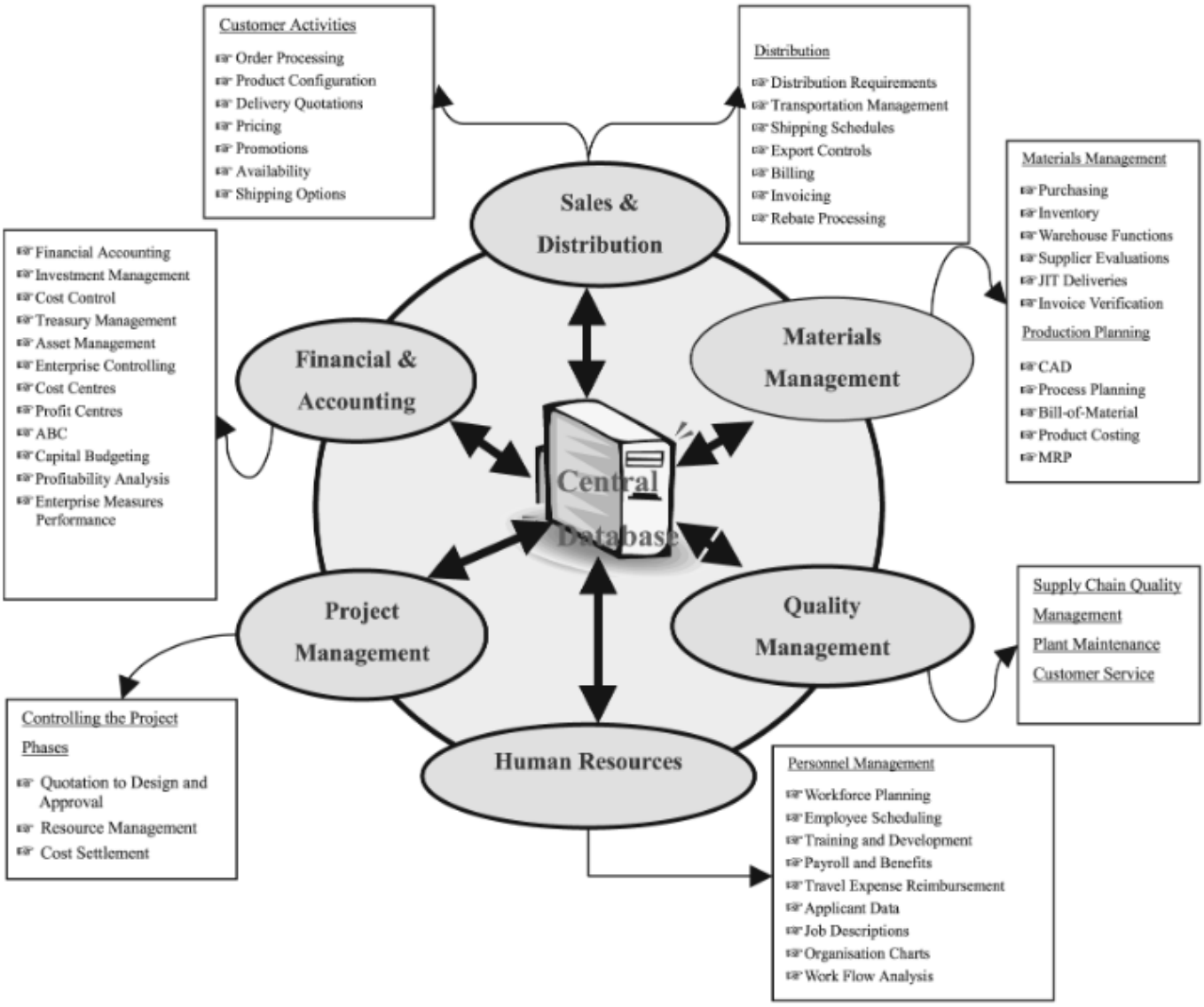

Figure 5: An example of ERP modules in one ERP system (Shebab et al., 2004)

2.1.2 Implementing an ERP system.

Implementing an ERP system is not an easy task. Failed ERP system implementation rates are high, proving that the implementation of an ERP system should not be underestimated. 70% of the ERP implementations do not offer the expected benefits that the ERP system should bring (Ahmad et al., 2013). An implementation that is not successful could result in less efficient processes resulting in higher costs. The previous section stated that ERP systems could contribute to a competitive advantage, however, this competitive advantage might diminish when the system is not implemented properly.

The implementation of an ERP system should be analysed thoroughly. Panayiotou et al. (2015) describe multiple steps for the implementation of an ERP system. The steps necessary to implement an ERP system are presented in Figure 3 of section 1.4.

Typically, implementation processes start with studying the AS-IS situation for the system. The AS-IS situation represents the current state of the system. Business process modelling is required in this stage. The focus should be on the current processes and the technology in use of the current processes. The next step is to study the TO-BE situation for the system. The TO-BE situation describes the desired state of the system. Requirements engineering is a method to identify this TO-BE situation since adjustments to the organisation's processes should be provided through a structured requirements engineering framework (Panayiotou et al., 2015). Section 2.3.1 will go into detail regarding requirement engineering. This means that the current system and the desired system should be identified before choosing an ERP system. The next step is to identify a fitting approach. Two approaches are presented for the implementation of an ERP system (Panayiotou et al., 2015):

- Process-driven approach. A process-driven approach starts with identifying the requirements of the current process and comparing those with the systems that are used at that moment. This will result in a discrepancy between the current situation and the desired situation. Processes should first be redesigned to meet the requirements of the organisation. The second step is to identify the technology that fills the requirements of the redesigned processes.
- The technology-driven approach. The technology-driven approach identifies the technology that is necessary to realise the current requirements and ambitions of an organisation. The selection of an ERP package is a step that is executed before the business process redesign takes place. The idea is that the ERP solution will influence the current processes. The current processes cannot be executed with the new ERP system. Thus, business process redesign should take place to meet the principles of the chosen ERP system.

Both approaches lead to an ERP selection and to business process redesign to fit the requirements of either the ERP system or the requirements of the processes. The final step is to implement the ERP system. A successful implementation is achievable if the steps are executed properly.

2.1.3 Requirements engineering

The TO-BE situation could be analysed through requirements engineering. Sommerville (2005) defines requirements engineering as a name given to a structured set of activities that helps develop understanding and that documents the system specification for the stakeholders and engineers involved in the system development (Sommerville, 2005). This section describes the process of gathering requirements and a set of rules to formulate consistent requirements.

2.1.3.1 Identifying requirements

The definition of requirement analysis mentions a structured set of activities. These activities include understanding the application domain, the system's operational constraints; the specific functionality required by the stakeholders and system characteristics. Requirements engineering could also be described as the process of closing the gap between a specific problem and the solution for that problem (Panayiotou et al., 2015). Requirements Engineering can be performed in different ways. However, some activities are fundamental to requirements engineering. These activities are the following (Sommerville, 2005):

- **Elicitation.** Identify sources to gather information about the system. These sources are most probably stakeholders. Translate the information into requirements.
- **Analysis.** Analyse the requirements. Understand the requirements of the system and discover overlaps and conflicts.
- **Validation.** Validate the requirements. Return to the sources and check whether the sources agree with the requirements.
- **Negotiation.** It is most likely that stakeholders do not agree with requirements or that stakeholders interpret requirements differently. Take the opinion of stakeholders into account and generate a consistent set of requirements.
- **Documentation.** The requirements must be documented in a way that these requirements are understandable for every stakeholder.
- **Management.** Control changes in requirements since it is unlikely that requirements will not change.

These activities take place in chronological order. The order is shown in Figure 6:

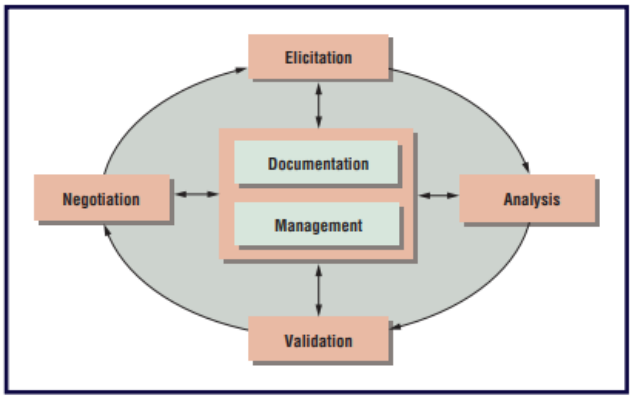

Figure 6: Requirements Engineering cycle (Sommerville, 2005)

The negotiation phase may result in changes or conflicts. Then, it might be wise to start the cycle again to identify better requirements. Moreover, documentation and management are required throughout every phase.

2.1.3.2 Rules for establishing requirements

The rules for establishing requirements are identified according to the guidelines presented by the requirements working group of the International Council on Systems Engineering (INCOSE) (Requirement Working Group, 2012). INCOSE presents a framework to ensure that good requirements are identified. The quality of a requirement is guarded using characteristics of requirements. The INCOSE guidelines present many characteristics of quality requirements. It is not possible to assess every characteristic for every requirement or to make a structured selection due to time limitations. Therefore, a selection is made based on the opinion on what fits best concerning this research. The selected characteristics are shown in Table 2:

Table 2: INCOSE requirements (source: Requirement Working Group, 2012)

Characteristic	Description
Necessary	A requirement should be removed when it is satisfied through another requirement. A requirement is unnecessary if the requirement is satisfied through another requirement.
Implementation independent	A requirement must state what is required, not how the requirement is attained.
Unambiguous	Requirements must be understood in the same way by every reader. A requirement can only have one interpretation.
Verifiable	A requirement must be verifiable or testable.
Singular	The effectiveness of verification is improved when requirements are singular. Singular requirements are statements that address a single thought.
Feasible	Requirements that are unachievable waste time. Requirements should be analysed critically to ensure the feasibility.

2.1.4 Critical success factors

The phases for the implementation of an ERP system are described. Though, success is not guaranteed when taking these guidelines as a standard. Certain factors contribute to successful implementation. These factors are called critical success factors (CSFs). In general, CSFs are variables that are affected through strategic decision-making and influence the competitiveness of a company significantly (Talluri & Vasu Deva Reddy, 2019). Underperformance is a result of factors that are not on the desired level.

2.1.4.1 Identification of the CSFs

Critical success factors could be identified for the implementation of an ERP system. Research performed by Ahmad et al. (2013) identified the ten most important critical success factors for ERP implementation in SMEs. These critical success factors are shown in Figure 7.

Classification	Stages	CSFs	Impact	Factor
Dependent	6-Infusion	Evaluation progress	8/10	Organisational
		Communication	6/10	Organisational
	5-Routinisation	Cooperation	5/10	Organi/Operat
Critical	4-Acceptance	Cultural change	4/10	Organisational
		Management support	3/10	Organisational
	3-Adaptation	Use of consultants	3/10	Organisational
Basic	2-Adoption	Resources	2/10	Operational
		Data analysis	1/10	Operational
		Experienced project manager	0/10	Organisational
	1-Initiation	Project team skills	0/10	Organisational

Figure 7: Top ten CSFs (Ahmad et al., 2013)

The first column presents the classification of the CSFs. There are three classifications. These three classifications could be linked to the stages of an ERP implementation:

- Basic CSFs are associated with the initial state of the system and the ERP selection. These CSFs are used to monitor the typical steps of the implementation of an ERP system. The CSFs cover the initiation and adoption phase, these phases consist of acquiring and implementing an ERP system.
- Critical CSFs are factors that are impacted by basic CSFs. These CSFs are used to monitor the first phases after the implementation. The adoption and acceptance phase. The adoption phase is the phase in which employees use the new system without clear knowledge of the system. The acceptance phase describes the phase in which employees are getting used to the system and start seeing the benefits of the new system.
- Dependent factors are factors impacted by both basic CSFs and critical CSFs. These dependent factors monitor the process of tuning the system and optimize the implementation to obtain the maximum benefits attainable from the ERP system.

Then, the third column presents the selected CSFs. Section 2.1.4.2 describes each CSF. Furthermore, the fourth column displays the impact of a CSFs. This impact number correlates with the classification of dependent, critical or basic and shows how the CSFs are influenced by other CSFs. For instance, the impact on the evaluation of progress CSF is impacted by many other CSFs resulting in high impact. The final column shows the type of factor. The different types of factors are organisational factors and operational factors. Organisational factors are related to the organisation and its culture. Operational factors are factors related to the operations and its technology.

2.1.4.2 Description of the top ten CSFs

The research paper identifying the top ten CSFs did not describe the CSFs individually. The sources of the research of Ahmad et al. (2013) could be used to describe the CSFs and create a better understanding. Table 3 explains the CSFs:

Table 3: Top ten CSFs

Top ten CSFs	Description
Project team skills	The project team should be comprised of the best and brightest individuals with a proven reputation and work full-time on the implementation (Finney & Corbett, 2007). Another important factor is whether the team knows the ERP system (Esteves-Sousa & Pastor-Collado, 2000). Thus, training might be required to ensure successful implementation. Finally, the team should be balanced. The team should consist of members across the whole organisation (Finney & Corbett, 2007).
Experienced project manager	The paper by Finney and Corbett calls this the "project champion". This "project champion" should have strong leadership skills should be a skilled manager regarding the business, technical and personal perspective (Finney & Corbett, 2007).
Data analysis	The data analysis is related to the conversion and integrity of the data. Implementation success depends on whether the conversed data is accurate (Finney & Corbett, 2007). The garbage in, garbage out principle holds. The ERP system will not run optimally when the input data for the system is inaccurate.
Resources	Financial, human and other resources are used to implement an ERP system. Problems often occur regarding committing these resources to the implementation of a digital solution. Resource requirements need to be determined in the first phases of the project. Moreover, it should be taken into account that these resources often exceed initial estimates (Somers & Nelson, 2001).
Use of consultants	Third-party consultants could benefit the implementation process a lot as mentioned above. The use of consultants should depend on the internal know-how that the organisation has at the moment concerning ERP systems. (Esteves-Sousa & Pastor-Collado, 2000).
Management support	Management support is essential for the implementation. The management can allocate important organisational resources (Esteves-Sousa & Pastor-Collado, 2000). Moreover, the implementation should be aligned with the strategic goals set by the management. Therefore, there should be support from the management to ensure that the set goals are reached (Esteves-Sousa & Pastor-Collado, 2000).
Cultural change	The ERP implementation could lead to cultural changes within an organisation. These changes should be managed. Change management strategies should be identified and used to implement the cultural change that results from the ERP implementation (Finney & Corbett, 2007).
Cooperation	Interdepartmental cooperation appears to be critical, the involvement of multiple departments is essential (Somers & Nelson, 2001).
Communication	Communication is important for all kinds of projects. Therefore, the implementation of an ERP system is no exception. There are two kinds of communication for these types of projects. There should be inward communication and outward communication (Esteves-Sousa & Pastor-Collado, 2000). Inward communication includes all the information received by the project team from people outside of the project team. Outward communication is the communication maintained with the outside world.
Evaluation	Evaluation within a project is essential for it to succeed. Feedback networks should be identified for the evaluation of a project (Finney & Corbett, 2007).

Finally, there is one CSF that deserves consideration as well. The implementation steps of the previous section show that business process reengineering (BPR) is inevitable. Moreover, Finney & Corbett (2007) mention that the BPR CSF is the third most cited CSF in their literature review. Therefore, it can be concluded that this CSF contributes to the success of the implementation of an ERP system in an organisation. Although the CSF is not included in Table 3, it does apply to this research. There is one remark when performing business process re-engineering. Try to avoid customization as much as possible. Try to adhere as much as possible to the standardised specifications supported by the ERP system (Esteves-Sousa & Pastor-Collado, 2000).

2.2 Monitoring inventory performance

This research aims to provide insight into the performance of the inventory management of Matco International. It is important to identify the means to analyse the performance of the inventory. This research question formulated to answer this problem is the following:

"How can inventory performance be monitored?"

2.2.1 Inventory business process

Monitoring inventory management could provide important data for strategic decision making. The inventory management process must be identified first, before checking how to monitor this process. Inventory management can be defined as a task of managing and maintaining the inventory (Nallusamy, 2016). Inventory management could be split up in multiple sub-processes. The inventory management process consists of five sub-processes (Van Heck et al., 2010):

- **Forecasting.** Forecasting is the first sub-process. Forecasting aims to maintain a continuous production or service level. It acts as a basis for scheduling and planning.
- **Purchasing.** Purchasing represents the activity of ordering goods.
- **Goods receipt.** The purchasing process is followed-up by goods receipt. This process consists of checking incoming goods. Order information is compared with the received goods. Moreover, a check could be performed to assess the quality of the received goods.
- **Storage.** Goods could be stored if the quality is ensured. The goods enter the inventory.
- **Goods issue.** Goods are stored for a purpose. Thus, the final stage of the inventory management process concerns the issuance of goods. These goods could be sold or used for production.

Thus, Figure 8 represents inventory management according to these five steps:

Figure 8: Inventory management process

2.2.2 Performance management techniques

There are multiple methods and techniques to monitor performance. Six important techniques are identified, namely, (1) Key Performance Indicators (KPIs), (2) Balanced Score Card (BSC), (3) Return on Investment (ROI), (4) Net Present Value (NPV), (5) Critical Success Factors (CSFs) and (6) Supply Chain Operations Reference model (SCOR) (Van Heck et al., 2010). Van Heck et al. (2010) chose KPIs as the most suitable performance management technique. KPIs are quantitative metrics. These metrics are important to evaluate business processes. Businesses thrive or fail based on their ability to identify, define, track and act upon inventory and financial KPIs (Nallusamy, 2016).

The conclusion made by Van Heck et al (2010) is understandable. First, ROI and NPV are financial KPIs. Thus, ROI and NPV are not excluded when choosing KPIs. Moreover, CSFs could use KPIs to measure the critical success factor. Therefore, KPIs cannot be excluded when choosing CSFs.

The two remaining performance management techniques are the BSC and the SCOR. The balanced scorecard is a technique that throws an insight into an organisation's performance by creating insight in both financial and non-financial performance (Ghosh & Mukherjee, 2006). This control framework could present important answers to the performance of a company. However, its disadvantage is that

it is hard to determine the metrics that are suitable for the framework. This could result in less specific results. Therefore, it might not be the best performance monitoring technique. Finally, the supply chain operations reference model should be assessed. This model is about the capability of an organisation regarding the management of a supply chain, it provides a common setting for determining, unifying and accomplishing supply chain processes (Divsalar et al., 2020). SCOR focusses on five main processes, these are plan, source, make deliver and return (Divsalar et al., 2020). Though, SCOR focusses on an entire supply chain, which is larger than the set scope for this research. Thus, both frameworks are not suited. However, both frameworks could be monitored through metrics. Thus, both frameworks could use KPIs.

All in all, KPIs are a logical choice, since choosing KPIs does not necessarily exclude the other performance management techniques. Moreover, the BSC and SCOR framework could be used. However, Van Heck et al. (2010) chose to develop a new framework as seen in section 2.2.3.

2.2.3 Identification of different key performance indicators

The performance management technique has been chosen. The next step is to identify the key performance indicators that will provide insight into the inventory performance of SMEs. Research by Van Heck provides a measurement framework using KPIs for the assessment of the performance of inventory management in a company (Van Heck et al., 2010). The framework is shown in Figure 9. The framework uses the definition of inventory management that is explained in section 2.2.1. Moreover, the framework identifies a trade-off between sets of KPIs. The trade-off is between the appropriate service level and optimal (investment) cost control. The tiles below the trade-off show focus points for each sub-process regarding inventory management. Then, the most important row for this research is shown below the process focus points. The row shows a collection of KPIs regarding inventory management. These KPIs are linked to each sub-process of inventory management. The KPIs were gathered and selected through extensive literary research, process mapping and based on the opinions of experts (Van Heck et al., 2010). Finally, there were some KPIs that did not focus on a specific sub-process. These KPIs are displayed in the bottom row of the framework.

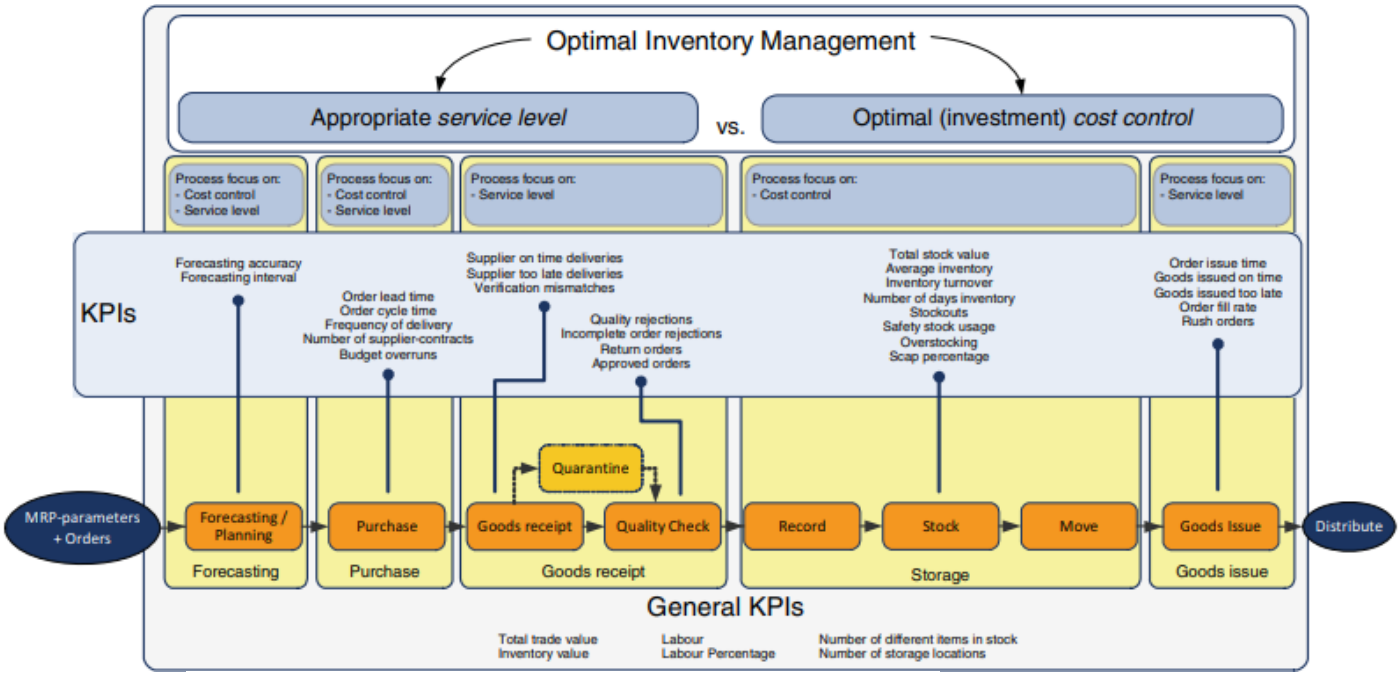

Figure 9: Inventory management framework (Van Heck et al., 2010)

2.2.4 Selection of the key performance indicators.

Thirty-three key performance indicators were identified and displayed in the framework. The number of different KPIs might be too large to visualise in, for example, a dashboard. Therefore, the number of KPIs should be narrowed down. The researchers that generated the framework also created a top ten KPIs in collaboration with four experts in the field of logistics and inventory management. The top ten list consists of the following KPIs, listed per sub-process (Van Heck et al., 2010):

- **Forecasting**. Both the forecasting accuracy KPI and the forecasting interval KPI are included in the top ten list. The forecasting process usually consists of statistical time forecasts using disaggregated levels of stock-keeping units (SKUs) (Davydenko & Fildes, 2013). This means that the time series of stock-keeping units are analysed to forecast the demand. The accuracy of this process could be measured using an error measure. There are multiple options, however, they are dependent on the situation. For instance, mean absolute percentage error (MAPE) is the most popular, however, it is often inadvisable since large percentages occur from units that have relatively low demand values (Davydenko & Fildes, 2013). The forecasting interval is a duration in days that are based on the total lead time for an order, plus the variable order interval, which is a duration in days based on when the next order is to be placed. (Sinkel, 2014).
- **Purchase.** Order lead time is the only KPI included for the purchase process. Lead time is the time between order placement and order receipt (Senapati et al., 2012).
- **Goods receipt.** Five KPIs are selected to monitor this process. Three KPIs to monitor the receipt and two to monitor the quality of the orders. The percentage of on-time deliveries per vendor, the percentage of too late deliveries per vendor and the percentage of mismatches per vendor monitor goods receipt. The number of quality rejections and the number of return orders monitor the quality check process.
- **Storage.** The research team and the experts did not include performance indicators for the top ten. Service levels are prioritized in compared to cost control. Moreover, it can be concluded that service-level is the most important since the storage process is not monitored. The other processes that are monitored are somewhat related to the service level.
- **Goods issue.** This sub-process should be monitored using at least the two following KPIs: Order fill rate and the number of rush orders. The order fill rate is defined as the probability of filling an entire customer order within a specified period (Iqbal et al., 2017). Rush orders are orders that need to be delivered more quickly than the normal delivery time.

3 Current situation

The current situation should be analysed to successfully implement an ERP system and create insight into inventory management. This chapter gathers data given the current situation. Thus, this is part of the sixth cycle of the research cycle. An answer to the following research question is presented:

"What is the current state of the implementation process at Matco International?"

The tasks executed by Matco International to ensure successful implementation have to be identified according to the framework and critical success factors presented in the theoretical framework. This is described in section 3.1. Section 3.2 describes the AS-IS situation.

3.1 ERP implementation framework

Matco International has already started the ERP implementation process. However, an analysis of the current implementation process should be carried out to check whether the first steps of the implementation are executed properly. Moreover, problems or risks could be identified. First, the implementation approach of Matco International will be discussed. Then, the critical success factors will be analysed.

