University of Twente
the Faculty of Behavioural, Management and Social sciences
Industrial Engineering and Management

The creation, evaluation and implementation of an ERP system with supporting dashboards, designed for the logistical operations of FM Chemistry

Author:

L.E.J. le Fever (Luc)

l.e.j.lefeverluc@student.utwente.nl

Supervisors University of Twente:

1st Dr. D. Braun (Daniel)

2th Dr. M. R. Machado (Marcos)

Supervisor FM Chemistry

J. Buitenhuis (Jesse)

UNIVERSITY OF TWENTE.

FM Chemistry

Management summary

FM Chemistry is a company in the chemical sector, they buy, sell, transport, repackage and restore quality of various types of chemicals. With multiple other entities they create the FM Group. In the company data about prices, transport, activities, containers, products etc. are stored inside mails, local excel and word files and sometimes not stored at all. The company desires a situation where an advanced system in place from which they can manage, monitor and evaluate the logistical operations of the company with the use of KPIs.

In this thesis, the design science research methodology (DSRM) is used to design, create and implement an artifact and answer the following research question: *How should an enterprise resource planning (ERP) system with KPI dashboards be designed and implemented to support the logistical operations of FM Chemistry?*

After analyzing literature about critical success factors and challenges for creating ERP systems. Unstructured interview were conducted to determine the requirements for the tool. Parallel to continuing the creation of the artifact, KPIs were selected, based upon literature review and unstructured expert interviews. The created artifact consists of an ERP system created in excel with KPI dashboards in power BI. The components of the ERP system consist of userforms, overviews and databases. With the ERP system employees can save a lot of time, for example, complex documents can now be automatically created which in the old scenario could take up to hours. The KPI dashboards are aimed to support employees in monitoring and evaluating the company processes.

Figure 1: Final design of the operational KPI dashboard.

To validate the system, the system have been tested, demonstrate and evaluate. The results of both the unstructured interviews and the questionnaire were positive. All employees concluded that especially compared to the old situation the system is very beneficial. Additionally, the artifact have given the company a better grasp on what is going on inside the company.

In this research, literature review and observations have shown potential opportunities for further development and preserving quality. Therefore, we have created the following recommendations:

- Create a SQL database
    - The tools performance and its life span can be increased when creating and hosting the databases in SQL.
- Iterate through DSRM and increase population size
    - If FM Chemistry decides to further develop the tool, it is recommended that FM Chemistry iterates to the DSRM and increases the population size during the evaluation stage.
- Periodically evaluate and improve the KPIs.
    - Regularly evaluate KPIs to ensure they provide the desired insights. Initially, a monthly review is recommended, which can be extended if KPIs remain stable.
- Maintain a high precision when inserting the data.
    - The quality of data analysis is limited to the quality of the data inserted. Making sure that all the userforms are filled in correctly will make sure that the quality of the data analysis remains consistent and usable over time.
- Do further research in potential analysis
    - Explore additional evaluations to enhance insights, such as material prices and sales performance. Further research in these areas is advised.
- Normalize the databases
    - The current system has been designed in such a way that many variables are double placed in the database. Restructuring the database can have a positive effect on the performance of the ERP system since.

Table of Contents

Abbreviations

ADR - Accord Dangereux Routier

BPM – Business Process Model

DSRM – Design Science Research Method

ERP – Enterprise resource planning

KPI – Key Performance Indicator

CI – Commercial invoice

PI – Performa invoice

PO – Purchase order

EX-A - Export declaration outside Europe

T1 – T1 custom clearance

DGD – Dangerous Goods Declaration

PL – Packing List

ROI – Return on Investment

ROP – Return on Project

UEQ - User Experience Questionnaire

Table of Figures

Table of Tables

Chapter 1: Introduction

This introductory chapter aims to provide background information about the problem that the stakeholders of FM Chemistry are facing. After sketching the scenario, the desired situation will be explained. Followed by an elaboration on the problem solving approach.

1.1 Company description

FM Chemistry is a company in the chemical sector. They buy, sell, transport, repackage and restore quality of various types of chemicals. With multiple other entities they create the FM Group. The operations of the FM group stretches across the entire world. The main focus of the company lies with jumping on opportunities. Since the group has “know how” and a wide network, it can often help its clients acquire difficult to get materials. A group of materials where these chances often occur is Accord Dangereux Routier(ADR) chemicals. These are hazardous materials that need to be treated with special care. The company is specialized to coop with the special treatment and regulations that are required to acquire and sell these materials. Apart from these materials oils and organic materials are operated with.

The company was founded in the north of the Netherlands in 1984 and it has been family owned ever since. Back then it was called FMB, the company made compounds. In 1992 the name was changed to FM Plastics, and it shifted its focus to of high value added compounds. Since then, it always sought emerging markets and partners. A fun fact about FM Plastic is that the company was one of the first companies in the Netherlands to recycle. Old telephones were disassembled for the expensive materials, like gold, that were used inside of them. It even had a whole facility in Steenwijk to process it. Since then, a lot has changed. Since the son has taken over the company the strategy has shifted. From an R&D production company, it has transitioned towards a trading company focused on identifying and making use of opportunities in emerging markets.

Nowadays, due to the growth in the chemical sector FM chemistry was created as a separate entity. The aim of this sister company is to have a business unit that is focusing on other opportunities than plastic compounding. The company is involved in providing business to business services all over the world. To provide these services, the company operates with a complex supply chain that stretches to every remote corner of the world. To manage this complex network the company established offices in multiple countries outside the Netherlands. The location of the offices are chosen for strategic reasons, like local connections, lower employee costs and tax advantages.

The company does not own a fleet of transportation vehicles and/or tank containers. Nor does FM Chemistry own depots for their materials. Instead, the services that are needed to acquire, store and sell the materials are outsources to other parties. For example, in the Netherlands FM chemistry works closely with company X a transport company and company Y a depot for container storage. Both are licensed to handle ADR material. Other types of companies that the FM group works together with are, manufacturers, container lessors, shipping companies, testing facilities, tank cleaners and repackage facilities.

So in short, FM chemistry falls under the FM Group an organization that helps companies acquire difficult to get materials such as ADR chemicals. The company operates worldwide and has offices in multiple parts of the world. The operations of the FM group are mostly outsourced to third parties.

1.2 Problem Identification

1.2.1 Problem identification process

In order to investigate the current processes as well as existing problems at the company, the daily operations have been observed for over a month. Additionally, employees have been interviewed to share their experiences and perspectives on the processes and improvement points.

Apart from these conversations, to gain a deeper understanding, an incident report was created of the problems that occurred. In the incident report, all the last-minute changes or things regarding operations that went wrong where noted down. Also the effect that it has on the rest of the process was written down.

For instance, one incident involved a chauffeur dropped a container at a the incorrect depot in another city. Another company that required the container for the next step was waiting for the container to arrive. The transport company said they had already delivered the container, while the other company said it did not arrive. It took a while to trace it and had an impact on the rest of the planning. Due to the delay of the container the planned activities had to be rescheduled. This impacted the whole planning, and later that week, the truck drivers lacked sufficient capacity to transport all containers. This resulted in increased storage, rental, transport cost. Next to the fact that it shows how the incident reporting works, this example showcases that small mistakes such as misreading an address can have a big impact on a larger scale.

So in short, at the start of the project assistance was provided to FM Chemistry. Through employee interviews and incident tracking, the current situation and challenges faced by FM Chemistry were systematically mapped for improved

1.2.2 Current situation

Before starting working on the ERP system, the company was observed for a period of 4 months. In this period various problems where discovered that have a decreasing effect off the efficiency of FM Chemistry. First of all, it was discovered that data about prices, transport activities, container, products, etc., is stored inside mails, local Excel sheets, and Word documents. This results in significant time spent searching for details and making it challenging to keeping an comprehensive overview. Especially if the team that is working together all have a piece of the puzzle and they are dependent on the information they need from each other.

Next to that, the operations of the company are not measured that effectively. In the time spend at the company it looked as if money was the only thing that is monitored continuously. Other performance indicators as delivery time play a role, but they are not continuously monitored. Monitoring these type of KPIs could help FM Chemistry to get better insides in their processes.

Furthermore, FM Chemistry uses an accounting system called ZOHO. This system offers options to integrate with other systems. But due to the lack of other systems FM Chemistry now needs to manually duplicated all documents that they want in ZOHO, resulting in inefficiency.

As stated earlier, FM Chemistry hires a lot of third parties to help them with their operations. Depending on the company the collaboration is with, the amount of communication and managing requires can vary. Here the fact that information is stored only on local computers brings difficulties. For example, if

an employee is unavailable due to a holiday or day off and was the sole person in contact with a company, it becomes challenging to retrieve previously discussed details.

The current use of the systems results in the following online landscape. First of all, there is no central accessible location that employees can use to store or lookup information. Outlook is the main communication platform. Inside mail strings communication between employees and third parties is stored. Furthermore, the company uses ZOHO, an accountancy program. A few employees can open the account and see the stored documents. All employees create their own local Excel and Word documents to create plannings, store procurement data and make financial overviews. Apart from the fact that this are local files instead of shared once, the fact that the company does not have templates creates chaos and facilitates room for mistakes due to miscommunication.

In short, data is not stored in a central accessible place for employees, apart from costs operations are not monitored, al financial documents need to be duplicated, information is often only accessible for one employee, and a lack of consistency among documents result in a decrease in efficiency and an increase in the probability of mistakes happening.

1.2.3 Problem cluster

During observing the company for a while, the action problems were identified, forming the bases for the analysis. Layer by layer problems were identified until the core problems were reached.

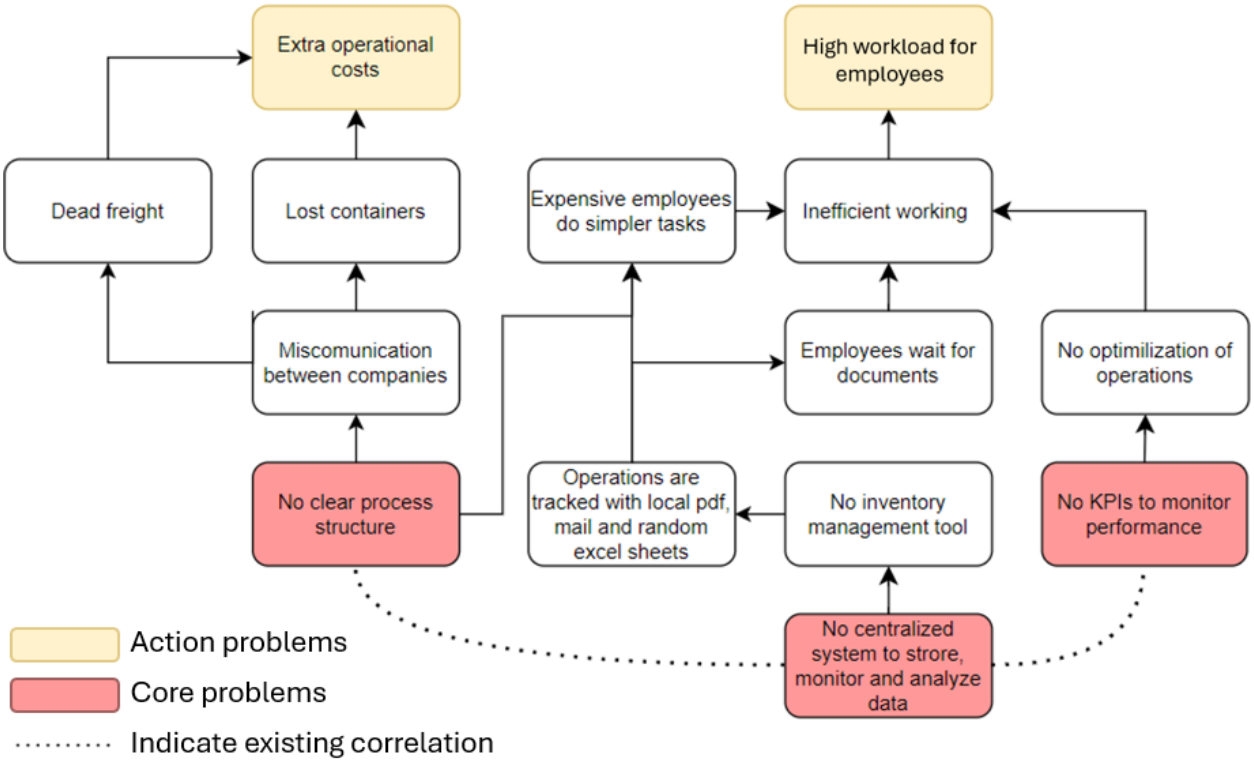

Figure 2: Problem cluster

As shown in the figure 1, the problem cluster has three core problems and two action problems. The core problem that is addressed in this thesis is “No centralized system to store, monitor, and analyze data”. Before elaborating on the reasons for selecting this problem, its associated challenges will be discussed.

The core problem that will be investigated in this project is connected to other core problems. The second core problems concerns the structure of the operational processes and the last identified core problem entails the ineffective monitoring of the operations. These two problems are closely related to the core problem that will be addressed in this research. Lastly, the lack of a centralized system initiates other problems. Next to the core problems, there are two action problems. These are the problems that the company wishes to tackle. In figure 1, these problems are highlighted with the color yellow. The next paragraphs will discuss the relations between the problems.

Core problem: No clear process structure

The fact that there is no clear process structure within the company, has a negative effect on the company’s performance. Upon this point, the company has not mapped out the steps that need to be performed when completing a certain operation or task. All the employees that work within the company need to know all possibilities by heart.

It is not necessarily negative that employees need to know all the steps of each process, but it can lead to mistakes. Because there is no specific list or order in which the tasks need to be done, it can happen that task are overlooked or miscommunicated.

Especially new employees can have a hard time with this. If they have not previously worked in similar business, they need to reinvent the wheel. This process is time-consuming for both employees and their managers. No structure creates the need for extensive supervision of employees. This leads to more higher educated employees or people with experience performing or assisting with basic tasks. This inefficiency increases the workload for managerial staff.

Apart from that, no clear structure can lead to miscommunication. Most of the times these misunderstandings are harmless. By a call or a mail the problem can be fixed. However sometimes minor misunderstandings can lead to a real problem. As shown in the example above about the truck driver, something as banal as a misunderstanding of a transport assignment had big consequences.

This miscommunication leads to extra costs. The most occurring cost that followed are dead freight. Furthermore, it happens that containers get lost. All of these things lead to extra operational cost that could have been avoided by having a clear check list for employees to use. Creating this structured way of working could potentially also make the work more doable for less experienced/lower educated employees.

It is an ambition of the company to create an work flow for the employees. However, since it is not here yet, it still causes disturbance in the whole process. As stated above, not having a clear defined process structure leads to multiple other problems. In the end leading to, extra operational cost and managing personal having a bigger workload.

Core problem: No inventory management tool

As stated earlier in the description of the current situation, the company does not use a centralized system to store and monitor all container and operational data. Instead the FM Group uses local Excel files to make financial overviews, plans, and track inventory. Apart from that, the input for these files is given by local depots occasionally. Per depots the frequency of stock list updates varies, they may send it daily, weekly, monthly, or upon request. Furthermore, important details are often located in mail chains that are accessible for one or two employees.

For employees not directly involved in operations, it can be challenging to follow and understand ongoing activities. They rely on what others tell them, and given the rapid pace of change, it is easy for them to lose track of developments. This leads to two other problems, expensive employees do simpler tasks and employees wait for documents or details.

An example to illustrate the relationship between these problems is as follows: Changes in transport planning often occur when a transport company fails to deliver a container on time. Therefore other handlings with the container need to be rescheduled. When hearing such news, debriefing a coworker about the situation and required changes often takes more time then directly handling the situation. If all involved employees would have access to a centralized database all the information could be accessed by the supporting employee. Thus saving time of a debrief and information can be found much easier.

What also often happens is that an employee asks for an overview of project cost. Now all invoices need to be located and send. Often they differ from location and people who have access to it. Therefore, employees spent time looking for these documents. In an ideal system, the invoices that are linked to a project should be easy accessible for these employees.

Informing people, sending documents and/or details of an operation that otherwise could be accessible in a centralized system is a waste of time. This way of inefficient working leads to a higher workload for all employees.

Core problem: No KPIs to monitor performance

The last problem within the company is the fact that there is a lack of key performance indicators. It is not that the company does not evaluate their performance. Both its employees and operations are monitored and evaluated. The main problem with the current way of evaluating, is that the evaluations are not stored and looked at over time. Since so much is happening in the company, it can easily be the case that people forget about minor mistakes that happened or factors that influenced the performance.

As said earlier, FM Chemistry manages its expenses and makes financial evaluation of projects that have happened. This is good, there is only still room for improvement. If other KPIs were installed, regulated and evaluated. The profitability, risks and time required could be easier determined upfront.

The lack of KPIs to monitor all the operational performance leads to sub optimal performance. Next to that, it makes it harder to evaluate what is been going on and how to improve and evaluate if something is not working as intended. This means room for inefficiency and having to deal with these consequences leads again to a bigger workload for employees.

In short, In the current situation of the company there is quite some room for improvement. The main problem in the current situation is that FM Chemistry does not have a centralized system to store monitor and evaluate data. This leads to a variety of other problems that could be divided into no clear process structure, no inventory management tool and no KPIs to monitor performance.

1.2.4 Desired situation

In the desired situation the company would have an advanced system in place from where they can manage, monitor and evaluate the operations of the company. From out this tool projects can be made, documents can be automatically created and estimations about cost and the duration of the project automatically shown based on historical data.

The goal of the company by initializing this project, is to develop an ERP system and dashboard with which they can clearly see what is happening within the operational department of the company. The main focus for this ERP would be on the transportation of goods, the warehousing of containers and the costs. To achieve this, the tool should have multiple dashboards that are connected to an online database. Next to the fact that the dashboards should give a clear overview of all the information that is stored, KPIs should be installed to see how the operational department of the company is functioning. Lastly, FM Chemistry desires a secure system that is integrated in the current online landscape.

In short, FM Chemistry desires a situation where they have a system in place that is able to store information about the logistical operations and include KPIs that give insides in the performance of the companies.

1.3 Problem solving approach

To narrow the gap between the current and the desired situation an artifact will be developed to store, monitor and analyze data. Making this will consist out of 2 parts. The first part will be about selecting KPIs. These KPIs need to be applicable for FM Chemistry, so that the operations can be monitored and evaluated effectively. The second part will be about designing and creating an artifact. With this artifact the operations will be monitored and the data that is generated will be stored. In this part of the thesis the two parts of this research will be elaborated on. The used methodology and how it works will be stated. This followed by the research question and lastly the deliverables.

1.3.1 Methodology

For this research, a research methodology has been selected to make sure the research and creation process goes as smoothly as possible. The methodology that is selected is the design science research method (DSRM). This method is created for the creation of artifacts (Peffers et al., 2007). Since the main goal of this research is to create an artifact to support the operation of FM Chemistry, the DSRM is the most appropriate method. The selection process of the KPIs will also be done with the DSRM. Although the KPIs will mainly come from literature, the selection and evaluation process will be closely done with the company. Thus DSRM is the right methodology to use.

Design science research method

The design science research method (DSRM) methodology is divided into 6 different stages that all contribute to the end goal. A successful development of a tool, dashboard or software. The first one is about problem identification and motivation. The second stage is used to define the objectives for a

solution. This is followed by the design and development. The fourth stage is used to demonstrated the current developed artifact. After this demonstration, the tool is evaluated. Lastly, the sixth stage is communication. (Peffers et al., 2007)

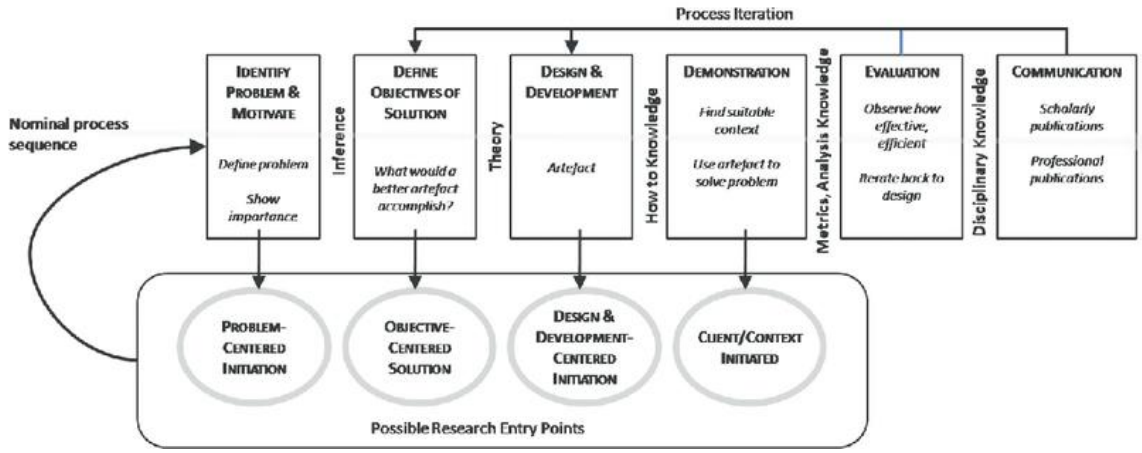

Figure 3: Design Science Research Model

Stage 1: Problem identification and motivation. In this part of the research the specific research problem needs to be defined and the value of a solution to this problem should be justified. The problem definition will be used in later stages to develop an artifact that tackles the complex problem. Having a clear problem statement that is agreed upon by all relevant stakeholders will make sure that the proposed solution is aligned with the needs to tackle the problem.

