EFFICIENCY ANALYSIS
OF A PLANNING PROCESS
IN CHEMICAL INDUSTRY

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EFFICIENCY ANALYSIS OF A PLANNING PROCESS IN CHEMICAL INDUSTRY
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**Foreword**

“Every day you make progress. Every step may be fruitful. Yet there will be stretch out before you an ever-lengthening, ever-ascending path. You know you will never get to the end of the journey.”

-Sir Winston Churchill-
(1874 – 1965)

This Master Thesis is performed for the study System Engineering, Policy Analysis and Management at the faculty of Technology, Policy and Management at Delft University of Technology. The thesis was concerned with improving the planning process of the polyols’ supply chain, executed at the CVP department at Shell Pernis. Even though improving a planning process is not a new phenomenon, this thesis does apply Lean Six Sigma on an unique supply chain in the process industry and makes use of an interactively SIPOC (Supplier, Input, Process, Output, Customer) workshop. The results of the workshop provide an complete overview of the different process steps within the supply chain, which can be used as platform to define opportunities for improvement. Handling these opportunities result in better insights in processes and an increased performance of the supply chain.

This report consists of four parts. The first part introduces in chapter 1 the problem situation, the current performance of the CVP department at Shell Pernis, the scope and the research question. The readers who are only interested in the results should read further at part 4, chapter 14, which contains the conclusions of the research. The second part, which is described in chapter 3 and 4, consists of analyses of the problem environment and defines the complete supply chain in detail, which enables opportunity framing. The third part, which is described in chapter 5 till 13, selects and processes four opportunities in order to improve the current performance. The DMAIC (Define, Measure, Analyze, Improve, Control) development steps are applied on these opportunities, to set up and structure four individual projects.

During this thesis project I was very well guided by the four members of my graduation committee. For this, I want to thank my university supervisors; Alexander Verbraeck, Sander van Splunter and Sebastiaan Meijer. Constructive comments during many meetings constantly safeguarded the progress of the project. Special thanks goes to my supervisor at Shell Pernis, Nazire Gunay-Dogan. Day in day out she did realize me of my performances and during the project she came with a lot of helpful observations. I also would like to thank all other involved Shell employees for their unvarying support during this project, and for creating an unforgettable, enjoyable and learning experience. I really appreciate all support and effort that all supervisors have provided, which lead to this final product.

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In den Pluym, February 25th, 2011

Ralph van Oss
Management Summary

Based on a detailed overview of the planning processes of the supply chain of polyols, created during an interactive workshop with all key stakeholders involved, ten opportunities were defined to improve the current performance of the supply chain. Four opportunities were selected, based on ease of implementation and impact. Individual improvement projects were started to use the opportunities to improve the performance of the supply chain.

The four executed projects are focused on feedback on delivery of raw materials, insights in tasks of the logistics coordinator, delays of laboratory analyses and optimal balance between flexibility and inventory.

The first project focused on elimination of unexpected production delays, caused by unexpected shortages of raw materials. New communication structures and standards were designed and secured in the organization to improve the feedback on deliveries of raw materials to the logistics coordinator and production administrator. Besides this internal solution, the performances of the suppliers are monitored during the coming weeks, which enables externally focused follow up actions, to improve the performance of the suppliers of raw materials.

The second project goal was to improve the insights in the tasks of the logistics coordinator, which makes it easier to replace the logistics coordinator during middle and long term absences. Flow diagrams provide insights in the tasks of the logistics coordinator on different aggregated levels. The detailed description also defines the constraints, that should be taken into account when the production planning is created and when production is monitored. A Recommendation for future improvement is to integrate the production planning, raw material planning, loading availability list and a laboratory list, including all samples with priorities. An integrated excel file could automatically controls all necessary input, and decreases the chance of problems causes by inattentions.

Project three focused on delays of laboratory analyses. The laboratory uses target times, instead of actual times. An analysis performed on a large data set, shows insights in the delays of the sample analyses. The differences between target times and actual times directly affect the performance of the supply chain, because the current planning is based on the target times. The graph presented on the left, shows the differences between target and actual times. 64% of the samples is on time analyzed and 14% is ready within 4 four hours after the target time, set by the laboratory. The results provide insights in the current performance of the laboratory. These results are presented to laboratory and the project lead is handed over. The laboratory should take follow up actions to improve the performance related to the analyses times of the CVP-samples.
The results of the third project are direct inputs for the last project. The project focused on an optimal balance between flexibility and inventory. The current planning philosophy tries to minimize the total time between production and delivery to trucks/ships. A value stream map analyzed the necessary steps of the supply chain of polyols and indicated an average value added time of 69.5 hours. It also showed that the majority of processes are executed in a fixed sequence. The last process step of this fixed sequence; delivery to the customer, is directly planned after the moment that the sample analysis is expected. For this reason, delays occurred in earlier process steps in the supply chain, directly negatively affect the perceived performance by the supplier. The results on the sample analyses times and the results of a research on various plants impact, are arguments to apply a different planning philosophy. Recommended is to build in slack time between the expected moment that the tanks are freed for sale and the moment deliveries are planned. This diminishes the number of issues experienced by the carriers and customers and thus improves the perceived reliability of the supply chain.

It is recommended to schedule deliveries the next morning at 07.00 o’clock and onwards. This creates a reliability improvement of 16%, to a total reliability of at least 80%. This situation doesn’t affect deliveries of day trippers. Potentially this percentage could be increased to 85%, but this depends on possibilities of the laboratory to perform sample analyses during the night, which is under investigation. The percentages are based on performance improvements related to laboratory analyses, but including slack time also offers opportunities to adapt other delays affecting the delivery time. By planning deliveries the next morning, day trippers still are able to deliver the product on the same day, which makes sure that customers will not experience changes other than a higher reliability.

Regarding the communication at CVP, three recommendations are given: First stakeholder engagement between SCE and CVP is recommended to increase the mutual understanding. Secondly a time indication (clock) should be used to define the last update of the production planning in the production control room. Finally a communication barrier should be created between the supply coordinators and the logistics coordinator, to avoid frequent changes in the production planning.

The last general recommendation is related to the documentation at Shell Pernis. To realize a high level of safety and in order to keep the company manageable, all actions and tasks are formalized. It is essential that higher and middle management constantly try to find a optimal balance between the safety policy and the ability to perform the tasks properly.

The project results and recommendations to improve the current performance of the planning process, show the potential of the defined opportunities. Six opportunities can still be used to improve the overall performance of the supply chain. These opportunities could be used to start individual Lean Six Sigma projects, which fits to the new goals set by the management of Shell Pernis.
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Efficiency analysis of a planning process in chemical industry
Part I - Introduction
1. Introduction

Royal Dutch Shell, commonly known as Shell, is the largest energy company and the second largest company in the world measured by revenues and is one of the six oil and gas “supermajors”. Shell operates more than 44,000 service stations worldwide, produces around 3.1 million barrels of oil equivalent per day and has operations in over 90 countries (Shell 2009). Shell has indicated five core businesses: exploration and production (the upstream), gas and power, refining marketing (the downstream), chemicals (also downstream) and trading and shipping. The downstream generates a third of Shell’s profits worldwide and is known about its global network of more than 40,000 petrol stations and its 47 oil refineries (Shell 2010).

One of the 47 oil refineries is Shell Pernis, located near Rotterdam in the Netherlands. The refinery at Shell Pernis is the largest in Europe and one of the world’s largest. The refinery is located on an industrial complex covering around 425 hectares, where crude oil from various continents is processed and where products are manufactured for the global market. Besides oil products, also base chemicals are manufactured on the site. Two out of the nine business units are dedicated to chemical related products (Shell 2010).

In 2009, Shell developed a new global downstream strategy. This downstream strategy is presented in figure 3. Special attention should be given to the three keys to winning. As a result of this downstream strategy, Shell Pernis started a reorganisation in 2010 named the Flexible Flagship Organisation (FFO). In order to become and/or stay one of the world’s most innovative and competitive refinery and chemical plant.

The Flexible Flagship Organisation aimed at five keys to winning, which are summarized. The three keys presented in the figure, added with goal zero and GAME. Goal Zero refers to the safety targets at the refinery. GAME refers to Global Asset Management Excellence. Which is focused on applying robust work processes and continuously improvements.

Figure 3: Downstream strategy (source: (Shell 2009)
As a result of the Flexible Flagship Organisation many people changed position in middle- and higher management, because everybody had to apply again on a position at Shell Pernis. At all levels, also on the operational level, new goals were set. Management aimed at site wide introduction of structural improvements.

The FFO of course also effected one of the two chemical units, called CVP (Chemische Verladingen Polyolen). The CVP unit consists of three plants; Phoenix, Flexibles and Sannest, all producing polyols (See appendix 1). Polyols are polymers, which are used as main building materials for a wide range of products in the polymer industry; e.g. dashboards, steering wheels, memory foam (tempur), polyethuraan (PUR) foam, isolation, etc. The main use of polyols is as reactants to make other polymers. A secondary use is to create monomeric polyols or polymeric polyols, such as polyesters or polyethers.

Besides the production of polyols, CVP is also responsible for the filling and dispatch of chemical products. The combination of transportation and manufacturing combined within one unit, offers possibilities to analyze and improve the planning processes of both the production and transportation of chemical products. Besides the production and transportation departments two other elements are of importance in this supply chain, namely the commercial and supply departments. These tasks are performed by Shell Chemicals Europe (SCE), located at Rotterdam Alexandrium. SCE is among others, responsible for the sales and supply of polyols, produced and transported at CVP.

CVP also applied the FFO strategy and focused on the five keys to winning. This research focuses on one of these keys to winning, namely operational excellence. CVP indicated several areas within the supply chain that could be organised more effectively. To be able to concretise and define these areas in more detail, CVP decided to perform research in order to create opportunities and realise a more robust supply chain by striving to eliminate waste within the production and planning.

### 1.1 Problem exploration

The Flexible Flagship Organization formulated five keys to winning in order to increase the overall performance of Shell Pernis. One of the first actions of Shell Pernis management was to create the possibility and a platform for everybody to set up small projects based on a Lean perspective, in order to eliminate waste in the organization. Many small projects were executed resulting in a cost reduction millions of dollars since the start of this waste reducing initiative. These projects have two main goals, first of all creating a focus on simplifying processes in general, secondly to create awareness by the employees on all levels, in order to make a difference (Shell 2010). This perception is useful during this project, because it shows that there is room and support to improve.

CVP as a unit shares the earlier presented five keys to winning in order to increase the performance. A very important key to winning for CVP is operational and functional excellence. In this case, several departments are involved, namely commercial at SCE, supply at SCE, manufacturing at CVP and filling and dispatch at CVP. Although the four departments have one common high level goal, viewpoints of these departments are different, which creates different approaches to achieve this high level goal. These different approaches create many opportunities for improvement, for example by creating
more alignment and by improving the linkages between the different elements of the four departments. Various management indications, originated at different parts the supply chain, indicate that the operation of the supply chain is not at an outstanding level. Planning and other logistic processes are too sensitive to disruptions at the moment. When the supply chain is this sensitive, disruptions are directly causing production delays, delivery delays, extra costs and demurrage. For this reason should the sensitivity to disruptions be minimized. The origins of these disruptions, and how to manage the implications of these disruptions, need to be determined. The involvement of four departments in the supply chain poses an additional challenge: all have the same end goal, but they have different optimal paths to reach the goals. These different approaches create a situation in which all departments define different causes and reasons for the disruptions. Communication on a high level, covering all departments, should be improved before it is possible to precisely define the impact of the disruptions on the whole supply chain. This problem is reinforced because the perceived causes of the disruptions are not shared enough by the different departments of the supply chain and for this reason are not perceived as mutual problems.

The previous paragraph explained the difficulties of categorizing the disruptions. However, initial interviews with management of the four different divisions of the supply chain, enabled categorization of the possible disruptions into four different broad groups. Each category indicates problems related to planning and scheduling activities within the supply chain.

The first category is the responsibility of SCE, the second, third and fourth group are the responsibility of CVP production and the last group is the responsibility of CVP filling and Dispatch.

1 Changes in production plan \(\rightarrow\) caused by decisions taken by SCE Commercial or necessary reasons.
2 (Non-) availability of raw materials \(\rightarrow\) planning or delivery problems
3 Production problems \(\rightarrow\) quantity or quality related problems
4 Delivery to customer \(\rightarrow\) problems with schedules and planning from customer and producer sides

The context of these categories of disruptions is defined using a schematic overview of the supply chain, presented schematically in figure 4. The red part of the figure indicates SCE, consisting of a commercial department and a supply department. The yellow part of the figure defines the parts of the supply chain of CVP, consisting of a filling and dispatch department and a manufacturing department. Finally the carriers and the customer are defined. These are both external actors, but mentioned because they are part of the project till a certain degree. Besides the colours, also different arrows are used. The striped arrows indicate all kinds of interfaces. This can be by delivery of a document, but also by using other modes of communication. The second arrow represents a delivery obligation, including one exception; this is a linear obligation from the beginning of the supply chain till the end, with the customer as starting and end point. The numbers besides the arrows indicate the position and location of the possible disruptions, indicated in four categories and presented and explained above.
Disruptions occurring in one of these categories are causing decreasing production availability, increasing potential costs and/or increasing delays and demurrage. This finally leads to lower turnover rates and lower profits. To create a focus during this research it is essential to define how these disruptions can be prevented and which parts of the supply chain are playing essential roles in creating these disruptions.

After initially analyzing the supply chain and performing some interviews, it became clear that the planning processes of the entire supply chain play are critical and play an essential role. At the moment insights in the complete planning processes of the supply chain is missing. These insights are not clear because it is divided between the different departments and organizations that are part of the complete supply chain.

To improve the robustness of the supply chain, it is necessary to identify and minimize the disruptions, causing waste, in order to increase the performance of the polyols supply chain. Nevertheless, the first necessary step is to create insights in the different processes of the complete supply chain.

Summarized, the management of the CVP unit at Shell Pernis wants to have better insights in the different planning processes of the complete supply chain of polyols. These insights should provide possibilities to identify disruptions causing waste in the supply chain and should help to increase the robustness of the entire supply chain. By increasing the robustness of the supply chain, the processes should become more reliable and predictable.
1.2 Research questions

The main research question is divided into two parts. Sub-questions are defined, to answer the two main research questions.

1. **What are the main factors affecting, positively or negatively, the planning process of the defined supply chain (of CVP and SCE) and what is the impact of these factors?**

   1.1 What are the relevant state of the art theories and practices to analyze supply chains and to identify waste and disruptions within organizations and supply chains?

   1.2 Which processes being performed within the commercial, production and transportation part of the supply chain are relevant for the planning process?

   1.3 What are the most significant disruptions and waste within the processes of the CVP commercial, production and transportation unit and which causes can be identified?

The first question aims at a logical first step in the process, namely identify, describe and analyze the relevant processes. As previously explained is there not enough documentation or knowledge of the planning processes affecting and/or operating in multiple departments.

Because the question is too broad to answer at once, three sub-questions are formulated. A combination of answers on the three sub questions provides the answer on the first main question.

2. **Which solutions and/or recommendations can be formulated to make the planning process of the supply chain (of CVP and SCE) more predictable and reliable (robust) and how should these findings be implemented?**

   2.1 Which recommendations and possible solutions can be generated to improve the planning processes of the commercial, production and/or transportation division and eliminate waste?

   2.2 What steps are necessary to implement the solutions and recommendations and how could these processes be replicated?

The second question is a follow up on the first question, in other words, the answer and results of the first question are the inputs for the second question. After the relevant processes and most relevant waste within the supply chain has been identified, these opportunities can be analyzed and improvements can be proposed. Again the sub questions are used to help answering the second main question. Sub question 2.2 creates additional academic value, because it shows how the theories and methods used during the research can be used again, in other words; replication of the research project.

1.3 Towards the research questions

In order to provide answers on the research questions, several steps should be taken. It is now possible to explain these steps more concrete.

Figure 4 already visualized the involvement of several divisions of Shell Nederland in the complete supply chain of polyols. As explained before, sufficient insights in the processes are missing at the moment, which is causing uncleanness about responsibilities within the supply chain.