3.1.1 Implementation approach

The typical steps of the implementation of an ERP system are shown in Figure 3 in section 1.4. The only step that has been completed by Matco International is the ERP selection step. The managing director and the business improvement manager used their experience and their vision regarding the current and desired situation to choose an ERP system. Thus, it can be concluded that the technology-driven approach has been chosen. Though, the first two steps are not executed properly. Therefore, these two steps should be revisited. Then, business process re-engineering should be performed to meet ERP package constraints. Finally, the ERP system can be implemented. All in all, the tasks given the technology-driven approach, its status and the to-do list are summarized in Table 4:

Table 4: Assessment of ERP implementation framework

Task	Status	To do
Perform preliminary AS-IS study for the system.	Should be revisited.	Business process modelling (using BPMN)
Perform preliminary TO-BE study for the system.	Should be revisited.	Requirements engineering
Select the approach	Completed, the technology-driven approach has been chosen.	
Select ERP package	Completed, AFAS has been chosen.	
Perform BPR to meet ERP package constraints	Has not been started.	Analyse AFAS Business process re-engineering
Implement final ERP system	The implementation is started.	Use gathered information to implement the current processes in AFAS.

3.1.2 Critical success factors

Critical success factors are important to assess when an implementation starts (Ahmad et al., 2013). Determining whether Matco International is ready to start the implementation phase is done by assessing the selected CSFs. The implementation of AFAS at Matco International has just started. Therefore, there is still enough time to evaluate the factors and improve the factors when necessary. The factors that are assessed are identified in section 2.1.4.2. The table with the assessed CSFs are shown in Appendix A. Six CSFs are not sufficient as shown in Table 5. Therefore, Matco International should invest time and resources in the improvement of most CSFs. It is otherwise possible that the results of this thesis do not comply with the implemented AFAS system at Matco International.

Table 5: Top ten CSFs assessment

Top ten CSFs	Sufficient or not	Comments
Project team skills	Not sufficient	- Hardly anybody can work full-time on the project. - The employees of Matco are not experienced regarding ERP implementations.
Experienced project manager	Not sufficient	- The internal project manager is not experienced in ERP implementations.
Data analysis	Sufficient	- Sufficient, the data transfer is not rushed.
Resources	Not sufficient	- Internal resources are not budgeted. Though, external resources are.
Use of consultants	Sufficient	- Third-party consultants are used (Forque).
Management support	Sufficient	- Management support is present. The internal project manager is part of the managing team.
Cultural change	Not sufficient	- Matco International does not use a change management strategy.
Cooperation	Sufficient	- Multiple departments are included. - Meetings are planned to ensure cooperation.
Communication	Not sufficient	- There is only a plan for communication with Forque. There is no other communication plan.
Evaluation	Not sufficient	- There is no evaluation plan.

Section 2.1.4.2 covered one other CSF. This CSF is called business process reengineering (BPR) and is one of the tasks that need to be executed before the implementation. Avoiding customization considering the ERP system will be a guideline regarding BPR (Esteves-Sousa & Pastor-Collado, 2000).

3.2 As-Is situation

The first step of the framework mentioned in section 2.1.2 is to determine the AS-IS situation for Matco International. The role of the current ERP systems should be identified, just as the other data storage and data transfer methods in the system.

3.2.1 Modelling method

Business process modelling notation (BPMN) is a useful method to illustrate the AS-IS situation. The advantage of BPMN is that the notation is understandable by everybody in the organisation. Moreover, BPMN can create a standardized bridge for the gap between the business process design and process implementation (White, 2004). A legend and a detailed explanation of the use of BPMN can be found in Appendix B. Finally, the tool used to model the processes is Bizagi.

3.2.2 AS-IS models

As mentioned in section 1.7.1, the scope is related to the order management module of AFAS. Next, the scope also includes inventory management. Section 2.2.1 identified inventory management according to the literature of Van Heck et al. (2010). Figure 10 presents the functions in order management (*Productie - AFAS Help Center*, n.d.):

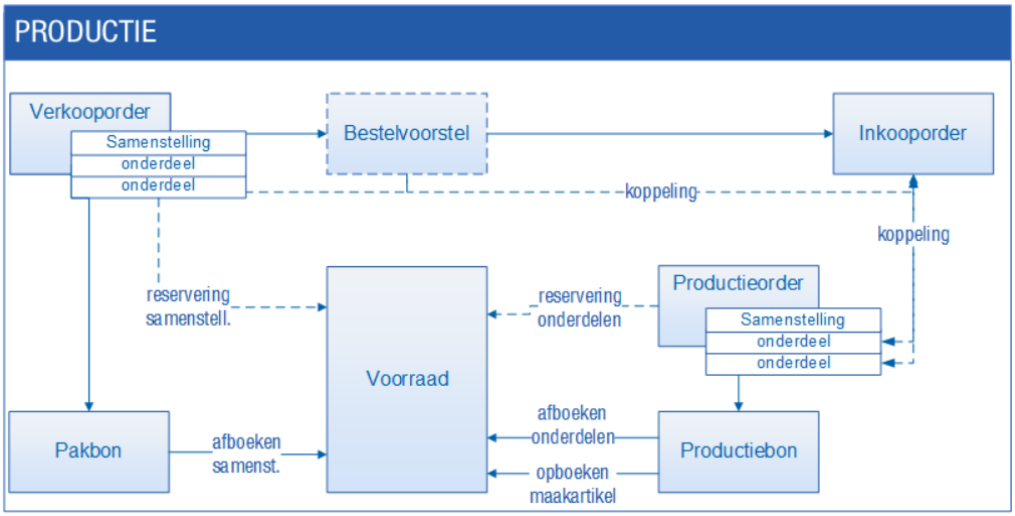

*Figure 10: Functions in order management (*Productie - AFAS Help Center*, n.d.)*

Thus, the processes including purchasing, production and sales should be identified. The order management module and the framework by Van Heck et al. (2010) can be combined to see what AFAS offers regarding Inventory management. Figure 11 presents the scope:

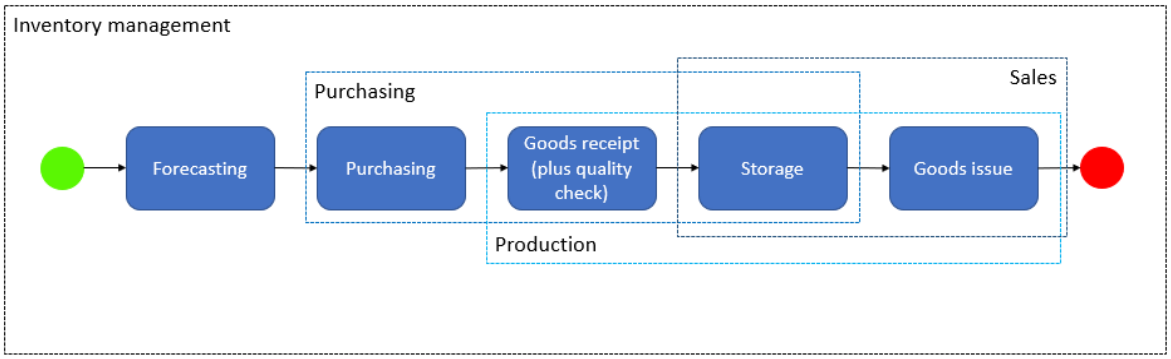

Figure 11: Order management functions in inventory management

There are three processes at Matco International that apply to the order management module. These processes include the sales, purchasing and outsourced production of fully-automatic pallet wrappers, the sales, purchasing and production of semi-automatic pallet wrappers and the sales, purchasing and production of spare parts.

These processes were modelled according to the BPMN. This resulted in processes that were too large to include. Moreover, the BPMN flow-charts had overlap. Thus, the processes were split up in sub-processes. Four sub-processes were selected:

- The sales process of semi- and fully-automatic pallet wrappers. The sales process influences storage by placing reservations and influences the goods issue part by issuing the machines and issuing additional options.

- Planning and assembly of semi-automatic pallet wrappers. The production part is applicable since the production process reserves parts and issues them for production. Then, the new assembly is booked in inventory again, which is a receipt.
- Preparation outsourcing fully-automatic pallet wrappers. This process prepares for outsourced production, by creating purchase and production orders influencing stock positions.
- Purchasing and issuing of spare parts. A demanded spare part can be purchased, produced and sold, influencing purchasing, goods receipt, storage and goods issue.

Finally, the management of the inventory processes is discussed for Matco International to ensure that the scope is completely covered. Moreover, every process is verified by the employees of Matco International to ensure validity.

3.2.2.1 Sales process semi- and fully-automatic pallet wrappers

The choice has been made to not include the process description in the body of the thesis. Section 4.5 shows a selection of requirements based on requirements engineering. There were no requirements selected for this process. The process model and description can be found in Appendix C.

3.2.2.2 Planning and assembly semi-automatic pallet wrappers

The planning and assembly of semi-automatic pallet wrappers process is shown in Appendix D. The used production planning is shown in Appendix E. The original production planning included confidential information. The confidential information is replaced by pseudo information.

The planning and assembly of semi-automatic pallet wrappers process is given shape using the information presented by a sales support employee, a service and assembly coordinator and two warehouse employees. This process shows how semi-automatics are planned and assembled. This assembly process takes place in Waalwijk.

The process starts as soon as there is a semi-automatic pallet wrapper sold and ready to be planned for assembly. Order information is stored in ERP and in the M:Drive. Though, the information in the M:Drive is more elaborate. The planning is also stored in the M:Drive. Thus, information is manually transferred to the M:Drive. The production planning is completed in agreement with warehousing.

The completed production planning is used daily to check what has to be done. The production of a pallet wrapper is as follows: a turntable and column are assembled to one wrapper. Then, additional options are assembled. Next, the work orders created in Excel are printed and saved in a green folder. Then, the status of the order is changed to “in progress” and a pick order is made in the ERP system based on the sales order. The parts picked are manually booked out of the inventory, excluding the column and turntable. At this point, the wrapper could be assembled. The status in the planning is updated when an assembly is finished. However, assembling a wrapper does not affect the stock positions since the newly assembled wrapper is not booked into the system. The column and turntable, a basic machine, are purchased as one machine and thus saved in ERP as one product. The basic machine, which consists of a column and a turntable, used for the assembly remains in the inventory after assembly. The basic machine is booked out of the inventory at the day of delivery.

These set of steps result in inventory differences. Inaccurate quantities are shown at any time when reviewing stock positions. Moreover, there is no discrepancy in the system regarding assembled wrappers and un-assembled turntables and columns. The newly assembled wrapper is not booked into the inventory and the basic machine is not booked out of the inventory since it is used to assemble a new machine. Though, the optional parts are booked out of the inventory when picked.

3.2.2.3 Preparation outsourcing fully-automatic pallet wrappers

The choice has been made to not include the process description in the body of the thesis. Section 4.5 shows a selection of requirements based on requirements engineering. There were no requirements selected for this process. The process model and description can be found in Appendix F.

3.2.2.4 Purchasing and issuing spare parts Deventer and Waalwijk

This process takes place in both Deventer and Waalwijk. The process of purchasing and issuing spare parts in Waalwijk is shown in Appendix G. The process of purchasing and issuing spare parts in Deventer is shown in Appendix H. The information is gathered through information from three employees. One employee is responsible for the whole purchasing and issuing of spare parts process in Waalwijk, another employee is responsible for the purchasing and issuing of spare parts process in Deventer and the third employee is responsible for work preparation in Deventer and has many years of experience regarding the situation in Deventer. Moreover, the processes were modelled according to the same structure to make it easier to see differences between the processes.

The processes are quite similar. The processes start as soon as someone needs a spare part. This could be a customer or somebody else within the organisation. The process is created through the perspective of a customer. The process is almost completely similar when a part is ordered for another department. A sales order is created in the ERP system. The next step differs for both locations. Deventer creates a production order if an assembly part is required. Waalwijk does not use production orders.

The next step is the same for both locations. The parts should be purchased in case the parts are not available in the inventory using the purchase proposals in both ERP systems. Then, the sales order can be completed and sent to the customer.

The next step to determine the routing for both processes. There are two routes, the top one is always included in the process. The spare parts department in Deventer sends a message to warehouse staff that there is an order that needs to be filled. The spare parts department in Waalwijk sends a pick order to the warehouse staff. This pick order includes assembly parts. Thus, no production order documents the assembly of parts in this process. The other route is taken when there is a purchase order that should be received by the warehouse. The supplier should deliver the materials and the reception is done by the warehouse staff. Then, a quality and quantity check should be performed.

Finally, the two routes join when either a pick order or a notification is received. The facility in Waalwijk assembles based on the pick order and books parts out of the inventory when the parts are sent to the customer. The facility in Deventer assembles based on production orders and books parts out of the inventory when a pick order is generated.

3.2.2.5 Inventory management

The inventory management framework presented in Figure 7 will remain the guideline. The process information is gathered through many conversations with the management and employees. The finance and operations managers provided information regarding monitoring inventory. Work preparation, spare parts and warehousing employees provided information concerning the daily use of the inventory.

3.2.2.5.1 Inventory process

The inventory process includes some key tasks. These tasks are presented per location in combination with the responsible department and sub-process. Table 6 presents the overview:

Table 6: Key tasks inventory process

Sub-process	Department	Task (Deventer)	Task (Waalwijk)
Forecasting	Sales	- Predict sales semi-automatic pallet wrappers based on their expectation (monthly).	- The sales team is located in Deventer
Purchasing	Work preparation / spare parts	- Execute order proposals (weekly). Fill inventory to a minimum level. - Check every line for the order proposal manually since minimum inventory levels are not up to date. - Send purchase orders	- Execute order proposal (weekly), fill inventory below the minimum level to the maximum level. - Check every line for the order proposal manually since minimum inventory levels are not up-to-date. - Send purchase orders
Goods receipt	Warehousing	- Check quality and quantity. - Book parts in inventory with correct quality and quantity. Use partial receipt if quantity or quality of the order is below agreed with the supplier.	- Check quality and quantity. Book parts in inventory with correct quality and quantity. Use partial receipt if quantity or quality of the order is below agreed with the supplier.
Storage	Warehousing / spare parts	- Parts need to be sold and billed to the other location when parts are moved from one location to the other.	- Parts need to be sold and billed to the other location when parts are moved from one location to the other.
Goods issue	Warehousing	- Book parts out of the inventory when the pick order is generated.	- Book parts out of the inventory when parts are physically out of the inventory.

3.2.2.5.2 Monitoring inventory performance

The framework sketches multiple KPIs. However, inventory performance is hardly monitored at this moment. Total inventory value is the only variable that is checked since it is compulsory for completing the balance sheet. The management believes that this value is too high. Currently, inventory is discarded occasionally, to ensure lower inventory levels. The removal of inventory is based on the value of the inventory and the mutation date. Stock items with relatively old mutation dates are checked and removed from the inventory for instance. Though, the inventory database is contaminated and the selection is made manually.

At this moment, other KPIs than mentioned above are not used to monitor inventory performance. Thus, there are many options to improve on the situation given the inventory management framework presented in the theoretical framework.

4 TO-BE situation

The TO-BE analysis could be carried out through requirements engineering (Sommerville, 2005). This chapter should answer the following question for the sixth phase of the research cycle:

"What does Matco International require regarding the order management module in AFAS?

Requirement engineering is used to answer the research question. The requirements engineering cycle is shown in Figure 6 of the theoretical framework. This section will be divided into five sub-sections according to the phases of the research cycle. Section 4.1 describes the elicitation phase. Section 4.2 explains the analysis phase. Then, section 4.3 covers the validation. Section 4.4 covers the negotiation phase. Finally, section 4.5 covers the selection of requirements.

4.1 Elicitation

The elicitation phase is used to gather information about the system. The information should be translated into requirements. The first step is to identify the sources that should provide the information that is used to translate into requirements. The sources used to identify information for requirements are the same as the sources used to identify the processes.

The second step is to gather the information through the sources that were identified. The information is gathered through semi-structured interviews. The created AS-IS processes were used as input for the interviews. The processes were used to guide the interviewees and discuss what the problems and opportunities are of the given process. These interviews were recorded to ensure that all the information that is given can be used. The recorded interviews were analysed and the requirements were identified. Permission to record the interview is requested before the start of the interview. Moreover, the recordings are deleted after the review of the research to ensure the privacy of employees. The findings per interview are described in Appendix I.

4.2 Analysis

The information gathered through interviews should be translated into clear requirements. The characteristics presented by INCOSE are taken into account (Requirement Working Group, 2012).

The interviewees presented many statements that could be identified as requirements. However, some requirements did not have the implementation-independent characteristic. The implementation of one ERP system solves the problems that were only caused by using two ERP systems. These statements are:

- Only one CRM database should be used.
- Orders have to be stored in one ERP system.
- Internal billing should not take place.

These problems will most definitely be solved by implementing AFAS. Most of the other requirements that are identified are sorted per process.

4.2.1 General requirements

Some requirements are not bound to a single process. Overlap in statements presented in the interviews is identified and translated in requirements. This resulted in three requirements applicable to every sub-process:

- The standard of AFAS as presented in the AFAS section should be used as a guideline to shape processes.
- A plan for the evaluation of the implementation process should be created to ensure the quality of the system.
- A plan for the evaluation of future updates should be created to ensure the quality of the system.

These requirements are general. AFAS will be researched to ensure that the structure of AFAS is taken into account. Moreover, avoiding customization as much as possible is advised regarding the implementation of an ERP system (Esteves-Sousa & Pastor-Collado, 2000). The other requirement is also mentioned a couple of times. The requirement is in line with the "evaluation" critical success factor explained in the theoretical framework.

The next sections cover the requirements per process based on the information gathered through the interviews:

4.2.2 Sales process semi- and fully-automatic pallet wrappers

These are the requirements concerning the sales process of semi- and fully-automatic pallet wrappers:

- Cost estimates have to be stored in AFAS.
- Cost estimations have to be made in AFAS.
- Quotations should be generated in AFAS.
- Quotations should be sent through the AFAS system via e-mail.
- Memos linked to quotations must be available to store remarks regarding the quotation.
- The current quotation templates should be used in AFAS.
- Quotations have to be followed-up according to a fixed process.
- Order confirmation has to be sent by e-mail using AFAS.
- Documentation of the sales process should be done in AFAS per sales relationship to centralize the process in AFAS.
- AFAS has to offer filters based on orders, quotations and relationships.

There is a conflict regarding the quotation requirements. The requirements suggest quotation standardization since the quotations should be generated in AFAS and sent in AFAS. However, the current quotation templates offer more personalisation options than AFAS can offer.

4.2.3 Planning and assembly semi-automatic pallet wrappers

There are two requirements regarding the planning and assembly semi-automatic pallet wrappers:

- Planning has to be done using AFAS instead of using Excel sheets.
- Assembly should be documented in the system using production orders in AFAS.

4.2.4 Preparation outsourcing fully-automatic pallet wrappers

There are three requirements regarding the preparation of the outsourcing of fully-automatic pallet wrappers:

- The output of SolidWorks has to be used as input for the creation of production orders.
- The output of E-plan has to be used as input for the creation of production orders.
- Multiple attachments have to be attached to an order to complete the information that is sent to Alfa Las.

4.2.5 Purchasing and issuing spare parts in Deventer and Waalwijk

This process also has three requirements for solving problems concerning the current system:

- Production orders have to be included in the process when assembly parts are sold.
- Booking of parts out of the inventory should be done when parts physically leave the inventory.
- Inventory purchase should be done with purchase proposals according to one procedure for both locations.

4.2.6 Inventory management

Inventory management requirements are identified according to the inventory management framework. The requirements regarding daily use are mentioned in the other parts since these could be organized using order management. The requirements that are not covered are the requirements related to inventory management. These requirements are focused on monitoring inventory performance. KPIs were selected as a measurement method to identify performance. Thus, KPIs are linked to the requirements. The focus during the interview was on KPIs provided by the framework with specific attention to the top ten KPIs. The requirements are displayed in the left column of Table 7. The sub-inventory process is mentioned in the middle column and the KPI that fits the requirement and sub-process best is displayed in the right column. The sub-inventory process and the KPIs are identified according to the top ten KPI list and the inventory management framework itself.

Table 7: KPIs per requirement

Requirement	Sub-process	KPI
The quality of the forecasts created by the sale departments should be monitored.	Forecasting	- Forecasting interval - Forecasting accuracy
The lead time of purchase orders should be monitored.	Purchase	- Lead time
The management should be able to monitor supplier reliability.	Goods receipt	- Supplier too late deliveries - The number of partial deliveries per purchase order per supplier.
The value of the inactive inventory has to be measured.	Storage	- Inactive inventory value
The inventory value per storage location has to be measured.	Storage	- Inventory value per storage
The inventory turnover in general and per good has to be known.	Storage	- Inventory turnover
The quality of the minimum inventory levels should be measured.	Storage	- Difference inventory level and minimum inventory level.
The delivery reliability of Matco International towards its customers should be measured.	Goods Issue	- Order issue time - Goods issued too late

Some exceptions were made regarding the inventory management framework. The exceptions were requested by the management of Matco International since the KPIs fit the situation of Matco International. The KPIs that were not presented in the framework, but by the management are:

- **The number of partial deliveries per order.** Matco International accepts partial deliveries and does not register quality mismatches. Instead, the parts are not booked into the inventory and new parts are demanded. Thus, the number of partial deliveries per order could provide important information about the quality and reliability of the supplier in an objective manner.
- **Inactive inventory value.** The management of Matco International emphasized the importance of identifying the value of inactive inventory value. The management is interested in the value of inventory without inventory mutations for the past year. This is a problem that the management struggles with and therefore, they need to measure it.
- **Difference inventory level and minimum inventory level.** Minimum inventory levels will be used in AFAS. The difference in inventory and inventory minimum is a KPI that is presented in AFAS. The KPI measures the difference between the fixed inventory minimum and the current inventory in numbers or amounts of money. The KPI should show a negative difference if the actual inventory level is below the minimum level and a positive difference if the actual difference is above the minimum level. Matco International uses minimum inventory levels currently. However, these minimum inventory levels are estimated based on experience. Therefore, the quality of the minimum inventory levels should be monitored.

4.3 Validation

The validation phase is defined as the phase in which the requirements are checked with the sources. The sources are all employees within Matco International. Thus, the requirements are sent back to the interviewees to validate the requirements. Moreover, the requirements are checked by the business improvement manager ensuring the necessity of the requirements. Finally, the INCOSE guide presented characteristics to guard and validate the quality of the requirements (Requirement Working Group, 2012).

4.4 Negotiation

The final phase is negotiation. The negotiation phase is described as a phase in which the feedback of the validation phase is taken into account. The interviewees all agreed with the requirements. This could be explained through the structured approach of identifying requirements. An inventory management framework and the AS-IS processes were identified and used to structure the interviews. Missing requirements might be prevented in this way. Moreover, the interviews were recorded. Therefore, details were not missed when analysing the interviews. Furthermore, a reason for the agreement without negotiating was that the requirements were identified using the INCOSE guidelines. Finally, the agreement could be caused by confirmation bias of the interviewees since it is an interpretation of the information presented by the interviewees. However, the bias is considered given the structured approach. Though, it cannot be excluded completely. All in all, the requirements present the wishes and demands illustrated by the employees.

4.5 Selection

Selection is not part of the requirements engineering cycle. However, it is necessary to determine a selection of requirements due to time and scope limitations. This elicitation resulted in a large amount of information that is translated into requirements during the analysis phase. However, many requirements do not fit the scope of the project. The scope is defined as a combination of inventory management in general and order management in AFAS as presented in Figure 11. Not all

requirements fit the scope that is set in the description. Therefore, a selection has to be made. The selection of requirements is as follows:

1. The standard of AFAS as presented in the AFAS section should be used as a guideline to shape processes.
2. Planning has to be done using AFAS instead of using Excel sheets.
3. Assembly should be documented in the system using production orders in AFAS.
4. Production orders have to be included in the process when assembly parts are sold.
5. Booking of parts out of the inventory should be done when parts physically leave the inventory.
6. Inventory purchase should be done with purchase proposals according to one procedure for both locations.

The requirements are linked to the scope as shown in Figure 12:

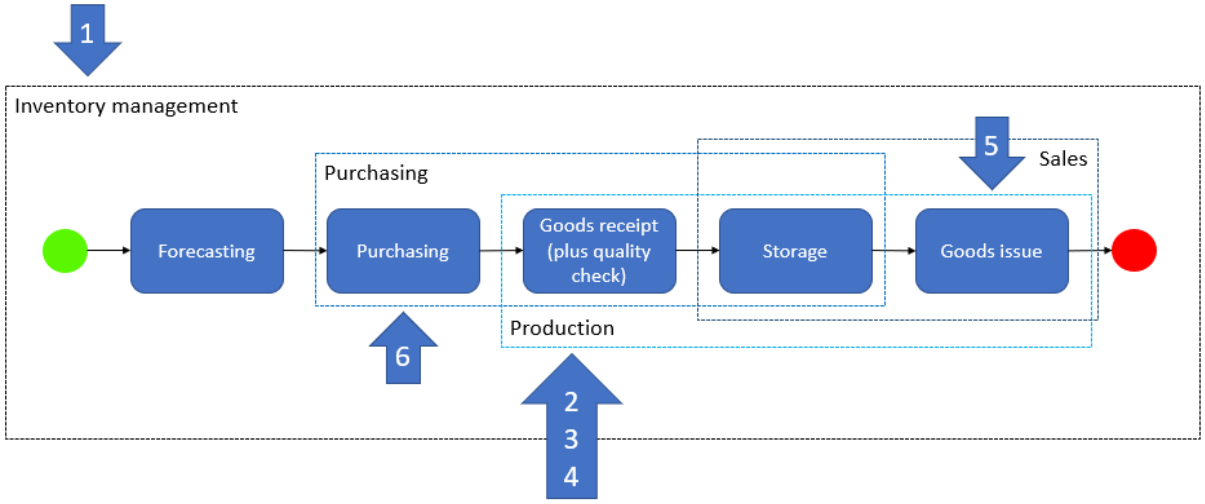

Figure 12: Link requirements and scope

The first requirement acts as a guideline and applies to the complete implementation of inventory management in AFAS. The second, third and fourth requirement apply to the production process. The planning reserves parts and mentions underlying parts and production orders could document reservations, issue of underlying parts and the receipt of the new assembly. The fifth requirement influences stock positions since it concerns the moment of issuing goods in ERP. Finally, the sixth requirement is included since it influences the inventory process by purchasing parts.