The value proposition accomplishes two things: it motivates the stakeholders in the process to pursue the solution and help them see that the researcher/developer understands the problem.

Stage 2: Define the objectives for a solution. The objectives of a solution can be derived from the problem definition and the knowledge of what is possible and actually feasible. These objectives can be quantitative or qualitative. Here a quantitative objective entails looking at the terms in which a desirable solution would be better than current ones. An qualitative objective on the other hand is a description of how the artifact is expected to support solutions to the problems.

Stage 3: Design and development. In this stage of the project it is about creating the artifact. Firstly designs as models methods or blueprints should be made. After checking if the design would meet the objectives for the solution it can be created. Optional is to go for a minimum value product that can demonstrate if a model or a concept that is included in the artifact works. It is also possible to skip this and immediately start to create a full working prototype. Either way, the work should be demonstrated, evaluated and improved. When implementing the feedback in the artifact the developer is again in this stage and will loop to the next two stages until all the objectives for a solution are implemented correctly in a way that the initial problem is solved.

Stage 4: Demonstration. The name of the stage clearly describes the activity that should be done. Via experimentation, simulation, case study or other appropriate activities the artifact should be demonstrated. When demonstrating it is important to note the findings for improvement. This will be helpful in the next stage.

Stage 5: Evaluation. The evaluation stage is one of the most important phases within the whole methodology. Here the developer should critically look at the artifact and identify what needs to be improved to fulfil the criteria to tackle the problem (Sonnenberg, C., 2012). Before the evaluation starts, the researcher should make a strategy for the process. This includes what evaluation method is selected, which stakeholders are involved in the evaluation and what the variables are that is evaluated on. (Appendix A2)

Stage 6: Communication. To complete the activities in this stage the developer should communicated all there is to know about the artifact that he has created to the relevant stakeholders. So it is not only about the artifact itself, also the results from the other stages should be communicated. This to make sure that the stakeholders understand where the solution comes from and with knowing that agree to the designed solution for the problem. After this stage the developer can always choose to revisit one of the previous described stages.

The order in which the stages are visited depends on two things. First of all the starting point, it could be that a company hires a developer and already knows what it is that needs to be made. Therefore, it could be that the developer would start in the second or even in the third stage. The other reason that the path through the process differs in each situation is influenced by the amount of times a developer needs to revisit a stage to improve the current work that has been done. Continuing in the same example of a developer that starts at the design and develop stage, it would be wise to reevaluate the previous stages that were done by the company, this to make sure that the solution they had in mind actually solves the problem that they proposed. In this case the process starts from the first phase and then moves on.

1.3.2 Research questions

Now that the selected methodology for this project has been described, the frame of the research will be stated by introducing the research questions and the deliverables. The main research questions that will be answered is:

"How should an enterprise resource planning (ERP) system with KPI dashboards be designed and implemented to support the logistical operations of FM Chemistry?"

To give an answer to this question we made five sub-questions that will be investigated. The sub-questions are created to support the main question and smoothen the design and development process. The sub-questions are:

Design and development

1. *What criteria are required for the ERP system?*
2. *What KPIs are insightful to use to monitor and evaluate the operations of FM Chemistry?*
3. *What KPIs will be implemented in the dashboards design?*
4. *How can a dashboard support the operations of FM Chemistry?*

Evaluation:

5. *What is the most suitable strategy for the evaluation of the artifact?*

1.3.3 Deliverables

As stated earlier, next to the questions, the deliverables will be stated to clarify what can be expected at the end of this project. The deliverables are as follows:

- KPIs to monitor operations
- Operational system
    - Inventory management system
    - Data warehouse
    - Integration with ZOHO
- Operation dashboard
    - KPIs dashboard

To conclude, this research is focused on finding the best way to design, create and implement an ERP system with KPI dashboard. Doing this can be motivated by a lack of a centralized system, or no ERP system and the desire to monitor operations with KPI dashboards. In this part the method for solving the core problem has been described. The project consist out of two parts. First, KPIs will be identified out of the theory. With the help of the DSRM and the company these KPIs will be selected and evaluated. The second part will consist out of creating an artifact using the DSRM methodology, this artifact will monitor the operation and store the data. This will be done to deliver the company with KPIs, an operational system, and an operational dashboard.

1.4 Conclusion

The chapter concludes that FM Chemistry's operational inefficiencies stem from fragmented data management, lack of transparency, and unclear process structures. Using the design science research methodology am ERP system will be created. Next to this, KPIs will be selected for a KPI dashboard. By adopting the proposed system, FM Chemistry aims to optimize its processes, reduce costs, reduce workload and achieve greater operational efficiency.

Chapter 2: Design of the ERP system

In this chapter, the design and development of the ERP system will be discussed. The chapter begins with a literature review about the success factors and challenges for ERP system creation. Followed by transforming the deliverables set by FM Chemistry into requirements for the ERP system. After this the selected software will be elaborated on. The chapter will then address the design of the ERP system. The scope starts with the online landscape and how the ERP system fits in there. From there the scope will be narrowed until the focus is placed on a userform level. Lastly, there will be a brief discussion on the intended use of the ERP. This section aligns with the design and creation phase of the Design Science Research Methodology.

2.1 Literature review

In this section, theory is investigated to determine what factors play a critical part in the changes of successful creation of an ERP system. These factors will be divided in success factors and risks. Next to identifying these factors, ways to cope with them will be identified. Apart from that, research has been done about criteria, how to determine them and what is important are among the investigated topics.

2.1.1 Success factors and challenges for ERP creation

By 1990, the research firm Gartner came up with the name enterprise resource planning systems, a single information system to increase the efficiency in the whole organization. Since than these systems have evolved a lot, new ideas and technology have made them even more efficient. multiple research (Kiran & Reddy, 2019); (Vayyavur, 2015) project show that there is a substantial amount of companies that are not so satisfied with the results a ERP system has given them. In this section, we look into the critical success factors that can make or break an ERP project.

On the one hand, when looking at the critical success factors a few factors repeatedly stand out, respectively, clear goals and objectives, the support of top management, the reshaping of business processes, education and training, and selection of the right ERP (Kiran & Reddy, 2019); (Vayyavur, 2015).

On the other hand, when pinpointing the factors that lead to unsuccessful creation and implementation of an ERP, the following critical failure factors stand out, lack of top management support, insufficient education and training, ineffective communication with users, unwillingness to use ERP, failure to redesign business processes, lack of clearly defined objectives and inadequate resources (Huang et al., 2004); (Kiran & Reddy, 2019); (Rajapakse & Thushara, 2023b).

Another type of challenging criteria is nested in the technical side of ERP projects. For the creation of the system these criteria are also worth investigating. Technical parts of the projects that have potential to create problems include, system integration, data migration, customization, maintenance, and system reliability (Al Bashar et al., 2024).

Analysing both the success factors and the failure factors the top 5 factors that stand out the most are, support of top management, clear goals and objectives, education and training, reshape of business processes and available resources. What can be seen from this list is that the organization plays a big role in the success of the implementation of the ERP. A lack of support from top managers has a huge impact on the chances of success. Many factors are correlated with the support, for example, clear goals and objectives follow from good management within the top layers of a company. Furthermore, the amount

of resources that are allocated to the project need to be approved by the managers. These resources include financial costs that can occur do to, initial investment, customization cost, support systems, maintenance , upgrades, and trainings. Apart from financial costs these resources include the time of employees. Furthermore, the amount of trainings is also something that needs to be negotiated with the top management. Lastly, the openness for change needs to come from these people in order for other employees to open up to the new way of doing business.

Apart from the top managers motivation and involvement, the behaviour of employees also play a vital role. Unwillingness to change often is a killer for a smooth implementation. This unwillingness to change can be motivated by a lack of understanding or a fear of job displacement.

Many ways to coop with these factors, are rather straight forward. Involvement of the top managers and effective project management for example. As seen in the paragraphs above, this plays a big factor on the chances of success. Furthermore, the inclusion of employees at beginning stages of the projects and education about the goals and benefits of ERP systems can help employees be more accepting to the new systems. Sufficient training with these systems is another ingredient for successful implementation.

2.1.2 Requirement engineering

The creation of requirements is a critical part in the development of artifacts. Literature shows that requirement engineering is a social creative conative process. (Dawson, 2013) It is a social process since it requires understanding by all parties to reach an agreement. For understanding, communicational skills are needed. For an agreement negotiation skills come into play.

Apart from that, reaching a deal requires creative modelling skills to create understandable information models. The process of creating these models relies on cognitive skills including abstraction, mental modelling, problem-solving and reasoning skills.

In this social creative conative process, the clients problem perspective and the developers solution perspective are brought together. (Adisa et al., 2010) When criteria follow from this process they are not set in stone, over the time criteria can change.

In literature many models have been created to determine the desired criteria of a client. These models vary from the Fuzzy Analytic Hierarchy Process (Emrouznejad & Ho, 2017), Weighted Scoring Model, and Delphi Method (Brady, 2015). All emphasize that it is important that stakeholders should be included in order to determine the relevance of a criteria and its alignment with the goal of the project. Furthermore these methods also emphasise the importance of prioritizing the criteria.

2.2 Requirements

As described in the DSRM, in the second stage the objectives for a solution need to be pre-determined. The theoretical framework shows that clients need to be involved in the creation process of requirements. To make sure that all the companies desires where transformed in requirements, unstructured interviews were conducted. The most important stakeholders, CEO and supply chain manager, were asked what needs to be included in the tool, what processes it should support, how it should be integrated into their current landscape, what tools they want me to use, and what information needs to be stored. Out of conducting these interviews, it was concluded that FM Chemistry desires a system that has the ability to monitor inventory, store data and integrate with ZOHO. To ensure the ERP

system addresses these needs, each deliverable is translated into one or multiple requirements that the ERP needs to fulfill. The requirements that have been selected for the project consist out of:

- Inventory management system
- Document creation automation
- Integration with ZOHO
- Data warehouse
- Interconnection
- Security

Below, the reasoning of selecting the criteria and the impact for the ERP that the criteria will have are elaborated on. From literature was found that weights can be applied to criteria to oversee what is more important. All criteria listed below are needed in the system. Therefore applying the weights did not add value.

Inventory management system

For making good decisions, it is crucial for FM Chemistry to have accurate insights in both equipment and material inventories. As a result, one of the primary requirements for the development is an inventory management system. This part of the system must consist out of a fleet overview and a material overview. The fleet overview should contain all equipment, from leased ISO tanks to jerrycans whether they are filled or not. For materials all bought stock should be present, regardless if the materials are already in stock.

The overviews should give clear insides in what is present. Furthermore, at the overview it should be possible to search and filter. This advanced filter should have the option to filter on different variables that are important for that overview.

Document creation automation

Currently, the operations department at FM Chemistry manually generates a large number of documents, particularly for the shipments of dangerous goods across the globe. The automation of the creation of these documents has the potential to significantly reduce the employees workload. The second primary requirement is therefore that the ERP should be able to automatically create documents if that is possible. The document types it should at least be able to create are, Purchase Order (PO), Performa Invoice (PI), Commercial Invoice (CI), Packing List (PL), Dangerous Goods Declaration (DGD), Export declaration outside Europe (EX-A), T1 Customs clearance (T1), and Transport assignments.

Integration with ZOHO

FM Chemistry uses ZOHO for its accounting. Currently, employees first create documents and after that manually enter these documents in ZOHO. As discussed above, making these documents is unnecessary, since the process can be automated. Doing this twice is nothing more than a waste of time. To eliminate this waste, the automatic insertion of data into ZOHO is a requirement.

Data warehouse

The new online landscape of FM Chemistry must feature a centralized data warehouse. All the data generated with the ERP should be stored in this data base. Additionally, both the information stored in

the data warehouse and the tables where the data is stored should strictly be accessible for authorized personal.

Interconnection

All employees using the ERP should have real-time access to the data, on the condition they have an internet connection. This requirement ensures that data entered by one user is immediately visible and accessible to all personnel. Ensuring a collaborative and transparent work environment.

Security

Not all employees are allowed to have access to the data that is stored in the data warehouse or ERP. Therefore, the system must incorporate robust security features. These security features should include, a access control system and a secure login process. The access control system enables the owner to give employees access to data and overviews. The login process should require a unique username and password for each employee to enter the system. This ensures that sensitive information is protected while still allowing appropriate access for those who need it.

As stated in the theory, the requirements above are not set in stone. If needed they will be adjusted according to the needs of the company.

2.3 Software selection

The software that has been selected to create the ERP system is Excel with the corresponding code language VBA, both the interface and database will be created in the software. To support the ERP system, Power BI will be used for the dashboard creation. The three main driver for this decision are, current online landscape, skills, and costs. The company currently already uses Microsoft Excel software and it fits in their current online landscape. The second reason is that the researcher already has experience with coding in this program. This could not be said about other potential options as python for example. The last main driver for this decision is that using this software does not generate additional cost for the company. Since the company already pays for a Microsoft package Excel and Power BI can be used without additional costs.

Furthermore, the requirements interconnectivity and security are fulfilled by the selected software. In contrast to Power BI, to create interconnectivity excel requires additional coding, Power BI has integrated functionalities for sharing. In regards of security, both creating an access control system and a secure login process are feasible in Excel. In Power BI, the login feature will not be included. Yet, it will be possible to share parts of the dashboards separately, the owner of the dashboards has the control to decide what parts of the dashboards he or she wants to share.

2.4 Business Process Model (BPM)

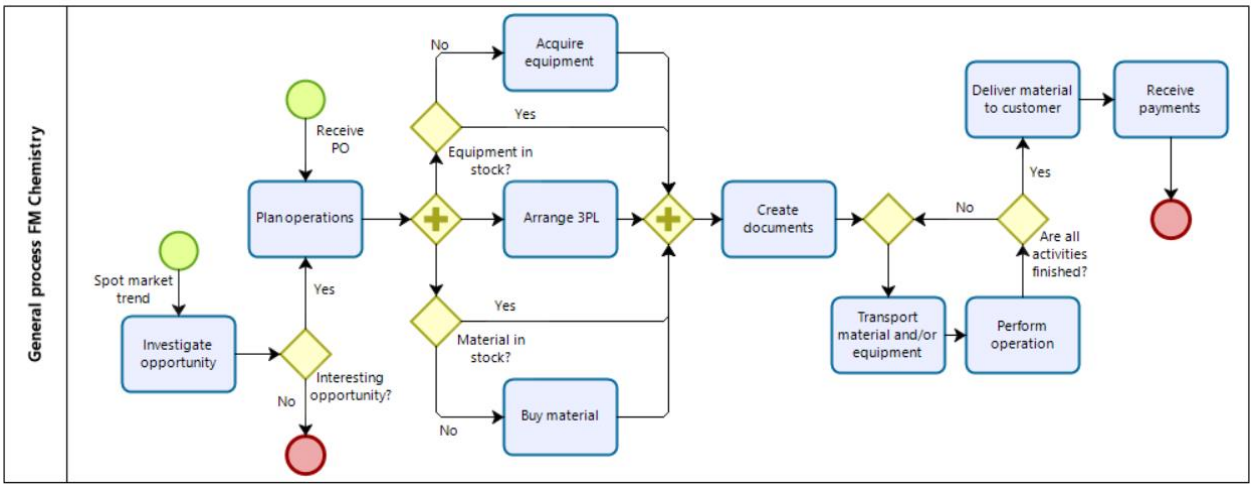

Figure 4: Simplified BPM of the operations of FM Chemistry

Figure 4 shows a simplified version of the processes in the company that the artifact will support. In appendix A.3 the procurement-, transport-, operational-, and selling process are shown in more detail. From this figure it can be seen that the created artifact is not designed to support all company processes. For example, the human resources department of the company will not supported by the designed system. Although, a normal ERP system would support all departments of a company, in this tailor made artifact it is not incorporated into the design since the company does not want it.

The simplified BPM functions as brief overview of what the company processes entail. This overview is used to analyze when what type of actions are performed in the operations. That analyses helped to identify when and how the system should support the actions done by the employees in the operations.

2.5 ERP system design

In this section, the ERP system design will be discussed in detail. The combination of the requirements and BPM are used to design the system. Throughout this section, we will progressively examine the design of the system, beginning with new online landscape and connections. This will function as the foundation of the explanation of the ERP system design. Then the focus will be narrow to the core infrastructure that forms the backbone of the ERP system. The next step involves examining the individual components that make the system. Furthermore, the relationships and interactions between different users and various software platforms will be discussed. Al these components will be integrated into the BPM model shown above. Finally, the security of the system will be explained.

2.5.1 Online landscape and connections

To understand the ERP on a micro level it is essential to understand the bigger picture. In this part the new online landscape will be shown. To recap the previous chapter, currently the employees all make their own documents. Nothing is stored in a public location. Next to this, all the information that goes into ZOHO, the accountancy platform, is already been made before the data is inserted. In this way, the employees do double work and waste a lot of time.

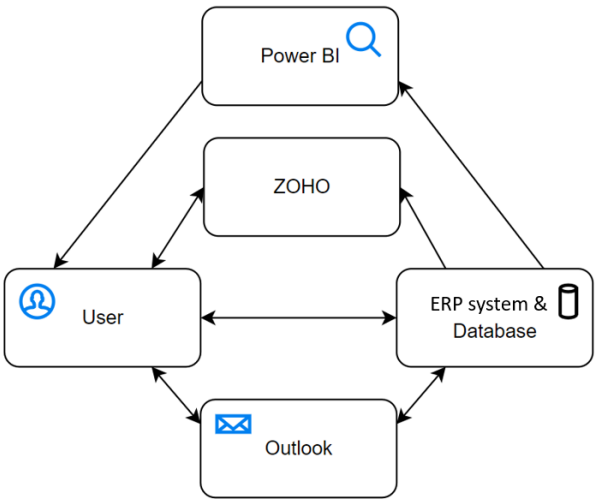

Figure 5: New online workspace of FM Chemistry.

The figure displays the new situation where power BI, the ERP system and the database have been added. Again, this online workspace indicates the way employees can share information and display the received data. The arrows showcase the information streams between the different software's. The arrowhead indicates the person or software that receives the information. In case that there are two arrowheads both receive and send data. In case of one arrowhead there is a one way stream. The software that the arrowhead points towards receives the data, the other side sends it.

Inside the ERP users can create new data, it is important to mention that if a document is created and saved in PDF form, the outlook database functions as a central place where people can store these documents.

The new workspace does not only increase the efficiency of the employees, it also provides structure, clarity, and transparency.

2.5.2 Modules

To create more structure in the design, four Modules where created to divide the components of the ERP. Respectively, document making, inventory management, activity tracking and projects/overarching. In this part of the research a brief description of these Modules will be given. Next to that, what is included in each Module will be stated. This to create an overview of what the ERP is about before we will zoom in on the specifics elements.

Document making

As stated the creation of documents is a big part of the day to day business for FM chemistry. One of the goals for this ERP is to create the documents automatically. All userforms and worksheets that have anything to do with the documents or the creation fall under this Module.

Inventory management

As predetermined in the requirements, an inventory management system is required to make this ERP a success. To keep all the components of this part of the system together, a Module is introduced for this. All interfaces, databases and the code that makes them run, fall under this Module.

Activity tracking

All the activities that happen with the fleet and material in the operations of FM Chemistry need to be tracked. Currently, employees did this in there head or used excel in order to track it. In the ERP an interface is created to do this. All the userforms and worksheets related to this fall under the activity tracking Module.

Projects / overarching

FM Chemistry describes itself as a company that jumps on opportunities. When they find such an opportunity a project is started. The whole process of buying an material, transporting it, repackaging it doing other activities with it and then selling it false under a project.

A brief example of a project cycle. FM Chemistry identifies an opportunity, they have identified that the gap between the buying price and the selling price is profitable enough to start the further research. From the moment that they identify such an opportunity a “project” is been created. Research is done to identify if the cost and risks that come with the operations leave enough room for a profitable project. If this is the case, the project will be executed. All the logistics fall under that project.

To relate this to the Modules, tanks can be used to transport a material. For that the inventory sheet is required to see which tanks are available. At the activity interface the activities done with the selected tank will be traced. Lastly, the documents needed for the activities will be created with the document making system. As this example shows, projects have overlapping with all the Modules above.