The planning of the production plays an essential and central role in the supply chain of polyols. However, it are also process steps that cover all departments. More insight in these planning processes is necessary to increase the robustness of the complete supply chain, reduce the impact of disruptions and create more clearness about responsibilities when the ideal situation changes. For
this reason the first step during this research is to focus on the identification of these planning processes. An important focus point during this research is the involvement of all departments. The insights gained during this research should also create follow up actions after the project is finished. To be able to define the processes and come up with solutions in order to increase the robustness of the supply chain, literature will be applied. At the moment Shell already makes use of theories to make it easier to identify the 'stream' of processes. Insights in the 'stream' is necessary to improve these processes. The main process improvement method used by Shell Pernis is Lean thinking, also called Lean manufacturing. This method is also applied by the earlier mentioned small lean projects. Lean focuses on the identification and elimination of waste (Nave 2002). A main step in Lean thinking is the identification of the value stream. Lean is flow focused and could be used to define and identify the different flows of the supply chain (Abdulmalek and Rajgopal 2007). This method will also be leading during this research, in order to visualize and define the different streams and to be able to create a clear overview of the different steps affecting the logistics planning processes. Lean Thinking will be combined with Six Sigma theories, in order to deal with criticism on the lean thinking method and to maximize the performance improvement. Lean Six Sigma, as the combination is called, uses strong points of both theories and focuses on customers to be happy by producing quality products and services with the required speed. These (value) streams and Lean Six Sigma thinking make it also easier to define the main disruptions and create solutions and recommendations to diminish the impact and frequency of the problems, in other words eliminate the waste. Supply Chain Management theories will be applied parallel to Lean Six Sigma methods during the project, in order to come up with more detailed solutions that will optimize the Supply chain. Attention should be given to the strategically, tactical and operational levels of the organisation (Simchi-Levi, Kaminsky et al. 2003).

It is now possible to define and summarize the four different phases during the research:

I. Present clear documentation of the most relevant logistic planning processes of the supply chain, including the commercial and supply parts, which are the responsibility of SCE.

II. Identify the main disruptions causing waste and inefficiencies within the logistical supply chain, and define the processing causing it.

III. Provide recommendations and possible solutions for future change that diminish the impact and frequency of the disruptions.

IV. Document this process (procedures) for future use, advice in implementation steps and advice in replication of the research.

1.4 Report Structure
The report is structured in four main parts. Part I – Introduction, describes an introduction in chapter 1 and provides the methodology, including a literature review in chapter 2. Part II – Analyses applies this methodology on the case study of Shell Pernis – CVP. Chapter 3 analyzes the network and explains the stakeholder environment. Chapter 4 identifies and maps the processes of the planning process of the polyols' supply chain. Part III – DMAIC, starts at chapter 5 and applies the DMAIC structure to execute the projects. Chapter 5 builds further on the previous chapters and maps the most relevant opportunities. Chapter 6 goes further into detail on the DMAIC methodology, applied to start and process four projects. Chapter 7 – 10 describe the four projects, based on the five DMAIC development phases. The control phase includes the monitored results of an implemented pilot project. Chapter 11 evaluates the projects. Chapter 12 provides a framework how to transfer the
knowledge, gathered in the projects, to the organization. The overarching chapter 13 is the last chapter of this part and reflects and evaluates the DMAIC method generically. Finally, part IV – conclusions, consist of chapter 14, conclusion and recommendations, which summarizes the findings and draw conclusions on the executed research.

The overview presented below in figure 5 visualizes the structure of this report.
2. Methodology

2.1 Introduction

To answer the research questions it is necessary to apply the right method. A method or theoretical framework introduces a logical sequence of several steps. These are used to process certain steps in order to provide clear answers on the main research questions. This chapter introduces the main literature used during this research. The literature provides a handheld during the project and also creates more opportunities to reflect in general on the methods used, evaluate the results and describe possibilities to replicate some of the process steps.

Chapter 1 introduced the Flexible Flagship Organization. This reorganization of Shell Pernis was executed to become more competitive and profitable by reducing unnecessary operational costs and by creating selective growth. In order to create operational excellence and eliminate unnecessary costs, Shell introduced small lean projects focused on quick wins in order to increase the operational performance, called ‘BOB-Projects’\(^1\). Lean thinking (Shell 2010) was broadly introduced to Shell personnel to create support and optimize the result of these lean projects.

This chapter first provides a literature review in paragraph 2.2 and focuses in paragraph 2.3 on the applied methods.

2.2 Literature reviews

The management of Shell Pernis broadly introduced lean thinking to Shell personnel in the last years. Lean thinking is a performance improvement method that is applicable for the research in this thesis, as the goal of this research is to improve the current performance of the supply chain of polyols. However, Lean thinking is not the only theory or improvement method that suits this research. This paragraph first provides some background on lean thinking, followed by information on other theories which could be applied in order to create useful results during this research.

In 1990, Womack, Jones et al. (Womack, Jones et al. 2007) published a book called ‘The Machine That Changed the World: The Story of Lean production’. This book tells the story of the Japanese answer on standardized automobile parts of Henry Ford by introducing the Toyota Model, called Lean Manufacturing (Abdulmalek and Rajgopal 2007). Lean is focused on cost reduction by eliminating non-value added activities. In other words, trying to maximize the reduction of waste. Miller (2005) defines lean as using less to do more, by determining the value of any given process by distinguishing value added steps from non value added ad eliminating waste so that ultimately every step adds value to the process.

Because Shell is already using the Lean thinking method, this technique is well supported and understood within the organisation. A second advantage is that the research phases mentioned earlier can be compared with a typical Lean approach, by performing the first phase; the identification of waste, the second phase; the elimination of waste and also more or less the third phase; implement, sustain and replicate (Unknown 2010).

Besides these positive effects, there is also criticism on the Lean method. The main criticisms are summarized in the following points; Lean has a lack of consideration for human factors, a lack of strategic perspective, it has a relative inability to cope with variability, it means laying off people, it is only for manufacturing and Lean only works in certain environments (Bevan, Westwood et al. 2005). To deal with this criticism other process improvement methods, that are capable of compensating the criticism, can be used in addition to Lean thinking.

\(^1\) BOB = Balast OverBoord - projects
A possible compensating method is the Six Sigma method focuses on reduction of variation, which will solve process and business problems and increases quality. By using a set of statistical tools to understand the fluctuation process, management can begin to predict the expected outcome of that process (Unknown 2004); (Schroeder, Linderman et al. 2008). Several typical Six Sigma tools are very useful during different phases of the research. For example the SIPOC (Supplier Input Process Output Customer) tool, which can be used to identify and define ‘as is’ processes.

However there is also criticism on Six Sigma. The most important criticism are summarized as follows; Six Sigma does not consider system interaction, processes are improved independently, there is a lack of consideration of human factors, it is over detailed and complicated for some tasks, it is focusing on quality and the final criticism is that the goal of Six Sigma is absolute (Bevan, Westwood et al. 2005).

So the question should be asked, can both methods be used at the same time to increase the benefits and relevance of the theories for this project? And are the criticism on both methods be diminished by using a combination of methods? This answer can be given with help of some background information and experiences on possible combinations of these methods. First of all to make sure, it is clear that both methods can be used to improve business processes and can be applied on this thesis! Nave (2002), provides theoretical background to compare these methods and provide a handheld to choose one of these methods.

However, his conclusion that these theories all creating different benefits is not fully supported. Webber State University at Utah (Pirasteh and Horn 2010) introduced and claimed that a combination of Process Improvements methods deliver higher results than usage of these methodologies individually (Pirasteh and Horn 2009; Pirasteh and Horn 2010). So this statement provides an answer on the question mentioned earlier, namely: Applying a combination of Lean thinking and Six Sigma theories will create benefits and deliver higher results.

Applying a combination of Lean and Six Sigma is not an innovation and already happens a lot. Shell already used combinations of Lean and Six Sigma before. Lean Six Sigma, as the combination is called, focuses on customers to be happy by producing quality products and services with the required speed. This is done by reducing variations and defects and by improving process flows. It is key that the process is assessed and not the people. Data and facts form the basis for Lean Six Sigma and for this reason it always starts with measuring. The Lean Six Sigma house presented in figure 6 on the right side, presents the most important aspects of the Lean Six Sigma approach previously used by Shell (Unknown 2010).
The combination of these methods is successful because it combines the focus of Lean on reducing waste and increasing speed with the focus of Six Sigma on improving quality and performance on critical customer requirements and reducing costs. It reduces criticism given earlier in this paragraph, by incorporating the best of Lean and the best of Six Sigma. The focus on the speed of Lean and on the quality of Six Sigma are better together. But also the combination of common sense (Lean) and common science (Six Sigma) offers the potential to achieve uncommon results (Bevan, Westwood et al. 2005).

Lean provides several tools to define waste in the organisation, Shell uses a Lean tool; TIMWOOD (Shingo 1989), which makes a distinction between value-added time and non-value added time. Shell also uses DMAIC (define, measure, analyze, improve control) (Frahm 2003), a Six Sigma tool to define more clear solutions for our problems and to provide standards in process steps of projects.

These performance improvement methods can be combined with Supply Chain Management methods. What do these improvement methods have to do with the supply chain? The short answer is everything (James 2004), because both Lean Six Sigma and Supply chain Management focus on performance improvement and can help to improve the efficiency of a supply chain.

A huge amount of literature can be found on supply chain management. Supply chain management spans the entire network from initial source to the ultimate customer (Omta, Trienekens et al. 2001; Tan 2001) and is defined as a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses and stores. This integration is done in a way that merchandise is produced and distributed at the right quantities, to the right locations and at the right time, in order to minimize system wide costs while satisfying service level requirements (Simchi-Levi, Kaminsky et al. 2003). Control and coordination of stocks and material flows, exchange of information and the associated managerial and operational activities are the subject of study in Supply Chain Management (Meijer 2009).

Supply chain management should be combined with Lean Six Sigma thinking in order to diminish the effects of the disruptions occurring in the supply chain. Focus points in supply chain management are minimizing the system wide costs, while maintaining a certain service level and dealing with uncertainty. In order to optimize the Supply chain, attention should be given to the strategic, tactical and operational levels of the organisation (Simchi-Levi, Kaminsky et al. 2003). James (2004) provides a 12 steps Lean Six Sigma method that will lead to a clear map of processes feeding into and through a company before being realized by the customer. Martin (2007) describes a 10 Step solution process for Lean Six Sigma for Supply Chain Management. Both methods can help to define the steps that should be taken during this research and will be taken into account in formulating the steps in paragraph 2.3.

The above discussed methods and tools already take a lot of aspects to optimise a planning process of a supply chain into account. Specific attention during this research should be given to moments or process steps, where communication and coordination between divisions and/or departments play an important role. An example in this supply chain are the process steps containing interfaces between SCE and CVP. Lazzarini, Chaddad et al. (2001) describe two viewpoints used for analyzing supply across the borders of a firm. First the supply chain perspective and secondly the supply network perspective, which they call ‘netchains’, useful in the following chapter of this thesis. It is very important to analyze and optimize the different ‘transfer’ moments of information and/or
Efficiency analysis of a planning process in chemical industry

goods. This step focuses more on organization, management and coordination mechanisms within organizations. Woodward (Mintzberg 1983) talks about coordination divided in process, piece and mass production. To come up with solutions and recommendations, the coordination between divisions and departments within the supply chain also requires extra attention. A significant part of the waste in this case seems to be contained within organizational and coordination issues. This waste is especially located at issues where several departments within one organization, all with different goals and perceptions, are involved.

A theory that could be used as handheld is rooted in the new institutional theory transaction cost economics (Williamson 1998), with the four level framework of economics of institutions. It specifies three major characteristics of transactions, namely frequency, uncertainty and asset specificity. New institutional economics offers tools for analyzing interactions between organizational forms of supply of goods and the institutional environment in which they are embedded (Menard 2000).

Finally there are some important management theories necessary to apply during this research. One of the main aims of this project is to define the most relevant disruptions and create opportunities to improve the robustness of the supply chain. McIntyre (2010) states that most initiatives start to fail because they fail to start! According to him is one of the hardest things to do in many organizations, to set up a successful change initiative. In order to successful set up change initiatives, he defines seven essential steps. These steps are focused on building a strong core team, a project team (McIntyre 2010).

After executing these seven steps, the opportunities can be seen as a small projects within a large project that should be processed. Project management methods are necessary to manage these projects and create successful end results. To help predict and control the schedule, budget, scope, resources and tasks. However, one of the main reasons for failures of projects is because the changes they are aiming at, are structured as projects, with clear goals, tight schedules and targets. In a Network however, a project approach has limited significance, because the parties will not automatically accept the latter’s problem definition, aims and plan. And many projects have to deal with significant uncertainties, leading to surprises in the execution phase of the project. For this reason, the opportunities should also be approached by spending attention to process steps, in other words, the rules of the game (Bruijn, Heuvelhof et al. 2003). For this reason process and project management methods will be applied. Sometimes less obvious and in a more intrinsic way, but their share in gaining successful results should not be underestimated.

The above discussed literature and methods provide enough guidance during this research to analyze the problems and come up with solutions and recommendations in order to increase the robustness of the supply chain. The different steps that should be executed during this research are based on the literature described above and presented below. When a step needs certain tools or extra literature background to process it in order to be able to come up with improvements, these will be added and explained in the corresponding chapter.

2.3 Applied methodology

The Lean Six Sigma method will be used as leading theory during this research. Normally five steps are taken, which depends on the leading theory. DMAIC (Define, Measure, Analysis, Improve and Control) is used by Six Sigma (Harry 1994) and identification of the value stream is applied by Lean
thinking (Specify value, Understand Demand, Flow, Level, Perfection) (Rother and Shook 2003). As this thesis uses a combination of these methods, Lean Six Sigma, the steps used are also a combination of these methods (Bevan, Westwood et al. 2005). This approach consists of four phases, instead of five, which are presented below:

![Lean Six Sigma approach](Based on: Bevan, Westwood et al. 2005)

**Understand and reframe**
The first phase, understand and reframe, focuses on the ‘as is’ situation. The ‘as is’ situation is used as starting point for the analysis. Based on this situation, improvements and solutions can be created. To be able to define the ‘as is’ situation, interviews with the most relevant stakeholders (on operational and management levels) are providing the key information. The most relevant stakeholders are defined by processing a stakeholder analysis. A stakeholder analysis provides good insights in the most important people that should be informed about the project (Fletcher 2003), but also about the most relevant stakeholders that could give input to the project. To come up with improvements and solutions in a later phase, it is very important that the involved stakeholders are committed to the project. This is realized by involving them in the project from the first phase and onwards (Explizitz 2010); (Bruijn, Heuvelhof et al. 2003). Not only by performing interviews and asking for their opinions and input, but also by organizing interactive workshops. Hence, the stakeholder analysis is the first step in the process, before an interactive workshop can be organized to define the ‘as is’ process. The workshop not only focuses on commitment, but also tries to create consensus on the results, because the input and results are created together during one workshop. For this reason the results of the workshop will be validated with the involved stakeholders.

To identify the ‘as is’ situation different tools can be used. During this research the SIPOC (Suppliers, Inputs, Process, Outputs and Customers) tool (O’Loughlin 2010) will be used. First a process map will be designed of the main and most relevant process steps. This process flow is used as handheld to fill in the SIPOC diagram in more detail. Background on this SIPOC diagram is provided in chapter 4.

The identification of the ‘as is’ process also creates a platform that can be used to define the disruptions and opportunities occurring in the supply chain. These disruptions are not explained in detail, only indicated during the workshop, because the next step will perform research on these opportunities in more detail.

**Develop concepts**
The results of the SIPOC workshop form the input for the second phase. This phase focuses on all suggestions, unlike traditional six sigma projects that focuses only on suggestions impacting on one dimension of the project. This is done in an effort to engage and empower employees. In this phase special attention is spend on the root causes of the problems which were mentioned during the first workshop. (Tague 2004).

The opportunities indicated during the SIPOC workshop are used for follow up meetings with all attendees of the workshop. During follow up meetings the focus is on creation of a more detailed description of the opportunities.

After the follow up meetings it is possible to define a list of opportunities. It is necessary to focus on the most relevant disruptions and problems. Because of the limited timeframe of this project, only
the most relevant problems can be analyzed. This list should be prioritized, by ranking the opportunities on input vs. output. The ranking will be based on time, resources and cost vs. support and impact. The opportunities can be seen as small projects. This portfolio of projects focuses on a well balanced mix of quick wins and more complex long term projects. The next step is to set up small project teams and create commitment to realize improvement on the different opportunities.