These requirements apply to the planning and assembly of semi-automatics process and the purchasing and issuing of spare parts processes. Therefore, only these processes will be re-engineered. The requirements regarding the sales process of semi- and fully-automatic pallet wrapper are mainly related to the quotation process. Moreover, the requirements of the preparation of the outsourcing of fully-automatic pallet wrappers are related to the input that SolidWorks and E-plan present. These are not included in the scope as shown in Figure 12.

Finally, the identified KPIs will also be taken into account, except for the KPIs linked to the forecasting phase of the inventory management framework. Forecasting is not part of the order management module. Forecasting is part of the CRM module. Thus, it is not within the scope of this project.

5 AFAS software

AFAS is a Dutch company developing business software. The AFAS ERP software consists of multiple modules. This research focusses on the order management module as presented in the introduction. This chapter should present an answer to the following research question as a part of the sixth phase of the research cycle:

"What are the constraints and opportunities for Matco International's inventory management in AFAS?"

The order management module should be analysed to identify the structure of the ERP system regarding order management and business intelligence. The knowledge regarding AFAS is obtained through training sessions organised by AFAS consultants and using the AFAS test environment. Section 5.1 discusses the basic structure of inventory management concerning AFAS, section 5.2 explains the use of order proposals within AFAS and finally, section 5.3 discusses the possibilities regarding monitoring inventory performance in AFAS.

5.1 Inventory management

ERP systems offer modules to manage inventory as mentioned in section 2.1.1. AFAS does offer a module that could be used to model inventory management. Inventory management is incorporated into the order management module. The inventory process has a fixed structure in AFAS. This structure is shown in Figure 13:

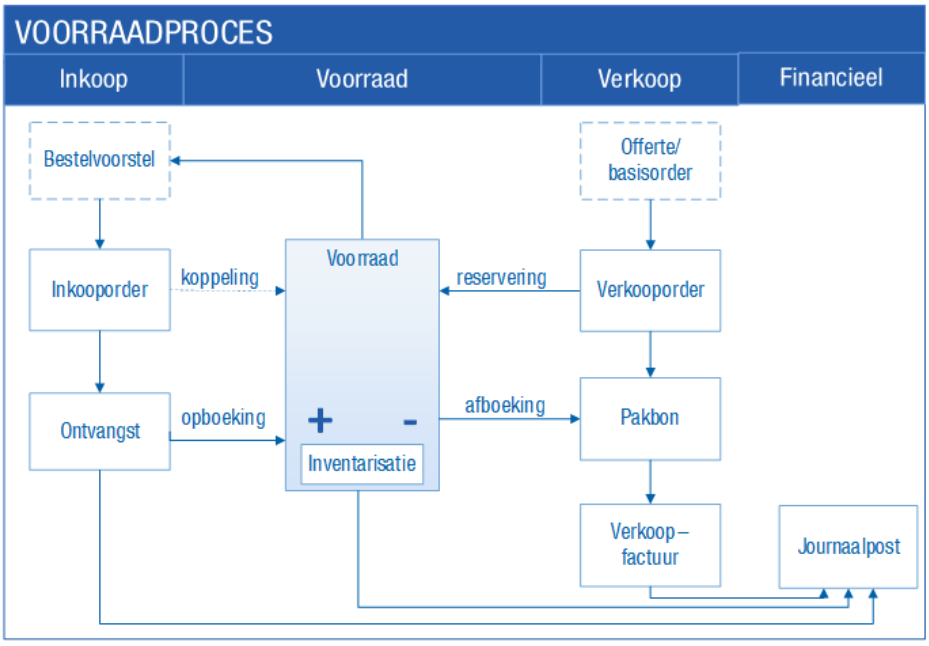

Figure 13: inventory process structure AFAS (source: AFAS training)

A comparison between this process and the inventory management process presented in the theoretical framework should be done to determine similarities and differences:

- **Forecasting.** The theoretical framework mentions forecasting as the start of the inventory management process. Inventory forecasting is not an option in order management as AFAS suggests. Forecasting is part of the CRM module and therefore not part of the scope of this project.
- **Purchasing.** The purchasing process in AFAS is almost completely managed through purchase proposals. Though, it is possible to create orders without using purchase proposals. The

purchase orders are linked to the inventory. The link is made through an “in order” classification. The ordered parts are recorder in the inventory as “in order”. The purchasing process is completely available in AFAS. A purchase order is completed in order management when the receipt is confirmed in the system. The process transfers to the financial module for invoicing.

- **Goods receipt.** The receipt of goods can be executed in AFAS. The function “receipt” offers the option to book parts into the inventory in a structural way. The parts are removed from “in order” and added to the physical inventory. There are no options to document the quality check and the results of it directly. It is not included in the AFAS standard.
- **Storage.** The theoretical framework states that the storage process consists of recording, storing and moving. Recording is the main task of an ERP system. Moreover, moving items from one storage to another is executed easily. AFAS offers a transfer option in the order management module. Furthermore, expeditions are also possible to check whether the online storage is in line with the physical storage. Differences are documented and linked to the finance module in AFAS.
- **Goods issue.** The issuance of goods is based on a sales order. The order reserves the sold goods. The pick order books the reserved parts out of the inventory. Invoices can be generated based on the completed pick orders. Moreover, issuance of goods could also be necessary for the assembly of parts. The assembly parts enter the process in the goods receipt phase. The difference is that production bills are used instead of receipts. Production is discussed elaborately in the next section.

The receipts, expeditions and invoicing are linked to the finance modules and are journalised in AFAS.

5.2 Purchase proposals and production proposals.

Purchase proposals and production proposals are tools presented by AFAS to automize purchasing parts, maintaining correct inventory levels and documenting the process. First, inventory profiles are discussed to provide insight into purchase proposals. Then, production proposals are discussed.

Inventory profiles should be discussed to understand the role of order proposals within AFAS. The profiles cover different settings that are used to manage inventory. The different profiles are presented in Table 8:

*Table 8: Inventory profiles (*Voorraadprofiel voor controle artikel voorraad - AFAS Help Center*, n.d.)*

Inventory profile	Description	Inventory check	Inventory replenishment	Order proposal	Allocation
Always inventory	No monitoring in sales process, purchasing through order replenishment.	No	Yes	No	No
High turnover rate/ purchasing in bulk	Monitoring through pick order, purchasing through inventory replenishment.	Inventory control on free inventory (pick order)	Yes	No	No
Order in case of shortage	Monitoring inventory in sales order and pick order. Deliver free inventory. Purchase and allocate inventory shortage using purchase proposal.	Inventory control on free inventory (sales order and pick order)	No	Yes, through Rest	Automatically for sales orders, also for backorders
Small inventory, large order quantities direct order	Monitoring inventory in sales order and pick order. Choice in sales order to deliver free inventory or purchasing through inventory proposal including allocation.	Inventory control on free inventory (sales order and pick order)	Yes (to be sure)	Yes, through Question (independent of shortage)	Automatically for sales orders, not for backorders
Never in inventory	Monitoring inventory in sales order and pick order. Order the sales order line always through order proposal, allocate purchase order to sales order.	Inventory control on free inventory (sales order and pick order)	No	Yes, always complete order line	Automatically for sales orders, not for backorders

The first characteristic is inventory check. Inventory check checks free inventory. Free inventory is the number of parts in inventory subtracted by the number of parts reserved for production or sales. The order proposal characteristic is dependent on the inventory check when generating a sales order. The inventory check characteristic is directly related to the order proposal characteristic. In this case, the order proposal characteristic is specifically directed towards the link with a sales order. The inventory check when generating a pick order does not influence the order proposals. There are three ways to generate an order proposal based on the sales order. The first is to propose to purchase the rest value. The rest value is the number of parts necessary to maintain the minimum inventory value. The second option is to ask a question regarding the order proposal every time a part is sold. Then, the user has to determine whether an order proposal is used. The final option is that all the parts of a sales order are added to an order proposal, without question.

Next, inventory replenishment is the other characteristic that influences the use of order proposals. The difference with the order proposal is that the order proposal is linked to sales orders. The inventory replenishment is not based on sales orders, thus the order proposals could be generated anytime. The inventory replenishment is based on the minimum inventory levels and the replenish to level. An order proposal line is generated when the inventory level of a part falls below the minimum inventory level.

Finally, there is the allocation characteristic. It reserves parts by linking orders to each other.

The importance of inventory profiles in combination with sales orders is explained. However, the production orders should be discussed as well. The interaction between production orders and order

proposals is the same. Therefore, the inventory profiles also hold for assembly parts that created through production orders. The inventory checks, replenishments, order proposals and allocations are actions in this case designed to monitor the inventory of the underlying parts. Production is an activation within AFAS. It is not always used within the order management module. The activation is useful in the case of Matco International. The facility in Waalwijk assembles semi-automatic pallet wrappers and the facility in Deventer already uses production orders in Isah to prepare for outsourcing. The general inventory management process remains the same. The difference is that a production order is added in between the sales orders and production orders. The links between sales orders, production orders, purchase orders and the inventory are shown in Figure 14:

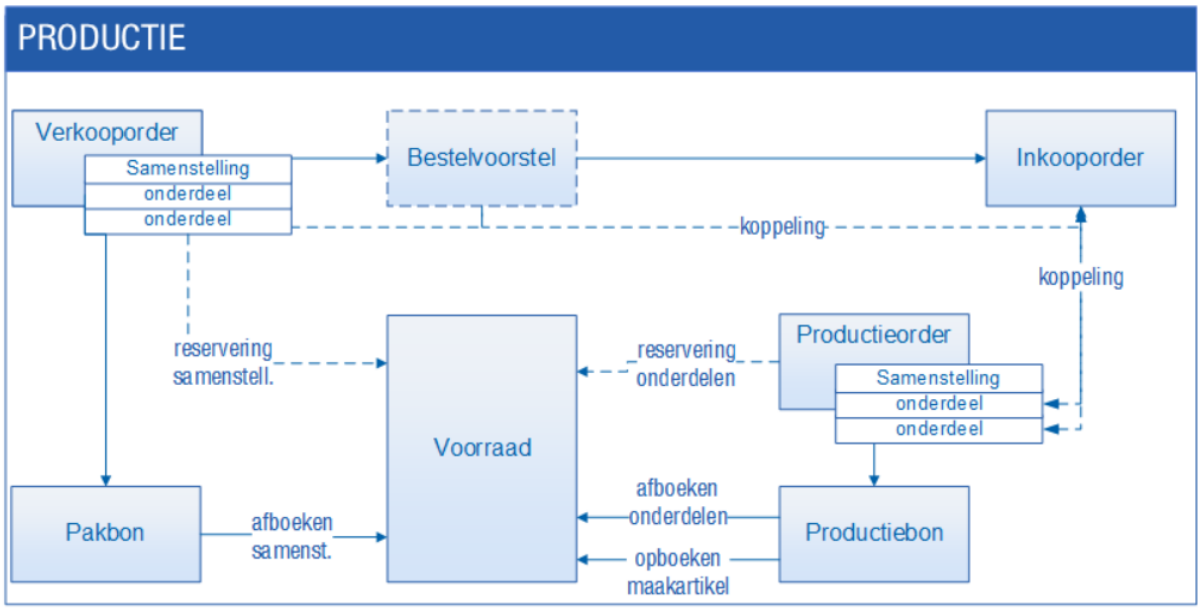

Figure 14: Production, sales and purchasing overview (Productie - AFAS Help Center, *n.d.)*

Figure 14 presents the links between orders and how they interact with the inventory. It will provide useful information when redesigning the business processes of Matco International. The links between orders provide important information concerning the sequence of tasks in these processes. The production proposal is missing in Figure 14 to clarify the links between sales, production and purchasing. The production proposal functions the same as a purchase proposal based on a sales order. Moreover, there is a link between production orders and purchase orders through the purchasing proposal. Thus, the inventory profiles should also be determined for assembly parts.

All in all, an inventory profile should be identified before business processes are reengineered. The sequence of tasks is different for instance when using the inventory checks instead of inventory replenishment for generating order proposals and production proposals. For instance, inventory checks might result in executing order proposals in the order process, while inventory replenishment does not invoke order proposals.

5.3 Monitoring inventory management

AFAS stores a large amount of data in their system. This data should be used effectively and translated into knowledge. AFAS offers multiple options to transfer data into knowledge. This section discusses the option to create reports and analyses, use dashboards and apply GetConnectoren. These could be used to monitor inventory. Reports and analyses were analysed. However, reports and analyses are not useful. Therefore, the assessment of reports and analyses is presented in Appendix J.

5.3.1 AFAS Dashboards

There are five dashboards available for the order management module. Every dashboard has its own set of KPIs and filters. The five dashboards are:

- Actual inventory
- Inventory
- Sales
- Sales turnover
- Purchasing

The dashboards present multiple KPIs and filter options. These are categorized within worksheets in the dashboard. These KPIs per worksheet in combination with filter options are shown in Appendix L. Then, screenshots of the figures will be included in Appendix K to show how KPIs are visualised. The AFAS help pages provided information on the visualisation of the dashboards. The sales and purchasing dashboard were illustrated using an overview of a complete worksheet. The actual inventory, inventory and sales turnover dashboard were illustrated using single graphs. These worksheets and graphs provide insight into the visualisation options of AFAS. The KPIs and filter options provide information in the performance measurements presented by AFAS. The overview of the different KPIs will be used when processing the data, which is executed in the seventh phase of the research cycle.

5.3.2 GetConnectoren

The final option is to retrieve data and analyse it in a self-created dashboard through for instance Power BI or Excel. GetConnectoren offer the option to integrate AFAS with external applications. The external applications receive real-time data. AFAS presents the following advantages:

- The connectors are maintenance-free since it is a standard function within AFAS.
- The retrieved data is real-time.
- The connectors offer a solution to the integration of multiple software solutions.
- The data transfer is quick and quantitative.

AFAS also offers the option to create GetConnectors. The connectors are always linked to one data collection. Multiple connectors should be used if multiple data collections are used. Furthermore, AFAS offers the possibilities to add “vrije velden” to increase the size of data collections. Columns could be added to data collections using the “vrije velden”. Thus, data could always be retrieved when it is stored in the system. This data could then be analysed by an external application.

The GetConnectors are operated using APIs (*REST API voor ontwikkelaars - AFAS Help Center*, n.d.). API is an abbreviation of application programming interface. An API copies files from one location to another. The function can be used by anyone after implementation. Moreover, REST (representational state transfer) is used to ensure that APIs can be used (*REST API voor ontwikkelaars - AFAS Help Center*, n.d.). REST is a software architectural style that allows web services to link to software programmes.

6 Business process re-engineering

This chapter will identify what requirements can be fulfilled and what requirements cannot be fulfilled. The seventh phase of the research cycle, processing the data, is fulfilled in this chapter. Much data is gathered in chapter 3 until chapter 5. The data can be processed to answer the following question:

"Which requirements could be fulfilled through the implementation of AFAS?"

The following sections should present an answer to the research question. Section 6.1 presents inventory profiles since these are necessary for BPR. Then, section 6.2 assesses the required KPIs. KPIs should be taken into account when re-engineering processes if the data for the KPIs is not stored in AFAS. Furthermore, section 6.3 presents the redesigned processes. Next, a demo is discussed in section 6.4 to validate the processes in section 6.3. Finally, section 6.5 will conclude this chapter.

6.1 Inventory profiles

Inventory profiles are an essential part of the processes as explained in the AFAS section. The identified inventory profiles are shown in Table 8 in the AFAS section.

First of all, it is impossible to determine an inventory profile for every part in the inventory database of Matco International due to time limitations. A solution could be to divide the inventory into inventory groups. The inventory of Matco International could be divided into three groups. The first group consists of the underlying parts for the assembly of semi-automatic pallet wrappers. The second group consists of finished semi-automatic pallet wrappers. Finally, the third group consist of spare parts. There is no group related to fully-automatic wrappers since these wrappers are outsourced and purchasing is done per project. Fully-automatic pallet wrappers are not stock-keeping units. Parts that are necessary for the service and maintenance of fully-automatic wrappers are included in spare parts.

The purchasing of the sub-assembly parts of the semi-automatic pallet wrappers is based on forecasts. Lead times of semi-automatic pallet wrappers are around two months. Therefore, it is required to have semi-automatic pallet wrappers in stock. The first inventory profile "always inventory" fits well. The always inventory profile will only use the inventory replenishment option, to ensure that the inventory is always maintained. Moreover, it could be combined with the sales forecast to ensure correct inventory levels. The other options are not included in this profile. Moreover, a discrepancy should be made regarding finished machines and spare parts. Assembled machines should be delivered to the customers directly, therefore the inventory profile never in stock fits best. This profile is in contrast with the profile of the underlying parts, the underlying parts should always be in stock and the assembled machines not. Thus, this inventory group has two different inventory profiles.

The other inventory group consists of spare parts. The goal of the management is to decrease inventory levels. Currently, the spare parts department often adds the sold parts to the order proposal to purchase parts based on a sales order as seen in Appendix G and H. This fits the "direct purchasing" profile perfectly. Moreover, this inventory group fits "small inventory" as well. The goal of the management is to maintain small inventories for emergencies. The "direct purchasing" and "small inventory" profiles have the same characteristics. Free inventory, which is the inventory that exceeds the minimum inventory and is not reserved for sales, is checked when generating a sales order or a pick order. The inventory check for the pick order is merely done to check whether the to be picked parts are actually in the inventory. The inventory check when generating a sales order is done to link the user to the purchase proposal. This inventory profile will always ask a user whether an order proposal should be invoked.

6.2 KPIs

One of the goals of this research is to identify KPIs that will help the management with their strategic decision making. The TO-BE analysis discovered a set of requirements in combination with KPIs that fit the requirements. The forecasting KPIs were not selected since these KPIs are not part of the order management module. The selected KPIs are displayed in Table 7. Moreover, a column is added. This column discusses whether the KPIs or the information to calculate the KPIs is documented in AFAS. Appendix L is used to check whether KPIs are available.

Table 9: KPI assessment

Requirement	Sub-process	KPI	Available in AFAS?
The lead time of purchase orders should be monitored.	Purchase	- Lead time	- Available, the purchasing dashboard offers order lead times with multiple filter options.
The management should be able to monitor supplier reliability.	Goods receipt	- Supplier too late deliveries - Average number of partial deliveries per purchase order per supplier.	- Available, the purchasing dashboard measures too late deliveries per creditor, which is a supplier. - Not available, completeness of orders is available in the purchasing dashboard though. Completeness of orders is measured as a percentage of orders per receipt.
The value of the inactive inventory has to be measured.	Storage	- Inactive inventory value	- Not available. The inactive inventory value is not shown.
The inventory value per storage location has to be measured.	Storage	- Inventory value per storage	- Available, the actual inventory dashboard shows the inventory per the warehouse.
The inventory turnover in general and per good has to be known.	Storage	- Inventory turnover	- Available, inventory turnover is shown in the inventory turnover dashboard.
The quality of the minimum inventory levels should be measured.	Storage	- Difference inventory level and minimum inventory level.	- Available, difference inventory level and minimum inventory level is shown in the actual inventory dashboard.
The delivery reliability of Matco International towards its customers should be measured.	Goods Issue	- Order issue time - Goods issued too late	- Available, average delivery time is offered by the sales dashboard. This is the pick order date minus the order date. Thus, it is the same. - Available, goods issued too late is displayed in the sales dashboard.

Many of the KPIs requested by the management are available in AFAS, except for two. The average number of partial deliveries per order per supplier is not available and the inactive inventory value is not available. Therefore, these two should be operationalized. The other KPIs are already operationalized in AFAS. Thus, the information necessary for the operationalisation should be identified.

The first KPI is simple, the information necessary is to display each partial delivery in combination with an order number has to be known. Receipts are documented in AFAS as presented in Figure 15:

Ontvangstnumı	Datum	Inkooprelatie	Referentie inkoopre	Bijbehorende inko	Status	Totaal excl. btw	Totaal incl. btw	Valuta	Betaalvoorwaar	Administratie	Magazijn
04548	09-06-2020	Technische Unie		01706	Actief	40,00	48,40	EUR	21	EnYoi ICT Services B.V.	Magazijn Amersfoort
04549	09-06-2020	Technische Unie		01706	Actief	80,00	96,80	EUR	21	EnYoi ICT Services B.V.	Magazijn Amersfoort
04550	09-06-2020	Technische Unie		01706	Actief	80,00	96,80	EUR	21	EnYoi ICT Services B.V.	Magazijn Amersfoort
04547	09-06-2020	Technische Unie		01705	Actief	600,00	726,00	EUR	21	EnYoi ICT Services B.V.	Magazijn Amersfoort
04546	09-06-2020	Groothandel Micro B.V.		01704	Actief	940,00	1.137,40	EUR	30	EnYoi ICT Services B.V.	Magazijn Amersfoort
04544	09-06-2020	Groothandel Micro B.V.		01703	Actief	1.650,00	1.996,50	EUR	30	EnYoi ICT Services B.V.	Magazijn Amersfoort
04545	09-06-2020	Groothandel Micro B.V.		01703	Actief	600,00	726,00	EUR	30	EnYoi ICT Services B.V.	Magazijn Amersfoort
04543	08-06-2020	Groothandel Micro B.V.		01702	Actief	1.135,00	1.373,35	EUR	30	EnYoi ICT Services B.V.	Magazijn Leusden

Figure 15: Database with receipts (source: AFAS test environment)

A database filter is used to filter on purchase order numbers. Every purchase order number is linked to at least one receipt if the warehouse received goods and to a supplier. The number of partial deliveries is the number of times a purchase order is mentioned in the system. For instance, the upper three purchase orders are related to one purchase order and one supplier, meaning that the purchase order is completed in three partial deliveries. Thus, the KPI can be calculated according to the following formula:

$$Average\ number\ of\ partial\ deliveries\ per\ supplier = \frac{Number\ of\ receipts\ per\ supplier}{Number\ of\ purchase\ orders\ per\ supplier}$$

The second KPI is the total value of inactive inventory. First, it is important to determine when stock-keeping units are inactive. The management stated in the interview that inventory is inactive when it is in inventory for a year without inventory mutations. AFAS does not offer an overview of every part in combination with the latest mutation date. Thus, parts should be linked to a mutation date in AFAS. These mutation dates must be based on receipts, completed pick orders or completed production orders. The AFAS section concluded that completed pick orders and receipts are journalised financially. Figure 13 shows that receipts and completed pick orders influence stock positions and the financial position due to the journalised receipts and pick orders. Therefore, mutation dates must be stored somewhere in AFAS. The mutations might be registered in the financial module. However, the demo does not offer the integration between the financial module and order management module. Thus, mutations are not registered in this module. Next, consulting individual stock-keeping units resulted in an overview of mutations as presented in Figure 18:

Mutaties

Mutaties 34 Regels

Datum	Type mutatie	Ordertype	Nummer	Locatie	Code	Item	Aant.	Eenheid
09-06-2020 15:28	Verbruik	Productieorder	00020	Standaard locatie	A10002	Kolom	-7	Stuks
09-06-2020 15:28	Verbruik	Productie	00006	Standaard locatie	A10002	Kolom	7	Stuks
09-06-2020 13:51	Verbruik	Productieorder	00018	Standaard locatie	A10002	Kolom	-3	Stuks
09-06-2020 13:51	Verbruik	Productie	00005	Standaard locatie	A10002	Kolom	3	Stuks
09-06-2020 11:14	Inkoop	Ontvangst	04546	Standaard locatie	A10002	Kolom	8	Stuks
09-06-2020 11:14	Inkoop	Inkooporder	01704	Standaard locatie	A10002	Kolom	-8	Stuks
09-06-2020 11:13	Inkoop	Ontvangst	04545	Standaard locatie	A10002	Kolom	12	Stuks
09-06-2020 11:13	Inkoop	Inkooporder	01703	Standaard locatie	A10002	Kolom	-12	Stuks
09-06-2020 11:13	Inkoop	Ontvangst	04544	Standaard locatie	A10002	Kolom	18	Stuks
09-06-2020 11:13	Inkoop	Inkooporder	01703	Standaard locatie	A10002	Kolom	-18	Stuks
09-06-2020 11:13	Inkoop	Ontvangst	04544	Standaard locatie	A10002	Kolom	-18	Stuks
09-06-2020 11:13	Inkoop	Ontvangst	04544	Standaard locatie	A10002	Kolom	6	Stuks
09-06-2020 11:13	Inkoop	Inkooporder	01703	Standaard locatie	A10002	Kolom	12	Stuks
08-06-2020 16:01	Inkoop	Inkooporder	01704	Standaard locatie	A10002	Kolom	8	Stuks
08-06-2020 15:59	Verbruik	Productieorder	00021	Standaard locatie	A10002	Kolom	4	Stuks
08-06-2020 15:59	Verbruik	Productieorder	00020	Standaard locatie	A10002	Kolom	7	Stuks
08-06-2020 15:50	Verbruik	Productieorder	00019	Standaard locatie	A10002	Kolom	2	Stuks
08-06-2020 15:50	Verbruik	Productieorder	00018	Standaard locatie	A10002	Kolom	3	Stuks

Figure 16: inventory mutations per article (source: AFAS test environment)

Figure 16 shows that the mutations are stored per part. Thus, every article has a mutation date. Therefore, it is possible to retrieve the article numbers with mutation dates. The data is stored in the leftmost column and sorted based on the latest mutation date first. Every part must have a fixed price in the system. Then, the value of inactive inventory can be calculated according to the following formula:

$$\text{Inactive inventory value} = \sum_{i=m}^{n} Total\ inventory\ value\ of\ a\ SKU$$

$$m = Lowest\ selected\ article\ number$$

$$n = Maximum\ selected\ article\ number$$

All in all, the information to determine both KPIs is available in AFAS. Moreover, the conclusion is made in the AFAS section that KPIs could be identified when the information for these KPIs is available. Thus, there is no need for extra documentation in AFAS when executing one of the two business processes. The standard of AFAS could be maintained completely, which is in line with the literature provided by Esteves-Sousa & Pastor-Collado, 2000. The next step for Matco International should be to invest time in the data transfer and visualisation using for example Power BI.