All components of the ERP that have an overlapping with multiple Modules or with none fall under the project / overarching Module.

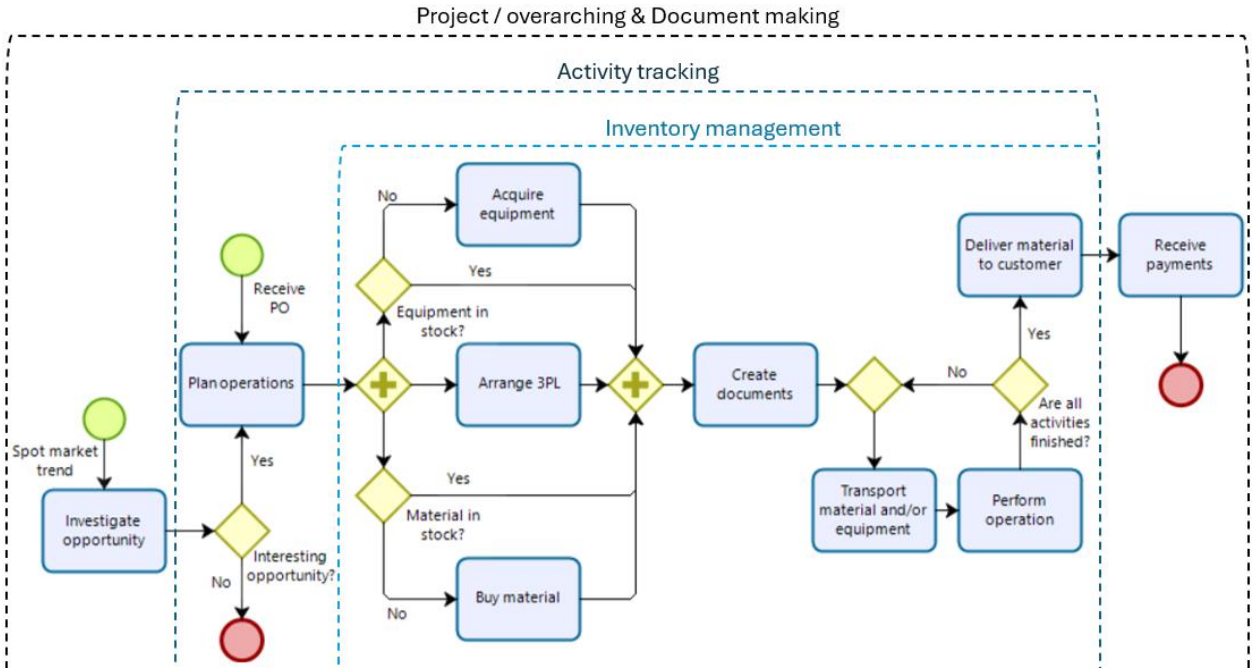

Figure 6: The combination of the BPM and how the module support the operations in the designed system.

As illustrated in Figure [X], not all modules support all processes within the system. For instance, the components within the inventory management module are utilized exclusively when employees need to check or modify stock levels. Similarly, the components of the activity tracking module monitor logistical operations within the company. The document generation module consists of components designed to facilitate the creation of necessary documents for operational execution, including the purchase and sale of goods.

Moreover, the project/overarching module oversees the entire system's operations. These components serve as reference points to which generated documents and recorded activities can be linked. Additionally, they function as storage locations and integral elements necessary for the system's overall functionality.

2.5.3 Worksheets & userforms

Now that the Modules have been explained it is time to zoom into the next layer of the ERP. That brings us to the worksheets, userforms and modules. This part starts with a brief explanation of what worksheets, userforms and modules are. This is followed by introducing all worksheets and userforms and how they are linked to the Modules. Next to that the different type of worksheets and userforms will be explained.

Worksheets

A worksheet is a cells collection divided by rows and columns. In excel, users can fill the cells with data and formulas. In the ERP system the worksheets have 3 main functions. Display information, store information and order information. Most users of the ERP system will only interact with the worksheets that display information. The other two are only accessible if access is granted.

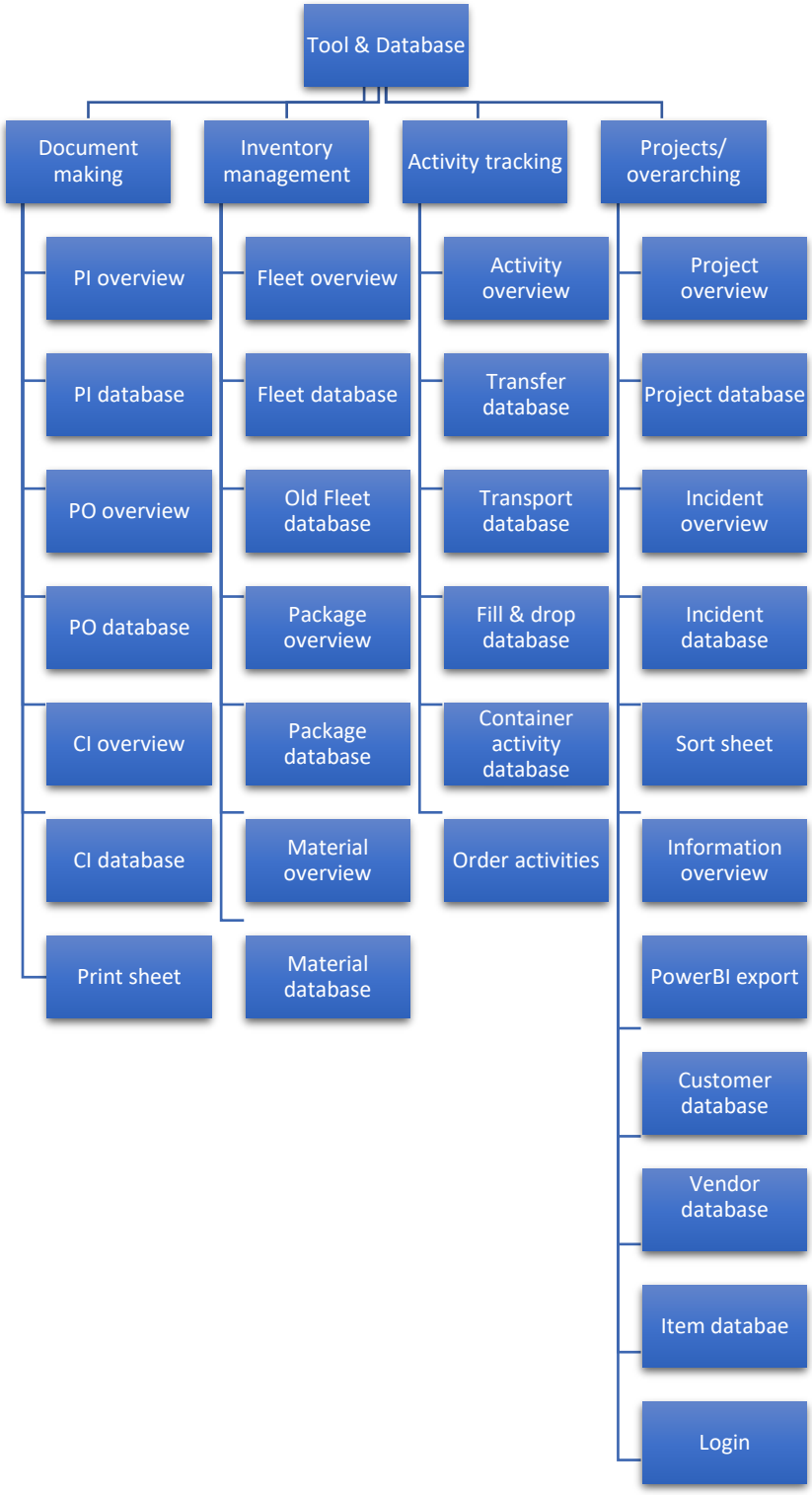

Figure 7: Overview of the worksheets and their correlation to the Modules.

Overviews

Figure 8: A snapshot of the Performa Invoice overview worksheet.

In this overview all PI's are shown that are located in the database. The table is designed to display all key details like customer names, item names, net weight etc.. Together with the company these key details are selected to make it easy for the user to navigate through the selection of PIs displayed. The worksheet is coded in such a way that when a user selects a row containing information, the selected row will be highlighted with a darker blue. This to enhance the user friendliness. Furthermore, after selecting a row 2 icons appear on the right side.

Databases

PI no	PI code	Customer Name	Status PI	item name	Amount	Customer cfr	In database	Dbrow	rate
1	PI 1	Noorin Polymer Limited	Accepted	Hexene-1 (C6)	€ 396.900,00	Yes	Yes	3	€ 1,89
2	PI 2	NP Engineering & Trade Servic	Accepted	Polyol BAYNAT 81IF66B	€ 6.900.000,00	Yes	Yes	4	€ 2,30
3	PI 3	Alpha-Plast	Rejected	Service bill	€ 7.200.000,00	No	No	5	€ 2,40

Figure 9: A snapshot of the database for the Performa invoices

This figure represents a snapshot of the Performa invoice database worksheet. The sole purpose of this worksheet is to store data that is generated by users.

These worksheets functioning as the primary layer of interaction and database location of the ERP system. This makes them a vital aspect of the ERP system's overall structure and operation.

Userforms

An userform is basically a pop-up window that can be used to create a custom made interface that user can uses to work with the ERP system. Using these interfaces enhances the user experience. Filling in data is much easier and can be done more accurately. Automatically filling the userforms if possible is an integrated functionality of the ERP system. Furthermore, the ERP system is designed to give the user feedback if they do not fill in all acquired fields or add wrong data.

Within the ERP system a variety of functions are given to these interfaces. The userforms are mainly used for adding data to a database, displaying data that is located in the database and chancing data in the database. Furthermore the userforms are used to navigate users through the ERP system, give users notifications and asking users to make a decision.

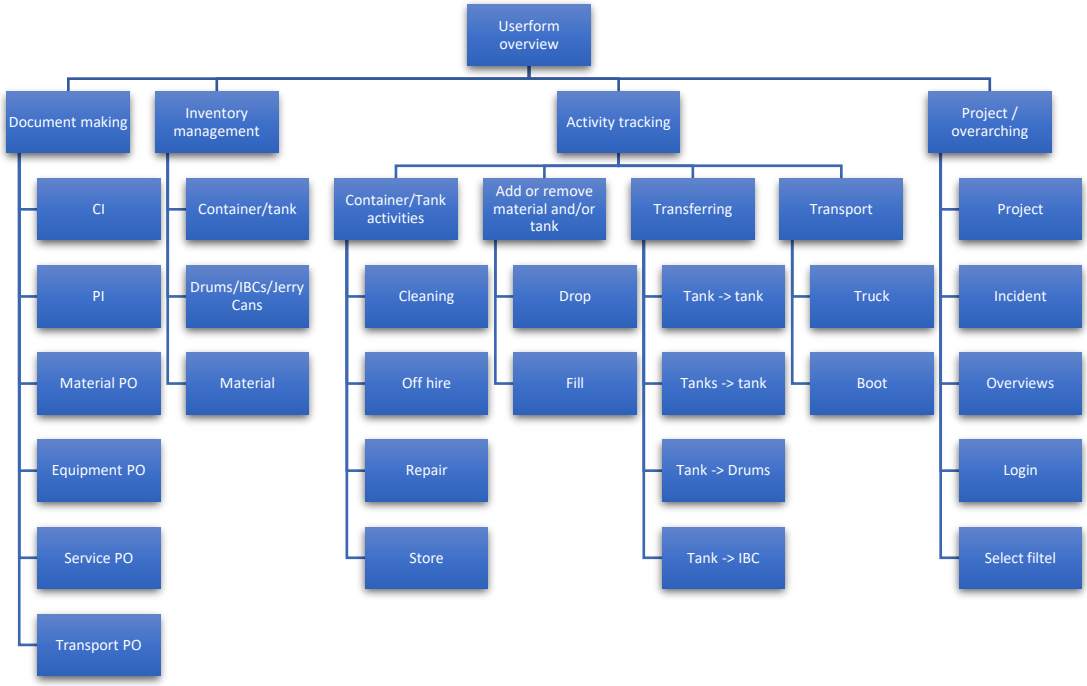

Figure 10: Overview of the userforms and their correlation to the Modules.

2.5.4 User connectivity and ZOHO integration

As mentioned in the requirement section it is important that people can work together in the ERP system from everywhere. As long as employees have internet all the changes made should be communicated to others that are using the ERP system. In this part the design to make this happen is elaborated on. Next to that, the integration with ZOHO will be elaborated on. Lastly, the link between power BI and the ERP system will be briefly explained.

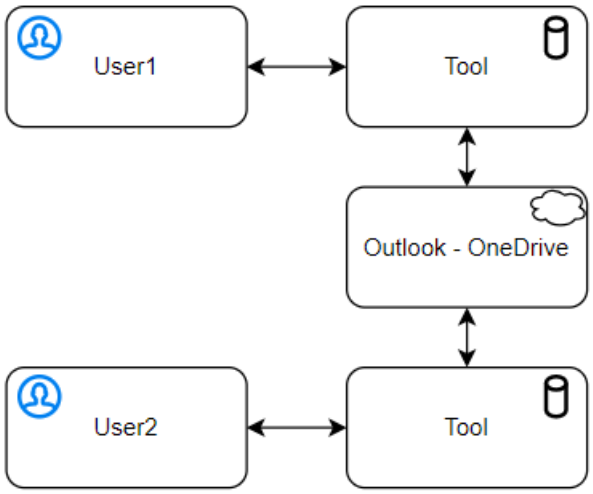

Figure 11: Link between the users, ERP system and Outlook server.

The ERP system is designed to share all changes that are made inside the databases with the other users. Every user has his own file/ERP system he or she can work in. In outlook OneDrive a location is created

allocated for temporary storage. When users insert data in their ERP system, code is activated that breaks down the data on cellular level and places it, with the location of the cell, in the OneDrive in the user folders. For all the users there is a specific folder. When another user opens their ERP system, code is activate to search in their specific folder, if there is data in there the ERP system will take the data of that cell and place it in the correct location. So, outlook functions not only as communication software for mailing, but also for communication link between the ERP systems. Furthermore, it is good to mention that when a new user is added to the system, code will automatically create a new folder in the OneDrive.

Next to the user connectivity the ZOHO integration was created. With the main goal of eliminating waste of creating documents multiple times. This integration with ZOHO is designed in the following way, if a user completes a document and tells the ERP system that it can be send to ZOHO the ERP system creates a web hook, this is basically a link. Than the ERP system restructures the information that is placed in such a way that ZOHO can read it. In the ZOHO account adjustments were made so that when the webhook is activated ZOHO automatically structures the data and creates the corresponding documents. In this way the users of the ERP system does not need to create the document multiple times.

2.5.5 Security

As stated in the requirements security plays an important role for FM Chemistry. Both in terms of the security of the ERP system and the access employees have. To secure the ERP system an login has been created. Users are required to fill in a username and password before they can enter the system. The admin and the CEO of the company have solely access to the admin sheet. Here passwords of employees can be changed. This place is also allocated for granting employees access to parts of the ERP system. The CEO desired a system were not all employees have access to all the sheets. So the design has incorporated that wish by allowing the CEO to give and take away people there access.

2.5.6 Designed use of ERP system

In this section the order in which the users need to use the ERP system is briefly elaborated on.

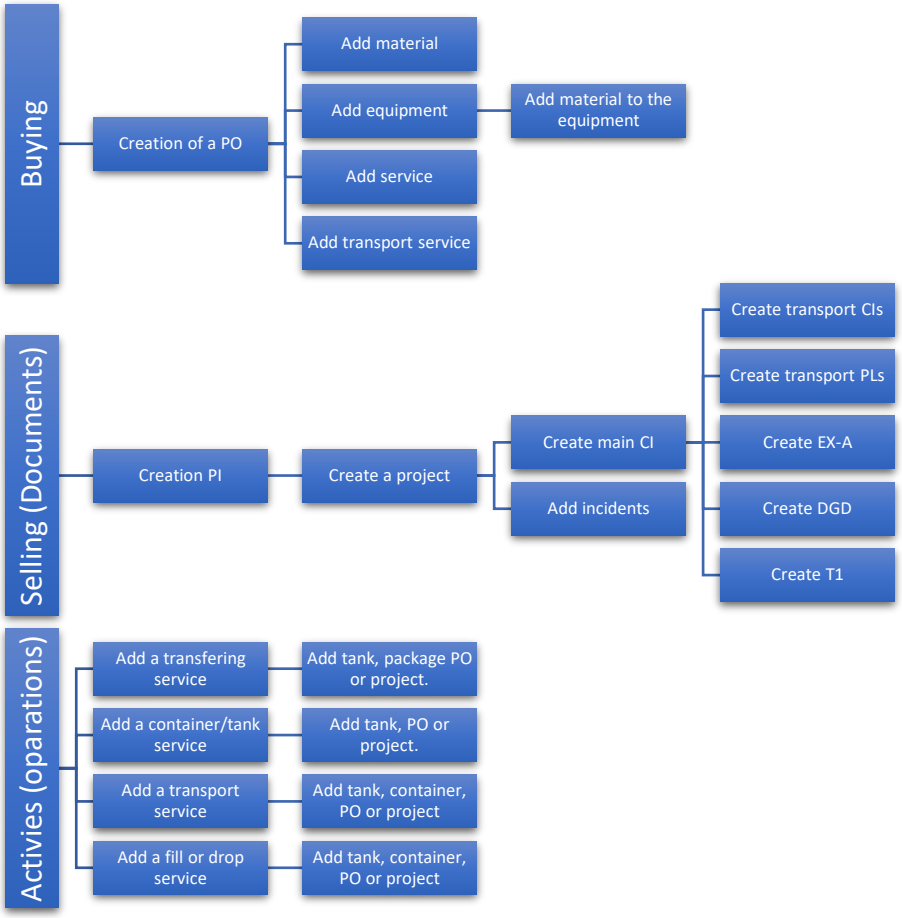

Figure 12: Overview of actions and order.

Figure 10 shows the order in which actions within the ERP system need to be taken. Per tree the actions go from left to right. For example, if an user wants to create a project, the user first needs to add a PI to the ERP system.

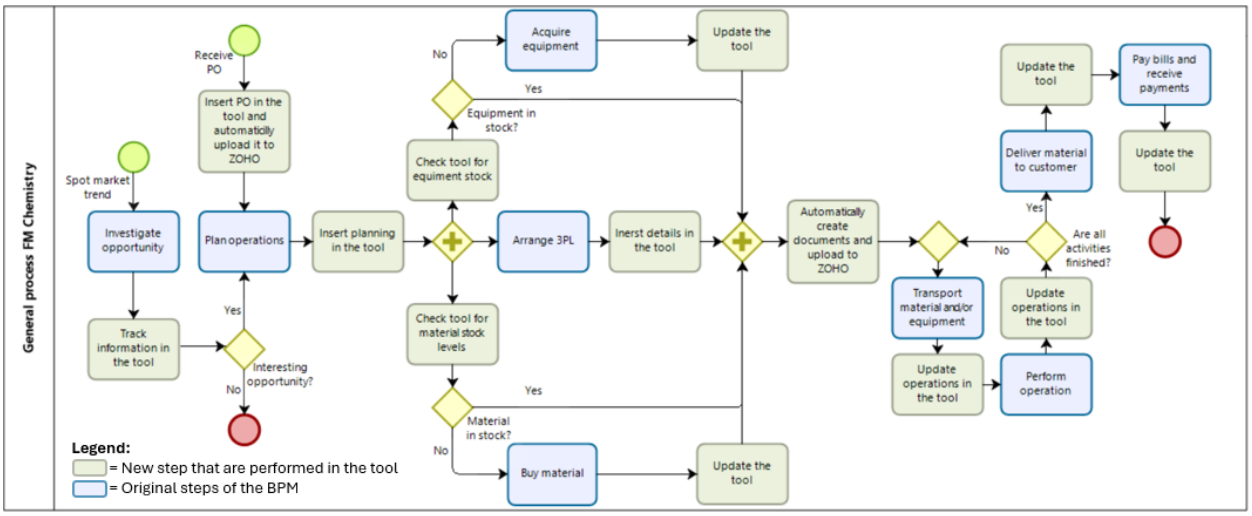

Figure 13: The simplified BPM including the designed use of the tool

In figure 13 the tasks that employees need to perform in the designed artifact are added to the simplified BPM. The green boxes indicated the minimal required tasks that need to be performed in the system to monitor the operations effectively. Per green box, the amount of worksheets and userforms an employee needs to interact with varies. The goal of this figure is to give an overview. Therefore, the detailed steps are excluded. Furthermore, a large quantity of additional actions the user can perform in the tool is also excluded. For example, the creation of a project and the possibility to report accidents is not included.