Test and learn
When the disruptions and problems are identified, the improvement phase starts. The highest ranked opportunities will be improved by starting small projects. Lower ranked opportunities are not completely neglected but are followed up in a different way. These opportunities are mentioned, so actions can be taken in the future or parallel to this project. The goal of this third phase; test and learn, is to develop appropriate improvement plans, by using the comprehensive toolbox that Lean Six Sigma offers. The use of these tools are in more detail explained in chapter 5 and 6. The projects also make use of supply chain theories and organizational methods. These methods also have a role in solving issues and occurring problems in more detail in the supply chain. The effects of the problems and disruptions can be diminished and solved in different ways. This will depend on the opportunity. Specific steps are explained in the corresponding paragraphs in chapter 5, 6, 7 and 8.

A small part of the Develop Concepts phase and the Test and Learn phase focuses in this research on the development of the four individual projects. The steps described in this part of the research, are similar to the DMAIC steps. This is a logical consequence, because the theory of Bevan, Westwood et al. (2005) is partly based on the Six Sigma theory. However, the DMAIC steps are commonly known at the organization. For this reason, both theories are combined. The complete research applies the four steps method and phases of the individual projects, are structured with help of the DMAIC steps.

Design the delivery
This phase designs the foundations for sustaining the gains. By implementing the solutions where possible and otherwise formalizing the solutions and recommendations, it is ensured that information and findings are not lost. By monitoring the implementation where possible, using e.g. score cards, it becomes possible to evaluate the implemented solutions and recommendations. At the end phase of this research, the commitment created during the projects should be fully used, by handing over the lead of the necessary projects to another team member. This method will finally lead to concrete results that improve the robustness of the supply chain, some projects already implemented and monitored, and some needing follow up actions.

As already partly mentioned, the methodology described above will be used as a handheld to identify these disruptions and problems. In order to solve these issues and come up with improvements and define the root causes etc. extra background information is necessary. The previous paragraph already introduced extra literature. When certain methods or theories are applied, this will be explained in the corresponding paragraph. The four main phases are used as a general handheld during the whole research.
After explaining the background theory and providing arguments to use these methods, the methodology can be described stepwise:

1. Understand and reframe
   a. Define the ‘as is’ process
      i. Stakeholder analysis; performing interviews
      ii. Define ‘as is’ process
         1. Create alignment and commitment with stakeholders by organizing a interactive SIPOC workshops
         2. Define initial opportunities
         3. Validate results during follow up meetings with involved stakeholders
   b. Define opportunities in more detail
      i. Based on results of SIPOC workshop
      ii. During follow up meetings with involved stakeholders

2. Develop concepts
   a. Focus on opportunities
      i. Create ranking of opportunities
      ii. Prioritize opportunities; based on mixed portfolio
   b. Define the ‘to be’ process
      i. Create alignment and commitment with stakeholders by organizing follow up ‘project’ meetings.
      ii. Set up project teams per opportunity

3. Test and Learn
   a. Use the comprehensive toolbox of Lean Six Sigma
   b. Develop appropriate improvement plans
      i. Possibly focus in more detail on literature and applying methods

4. Design the delivery
   a. Formalize implementations
   b. Monitor and evaluate the implementations and describe the results
   c. Hand over lead of the projects; secure follow up

2.4 Conclusions
This chapter provides insights in the useful methodology and literature to answer the research question. Paragraph 2.2 provides a literature reviews and starts discussing performance improvement methods. It goes further into detail on the leading theory of Lean Six Sigma. Then it spends attention to other supply chain performance improvement methods, followed up by organizations theories, that are helpful in a multi-actor environment. Fourthly management theories are mentioned to realize improvements.
Paragraph 2.3 uses the literature review to describe the applied methodology. A four step approach is applied to structure the research. The approach is based on the Lean Six Sigma theory and the four phases, understand and reframe, develop concepts, test and learn and design the delivery, are explained in more detail in this paragraph.
Part II - Analyses
3. Network Analysis

3.1 Introduction

Chapter 1, introduction, provided some background information on the supply chain of polyols at Shell Pernis. One of the explained elements of this supply chain is the involvement of different departments with different interests, operating within one organization. This creates a reality in which all parties have one common high level goal, but practice shows that they frequently have different problem perceptions. Different actors have different goals and ideas regarding the desired situation. This is essential information during the analysis phase of this project, because the actors and their perceptions are part of the solution and thus part of the process working towards a solution.

All involved stakeholders need awareness that there is not just one right perception of the problem, but there could exist several besides each other. It is important to remark that some of these perceptions are consistent together, while others are conflicting. In the end, they are all focused on change and it may feel that their own ideas are not sufficiently reflected in the proposed change. Only when all parties are involved in the change, they may recognize their own ideas in the problem definition and solution. Only then they will support the process and solution (Dawson 2003; Bruijn and Heuvelhof 2008).

3.2 Tamed vs. untamed problems

In order to come up with solutions in a technical environment like Shell Pernis, often requires a technical solution. This technical orientated solution is tended to be seen as the main problem solving solution and can be assessed on a normative base. However, the involved actors with various perceptions, demand attention to the social dimension during the problem analysis phase. One of the main occurring problems is a lack of consensus on the problem perception, this makes it harder to come up with a solution, because in practice there is dealt with a diverge set of problem perceptions. The actors tend to forget that they are, in a sense, dependant on each other. They need each other’s support in effectuating change or optimizing the performance (Bruijn, Heuvelhof et al. 2003). The different problem perceptions are aggravated by the fact that the problems are perceived on different levels within different parts of the supply chain.

To be able to choose between the social and/or technological aspects and to makes sure this are the right aspects of the problems, the disruptions or points of improvement need categorization. De Graaf and Hoppe (1989) provide a framework to indicate the technological and/or social causes of a problem. This framework shows that a disruption or opportunity can be indicated by a degree of uncertainty regarding the technological or social aspects.

<table>
<thead>
<tr>
<th>Degree of substantive uncertainty</th>
<th>Little</th>
<th>Much</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Degree of social consensus regarding the problem</strong></td>
<td>Much</td>
<td>1. Tamed problem</td>
</tr>
</tbody>
</table>

Table 1: Framework of technological and managerial tamed and untamed problems (Source: De Graaf and Hoppe, 1989)
1. Tamed problem: There is no social or technological uncertainty regarding this problem. E.g.: A broken valve or pump has to be repaired.
2. This is a problem which all the stakeholders share the opinion that it is a problem, but there is not a technological solution for it. E.g.: The reliability of the units has to be 100%.
3. This is a problem with no technological complexity but with a lot of social resistance regarding the problem. E.g.: Who should be responsible during a Off-spec procedure.
4. These problems have both technological and social uncertainty. E.g.: What is the best sequence to produce polyols.

Strategies to find solutions for problems in category 2, 3 and 4 aim to shift these problems to category 1. In other words, change an untamed problem in a tamed problem. During projects it depends on the problem how this should be done. Some points of improvement or disruptions deal with uncertainty on both a technological and a social dimension. Technological solutions can often be presented in a normative way. This can convince actors of the nature of a problem and creates support to work to a technological better future. However social solutions are more complex and need more insight on the social context of the involved stakeholders in the supply chain (Fletcher 2003). Insights in the network should be clear in order to:

- Identify interests and perceptions of actors, to prevent unexpected resistance during the project.
- Provide an analysis in which the involved actors recognize themselves. As a result it supports the cooperation during the next phases in order to diminish or solve the problem.
- Create a stakeholder analysis, which maps and defines the positions, interests, resources and relations of actors. This provides a good overview of possible involvement and input of actors during the analyses of problems and also offers insights in the chances and threats that the actors have to offer.

### 3.3 Stakeholders

To create more insights in the social dimension of this project, it is necessary to define the relevant stakeholders. To come up with a list of relevant stakeholders and to be able to categorize them, it is important to first perform a quick actor scan (Bruijn and Heuvelhof 2008), which identify the actively involved actors in the planning process of the polyol supply chain. The second step should define the actors that have power to influence and play a role regarding the solution of the problem. Then other resources of actors involved should be defined, which are important to the come up with points of improvement. The last step should analyze which actors are not participating actively, but are affected by the problems and actions taken (Fletcher 2003). Because the exact disruptions and points of improvement are not specified at this moment, the results are based on problems affecting the planning of the polyols supply chain in general. Chapter 5 specifies the disruptions and explains the social dimension in more detail.

Before going into more detail on the stakeholders, it is important to remember that there are four different departments involved in the supply chain. These departments are explained and introduced in chapter 1. They are: Commercial, Supply, Manufacturing (CVP-P) and Filling and Dispatch (CVP-F&D).

The following actors are identified by providing answers to the goals stated above. The actor which is stated under the department, is directly affected by the related department:
### Table 2: Stakeholder overview

<table>
<thead>
<tr>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Production Unit Manager - CVP</td>
</tr>
<tr>
<td>2. Production Supervisor – CVP-P</td>
</tr>
<tr>
<td>3. Production Specialists production – CVP-P</td>
</tr>
<tr>
<td>4. Production Supervisor filling and dispatch – CVP F&amp;D</td>
</tr>
<tr>
<td>5. Production specialist filling and dispatch – CVP F&amp;D</td>
</tr>
<tr>
<td>6. Supply manager – Supply</td>
</tr>
<tr>
<td>7. Product managers – Commercial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Executive employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Team leaders– CVP-P and CVP-F&amp;D</td>
</tr>
<tr>
<td>10. Logistics planner – CVP</td>
</tr>
<tr>
<td>11. Supply coordinators – Supply</td>
</tr>
<tr>
<td>12. Customer Relation Centre representatives – Supply</td>
</tr>
<tr>
<td>13. Traffic office employees – CVP-F&amp;D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External parties</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Raw material and adjuvant suppliers</td>
</tr>
<tr>
<td>15. Carriers (including shipping companies)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross organizational parties</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. HSSE supervisor</td>
</tr>
</tbody>
</table>

1. Production Unit manager is accountable for the daily operation of the CVP unit. He has to approve new initiatives.
2. Production Supervisor is responsible for the day to day operation of production, direct responsible for executive employees of manufacturing and in charge of the resources planning.
3. Production specialists (2) of production are responsible for long and midterm improvements.
4. Production Supervisor of filling and dispatch is responsible for the day to day operation, direct responsible for executive employees and in charge of the resources planning of F&D.
5. Production Specialist of F&D is responsible for long and midterm improvements.
6. Supply manager is accountable for the day to day operation of the supply department.
7. Product Managers are responsible for the demand forecast and long term strategy of several product groups, inclusive polyols. They have a commercial focus and this is also the place where the demand of customers is processed.
8. Team leaders are responsible for a team on the floor (5-8 persons). During the day there are eight hours shifts for F&D and production. Shift 6 is responsible for a small part of filling and dispatch and is only during day times on the site.
9. Operators operate and control the units and load stations.
10. Logistics planner translates the production planning received from supply into a running planning.
11. The supply coordinators translate the demand and capacity forecast in a production planning.
12. The CRC representatives inform customers on changes and deliveries regarding deliveries of polyols.
13. Traffic office employees are responsible for the paperwork, timeslots and entrance and exits of the haulers on the site.
14. Suppliers of materials supply ordered raw materials, which is necessary input for production.
15. The carriers or haulers, including shipping companies, transfer the product to the customer.
16. HSSE supervisor is responsible for the Health Safety Security and Environment on the site. An important aspect at Shell Pernis. New initiatives need approval on HSSE aspects.

### 3.4 Mapping the formal relations

Behavior and power of actors are based on a formal and informal position within an organization. Knowledge of both positions is necessary to understand their environment and behavior. The stakeholder analysis presented in appendix 2.1 is based on interviews and documents. This input made it possible to map the formal and informal relations. The formal relations are mapped in a formal card in appendix 2.2 – stakeholder analysis. Because it is difficult to interpret the formal card at once, a simpler version is presented below. This simpler version also shows informal relations. The model can help to identify the mutual relations within the organization. The model is being used
when defining opportunities in chapter four, because the model can help to analyze the role of communication within the organization related to the opportunity.

Figure 8: Organizational chart of the formal and informal relations within the polyols’ supply chain

The organizational chart presented above in figure 8, provides clear and easy insights in the formal and informal relations between the involved stakeholders. Some interesting conclusions are drawn based on this chart. Hierarchy in the organization is the first aspect shown by the organizational chart. For this research the Production Unit manager is of special interest. The PU-manager has direct contact with the four management divisions. But the PU–manager has no formal power over the supply and commercial (SCE) departments and stakeholders. This could effects the current process, e.g. does this lack of formal power have direct effects on the processes and especially on the possibilities to use recovery measures? Are there any contacts between the PU-manager at CVP and higher management at SCE? What enables the PU-manager to, when necessary, control the management of SCE? These questions are answered, when the opportunities are processed and the communicational aspects are reflected per opportunity.

Besides the role of the PU-manager and the high degree of hierarchy in the organization, the communication lines with the management not only exist on one level in the organization, but basically on all levels. Also interdepartmental communication does not only exist on a management level: there are several interdepartmental communication lines, for example between the product manager of commercial and the supply coordinators at the supply department.

The last interesting aspect showed by this organizational chart is the important and central position of the logistics coordinator. This is an operational function within the organization, but centrally located, and many people rely on this person to gather critical information.
Formal card vs. organizational chart

The formal card is based on an analysis performed in the beginning of the project. At that time, insights were missing to define informal important communication lines. The formal card is mostly based on available organizational charts and basic input generated during interviews. The questions asked during these interviews were not focused on informal communication lines, but more on formal positions in the organization. However, an actor scan is a continuous activity (Bruijn, Heuvelhof et al. 2003) and requires updating.

Not only formal relations are important in the complete process of operating the supply chain: many people gather information using informal relations. Informal does not mean in this case that communication is not about business, but it is not according the formal ways, as shown in the formal card.

This informal information gathering can be an explanation for miscommunications in the supply chain. Figure 6 proves that informal information gathering is used by several functions in this network at the moment. This can be a risk, because the quality and frequency of informal relations. In addition, informal information sharing is more dependent on the persons involved: when certain persons on positions change, this often effects informal relations, possibly leading to information losses.

The most important informal relations existing in the organization can now be defined. This is done by comparing figure 8, the organizational chart of informal and formal relations within the organization with figure 41, the formal card of involved stakeholders presented in appendix 2.2. The four informal relations are defined below.

One of the informal relations is between the product manager at the commercial department and other personnel in working at CVP. The product manager formally only has direct communication to the PU manager. But the current product manager used to be a production specialist at CVP and has a lot of experience and contacts at CVP. The product manager has informal contact with the management of CVP of production and filling and dispatch. Formally these relations do not exist, because the product manager has insights in targets that are not useful for the production facilities.

Another informal relation is between the logistics coordinator (production planner) and the PTL and operators of the filling and dispatch department. Formally information sharing between these persons is not directly, but via the supervisors. However, in practice there are informal relations that share information. By doing this on a frequent base, it creates an increasing importance of the function of the logistics coordinator. Because this function slowly becomes a critical link in the web. When this person is not available, key information is missing because the informal information flows are not formalized and thus not shared anymore.

The other two informal relations are between the logistics coordinator and the supply coordinators. This relation is also defined as an formal relation. However, the communication is very frequent and the content of the communication is bad structured. Both players have a lot of tacit knowledge, which is used during the process. This creates a informal relation, which is used to fulfill formal tasks.

The last informal relation indicated in the figure is between the production specialist of manufacturing at CVP and the supply coordinators. The production specialist often uses this source to gather information about decisions taken at SCE. Formally this information should be transferred via management levels.
These four informal relations are the most important ones and for this reason indicated the overview. There are more informal contacts within the organization, but they are not crucial for the process or directly affect the process. The example of the logistics coordinator makes clear that informal communication could be a threat to the organization, because it is not documented. In addition, when people change their position or are not available, necessary critical information sharing will be lost, which has negative consequences for the performance of the supply chain.

3.5 Interest, aims and problem perceptions
Contrary to the previous step, this paragraph explicitly focuses on the formal relations between the stakeholders, their interests, aims and problem perceptions. These are all presented in Appendix 2; stakeholder analysis. Interests are the most guiding values pursued by stakeholders. The aims are directly connected to the interests of the actor, in contrast to the problem perception. Aims indicate what an actor in a certain situation would want to reach and which changes it want or does not want to reach. Both are presented below.