6.3 Business process re-engineering

The information necessary to start the business process reengineering is gathered. It is concluded that all the information to measure the KPIs is available in AFAS. Therefore, no additional information should be registered during the process. AFAS standards can be attained. Moreover, inventory profiles are discussed since the profiles influence the purchasing process. The processes that are reengineered are the processes selected in the selection section in the TO-BE chapter. The selected processes concern the purchasing and issuance of spare parts process and the planning and assembly of semi-automatics process. The inventory management process is, as mentioned before, covered in the requirements related to the processes. Moreover, the information stored in AFAS is sufficient to calculate the KPIs as soon as AFAS will be used.

One CSF must be taken into account when re-engineering the processes. The CSF concerns avoiding customisation (Esteves-Sousa & Pastor-Collado, 2000). This is also one of the requirements identified in the TO-BE chapter. Thus, AFAS should be used as a guideline. The demo in section 6.4 shows that the standard of AFAS is maintained.

6.3.1 Purchasing and issuance of spare parts.

The re-engineered version of the purchasing and issuance of spare parts process can be found in Appendix M. The process in Deventer and Waalwijk are unified into one process since one ERP system will be used. Thus, documentation should be the same to prevent system pollution. The AS-IS situation should be considered. Moreover, the AFAS standards must be used as a guideline. Finally, the requirements created in the TO-BE analysis have to be implemented. This results in the following requirements applicable to this purchasing and issuance of spare parts process:

- Assembly should be documented in the system using production orders in AFAS.
- Booking of parts out of the inventory should be done when parts physically leave the inventory.
- Inventory purchase should be done with purchase proposals according to one procedure for both locations.

Two of these requirements are fulfilled as presented in Appendix M. The process starts with a sales order that should be created when a customer requires a part. The lines of the sales order are copied to the purchase proposal if the user answers the purchase proposal question of AFAS with a “yes”. Then, the sales order can be mailed directly to the customer by AFAS. Next, the production orders are automatically generated using production proposals. The production proposal recognizes stock positions and the requested sales order. Production proposals should be approved when presented. Subsequently, purchase proposals can be generated. The purchase proposal function knows what is requested by production dependent on the inventory profiles. In this case, spare parts have the “small inventory” profile. Thus, the purchase proposal function proposes to order the parts that are approved in the sales order and the parts which inventory level is below the minimum inventory level since there is a link with the sales order and inventory replenishment is activated. Accept the purchase proposals if presented and AFAS will generate the purchase orders. E-mail the purchase orders using a button presented by AFAS.

The next step is to check the inventory levels of the parts sold in the sales order. Inventory values are shown when clicking the parts in the sales order in AFAS. This is necessary for the process to know what steps remain. The second inclusive gateway determines the flow. There are three options, the first is to loop the events of receiving a purchase order, the second is the delivery of a sales order and the third is quitting the process. The first option is activated when there is a purchase order to be received. The process will loop and return before the inventory check. The second option is activated when the inventory levels are high enough to deliver the sales order, this could happen simultaneously with the receipt of new parts. Therefore, there should be an option to exit the process since the sales order might be completed during the receipt of the goods. Then, the third option is activated.

The receipt of purchased goods starts for Matco International with a quality check. The receipt function linked to the purchase order is used to document the receipt. However, there is a possibility that the order is partially delivered or the quality is not as agreed. Then, the parts that are delivered with a good quality level are booked in the inventory and the complaint is processed. The complaint is processed without the use of an ERP system, AFAS does not offer the option to monitor the quality of received goods as shown in the AFAS section. Both facilities handle complaints differently as shown in the AS-IS analysis. The difference does not influence the documentation of the process. Therefore, the ERP procedures for each facility will remain the same. In the end, the purchase order is completed by documenting the final partial delivery. Finally, the process loops back to the inventory check since this can be performed simultaneously with the issuance of spare parts.

The issuance of spare parts starts by notifying the warehouse if necessary. Firstly, it has to be checked whether a part has to be assembled. Then, a production bill could be generated using AFAS given the production order. The production bill could be generated when the assembly is completed. Then, the underlying parts are booked out of the inventory and the assembly is booked into the inventory. The final steps are to generate a pick order based on the sales order. Then, the pick order is generated. Then, the parts required by the sales order can be gathered. Finally, the parts could be sent to the customer and the pick order could be completed to finish the sales order and make the sales order ready for the invoicing. Though, parts are booked out of the inventory when generating the pick order. Thus, the requirement at the second bullet point cannot be fulfilled. This is a constraint of AFAS.

6.3.2 Planning and assembly semi-automatic pallet wrappers

The re-engineered version of the planning and assembly of semi-automatic pallet wrappers is given in Appendix N. The planning and assembly of semi-automatic pallet wrappers presented in the AS-IS situation is re-engineered according to the standards and opportunities offered by AFAS and the requirements presented in the TO-BE analysis. The requirements that could be taken into account for this process are:

- Planning has to be done using AFAS instead of using Excel sheets.
- Assembly should be documented in the system using production orders in AFAS.
- Booking of parts out of the inventory should be done when parts physically leave the inventory.

The major change to the process is that every task could be executed in AFAS. Therefore, physical documentation and typing orders into the planning is not necessary. The process starts at the same point when a completed order is to be planned. Then, the sales order information had to be manually typed into the sales and production planning. However, the info could be transferred automatically using production proposals, since the semi-automatic pallet wrappers have the inventory profile “never in inventory”. The profile obliges AFAS to produce every semi-automatic sales order. Then the production order should be accepted resulting in automatically generated production orders. The overview of the different production order lines could act as a planning if the correct attributes of a production order are assessed. The demo section will show the display in AFAS, to validate that the attributes of the planning in Excel are shown in an AFAS overview.

The moment to discuss the planning remains the same. The outcome of the discussion is a date or week when the wrapper should be finished. Thus, this deadline should be added to the production order in combination with a mechanic responsible for executing the order. Updating a production order is executed through the booking layout in AFAS.

Then, the production staff should check the planning daily in AFAS. The warehouse staff starts assembly based on the planning. A production bill could be generated based on the production order when the assembly is completed. The bill will be stored in a new display. The parts necessary for the production will be booked out of the inventory and the assembly will be booked into the inventory, resulting in correct stock positions. Though, work-in-progress is not documented in AFAS. Thus, assembly parts that are currently used are not booked out of the inventory.

The assembled machine will remain in inventory until the day of transportation. Then, a pick order could be generated based on the sales order. The machine and additional items could be picked. Finally, the pick order should be completed as soon as the machine is sent to start the invoicing process.

6.4 Demo

A demo is presented to validate the models constructed in the previous section. Moreover, it can confirm whether the requirements regarding daily use set by Matco are met. The actions that are done in the ERP system are presented in chronological order. The actions are substantiated using screenshots of the AFAS software system. The demo includes the order management process and shows the production planning. Several steps had to be taken to adjust the demo to the situation of Matco International. These steps are shown in Appendix O. The AFAS demos are presented in Appendix P.

6.5 Conclusion

The goal of this chapter is to fulfil the selected requirements. The result is that all but one requirement can be fulfilled. AFAS is not available to generate a pick order and to wait with booking out parts until pick orders are completed. Moreover, the literature states that the standard of an ERP system should be maintained (Esteves-Sousa & Pastor-Collado, 2000). Therefore, the advice is to take the literary statement into account. Thus, the creation of workarounds is not recommended.

Furthermore, the KPIs are either displayed in AFAS or the data is available in AFAS for calculation. Therefore, no additional data has to be documented in AFAS in the business processes of Matco International. Moreover, the requirements regarding daily use could all be included when redesigning Matco International's business processes.

7 Conclusion, discussion and recommendations

This chapter consists of three sections. Section 7.1 covers the conclusion. The conclusion presents an answer to the problem statement given in the introduction, completing the research cycle. Section 7.2 discusses the limitations of the research and the interpretation of the results. Finally, recommendations for further research are presented in section 7.3.

7.1 Conclusion

This thesis should present a solution to the core problem. The core problem could be solved by answering the problem statement. Answering the problem statement is the final phase of the research cycle. The problem statement is:

"How can Matco International gain insight into the performance of their inventory management for Deventer and Waalwijk through the implementation of AFAS?"

Matco International can gain insight into the performance of their inventory management for both Deventer and Waalwijk by using KPIs as the selected performance measurement technique. General inventory management is identified in the theoretical framework. KPIs were selected according to the framework of Van Heck et al. (2010) and given the requirements of the management of Matco International. AFAS offers the opportunity to document the information necessary for the KPIs. Many KPIs are displayed in the AFAS dashboards. Thus, AFAS offers Matco the ability to gain insight into their inventory management performance.

There are remarks, AFAS should be implemented appropriately to gain the advantages mentioned above. Therefore, the ERP implementation process is analysed and the process is rushed since the AS-IS situation and the TO-BE situation were not analysed. Furthermore, six CSFs were not sufficient as described in Table 5. The theoretical framework shows that underperforming CSFs result in underperformance of the organisation (Talluri & Vasu Deva Reddy, 2019). The following CSFs require further attention by Matco International:

- Project team skills (Finney & Corbett, 2007)
- Experienced project manager (Finney & Corbett, 2007)
- Resources (Somers & Nelson, 2001)
- Cultural change (Finney & Corbett, 2007)
- Communication (Esteves-Sousa & Pastor-Collado, 2000)
- Evaluation (Finney & Corbett, 2007)

Moreover, the inventory-related processes should be aligned to the AFAS standards given the requirements offered by Matco International according to the re-engineered processes. Insight in inventory management can only be realised when the processes function properly in AFAS. The re-engineered processes shown in Appendix M and N should act as a guideline. Additionally, modelling the processes that interact with the inventory might grant insight into inventory management as well. Modelling the current situation already resulted in problems in the current processes. For instance, Deventer booked parts out of its inventory while these parts were not yet sent and Waalwijk did not document production, resulting in inventory differences. The newly designed processes prevent these mistakes, as shown in the demo.

7.2 Discussion

This research was subject to limitations. Limitations appeared due to time limits. The scope had to be maintained strictly due to time limitations. This resulted in the focus on the purchase and issuance of spare parts and the planning and assembly of semi-automatic processes. The sales of semi- and fully-

automatic pallet wrappers and work preparation could not be included since the requirements did not fit the scope.

Moreover, there were limitations concerning the use of the AFAS demo. First, the online AFAS environment that is used for the demo is a pseudo environment. Therefore, it is not designed specifically for Matco International. Some settings had to be changed as shown in Appendix O to resemble the situation of Matco International. Moreover, the dashboards were not activated. Therefore, not all the information given the dashboards could be shown in the dashboards itself. Dashboards representing the situation of Matco International could not be created since AFAS is still to be implemented for Matco International. Thus, creating dashboards should be included for further research.

Additionally, AFAS has no option to document work-in-progress. This means that underlying parts that picked out of the inventory are not booked out of the inventory when these are used for production. The parts remain in the production hall. The parts are booked out of the inventory when the production order is completed. Moreover, booking parts out of the inventory for a sales order is only done when generating a pick order. Therefore, generating a pick order and not booking parts out of the inventory is not possible. Though, Esteves-Sousa and Pastor-Collado (2000) state that the standard of an ERP system should be attained. Thus, this is a constraint of the system.

7.3 Recommendations

The first recommendation concerns the six insufficient CSFs shown in section 7.1. It is recommended to assess the evaluation CSF specifically since it is influenced by all CSFs according to Figure 7. For instance, it might be possible that another EPR system would have been chosen if the framework of Panayiotou et al. (2015) is used for the ERP selection process. Moreover, it can be evaluated whether the provided frameworks identified through a literature study offered the right guidelines for the ERP implementation and whether the estimated benefits will be achieved.

Secondly, further research should include integration with the other modules within AFAS. The scope of this research is only on order management. However, order management is linked to multiple other modules, like AFAS financial and AFAS projects. Thus, the integration is not taken into account for this research. Though, it is important to look at the bigger picture. Moreover, there are requirements presented in the TO-BE analysis that are not considered. These should also be taken into account by Matco International before the implementation is finished.

Additionally, many of the requested KPIs are already present in AFAS. However, two of the requested KPIs were not displayed as a KPI. Though, the information to calculate the KPIs is present in the system. Thus, a dashboard should be created for the two new KPIs when AFAS is implemented. The final step could be to gather all the KPIs and create one dashboard with the existing KPIs and the two new KPIs. GetConnectors and for instance Power BI could offer a solution to the creation of the dashboard. Then, the visualised KPIs should be monitored regularly to manage inventory in combination with experience and observations.

Finally, there are multiple effects on the core problem. The problem cluster sketches that a higher turnover rate is attainable. Thus, this could imply that there are too many parts in inventory. Moreover, the cluster states that there is no specific inventory management strategy chosen. The implementation of AFAS should result in better insight into inventory management. Thus, a strategy could be chosen based on the information presented in AFAS. Inventory policies and safety stock optimization for supply chain planning might present useful policies for Matco International (Brunaud et al., 2019).

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Appendix A: Assessment of the top ten CSFs

Table 10: Assessment of the top ten CSFs

Top ten CSFs	Description	Assessment
Project team skills	The project team should be comprised of the best and brightest individuals with a proven reputation and work full-time on the implementation (Finney & Corbett, 2007). Another important factor is whether the team knows the ERP system (Esteves-Sousa & Pastor-Collado, 2000). Thus, training might be required to ensure successful implementation. Finally, the team should be balanced. The team should consist of members across the whole organisation (Finney & Corbett, 2007).	The project team consists of people from different departments. Whether these people are the best and brightest is hard to determine. However, individuals are experienced and do have a proven reputation regarding their own processes. However, these individuals might lack the knowledge of AFAS. Thus, three individuals attended training sessions at AFAS to gather knowledge about the ERP system, including myself. These three individuals are expected to take the lead regarding the implementation. The major downside of the team is that not everyone can work full-time on the implementation.
Experienced project manager	The paper by Finney and Corbett calls this the “project champion”. This “project champion” should have strong leadership skills should be a skilled manager regarding the business, technical and personal perspective (Finney & Corbett, 2007).	The implementation project has two project managers, one internal manager and one external project manager. The external manager is the leading consultant and is skilled regarding ERP implementation. The internal project manager is managing business improvement at Matco International. Therefore, the ERP implementation fits perfectly within his responsibility. However, the internal project manager has no experience regarding the implementation of an ERP system. Though, the internal manager does have experience implementing other software systems.
Data analysis	The data analysis is related to the conversion and integrity of the data. Implementation success depends on whether the conversed data is accurate (Finney & Corbett, 2007). The garbage in, garbage out principle holds. The ERP system will not run optimally when the input data for the system is inaccurate.	The implementation team is aware of the garbage in, garbage out principle. Much data is imported from the old ERP systems to the new ERP system. This data is analysed before the import. Employees make a selection based on their experience. Forque, the consultants, delivers import sheets for the data transfer. Selections are made with the manager responsible for that department. The consultancy group is emphasizing this aspect and the import is not rushed.

Resources	Financial, human and other resources are used to implement an ERP system. Problems often occur regarding committing these resources to the implementation of a digital solution. Resource requirements need to be determined in the first phases of the project. Moreover, it should be taken into account that these resources often exceed initial estimates (Somers & Nelson, 2001).	Many members across the organisation are expected to be involved in the implementation project. However, there is no intern budget created for the implementation of the project regarding the resources. Though, there is a guideline presented by AFAS that gives an approximation of the hours that need to be invested. The number of working days an employee has to invest is eighty-one. It is the number of days that the consultancy company spends on the implementation multiplied by three.
Use of consultants	Third-party consultants could benefit the implementation process a lot as mentioned above. The use of consultants should depend on the internal know-how that the organisation has at the moment concerning ERP systems. (Esteves-Sousa & Pastor-Collado, 2000).	Third-party consultants are being used. The service of an AFAS partner company called Forque is used to guide Matco International with their ERP implementation.
Management support	Management support is essential for the implementation. The management can allocate important organisational resources (Esteves-Sousa & Pastor-Collado, 2000). Moreover, the implementation should be aligned with the strategic goals set by the management. Therefore, there should be support from the management to ensure that the set goals are reached (Esteves-Sousa & Pastor-Collado, 2000).	Management support is present. The manager business improvement is the internal project manager. He is aware of strategic goals and those are kept in mind. Moreover, the organisation is transparent. The transparency results in a clear overview of the goals of the implementation.
Cultural change	The ERP implementation could lead to cultural changes within an organisation. These changes should be managed. Change management strategies should be identified and used to implement the cultural change that results from the ERP implementation (Finney & Corbett, 2007).	Employees are involved to create implementation support. However, there is no change management strategy identified to consider when implementing an ERP system. However, the goal of the implementation is to decrease the number of differences between the facility in Deventer and the facility in Waalwijk. The facilities should have the same processes and use the same systems.
Cooperation	Interdepartmental cooperation appears to be critical, the involvement of multiple departments is essential (Somers & Nelson, 2001).	The project team consists of members across the whole organisation. Multiple departments are involved in the process. The project team includes members across the whole organisation. Moreover,

		meetings are planned to ensure cooperation.
Communication	Communication is important for all kinds of projects. Therefore, the implementation of an ERP system is no exception. There are two kinds of communication for these types of projects. There should be inward communication and outward communication (Esteves-Sousa & Pastor-Collado, 2000). Inward communication includes all the information received by the project team from people outside of the project team. Outward communication is the communication maintained with the outside world.	There is only a plan for communication with Forque. Forque presented a planning with the days that they are available for Matco. However, there is no communication plan within the organisation or the team. There has been one e-mail stating the start of the implementation, nothing more. Inward and outward communication is only used when information from someone outside of the project team is required. The structure should be added to the communication. Regular updates are not presented.
Evaluation	Evaluation within a project is essential for it to succeed. Feedback networks should be identified for the evaluation of a project (Finney & Corbett, 2007).	At this point, there is no plan for evaluation. Therefore, post-implementation evaluations should be planned. Moreover, it should be identified who is going to present the feedback.

Appendix B: BPMN explanation with legend

BPMN is a flow-chart diagram. A BPMN flow-chart has multiple standard characteristics (White, 2004):

- **Swimming pool and lanes.** The flow-chart is given shape using swimming pools with distinguished swimming lanes. The pool presents a process and lanes are used to categorize activities.
- **Flow objects.** The swim lanes are filled with flow objects. These flow objects are categorized in events, activities and gateways. Events are circle-shaped objects that affect the flow of the process, by starting, pausing or ending an event. Most of the times, events have triggers or impacts. Activities are rounded-corner rectangles. It represents an activity within a process. The final flow object is a gateway. A gateway is a diamond-shaped flow object that controls divergence and convergence within the flow, it could be used to model decisions or joining processes.
- **Connecting objects.** There are three types of connecting objects. The connectors operate as the skeletal structure of a model. The first connector is the sequence flow. It is displayed with a solid arrow. It represents the order of the activities. Message flows are displayed using a dashed line. It shows the flow of messages between swimming pools. The final connecting object is called association. The association is represented by a dotted line. This connector is used to link data and text to for example the flow objects.
- **Artefacts.** Artefacts offer extra flexibility. An example is a data object, displayed as a piece of paper with a folded edge. It shows data required for a task or transferred between tasks. Datastore are also artefacts, databases are the rounded boxes with a lid.

Figure 17 shows an example of a small flow-chart constructed using the BPMN method.

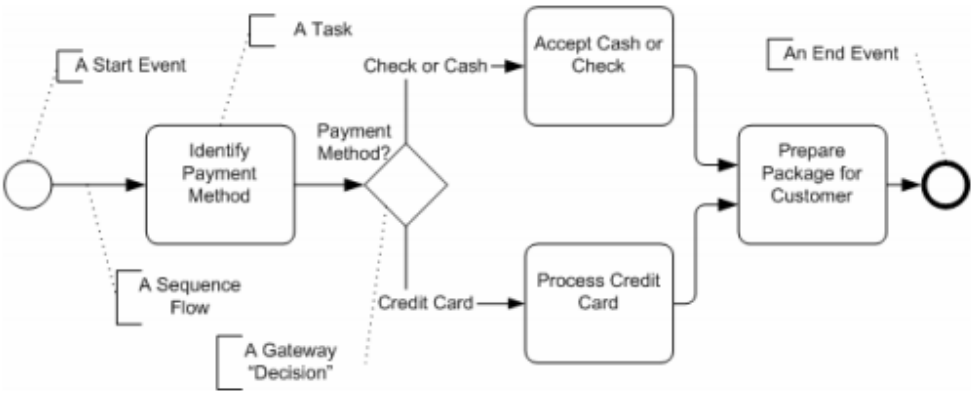


Figure 17: an example of a BPMN flow-chart (White, 2008)

The tool used to create the business process models is Bizagi. Figure 18 presents the legend of Bizagi.

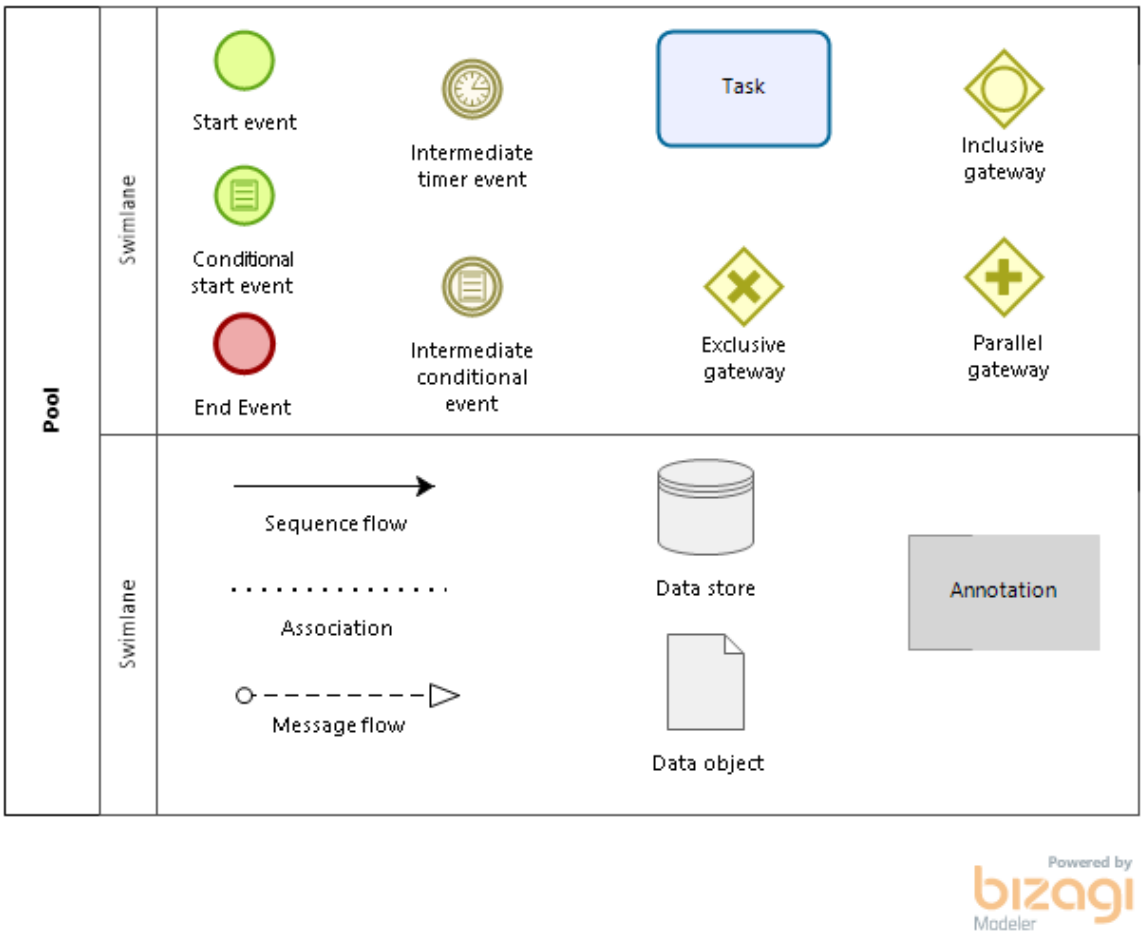


Figure 18: Bizagi BPMN legend

Appendix C: Sales of semi- and fully-automatic pallet wrappers

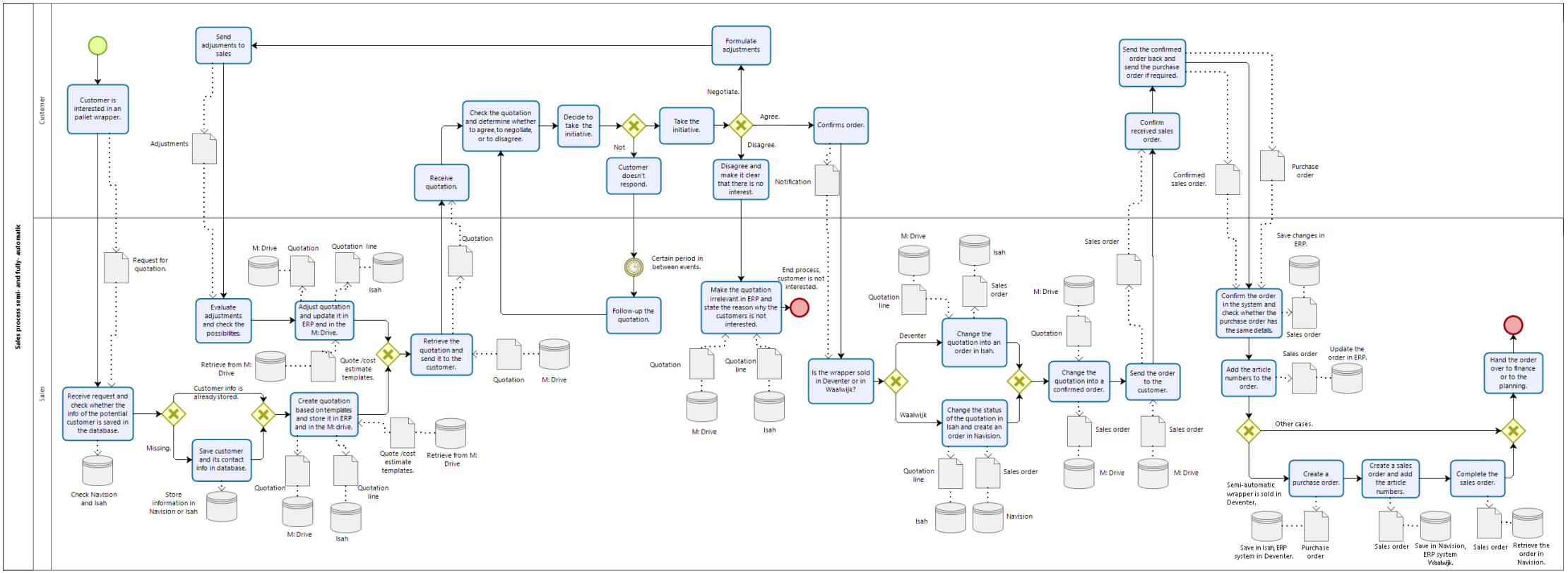


Figure 19: BPMN flow-chart of sales process

Description of the model

The model is created using the information provided by the employees of Matco International. There are four employees with the function sales support and sales manager that provided the information.