2.6 Conclusion

This chapter outlined the design and development process of the ERP system for FM Chemistry, emphasising how theoretical frameworks, client requirements, and technical considerations has led to the created system. In conclusion, this ERP system is tailored to meet FM Chemistry's needs. As shown by figure .. , the designed worksheets and userforms support the logistical operations of FM Chemistry. To conclude, the system fulfils all the requirements listed in this chapter.

Chapter 3: KPI selection

In this chapter of the research the KPI selection will be elaborated on. The selection process consists out of two parts. The literature review and the expert discussions. In the literature review the goal is to find all possible interesting KPIs for FM Chemistry. From these interesting KPIs a selection will be presented during a discussion with the relevant stakeholders. During this discussion it is the goal to determine the KPIs that will be used in the dashboard.

The list of KPIs is made for FM Chemistry's operations, per Module of the ERP system a few KPIs will monitor the performance. Previous discussions with the employees determined the parts of the company that the KPIs should focus on. Respectively, supply chain, warehousing, third party collaborations and finance KPIs. For the sake of creating more structure and clarity the list of KPIs will be divided in these same focus points.

3.1 Literature review

In this part of the research literature will be evaluated and with the relevant discoveries will be shared. The aim of this is to see what can be found in the literature that can be used to answer the knowledge questions that where proposed in the previous chapter. Via systematic literature review and snowballing the relevant articles are found. The process of the systematic literature can be found in appendix A.1 above that in references an overview of all important articles can be found.

In the current world operations of companies become more complicated than ever. Materials often need to travel great distances around the world to be used in the next manufacturing step to become an end product for consumers. The increase of complexity in supply chains is not any different in the chemical industry. There is a large network of companies that is involved in the keeping this complex supply chain in place. (Srinivasan et al., 2006)

To cope with these complex supply chains information systems are used to regulate monitor and evaluate the performance of supply chains and operations of companies. This to help people in the decision making process. Data interpretation methods that are commonly used are balanced scorecards and dashboards (Bentley, 2017). Balanced scorecard is a system that is used by businesses to monitor, evaluate and forecast. It is mostly utilized to manage and control the performance of business processes (Yanine & Córdova & Durán, 2020). Dashboards are systems that aim to increase the understanding of data so that the user can effectively make decisions upon the shown data. The difference lies with the data that is used as input. For dashboards this is real-time data, whereas balance score cards use periodical data. As FM Chemistry has asked about real-time evaluation ERP system, the dashboard is the most appropriate information system.

A dashboard consists of KPIs that are shown in a clear way. KPIs reveal the gap between plan and execution and helps identifying and correct potential problems and issues (Chae, 2009). To make sure that it remains clear a minimal amount of KPI should be chosen, the needed KPIs only. If there are too many KPIs placed in a dashboard the positive effect that having a dashboard has vanishes. It makes the evaluation of the operation hard by the confusion that can occur when there are too many factors in the dashboard (Molina-Carmona., 2018). To select KPIs there are many different ways that can be chosen. Literature shows that the Delphi method, the Analytic Network Process, and the Analytic Hierarchy

Process are the most commonly used selection methods(Saaty, 1988; Liu & Tsai, 2007; Barber et al., 2023).

As stated before in this theoretical framework the final KPIs will not be selected, here it is about identifying KPIs that could be interesting for monitoring and evaluating the operations of FM Chemistry. In a later section of this chapter the final selection of KPIs will be determined. In the literature many KPIs can be found (Dumitrascu et al., 2020); (Staudt et al., 2015); (Wang & Liu, 2007); (Leal et al., 2021); (Elsaghier, E. H. 2017); (Meier et al., 2013); (R. Brealey et al., 2020); (Liu et al., 2009).

Below the list of KPIs is divided into 4 categories, supply chain, warehousing, third party and finance. Between the 4 list there was a lot of overlapping. The KPIs that are applicable for multiple categories were placed in the first category where they were found. Furthermore, not all the KPIs that are found in the literature were placed in the lists. Some of the KPIs are irrelevant for FM Chemistry.

3.1.1 Supply chain KPIs

KPIs	What do they measure?	How do they measure?	Source
Distribution cost	The total cost of distribution including transportation and handling cost.	Sum of all cost related to the delivery of a product.	(Beamon, 1999); (Kusrini et al., 2020); (Elsaghier, 2017); (Tundys & Yudi, 2019)
Forecasting Accuracy	The percentage of orders/service that is correctly forecasted upfront.	(Forecasted demand – actual demand) / actual demand	(Liu et al., 2009)
Material acquisition cost	All cost associated with supplier sourcing, contract negotiation and qualification, and the preparation, placement, tracking of purchase order, including all costs related to buyer/planners.	All cost associated to the material acquisition / total amount of materials acquired	Introduced by the writer
Order fulfillment cost	The total cost of all the expenses involved in the course of handling product from receiving to distribution.	Sum of all the cost generated between the receiving of an order and delivering it.	(Brealey et al., 2011); (Tundys & Yudi, 2019)
Supplier lead time	The time it takes for a supplier between getting an order and delivering the products.	Order deliver date – order received date	(Tundys & Yudi, 2019)
Supplier on time delivery	The % of on time delivered products by the supplier.	(Total on time delivered orders/ Total orders) * 100	(Kusrini et al., 2020); (Elsaghier, 2017)

Unexpected operational cost	The amount of cost extra per “handling”.	Sum of unexpected cost	Introduced by writer

Table 1: Supply chain KPIs

Beamon(1999) states that supply chain KPIs should be based upon 3 main drivers. Respectively, resources, output and flexibility. Resources are measured based upon, costs, inventory levels, personal requirements, equipment utilization and energy usage. Output does not only refers to the amount of resources that are produced. Beamon states that apart from the organizations strategic goals, the customers goals and values also needs to be incorporated. Flexibility can measure a system’s ability to accommodate volume and schedule fluctuations from customers, manufacturers and customers. (Elsaghier, 2017)

Ying et al. (2009) identify common issues in creating effective KPI matrixes. To help companies he identifies and prioritizes a set of KPIs relevant for supply chain management. Some of the suggested KPIs are incorporated in the tables.

Tundys, B., & Yudi, F. (2019) identifies the need for including a new dimension to monitor supply chains. He states that in today’s world sustainability should be incorporated in supply chain management.

Lastly, two KPIs are introduced by the writer. Respectively, unexpected operational cost and material acquisition cost. In chapter one, one of the action problems of the problem cluster is the extra operational costs. Due to errors in logistical operations extra cost occur and the return per project decreases. To monitor if the company performs more effectively after the implementation of the tool, this KPI is believed to give clear insight.

The amount of profit the company can generate is highly based upon the acquisition price of materials. These prices can change on a daily basis, proactively tracking these prices will give FM chemistry the ability to identify trends and thus identify more opportunities. Furthermore, the prices of materials in the chemical supply chains are dependent on each other. Materials that are bought are most of the time not the end product nor raw materials. Tracking the prices of all the materials in the supply chain over a period of time can also help FM Chemistry to identify trends and opportunities.

Almost all the selected KPIs for this thesis align with one of the dimensions of Beamon, output, resources and flexibility. Solley forecasting accuracy, introduced by Ying et al., does not immediately fall under these dimensions. Although, sustainable supply chain management is important in today’s world. For FM Chemistry they fall outside their scope of interest. The tailor made KPIs fit the monitoring and evaluation of the operations of FM Chemistry.

3.1.2 Warehousing KPIs

KPIs	**What do they measure?**	**How do they measure?**	**Source**
Delivery accuracy	The % of deliveries that have been fulfilled accurate.	(Accurate deliveries /total deliveries) * 100	(Tundys & Yudi, 2019)
Delivery Lead time	The time it takes to deliver an order.	Order deliver date – order received date	(Sergeeva et al., 2019); (Tundys & Yudi, 2019)

Inventory accuracy	The percentage of inventory that is tracked accurate.	(The counted units/ units on record) * 100	(Jothimani & Sarmah, 2014b)
Inventory cost	The sum of all the cost associated with holding an product in inventory.	Sum of the costs generated by inventory	(Jothimani & Sarmah, 2014); (Tundys & Yudi, 2019)
On-time delivery/Delivery reliability	The % of orders that is delivered on time.	(The total on-time delivered orders/ total orders) * 100	(Kusrini et al., 2020); (Domingues et al., 2015)
Order fill rate	Measures the percentage of total orders that have been fulfilled.	(Filled orders/total orders) * 100	(Liu et al., 2009); (Jothimani & Sarmah, 2014); (Kusrini et al., 2020)
Order lead time	The time it takes between the order placement and fulfillment.	order deliver date - order receiving date	(Jothimani & Sarmah, 2014)
Order picking time	The time it takes to take an order out of the warehouse.	Point in time order picked – order receiving time	(Sergeeva et al., 2019)
Orders shipped on time	The % of orders that is shipped on time.	(Total orders shipped on time/ Total orders) * 100	(Sergeeva et al., 2019)
Perfect orders	The % of orders that have been fulfilled perfectly. Perfectly means: on time, orders complete, orders damage free and perfect documentation.	(Percent of orders delivered on time + percentage of damage free orders + percentage of completed orders + percentage of orders with accurate documentation) * 100	(Jothimani & Sarmah, 2014); (Tundys & Yudi, 2019)
Put away time	The time it takes to place a product in the warehouse.	Point in time unit stored – unit receiving time	(Sergeeva et al., 2019)
Stock-out rate	The % of items not available when needed for sale.	(The total amount of items that are not available for sale/ The total amount of sales) * 100	(Elsaghier, 2017)
Transport utilization	The % of time all transport modes are used.	(The total amount of hours transport is used/ total of hours transport is available) * 100	(Jothimani & Sarmah, 2014b)

Throughput	The amount of an unit a company can deliver in a specified period.	Total amount of time/ amount of time it takes to produce one unit	(DeSutter & Gao, 2021b)
Warehouse utilization	The % of space used in the warehouse.	(The amount of space used/ total amount of space)* 100	(Jothimani & Sarmah, 2014b)

Table 2: Warehousing KPIs

In table two warehouse KPIs are listed. The selected KPIs come from various sources that look from different angles to warehousing. Jothimani and Sarmah (2014) explored the applicability of the Supply Chain Operations Reference (SCOR) model. Furthermore they identify the key performance indicators (KPIs) for the service-oriented sector – namely a third-party logistics (3PL) service provider.

Tundys and Yudi (2019) aim to organize knowledge about the KPIs used in literature and economic practice. They aim to relate them to a new business strategy, which is sustainable supply chain.

Apart from the more theoretical sources, two case studies are also included in this research. DeSutter and Gao (2021b) created a case study about modelling throughput in warehouses in the food industry. Kusrini et al (2020) has created a case study about KPIs for sustainable warehousing at a leather manufacturer.

These different sources helped create a big portfolio of KPIs that are potentially interesting for FM Chemistry.

3.1.3 Third party KPIs

KPIs	**What do they measure?**	**How do they measure?**	**Source**
Acceptance rate	The % of orders that are accepted.	(Accepted orders/ total orders) * 100	(Jothimani & Sarmah, 2014b)
Error rate	The % of task that go wrong.	Number of errors/ total number of task attempts	(Jothimani & Sarmah, 2014b); (Tundys & Yudi, 2019)
Freight cost per unit shipped	The transport cost per unit.	Freight cost / total units shipped	(Panousopoulou & Manthou, 2016)
Transit time variability	The variance in lead time.	Sum of all (lead time – average lead time)^2 / total number of lead times included	(Liu et al., 2009)

Table 3: Third party KPIs

For the monitoring and evaluation of third party operational providers the KPIs in table three have been listed. Jothimani and Sarmah (2014) explored the applicability of the Supply Chain Operations Reference (SCOR) model. Furthermore they identify the key performance indicators (KPIs) for the service-oriented sector – namely a third-party logistics (3PL) service provider. From this research the acceptance rate and error rate are identified as most applicable for FM chemistry. Tundys & Yudi(2019) and Panousopoulou & Manthou (2016) summarize a lot KPIs. From those and the earlier described sources the KPIs most relevant to the case of FM chemistry have been selected.

3.1.4 Finance KPIs

KPIs	What do they measure?	How do they measure?	Source
Cash-to-Cash Cycle Time	It measures the time it takes for a company to convert its investments in inventory back into cash. A shorter cash-to-cash cycle time indicates better liquidity and financial health.	Days inventory outstanding + days sales outstanding - days payable outstanding	(Liu et al., 2009); (Jothimani & Sarmah, 2014b); (Brealey et al., 2011); (Tundys & Yudi, 2019)
Gross Profit margin	Calculates the % of revenue remaining after deducting the cost of goods sold.	(Gross profit/Revenue)*100	(Brealey et al., 2011)
Net Profit Margin	Measures the percentage of revenue remaining after deducting all expenses.	(Net profit/revenue)*100	(Liu et al., 2009); (Brealey et al., 2011)
ROI (Return on Investment)	The amount of money that is generated with the made investment.	(Net return/ Cost of investment)*100	(Liu et al., 2009); (Elsaghier, 2017); (Brealey et al., 2011); (Sergeeva et al., 2019)

Table 4: Finance KPIs

In table four, the financial KPIs included are stated. Almost all research that investigates KPIs include a financial element in the scope. No matter the focus is on warehouse, supply chain management, and/or third party logistical KPIs, there is always a link to financial KPIs. For example, Beamon(1999) states that one of the ways to measure resources is to measure costs in a supply chain.

To conclude, there are many KPIs that can be found in the literature that are relevant for measuring the performance of a company in the fields of supply chain, warehousing, third parties and finance. Over the years the field has developed the scope has increased from, resources, output, and flexibility to including sustainability. Yet, not all KPIs will be selected for FM chemistry, only around 4 or 5 will be selected from the list above. This to achieve the goal of creating an easily understandable dashboard.

3.2 KPI selection

This section explains the second phase of the KPI selection process. Based on the literature review, a wide variety of KPIs was identified that have the potential to enhance the insights into the company's performance. This section will focus on how the final KPIs where selected, which ones where selected and how these KPIs will help the company evaluate its performance. The selection process consists out of 2 parts. First the list of KPIs was narrowed down, selecting only those who are definitely relevant for FM Chemistry and feasible to implement. Secondly, a discussion was held with employees. In this discussion the remaining KPIs where critically evaluated. The stakeholders involved in this process

consist of the companies CEO and the supply chain manager. Together with the tree of us a list of KPIs was created that will be used in the dashboard.

To narrow the list of KPIs for the meeting the KPIs that where selected in the previous section where reevaluated. In this evaluation two major factors played a role, feasibility and value. The first factor is feasibility. Although the ERP system captures a wide range of data, there are some KPIs that require information that is currently not stored. This makes it impossible to use these KPIs. This goes together with the quality of data. In some cases there is some data stored, hence the amount of data is not enough to create a reliable KPI thus these KPIs are now also excluded. If the ERP system is running for some time these KPIs can become more interesting. In addition, the project main goal is to increase efficiency. Therefore, time consuming manual data entry should be avoided, as it would defeat the purpose of increasing efficiency. That is why KPIs that require additional handlings to become insightful are also neglected.

The second factor is value. The company should direct and actionable insights out of the selected KPIs. If the KPI is not directly inside full or does not provide opportunities for improvement it will be excluded. Additionally, the employees that work with the dashboard should be able to clearly understand what should be done if a KPI shows a certain value that exceeds a threshold.

As a result of this second criterion, many warehouse KPIs were excluded. The FM group does not have a storage facility. Instead it relies on external companies for container, tank and other packing storage. This limits the relevance of many warehouse KPIs.

Next to excluding KPIs one KPI was included on the list that was not already found in the literature review. The KPI is "Number of Documents per Status" which provides a clearer view of the current progress of document processing. This insight helps identify bottlenecks in documentation workflows, enabling better resource allocation to complete pending tasks efficiently. Apart from identifying bottlenecks in the documentation workflows, it provides insights in payment status. The accountant is able to see if purchasing orders are paid and money received from the commercial invoices.

The list of KPIs that were selected for discussion consisted out of the following:

- Return on Investment (ROI)
- Error rate
- Forecasting Accuracy
- Transit time variability (for shipping)
- Freight cost per unit shipped
- Container utilization
- Perfect order
- Incident rate
- Acceptance rate
- Freight cost per unit
- Number of Documents per Status

The interview was an unstructured interview, structured in the following way. Per KPI a small elaboration was given. Afterwards the advantages and disadvantages where discussed. During the meeting additional KPIs were proposed by the involved stakeholders, “Waiting Time at Location”, “Cycle Time per Tank” and “Budgeted vs. Realized Costs”.

Waiting Time at Location, is the average amount of time that a truck driver needs to wait at a specific location. This phenomenal frequently takes place. Every time it occurs the FM group needs to pay the transport companies an additional fee for standing still. The CEO was interested to see how often this occurs and if it is possible to identify bottlenecks that can be tackled.

The second KPI, Cycle Time per Tank, tracks the number of cycles a tank goes through during its leasing period. Each cycle consists of preparation, filling, emptying, and cleaning of the container or tank. Monitoring this KPI allows the company to optimize its container fleet usage, improving efficiency and reducing idle time.

The third proposed KPI, Budgeted vs. Realized Costs, is the difference between the estimate cost of an activity and the final costs. In the operations often activities do not go as initially planned. As stated above, trucks need to wait at depots, activities cannot take place anymore causing delay in the whole supply chain. These changes often lead to increased cost. The proposed KPI gives insides in how accurate the costs are calculated.

With all the KPIs on the table the final selection was made. Bellow the KPIs are categorized similarly as done for the ERP system.

Document making

For the Module document making one KPI has been selected, “Number of Documents per Status”. As stated above it gives better insight into the workflow of document makers. Furthermore it enhances insides in who has paid what.

Inventory management

Two KPIs were selected for inventory management, “Container Utilization” and “Cycle Time per Tank”. Container Utilization measures the percentage of containers and tanks that is used for material storage. This KPI helps ensure that the company’s stock of containers and tanks aligns with actual demand. Over time, FM Chemistry can better predict the necessary number of containers required for efficient operations.

The second KPI, Cycle Time per Tank, tracks the number of cycles a tank goes through during its leasing period. Each cycle consists of preparation, filling, emptying, and cleaning of the container. Monitoring this KPI allows the company to optimize its container fleet usage, improving efficiency and reducing idle time.

Activity tracking

This category focuses on tracking third-party logistics and external service providers. This is a critical aspect for the FM Group, which relies heavily on outsourcing. Four KPIs were selected for this category, “Budgeted vs. Realized Costs”, “Incident Rate”, “Waiting Time at Location” and “Freight Cost per Unit Shipped”.

By monitoring these KPIs, FM Chemistry can consistently evaluate the performance and reliability of its external partners over time, ensuring long-term improvements in the company's third-party collaborations.

Projects

Two KPIs were chosen for this category: "Return on Project (ROP)" and "Execution Time". ROP is similar to Return on Investment (ROI), both representing the percentage of net return over the cost of the project. However, given that the company refers to its activities as projects rather than investments, the KPI was renamed. The second KPI, Execution Time, measures the duration of the project, which the company values as they have observed that longer project timelines often lead to reduced profitability.

The combination of ROP and Execution Time allows the company to assess how changes in project timelines affect profitability. By analyzing these KPIs, the company can identify causes of increasing project execution times and understand which factors reduce ROP. Additionally, this analysis will provide valuable insights into project risks, enabling FM Chemistry to better assess which companies or activities impacted the return and execution time. The ability to assess project profitability in this manner strengthens decision-making.

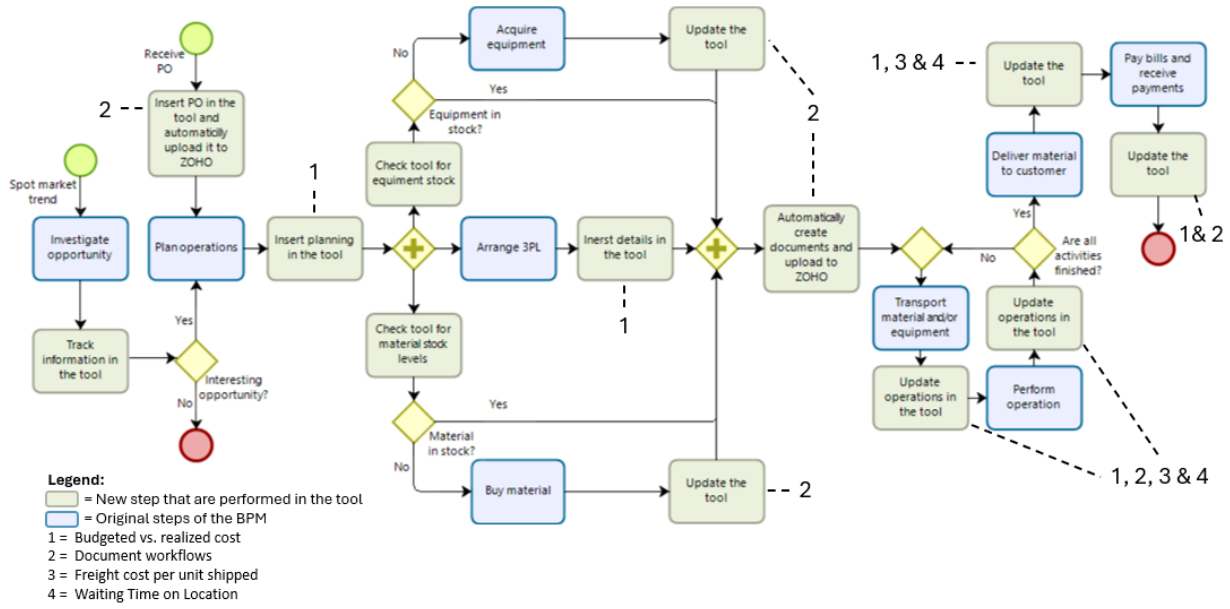

Figure 14: The simplified BPM including the designed use of the tool, and where KPIs are monitored in the operation.