The Production Unit manager (1) wants to guarantee continuity and efficiency of the production unit by realizing the targeted goals. The management of CVP – production (2) also wants continuity and efficiency of the production unit. However, their focus point is to decrease the sensitivity of disruptions and decrease cost. The Management of CVP – filling and dispatch (3) has the same interests as the management of the production part of CVP, but they also want to maximize the satisfaction by carriers and indirect by the customers. Their aim is also on decreasing the sensitivity to disruption and decreasing cost. Interests of the management of SCE – commercial (4) are continuity, efficiency and maximizing customer satisfaction and maximizing profit. To realize this, they are aiming on maximizing the turnover rate, the flexibility and minimizing the costs. The management of SCE – Supply (5) has the same interests as the commercial management, but they are aiming on minimal sensitivity to disruptions and maximizing the customer satisfaction by doing so. The different managements within this supply chain all have similar goals, but from different perceptions and different aims. However, clear communication should make it possible to get on the same track. There are besides the management related functions also a number of executive related functions. The stakeholder analysis identified 8 different executive functions. First of all are the team leaders of the production teams (6) an important actor. They want to produce the order list within the given timeframe and they are aiming on increasing performance of the polyols production units and want to reduce the reliability issues. They are directly responsible of the operators. The operators (7) aims and interests are the same, they want maximum output of their part of the production process. Crucial input is provided by the production planner (8). As presented in the previous paragraph, the production planner has a crucial position in the network. He wants to produce the order list within the given timeframe and maximize the continuity and efficiency. His aim is to increase the performance of the polyols production. Besides the manufacturing executive employees there are also employees focusing on the filling and dispatch part of the supply chain. They also have a team leader (11) and operators (10), which have the same interests and goals as the team leader and operators of production. The Filling and Dispatch department also has a traffic office (9). The Traffic Office wants to realize the order list within the given timeframe and maximize the continuity and efficiency. They are aiming to increase the performance by reducing time on site and queues of trucks. The executives employees of commercial are positioned as customer relation center (12). They want to maximize customer satisfaction and optimize contact with the customers. They are aiming on optimizing the communication and coordination between order and delivery.
Supply has two coordinators supply chain (13), they are responsible for the production planning and their interest is at maximizing customer satisfaction and profit. They try to realize this by optimizing coordination between production, filling and dispatch and the customer. During normal circumstances they are very important for communication and harmonization between the different departments. There are also some cross organization parties identified, less important during this research. This are the HSSE supervisors (14), which are aiming on maximum safety on site: goal zero. Their aim is to optimize a safe work environment and provide clarity about life saving rules. Other cross organization parties are the management of Shell Pernis (15), reliability engineer (16), maintenance engineer (17). Their interests are explained in appendix 3 and are not very important factors for this research. The last group of actors is indicated as external parties. Several actors in this group are important for the processes. First of all the raw materials suppliers (18). Their interest is to produce and deliver on time, with lowest cost. And they are aiming on delivery on maximum profit. Carrier or haulers (18) are interested in maximizing the volume, minimizing cost, maximizing flexibility and maximizing time slots. They are aiming for maximum profit and customer satisfaction. Also the customer is identified as external party (19). The interests of the customer are minimal product price and on time delivery. Finally the refinery at Moerdijk - supplier of PO/EO (20) is important during the processes. Their input is crucial for the supply chain and they are interested in continuity and efficiency. And are aiming on delivery on time with the lowest cost.

Besides interests and aims the stakeholders also have problem perceptions. These problem perceptions are the visions of the actors over the nature of the problem or the current situation. The most important ones are presented below, the others can be found in appendix 2; stakeholder analysis. The problem perception of the PU manager (1) is that the performance can always be better. The rest of the management (2,3,4 and 5) perceives the problem as a production process that is too sensitive of disruptions: the supply chain is not robust enough. The operators (7) and team leaders (8) perceive under performance as the problem. The logistics planner (9) has a problem with the production planning that is changed too often. His decisions are based on knowledge, but he can’t be missed, because other people don’t have the same knowledge. The traffic office (10) has problems with communications with departments about delivery delays and the time on site of trucks can still be reduced. The supply chain coordinators (14) are experiencing problems with short term changes caused by spot market and/or commercial reasons. Finally the carrier or haulers (18) are experiencing problems with scheduling because they cannot always exactly predict their arrival time.

**Conclusion**

The interests, aims and most relevant problem perceptions of the involved stakeholders presented also define several conflicting interests. While the managements want to realize their targets and maximize the performances, there are other actors which have opposed interests. Although the different managers of the departments have one high common level goal, there are differences in lower level, operational, goals. These differences are logical and explained above, but should be kept in mind when the opportunities are processed.

The group of operators, including the team leaders, are a potential actor group with conflicting interests. They want to minimize issues by creating higher buffers, higher storages and better maintenance, so that they are not interrupted by a lack of materials and have to deal less with quality related issues. These interests are more individual focuses compared to the management interests and aims. The so called ‘local’ optimizations are conflicting with the overall objectives.
In addition to this conflict, there are also a number of stakeholders focusing on customer satisfaction, while others don’t deal with this problem. This also creates local optimizations, because here are tradeoffs between on time delivery and maximum output of the units with less reliability. A third obvious tension between different local optimizations and problem perceptions is between the logistics planner and supply coordinator on one side and the commercial management on the other. Short term changes are necessary for optimal commercial results, but affect the complete planning and production process.

The identified contrasts and local optimizations evolving out of this analysis and conclusion are used to identify the different perceptions on the opportunities that will be identified in chapter 5. The insights on these different perceptions can be used to understand the different positions of involved stakeholders and to come up with better fitting solutions.

### 3.6 Mapping the dependencies

Before the processes and opportunities are defined, the stakeholder analysis need to be completed. The formal relations, the interests, aims and problem perceptions of the stakeholders are defined, but the dependencies between the actors are missing. Insights in these dependencies prevent friction in a later stadium, avoiding undesired results of the implemented measures, especially because it seems that a lot of problems are caused because of a lack of optimal communication. The overview with dependencies is defined by mapping all the important resources of actors for the planning process of the supply chain and to what extent these are replicable by others. This enables to examine which actors are critical in order to improve the planning process and diminish the impact of disruptions (Hermans and Thissen 2008).

In order to optimize the planning processes, the actors need resources to improve parts of the supply chain. Some of these actors are very replaceable, while others are hard to replace.

All management related stakeholders are hard or almost impossible to replace. Most of the executive employees have a tacit knowledge or essential information or education to perform their tasks, so on the short term they are not replaceable, but on the long term or in small groups, they can be replaced. The majority of the cross organizational actors can be replaced, because they have resources and necessary information to operate and maintain the supply chain, but on the long term, or in small groups, they can also be replaced. The external parties are partly replaceable. Without a carrier or supplier of raw materials it is not possible to operate the supply chain. However, there are more suppliers and carriers available. So on the short till middle term, alternatives can be found. Customers are scarce and are not replaceable. The government cannot be replaced and the permits are necessary to operate. The delivery of EO/PO is also necessary and cannot be replaced.

The previous paragraph mentions the actors that are critical for the processes. So it is important to analyze which stakeholders are dedicated to the problem. Furthermore , whether these stakeholders have common or conflicting perceptions needs to be defined. The stakeholders that have conflicting perceptions, interests and/or aims, but are critical and dedicated, are essential actors (Hermans 2004). Dialogue with these actors is important. However, in this research the interests of the customer are monitored and included in perception of the commercial management.

The actors that are both critical and dedicated are very important in order to improve the planning process. However, table 3, presented below, indicates the executive employees as non-critical. This is from the perspective that they can be replaced, but their cooperation and input is critical to succeed during this project.
Table 3 shows six critical and dedicated stakeholders. The table shows a majority of stakeholders as dedicated and with common perception. Only four actors have conflicting perceptions, these are all external parties.

| Common perceptions, interests & goals. | Production Unit manager | Reliability engineer Maintenance engineers Traffic Office Team leaders (CVP-V and P) Operators (CVP-P) Operators (CVP-V incl. Shift 6) Production Planner Customer relation center (+ Team leader) Coordinators supply chain | Refinery of Moerdijk – EO/PO Management of Shell Pernis | HSSE supervisors |
| Conflicting perceptions, interests & goals. | Customer | Local government | Carriers External suppliers of raw materials |

Table 3: Actor field (Hermans 2004)

### 3.7 Conclusions

Before drawing conclusions from the analysis, it is important to mention that a network analysis is always a snapshot of a moment in time. In other words, the problem perception, mutual relations and strategies of the involved stakeholders change continuously over time.

Several conclusions are drawn based on the analyses. First of all, how complex and technical an environment is or will be, the social dimension is always essential, because it remains crucial to involve the actors before a (technical) solution can be implemented. Otherwise, when the actors feel that they are not taken seriously, the acceptance of the technical solution will experience a lot of resistance.

Paragraph 3.3 showed a high degree of hierarchy in the organization, but at the same time also many direct communication lines between management levels and operations. This proves that even implementing a simple improvement can become more complicated, because of the involvement of many actors acting on several levels within the organization.

Paragraph 3.4, the identification of interests, aims and problem perceptions, show divergence between the perceptions of the different management groups and the operational employees. During this project, this is very important to keep in mind and monitor, because Shell Pernis is in the middle of a reorganization, and the management needs support of the operational employees.

The final paragraph provides an overview of the dedicated, non-dedicated, critical and non-critical stakeholders. This overview shows that the majority of stakeholders have common perceptions. However, it is also important to spend attention to the critical stakeholders with conflicting interests, because they have potential opposing power.
4. Exploration of the processes within the supply chain

4.1 Introduction

This chapter provides a clear overview of the different processes of the supply chain and it also presents a Value Stream Map. The exploration and documentation of the processes are used as base to define points of improvement. These so called opportunities are presented in chapter 5. The overview of process steps creates possibilities to come up with solutions in order to create a more robust supply chain. Before the processes can be identified, the insights in the key stakeholders network and position of stakeholders, created in the previous chapter is very useful. These stakeholders contain critical input, which is necessary information during the exploration of the processes.

Paragraph 4.2 maps the ‘as is’ processes by describing the process flow scheme and providing the results of the SIPOC workshop. The last paragraph of this chapter, 4.2, is used to present the conclusions of this chapter.

4.2 Mapping the ‘as is’ processes

Performing interviews with (key) stakeholders made it possible to create a clear initial picture of the supply chain. These interviews also provided information about some focus points that are essential during the analyses of the supply chain. The interviews made clear that in first instance a focus on the supply chain without the involvement of the filling and dispatch processes was needed. By splitting up the first part of the supply chain (commercial, supply and production) and the filling and dispatch part of the supply chain, it becomes easier to focus on certain processes and gather all key stakeholders during one meeting. So these paragraphs are focused on the supply chain without Filling and Dispatch involved. A visualization of the analysis area is presented below in figure 9.

![Figure 9: Overview of supply chain without F&D](image)

After the decision was made to focus on the ‘first’ part of the supply chain and gaining information during interviews on the different process steps, it was necessary to define the current processes. By organizing a workshop with all key stakeholders involved, from all departments of the supply chain, it becomes possible to define the process ‘as is’ and create consensus on the results. The ‘as is’ process is the main step before opportunities can be identified (Bevan, Westwood et al. 2005). The Lean Six Sigma theory makes distinction between the process ‘as is’ and the process ‘to be’ (Martin 2007). In other words, before disruptions can be indicated and points of improvements can be formulated it is necessary to have consensus with the involved stakeholders on the current situation (Shell 2008). When the ‘as is’ processes are defined and consensus on these steps is created, focus can be shifted to the indication of points of improvement, also known as opportunities. The ‘as is’ situation is the...
starting point on which possible opportunities are indicated and is important during subsequent phases. Because when the opportunities are indicated and are processed and implemented, it is necessary that the analysis is broadly supported (Explizit 2010).

For this reason a workshop was organized with stakeholders involved to define the process ‘as is’. Lean Six Sigma theory provides a useful tool to create a clear overview of the different process steps. This method is very useful during the limited time of a workshop and can be used interactively. The tool is called SIPOC, which is an acronym for Supplier Input Process Output and Customer and originally is a Six Sigma tool (O’Loughlin 2010). This workshop is executed and the results are presented below. The presented results are validated during follow up meetings, as described in chapter 2 methodology, with the involved stakeholders.

### 4.2.1 7 steps linear process flow

The first step in defining the process ‘as is’, is to define the process flow in roughly 4-7 main phases (O’Loughlin 2010). Hereunder is an overview provided of seven main steps, on which consensus is created with the key stakeholders involved during the SIPOC workshop.

#### Process flow – Planning process of the supply chain of polyols

![Process flow diagram](image)

**Figure 10: Process flow - planning process of supply chain of polyols**

The process flow consists of 7 main steps. These seven steps describe the planning process of the supply chain of polyols. The figure also indicates a responsible person and a responsible department for every phase in the process. Input of the first step is given by the commercial and manufacturing department. The output is an on-spec analyzed product (phase 7) and all indicated parts of the supply chain are dealing with this result. In practice, also the filling and dispatch part of the supply chain is dealing with this final product.

It should be remarked that the process flow scheme is indicated as a linear flow. Paragraph 4.2.2 will go further into detail on this matter. But before the processes are explained in more detail, is this process flow used as handheld during the identification of the different process steps in more detail. The first two phases create forecasts. This forecasting is the main input to create a production planning on a daily base. A crucial step after the production planning processes is monitoring of the availability of raw materials and adjuvant and order when necessary. This is necessary to produce. The exact steps processed during the manufacturing phase are out of scope for this project, because the focus is on the planning process. However the output, input and total production time is really important, because these are vital inputs for the following steps. Phase 6 the analysis, is herein crucial, because the total production time is not always as planned, which has direct consequences...
on the sample analysis and the available sample time. The final indicated phase 7, on-spec analyzed results, is the end result of the process flow and becomes interesting when the result doesn’t meet the specifications and is not called on-spec, but off-spec (off-specifications).

4.2.2 SIPOC overview

The seven phases presented in a linear process flow scheme are a first step during the identification of the processes. However this linear process is of course not a complete representation of the reality and is also not detailed enough to exactly define disruptions and come up with opportunities. The process flow scheme can be used as clear handhelld to define the ‘as is’ planning process of the polyols supply chain in more detail (O’Loughlin 2010).

The process flow of 7 steps, is used during a second phase of the workshop to create a SIPOC (Supplier Input Process Output Customer) scheme. This SIPOC scheme is attached in appendix 4. The SIPOC presents an overview of the main inputs, suppliers of these inputs, processes, outputs and customers of these outputs. The indications of suppliers and customers of the different process steps also give a clear idea of the responsibilities within the organization. It provides a more detailed overview of the inputs and outputs of the process steps and to the persons that are involved per step. The earlier indicated 7 steps formed the basis for the SIPOC, that consists of 10 process steps in total.

The SIPOC represents a consensus based formulation of the ‘as is’ process. And as previously explained, the filling and dispatch processes were out of scope during the creation of the SIPOC scheme. The SIPOC will also be used as basis for the opportunity identification, presented in chapter 5.

Based on this SIPOC scheme (appendix 4), a process flow scheme is used to visualize the process steps, defined in the SIPOC diagram. Information which is not presented in this overview, will be used during more detailed analyses.

The different processes defined during the workshop are presented below in figure 11, including feedback loops and certain decision moments on a high level.
To explain the complete planning process of the supply chain in more detail, all the process steps are explained below. The defined feedback loops and decision moments are further explained and attention is given to the other aspects defined in the SIPOC scheme; the inputs, outputs, customers and suppliers.

The input to describe these steps in more detail is partly gathered during the SIPOC workshop, but also during follow up interviews with the involved stakeholders.

1.1 Demand forecast

The demand forecast is generated by the product managers, based on the seasonality, expected customer demand and expected availability. The expected customer demand is based on the, growth, expectations and strategy formulated by the product managers. The demand forecast in kt/grade is the final output of this first process step. This output is generated for all different units (Flexibles, CASE and Sannest) per year and per month. The customers of this process are the production specialists that are using it to define the capacity forecast.

1.2 Capacity forecast

The capacity forecast is supplied by the production specialists. The output of this process consists of a technical availability of the units translated in kt/day and an output of PO and EO in kt/yr. These figures are based on demand forecast generated in step 1.1, reliability performance in % including turnarounds (maintenance stops) and they also need input from SCE on the availability of PO and EO. The output of this step is finally provided to the supply manager.

2.1 Enterprise optimalisation modeling (GMOS)

The product managers are able to generate production volumes for one of the units, based on the demand and capacity forecast, the inventory and a specific demand planning of a special dedicated customer (Huntsman). With help of an Enterprise optimalisation tool are the production volumes generated. These volumes are input for production specialists, commercial product managers and supply coordinators.