The process starts when a customer is interested in purchasing a pallet wrapper. The first task is to check the CRM (customer relationship management) database to determine whether the customer data is already stored. Both Navision and Isah should be checked since there is no integration between Navision and Isah. The second task is to create a quotation. The quotation is generated using templates stored in the M: Drive in combination with the cost estimates that are stored in the M: drive. This drive is stored in the Matco International server. The quotation line is created in Isah since the quotation is always processed by an employee that works in Deventer. The word templates are used since the ERP systems do not offer the options necessary to generate the details that are required for the quotation. The quotation is sent by e-mail to the customer when retrieved from the M: Drive.

The customer has multiple options. The first is not responding. Sales should follow-up the quotation after a certain time has passed. At this point, there is no structure in following-up these quotations.

Then, there are three decisions that a customer could make. These are negotiating, agreeing and disagreeing. The status of the quotation should be changed to “not scored” in combination with the reason why it is not scored when a customer disagrees. Another option for the customer is to negotiate. In that case, adjustments could be sent to sales and sales could make changes in the quotation line in ERP and the quotation in the M: Drive. Finally, the changed quotation is sent to the customer and the loop starts again. The best result for Matco International is attained when a customer agrees with the quotation. The customer notifies sales and sales should confirm the order. This order confirmation process is depending on the location in which the order is sold. The quotation should be changed into an order when a machine is sold in Deventer. The situation is different when the wrapper is sold in Waalwijk. The status of the quotation line should be changed to scored, however, the quotation is not changed to an order. The order is created in Navision, the ERP system of Waalwijk. In this stage, the distinction between the location is made. The quotation in the M: Drive should be changed into a confirmed order and send it to the customer.

The next task for a customer is to confirm the order. Next to that, there is a possibility that the customer sends a purchase order to Matco. The purchase order and sales order should be checked to ensure that there are no differences between these orders that could lead to issues in the future. Possible changes are discussed with manager sales and resolved. Then, product numbers could be added. The process continuous more difficult when a semi-automatic wrapper is sold in Deventer since it is produced in Waalwijk. The semi-automatic wrapper has to be sold from Waalwijk to Deventer since it is sold in Deventer and produced in Waalwijk. This internal sales process results in the creation of a purchase order in Deventer and a sales order in Navision. Finally, the project can be handed over to plan production.

Appendix D: Planning and assembly semi-automatic pallet wrappers

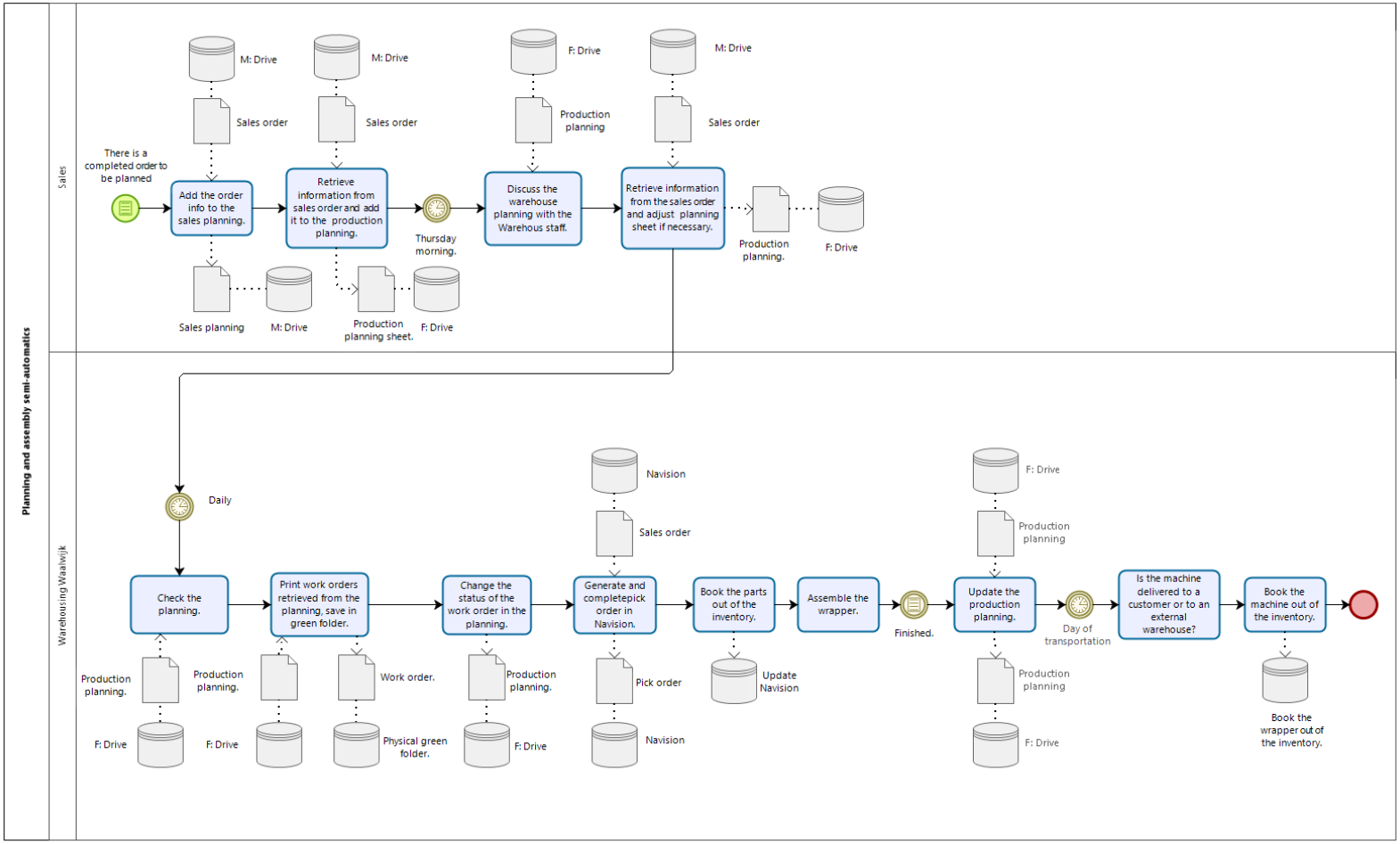


Figure 20: BPMN flow-chart of planning and assembly process

Appendix E: Production planning

				SALES				WAREHOUSE			WP	
Machine numm	V-ORD	Klant naam	Machine type	Opmerkingen / Aanpassing	Taal	Gereed week Sal	Installa	Order gepickt	Uurinschatti	Monteur	Gereed week V	Status project
werkplaatst		overige werkzaamheden	voorwerk machines						16	Monteur A	17	
werkplaatst		overige werkzaamheden	voorwerk machines						8	Monteur B	17	
MA-2000	V-00000	Company A	A-700	Foliewagen is afgekeurd door Monteur A, deze graag helemaal goed nakijken en weer repareren	Nederland	11				Monteur C		
MA-2001	V-00001	Combany B	B50	Oprit 1000x1000	Nederland	12	JA	JA	5	Monteur B	11	Machine uitgeleve
MA-2002	V-00002	Company C	T7 Pro	Deze komt retour. Er zitten storingen in deze machine deze moeten opgelost worden. Daarna even overleg met Planner. wat er met deze machine moet gebeuren	Nederland	15	JA			Monteur C	17	
MA-2003	V-00003	Copmany D	T7 Eco	Afroep, geen opties	Nederland	16		NEE		Monteur D	16	Machine gereed /
MA-2004	V-00004	Company E	A400	Oprit 1500x1000 + oprit 1500x1000 voor Mustang serie (deze oprit is voor een A400 van Extend, machine staat al bij de klant)	Nederland	17	ja	JA	4	Monteur A	17	Machine uitgeleve
MA-2005	V-000005	Company F	B400	Oprit 1000x1000 + 3 rollen folie Octastretch 1000P 23mu	Nederland	17	ja	JA	6	Monteur A		Machine gereed /
MA-2006	V-00006	Company G	A700	Fotocel voor donkere lading	Nederland	18	Ja	JA	5	Monteur D	18	Machine gereed /
MA-2007	V-00006	Company G	A700	Fotocel voor donkere lading	Nederland	18	ja	JA	5	Monteur D	18	Machine gereed /
MA-2008	V-00007	Company H	T7 Eco	Afroep, geen opties	Nederland	18		NEE	4	Monteur B	18	Machine gereed /
MA-2009	V-00007	Company H	T7 Eco	Afroep, geen opties	Nederland	18		NEE	4	Monteur B	18	Machine gereed /
MA-2010	V-00007	Company H	T7 Eco	Afroep, geen opties	Nederland	18		NEE	4	Monteur B	18	Machine gereed /
MA-2011	V-00008	Company I	T7 Eco	Geen opties	Nederland	18	JA	JA	4	Monteur A	18	Machine uitgeleve
MA-2012	V-00009	Company J	T7 Eco	Geen opties	Nederland	19	Ja	JA		Monteur C		Machine uitgeleve
MA-2013	V-000010	Company K	T7 Pro DT2000	Laio Stickers + Draaitafel 2000mm + Fotocel voor donkere lading + Pakbon van Company K op de machine plakken. Deze staat in de machinemap bij vrachtbrief	Duits	19	nee	JA		Monteur D		In behandeling

Figure 21: Excel production planning Matco International

Appendix F: Preparation outsourcing fully-automatic wrappers

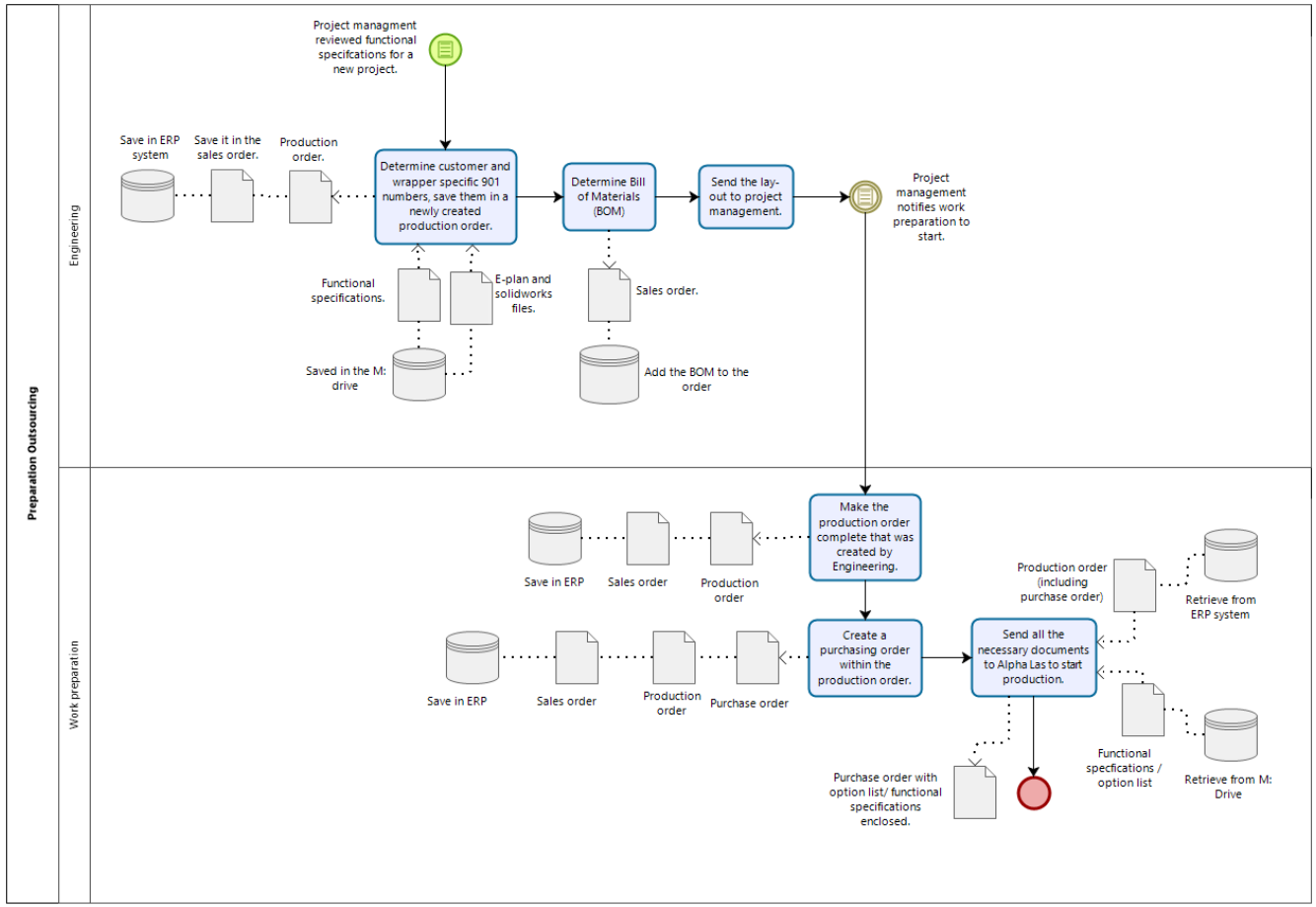


Figure 22: BPMN flow-chart of preparation outsourcing process

Description of the model:

This process model is created using the information from an employee responsible for the work preparation and from the project manager. Though, work preparation gave the most input for the process model. This process shows what needs to be done to send a purchase order to Alpha Las. Alpha Las is the company that builds the most complicated machines that Matco International offers. These machines are mostly fully-automatic pallet wrappers. The purchase order that is presented to Alpha Las is the most complex order in Matco International's business processes.

This process starts when the project management reviews functional specifications that describe the technical and visual characteristics of a project based on the sales order. These are presented to Engineering. Engineering creates a project-specific 901-number and saves this in a newly created production order. These 901-numbers represent the combination of specifications. The 901-number is a composition of functional specifications summarized in a number. This results in a bill of materials (BOM), which is the layout of the project. The 901-numbers are created using the input of SolidWorks and E-plan. SolidWorks and E-plan are software used by the engineering department to create a model of the sold wrapper. Moreover, an import generates the option to document the 901-numbers in Isah from SolidWorks or E-plan.

The next step for engineering is to send the layout to the project management. Project management ensures that the wishes and demands of the clients are satisfied. Project management notifies work preparation as soon as the clients confirm the layout. The creation of the production order can be completed. A purchasing order is created within the production order. The purchase order purchases the service of Alpha Las. Alpha Las is a partner company of Matco International that produces the fully-automatic pallet wrappers sold by Matco International. The purchase order includes the layout and functional specifications. These are added as attachments to the order.

Appendix G: Purchasing and issuing spare parts Waalwijk

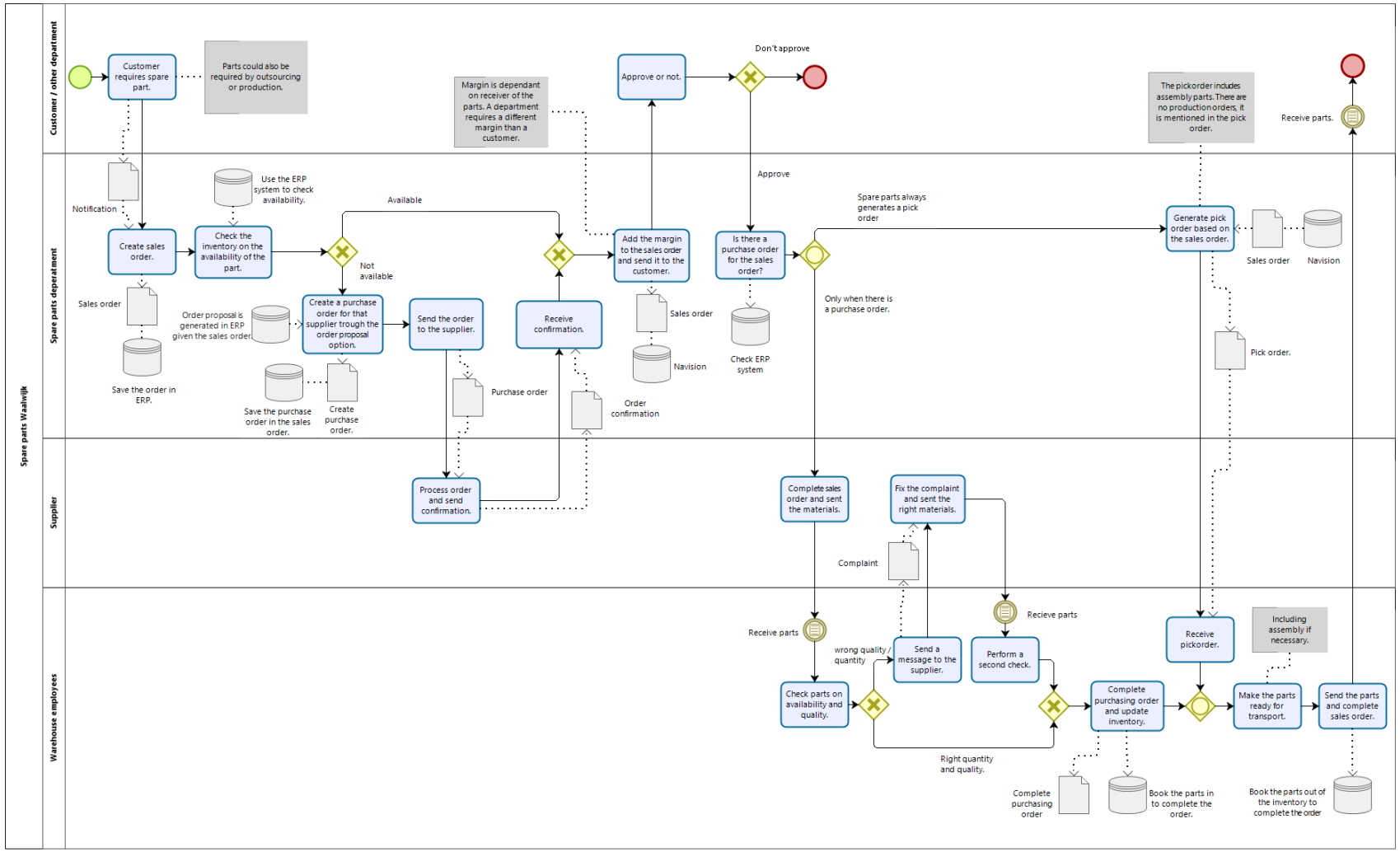


Figure 23: BPMN flow-chart of spare parts process Waalwijk

Appendix H: Purchasing and issuing spare parts in Deventer.

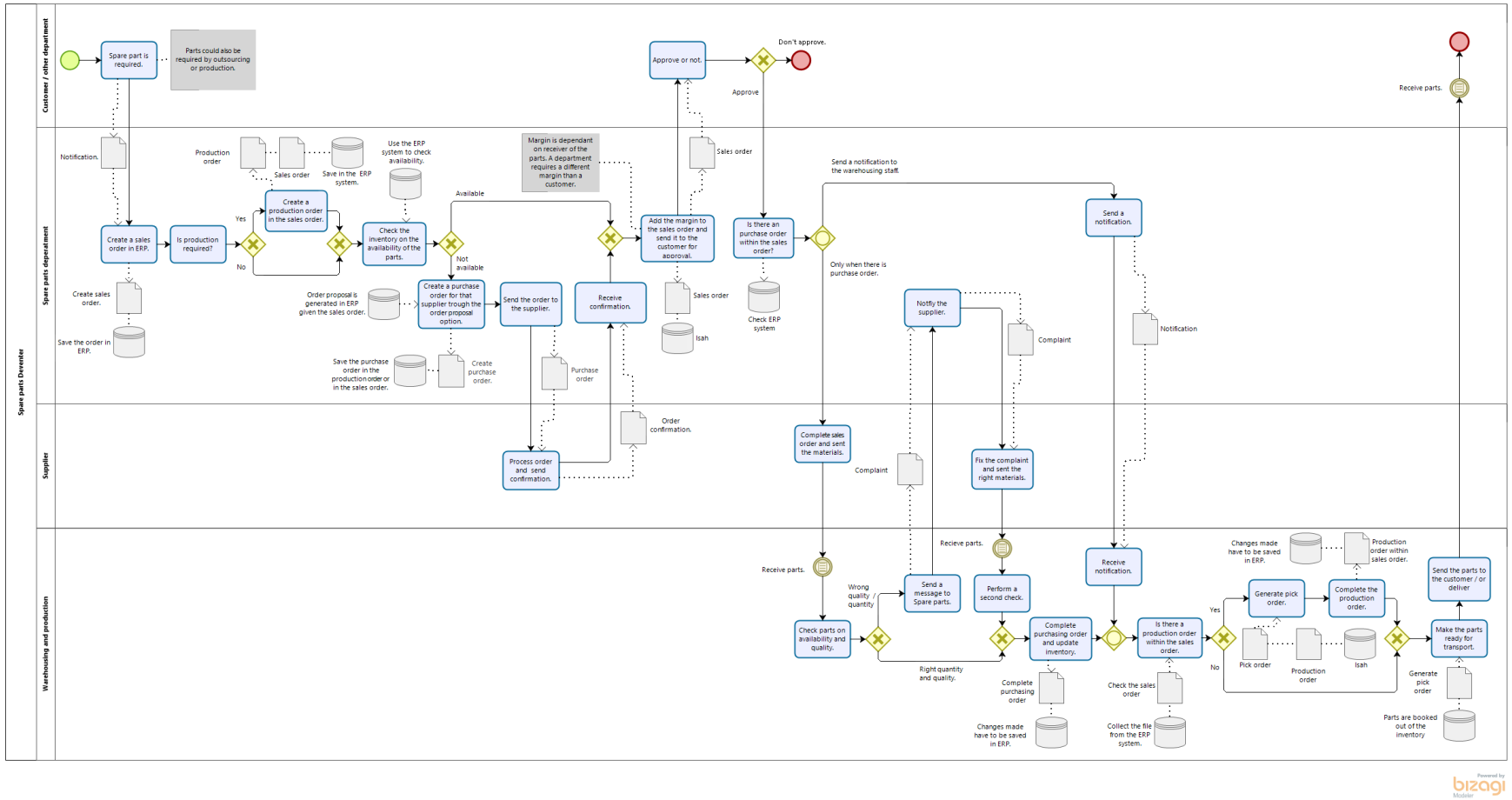


Figure 24: BPMN flow-chart of spare parts process Deventer

Appendix I: Interview results

The results of the interviews are described in the following sections. These sections are ordered per AS-IS process. A general result of the interview is that the standard of AFAS should be used as a guideline for the processes. Experience has provided the interviewees with the insight that personalisation of a system results in a system hard to maintain. Isah, for instance, is personalized much resulting in a non-updatable system.

Sales process semi- and fully-automatic pallet wrappers

The first step of the process concerns the CRM database. A check has to be executed to check whether the potential customer is already known in the Matco International database. At this point, there are two databases, one for each ERP system. Therefore, one CRM database is required instead of two.

The second point of discussion is regarding the cost estimates of semi- and fully-automatic wrappers. Cost estimates of a project are used to generate a price for the quotation. These cost estimates are retrieved from the drive. It would be better to store the cost estimates in ERP and execute the cost estimation process in ERP.

The third point of discussion concerns documenting and mailing the quotations. Quotations are generated in Word using templates and mailed to the customer without the use of ERP software. It is suggested that it would be easier and clearer to centralise the quotation process in ERP. Next to that, sales should be able to add memos to quotations to ensure that important information regarding the quotation is stored well documented per quotation. However, one remark is given regarding the quotation process. Quotations for fully-automatic pallet wrappers are complex quotations, often with multiple attachments like lay-outs. Therefore, the quality of the quotations should be ensured. These quotations are created using templates. These templates should be filled with sales input. This should be possible in AFAS if implemented.