In figure 14 the tracking of KPIs is visualized. The KPIs that are influenced by performing a step are presented next to the box. Not all KPIs are included into the figure, to keep the figure clear only KPIs that are not updated continuously are displayed. For example, incidents can occur everywhere in the process, all boxes could have a reference to incident rate. The KPIs, Container utilization and Average cycle time per tank, are monitored with or without FM Chemistry performing operational activities, thus these KPIs are also excluded from the figure. Finaly, the KPIs Execution time and ROP are determined by the start

and finishing of a project, a project can exist out of multiple loops through the activities of the BPM. Therefore these KPIs have also been excluded from the figure.

3.3 Conclusion

In short, in this chapter, the KPI selection process was elaborated on. Via literature review and conversations with stakeholders the set of KPIs has been determined. The set of selected KPIs function as the input for the dashboards, furthermore giving the company the ability to evaluate their projects, operations and other companies. The projects can be evaluated in terms of profitability and duration. For the operations, the FM group has the ability to get better insights into the utilization of the equipment. Furthermore, the insights of the documents and payments is enhanced. These insights in the operations go hand in hand with the evaluation of the third parties.

Chapter 4: Dashboard designs

To visualize the selected KPIs dashboards have been created. One dashboard per category has been designed to help the company evaluate its operations. In this chapter, the designs of these dashboards will be discussed in details. Before the dashboards and software have been created. One dashboard per category has been designed to help the company evaluate its operations. After that the focus will be on the created dashboards and how the company can use them.

4.1 Literature Dashboard design

In literature, researchers have come up with various definitions of dashboards, They generally define a dashboard as an interactive visual display of the most important performance information, used to reflect on both short and long term goals. Dashboards enable employees to quickly assess how the company is operating.

There are three types of purposes for dashboards, respectively, strategic, analytic and operational purposes. (Few, 2006) Strategic dashboard display high level measures of performance these dashboards provide a quick overview of the health and opportunities of the business. Analytical dashboards require more in depth information displayed on the dashboard. Apart from KPIs, a user needs to be able to determine what the reason can be for the current performance. These dashboards require greater context like, rich comparisons, more extensive history and subtler performance evaluators. Lastly, operation dashboards are used to monitor operations, these dashboards display parameters that initiate immediate action when going over or below a certain threshold. Clarity and simplicity is in the nature of these dashboards. This to motivate immediate response if parameters show certain values.

For the design of dashboards, literature emphasizes on design trade-offs and critical factors to incorporate in the design. There is not one solution for all dashboards, each company needs to find its own formula to success (Yigitbasioglu & Velcu, 2012). Bach et al. (2022) created a model to depicture the design trade-offs.

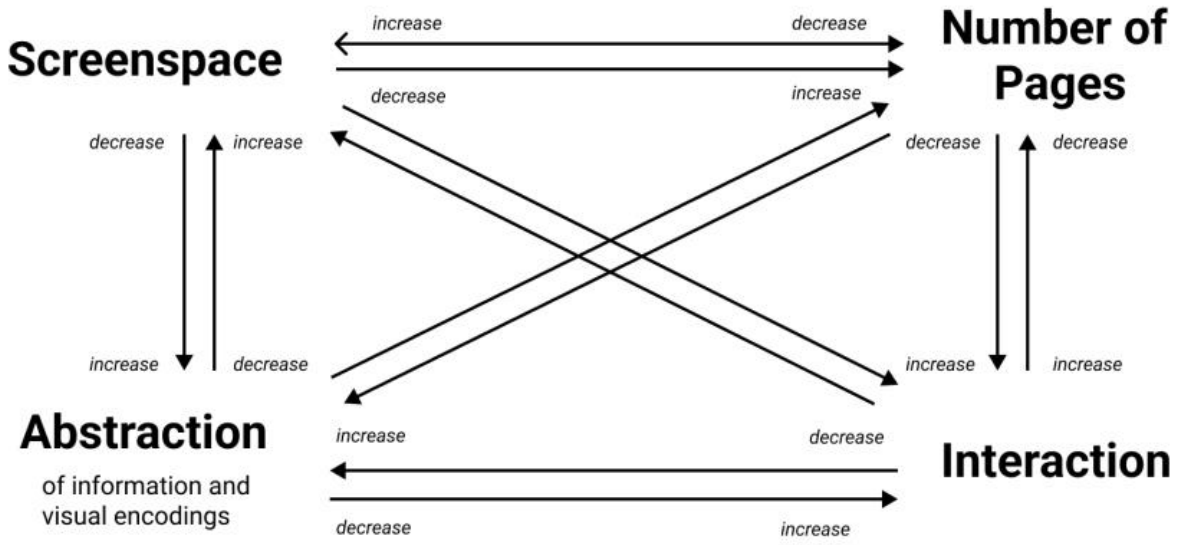

Figure 15: Design trade-offs in dashboard design (Bach et al. 2022)

As stated, apart from design trade-offs there are many critical factors that need to be incorporated in the design process. From literature the following ten factors stand out(Few, 2006) (Bach et al., 2022) (Vilarinho et al., 2018).

- Audience and user expertise
- Providing insufficient data
- Displaying too many details
- Visual representation
- Ineffective highlight of important information
- Data quality
- Ease of use
- Mis- or overuse of color
- Surpassing the borders of single screen
- Display of irrelevant information

From this section it can be concluded that different types of dashboards require tailored designs and visualizations. Per client a tailor made dashboard is the formula to success. Apart from that, in this section we identified potential trade-offs and critical factors that need to be thought about when designing.

4.2 Dashboard design

FM Chemistry desires a dashboard design that gives quick insights in the performance of the operations in the company. According to the literature, achieving this requires a balanced dashboard design, with trade-offs made to develop the most tailored solution. In literature review it was identified that dashboards should avoid including too many variables and ideally display all relevant information on a single page. Since the company desires more KPIs than possible to place on one page without creating chaos, more dashboards will be created. The dashboards will be divided into two, a management

dashboard aimed at monitoring the operations and an analytical dashboard where employees have the ability to investigate the overall performance of the company by analyzing the documents.

In chapter 3, we selected multiple KPIs to monitor the performance of the company. The design should incorporate all of the selected KPIs and pair them with visuals that enhances the user's experience and understanding of the displayed data.

Module	**KPI**	**Visualization**
Document making	Per document type, amount of documents per status.	Funnels
Inventory management	Container utilization	Gauge
	Average cycle time per tank	Card
Activity tracking/ third party logistics	Budgeted vs. realized cost	Bar diagram
	Incident rate	KPI
	Waiting time on location	Bar diagram
	Freight cost per unit shipped	Bar diagram
Projects	ROP	KPI
	Budgeted vs. realized cost	KPI
	Execution time (Months)	Bar diagram

Table 5: KPI visualization per Module.

In table 5, it can be seen that a variety of visualization will be used to enhance the user experience. For the document workflow a funnel will be used to create an easy-to-understand and clear workflow. The management dashboard will contain a variety of different visualizations, the KPIs that highlight an overall performance will be visualized by using a Cards, KPIs or Gauges. These visualizations display only the KPI. By use of color the performance will be indicated. KPIs that monitor fractions of the performance will be visualized using bar or pie diagrams. In this context the fractions can be a separate project or activity. The user can use these visualizations to see what causes disturbances. For the document workflow dashboard funnels will be used per document type. The funnels give a quick overview of the documents in the pipeline and by using the same style and format users can easily identify what is going on.

Figure 16: Snapshot of the operational dashboard

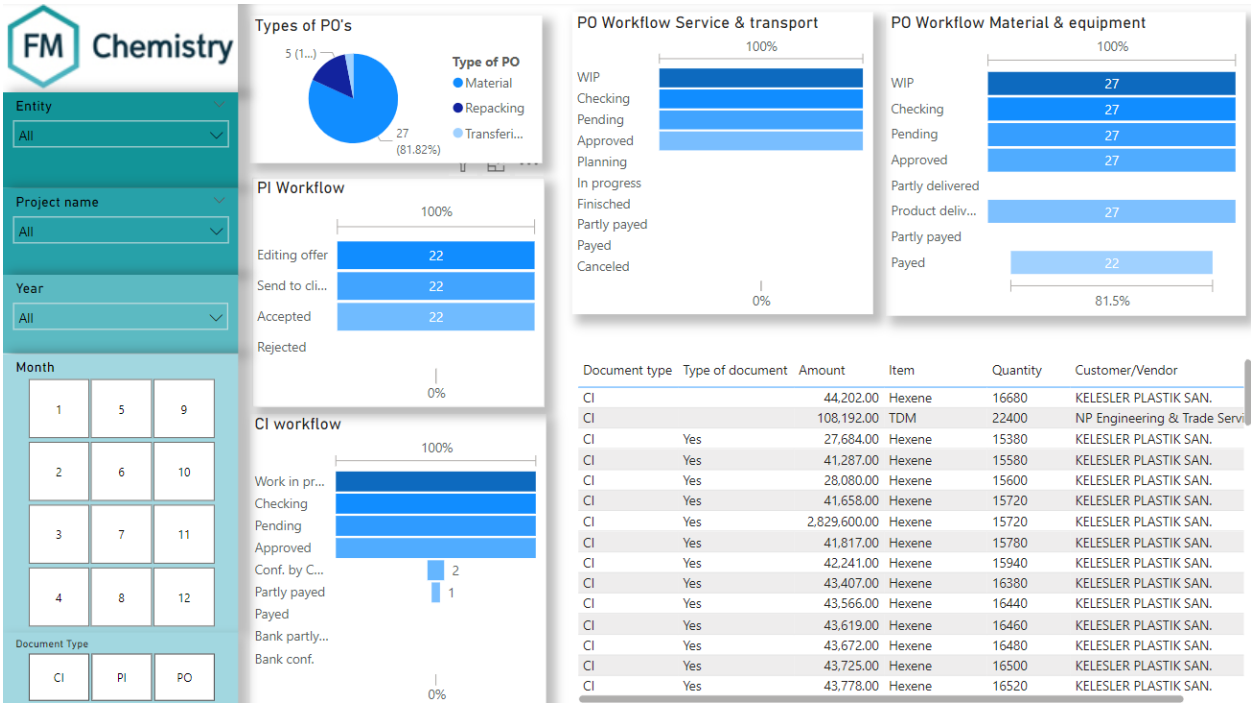

Figure 17: Snapshot of the document workflow dashboard.

On the left side of both dashboards multiple filter options have been created. Respectively, filter for the used entity, project and timeframe. The filters are created to give te user the ability to zoom into the information that the user desires to learn more about.

To highlight important information in the dashboards colors are used in two ways. Firstly, create a boundary/frame around the dashboard, and secondly, creating clarity inside the visualizations. The colors of the boundary/frame are based upon the colors used in the company's own color palette. This color palette is used in the logo, website and documents. The goal of this frame is to make the important KPIs and the filter options pop out, making sure that attention of the user is drawn to the most important KPIs and the possibilities that the filter options bring.

The visualizations are colored by three different color palette designs. The blue gradients palette, the FM Chemistry palette, and the green-yellow-red color palette. The blue palette is selected for three main reasons, the associations with blue, calmness in design, and alignment with company style. First of all, blue is associated with trust, professionalism and tends to have a calming effect on people (Van Zeeland, 2022). These characteristics are useful to enhance the possibility that the company will make data driven decisions, while calmly keeping the overview during the observation of the dashboard. The second reason is that use of many other colors in the graphs would make the dashboards rather chaotic and maybe even confusing. The blue gradient palette is only selected if the information in the visualization is not very important or/and when that the information displayed does not require additional attention from the user when it has a specific value. Lastly, the gradients of blue aligns with the colors of the company.

The FM Chemistry palette is used in the operational dashboard to display the graphs. Similar as the blue pallet the color palette is associated with professionalism and calmness. Additionally, it is not the most important information on the dashboard, the KPIs in the top row are. Based upon this, the less important KPIs are colored with this palette. Additionally, the design matches with the outlines of the dashboard, making it easier to look at.

The KPIs in the top row of the operational dashboard are designed with the green-yellow-red color palette. The colors change based on the value that they have. Respectively, green for good performance, yellow if the business controller needs to take a look at it, red if the business controller needs to immediately take action, and black if there is not enough information available to display the KPI. The values at which the colors change are determined by the company and can be change at any moment.

In short, three color palettes have been used in the dashboard design to draw the users attention to the most important visualizations in the dashboard. The primary reason that we selected thee palettes is to decrease the amount of abstractions that additional palettes would bring to the visualizations.

4.2.1 Connection with the ERP system

As shown in chapter 2, the dashboards are connected to the ERP system. Updating the dashboards requires a few steps. To maintain high performance inside the ERP system, the data generated is not immediately calculated and placed in the tables that are used for the dashboards. To do this the user needs to press a button on the home screen. After that, the user can refresh the data in Power BI. After refreshing all the tables are automatically updated.

4.3 Conclusion

The literature review identified key trade-offs and critical success factors. The design process balanced these trade-offs and factors with the company's requirements, resulting in two dashboards. Firstly, the management dashboard, aimed at analyzing the KPIs of the company on a top line level with the

potential to zoom in to activity level in some areas. Secondly, the analytical dashboard, aimed to give employees insight into the company's performance by visualizing the document flows within the company. Both dashboards work in combination with the tool. In the next chapter, the created KPI dashboards and ERP system are evaluated. In that section, an assessment is conducted to determine whether the designed goals for the dashboards have been achieved.

Chapter 5: Demonstration, evaluation & implementation

This chapter focuses on the evaluation of the created artifact. Together with the company the ERP system was evaluated. The evaluation process is divided into three parts: demonstrating and testing, evaluation, and implementation. Before these sections are discussed, the strategy of this process will be elaborated on.

As stated in appendix 3.2, when using the DSRM the evaluation process is important. For a good evaluation the creator of an artifact needs to have an evaluation strategy, evaluation method, evaluation criteria, and select appropriate stakeholders for the evaluation. In this section of the report, these factors for a good evaluation will be elaborated on. Starting with the evaluation strategy, an overarching strategy is useful to make sure that the researcher can do a swift an accurate evaluation and does not lose focus on what needs to be done.

The strategy used in this research consists of two parts. The first part is demonstrating and testing. Although it seems to not directly link with the evaluation of the ERP system, the end users need to work with the ERP system themselves, giving them the first experience with using it. The objective of this phase is to identify and address any issues or bugs. Furthermore, the user feedback can immediately be implemented in the next iteration.

The second part of the strategy is the evaluation, with an questionnaire and unstructured interview the ERP system will be evaluated. The feedback generated will be implemented in the next iteration.

The second factor is the evaluating method, as stated above the methods used in this research are unstructured interviews and an questionnaire. Relevant stakeholders are asked questions that will guide them to evaluate the ERP system. Apart from the questions the stakeholders are asked to fill in the User Experience Questionnaire (UEQ) developed by Dr. Martin Schrepp (2023).

The third factor is stakeholders, per part of the evaluation process different stakeholders are involved in the process. In the first part of the strategy, demonstrating and testing, the CEO, supply chain manager, accountant and business controller are involved for the demonstrating. For the testing itself only the business controller and accountant are involved. The accountant only played a minor role compared to the business controller. He has only been involved in the evaluation of the link between ZOHO and the ERP system. Whereas the business controller was asked to test the whole ERP system. The reason for that is that she will be the main user of the ERP system and apart from being the main user, the company has asked her to also become the expert about it. The other two stakeholders are excluded from the testing because their inclusion is deemed unnecessary. For the evaluation phase the CEO, supply chain manager and business controller are selected to participate in the interview and questionnaire.

The fourth factor is the evaluation criteria. To conduct a consistent and efficient evaluation, a researcher must predetermine the evaluation criteria. Next to the evaluation criteria, the researcher needs to create ranges making it possible for participants to use the criteria to evaluate. In the questionnaire of Dr. Martin Schrepp the evaluation criteria are already included. In the unstructured interview, the focus is on if the requirements, easiness of use and satisfaction with the result. Ranges will be excluded since we want to give the participants the opportunity to answer with words.

5.1 Demonstration and testing

This section elaborates on the demonstration phase of the DSRM. During the course of this research, several demonstrations were conducted to collect feedback. After creating a beta version employees were asked to test the ERP system. The connections between the ERP(s), ZOHO, Outlook, and Power BI have been tested extensively.

The testing of ZOHO was done with the accountant of the company. He is one of the few with access to the ZOHO platform. Together we tested the link to ensure that the information entered into the ERP system was sent to ZOHO and automatically converted into a document. The process of creating this link was very time consuming. The development was basically a trail-on-error process, there was little to nothing known about creating a link between the software's. During the process of testing the designed code, problems started to appear. On both the side of the ERP system and ZOHO errors occur that even the employees of ZOHO themselves could not help us with. After some intensive days of trying and testing code a working link was established.

The process of creating a link between the ERPs also did not go as smoothly as planned. Except for one user it worked fine. We tested for weeks, adjusting the code countless times, adjusting settings and testing it again. At the end we found that the problems was not in the code but was inside the users drive. The sharing process of the ERP system failed because the drive was overloaded with information.

Lastly, during the creation of the link between the ERP system and power BI, the databases were transformed into tables to make it easier to handle the data in Power BI. Changing this created many problems that were identified and patched during the testing of the link and the overall ERP system.

Apart from the testing of the tool there have been multiple instances where the ERP system and KPI dashboard have been demonstrated. In these instances various stakeholders where invited to look at the tool and sometimes asked to perform tasks with the tool. After these sessions feedback was collected, in the cases that there was a lot of feedback earlier stages of the DSRM where visited. The feedback generated during the sessions gave new insights and created optimization opportunities. In total we looped through the demonstration phase three times. All times, the ERP system was demonstrated and two time the KPI dashboard was included in the demonstrations.

Examples of improvement points that were created from the feedback gained during the demonstration ranged from, changing a part of the user interface, rearranging the inventory management sheets, and making it easier to shift between times in the dashboards.

Overall the testing have been a time consuming but fruitful process. Problems within the ERP system were identified and patched. The demonstrations have proven to be also very beneficial, the feedback generated within the sessions was used to reiterate through the DSRM. This helped aligning FM Chemistries needs with the functionality of the created artifact.

5.2 Evaluation

In this section the evaluation of the ERP system is discussed. This section relates to the evaluation phase of the DSRM. The goal of this evaluation is to collect feedback and see if there are parts that still need to be adjusted. Furthermore, to see if the created artifact improves the current situation. As stated at the beginning of this chapter, this evaluation will be done using a questionnaire and unstructured interviews.

The stakeholders that are involved in the evaluation are the following three, the CEO of the company, the supply chain manager, and the business controller. As stated, the questionnaire used is the UEQ. In the unstructured interview we will get answers to open questions, consisting of:

- Does, and if so, how does the system support the current company activities?
- How easy is it to navigate the ERP system based on your experience so far?
- Based on your initial experience, how satisfied are you with the ERP system?
- Do, and if so, how do the dashboards give the company insides in the performance?
- How easy is it to navigate the dashboards based on you experience so far?

The main findings from the interview will be stated. Compared to the old situation, that was called “Big trouble” by one employee, it is easier and faster to do your work. Especially for starting people it was difficult to get the hang of the company processes. The ERP system gives employees guidance, the business controller told: “I learned a lot from the ERP system, the order that we do business became a lot more clear when looking at the ERP system.”. Other employees stated that the activities in the company have become easier and more accessible with a smaller window for mistakes. The CEO and supply chain manager told that the ERP system fulfilled the requirements and has enabled them to hire less educated people that can now contribute to the company with little guidance. All employees find it easy to navigate through the ERP system. Based on their current experience all employees are happy with the results.