2.2 Hand shake; review with commercial, supply and manufacturing

The production volumes of the Sannest and the flexible unit are generated with help of a handshake process. This handshake process is nothing more than a meeting with key stakeholders involved. Input for this handshake process is inventory, monthly demand update in the Enterprise optimalisation tool, the demand forecast and the capacity forecast. This input is supplied by all parts of the supply chain, but the commercial product managers are leading in this process. The customers of the output; the production volumes of the Sannest and the Flexible units, is input for the production specialists of manufacturing, the commercial product managers and the supply coordinators. This output is again important for the production specialists, commercial product managers and supply coordinators.

3.1 Production planning SCE

The supply coordinators are responsible for the production planning on a daily base. Necessary input is inventory (daily), updated demand forecasts based on hand shakes and daily updated info by email or phone. This production planning includes a planning indicating the batches and number of grades/day. This production planning is used by the logistics coordinator.
3.2 Running planning CVP
The running planning is created by the logistic coordinator. He is located at the control room of the production facilities and uses as input the production planning of step 3.1, the actual performance of the units and the inventory. The actual performance of the units includes stops or delays caused by maintenance etc. Based on these inputs the running planning is created. The running planning consists of an overview which tanks are free for filling and dispatch, a list with samples that should be directed to the laboratory and with a running planning that indicates the number of batches/grade per unit. This output is transferred to the operations of CVP and to the laboratory.

4.1 Order Adjuvant and raw materials
The logistics coordinator uses the running planning, the recipes of the different grades, the inventory of raw materials and the delivery times of raw materials to create an order list of the raw materials. This list is created in excel and input for operations, in this case ‘Shift 6’. ‘Shift 6’ orders and handles the deliveries of raw materials from this point onwards.

5.1 Make products
It is not of the research’s interest how the products are exactly made. But it is very important what the impact is of delayed or cancelled productions. To be able to make products a daily updated running planning provided by the logistics coordinator, a resource planning delivered by the production supervisor and enough raw materials supplied by ‘Shift 6’ are necessary. These inputs are necessary materials for quite complicated chemical processes, which produces a product in tanks ready for analysis. The responsible person of this output is the production supervisor of manufacturing.

6.1 Tank analysis; RLP
When the production is completed, the tanks are circulating for a pre-described time. After this circulation time a sample is taken by operations. This sample gets a priority 1, 2 or 3, on which is decided by the logistics coordinator in cooperation with the supply coordinators. The sample is then ready for analysis. The result of this analysis is ready after a couple of hours, depending on the priority, and visible in LIMS. A software program used by the laboratory. This result is necessary input for the production supervisor.

7.1 Tank available for filling and dispatch (free tanks)
Depending on the result, an on-spec or off-spec result is visible in LIMS or GSAP. GSAP only shows a positive or negative result, LIMS also shows the specification of the result. When the result is positive, the tanks are free for usage and on-spec product is available in the tanks for sale, or to deliver to the customer. In other words, it can be used by the last part of the supply chain, the filling and dispatch part. This result is necessary input for the production supervisor of filling and dispatch.

All key stakeholders were involved during the development of the schemes representing this part of the supply chain. They all agreed on the defined process as presented above and presented in appendix 4. The level of detail of this SIPOC overview, which represents the process ‘as is’, can now be used to define and to identify possible disruptions and opportunities in the process. Possibly it is necessary to define some process steps in more detail for further analysis. But analyzing these processes in more detail is done selective after the identification of disruptions and/or points of
improvements. As a result the SIPOC scheme will in first instance be used to define possible disruptions and/or points of improvements.

### 4.2.3 Value Stream Map

The description of the ‘as is’ process presented above provides the opportunity to define a Value Stream Map. A Value Stream Map is a lean manufacturing technique used to analyze the flow of materials and information currently required to bring a product or service to a consumer (Shell 2010). It can be used in any process that needs an improvement (Rother and Shook; Rother and Shook 2003). Mapping the value stream means that all the flows within the polyols supply chain, (e.g. all the production process activities, both value adding and non-value adding) required to produce polyols, need to be identified and the relationships between the physical and information flows have to be mapped. This tool is made to understand how materials and information flows throughout an organization deliver value to the customer (Serrano, Ochoa et al. 2008).

The Value Stream Map shows the sequence of all necessary production process steps. Before improvements can be made on the supply chain, it is necessary to get an impression of the lead times and buffer sizes within the supply chain. Each step in the supply chain is indicated in a box. The steps are based on the SIPOC, which is used as input for the VSM (Shell 2008). The box contains specifications of the specific process; CT (Cycle Time/process), CO (Change Over time), Uptime and sometimes the dependencies of the speed of the process. The triangles represent the stocks in between. It is very difficult to define the volumes and times for these stocks, but they give an indication of moments where stocks are necessary, which can be defined as non-value added time.

The Values Stream Map shows a minimal production time of 69.5 hours. This is based on the minimum times per process and can be defined as value-added time. The suppliers and customers are represented with a truck. In the upper middle, the production control is indicated, this regulates the whole process.

Based on this Value Stream Map can be concluded that the non-value added time, which is not specified in this diagram, should have a focus during the improvement phase. An improved planning process can reduce the non-value added time, which will improve the total performance of the supply chain. Because this research focus on the planning process and not on improvement e.g. of the production process.

However, figure 12 provides a clear overview of the process and total value-added time. But it was not possible to define the non-value added times. Partly caused by the fact that they are too divergent. The non-value added times are represented by the triangles, representing inventories. Although, the durations of these non-value added steps are not specified, it is possible to draw some conclusions. The first and second triangles represent the inventory of raw materials. A raw material planning tries to optimize this, but it could be a focus point to optimize this duration.

The third moment of inventory is defined as product in tanks, waiting for availability of pumps. A pump is necessary to circulate a tank. Pumps are also necessary to deliver products. In the majority of the tanks, the pump is the bottleneck in this process. For this reason, tanks are often circulated during the night, when deliveries are not planned. This creates an unnecessary delay when the planning is changed, based on this bottleneck.

The fourth moment of inventory is defined as product in tanks. This is the case after circulation, when the product is waiting for the tank analysis. The tank analysis is executed by the laboratory as
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explained in the previous chapter. Also this non value-adding moment could be a focus point during the rest of this research.

The final moment of inventory is defined as the moment when the product is ready to deliver to the customer. This is depending on the demand of the customer, the expected available time, the planning made by SCE with customers and the coordination and communication between these parties. This moment could also be a focus point during the rest of the research.

The VSM provides clear insights in the value-added and non-value added activities. Although the durations of the non-value added activities are not specified, it still provides input for potential focus points during the rest of this research or as input during interviews.

Figure 12: Value stream map of the polyol supply chain

### 4.3 Conclusions

As a result of the analyses executed in this chapter it is possible to provide a clear overview of a major part of the ‘as is’ processes of the supply chain of polyols. This chapter focused on defining the processes of the supply chain without the filling and dispatch processes. During an interactive SIPOC workshop with all key stakeholders involved, consensus was created on the process steps and the inputs, outputs, customers and suppliers of the supply chain. Initially seven process ‘phases’ were identified, which formed the base for a more detailed process map of 10 steps. The final overview of the processes presented in a SIPOC overview will be used to define and identify the most relevant disruptions in the polyols supply chain.

Finally a Value Stream Map was designed, which provides clear insights in the relationships between the physical and information flows. This analysis made clear that there are, during the production process, several moments of inventory which are unnecessary and could possibly be diminished.
4.4 Evaluation - Part II Analyses

After finalizing the conclusions of chapter 4, it is now possible to evaluate part II of this research; Analyses. The next chapter starts with part III – DMAIC and uses the information of this part to define and process opportunities.

Chapter three introduced several theories to perform a network analysis. The framework provided by Graaf and Hoppe (1989) provided useful input to offer clarity about potential categorization of problems. The rest of chapter three focused on defining relations and positions of stakeholders, which created necessary insights, useful during the rest of the project. Mapping the dependencies between stakeholders (Hermans and Thissen 2008) and defining an actor field (Hermans 2004) provided critical information for the rest of the project. It provides insights in the stakeholder that should be invited to join the next phase of this research and it makes it possible to put extra effort in specific stakeholders during the next phase. Stakeholder management is a crucial element during this research to make sure the research leads to performance improvements.

Chapter four focused on the exploration of the processes within the supply chain. A Lean Six Sigma tool, called SIPOC, was applied to gather these insights. This tool made it possible to identify and visualize the processes. SIPOC was interactively applied during a workshop, a method which was similar described by O’Loughlin (2010). Several steps were added to the normal SIPOC method, to converge the information provided by the stakeholders and to limit the amount of information generated by the stakeholders (Kessler 2004). The additional steps were essential to make the stakeholder participation successful. The analyses steps, executed as preparation, made sure that the workshop leader had enough insights to lead the workshop strictly, which avoided information overloads.

By changing the suggested approach and start to define a main process flow before the detailed process was defined in more detail, the goal of the workshop became more clear for the attendances of the workshop and improved the final results. Also the decision to start defining the last process and go backward, during the identification of the process flow, created more guidance and clarity during the workshop. This created a clear endpoint which saved a lot of valuable time.

Verifying and validating these results using POCIS instead of SIPOC, (which means starting with the processes) made sure that the input of stakeholders was structured. The defined processes were used as guideline and again converge the output delivered by the stakeholders.

The insights in the processes and the clear overview of the processes, provide a very good platform to define opportunities for improvement on, which will be done in the next chapter.

The Value Steam Map was a useful tool to present the sequence of the processes and the total time. It provided useful insights to communicate and present information to involved stakeholders. If more specific information would have been available on non-value added time, the tool could have been more useful, because optimal situation could have been calculated in a more quantitative way.
Part III - DMAIC
5. DMAIC preparation - Mapping the most relevant opportunities

5.1 Introduction

It is now possible to identify the most relevant disruptions. Chapter 2, methodology, already explained how the most relevant disruptions can be defined and identified. Chapter 1, introduction, defined four categories of opportunities or disruptions. These categories were based on information gathered during interviews with stakeholders on management level of the four different departments acting within the supply chain. These four categories can still be used to categorize the opportunities that will be identified in this chapter. These categories are shortly repeated below.

1. Changes in production plan → caused by decisions taken by SCE Commercial or necessary reasons.
2. (Non-) availability of raw materials → planning or delivery problems
3. Production problems → quantity or quality related problems
4. Delivery to customer → problems with schedules and planning from customer and producer sides

It is not possible to explore all disruptions and define all opportunities within the planning process of the supply chain of polyols due to the limited timeframe of this research. As stated in the research question, the most relevant disruptions will be indicated and analyzed. Different types of disruptions and points of improvements can be considered.

This chapter will do the necessary preparations, before the DMAIC project can be started. The choices made to select certain points of improvement, which will be analyzed, are explained. Paragraph 5.2 will explain the considered types of opportunities and points of improvement. The third paragraph defines the opportunities in more detail. Paragraph 5.4 ranks and prioritizes the opportunities, followed by conclusions in paragraph 5.5.

5.2 Listing the opportunities

Based on the results of chapter four it is now possible to define opportunities to improve the complete process. Problems are the main input to define opportunities. Before the opportunities can be defined and explained in more detail, it is necessary to explain the process steps and decisions made, which finally lead to a complete list with opportunities. The previous chapters resulted in an analysis which finally lead to a consensus based overview of the complete planning process of the supply chain. This overview is used to define the opportunities on.

Previous chapters already explained a wide supported feeling to improve certain process steps related to the planning process. Based on the network analysis presented in chapter 3, all stakeholder related to one of the process steps, were involved during the SIPOC workshop. This directly provides the best possible argument to use the SIPOC workshop also to define the opportunities.

The consensus based overview of the process steps provides a useful starting point to start a discussion with the involved stakeholders. By starting to evaluate the process at the last process step and going backwards (O’Loughlin 2010), this proves vagueness when previous steps are not clear or simple don’t fit. This a structured and easy method indicates the most important problems. The involvement of all stakeholders make it possible to directly create consensus on the defined
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problems. This interactive method was used during this research. During the research five problems were identified. These problems were not explained in detail, but the involved stakeholders agreed on the problems mentioned. The problems differed in size, complexity, etc., but they also had different stakeholders. Which were defined during the workshop. Based on the results of the workshop, it was possible to gain more detailed background on the problems by performing interviews with the (key) stakeholders. A combination of the gathered input made it possible to define opportunities. Five opportunities were defined during the workshop, on which all stakeholders agreed. For this reason they are all included in the overview presented in the next paragraph. Including these opportunities in the rest of the research also creates follow up actions, and creates a feeling with the stakeholders that their input given during the workshop is taken seriously.

However, the list of five opportunities created during the SIPOC workshop didn’t represent a complete overview of all possible opportunities. Interviews with management and stakeholders on an operational level indicated insights on potential problems and/or points of improvement. These indications were used during follow up interviews and based on these interviews more problems were defined. Many problems were indicated which were not related to the planning process and the process steps presented in the previous chapter. These problems were not taken into account. The problems related to the planning process were taken into account and indications provided by the management were valued as more important than indications made by operational employees. Finally, this evolved in a list of five widely supported opportunities, supported by several employees on a management level and also by employees on a operational level. These five opportunities were the only ones mentioned by at least two managers and also mentioned by employees on a operational level. It was not necessary to make a selection, because only these five opportunities were mentioned and fitted this requirement. The Lean Six Sigma theory describe as first step in the define phase of DMAIC that the opportunities should be validated before they are further processed. The purpose of this validation phase is to create a definition of a valid and important business task for the project that the future project team and key stakeholders can agree on. This can be done by describing the opportunities in more detail and finally produce a project description (Shell 2002-2008).

The overview of opportunities presented in the next paragraph still doesn’t provide a complete list of opportunities of the planning process. This was given the limited time of the research not possible and also not the goal. However, the process explained above, provide arguments to assume these ten opportunities as the ten most relevant ones.

5.3 Defining the opportunities

Chapter 2 Methodology, already explained how the opportunities should be identified and defined. Chapter 4 presented and explained the results gathered during a interactive SIPOC workshop. The results presented the ‘as is’ processes of the planning process of the polyols’ supply chain. All stakeholders agreed with the results, in other words, the results are validated by the involved stakeholders.

During the workshop initially five opportunities were defined. Some involved stakeholders used follow up meetings to initialize other issues. These issues were explained to all involved stakeholders during a presentation to the management. Other key stakeholders were personally informed during follow up meetings. Figure 13, presented below, shows the ten formulated opportunities. The five opportunities presented on the left (dark grey) evolved directly out of the workshop, the other five
have different origins as explained in the previous paragraph. Appendix 5; presents an overview of these opportunities where the input, key stakeholders, focus (technical, organizational and/or communicational) and an initial priority (low, medium, high) is given.

Evolved directly out of workshop
- Optimal balance between inventory and flexibility
  - 1 day slack
  - Optimal stock level
- Feedback delivery raw materials
- Responsibility and monitoring of stock of ‘in house’ produced raw materials
  (ppg315, md30-08, g800, as2000)
- Product quality related issues
  → Off-spec production; Waivers
  → Ownership: Erik K.
- Reporting Time vs. Tonnage

Evolved indirectly out of workshop
- Insights in tasks logistics coordinator
  - Possible improvements
- Content and goals of monthly Hand Shake process
- Temporarily process of Acidifying of polyols
- External demand of samples
- Laboratory analyses delays
  (Actual times vs. Target times)

Figure 13: Overview of opportunities

Figure 14 presents an indication of the location of the opportunities in the supply chain. The overview is based on figure 11 and the numbers are corresponding with the numbers given to the opportunities in the explanation below.
Evolved directly out of the SIPOC workshop

1. Optimal balance between inventory and flexibility
   This opportunity can be divided into two parts.
   a. Create extra slack
      This part of the opportunity is to perform research on the possibilities to create one extra day of slack between production and delivery of the products, in order to decrease the effects of delays in production, sample analysis, etc. on the supply chain. Key stakeholders are the supply coordinators, customer relation center and logistics coordinator. Other important stakeholders are also the production and filling and dispatch supervisor and the product manager.
   b. Find optimal balance between inventory and flexibility of the supply chain
      This is the most complex opportunity defined in the list. At the moment the supply chain is very sensitive to all kind of disruptions. Finding an optimal balance between inventory and flexibility of the supply chain could identify the need for more flexibility. At the moment this is not clear. Almost all stakeholders are involved with this project. This could be a long term project during this research, possible a project that is handed over after performing the first steps.