There is a probability that a quotation should be followed-up after it is sent. At this moment, there is no structure in following-up quotations. Thus, structure is requested in a list that is received weekly and shows the quotations that require following up.

The next step is to send an order confirmation to the customer when the quotation is accepted. All the documentation is done in Isah until this point. However, a sales order and confirmation should be created in Navision if the wrapper is sold in Waalwijk. This results in open quotations in case of sales in Waalwijk. The quotation and order process should be done in one system. Moreover, the documentation of the process is done partly in ERP and partly in the M: Drive. Though, most information is stored in the M: Drive. It would be an improvement of the current situation if most of the documentation is done in the same system at the same place. AFAS could provide a solution to this problem. The documentation should be done per customer and the filters should be used to receive information easily.

Planning and assembly semi-automatic pallet wrappers

The process starts with an internal sales process if a semi-automatic pallet wrapper is sold in Deventer. The wrappers are bought in Waalwijk and have to be sold to Deventer if Deventer wants to sell the wrappers since two ERP systems are used. Thus, the internal sales concerning semi-automatic wrappers should be removed from the process.

This process consists of two general tasks. Planning and assembly. Planning is done using an Excel sheet. The information from the M: Drive and the ERP system is used as the input for the Excel sheet. The excel sheet is shown in Appendix E. This information is copied manually or, in some cases, typed

in the sheet. Moreover, this process is prone to mistakes due to the lack of integration and the large number of manual actions. Therefore, there is a wish to plan in AFAS. Every attribute, except for the hour estimation, should be included in the new planning. Moreover, the planning is comprehensive. Therefore, feedback to the service coordinator is sometimes missing when changes in the planning occur. The assembly phase of a machine is not documented using production orders. The AS-IS situation explained that it results in inventory differences. Thus, the use of production orders is requested to solve the inventory difference problem.

Preparation outsourcing fully-automatic pallet wrappers

The preparation of outsourcing is a process that creates a purchase order that purchases the service that is offered by Alfa Las. The interview resulted in two points of discussion. The first point of discussion is regarding the link between the ERP system and the software used to generate the detailed layout of a project. SolidWorks and E-Plan are used to generate the mechanical and electrical layout. The software generates a list of parts that should be included in the order. This should be imported in the production order. This link is essential and should be included.

The second point of discussion concerns the purchase order for the service of Alfa Las. This purchase order for Alfa Las has multiple attachments. Functional specifications, the layout and the options list should be included. Thus, multiple attachments should be attachable to an order.

Purchasing and issuing spare parts Deventer and Waalwijk

The first remark is general. It concerns the personalisation of the system. A general wish is to shape processes to the standard of AFAS. Though, evaluation of updates is required according to one of the interviewees. There were three other remarks regarding the process.

The first remark of the process concerns production orders. At this point, production orders are not used in Waalwijk. Thus, assembly is executed based on pick orders and manually booking parts. As explained in the AS-IS model description, this results in inventory differences. The use of production orders should solve this problem. The location in Deventer already uses these production orders and it works well.

The second remark concerns the booking of parts out of the inventory. The booking is done on the wrong moment as explained in the description of the AS-IS model. The booking should be done when the parts are sent to the customer since that is the moment when the parts physically leave the inventory.

The third remark states that both purchase processes should be executed similarly to increase consistency within the organisation. This means that order proposals should be executed following the same procedure.

Inventory management

The identification of the requirements regarding inventory management is slightly different. The interview had structure since there was an order of the topics discussed. The inventory management framework is used to identify requirements regarding inventory management. The requirements regarding the inventory process are covered in the interviews with the employees responsible for the purchase and issuance of spare parts, work preparation and warehousing. The requirements regarding the management and monitoring of the performance of the inventory are not covered in these interviews. Therefore, an interview with the finance manager and the operations manager is planned to identify the needs of the management. The management presented their needs to improve its decision-making process. The management wants to know the following information for the improvement:

1. The quality of the forecasts created by the sale departments should be monitored. This requirement is directed towards the sales of semi-automatic pallet wrappers. The lead time of these wrappers is long and the machines are stored in the inventory. Fully-automatic pallet wrappers are produced and purchased to order.
2. The lead time of purchase orders should be monitored.
3. The management should be able to monitor supplier reliability.
4. The size of the inactive inventory has to be measured.
5. The inventory value per storage unit has to be measured. This includes the inventory per service van.
6. The inventory turnover in general and per good has to be known.
7. The quality of the minimum inventory levels should be measured.
8. The delivery reliability of Matco International towards its customers should be measured.

The theoretical framework provided a guideline for the management to formulate the requirements. The requirements are ordered according to the stage of the process that fits best. The first requirements are related to the forecasting process. The second requirement is related to the purchase process. The third is related to receipt goods part of the inventory management process. The fourth, fifth and sixth requirement could be linked to the storage part. The seventh requirement is dubious. It could be linked to purchase and storage, though it is more applicable to storage since the levels determine the storage value. Minimum inventory levels influence inventory levels greatly. Thus, it is important to measure the quality of these inventory levels. The final requirement is linked to the final part of the inventory management framework. Delivery reliability is linked to the issuance of goods. Finally, KPIs were selected with a maximum of two per requirement. These are shown in the analysis.

Appendix J: Analyses and reports

AFAS offers reports and analyses to gain knowledge about the performance of processes. The first section shows the analyses. The second section discusses the reports.

Every module has its analyses. The analyses available in the order management module are shown in Figure 25:

Definitie	Toelichting
Artikel analyse (Profit)	Artikel analyse met voorraadgegevens, prijsgegevens en aantallen.
Inkoopwaarde (huidige voorraad) / gemiddelde inkoopprijs	Deze analyse toont de gemiddelde inkoopprijs voor de huidige voorraad en de huidige voorraadwaarde op basis van deze prijs (uitgaande van FIFO)
Omzet per land in Europa (Profit)	Speciaal voor verdichten en filteren ten behoeve van analyses en statistiek-rapporten.
Omzet per provincie	This subscription analysis shows the expected turnover for the current and previous year. These data are compared with the subscription turnover tha
Omzet/afzet per periode en verkooprelatie (Profit)	Analyse die de omzet en afzet per periode per verkooprelatie weergeeft.
Productieanalyse (Profit)	
Verpakkingsregels voor Afvalbeheersbijdrage verpakkinge	Alle verpakkingsregels, waarbij in de verpakking een gewicht is aangegeven voor een verpakkingsmateriaal op het tabblad 'Afvalbeheersbijdrage'.
Voorraad cockpit	Te gebruiken om indicatoren die te maken hebben met voorraadhoudende artikelen en voorraadjournalisering te controleren.
Voorraadprognose in weken (Profit)	Deze analyse geeft de voorraadprognose voor de komende vier weken weer. Hierbij wordt uitgegaan van de huidige voorraad en de nog te ontvang

Figure 25: Overview analyses (source: AFAS test environment)

The number of different analyses is limited as shown in Figure 25. The analyses are based on information documented in the order management module. The “toelichting” column explains what the analysis does. The analysis offers three revenue related analyses, namely: revenue per country, revenue per province and revenue per sales relationship. Moreover, there are four inventory-related analyses. There is an article analysis, a purchase value / average purchase price analysis, an inventory cockpit and an inventory prognosis. The article analysis provides an overview of different parts and their inventory information and price information. The purchase value / average purchase price analysis offers average purchase prices and the current total inventory value. The inventory cockpit presents indicators that are related to stock-keeping units and monitor inventory journalising. The inventory prognosis presents a prognosis for inventory levels for the upcoming four weeks. The prognosis is constructed using the current inventory levels and the uncompleted purchase and sales orders. Thus, it is not a forecast since there is no prediction of variables. Two analyses remain. These are the production analysis and the packaging lines for waste management analysis. The production analysis presents the assemblies that need to be produced and the underlying parts in combination with their inventory levels in combination with assembly and delivery dates. The packaging lines provide information about waste management since it shows information on packaging.

Two analyses might be interesting for this research. The inventory cockpit analysis, shown in Figure 26, is interesting since it provides indicators that are related to inventory management. Moreover, the production analysis might present interesting information regarding production. The production analysis also offers a cockpit with indicators as presented in Figure 27. The inventory cockpit consists of one summary sheet with indicators and multiple worksheets elaborating on these indicators. The indicators are merely focused on the quality of the input in AFAS. Therefore, there are no KPIs that could be used for performance management. The production cockpit also offers indicators. Moreover, worksheets elaborate on these indicators. These indicators offer current production indicators per assembly part. Next to the cockpit, the two worksheets in Figure 28 and Figure 29 might offer interesting information. The worksheets offer an overview of the production orders linked to the sales orders. Then, there is a worksheet with that shows the assembly per order and its underlying parts. This information might be important to structure the production process.

Analyses visualised

There are different visualisations and overviews in AFAS given trough reports, analyses or dashboards. Figures of the most interesting analyses are shown in this section.

AFAS Profit. ERP software voor iedereen.

Voorraad cockpit

Toelichting op de cockpit — 8-6-2020 16:23

Prijzen		
Aantal artikelen zonder een vaste verrekenprijs	7	details
Aantal artikelen zonder een inkoopprijs	0	details
Te journaliseren		
Aantal niet gejournaliseerde pakbonnen ouder dan een week	0	details
Aantal niet gejournaliseerde goederenontvangsten ouder dan een week	0	details
Inrichting artikelgroep		
Aantal foutief gekoppelde rekeningen "voorraad opboeken"	0	details
Aantal foutief gekoppelde rekening "voorraadverschil"	0	details
Aantal foutief gekoppelde rekening "assemblage"	0	details
Aantal foutief gekoppelde rekening "assemblage verbruik"	0	details
Voorraad		
Aantal artikelen met een negatief voorraadaantal	0	details

Figure 26: Inventory cockpit (source: AFAS analysis tool)

S10000 - Semi-automatic wrapper

S10000 - Semi-automatic wrapper

02 - Magazijn Amersfoort

☑ Virtuele bestellingen/ontvangsten

	Berekend	Afwijkend
Assemblagetijd:	0	14
Levertijd:		7
Ontvangsttijd:		15

assemblages te leveren	assemblages gereed	assemblages voorbereiden
10	0	10

Type	Totaal	2020 - 24 BV	TE	J	N	EV	2020 - 25 BV	TE	J	N	EV	2020 - 26 BV	TE	J	N	EV	2020 - 27 BV	TE	J	N	EV	2020 - 28 BV	TE	J	N	EV	BV
Te leveren orders / voorcalculaties	10							3					7													
Te assembleren	0	0				0	0				0	0				0	0				0	0				0	0

Onderdeel		Aantal	Vrd	Mogelijk	Levertijd	2020 - 24 BV	M	VI	VG	EV	2020 - 25 BV	M	VI	VG	EV	2020 - 26 BV	M	VI	VG	EV	2020 - 27 BV	M	VI	VG	EV	2020 - 28 BV	M	VI	VG	EV	BV
A10002	Kolom	1	0	0	7	0	5			0	0	-5		5	0	0	15			15	15			15	15			15	15
A10003	Draaitafel	1	0	0	7	0	5			0	0	-5		5	0	0	15			15	15			15	15			15	15

Figure 27: Production cockpit (source: AFAS analysis tool)

Koppeling verkoop aan assemblage

NrAantal.	Assemblagenummer	Ordernummer	Orderdatum	Type	Code	Aantal	Aantal te lev	Afwijkende afleverdatum	Toegez. levering	Gew. levering	Leverdatum	Levering week	Levering week -
000183	00018	60007042	08-06-2020	7	S10000	3.00000	3.00000		16-06-2020	16-06-2020	16-06-2020	25	2020 - 25
000192	00019	60007042	08-06-2020	7	S10001	2.00000	2.00000		16-06-2020	16-06-2020	16-06-2020	25	2020 - 25
000207	00020	60007045	08-06-2020	7	S10000	7.00000	7.00000		23-06-2020	19-06-2020	23-06-2020	26	2020 - 26
000214	00021	60007045	08-06-2020	7	S10001	4.00000	4.00000		23-06-2020	19-06-2020	23-06-2020	26	2020 - 26

Figure 28: Link sales and production (source: AFAS analysis tool)

Onderdelen assemblagevoorbereiding

Ordernummer	Datum	Samenstelling	Onderdeel	Omschrijving	Aant. onderd.	Aantal	Aantal eenheden (totaal)	Aantal te leveren (totaal)	Afw. aanmaak	Toeg.aanm.datum	Gew.aanm.datum	Orderdatum
20	08-06-2020	S10000	A10002	Kolom	1.00000	7.00000	7.00000	7.00000	23-06-2020		23-06-2020	
00020	08-06-2020	S10000	A10003	Draaitafel	1.00000	7.00000	7.00000	7.00000	23-06-2020		23-06-2020	08-06-2020
00021	08-06-2020	S10001	A10004	Voorreksysteem	1.00000	4.00000	4.00000	4.00000	23-06-2020		23-06-2020	08-06-2020
00019	08-06-2020	S10001	A10002	Kolom	1.00000	2.00000	2.00000	2.00000	16-06-2020		16-06-2020	08-06-2020
00018	08-06-2020	S10000	A10002	Kolom	1.00000	3.00000	3.00000	3.00000	16-06-2020		16-06-2020	08-06-2020
00021	08-06-2020	S10001	A10002	Kolom	1.00000	4.00000	4.00000	4.00000	23-06-2020		23-06-2020	08-06-2020
00019	08-06-2020	S10001	A10003	Draaitafel	1.00000	2.00000	2.00000	2.00000	16-06-2020		16-06-2020	08-06-2020
00018	08-06-2020	S10000	A10003	Draaitafel	1.00000	3.00000	3.00000	3.00000	16-06-2020		16-06-2020	08-06-2020
00021	08-06-2020	S10001	A10003	Draaitafel	1.00000	4.00000	4.00000	4.00000	23-06-2020		23-06-2020	08-06-2020
00019	08-06-2020	S10001	A10004	Voorreksysteem	1.00000	2.00000	2.00000	2.00000	16-06-2020		16-06-2020	08-06-2020

Figure 29: Underlying parts production (source: AFAS analysis tool)

Reports

Every module can also generate reports. Order management has a selection of reports. Figure 30 shows some of these reports:

Definitie	Toelichting
Aantal geleverde artikelen per debiteur/maand	
Artikel etiketten (Profit)	Artikel etiketten. De etiketten zijn van het type Avery 5162.|De volgende gegevens worden afge
Artikel etiketten barcode EAN13 (Profit)	Artikel etiketten met barcodes van het type EAN13. De etiketten zijn van het type Avery 5162.
Artikel etiketten barcode EAN8 (Profit)	Artikel etiketten met barcodes van het type EAN8. De etiketten zijn van het type Avery 5162.
Artikel stamkaart (Profit)	Op de artikel stamkaart worden de stamgegevens van het artikel afgedrukt met de huidige prijsg
Artikellijst (Profit)	Overzicht waarmee de algemene gegevens van de artikelen kunnen worden afgedrukt.
Assortimentsregels (Profit)	Dit rapport toont de assortimentsregels per assortiment.
Bestelvoorstel: Koppeling Inkooporders / Verkooporders	Met dit rapport druk je de verkooporders en gekoppelde inkooporders af per artikel.
Bron factuurregels (Profit)	In dit rapport wordt per factuurregel de bron afgedrukt van de factuurregel. Er wordt afgedrukt w
Bron verkooporderregels (Profit)	Dit rapport drukt per verkooporder de orderregels af en de eventueel aanwezige gekoppelde ink
Confrontatie: te ontvangen facturen (Profit)	De niet geconfronteerde ontvangstregels en de gedeeltelijk geconfronteerde ontvangstregels w
Controle journaalpost verkoopfactuur (Profit)	
Dagstaat facturen (Profit)	In de dagstaat facturen worden de gejournaliseerde facturen afgedrukt.
Dagstaat voorraad (Profit)	In de dagstaat voorraad worden de gejournaliseerde voorraadmutaties afgedrukt.

Figure 30: Overview reports (source: AFAS test environment)

These reports are overviews and collections of data. For instance, the report “Artikellijst (Profit)” provides an overview of general information per part in a layout that is used for printing. Another example is the “Dagstaat voorraad (Profit)” report. This report presents journalised inventory mutations. Both reports have in common that they are structured data collections. Thus, the reports cannot provide strategic information without being analysed.

Appendix K: Overview of the KPIs

All available KPIs for the order management module are presented in the following tables.

Table 11: KPIs actual inventory dashboard

Worksheets dashboard actual inventory	KPIs	Filter
Inventory overview	Actual inventory	Product groups
	Reserved inventory	Individual parts
	Inventory that is in order	Number of units
	Economic inventory	Amount of money
Warehouses	Inventory per warehouse	Warehouse
		Location within the warehouse
Minimum inventory	Free inventory	Product groups
	Difference actual inventory and minimum inventory.	Item

Most KPIs in this dashboard speaks for itself. Two KPIs require further explanation: Free inventory is the number of parts in inventory subtracted by the number of parts reserved for production or sales. The final KPI, difference between the actual inventory and the minimum inventory, is the number of parts or amount of money of the parts that are in inventory that exceeds the minimum inventory. A negative number is presented when the number of parts or the amount of money of the parts that are below the minimum inventory level.

Table 12: KPIs inventory dashboard

Worksheets dashboard inventory	KPIs	Filter
Inventory stream	Inventory turnover	Year
	Flowrate (quotations)	Number of units
		Amount of money
Inventory numbers	Quotations scored	Year
	Quotations lost	
Article groups	Uncompleted orders	Number of units
		Amount of money
Warehouses	Delivered orders	Year
Turnover rate per item	Turnover rate per item	Year

The KPI that requires further explanation is the flowrate KPI. The flowrate shows the number or the amounts in money of the open quotations. The flowrate concerns quotations. The flowrate concerns the number of quotations or the amount of money of the quotations.

Table 13: KPIs sales dashboard

Worksheets dashboard sales	KPIs	Filter
Sales	Total revenue	Current year or past twelve months.
		Per administration, debtor, type sales relationship, item, product group.
Quotation	Quotations in progress	Current year or past twelve months.
	Conversion rate	Per administration, debtor, type sales relationship, item, product group.
	Confirmed quotations	
Daily financial statement	Sum of orders	Current year or past twelve months.
		Per administration, debtor, type sales relationship, item, product group.
Margins	Overall margin	Current year or past twelve months.
		Per administration, debtor, type sales relationship, item, product group.
Delivery reliability	Average delivery time	Current year or past twelve months.
	Percentage too late	Per administration, debtor, type sales relationship, item, product group.
	Average number of days too late	
	Orders issued in one delivery	
Credit invoices	Total credited	Current year or past twelve months.
	Number of credited invoices	Per administration, debtor, type sales relationship, item, product group.
Discounts	Total given discount	Current year or past twelve months.
	Percentage given discount	Per administration, debtor, type sales relationship, item, product group.

The sales dashboard offers many different KPIs. The most KPIs speak for itself, especially in combination with the worksheet name.

Table 14: KPIs sales revenue dashboard

Worksheets dashboard sales revenue	KPIs	Filter
Total revenue	Revenue	Year
	Gross margin	Period
Revenue per item	Revenue	Item group (product group or integration group)
Margin per item	Gross margin	Item
		Item group (product group or item)
Revenue per industry	Revenue	Industry (based on an SBI-code)
		Item
		Item group (product group or item)
Revenue per representative	Revenue	Representative
		Representative group
Revenue per sales relationship	Revenue	Sales relationship

This dashboard is completely related to revenue and gross margin. Therefore, there are not many different KPIs.

Table 15: KPIs purchasing dashboard

Worksheets dashboard purchasing	KPIs	Filter
Purchases	Purchasing value	Current year or past twelve months
		Per administration, creditor, item, product group and warehouse
Current orders	Age of current purchase orders	Week or month
	Amount of current purchase orders	Per administration, creditor, item, product group and warehouse
Discounts	Discounts	Current year or past twelve months
		Per administration, creditor, item, product group and warehouse
		Percentage discount
		Amount of money
Supplier reliability	Average lead time	Current year or past twelve months
		Per administration, creditor, item, product group and warehouse
Too late	Percentage too late	Current year or past twelve months
	Average days too late	Per administration, creditor, item, product group and warehouse
	Number of orders to be delivered	
Completeness of orders	Complete	Current year or past twelve months
	Too late	Per administration, creditor, item, product group and warehouse
ABC analysis	Purchase value	Current year or past twelve months
		Per administration, creditor, item, product group and warehouse

The purchasing dashboard offers many standard KPIs. Though, there is one KPI that might need some explanation due to the worksheet in which it is placed. One worksheet offers a complete ABC analysis based on the purchase value KPI. The ABC analysis divides the selected filter group into three categories, namely: A, B and C. Category A represents the part of the filter that represents 80% of the purchase value. Category B represents 15% percent of the purchase value and category C represents 5% of the purchase value.

Appendix L: Dashboard graphs and figures

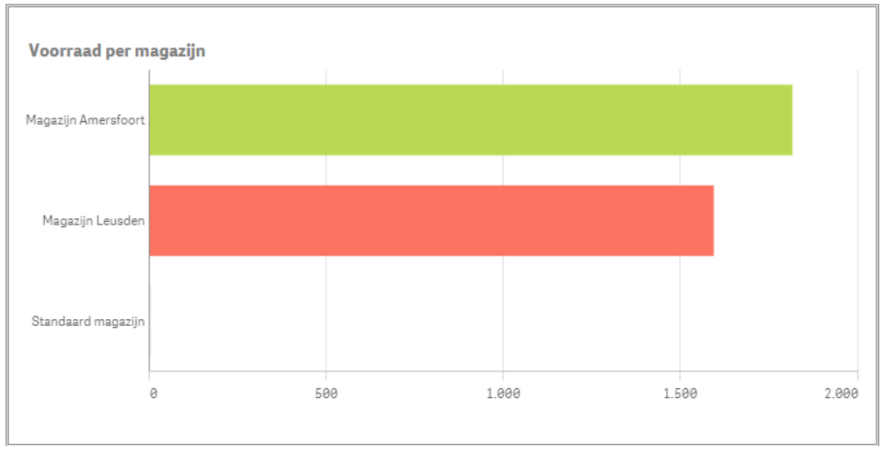


*Figure 31: Actual inventory dashboard graph (*Dashboard Actuele voorraad - AFAS Help Center*, n.d.)*

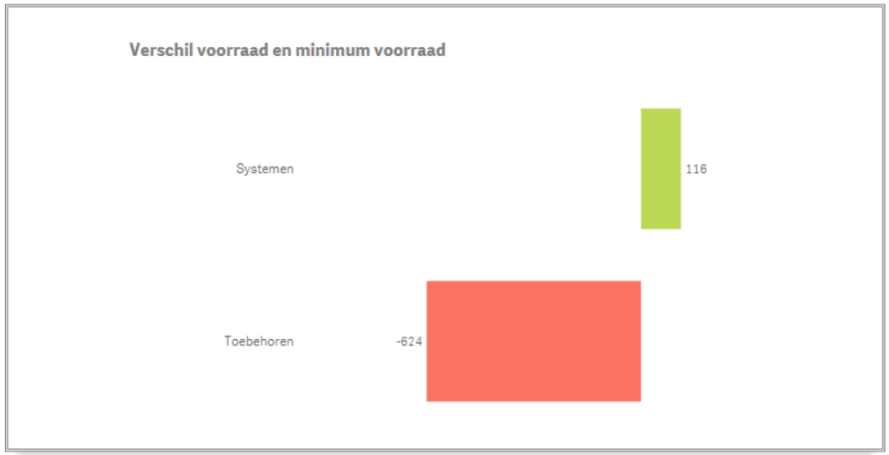


*Figure 32: Actual inventory dashboard graph (*Dashboard Actuele voorraad - AFAS Help Center*, n.d.)*

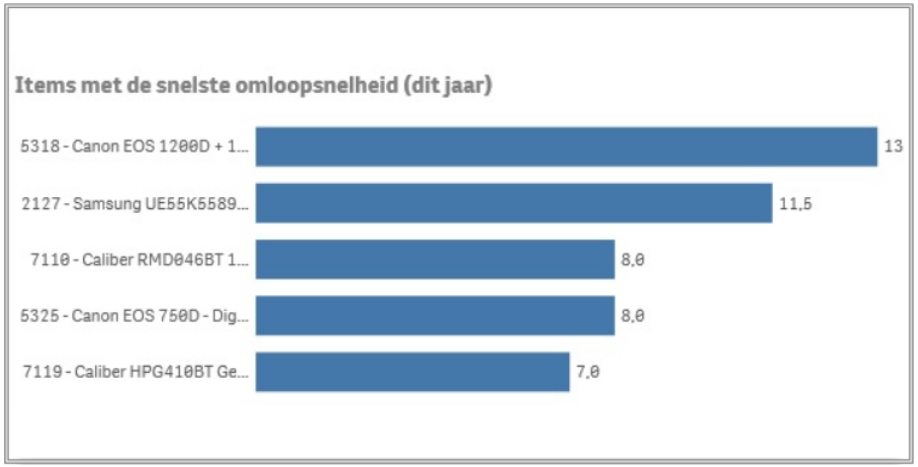


*Figure 33: Inventory dashboard graph (*Dashboard Voorraad - AFAS Help Center*, n.d.)*

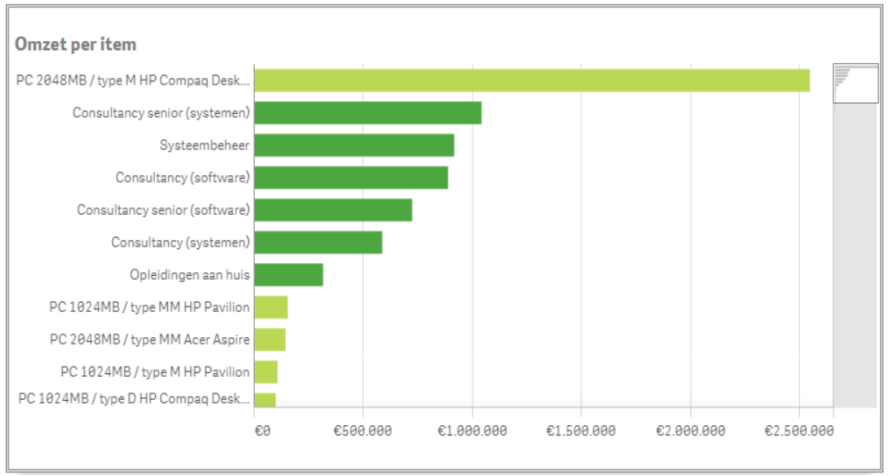


Figure 34: Sales revenue dashboard graph (Dashboard Verkoopomzet - AFAS Help Center, n.d.)