The employees also spoke highly about the dashboards. Although more real time information needs to be added to the dashboards to fill all the KPIs the employees are happy. It gives them the ability to see the company’s performance in a blink of an eye. The dashboard is also easy to understand and navigate. It provide clear insight into the performance of the company.

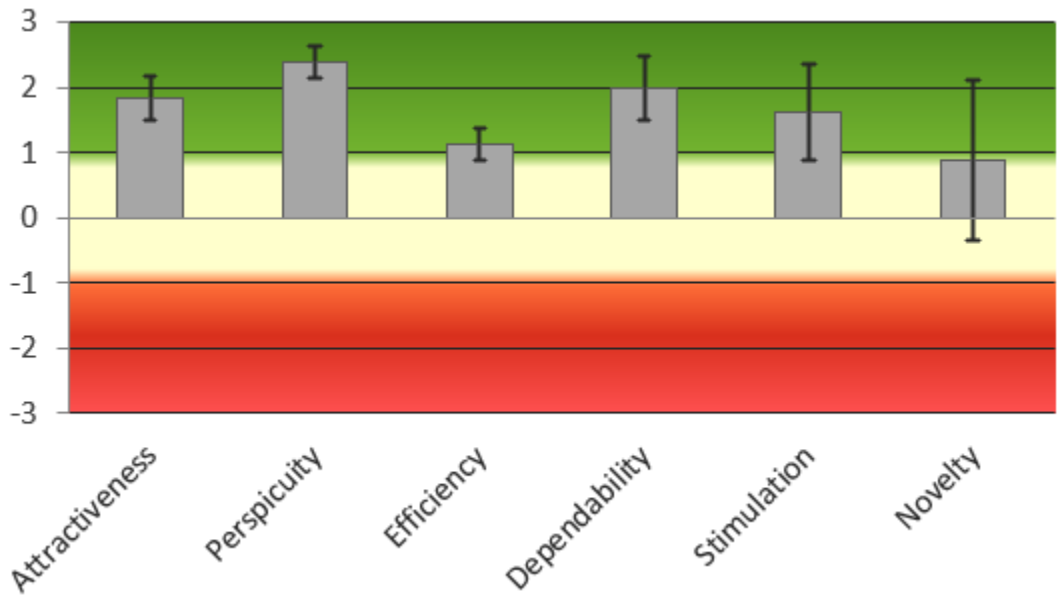

Figure 18: UEQ result graph

In figure 14 the results of the UEQ are graphed. The interpretation of the scale means is that values between -0.8 and 0.8 represent a neural evaluation of the corresponding scale, values > 0,8 represent a

positive evaluation and values < -0,8 represent a negative evaluation. The results show that the participants filled in a positive evaluation, only for novelty the participants were rather neutral. Regarding efficiency it was close to neutral but still positive. It is important to mention that the survey was only conducted with 2 employees.

Overall the evaluation was positive, both in the interviews and the questionnaire the results where positive.

5.3 Implementation

The last phase of the DSRM is the communication stage. In this research, this stage will be addressed as the implementation. This section will state the main findings from literature for the implementation of an ERP. Furthermore, the implementation of the ERP system will also be elaborated on.

5.3.1 Implementation ERP system literature

The goal of this literature review is to identify critical factors that need to be taken into account for the implementation of an ERP system and/or dashboard. To enhance the chances of a successful implementation, these factors will be taken into account. In a literature a lot can be found about the factors. In this research we will highlight the most common ones. (Rajapakse & Thushara, 2023) (Wong et al., 2005)

The factor that stands out the most is the involvement of top management. In the literature review about design influence factors this was also the most critical factor for success. Top management has a lot of influence on the overall project. They are responsible for project scheduling, setting realistic expectations, allocating financial and other resources, and play a significant role on the change management that is needed for the implementation.

Secondly, a mismatch between the system and business processes can lead to an unsuccessful implementation or even project. If a mismatch occurs the positive effects of an ERP system decrease. Factors that can have an impact on this and the overall implementation are poor consultancy effectiveness and/or a poor quality of business process re-engineering.

Adequate education and training is another factor that plays a big role in the success of a implementation. Allocating time and resources toward this enhances the chances of successful implementation of the new system. Lastly, user unwillingness to use the ERP system was one of the factors that also was standing out.

5.3.2 Implementation ERP

The implementation consisted of the following parts, training during testing, training during evaluation, manual, and coping with errors. During the testing, the business controller was taught how to use the system. As stated earlier in the research she is the one who will use the system most frequently and will function as the expert. During the testing she has seen and learned about every corner of the system.

Before and after the system was completed, we did evaluations. In these evaluations, the participants were shown how the system works, provided feedback and could ask questions about the ERP system. This allowed employees to observe the processes and learn about the ERP system.

Apart from this, a manual was created. A manual gives the employees the ability to learn about the ERP system ERP system in their own time. Furthermore the new employees or employees that could not participate in the trainings can learn from the manual.

Lastly, the business controller was taught how to work around common problems. Especially, in setting up the ERP system there is no room for deviating from the pre-determined steps. The testing and evaluation have shown that following the steps can be difficult. Therefore she was taught how to cope with situations where things do not go as planned.

When comparing what was learned from theoretical review and the implementation that the company desires, we foresee some trouble upon the road. Primarily, a lack of training and education has led to the conclusion that the transformation to the new system will be difficult. We anticipate that the business controller will probably spend a lot of her time teaching others about how to use the system instead of focusing on her own work.

5.4 Conclusion

In this chapter, the last three stages of the DSRM have been described. It outlines the demonstration, evaluation and implementation process of the developed ERP system and KPI dashboards. During the course of the project there were multiple occasions for reiterating through the DSRM. Overall, the evaluation and implementation of the created artifact were largely successful. On the one hand, the system improved efficiency, reduced errors and provided FM Chemistry to monitor and evaluate their new KPIs continuously. On the other hand, the evaluation showed that there is still room for improvement. Regarding the implementation, FM Chemistry is able to use the system. The business controller will have to take on the role of support to make sure that the others in the organization are also using the system.

Chapter 6: Conclusion, Limitations and Recommendations

In this chapter, the conclusion of this research will be outlined. Furthermore, the limitations of this research are stated. And lastly, the recommendations and future research will be elaborated on. The conclusion of the research will be formed by answering the research questions in the first paragraph. Starting with the sub-questions and working towards the main question.

6.1 Conclusion

The first sub-question that was answered in this research is *"What criteria are required for the ERP system?".* In chapter two of this research, the following criteria are determined for FM Chemistry to create a successful ERP system. *"Inventory management system", "Document creation automation", "Integration with ZOHO", "Data warehouse", "Interconnection"* & *"Security",* in the second chapter these criteria are elaborated on in more detail. By answering the sub-question we created a foundation for the ERP system that was used in the design and development.

The following two sub-question relate to the identification and selection of the KPIs. The sub-questions *"What KPIs are insightful to use to monitor and evaluate the operations of FM Chemistry?"* and *"What KPIs will be implemented in the dashboards design?"* were both answered in the third chapter of this research. The first sub-question gave an overview of the potential interesting KPIs. This list served as the foundation for answering the second sub-question. Together with stakeholders from FM Chemistry, the final selection of KPIs for the dashboard were selected. In Chapter three, the final selection is stated. With this selection the ERP system and dashboard were developed.

In the fourth chapter, the dashboard design process was elaborated on. Before the development of the dashboard was discussed, the chapter started with identifying from theory what is important for a well-functioning dashboard. With this part the following research question is answered, *"How can a dashboard support the operations of FM Chemistry?".* Dashboards are interactive visual displays of the most important performance information that is used to reflect on both short and long term goals. FM Chemistry can evaluate the tailor-made KPIs on this dashboard to reflect on the current operations and steer the company towards the right course.

Within chapter five, the question *"What is the most suitable strategy for the evaluation of the artifact?"* is answered. Research shows that for a good evaluation the researcher needs to think make design choices about the strategy, methods, variables and stakeholders that he or she wants to include in the evaluation. In chapter five these factors have been elaborated on in depth. In short, the strategy consisted out of two parts, the "demonstration and testing" and "evaluation" the methods used to evaluate are unstructured interviews and the UEQ questionnaire. The focus of the evaluation was determining of the predetermined criteria are implemented to the liking and test the overall satisfaction of the created artifacts. The people involved in the evaluation varied per phase. The importance of inclusion and the time availability of the employees have been weight against each other resulting in the stakeholder selection described in chapter five. The selected strategy have been suitable for the evaluation of the designed artifacts for FM Chemistry, the interviews and questionnaire have given clear insight into the opinions about the artifacts.

By answering and evaluating the sub-questions, the main question, *"How should an enterprise resource planning(ERP) system with KPI dashboards be designed and implemented to support the operations of*

FM Chemistry?", is addressed in this section. The question is divided in the design and implementation of the ERP system and dashboards.

Following the DSRM have proven to be an effective framework for the creation and implementation of the artifacts. In the beginning of the research the requirements and KPIs have been determined, this has been extremely useful in the development of the artifacts. As stated in the first chapter, the DSRM is not a linear process, many stages have been visited multiple times. After creating parts of the artifacts, demonstrations were given to find out if the developers vision still aligned with the company's wishes. This together with the testing and evaluating, contributed to the amount of iterations that have been done in the development process. Revisiting the previous stages have resulted in a tailor-made artifacts proven to support the operation of FM Chemistry. The implementation process was done by including employees in the testing. During the testing the business controller was trained and educated about all the parts of the system. Other employees desired a manual and getting familiar with the software's on their own time.

In short, the DSRM has proven to be an effective method for developing the ERP system with KPI dashboards. Involving the company in all the steps has been a useful strategy for identifying their needs and aligning our views. The evaluation shows that the company is happy with the results of the ERP system.

6.2 Limitations

Despite the positive outcome of the evaluation and conclusion, several limitations should be acknowledged. Respectively, the efficiency for Excel as database, the population size in the evaluation phase, and the amount of iterations done.

First of all, the creation of the tool faced challenges due to the selected software. Although Excel is an easy to use tool widely integrated by many companies, it does not function well as database. Excel has a lot of automatic functions embedded in the software. For example, it automatically rounds up numbers or shows the currency based on the language that is selected by the user. When adding code to Excel these functions can conflict with the designed code. Furthermore, the program is not so robust. Small errors can shut down the whole file and even make them unworkable. To avoid these difficulties, a different software should have been selected. The software that would have been selected with the current knowledge is Structured Query Language (SQL). The time learning the program would have outweigh the time it took to face the difficulties of using excel.

Secondly, the population size of the evaluation was inherently limited due to the size of the company. Since FM Chemistry is relatively small, the number of participants available for the evaluation is limited. While the insights gained from the evaluations are valuable, this constraint may have introduced potential bias.

Lastly, the amount of iterations conducted is the last limitation. Iterating back to earlier phases of the DSRM is a necessity to make the artifact robust and in alignment with the customers desires. As stated in chapter five, after the demonstration phase reiteration where done to prior phases in the DSRM. The feedback generated in the demonstration phase was implemented before moving to the next stage. Due to time constrains, the iteration process was not conducted as many times as desired in the evaluation

and communication phase. After the evaluation the artifact was improved one time. Ideally the amount of iterations was extended.

6.3 Recommendations

The first recommendation to the company is that they should consider to create and host the databases in SQL. As stated in the limitations, due to the automatic functions in Excel it is not a software that is particular suitable for database design. SQL on the other hand is a software program designed for data storage. Placing the databases in SQL will improve the speed of the tool and is believed to enhance the life expectancy.

If FM Chemistry wants to improve the tool, it is recommended to iterate to the DSRM a few more times. To make the results of the evaluation statistically speaking valid, FM Chemistry should consider increasing the population size of the evaluation. Thus, including people from outside the company to validate the tool.

The third recommendation is that FM Chemistry should be as accurate as possible when entering data in the ERP system. The accuracy of the dashboards comes from the input data quality. Connecting all the activities to the projects and including all data like expected cost and realized cost gives the company the ability to monitor the performance over time and evaluate better what works best. Especially, when the artifacts are used for a longer period of time the quality of the data set gives the company the ability to spot trends.

The company should evaluate the KPIs periodically. Over time new KPIs can be interesting to display and current KPIs can become irrelevant. The literature has shown that it is important to minimize the amount of information displayed, so that the dashboards still have the desired effect of giving an overview in a blink of an eye. Replacing the irrelevant KPIs with new interesting ones, keeps the dashboards useful and effective. In the beginning we recommend the company to evaluate the KPIs on a monthly basis. If the KPIs remain the same over a few months FM Chemistry can think about expanding the period to a few months to even a year.

Aligned with the previous recommendation is that the company is recommended to create other analysis. The ERP system saves a lot of parameters. After some time the company can start making analysis about other parts of the operations. For example, by keeping track of the prices on the PIs of a certain material, the company can better determine whether an interesting opportunity has appeared.

Another recommendation that the company can think about is normalizing the database of the ERP system. The current system has been designed in such a way that many variables are duplicated in the database. Restructuring the database can have a positive effect on the performance of the ERP system since the size of data that is transferred decreases and therefore the speed of the ERP system can increase.

References

Adisa, F., Schubert, P., & Sudzina, F. (2010). The Living Requirements space: towards the collaborative development of requirements for future ERP systems. In *Lecture notes in business information processing* (pp. 34–49). https://doi.org/10.1007/978-3-642-14874-3_3

Al Bashar, M., Taher, M. A., & Johura, F. T. (2024). CHALLENGES OF ERP SYSTEMS IN THE MANUFACTURING SECTOR: A COMPREHENSIVE ANALYSIS. *International Journal of Progressive Research in Engineering Management and Science*, 1858–1866. https://www.researchgate.net/publication/381094173

Ali, M., & Miller, L. (2017). ERP system implementation in large enterprises – a systematic literature review. *Journal of Enterprise Information Management*, *30*(4), 666–692. https://doi.org/10.1108/jeim-07-2014-0071

Bach, B., Freeman, E., Abdul-Rahman, A., Turkay, C., Khan, S., Fan, Y., & Chen, M. (2022). Dashboard Design Patterns. *IEEE Transactions on Visualization and Computer Graphics*, 1–11. https://doi.org/10.1109/tvcg.2022.3209448

Beamon, B. M. (1999). Measuring supply chain performance. *International Journal of Operations & Production Management*, *19*(3), 275–292. https://doi.org/10.1108/01443579910249714

Bergen, J.P. (24-02-19). MEETING 2: IS SCIENCE APOLITICAL?[14]. BMS, University of Twente. https://canvas.utwente.nl/courses/14110/pages/meeting-2-is-science-political?module_item_id=471202

Brady, S. R. (2015). Utilizing and adapting the Delphi method for use in qualitative research. *International Journal of Qualitative Methods*, *14*(5). https://doi.org/10.1177/1609406915621381

Brealey, R. A., Myers, S. C., & Allen, F. (2020). Principles of Corporate Finance (13th Edition). https://repository.tudelft.nl/view/MMP/uuid:27b053b5-819d-466b-94fe-b09bbbfb0324/

Brock, S. (2007). Realism and Anti-Realism. https://doi.org/10.1017/upo9781844653645

Chae, B. (2009). Developing key performance indicators for supply chain: an industry perspective. Supply Chain Management, 14(6), 422–428. https://doi.org/10.1108/13598540910995192

Cooper, D. R., & Schindler, P. S. (1976). Business research methods (12de editie). http://182.160.97.198:8080/xmlui/handle/123456789/762

Dawson, L. (2013). A Social-Creative-Cognitive (SCC) model for requirements engineering. In *Springer eBooks* (pp. 113–125). https://doi.org/10.1007/978-1-4614-7540-8_9

Dennert, A., Lehmann, R., Schneider, S., & Wollschlaeger, M. (2018). Providing process-centered key performance indicators for system management. Technische Universität Dresden. https://doi.org/10.1109/icit.2018.8352424

DeSutter, D., & Gao, S. (2021b). The Secret Recipe for Modeling Warehouse Throughput. *MASSACHUSETTS INSTITUTE OF TECHNOLOGY*. https://dspace.mit.edu/handle/1721.1/130971

Domingues, M. L., Reis, V., & Macário, R. (2015). A Comprehensive Framework for Measuring Performance in a Third-party Logistics Provider. Transportation Research Procedia, 10, 662–672. https://doi.org/10.1016/j.trpro.2015.09.020

Dumitrascu, O., Dumitrascu, M., & Dobrotă, D. (2020). Performance Evaluation for a Sustainable Supply Chain Management System in the Automotive Industry Using Artificial Intelligence. Processes, 8(11), 1384. https://doi.org/10.3390/pr8111384

Elsaghier, E. H. (2017). Planning and optimising of petroleum industry supply chain and logistics under uncertainty, 41-44. https://core.ac.uk/download/pdf/145186508.pdf#page=63&zoom=100,148,100

Emrouznejad, A., & Ho, W. (2017). *Fuzzy Analytic Hierarchy Process*. CRC Press.

Few, S. (2006). *Information Dashboard Design* (1st ed.). O'Reilly Media

Goetzel, R. Z., Ozminkowski, R. J., Sederer, L. I., & Mark, T. L. (2002). The Business Case for Quality Mental Health Services: Why Employers Should Care About the Mental Health and Well-Being of Their Employees. Journal Of Occupational And Environmental Medicine, 44(4), 320–330. https://doi.org/10.1097/00043764-200204000-00012

Huang, S., Chang, I., Li, S., & Lin, M. (2004). Assessing risk in ERP projects: identify and prioritize the factors. *Industrial Management & Data Systems*, *104*(8), 681–688. https://doi.org/10.1108/02635570410561672

Jothimani, D., & Sarmah, S. (2014). Supply chain performance measurement for third party logistics. Benchmarking, 21(6), 944–963. https://doi.org/10.1108/bij-09-2012-0064

Kiran, T. S., & Reddy, A. V. (2019). Critical success factors of ERP implementation in SMEs. *Journal of Project Management*, 267–280. https://doi.org/10.5267/j.jpm.2019.6.001

Kraljic, A., Kraljic T., Poels G., Devos J., "ERP Implementation Methodologies and Frameworks: A Literature Review", Proceedings of the 8th European Conference on IS Management and Evaluation ECIME2014, University of Ghent, Belgium, 11-12 September, 2014, pp 309-316.