2. Feedback delivery of raw materials
   This opportunity can be defined as a opportunity that could be implemented on the short term. Intern communication should be improved and is the most important aspect of this opportunity. Beside a solving solution, should also attention paid to a problem preventing solution, by performing research on incentives to avoid delays in deliveries.
   Key stakeholders are the operators of Shift 6, the supplier of raw materials, production supervisor and the logistics coordinator.

3. Responsibility and monitoring stock levels ‘in house’ produced raw materials
   This opportunity can also be defined as a quick win. Some ‘raw materials’ necessary for production of certain grades are produced at the units. Monitoring of the stock levels is necessary to avoid too low stock levels, which causes production problems. At the moment this monitoring and on time producing process of new products is executed on an optimal level and should be improved. Ownership and tasks related to this problem are not clear defined and this could be a major part of the solution. Key stakeholders are supply coordinators and logistics coordinator.

4. Quality related issues
   The quality related issues can also be divided into two opportunities. But for both opportunities are already project team in place to solve these issues. So further explanation is not necessary.
   a. Off-spec production (Waiver procedure)
   b. Ownership

5. Reporting, time vs. tonnage
   This opportunity is created during a discussion between the supply, commercial and production departments. Reporting in tonnage is essential for the supply and commercial departments, because they are selling and transporting tonnages. However the manufacturing department actually demands availability of their units in production time and not tonnage, because this is not always the same. So to evaluate the targets etc. in a
more optimal way, both could be necessary. On the other hand, only when this will not cost too much effort. Key players are Production specialist, production manager and the supply manager.

Evolved indirectly out of the SIPOC workshop

6. Insights in tasks logistics coordinator
This opportunity was the initial trigger to start this project. The logistics coordinator has a lot of tacit knowledge and is crucial for the complete planning process of the supply chain. But insights in his tasks are not available. His tacit knowledge is especially focused on the existing constraints, necessary during the creation of the planning process. By providing the insights in the tasks of the logistics coordinator, it also becomes possible to make improvements. Two possible improvements are already identified; integrate raw material planning into the production planning and integrate four different documents into one clear sheet.
Key players are the production supervisor, logistics coordinator of course and the supply coordinators.

7. Content and goals of monthly Hand Shake process
The Hand Shake process defines during telecom sessions an initial monthly production forecast. Commercial, Supply and the Manufacturing departments are involved in this process, which is only started a couple of months ago. All stakeholders involved defined possible improvements to optimize this process. The main question during this project is, is extra analysis necessary to improve the process? Or will the process on the short term automatically improve without the input of this project?
Key players are management of commercial, supply and manufacturing.

8. Temporarily process of Acidifying of polyols
Currently they are building a new unit at CVP, to produce acidified polyols, called the staircase project. Commercial already sells acidified polyols, which creates demand for a temporarily process of blending normal polyols into acidified polyols. This is not operating on an optimal level at the moment. Focus points of this opportunity could be quality and process related improvements or communicational improvements. Only the last category could be interesting for this project. On the other hand, high interesting is a temporarily process?
Key players are the manufacturing operators, production specialist of manufacturing and the logistics coordinator.

9. External demand of samples
Samples have to be tapped by the operators of manufacturing. Sometimes ‘external parties’, like the research centre in Amsterdam, demand high amounts of samples. This causes extra work and is often unplanned. This problem could be solved by implementing some barriers or by planning properly. This opportunity could also be defined as a quick win.
Key stakeholders are laboratory, external parties, operators of manufacturing and logistics coordinator.

10. Delays of laboratory analyses
The samples that are analyzed can be presented with three different priorities, 1,2 or 3. Depending on the priority the laboratory set target times. Sometimes the samples are delayed and not delivered on the promised target time. This creates discussion between using target times or using actual or real times.
Because the laboratory is an external party and not included in the supply chain, this problem is on the edge of the scope of this project. On the other hand it is sometimes a crucial delay.
Key stakeholders are the laboratory, logistics coordinator and filling and dispatch.

5.4 Ranking and prioritizing the most relevant opportunities
It is now possible to rank the opportunities. Ranking and prioritizing the opportunities is necessary to execute the rest of the project. Because the limited timeframe of this project, it is not possible to process all the identified opportunities in order to come up with improvements and/or solutions. During the rest of the project, the opportunities will all be defined as small single projects, which can help to improve the robustness of the supply chain and to reach the goals set in the earliest stage of this research. By ranking the opportunities, it becomes possible to start processing with the projects with the highest priority and possibly leave other opportunities out of scope.

The list of opportunities are defined during the first phase of this research. But they cannot easily be compared to each other, because they all have different characteristics. For this reason, key stakeholders were asked to define the impact and ease of implementation of the opportunities. By defining the impact and ease of implementation it becomes possible to categorize the different opportunities in four different categories. These four different categories are presented in the figure below: Do now, do later, plan to do later an don’t do. The category do now, means that the opportunities are easy to implement and have a relatively high impact. The category with a high impact, but more difficult to implement is defined as plan to do later. Because of the limited time frame of this project, it is possible that this group will be directly planned and also processed during this research. The other categories can be defined as opportunities that can be processed in the future. However, by naming and presenting them in this report, they are not forgotten and will be processed in the future.

![Figure 15: Ranking the opportunities by using four categories](image)

This method creates a clear handheld to rank and prioritize the opportunities. However it is still difficult to define the impact and ease of implementation of the opportunities. Appendix 6 provides background information on the positions of the different opportunities in the different boxes. It is important to mention that this method is mainly about defining the opportunities in four different categories or boxes. The exact position in the box is less important and more a subjective process. Because this detailed position is too arbitrary to define, based on the criteria’s, so this more detailed position is based on input gathered during interviews with the key stakeholders involved.
The limited time frame this research is dealing with makes it impossible to process all opportunities. For this reason a selection of the opportunities is made, based on a combination of the ranking of the opportunities in the four boxes presented above, and a subjective selection of the opportunities. Only the opportunities ranked in the boxes with the highest impact; box ‘plan to do later’ and box ‘do now’ are candidates to process in more detail.

Other subjective arguments which are taken into account are a balanced mix between quick opportunities and more complicated opportunities, and a subjective preference for some opportunities, sometimes based on opinions of key stakeholders. The arguments for the subjective preferences are provided in the chapter 7 till 10, which are also explaining the opportunities in more detail.

Based on these arguments the opportunities 1: Optimal balance between inventory and flexibility, Opportunity 2: Feedback delivery of raw materials, Opportunity 6: Insights in tasks logistics coordinator and Opportunity 10: Delays of laboratory analyses are selected and will be analyzed in more detail.

5.5 Conclusions
This chapter mapped the most relevant opportunities. Paragraph 5.2 explained how the opportunities were listed. These opportunities were defined in paragraph 5.3. Five opportunities evolved directly out of the workshop and the other five evolved indirectly out of the workshop. An indication of the location of these opportunities was provided in a schematic overview. Paragraph 5.5 ranked and prioritized the most relevant opportunities.
Figure 18: ranking of the opportunities, presented the ten different opportunities categorized into four different boxes. Interviews with stakeholders and extra analyses formed the main input to be able to create this diagram. Based on this figure 18, which is supported by the analyzes presented in appendix 6, it is possible to prioritize the opportunities. The ranking is used in order to start improvement projects, all separately organized and focused on one of the opportunities.

Four opportunities were selected and form the basis for the following chapters. The opportunities are: Opportunity 1: Optimal balance between inventory and flexibility, Opportunity 2: Feedback delivery of raw materials, Opportunity 6: Insights in tasks logistics coordinator and Opportunity 10: Delays of laboratory analyses are selected and will be analyzed in more detail.
6. DMAIC Methodology - set up four individual projects

6.1 Introduction

The previous chapter selected four opportunities. These opportunities are used to set up four individual projects. Individual projects are set up to be able to successfully improve the current performance of the supply chain. This chapter goes further into detail on the methodologies and frameworks used to make sure these four projects are executed properly and affect the current performance of the supply chain positively.

The structure of the following eight chapters is based on these four projects using the DMAIC methodology. This chapter explains the theory behind the five development phases and provides helpful information which should be used to set up the projects successfully. Based on the DMAIC methodology presented in this chapter, it is possible to set up four projects. The project development phases of these four ‘DMAIC’ projects are described in the chapters 7 till 10. These projects and results are evaluated in chapter 11. Chapter 12 describes how the gathered knowledge during the projects could be transferred to the organization. Finally it is possible to reflect and evaluate the DMAIC methodology in the overarching chapter 13.

Before the projects are executed, this chapter provides background on the DMAIC methodology and useful theory to set up projects. Paragraph 6.2 defines the DMAIC phases in more detail, followed by paragraph 6.3; start projects. This paragraph first describe several steps to turn an initiative into a successful change, secondly it talks about early stakeholder involvement and finally the four core elements of process design are discussed.
6.2 DMAIC - Development phases of a project

From this point onwards the DMAIC (Define, Measure, Analyse, Improve and Control) method, already mentioned and introduced in paragraph 2.3, is applied to process the opportunities. This method is used to eliminate weaknesses or improve existing processes (Wiesenfelder and McDonough 2010). DMAIC is a typical Lean Six Sigma approach and perfectly fits into the Shell environment (Shell 2002-2008).

DMAIC could be compared to a typical traditional approach of an engineering project, which has five phases. These traditional development phases are presented below in figure 18 (PMI 2010). However, the content and steps of the DMAIC method, see figure 19, fit better to this research and the research environment.

![Figure 18: Development phases of a project (PMI 2010)](image)

DMAIC methodology offers several benefits; its structured in such a way that it methodically analyses a process before attempting any improvements. It avoids jumping to conclusions and helps ensure an adequate search for alternative solutions to a problem (James 2004). This is an important step, because one of the most important reasons of performance improvement failure is a lack of analyses that is done prior to implementing improvements (Schroeder, Linderman et al. 2008).

A second benefit is that the method is widely used. As previously explained are the majority of people well known with the DMAIC steps in the Shell organization (Shell 2010). It is not only a problem solving method, but is common methodology, raising the performance of a great number of individuals. It has the benefit that the method could be used throughout the organization. DMAIC is not only focused on one specific part of a supply chain, but it has the ability to analyze and solve problem anywhere in the organization, not just the manufacturing department (Schroeder, Linderman et al. 2008).

Thirdly provides the DMAIC method several useful tools, which can be applied during the five development phases of a project (Harry 1994). The next subparagraphs explain the different DMAIC steps in more detail.
6.2.1 Define - Explaining the most relevant opportunities in more detail

This paragraph describes the define phase in more detail. The project leaders are responsible for clarifying the purpose and scope of the project, for getting a basic understanding of the process to be improved and for determining the expectations. These information actually confirms that a DMAIC project is appropriate. A key tool for this phase is the project charter. The project leader coordinates with team members and other stakeholders to compile the charter document. Project charters are commonly used at Shell and spells out the business case, scope, project schedule, project problem, goal, project team and expected benefits.

The roles and resources also need to be clarified up front to avoid misunderstanding. This research defines the project team and initially describe the project environment. The next phase is used to define the actor perspectives in more detail. A realistic time estimate of how long their participation will be needed is also provided.

This phase creates more insights in the process. Once the process is known and understood, it makes it possible to diminish the causes of inefficiency and frustrations.

The define phase explains the opportunities in more detail, defines the project teams and project goals (Wiesenfelder and McDonough 2010).

6.2.2 Measure – Gathering insights

The measure phase focuses on gathering insights or data, to describe the current situation. These insights help to identify the effects and verify the improvement made during the fourth phase. A normal approach is to create a process map, gathering data and summarizing the data. The process map is not created for all four projects, because this is not always useful. The data gathered is summarized and directly used as input in the analyze phase.

The measure phase defines the actor perspectives and the constraints.

6.2.3 Analyze – Identify the root causes

The goal of the analyze phase is to identify the potential root causes for the process problem being addressed. Where possible the root causes are confirmed with data. It is not possible to make improvements to the process until the most important causal factors are identified. Where possible, suspicions and hypotheses must be confirmed with data. Otherwise the project team must confirm
that these factors are present and that changes in these factors substantially impact the outcome. Where necessary the root causes and their effects are presented in (effect) diagrams or graphs.

The analyze phase defines the causes (problem situation) in more detail.

### 6.2.4 Improve – Create solutions

The goal of the improve phase is to identify a solution to the problem that realizes the project goal. Brainstorming is a useful tool to come up with solutions, finally a most promising solution is described. The project team members are involved in this decision process. Their input and support regarding potential improvements is critical. Several tools can be used to select one of the solutions. The next chapters describe the solutions for the four projects. These solutions were selected and/or created in cooperation with the stakeholders.

When one solution is selected or finalized, it is important that the solution is implemented to realize the improvements. This implementation is a matter of basic project management (Wiesenfelder and McDonough 2010). These steps are explained below in more detail.

**Execute and implement**

The different steps of the DMAIC method are explained in more detail. Before the improve phase can be finalized, the suggested solution should be implemented and controlled. The DMAIC phases are added with several implementation steps, which are necessary to fulfill the improve phase successfully. To ensure a successful implementation of the solutions and, the commitment of the members of the project team should be contained. Paragraph 6.3 goes further into detail on early stakeholder involvement, process design and early steps to make sure the opportunities become successful changes.

The DMAIC method structures the process and provides useful tools to execute the project, but does not focus on more practical details. These details are necessary to provide clarity to the project team and to make sure essential information is provided in order to create a successful improve phase. Which has the end goal to create useful results and improvements.

In general there are some important aspects that should be considered before the control phase can start. The aspects are explained in a way that it becomes clear how the improve phase is processed (Kerzner 200). These aspects are also taken into account during the planning and design phase, but now this chapter will describes the following aspects in more detail:

- Roles and responsibilities
- Deliverables
- Quality
- Activities needed to complete those deliverables
- Resource requirements
- Time path - planning
- Budget
- Risk planning
- Gaining formal approval to begin work

The improve phase also consists of the processes used to complete the work defined in the previous paragraph, to reach the final project goal. The improve phase involves coordinating people and resources, as well as integrating and performing the activities of the project in accordance with the project goal.
Because the projects can be approached as very small projects, it is not necessary to perform all steps that are traditionally included in a similar project phase. An example is procurement, which is not relevant for these projects. It is more important that the aspects mentioned above are executed as expected and where necessary lead in the right direction to make sure the project goal is realized.

Projects have to, like any human undertaking, create improvements and results. These results need to be performed under certain constraints. Project management theories traditionally describes these constraints with the project management triangle, where each side represent a constraint. The triangle includes scope, time and costs. One side of the triangle cannot be changed without affecting the others, which directly effects the quality or performance of the total project. It is necessary to keep this triangle in mind, because during this research the time is limited and cannot be increased. When for example the scope of a project is not well enough secured and increases, this will most likely affect the other two variables negatively. So during the executing phase it is important to control the time, scope and cost in order to avoid unexpected problems.

At the moment only the project ‘feedback when raw materials are delivered’ is in the improve and control phase. The results of the implemented solutions are monitored and controlled. The DMAIC visualization is presented in a loop. This method enables it to perform the phases iteratively. In other words, it is possible to evaluate the results and at the same time use these results to e.g. analyse and improve the presented solutions.

The improve phase defines the solution, including the disadvantages and advantages of the solution, process design and the stakeholder involvement. For one project, delivery feedback of raw materials, the execute and implement phases are also explained. These phases are described by using the elements mentioned by Kerzner (2008).

The improve phase presents the solution for improvement

6.2.5 Control – Test and make the solution robust

The control phase is the last phase of DMAIC method. The control phase tests and makes the solution robust, in order to ensure that improvements are fully embedded in the normal operation and expected benefits are delivered (Kwak and Anbari 2006). Attention is given to verification of the
solution. The solution should be mistake proof. The control phase helps to realize this (Pirasteh and Horn 2010). A pilot project is an important element in the control phase, the monitored data enables verification of the improvement project.

It is possible to add two extra steps or phases to the control phase of the DMAIC, namely standardize and integrate (James 2004). These two phases make it easier to transfer the knowledge to the organization in the future.

These steps are included in this control step. The standardize phase and integrate phase are described hereunder, but first the control steps are described for the project. When these steps are properly executed, more generic knowledge can be transferred to the organization.