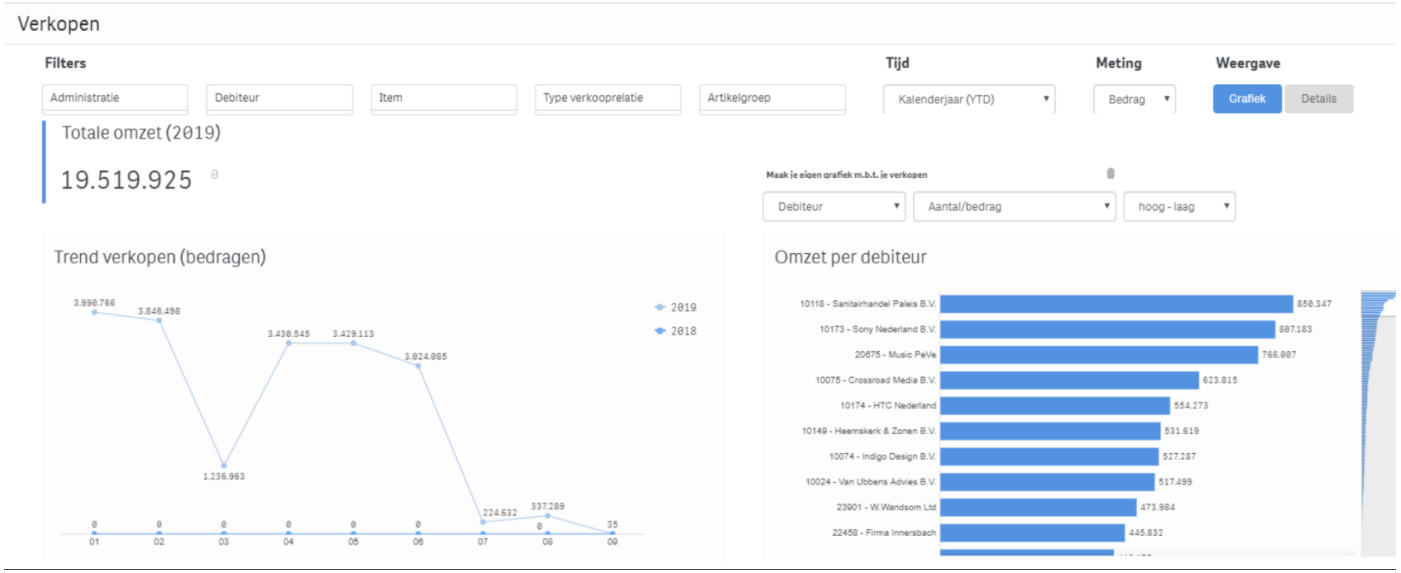


Figure 35: Sales dashboard (Dashboard Verkoop - AFAS Help Center, n.d.)

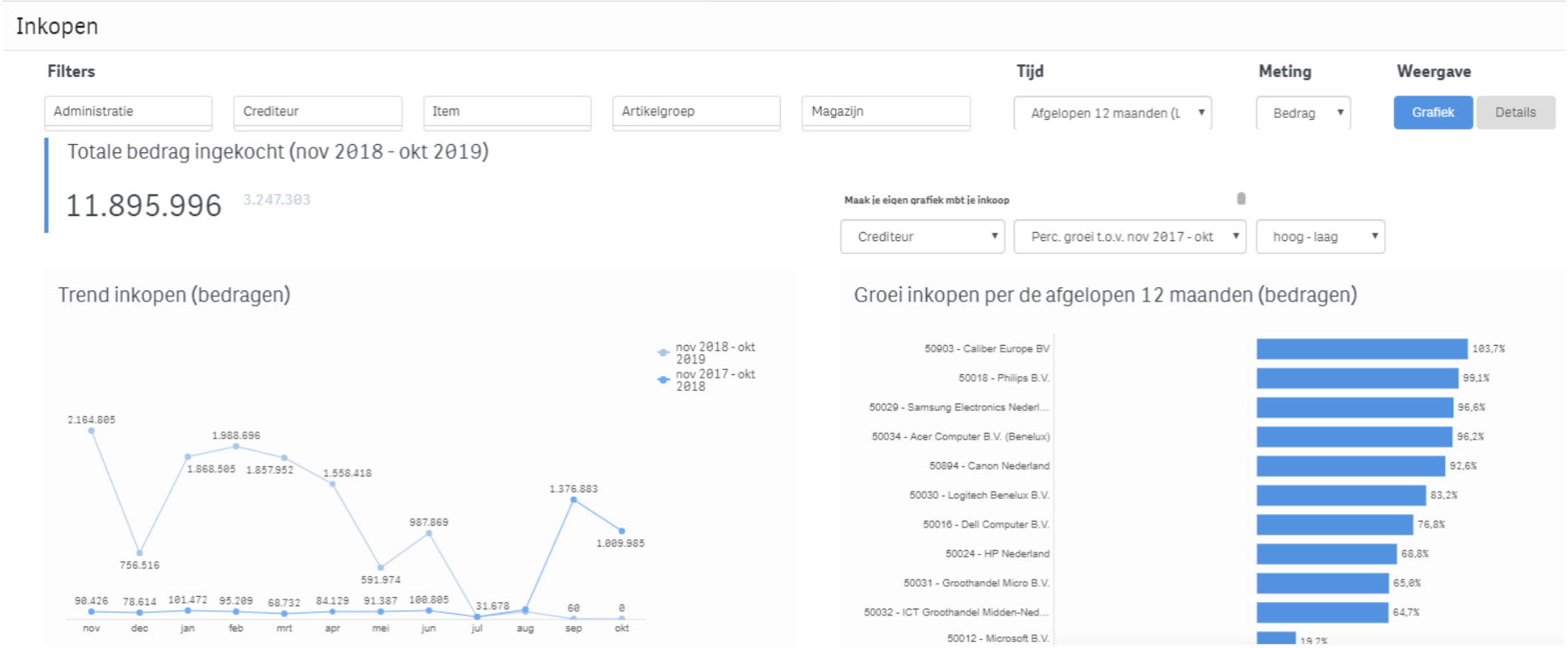


*Figure 36: Purchasing dashboard (*Dashboard Inkoop - AFAS Help Center*, n.d.)*

Appendix M: Purchasing and issuance of spare parts re-engineered

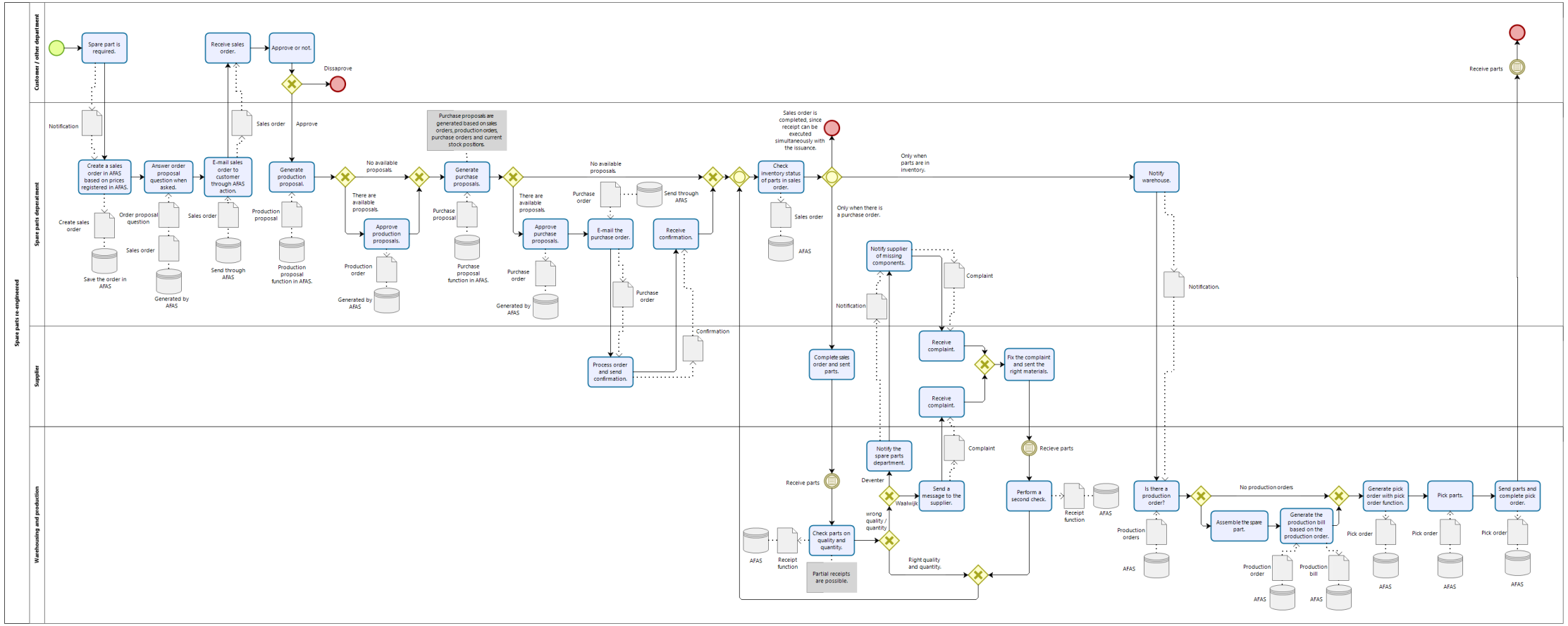


Figure 37: BPMN flow-chart spare parts process re-engineered

Appendix N: Planning and assembly of semi-automatics re-engineered

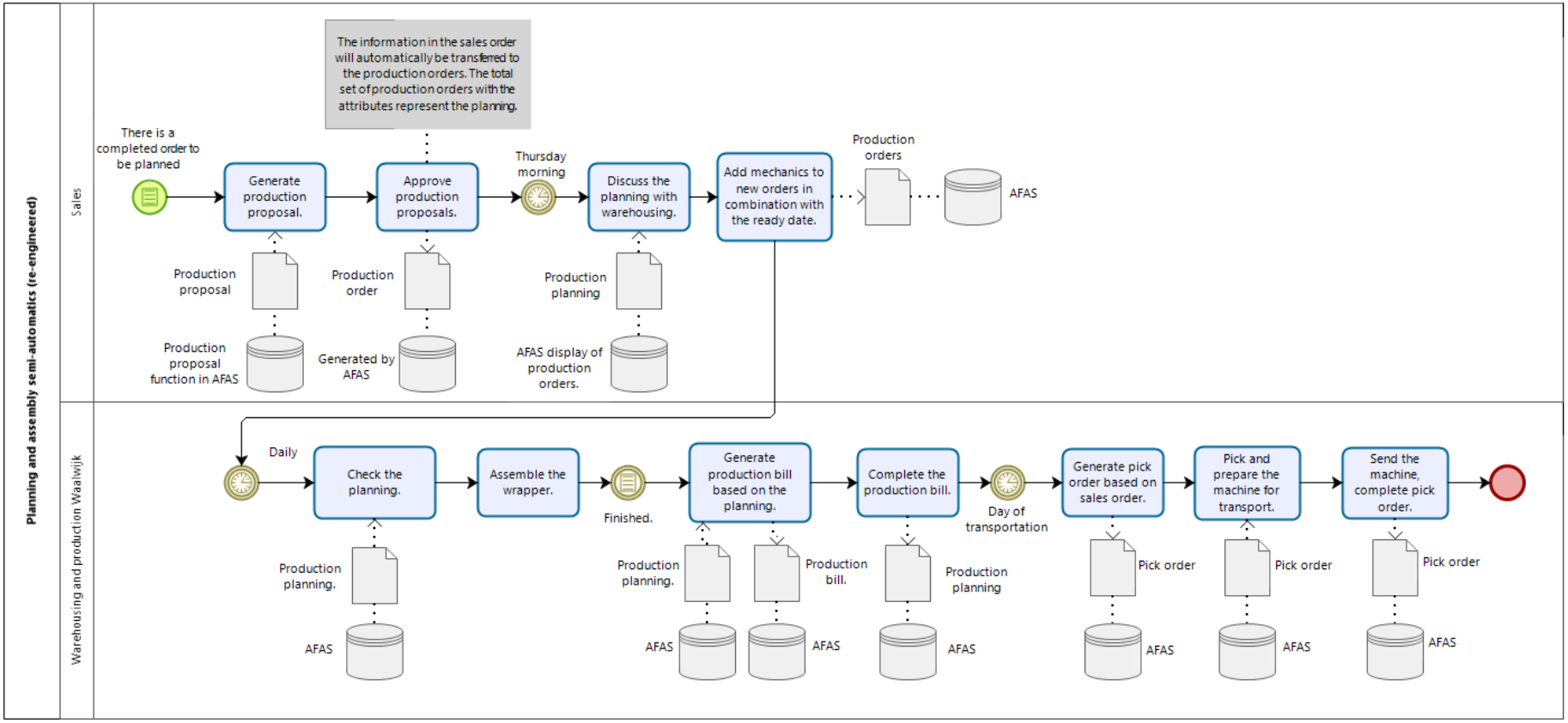


Figure 38: BPMN flow-chart of planning and assembly process re-engineered

Appendix O: AFAS demo implementation steps

Multiple steps had to be taken to create a working demo. These are the steps for the first demo:

- Four new parts are created in the product database, a column, a turntable, a pre-stretch system and gears.
- Two new assemblies are created using the new parts in the product database using the previous products as underlying parts. The first is a semi-automatic wrapper, which consists of a column and a turntable. The second is a semi-automatic wrapper with a pre-stretch system, which consists of a column, a turntable and a pre-stretch system.
- Every product and assembly has to have a standard purchase relationship and basic purchase price, cost price and sales price.
- Every product and assembly should have an inventory profile. The column and turntable have the profile “always in inventory” since these are base parts of semi-automatic pallet wrappers to create a semi-automatic pallet wrapper. The pre-stretch system and gears are given the inventory profile “small inventory” since these products could be categorized as spare parts. The finished assemblies have the inventory profile “never in inventory” as determined in the inventory profile section.
- The products should have a minimum and replenishment number when the product has an “always in inventory” or “small inventory” profile. These products have been given a minimum inventory of ten and a replenishment level of ten. Thus, a product will be replenished until ten when the inventory level falls below ten units.

Then, these are the implementation to present the second demo:

- Three attributes are added to the sales order bookings layout. These are the language of the customer, the preferred delivery date and whether the customer requires installation. Moreover, the input fields necessary for the production planning are marked yellow, which make the fields mandatory.
- Serial numbers have to be added to the assembly products. Serial numbers have to be activated in AFAS. Then, an automatic counter can be added to each assembly product.
- The production orders have to be divided per sales order and sales relationship. This is a simple setting in AFAS. Otherwise, some production orders are clustered into one. This results in planning with clustered data.
- Finally, a display of production orders can be copied and the newly created attributes can be added to the display to create the planning.

Appendix P: Demo

Appendix P shows a demo of the order management module in the first section. A demo of the production planning is shown in the second section.

Order management module demo

The order management demo focusses on the process of the sales and purchasing of spare parts. The AFAS test environment is used to present the demo. However, a couple of things should be installed before the demo could be executed, these are shown in Appendix O.

First, the order management home screen is shown to locate the functions offered by AFAS.

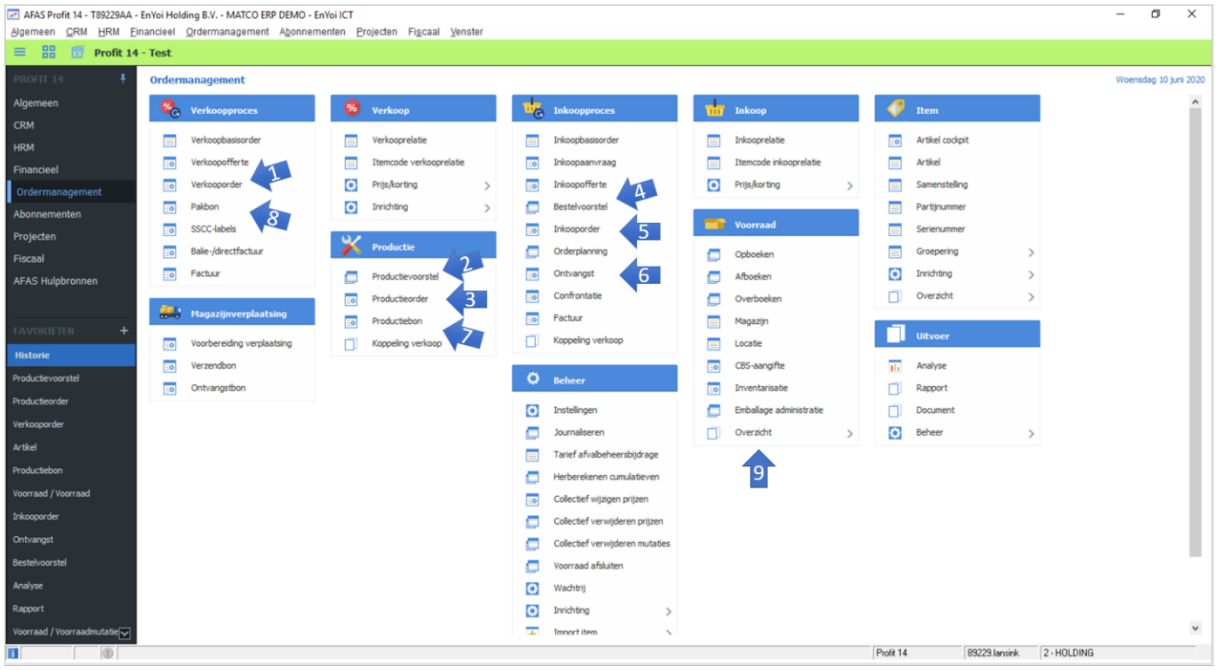


Figure 39: AFAS home screen (source: AFAS test environment)

Figure 39 shows arrows directing to the function used most when operating the order management process. Numbers are placed in the arrows for reference and to present a chronological overview.

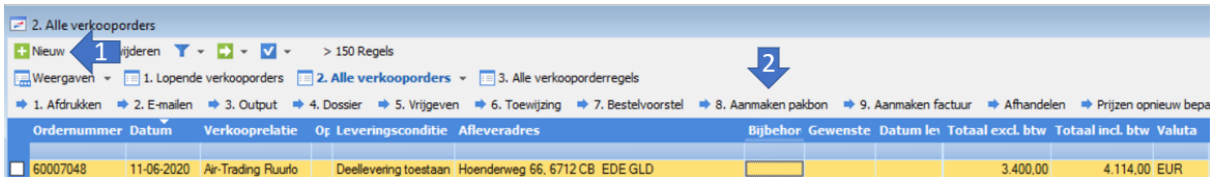


Figure 40: Sales order overview (source: AFAS test environment)

Figure 40 presents an overview of the sales orders. The first step is to create a sales order. The sales order function is marked by the arrow with a one in Figure 40. The second arrow shows how to create a pick order for the order fulfilment. The layout should be filled and completed, then a sales order is created. The booking-layout for a sales order is shown in Figure 41:

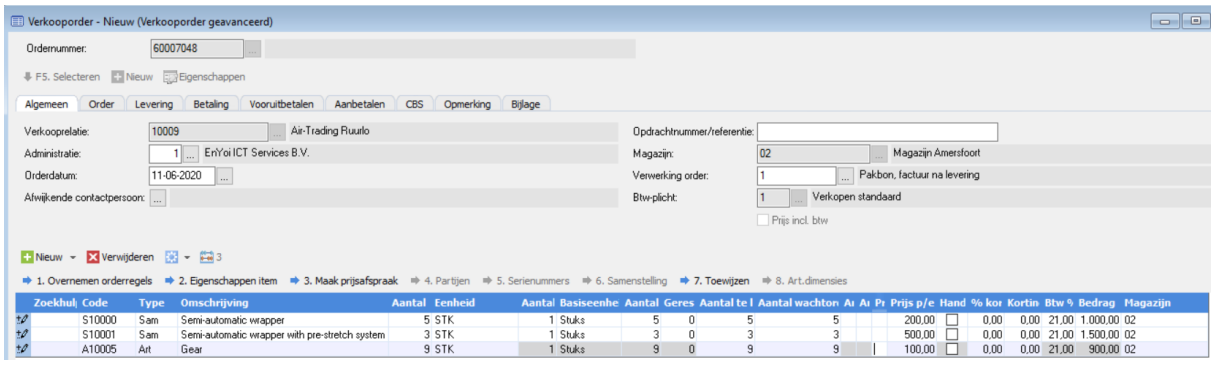


Figure 41: Sales order (source: AFAS test environment)

The lines at the bottom represent the sold products. A link between the sales order and purchase proposals is created if the link between the sales order and the purchase proposals is activated. Figure 42 shows the question that links the sales order line to a purchase proposal line. The article “Gear” has the “small inventory” profile. Thus, the link is activated.

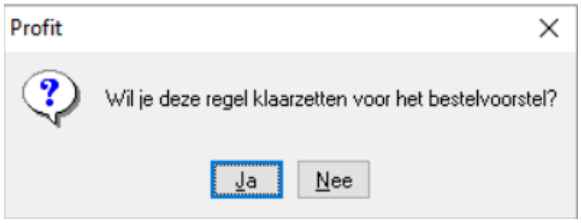


Figure 42: Link sales order and purchase proposal (source: AFAS test environment)

Next, assembly items are sold. Thus, a production proposal should be used to check whether production is necessary. The production proposal is located at the second arrow presented in Figure 43. The production profile suggests what should be produced to maintain the stock levels given the inventory profile and fill open sales orders. Approving these production proposals result in automatically generated production orders as presented in Figure 44.

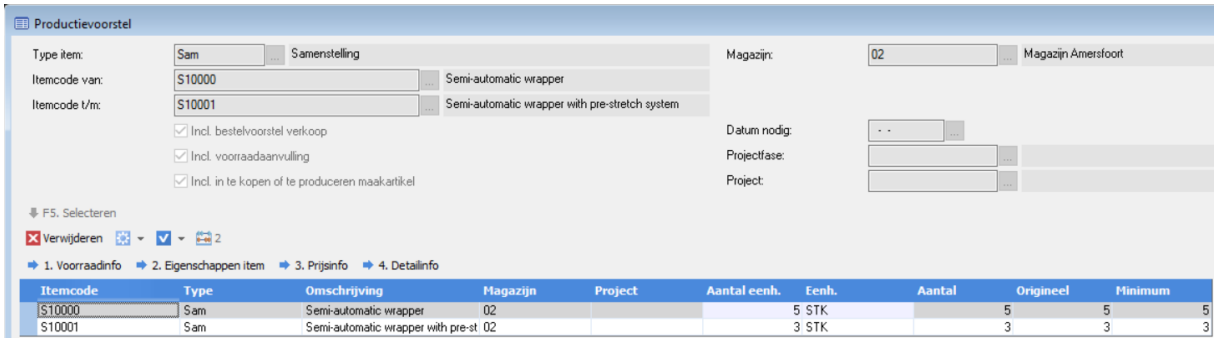


Figure 43: production proposal (source: AFAS test environment)

The production order overview in Figure 44 can be found when clicking the button marked with the third arrow in Figure 39.

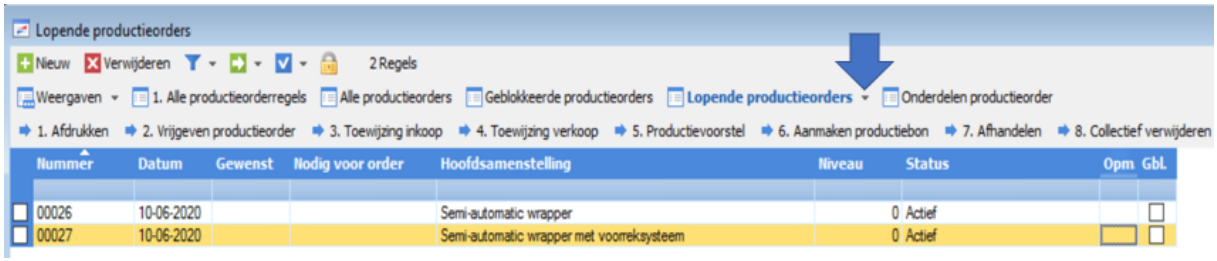


Figure 44: Production orders (source: AFAS test environment)

Production orders are not the only type of orders that are generated to fill sales orders or maintain inventory levels. The purchase proposal has the same functionality. Moreover, it can also be used to fill production orders. Underlying parts of a production order could be purchased through the purchase proposal. Therefore, it is recommended to use the production proposal before the purchase proposal. The purchase proposals are marked by the fourth arrow. The purchase proposal is shown in Figure 45:

Approving the purchase proposal results in purchase orders. These purchase orders are presented in Figure 46. Purchase orders can be found by clicking the button marked by the fifth arrow in Figure 39.