Kusrini, E., Ahmad, A., & Murniati, W. (2019). Design Key Performance Indicator for sustainable Warehouse: a case study in a leather manufacturer. *IOP Conference Series Materials Science and Engineering*, *598*(1), 012042. https://doi.org/10.1088/1757-899x/598/1/012042

Ladyman, J. (2012). Understanding Philosophy of Science. Routledge. https://r2.vlereader.com/Reader?ean=9780203463680

Leal, J. E., Krakovics, F., & Vieira, V. D. N. (2021). S-PI: A performance measurement system using an S-curve. MethodsX, 8, 101287. https://doi.org/10.1016/j.mex.2021.101287

Liu, Y., Xue, L., & Su, W. (2009). Designing Supply Chain KPIs for Upper-Level Management. Automation College Of Beijing Union University. https://doi.org/10.1109/ssme.2009.139

Mandava, H. (2024). Critical success factors of Cloud ERP in the enterprise business. *Universal Journal of Computer Sciences and Communications*, *3*(1), 1–5. https://doi.org/10.31586/ujcsc.2024.851\

Meier, H., Lagemann, H., Morlock, F., & Rathmann, C. (2013). Key Performance Indicators for Assessing the Planning and Delivery of Industrial Services. Procedia CIRP, 11, 99–104. https://doi.org/10.1016/j.procir.2013.07.056

Molina-Carmona, R., Llorens Largo, F., & Fernández Martínez, A. (2018, June 1). Data-driven indicator classification and selection for dynamic dashboards: The case of Spanish universities. Retrieved April 6, 2023, from http://hdl.handle.net/10045/86991

Nagpal, S., Khatri, S. K., & Kumar, A. (2015). Comparative study of ERP implementation strategies. *Applications and Technology*. https://doi.org/10.1109/lisat.2015.7160177

Netherlands Code of Conduct for Research Integrity. (2018). Netherlands Code of Conduct for Research Integrity. Netherlands. https://www.nwo.nl/sites/nwo/files/documents/Netherlands%2BCode%2Bof%2BConduct%2Bfor%2BResearch%2BIntegrity_2018_UK.pdf

Panousopoulou, P., & Manthou, V. (2016). Reverse Logistics Performance Indicators: A conceptual Framework for evaluating reverse logistics services [Journal-article]. *International Journal of Business and Management Invention*, *5*(10), 53–58. https://ijbmi.org/papers/Vol(5)10/version-2/H0510025358.pdf#:~:text=Beamon%20%281999%29%20suggested%20a%20system%20of%20three%20dimensions%3A,ability%20to%20respond%20to%20extraordinary%20customer%20services%20requests%29.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science research Methodology for Information Systems research. Journal of Management Information Systems, 24(3), 45–77. https://doi.org/10.2753/mis0742-1222240302

Petta, P., Pelachaud, C., & Cowie, R. (2011). Emotion-Oriented systems: The Humaine Handbook. Springer Science & Business Media. https://link.springer.com/chapter/10.1007/978-3-642-15184-2_12

Philips, J. (2023). De Kamer van Koophandel en Fabrieken te Venlo in historisch perspectief (1830-1955). Studies Over de Sociaal-economische Geschiedenis van Limburg/Studies Over de Sociaaleconomische Geschiedenis van Limburg, 3, 3–97. https://doi.org/10.58484/ssegl.v3i13050

Rajapakse, D. P. P. K., & Thushara, S. C. (2023). Critical Failure Factors in ERP Implementation: A Systematic Literature review. *Journal of Business and Technology*, *7*(1), 65–90. https://doi.org/10.4038/jbt.v7i1.109

Sonnenberg, C., & Brocke, J. V. (2012). Evaluation patterns for Design Science Research artefacts. In Communications in computer and information science (pp. 71–83). https://doi.org/10.1007/978-3-642-33681-2_7

Sonnenberg, C., & Brocke, J. V. (2012). Evaluations in the science of the Artificial – Reconsidering the Build-Evaluate pattern in design science research. In Lecture Notes in Computer Science (pp. 381–397). https://doi.org/10.1007/978-3-642-29863-9_28

Srinivasan, R., Bansal, M., & Karimi, I. A. (2006). A Multi-Agent Approach to Supply Chain Management in the Chemical Industry. In Studies in computational intelligence. https://doi.org/10.1007/978-3-540-33876-5_16

Staudt, F. H., Alpan, G., Di Mascolo, M., & Rodriguez, C. M. T. (2015). Warehouse performance measurement: a literature review. International Journal Of Production Research, 53(18), 5524–5544. https://doi.org/10.1080/00207543.2015.1030466

TEACHERS COLLEGE RECORD VOLUME 106. (2004). Teachers College Record, 106(12), 105–128. https://doi.org/10.1111/j.1467-9620.2004.00449.x

Tundys, B., & Yudi, F. (2019). Sustainable Supply Chain Management - Key Performance Indicators (KPI) as an element for measuring of processes. *Transport Economics and Logistics*, *83*, 31–50. https://doi.org/10.26881/etil.2019.83.03

Vayyavur, R. (2015). ERP Implementation Challenges & Critical Organizational Success Factors. *International Journal of Current Engineering and Technology*. http://inpressco.com/wp-content/uploads/2015/08/Paper822759-2766.pdf

Venable, J., Pries-Heje, J., & Baskerville, R. (2012). A comprehensive framework for evaluation in design science research. In Lecture Notes in Computer Science (pp. 423–438). https://doi.org/10.1007/978-3-642-29863-9_31

Vilarinho, S., Lopes, I., & Sousa, S. (2018). Developing dashboards for SMEs to improve performance of productive equipment and processes. *Journal of Industrial Information Integration*, *12*, 13–22. https://doi.org/10.1016/j.jii.2018.02.003

Wang, L., & Liu, N. (2007, 1 augustus). Evaluation of Operational Performance of Third-party Logistics: Based on the Merger Theory Model of Integration and Specialization. https://doi.org/10.1109/ical.2007.4339000

Wong, A., Chau, P. Y. K., Scarbrough, H., & Davison, R. (2005). Critical failure factors in ERP implementation. *Pacific Asia Conference on Information Systems*, 40. http://hub.hku.hk/handle/10722/112358

Yanine, F., Córdova, F. M., & Durán, C. A. (2020). The Impact of Dynamic Balanced Scorecard in Knowledge-Intensive Organizations' Business Process Management: A New Approach Evidenced by Small and Medium-Size Enterprises in Latin America. Journal of Information Technology Management, 12(2), 131–152. https://doi.org/10.22059/jitm.2020.75797

Van Zeeland, E. (22-11-2022). Lecture 2 [November 22 - 2022]. BMS, University of Twente. https://canvas.utwente.nl/courses/11102/files/3343210?module_item_id=368749

Appendix

A.1 Systematic literature review

Problem statement
The operational department of FM chemistry does not effectively monitor and evaluate its supply chain/logistical process. Key performance indicators(KPI) could support them in monitoring and evaluating the processes. It is unknown if or what KPIs can be used to support them.

Research goal and question(s)
What key performance indicators monitor and evaluate the operation department performance of FM Chemistry most effectively?

	Key concepts
1	*Key performance indicators*
2	*Operation department*
3	*Monitor (later removed)*
4	*Evaluate (later removed)*
5	*Dashboard (later added)*

	Key concepts	**Related terms**	**Narrower terms**	**Broader terms**
1	*Write down one of the key concepts from the previous step*	Write down related terms or synonyms	Write down terms that could be considered *narrower* (e.g. 'smartphones' could be narrower than 'digital technologies')	Write down terms that could be considered *broader* (e.g. 'chronic conditions' could be broader than 'dementia')
2	***Key performance indicators***	Key Success Indicator(KSI), Key Risk Indicator(KRI) Lead indicator, lag indicator		Metrics & Index
3	***Operations department***	Logistical department, Supply chain	Operation management,	Operations, Supply chain, department

		department, operational department		
4	***Monitor***	Observing, calculating,	Score	regulate
5	***evaluate***	reflecting		
	Dashboard	Artifact, tool	Artifact, tool	

Inclusion criteria	**Exclusion criteria**
Supply chain should cover the whole world	Not peer-reviewed
Key performance indicators	

Source	**Motivation or justification to use this source**
Write down the source (e.g., a database: 'Scopus')	*Why do you want to use this source? What do you expect to find in it? For example, because 'it is a large academic database covering a lot of high-quality literature from multiple disciplines of science.'*
Scopus	*it is a large academic database covering a lot of high-quality literature from multiple disciplines of science*
web of science	*it is a large academic database covering a lot of high-quality literature from multiple disciplines of science*
google scholar	*it is a large academic database covering a lot of high-quality literature from multiple disciplines of science*

Search log

Date	Source	Search string (databases) or search method (other sources)	Total hits	Remarks
17-04-2024	**Scopus**	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*”) AND (“operational department” OR “logistical department” OR “supply chain department” OR “transport department”) AND (“monitor and evaluate” OR observing OR reflecting)	*0*	*The search is to narrow, it also seems that monitor and evaluate do not belong in here.*
17-04-2024	Web of science	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*”) AND (“operational department” OR “logistical department” OR “supply chain department” OR “transport department”) AND (“monitor and evaluate” OR observing OR reflecting)	2	0
18-04-2024	Web of science	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*”) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND (“monitor” OR observing) AND (evaluate OR reflect)	32	The search is still to narrow
18-04-2024	Web of science	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*”) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”)	1611	After scrolling to the first few pages, I found some good results. To narrow the search I will add chemical sector as key concept. Next to that the abbreviation of KPI will be added.
18-04-2024	Web of science	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND (“Chemical sector” OR “Commodity market” OR “Chemical industry”)	8	To narrow, instead of only focusing on the chemical sector, I can exclude interevent once that are occurring often.

18-04-2024	Web of science	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) NOT (“food” OR “agriculture” OR “agricultural” OR “medicine*”)	1890	Good results, however a lot of irrelevant industries that are look at. Add dashboard to the concepts.
24-04-2024	Web of science	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND ("Dashboard*" OR "Tool*" OR "Artefact*") NOT (“food” OR “agriculture” OR “agricultural” OR “medicine*”)	371	Better results, still to much about healthcare and cities.
24-04-2024	Web of science	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND ("Dashboard*" OR "Tool*" OR "Artefact*") NOT (“food” OR “agriculture” OR “agricultural” OR “City*” OR “public” OR “Hospital*” OR “healthcare” OR “Doctor” OR “medicine*”)	312	Good results, almost only relevant sources that are closely related to the research. Much overlapping with sources found in previous search.
18-04-2024	**Scopus**	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”)	3624	Some good results, site broke need to comeback to this.
24-04-2024	**Scopus**	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND ("Dashboard*" OR "Tool*" OR "Artefact*") AND NOT (“food” OR “agriculture” OR “agricultural” OR “City*” OR “public” OR “Hospital*” OR “healthcare” OR “Doctor” OR “medicine*”)	722	To broad, I will include Chemical sector again.

24-04-2024	**Scopus**	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND ("Dashboard*" OR "Tool*" OR "Artefact*") AND (“Chemical sector” OR “Chemical industry”)AND NOT (“food” OR “agriculture” OR “agricultural” OR “City*” OR “public” OR “Hospital*” OR “healthcare” OR “Doctor” OR “medicine*”)	4	Only one relevant source so to narrow.
24-04-2024	**Scopus**	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND ("Dashboard*" OR "Tool*" OR "Artefact*") AND NOT (“food” OR “agriculture” OR “agricultural” OR “City*” OR “public” OR “Hospital*” OR “healthcare” OR “Doctor” OR “medicine*”) Used Filters: Limit to Business, management and accounting.	128	This generated almost no irrelevant sources. Not all usable but they align with the topic that is investigated.
18-04-2024	Google scholar	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”)	80000+/-	Here I can narrow the search with one of the previouses used search strings.
18-04-2024	Google scholar	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND (“Chemical sector” OR “Commodity market” OR “Chemical industry” OR “chemical industries”)	3980	
24-04-2024	Google scholar	(“key performance indicator*” OR “key success indicator*” OR “key risk indicator*” OR “lead indicator*” OR “lag indicator*” OR KPI*) AND (“operations*” OR “logistics” OR “supply chain” OR “transport”) AND (“Chemical sector” OR “Commodity	237	

		market" OR "Chemical industry" OR "chemical industries") Only Reviewed articles		

Screening of sources

To filter out the irrelevant sources we determined a screening process. It consists out of multiple steps going from filtering through scanning to full text analysis.

1. Selection on title.
2. Selection on abstract and/or management summary
3. Remove all the duplicate in endnote.
4. Full text analyses.
    a. Read full text
    b. Note down findings
    c. If interesting articles where used as reference they were added.
    d. Decision to add a research or article

Conceptual matrix

Article/Topics	KPIs	Operations management	Warehouse management	Dashboards	Third party logistics	Summary
(Domingues et al., 2015)	X	X	x		X	A list of KPIs is stated that are useful for evaluating the performance of third party logistics. Since FM works a lot with external parties these KPIs are valuable to consider.
(Liu et al., 2009)	X	X				In the article multiple KPIs are discussed for managing supply chains. This article differentiates itself by including KPIs that are not directly related to the operations.

(Srinivasan, R., 2006)		X	X	X	X	Describes an agent based model. Software agents emulate the entities such as procurement, sales, operations, storage and logistics departments of the refinery as well as the suppliers, logistics service providers, and oil-exchanges
(Dennert et al., 2018)	X	X		X		The main focus of the article lies in the information systems and how to use KPIs effectively.
(Jothimani & Sarmah, 2014b)	x	x	x		X	With the SCOR method KPIs are evaluated for measuring the performance of third parties

A.2 Tool for evaluating of the evaluation process within the design science research method methodology

Motivation

For the essay which follows, I have chosen its subject to be about the Design Science Research Model(DSRM). The motivation to do it about this research methodology is based on multiple reasons. The first reason is that during my thesis I want to use this research methodology. I want to use this specific method because after doing some research, I found that this method is perfect if you want to design a dashboard or system. Since I am planning on making a dashboard this research methodology seems right. To use this methodology effectively I believe that studying the process carefully can bring me a lot of benefits during the length of the research.

During the coming months I will write my bachelor thesis. This is by far the biggest project/research that I have conducted by myself. My goal is to create an end product that I can be proud of for the rest of my life. To achieve this, I want the company to implement the findings of my research and work with the dashboards for as long as possible. And I also want to graduate as high as possible. I know from myself that writing and reading are not my strong suit. Therefore achieving the results that I want will not be a simple task and preparing the best way that I can is essential.

It motivates me to see this essay assignment as an opportunity to practice my writing, reading and researching skills so that when I start working on my thesis assignment for FM Chemistry I will know what to do, how to do it and also do it efficiently.

Lastly my motivation comes from the fact that after finishing the essay I will have a deep understanding of how to reflect on the work that I have done. By looking at other bachelor assignments seeing how and why they were chosen and carried out, I want to learn from their approach. Doing the things that worked, while looking out for the mistakes that others have made.

Research aim

The aim of my research is to get a deeper understanding of how to use the methodology correctly. Next to that I want to further develop my writing, reading and researching skills. Lastly, by creating this essay I will have gained more knowledge about how to write a thesis and furthermore how to critically look at it.

Research question

How to evaluate if the evaluation step within the Design Science Research Model is done properly?

Sub-questions

How is the design science research model used?

What is the purpose of the evaluation?

What factors need to be taken into account to carry out a good evaluation?

Plan of approach

To write my essay correctly I want to follow the research cycle. This consists of the following 8 steps: 1. Research aim 2. Problem statement 3. Research question 4. Research design 5. Operationalization 6. Measuring 7. Analysis 8. Conclusions.

While writing this proposal I started with the first 4 phases of the cycle. By stating my motivation and learning goal I went to the first two steps of the cycle, namely, research aim and problem statement. After knowing what I want to gain from writing the essay, it was time to think about what my research question would be for this essay. Answering those parts of the essay have led me to this point : phase 4 of the research cycle, the research design.

Making a plan on how I want to conduct my research and write this essay will help me keep track of my progress. By doing a cognitive task analysis I have broken the parts of the cycle into smaller parts. In this way it is easier to plan when I want to do which part of the process and keep track of how it is going. After breaking it down I have planned all the smaller tasks in my agenda.

The next step in the process is going to be collecting data. This is to gain a deeper understanding about the methodology, to collect sources that I can use for my essay. Hereby I will be emphasizing the evaluation part of the research methodology. After collecting all the data that I need I will brainstorm about what criteria could potentially be used. Then I will select the criteria that need to be met. After selecting these criteria, each will get a clear range from 1 to 5. 1 would mean that the person did not meet the criteria at all and 5 would be the opposite. The criteria for getting this score will be described in one or two sentences.

After finishing my concept it is time to go into the measuring phase of the research cycle. I will select 4 bachelor theses that have used the DSRM and score each thesis on the selected criteria.

Once that is done I will analyze the results and look critically if the designed criteria are properly designed. The last part of the essay will be the conclusion. In this part I will write about the conclusions that I have made over the course of this essay. Next to that I will consider if the learning goals of this project are met.

Theoretical framework

The design science research model

The methodology is divided into 6 different stages that all contribute to the end goal. A successful development of a tool, dashboard or software. The first one is about problem identification and motivation. The second stage is used to define the objectives for a solution. After that is done it is time to design and develop. The fourth stage is used to demonstrated the current developed artifact. After this demonstration of the tool, it is time to do an evaluation. Lastly, the sixth stage is communication.

Stage 1: Problem identification and motivation. In this part of the research the specific research problem needs to be defined and the value of a solution to this problem should be justified. The problem definition will be used in later stages to develop an artifact that tackles the complex problem. Having a clear problem statement that is agreed upon by all relevant stakeholders will make sure that the proposed solution is aligned with the needs to tackle the problem.

The value proposition accomplishes two things: it motivates the stakeholders in the process to pursue the solution and help them see that the researcher/developer understands the problem.

Stage 2: Define the objectives for a solution. The objectives of a solution can be derived from the problem definition and the knowledge of what is possible and actually feasible. These objectives can be quantitative or qualitative. In this case, a quantitative objective entails looking at the terms in which a desirable solution would be better than current ones. An qualitative objective on the other hand is a description of how the artifact is expected to support solutions to the problems.

Stage 3: Design and development. In this stage of the project it is about creating the artifact. Firstly, designs as models and methods or blueprints should be made. After checking if the design meets the objectives for the solution it can be created. Optional is to go for a minimum value product that can demonstrate if a model or a concept that is included in the artifact works. It is also possible to skip this and immediately start to create a full working prototype. Either way, the work should be demonstrated, evaluated and improved. When implementing the feedback in the artifact the developer is again at this stage and will loop to the next two stages until all the objectives for a solution are implemented correctly in a way solving the initial problem.

Stage 4: Demonstration. The name of the stage clearly describes the activity that should be done. Via experimentation, simulation, case study or other appropriate activities the artifact should be demonstrated. When demonstrating, it is important to note the findings for improvement. This will be helpful in the next stage.

Stage 5: Evaluation. The evaluation stage is one of the most important phases within the whole methodology. Here the developer should look critically at the artifact and identify what needs to be improved to fulfil the criteria to tackle the problem. Later on there will be a lot more elaboration on this subject.

Stage 6: Communication. To complete the activities in this stage the developer should communicate all there is to know about the artifact that he has created to the relevant stakeholders. So it is not only about the artifact itself, also the results from the other stages should be communicated. This is to make sure that the stakeholders understand where the solution comes from and knowing this agree to the designed solution for the problem. After this stage the developer can always choose to revisit one of the previous described stages.

The order in which the stages are visited depends on two things. First of all the starting point, it could be that a company hires a developer and already knows what it is that needs to be made. Therefore, it could be that the developer would start in the second or even in the third stage. The other reason that the path through the process differs in each situation is influenced by the amount of times a developer needs to revisit a stage to improve the current work that has been done. Continuing with the same example of a developer who starts at the design and development stage, it would be wise to re-evaluate the previous stages done by the company, which will ensure that the solution they had in mind actually solves the problem that they proposed.

Evaluation phase

Now that the DSRM has been explained it is time to focus on the evaluation stage. In this part of this essay the importance and aim of a reflection will be discussed. Furthermore, 4 important factors will be discussed, respectively, evaluation method, evaluation structure, stakeholder and evaluation criteria. This chapter will elaborate on the importance of these factors and what the impact is.

When using the DSRM the goal is always to create an artifact that will be used by people, this artifact needs to be the solution for the problem stated by the problem owner. Many times, in designing an artifact, processes, tool or any other product it happens that a developer thinks he has a great product that solves all the problems of the target audience, but in real life it is found that people look at it totally differently and don't see the proposed value. To make sure that this does not happen it is essential to evaluate multiple times with the right stakeholders.

The aim of the evaluation is to find out where the artifact needs to be optimized. (Sonnenberg & Brocke, 2012) When it becomes clear where the artifact needs to be improved, the developer can make a tailored solution for the problem that the problem owner is facing.

Evaluation factors

To make sure that the process of evaluating goes as smoothly and efficiently as possible the developer needs to think about how he wants to do the evaluation upfront. As stated in the beginning of this chapter we found 4 main factors. The first factor to be discussed is the evaluation criteria. Examples of these criteria could be : functionality, accessibility, reliability, security, scalability and there are many more that could be included. It is important to determine these upfront so that stakeholders understand what the evaluation is about. The criteria should be relevant to the artifact that is been created. Next to this, there should be an indication on how the criteria should be scored. Scalability will be used in this example, if stakeholders are evaluating if an artifact is scalable then it is important to know what scalable is. Is it sufficient if the artifact is scalable to 2 users or does it need to be scalable to 2000. Clearly stating a range upfront helps to make sure that the people involved in the evaluation give similar input.

The second factor to be elaborated on is the stakeholders. It is important to make sure that all the important stakeholders are included in the evaluation, otherwise the evaluation does not make sense. If important people are excluded, relevant feedback will be missed, this has a direct impact on the quality of the final tool. On the other hand, if there are too many people involved, including irrelevant stakeholders then the evaluation process will be time consuming, expensive and wrong feedback could be given. That is why it is important that the researcher upfront determines who to include and exclude in the evaluation.

The third factor is the evaluation method. Every research is different, as is the artifact that is designed in the process. It is important that a suitable method of evaluation is chosen to evaluate the atifact that is being designed. For a tool or dashboard a different method is more useful than for a physical product. There are multiple different methods to do an evaluation, ranging from a focus group to a computer simulation. In appendix 2 we attached 2 matrixs for determining what evaluation method is applicable. This essay is not aimed at discussing these, only to point out that the selection of the right method is highly important.

The last factor is the evaluation strategy, it is an overarching factor that takes all factors discussed above into account. When the researcher is making his evaluation strategy, he or she should also take other things into account, like available resources, time, ethics and the amount of repetitions. The goal of making a strategy is to make sure that the goal of the evaluation is reached with the available resources. In the process of making the overall evaluation strategy the researcher needs to determine what the aim of the evaluation is and how to achieve this.

To conclude, the DSRM is a process consisting out of 6 stages. One of these stages is the evaluation phase where it is the aim to find out what is missing in the current designed artifact. In this stage there are multiple important factors that need to be considered when designing the evaluation process. A researcher should make decisions about what the aim of the evaluation is, what strategy to use to achieve that, what evaluation techniques need to be used, how many repetitions to do, who to include and what criteria to consider.