The five most important goals of the control phase are to implement improvements on a pilot basis, confirm that the change is an improvement, set up process management system, manage change in workplace, prepare for withdrawal and transfer learning to wider organization.

Nine steps are defined to make sure the five goals of the control phase are realized and the standardize and integrate steps are also included. These nine steps are:

- Pilot project
- Monitoring the pilot project
- Verify improvement
- Establish process monitoring
- Hand over process management
- Implement new process
- Identify opportunities for standardization, integration and replication
- Confirm benefits
- Close project and recognize team

These aspects are the key purpose of control. When these so called countermeasures are properly executed, they avoid failures of the project (Shell 2002-2008). All nine countermeasure is explained in more detail below:

**Pilot project**

Pilot projects are used as a risk-reduction action. Pilot projects try things out on a small scale wherever possible. For a specified temporarily period the new process will be watched very closely for signs of troubles and for opportunities to refine the details of the solution. This process is called monitoring and is executed after a certain predefined pilot period.

It is important that the involved stakeholders are engaged and that the pilot activities are carefully planned. The stakeholders should be briefed and trained where necessary, because they should be able to set up a data collection plan.

**Monitoring the pilot project**

Monitoring encompasses the tracking of processes, so that information on their state can be easily seen, and insights on the performance of one or more processes can be provided (DeCarlo 2009). The degree of monitoring depends on what information the business wants to evaluate and how business wants it to be monitored (Kohlbacher 2009). By monitoring this specific project, the goal is to optimize the current process performance and where needed applying enhancements in the design of the process. Because this finally lead to overall greater business value (Liegener 2010)
The results are gathered and presented in Appendix 11. Based on these monitored results and interviews with the key stakeholders, it is possible to evaluate the effectiveness of the project and to come up with possible improvements of the current process.

Verify improvement
The purpose of this step is to provide evidence that the new process is an improvement over the old. It is possible to draw conclusions, based on the so called control data gathered before and during the pilot project. Based on this control data the status of the improvement can be verified.

Establish process monitoring
To ensure that stability is maintained and to provide a basis for continual improvement, it is necessary that the process is monitored, also after transferring the project to the organization. To make sure this monitoring is done properly, one of the involved project members should be made responsible for this monitoring process. The project members are well enough committed to the project that they also have self interests in performing this task.

Hand over process management
The purpose of this stage is to complete the hand-over of a successful improvement, so that it is sustained and improved further by the involved stakeholders. Process documentation defines in appropriate detail how the selected solution in the process should be used. The definition of the process owners and process workers and their roles and responsibilities during the process are important aspect of this process documentation.

Implement new process
The purpose of this step is to get the improved process up and running in the routine operation. The previous steps are necessary before the process can be implemented. The result of these steps is a tested and formalized new process. After successfully executing these steps, the new process can be implemented in the organization, but not before all stakeholders involved are updated by the changes. After implementing the new process, it is important to build in a control step, to make sure that the new processes changes are executed.

Identify opportunities for standardization, integration and replication
To create maximum output of this project, it is important to suggest other application areas of this project. Keywords in this process are standardize and integrate. With standardize is meant; spread the gains and integration means; spread the thinking. Spreading the gains as well as spreading the thinking makes it easier to replicate the processes. Spreading the gains create support to replicate the projects, while spreading of the thinking increases acceptance and understanding of the process steps. Replication is focused on the expansion of a successful solution across a greater number of branches with identical or very similar processes (Shell 2002-2008).

Confirm benefits
The goal of this step is to confirm the benefits realized by the project. It is necessary to present and share the results of an executed project. This makes sure that the effort put in the project is appreciated and valued, which enables future possibilities to replicate or execute new projects.
Close project and recognize team
The goal of this step is to withdraw from the project as team lead, but not before a review of team’s own learning is done and transferred to the wider organization. The main focus is on the performance and learning points of the team lead, but this is presented more elaborated in the reflection of the complete research. Finally it is important to recognize the team for the improvements realized. Recognition motivates the involved persons to start a new project.

The control phase describes the nine steps taken to successfully realize performance improvements.

6.3 Start projects
The five DMAIC steps, which help to make improvements to an existing process are described and explained in more detail. The introduction of this chapter already introduced the individual projects which will be set up to process the opportunities and realize changes. Paragraph 6.2.1 presents seven steps to successfully realize performance improvement and paragraph 6.2.2 focuses on early stakeholder involvement. The final paragraph introduces the four core elements of a process design. Processes will be designed and managed during all four projects, to maximize the potential benefits of the projects.

6.3.1 Make the performance improvement initiatives successful
To make sure that the four selected opportunities become successful initiatives, which realize improvements of the performance of the supply chain, seven steps defined by (McIntyre 2010), which are already introduced in Chapter 2; methodology, are used.

The selected opportunities are used to improve the current planning process of the supply chain of polyols, as defined in chapters 1 and 2 of this thesis. In paragraph 2.4; literature reviews, McIntyre (2010) already defined a methodology to successfully create performance improvement initiatives. According to him, a necessary execution because most initiatives start to fail because they fail to start! He defines setting up a successful change initiative, as one of the hardest things to do in organizations. Mainly because creating change is not seen as integral to the future success of the organization, but also because people often don’t know how to do it. Although at least some of the opportunities seem easy to implement, change is necessary to realize improvements. McIntyre (2010), defines seven steps to set up a successful initiative.

1. Assign an accountable Sponsor
2. Identify a suitable Project Manager
3. Clearly articulate objectives and how they will be achieved
4. Get the buy in of the key stakeholders
5. Build a strong core team
6. Develop a realistic plan
7. Communicate the plan

These seven steps are used in this research to successfully create improvements. However, step 1 is not applicable during this research. Step 2 is defined in chapter 7. The objectives of the four opportunities are presented in the next paragraph, how they will be achieved is further explained in the next chapter. The buy in of stakeholders was done during the SIPOC workshop. By creating the opportunities together, a consensus based results directly created support of the key stakeholders to be involved during the improvement phases. The core team, which are called project teams, and a realistic plan to successfully realize improvements, are also defined in chapter 7.
McIntyre (2010) defines these seven steps which should be executed to successfully set up initiatives. However, the initiatives, which in this research are the opportunities, still should be processed, based on a realistic plan. By setting up project teams, key stakeholders can be involved in the different individual projects, to maximize the total performance improvement of planning process of the supply chain.

### 6.3.2 Project teams – Early stakeholder involvement

Approaching these opportunities as small projects, increases the chance to successfully improve the performances. Projects need involvement of stakeholders and indirectly create commitment and support for the project by the stakeholders. Besides these advantages, project teams also unite the knowledge and ideas for improvement, which is normally divided over the different stakeholders. However the stakeholders are the key element to make a project successful. Projects are not only defined anymore by the technical success, and the constraints of time, budget and quality. Also organizational and cultural impact of projects are important (Tammer 2009). Chapter 3; network analyses, provided insights in the multi-actor environment involved in this research. The fourth and fifth step presented in the previous paragraph are related to get the involvement of the key stakeholders and build a project team. The SIPOC workshop and the involvement and input delivered by the stakeholders during the identification of the opportunities created a solid base to get the buy in of the stakeholders for the individual projects. However, it is necessary to keep these stakeholders committed to the project and to define which stakeholders should be involved into the projects. Buhrmann (unknown), defines a six steps method for stakeholder involvement.

![Figure 24: Guidance for stakeholder involvement (Adapted from: Buhrmann, unknown)](image)

Step 1, 2 and 3 are already processed in chapter three and in the previous chapter. The four opportunities define the issues addressed. Based on the network analysis the involved stakeholders are identified per project, and their constellations (interests, power, influence, etc.) are described in this chapter. Step 4 and 5 are slightly more complicated, but different steps are already taken to complete step 4; SIPOC workshop, opportunities defining with involved stakeholders and start projects with project teams. However, detailed involvement steps during the process are not yet presented. This will be done in paragraph 7.3 per project. Step 5 is also defined in the same part at paragraph 7.3 and is more focused on how the activities that should be organized to successfully execute the strategy. Step 6 aims on informing the involved stakeholders, to show how their input is carried forward, which is also explained in paragraph 7.3. This step also spends attention on the possibility to hand over the lead of the project. The Project manager knows in first instance how to
execute the projects, but the project team offers the possibility to transfer the lead when time constraints demand this. Finally this complete involvement strategy of stakeholders is evaluated in chapter 9.

### 6.3.3 Process design

The reasons to set up project teams and the benefits of working with project teams are now clear, but it is also important to define how these projects should be organized. To create successful projects a process management approach is necessary. This process management approach addresses the requirements of a good process by explaining the four core elements of a process design. These elements are taken into account during the set-up and execution phases of the projects (Bruijn, Heuvelhof et al. 2003).

![Four core elements of a process design](image)

Figure 25: Four core elements of a process design (Adapted from: Bruijn, Heuvelhof et al. 2003)

1. **Openness** – open attitude of the initiator is necessary. Other parties are offered an opportunity to take part in shaping the agenda and the decision making.
2. **Protection of core values** – Participants need to perceive a safe environment. This is only possible when the core values of the participants are protected.
3. **Progress** – Openness and protection of the core values may stall the process. Therefore incentives for progress and momentum should be build in.
4. **Substance** – To avoid too much focus on keeping the process going, a need for arrangements that lead to sufficient substantive input into the process is necessary.

The process designs of the different projects all need to include these four core elements. However, every project is different and for this reason a trade-off between the core values is necessary. Per project the process will be designed and explained, based on these four core elements.

### 6.4 Conclusions

This chapter described the methodology used to successfully set up four projects. The five development phases of the DMAIC methodology, which helps to make improvements to the current supply chain, were explained in paragraph 6.2. Paragraph 6.3 introduced three methodologies, which are added/ included to the DMAIC steps. These methodologies make sure the performance improvement initiative becomes successful. They describe the advantages of early stakeholder involvement and introduce the four core elements of a process design. The next four chapters describe the four individual project. DMAIC and the other three theories will be applied on the four projects, in order to realize improvements.
7. Project 1: Feedback delivery of raw materials

7.1 Introduction
Chapter 5 defined and ranked ten opportunities. Based on this ranking four opportunities were selected, which will be processed in the following chapters as four individual projects. The previous chapter provided background information on theories and methodologies to be able to successfully set up and process these projects in order to improve the current performance of the supply chain. This chapter will come up with solutions and recommendations to solve or minimize the problems related to project 1: feedback delivery of raw materials. Employees are involved in the projects as project team members, to make sure that follow up actions are taken and the project is finished. This project is focused on the feedback delivery of raw materials. Paragraph 7.2 describes the define phase, paragraph 7.3 goes further into detail on the measure phase, 7.4 describes the analyze phase and 7.5 the improve phases. Paragraph 7.6 describes the last phase; the control phase. The control phase is executed for this research. A pilot project is executed and the monitored results are included in the control phase. The final paragraph 7.7 presents conclusions.

7.2 Define
Paragraph 5.2 already provided some background information on this opportunity. This paragraph already explained that this opportunity is related to communicational problems. Process flow schemes are useful to explain this opportunity in more detail.

The block on the top right in figure 26, presents the location in the supply chain of this zoomed overview. This is a small part of figure 11, process 4.1. The rest of the figure, defines these steps between 3.2 and 4.1 more detailed. The figure defines the process steps executed to make products based on the demand orders at SCE and all main steps in between.

Figure 26: Overview of steps opportunity 6; feedback delivery of raw materials
Figure 27 defines the two red blocks in more detail and is based on interviews performed with key stakeholders and analyses of documented procedures in task descriptions. The visualization in figure 27 is defined on a task level, where all decisions and tasks are represented in this process flow scheme. This visualization directly points out that the problem is caused by missing feedback which is not delivered by Shift 6. This conclusion makes it is possible to come up with a solution. However, the cause of the problems is still not entirely defined. Because the lack of feedback of Shift 6 causes problems in the supply chain, but when the raw materials are always delivered on time, the feedback is not necessary. In other words, a preventive solution could also be a possibility by performing research on the causes of the delays in deliveries of raw materials.

Figure 27: Opportunity 6 Problem identification

Figure 26 and 27 are used to share information with the key stakeholders. These interviews gave more insights in the problem in a broader context. As explained can the lack of providing feedback of Shift 6 be seen as the direct cause of the problem. However, Shift 6 has to provide feedback because the delivery of raw materials is not 100% reliable. These issues are also included in the research performed in paragraph 6.2.

Based on the results of this analysis, it is possible to set up a project team with the key players involved. Inform them on the issues and opportunities and define new communication standards etc.

Summarized
It is the responsibility of the logistics coordinator to make sure that there is enough raw material available to produce. Key stakeholders in this process are the Production administrator and the operators of Shift 6. Sometimes these deliveries of raw materials are critical for the production...
process. When ordered materials are not delivered and feedback on these issues is not shared, this directly creates production problems and delays. In order to improve this opportunity, it can be approached from two perspectives. A solving solution and a preventive solution.

**Project goal**
Unnecessary production delays are caused by an unexpected shortage of raw materials. Analysis of this problem should first of all provide a clear solution to improve the communication between the different stakeholders and secondly should the analysis provide insights in a preventive solution, to minimize the unexpected shortages of raw materials, which negatively effects the production planning.

**Project team**
To improve the current situation and come up with solutions and recommendations, it is also necessary to set up a project team. The project team consist of the key stakeholders. The project team consist of three team members. Shift 6 was not directly included in the project team, because via the Production administrator, which used to be a member of Shift 6, all necessary information was gathered. But Shift 6 was constantly informed during the project of necessary actions etc. It is also possible at this project to hand over the role of project team leader:

- Project team leader
- Logistics coordinator
- Production administrator
  - Shift 6

**Actor perspectives**
The most important actors are also part of the project team. Only one actor, which is not included in the project team, also plays a key role in this process. This is the Senior Buyer located at the central office at Shell Pernis. This person makes the mid- and long-term agreements with the carriers. When delivery problems which are caused by the carriers occur on a frequent base, this person is informed and is then responsible to take action and improve this process. The Senior Buyer is only interested in the performance of the carriers. At the moment this performance is not monitored in a structured way. The lack of up to date information makes it more difficult to assess the carriers on their performance.

The logistics coordinator is responsible for available raw materials. He monitors the stock levels and create a order list of the raw materials. His main interest is to have a clear picture of the current situation at all times. So when unexpected changes occur, he has to be informed.

The production administrator orders the raw materials, based on the order list. He is also direct contact person for Shift 6.

The operators of Shift 6 receive the trucks and are responsible for unloading process of these trucks. Their main interest is a situation which enables them to unload all the trucks within their shift. Preferably the arrivals of the trucks are in that situation on time.
7.3 Measure
It is now possible to start the measure, analyze and improve phases. The previous paragraph defined the project goal. After performing an analysis on this opportunity during this project, it is necessary to be able to answer the main question: How is it possible to improve the reliability of the supply of raw materials? This question will be answered by focusing on the feedback provided during the delivery of raw materials.

Constraints
The most important constraints, related to this subject, are mentioned beneath. To improve the feedback of delivery of raw materials these constraints should be taken into account, before a solution can be created.
- Shift 6 is available till 17.45 p.m.
- Suppliers of raw materials should be on the site at Pernis before 14.00 p.m.
- Suppliers who deliver raw materials cannot book a time slot, because these are not available. The main barrier to use existing time slots systems is the varying unloading times, depending on the product and ordered volume.

7.4 Analyze
Causes (Problem situation)
To come up with solutions, it is necessary to have clear insights in the issues and problems causing the delays. As already explained are two categories defined:
- A lack of information sharing between Shift 6 to the logistics coordinator and/or production administrator.
- Disorganized deliveries of raw materials by the suppliers.
After performing interviews with the key stakeholders the following points of attention became clear. They are all contributing to the main problem, but can be split up in internal and external points of attention:

Internal:
- There is no standardized communication between Shift 6 and the logistics coordinator and/or the production administrator. Because the production administrator and logistics coordinator are located in the same office, they have contact on a frequent base and information sharing between these two persons is not an issues. At the moment the necessary information is not received by one of these persons.
- There is a lack of control on the deliveries processed by Shift 6 and the information send by them. Because not all deliveries are critical for the production process, canceled or delayed deliveries are only notified when they create changes.
- Receiving and handling the raw materials are not the core tasks of Shift 6. This is a reason why Shift 6 sometimes forgets to provide the necessary feedback. This is aggravated by the fact that the persons of Shift 6 is changing quite often and there is no stable responsible person which can be used as contact point.
- It is Shift 6 that decides if they want to unload this truck after it arrives at 14.00 hr. Because the shift of Shift 6 ends at 17.45 hr. it means that they have to work longer to finish the process.
Delays and canceled deliveries are not documented and monitored. As previously explained, this disables focused actions.