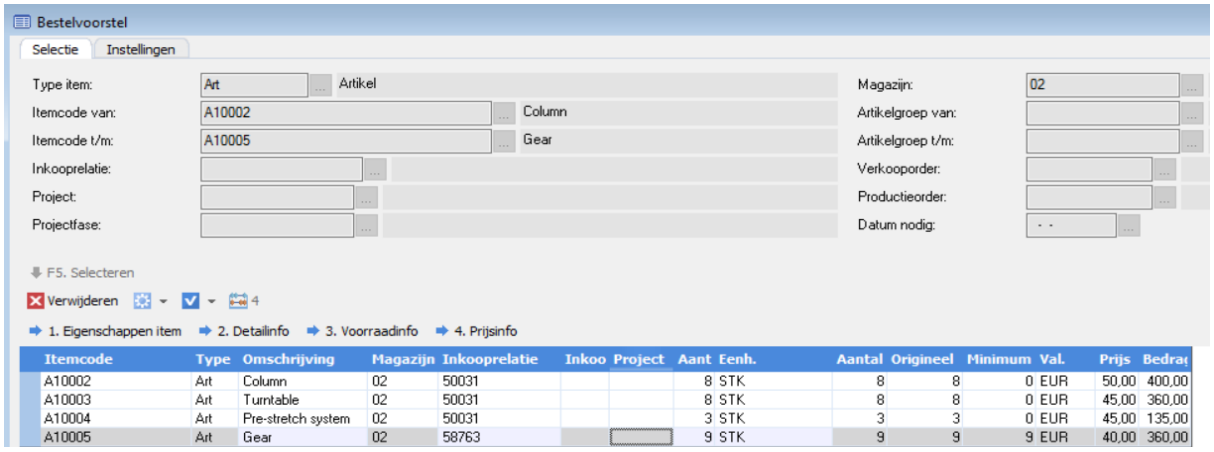


Figure 45: Purchase proposal (source: AFAS test environment)

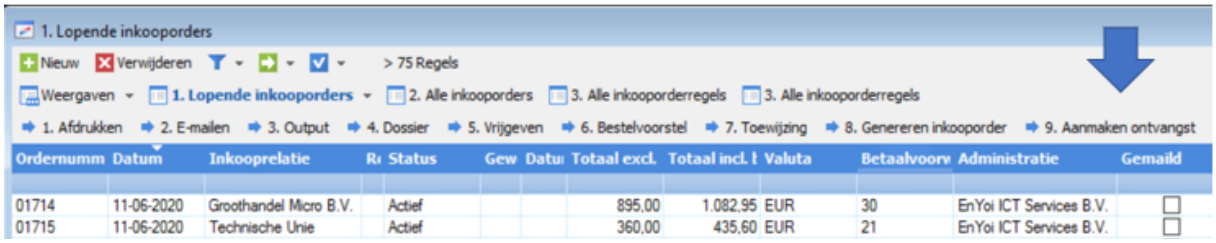


Figure 46: Purchase orders (source: AFAS test environment)

The purchase proposal presented four products to be purchased. However, there are only two purchase orders. Products are automatically clustered per purchase relationship. Thus, the system prevents unnecessary documentation. The purchased parts can then be received when the parts delivered. The delivery is documented using the receipt function marked with the arrow in Figure 26. Figure 47 shows how the receipt is documented:

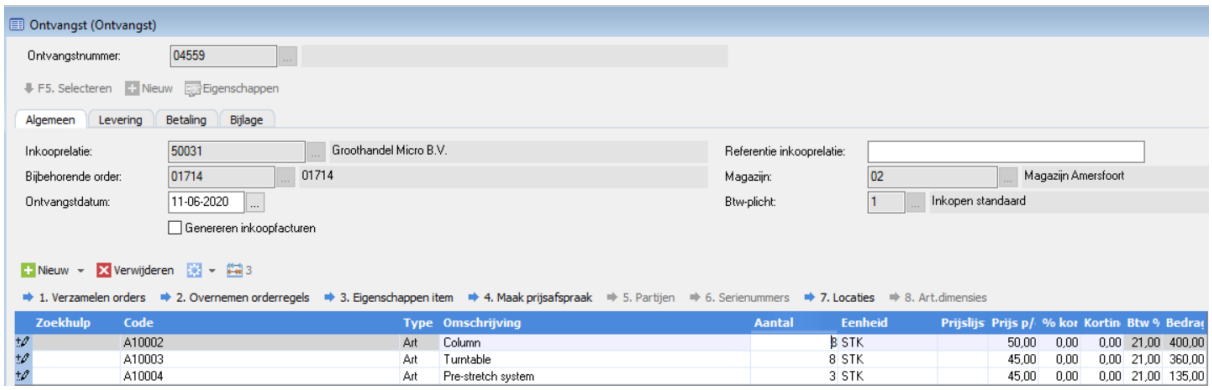


Figure 47: Receipt (source: AFAS test environment)

The received numbers do not have to be the total amount of the purchase orders since AFAS offers the option to receive partial deliveries. Completing the receipt in booking in the ordered parts. An overview of the receipts can be found when clicking the button marked by the sixth arrow in Figure 39.

Moreover, production orders could be completed as well. The arrow in Figure 44 shows the function to generate a production bill. The bookings layout of a production bill is as follows:

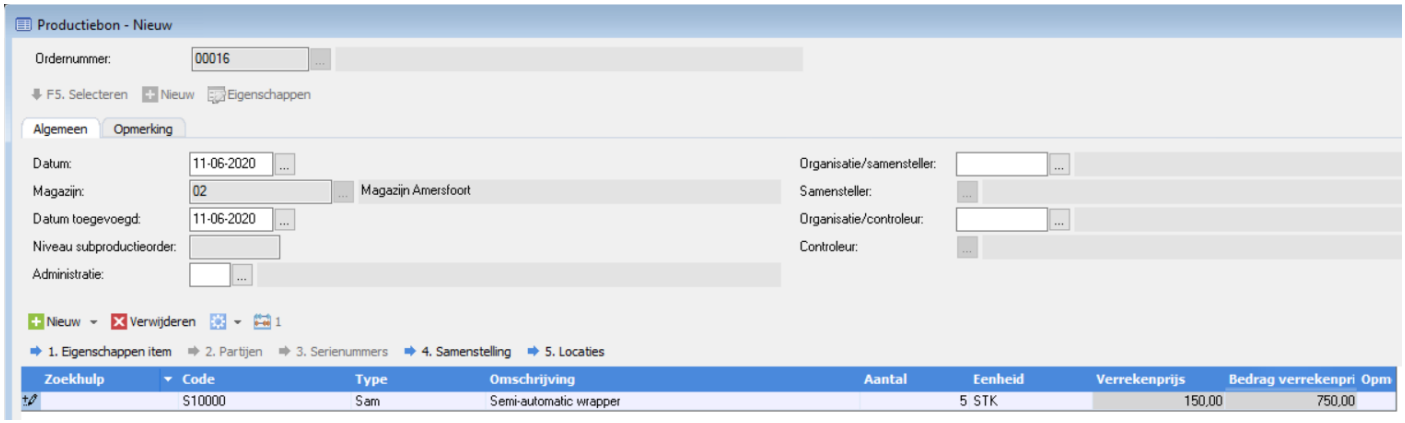


Figure 48: Production bill (source: AFAS test environment)

Then, the production bill is saved. In this demo case, there are two production bills generated. One for each production order. The production bill lines are shown in Figure 49 and can be seen when the action given by the seventh marker in Figure 39 is clicked.

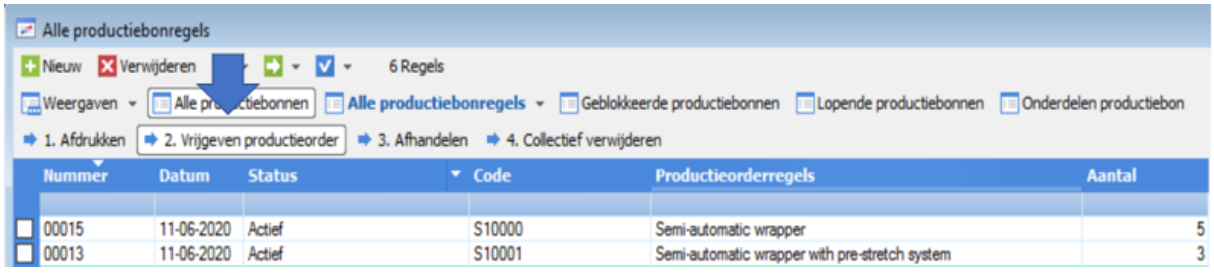


Figure 49: Production bill lines (source: AFAS test environment)

Production bills can be completed according to the function marked in Figure 49. However, completing production bills does not change stock positions or have financial consequences. Therefore, it is an unnecessary action. Moreover, AFAS only uses two production statuses. The first is active and the second is completed.

Finally, the sales order can be completed if everything is in inventory. The pick order can be generated by the second marked function in Figure 40. The pick order is shown in Figure 50. An overview of the pick orders can be seen when clicking the action shown by the eighth marker in Figure 39.

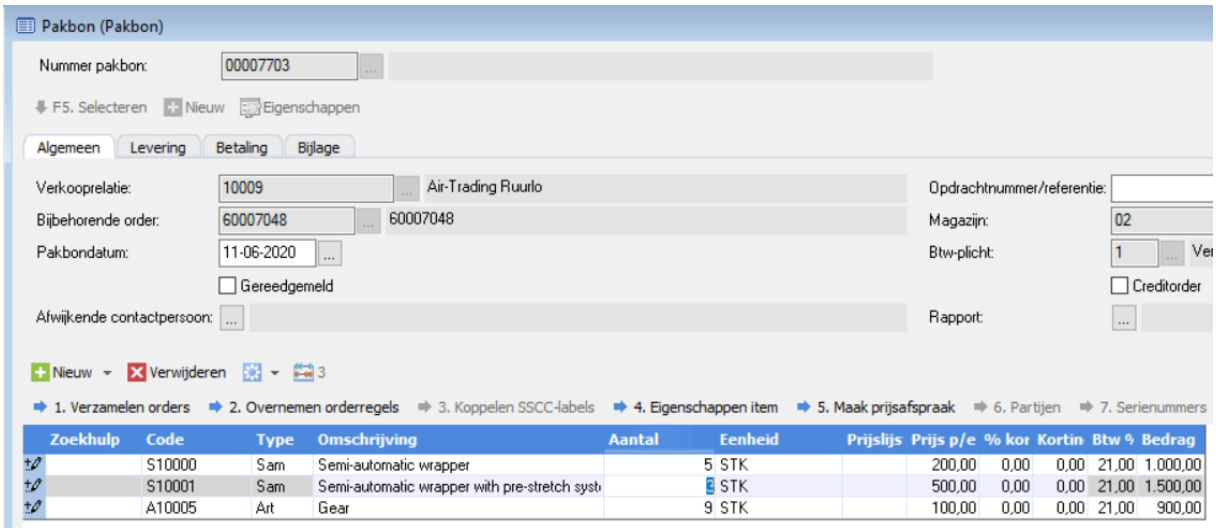
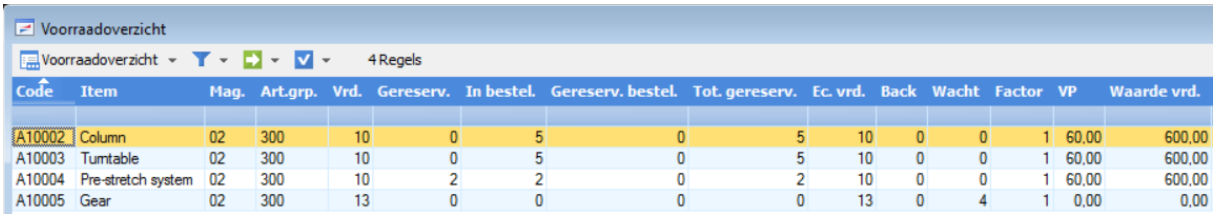


Figure 50: Pick order (source: AFAS test environment)

Completing the pick order results in completing the sales order. Then, parts are booked out of the inventory.

Finally, the inventory status of parts could be checked throughout the process. The ninth marker presented in Figure 39 shows where the overview could be invoked. This overview could provide useful information throughout every step in the order management process.



Code	Item	Mag.	Art.grp.	Vrd.	Gereserv.	In bestel.	Gereserv. bestel.	Tot. gereserv.	Ec. vrd.	Back	Wacht	Factor	VP	Waarde vrd.
A10002	Column	02	300	10	0	5	0	5	10	0	0	1	60,00	600,00
A10003	Turntable	02	300	10	0	5	0	5	10	0	0	1	60,00	600,00
A10004	Pre-stretch system	02	300	10	2	2	0	2	10	0	0	1	60,00	600,00
A10005	Gear	02	300	13	0	0	0	0	13	0	4	1	0,00	0,00

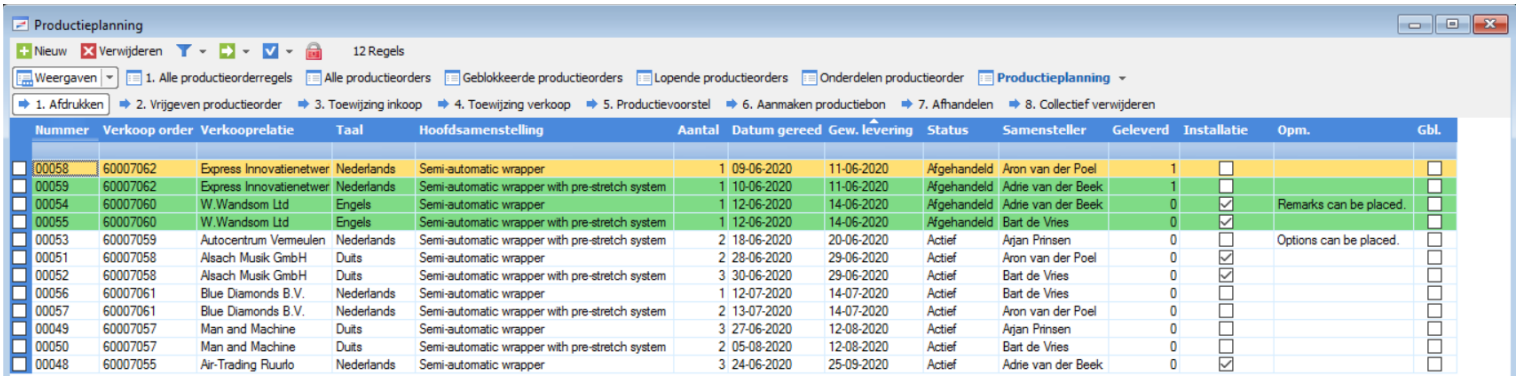
Figure 51: Inventory overview (source: AFAS test environment)

All in all, the steps to sell, produce and purchase the items are presented in this section. The steps are somewhat presented in chronological order. However, the order is not completely fixed. A sales order could be completed before the purchase order is received if the parts are available. Then, the purchase orders are used to replenish the sold inventory. The order possibilities of the process are visualised in the re-engineered purchase and issuance of spare parts process shown in Appendix M.

Production planning demo

The production planning has to be displayed as well. Though, some additional changes had to be made to the AFAS environment to create the planning. These changes are shown in Appendix O.

The production planning is a list of production orders with the attributes that are in line with the current production planning shown in Appendix E. The production planning is created based on information in sales orders, using the production proposal and the production proposal bookings layout. The production planning is shown in Figure 52:



Nummer	Verkoop order	Verkooprelatie	Taal	Hoofdsamenstelling	Aantal	Datum gereed	Gew. levering	Status	Samensteller	Geleverd	Installatie	Opm.	Gbl.
00058	60007062	Express Innovatienetwer	Nederlands	Semi-automatic wrapper	1	09-06-2020	11-06-2020	Afgehandeld	Aron van der Poel	1	☐		☐
00059	60007062	Express Innovatienetwer	Nederlands	Semi-automatic wrapper with pre-stretch system	1	10-06-2020	11-06-2020	Afgehandeld	Adrie van der Beek	1	☐		☐
00054	60007060	W.Wandsom Ltd	Engels	Semi-automatic wrapper	1	12-06-2020	14-06-2020	Afgehandeld	Adrie van der Beek	0	☑	Remarks can be placed.	☐
00055	60007060	W.Wandsom Ltd	Engels	Semi-automatic wrapper with pre-stretch system	1	12-06-2020	14-06-2020	Afgehandeld	Bart de Vries	0	☑		☐
00053	60007059	Autocentrum Vermeulen	Nederlands	Semi-automatic wrapper with pre-stretch system	2	18-06-2020	20-06-2020	Actief	Arjan Prinsen	0	☐	Options can be placed.	☐
00051	60007058	Alsach Musik GmbH	Duits	Semi-automatic wrapper	2	28-06-2020	29-06-2020	Actief	Aron van der Poel	0	☑		☐
00052	60007058	Alsach Musik GmbH	Duits	Semi-automatic wrapper with pre-stretch system	3	30-06-2020	29-06-2020	Actief	Bart de Vries	0	☑		☐
00056	60007061	Blue Diamonds B.V.	Nederlands	Semi-automatic wrapper	1	12-07-2020	14-07-2020	Actief	Bart de Vries	0	☐		☐
00057	60007061	Blue Diamonds B.V.	Nederlands	Semi-automatic wrapper with pre-stretch system	2	13-07-2020	14-07-2020	Actief	Aron van der Poel	0	☐		☐
00049	60007057	Man and Machine	Duits	Semi-automatic wrapper	3	27-06-2020	12-08-2020	Actief	Arjan Prinsen	0	☐		☐
00050	60007057	Man and Machine	Duits	Semi-automatic wrapper with pre-stretch system	2	05-08-2020	12-08-2020	Actief	Bart de Vries	0	☐		☐
00048	60007055	Air-Trading Ruurlo	Nederlands	Semi-automatic wrapper	3	24-06-2020	25-09-2020	Actief	Adrie van der Beek	0	☑		☐

Figure 52: Production planning (source: AFAS test environment)

The production planning has the same columns as the current production planning, except for the order picked attribute and the hour estimation. A pick order cannot be generated in a production order since production orders use production bills. One of the functions of a production bill is to act as a pick order. The use of production orders and production bills is already shown in the previous section. The hour estimation is an estimation of the time necessary to complete a production order. However, it is not used for analysis, currently. Therefore, it is not included in this planning since it results in unnecessary documentation.

The input for the planning starts when creating a sales order for semi-automatic pallet wrappers. The bookings layout of the sales order is shown in Figure 53:

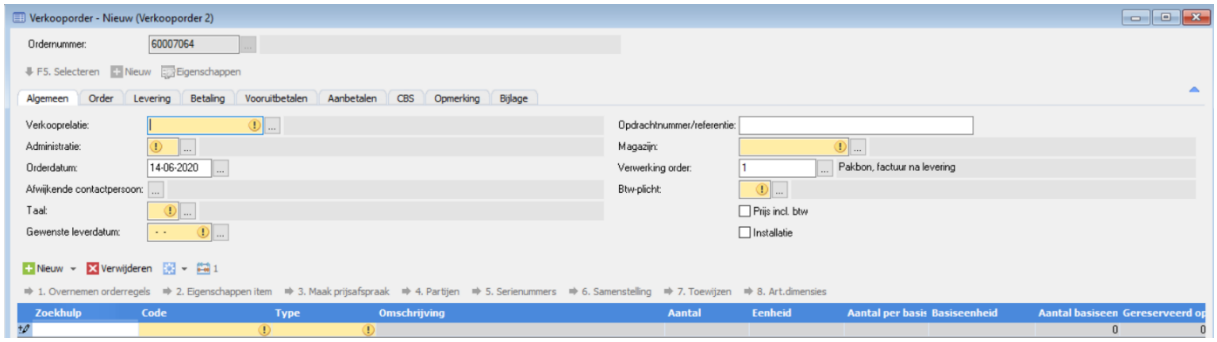


Figure 53: Bookings-layout sales order (source: AFAS test environment)

The yellow input fields with the exclamation mark are mandatory for completing the order. The information that is documented and displayed in the production planning is the sales relationship, the language and the desired delivery date. Moreover, the customer has to decide whether the machine has to be installed. Finally, the type of machine and the number of machines is added as an order line.

The information on the sales order is transferred to a production order through the production proposal system. Semi-automatic pallet wrappers have the inventory profile “never in stock”. Thus, the complete sales order line will be transferred to the production orders, since it has to be produced

according to the inventory profile. Thus, a semi-automatic wrapper will always be included in the production planning.

Then, the production order is included in the planning, however, the ready date and the mechanic fields are empty, distinguishing the planned orders from the other orders. The ready date and a mechanic should be added to the order by opening the production order layout as presented by Figure 54:

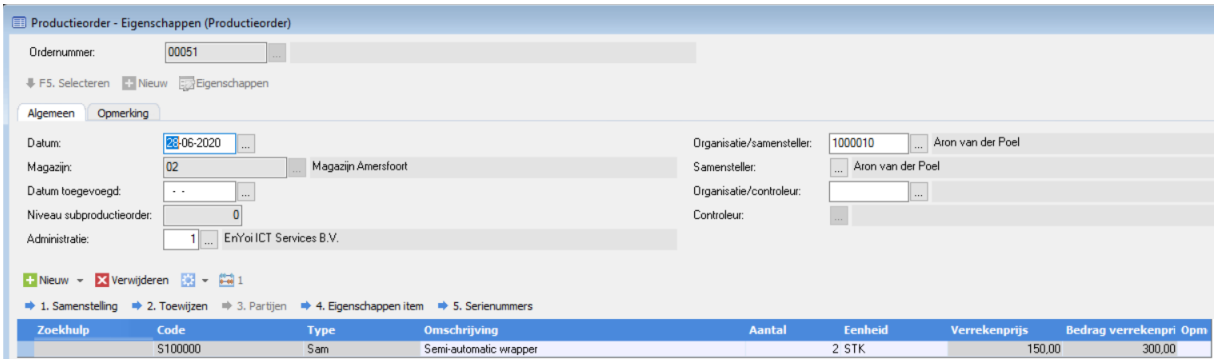


Figure 54: Bookings-layout production order (source: AFAS test environment)

The production order is finalised when a production bill is generated. However, a serial number has to be added to the created machines. The serial numbers are automatically requested before the completion of the production bill. The bookings layout in Figure 55 appears:

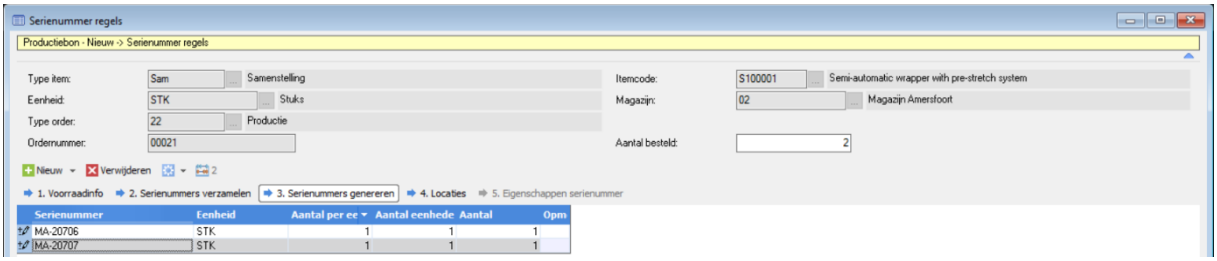
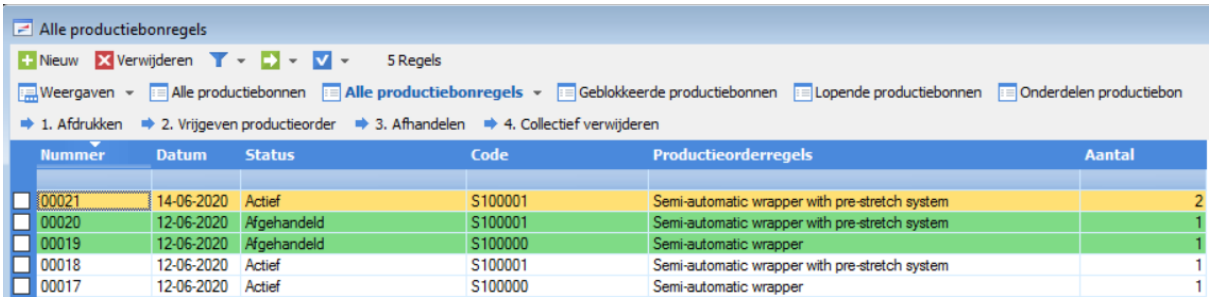


Figure 55: Generating serial numbers (source: AFAS test environment)

Then, the production bill can be completed as the order management module presents. Generating a production bill results in a completed production order. An open production bill is shown as shown in Figure 56:

Figure 56: Bookings-layout production bill (source: AFAS test environment)

The production bill line will turn green when the bill is completed as shown in the production bill overview in Figure 57. However, this does not have a function as discussed in section 6.4.1.



Nummer	Datum	Status	Code	Productieorderregels	Aantal
00021	14-06-2020	Actief	S100001	Semi-automatic wrapper with pre-stretch system	2
00020	12-06-2020	Afgehandeld	S100001	Semi-automatic wrapper with pre-stretch system	1
00019	12-06-2020	Afgehandeld	S100000	Semi-automatic wrapper	1
00018	12-06-2020	Actief	S100001	Semi-automatic wrapper with pre-stretch system	1
00017	12-06-2020	Actief	S100000	Semi-automatic wrapper	1

Figure 57: Production bill overview (source: AFAS test environment)

Then, a pick order based on the sales order can be generated and completed to deliver the machine. Then, the number delivered will automatically change in the production planning to show that the sales order is completed and the machine is delivered.