In the chapter we discussed the answers to the Sub-questions. The findings function as a foundation for answering the main question. To see if a researcher has done the evaluation stage of the design science research model correctly it is important to evaluate if the factors that are discussed above

are taken into account in the research. Next to including it in the research it is important that the researcher elaborates on what he or she does. In this way, the evaluation can be done repeatedly while generating the same results. In the next part of this research a scoring card has been developed to help the researcher evaluate if their evaluation process has been sufficient.

Conceptual model

The conceptual model is based upon the 4 factors that have been stated above. Namely, evaluation strategy, evaluation method, stakeholder and evaluation criteria. In this scoring card the presence of these factors is not the only thing that the researchers evaluation process is evaluated on. The description and reasoning of why things are the way they are also taken into account.

Criteria	1	2	3	4	5
Evaluation strategy Is the aim, structure and method clearly described?	There is no evaluation strategy described.	A brief strategy is stated, including the aim and the process.	There is an evaluation strategy. Including an aim and structure. However it is lacking in clarity	There is a clear evaluation structure, with a clear defined goal, process . However not everything is taken into account.	There is a clear evaluation strategy, with a clear defined goal, process. Also taking the available resources into account.
Evaluation method(s) Is the right evaluation method(s) used effectively?	No method is used in the evaluation	The wrong method is used in the evaluation	The right method is used, however the method is not used correctly	The researcher has selected the right method	The researcher has selected the right method and shows a deep understanding of the method and why it is the right one
Evaluation criteria Is the criteria reflected relevant?	No criteria selected	There are evaluation criteria selected. However they are not relevant to the evaluation	Relevant criteria are selected. Also irrelevant criteria is selected with little or no elaboration on why they are selected	Almost all relevant criteria is selected and the irrelevant is excluded. Brief explanation of why this is the case.	Appropriate criteria is selected. Inappropriate criteria is excluded. The criteria is elaborated on in depth
Stakeholders Are the selected stakeholders involved in evaluation process relevant?	No stakeholders are involved	Stakeholders are involved, only not relevant or are too many	Most important stakeholders are included. Some irrelevant and not clearly defined why	All relevant stakeholders are involved. Not clearly defined why all are relevant.	All relevant stakeholders are involved. It is clearly stated why these people are selected and why

			the stakeholders are relevant or not.		others excluded.

Process of testing the scoring card

As stated earlier in this essay, the scoring card will be tested on 4 theses. The aim of this is to see if the designed scoring card works effectively and to evaluate if there are parts that need to be changed. Before stating the results of the evaluation, the criteria for the theses, the selected theses and the process of testing will be briefly described.

The first criteria that a thesis needs to fulfil is that the design science research method needs to be used as research methodology. Secondly, the subject of the thesis is aligned with IEM, preferably the selected thesis is made by an IEM student. Next to that the thesis should have done an assessment. Although not having an evaluation is included in the scoring card, it seems to me that using this it is not beneficial in testing the effectiveness. Lastly, the thesis needs to be a bachelor thesis.

After the theses are selected based on the criteria, all theses will be read and analysed. After making a summary of the thesis the evaluation of the evaluation will start. The scoring card will be filled out and notes will be made alongside it on the ease of application of the evaluation and if the identified measures work.

The 4 selected theses:

Creating insight into the performance of the warehouse processes of a logistics company with a dashboard - Ivo Bakker

Dashboard as a Decision Support Tool to Minimize Empty Miles in Shipping Network: Locating Region for Improvement - Novianita Isnaynizahra

Increasing the quality of information used in office IT applications by developing a Data Management System and Dashboard - R.D. Maaskant

The selection criteria for these theses are that they need to make use of the DSRM - Iris de Kruif

Results of the tests

Results

All the results of the test are placed in the appendix 3.

Reflection

In this chapter the use of the scoring card will be assessed. The goal here is to identify improvements that could make the scoring card more useful. The results of the previous chapter will be analysed and findings will be presented. Lastly a new scoring card will be made if there is room for improvement.

Overall the scoring card worked well. There were some problems that we encountered when doing the tests. The main problem was that some of the theses in question, used the right strategy, methodology, criteria and stakeholders but the problem was that they did not elaborate on what

made it the right selected method for their research. The problem was most present with the stakeholder criteria. For example, I. Kruif used stakeholders for her interview and survey. Only she did not state who they are. In this way it could have been the genitor for all we know. The impact of this is that the evaluation is not as valid. Aside from this, the people gave her good insights, so it appeared that the employees involved where relevant. Trying to fill in these type of nuances was the hardest part.

Another thing that we immediately included in the scoring card was the notes column. In the beginning it was more for the evaluation of the card but later we realized that it is actually very helpful to make sure that the right box is selected. Next to that, after the evaluation the researcher can take a look at it and see why it is useful.

Lastly, some texts in the scoring card were not as clear as they could be and some punctuation was missing.

In short, the scoring card needs to have an extra column for notes. Secondly, the explanation of criteria will create the difference between a 4 and 5. For the lower scores elaboration is not included. This to make it easier to score. Lastly, the text in the scoring card needs to be improved.

Criteria	1	2	3	4	5	Notes
Evaluation strategy Is the aim, structure and method clearly described?	There is no evaluation strategy described.	A brief strategy is stated, including the aim and the process.	There is an evaluation strategy. Including an aim and structure. However it is lacking in clarity	There is a clear evaluation structure, with a clear defined goal, process . However not everything is taken into account.	There is a clear evaluation strategy, with a clear defined goal, process. Also taking the available resources into account.	
Evaluation method(s) Is the right evaluation method(s) used effectively?	No method is used in the evaluation.	The wrong method(s) is/are used in the evaluation.	The right method(s) is/are used, however the method(s) is/are not used correctly	The researcher has selected the right method. Briefly described why it is selected.	The researcher has selected the right method(s) and shows a deep understanding off the method(s) and why it is/are the right one.	
Evaluation criteria Are the criteria	No criteria selected	There are evaluation criteria	Some relevant criteria are	Appropriate criteria are selected.	Appropriate criteria are selected. The	

reflected on relevant?		selected. However they are not relevant to the evaluation.	selected. Not all or/and irrelevant criteria are selected.	Brief explanation of why the case.	criteria are elaborated in depth.	
Stakeholders Are the selected stakeholders involved in evaluation process relevant?	No stakeholders are involved	Stakeholders are involved, only not relevant or to many.	Most important stakeholders are included. Some irrelevant.	Only relevant stakeholders are involved. Briefly discussed why relevant	Only relevant stakeholders are involved. It is clearly stated why these people are selected and why others excluded.	

Conclusion

In this chapter the conclusion will be discussed. An overview of the whole process will be stated, the important findings will be included and will link back to how the developed scoring card answers the research question.

The aim of this research is to gain a deeper understanding of how to use the DSRM methodology correctly and also to further develop my writing, reading and researching skills. Lastly, gaining more knowledge about how to write a thesis and furthermore how to critically look at it. These criteria have led to the research question:

“How to evaluate if the evaluation step within the Design Science Research Model is done properly?”

To find out how this is done properly, the DSRM was investigated. From the investigation’s findings a scoring card was made to measure if the evaluation step of the DSRM is done properly. After creating the scoring card it was tested by analyzing 4 different IEM bachelor theses that used the DSRM. The results were evaluated and improvements to the scoring card were made.

The most important findings were that the scoring card put too much emphasis on the explanation why a selected method or criteria is chosen. Especially in the lower scores this caused confusion when reviewing. Often the selected method was correctly done but due to the fact that the researchers did not include an elaboration on why it is right, it was hard to score why these ended up being at most a 4. Another finding was that the text used in the scoring card could be improved.

The last finding that was discovered is that the inclusion of the notes column is effective during the evaluation. If you are reading a long thesis, making small notes helps in the evaluation while analyzing everything. Also it serves as a field for providing feedback.

After implementing these findings, the scoring card seems a sufficient tool to evaluate the evaluation step of the DSRM resulting in an answer to the research question. The evaluation step of the DSRM can be evaluated using this scoring card. There is still room for improvement, the recommendation we wish to give is that the scoring card should be tested on a larger scale. Also multiple different

stakeholders should be involved in the evaluation process, ranging from academia to business professionals using the DSRM.

A.3 BPM of the procurement-, operational-, logistic-, and selling process

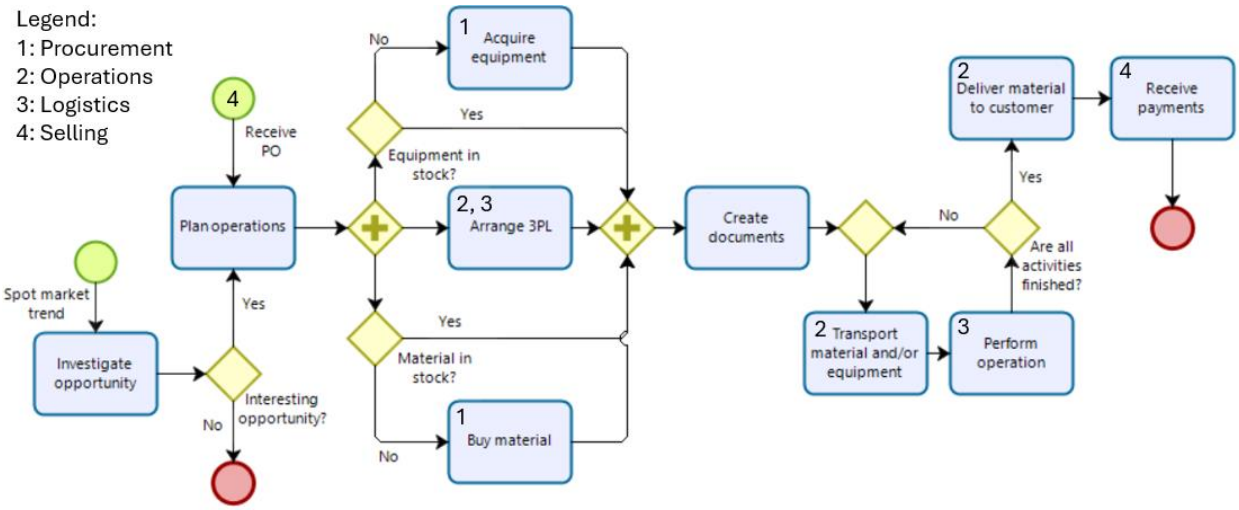

Figure A 1: The simplified BPM with references to the underlying detailed BPMs shown in figure A 2, A 3, A 4, and A 5.

The numbers in figure A.1 refer to the underlying BPMs. Per activity, the numbers on the top left display what operations FM chemistry can go through. Throughout the whole operations of FM Chemistry the different parts of the operations can happen simultaneously. For example, it often happens that customer requests are executed in parts. The first batch could be already delivered to the customer while in the meantime the second batch operations still need to be arranged. While the BPM is separated in parts, it is important to keep in mind that they are interdepended and happen simultaneously.

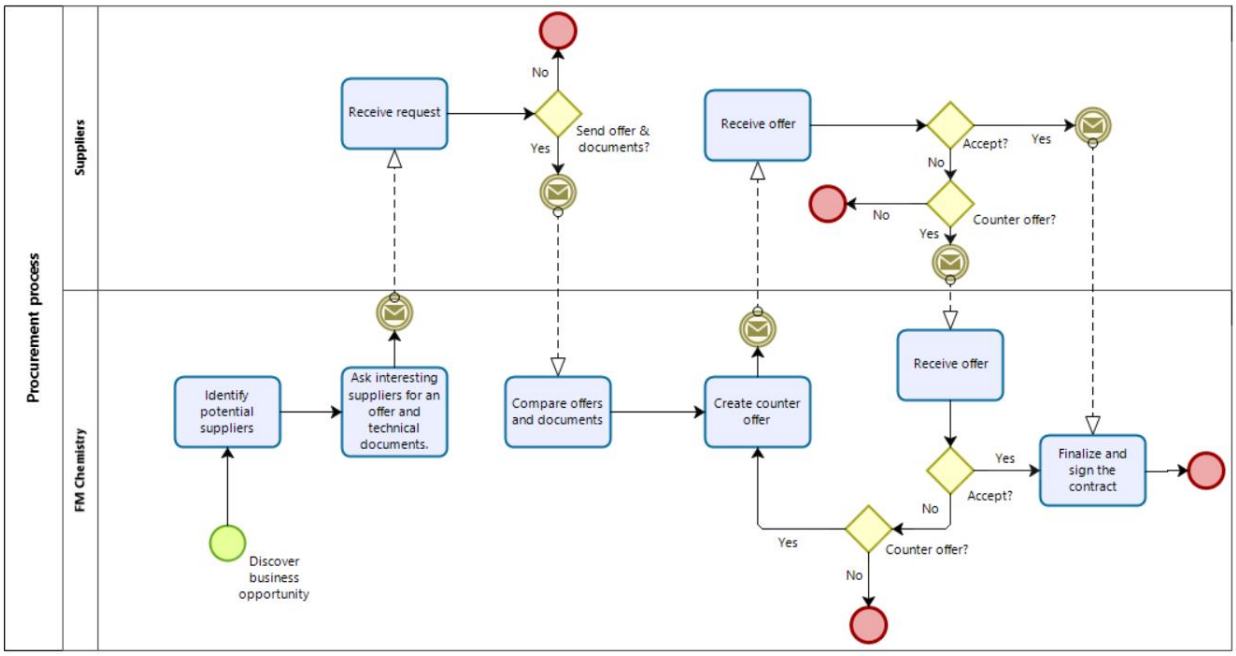

Figure A 2: BPM of the procurement process at FM Chemistry.

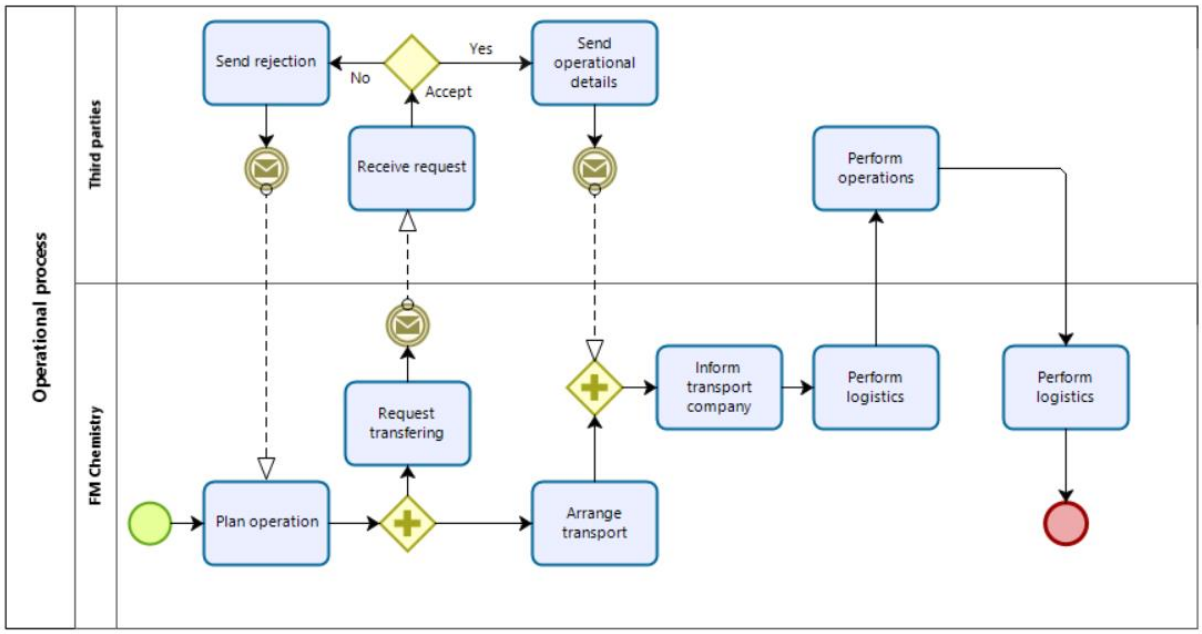

Figure A 3: BPM of the operational process at FM Chemistry.

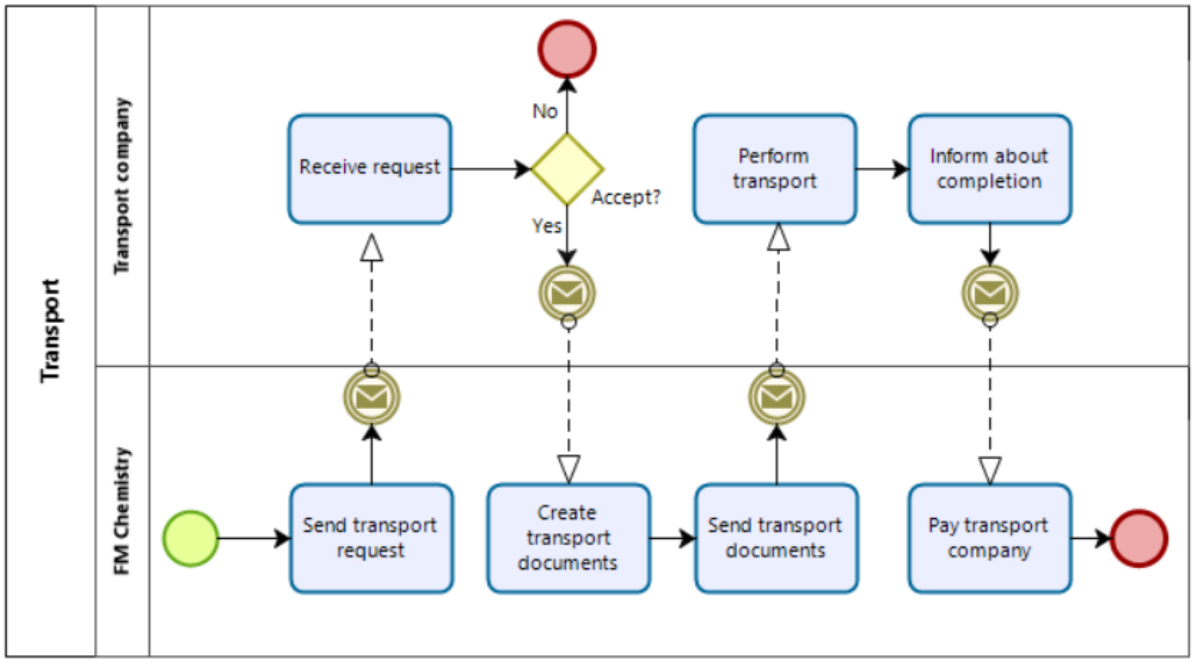

Figure A 4: BPM of the transport process at FM Chemistry.

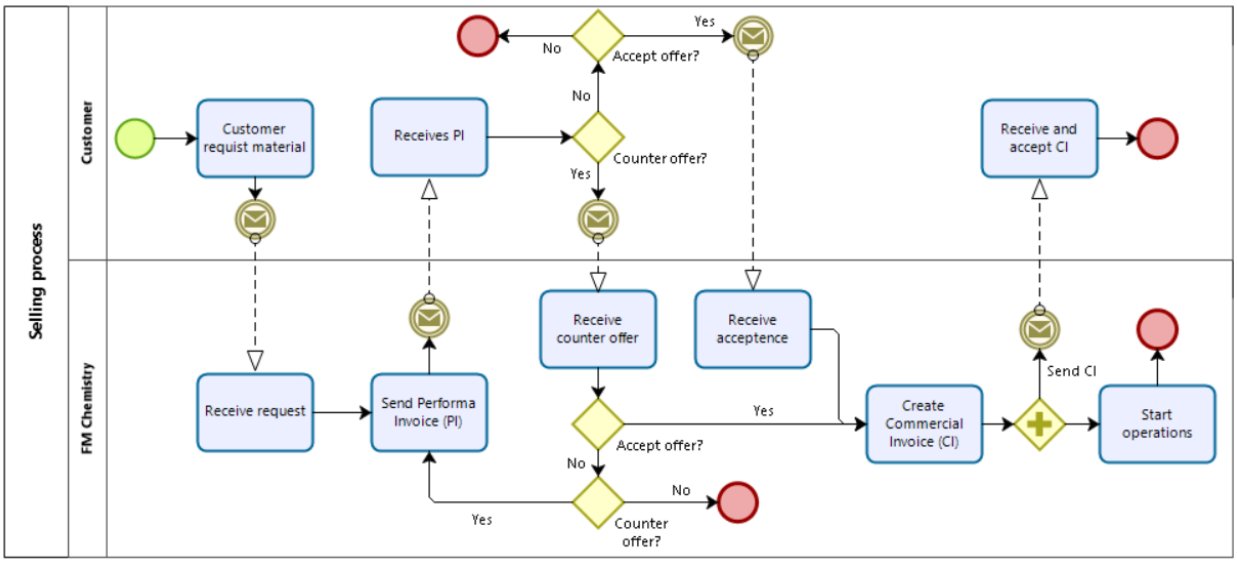

Figure A.4: BPM of the selling process at FM Chemistry.