**External**

-the supplier of raw materials officially has to confirm the order via the production administrator, but the suppliers not always confirm these orders. Necessary follow up actions are not always properly executed. Sometimes the supplier arrives without a confirmation, sometimes it doesn't arrive because the confirmation is not send. This depends on the company.

- Trucks arriving after 14.00 p.m. are officially delayed, but delays are not always officially communicated by the suppliers.

### 7.5 Improve

**Solution**

To minimize the unexpected problems caused by unavailability of raw materials, the points of attention/issues mentioned above are taken into account. Most of these issues are related to communicational failures, which directs solutions also in this direction.

The issues also make clear that external and internal directed solutions are necessary. Both solutions will be explained below.

**External**

One of the findings of the analyses was the lack of documentation of previous problems with the suppliers of raw materials. This makes it very difficult to create an externally aimed solution. All external issues are related to punctuality of the suppliers. They are aware of the necessary confirmations etc., but they are not acting in accordance with these agreements.

To improve the current behavior of the suppliers, it requests an increase of consciousness from the suppliers. To reach this:

- Incentives are created to send updates and confirmation from the supplier
- Incentive are created to deliver on time.

These incentives are build into the contracts in the future. Input is generated by the production administrator monitors, which monitors and document the current performances of the suppliers. But because this will take a while, the production administrator also send an email to notify the suppliers of our focus on this matter, and explains to the suppliers of the new procedures.

The senior buyer, will use the documentation on the mid-term to create incentives.

A long-term solution is to start using time slots for the trucks of the suppliers of raw materials as well. Currently Shell Pernis is using time slots for loading trucks on the site, but this is still in a start-up phase. Time slots will also create an incentive to be on time.

**Internal**

Standardized control on deliveries of raw materials is necessary to avoid unexpected problems with available materials. The following measures are necessary to improve the current situation:

- Extra daily control executed by the production administrator on the deliveries of raw materials. This person performs an extra check at Shift 6 at 14.00 hr. The moment that all trucks should be arrived at the site.
• This control task is backed up by the Logistics Coordinator when the Production Administrator is out of office.
• When the Logistics Coordinator is out of office, his tasks are backed up by the production supervisor.
• Necessary actions are, when necessary, escalated to the production supervisor or to the production specialist.
• The actions are secured in the checklist of the PTL.
• On January 2011 a new function of assistant team leader of Shift 6 is created. This person will be closely involved in the tasks of the logistics coordinator and the production administrator. During the next months will become clear which tasks and control functions can be transferred to this person.
• Start monitoring cancellations and delays of deliveries of raw materials from this moment onwards. This enables better insights in the problems and creates argumentation to design more precise incentives and actions. Background information and argumentation on this matter is already provided above in the external focused solutions.
  • Shift 6, Logistics Coordinator and Production Administrator should document delays and cancellations of deliveries.
  • Finally this information is escalated to the Senior Buyer.

Figure 28 provides an schematic overview of all the process steps related to the feedback on the delivery of raw materials. The green parts of the figure define necessary extra steps compared to the current situation. These steps are representing the internal solutions, as explained above.
Advantages

- Extra controlling measures minimize chance of production delays caused by non-availability of raw materials.
- Extra control by the production administrator creates an incentive for Shift 6 to focus more on the deliveries of raw materials.
- Measures don’t need investments, only change of working.
Efficiency analysis of a planning process in chemical industry

- Control measures are more robust, because the tasks are backed up and not depending on one person anymore.
- Monitoring provides insights in effectiveness of measures and creates possibilities for purposeful follow up actions and also for future external focused actions.
- Actions are secured in the PTL task list.

Disadvantages
- External focused measures are not included.
- Focus tends to shift after successful implementation of controlling measures.

Process – project team
The project team of this opportunity only consists of two key stakeholders; Logistics coordinator and the production administrator, one stakeholder that has to be constantly informed; Shift 6 and a project team leader who is in the lead of the project. The project team leader initialized the project and has to make sure that the stakeholders are committed to the project. After the start-up phase it should be possible to hand over the lead of the project to one of the key stakeholders.

Paragraph 7.2 already defined four core elements of a process design, which is necessary to implement the solutions.
Openness: The core elements are already used during the design phase of the solutions. A first meeting was set-up to initialize the problem in more detail. Together with the key stakeholder the problem was exactly defined. The next step was performed by the project team leader by performing some critical interviews with other stakeholders involved. The output was a complete problem description, which send to the key stakeholders on which they agreed on. Based on this problem description a follow up meeting was set up to initialize solutions where everybody could gave input.
Protection of core values: All actors involved in this project are also directly involved in the project solution. For this reason it was not so difficult to protect their core values. The most important aspect was that they all joined the project on a voluntary base, because they experienced the negative effects of the project. By monitoring the solution very strict it creates also exit options to quit the project or at least change the action. Because the center of excellence of this project is located at the execution phase and not at the design phase, this exit option protects their core values.
Progress: The progress was already safeguarded by the involvement of a project team leader. This person is responsible for the progress and results and has the power to control and direct the project. Because there was no monitored data, an internal solution was created to gain a quick win and experience improvements on the short term. Monitoring and evaluating the results will enables external focused actions on the long term.
Substance: The substance of the progress is partly safeguarded by the monitoring process which proves that improvements are realized. However, it is a relatively small project, so it is important to keep up the speed of the project realization in order to keep the interests of the key stakeholders. By using the skills of the project team leader in combination with the experiences on the subject of the key stakeholders, the key stakeholders are kept interested and stay focused.
Stakeholder involvement

Because this project is only dealing with two main stakeholders besides the project team leader, the involvement strategy is not that complicated. The commitment for the project was already created during earlier phases. Several involvement activities are organized to keep this involvement. The most important elements of the stakeholder involvement are hereunder described (Buhrmann unknown).

- **When are the stakeholders involved**
  The logistics coordinator and the production administrator will be involved from the beginning of the project, shift six will be involved after the measure phase.

- **Roles and responsibilities of the stakeholders in the project team**
  The project team members only provide input and information. Where necessary they execute the new tasks designed in the presented solution. The project team leader is responsible to use the input to design solutions and is responsible for the progress of the research. He is also responsible for updating the key stakeholders.

- **Required skills**
  The project team leader should be able to keep the progress going and he has to keep a right balance between quality, budget and the time constraints.

- **Reporting procedures**
  The project team leader is responsible to set up project team meetings which are used to report the progress. These meetings will be organized on frequent basis, this is not periodically defined, but based on results. At least four times are team meetings planned; after the measure, analyze, improve and control step.

The project meetings which are used to report the progress, are also used as involvement activities. One final meeting is planned, when the project is finalized or handed over, to evaluate the process, so all involved stakeholders can learn from it. This is also a incentive to keep committed.

When the project is not finished, the lead of the project will be handed over to the logistics coordinator, who will involve the other stakeholder in the same was described.

7.5.1 Execute and implement project

The solution for this project is presented above. To be able to realize the performance improvements, the project should be executed and implemented. Below are the most important elements described to make the implementation successful:

- **Roles and responsibilities**
  These are already explained in more detail in paragraph 7.2. All stakeholders are involved from the start of the project.

- **Deliverables**
  The most important short term deliverable is a new internal procedure which describes a controlling mechanism to avoid unexpected problems related to the availability of raw materials caused by problems with the delivery of raw materials.

  Long term deliverables are based on the monitoring data and are externally focused. The long term deliverables should include external agreements with the suppliers to diminish the delays and cancelled deliveries caused by them.
Efficiency analysis of a planning process in chemical industry

• Quality
The quality aspects are secured in two ways, namely by measuring and controlling the quality. Measuring will be done by executing an intensive monitoring procedure. All unexpected problems are monitored and documented. Problems are defined as remarked by new procedure, accidently remarked and not remarked. The documentation will provide clear insights in the quality of the new procedure. Problems encountered outside the new procedure say something about the quality of the new procedure.
By securing the new procedure in a checklist, the level of quality effected by the new procedure is guaranteed.

• Activities needed to complete those deliverables
The solution is presented and the planning and design phase is finalized. The project team is committed, so the first necessary activity is to gain formal approval to start the project. The second step is informing and updating Shift 6 of the findings and intentions of this project. Their commitment is also important as previously explained in paragraph 7.2. The third step is to formalize the new procedure and secure the new tasks in checklists of the operational team leader. These procedures are formalized in BBS (work instruction) procedures. The senior buyer is informed of the start of the project. When the lead of the project is transferred, she will be important to realize external solutions. All key stakeholders should start performing their new tasks, including daily monitoring and documenting the status of the delivery of raw materials. Meetings are planned to evaluate the performance and improvements of the new procedure. Where necessary changes are made to optimize the new procedures. The project lead is transferred to the logistics coordinator, which is responsible to organize a meeting after 3 months of monitoring including the senior buyer. External solutions and measures are taken to improve the performance of the suppliers.

• Resource requirements
The resources required are mainly labor. It costs extra time to perform the new tasks. However, minimization of unexpected problems also saves time. Next to this two more resources are required. First of all an operational checklist to secure and control the execution of the tasks. And finally an excel sheet to document and monitor the current performance.

• Time path – planning
Paragraph 7.5 previously explained the importance to keep the time path short. This is strengthened by the limited timeframe of this research. Implementation on the short term makes it possible to use the monitored data and make when necessary changes on the new procedure. Week 50, 2010: Formalization and implementation of the new pilot procedure Week 50, 2010 – week 2, 2011: Monitoring the performance Week 52, 2010: Short meeting to evaluate the performance and new procedure Week 2, 2011: Monitored data is analyzed and based on this data meeting is organized. Possible changes are made. New procedure is formalized Week 6, 2011: Project lead is transferred to the logistics coordinator. (key)-stakeholders are informed.
• Budget
The budget of this project is very low. Investments are not needed.

• Risk planning
The risk of this project is very low. The new procedures are extra controlling measures. They only form barriers to avoid unexpected problems. It is possible to change quickly to the old procedures when necessary.

• Gaining formal approval to begin work
As explained by the activities, formal approval is gained by the production supervisor and the supervisor of Shift 6. By presenting them the details of the solution, there approval will be gained. Because they were updated and involved during this research. First during the opportunity framing, secondly during the design and planning phase and finally they can approve the new procedures.

## 7.6 Control and monitor
The control phase is executed for this project: ‘feedback delivery of raw materials’. The project steps described and executed in the control phase of this project, can be used as an example to perform similar steps for the other projects.

This paragraph execute the control steps which are explained in more detail in paragraph 6.2.5. The eight steps should be taken to avoid failure of the project. The content of these so called ‘counter measures’ are explained below. Step one of these eight steps consists of a pilot project. The second step evaluates the results of this pilot project by evaluating the monitored results.

**Pilot project**
It is necessary to start a pilot project in this case. The pilot study will take 4 weeks and the results are monitored and documented per category in an excel file. The pilot study is based on the solution presented in figure 28: Delivery of raw materials – Overview of the process steps. All project team members were involved and committed to the pilot project. The next steps evaluate the presented solution, based on the monitored results gathered during this pilot project.

**Monitoring the pilot project**
The project goal of the pilot project is to diminish and finally eliminate the unexpected shortages of raw materials which give a negative effect on the production planning. By focusing on the short term on internal solutions, new communication structures and standards were defined. The key stakeholders; the logistics coordinator, production administrator and Shift 6, were committed from the beginning of the project and were closely involved during all project phases.

One of the actions of the new process consists of documenting the findings and unexpected events. This forms the basis for this evaluation and is the main input for the monitored data. A remark should be made on the total monitoring time of four weeks. This time allowed for monitoring and evaluating short term improvements. For evaluation & monitoring of knowledge transfer on the longer term, another evaluation and monitoring project needs to be initiated, which is outside the scope of this thesis.

**Commitment to the project**
The monitored results presented in appendix 11, show that the key stakeholders still are committed to the project and the new process. By executing the control steps build into the new process, the
problems are noticed in an earlier stadium, which makes it possible to take preventive actions in order to avoid unexpected delays and problems.

**Results**

These four weeks proved that it is possible to notify the problems in an earlier stadium. To be able to identify a trend line of the occurrences, four weeks of data are not enough to draw conclusions on the frequency of these occurrences, especially because historical data are missing. One of the new process steps is focused on creating data which is necessary information for the senior buyer, who is responsible for the contracts and performances of the suppliers, to take measures to improve the performance of the external party, the supplier. The project initially focuses on feedback improvement, in order to avoid unexpected problems. Since the start of the new process, no unexpected problems are occurred anymore. Concluding, the process implementation was successful, however the optimal situation is not yet reached.

**Gaps**

The feeling of the key stakeholders involved is that they are still missing important information. Although the results show no unexpected problems anymore, they sometimes have the feeling that they hear problems or delays accidently. Apparently shift 6 is not aware of the importance of sharing all problems related to the delivery of raw materials, so this should be a point of attention in the near future.

The monitored data show four trucks which were not on time and were send away. Two trucks are not arrived on the agreed date. It also shows that these delays are occurred at four different suppliers. Based on this data can thus be concluded that it is not a problem of one supplier, but it is more general problem. Besides this, the data also shows that there are especially problems with the deliveries of GB240-01 and Sorbitol.

The data does not show which measures are directly taken to minimize the direct effects and/or if there is made a trade off to send the truck away or unload it. This information is necessary for the senior buyer and should be added from this moment on to the monitored data.

Input gathered during the interviews with the key stakeholders provide answers on several questions. Because the monitored time was only four weeks, the key stakeholders still remembered the issues. A longer timeframe makes this more difficult. The key stakeholders told that most trucks were sent away in coordination with the logistics coordinator, however when he could not be reached, shift 6 made its own decisions.

The data also shows some temperature related issues. These are normal during very cold weather circumstances like the four weeks in which the data was monitored.

**Improve**

The problems encountered should be used to improve the developed process. This document provides the input for a follow up meeting in which this should be done. Reflecting on the proposed new process and tasks of the key stakeholders, the proposed process represented in figure 28; Delivery of raw materials – Overview of process steps, includes all necessary steps. The results show that it works, however there are some points of attention discussed above that need attention. The senior buyer should be involved during a follow up action after three months, when enough data is gathered to take actions to improve the performance of the suppliers. Based on these results it is possible to verify improvement.
Verify improvement
The results of the monitored pilot project described above, provides the input to verify the improvement of this DMAIC project. The project goal; to minimize the unexpected shortages of raw materials, which negatively effects the production, is at least partly realized. The involved stakeholders are all enthusiastic about the results and have the feeling that the current situation is improved. At the moment there are no unexpected delays anymore. However, the goal is not completely realized, because the results of the pilot study still show problems with late arrivals of trucks. Control data was not available before the pilot study started, so it is difficult to make conclusions based on the results of the pilot study. As defined in the previous chapter, follow up action taken by the senior buyer are necessary to change the behavior of the suppliers. The senior buyer is already introduced in a previous chapter and responsible for the contract and contact on a higher level with the supplier.

Establish process monitoring
The logistics coordinator is end-responsible to monitor the continual improvement of the system. The production administrator monitors the performance of the deliveries of raw materials. Periodically meetings are planned the next 6 months to evaluate the current performance and performance improvement. A format in excel to monitor the performance is necessary, to make sure that the same details and complete information are monitored every day. It is possible to add or delete a demand of information, based on the results of the pilot project. Monitoring the results is an iterative process during the next six months and when necessary for a longer period, this depends on the quality of the information and the conclusions that can be drawn on the information.

Hand over process management
The most important input for this step is the documentation provided in the figure 28: feedback delivery of raw materials – overview of the process steps. This figure provides the new process in appropriate detail, including roles and responsibilities. The logistics coordinator is, as previously explained, the process owner. The production administrator and Shift 6 are the involved process workers. This means that it is clear to the logistics coordinator and other stakeholders involved, that the Logistics Coordinator has the responsibility to ensure that workers have authority to change the process. In addition, the Logistics Coordinator also ensures that the change is properly controlled and documented.
The next paragraph goes further into detail on transferring information to the organization. It is essential that common and well known Shell procedures are used. The Lean Six Sigma method already is familiar to the organization. In addition, project charters and BBS procedures are used by Shell.

Implement new process
The extra action taken in this process is to secure the actions by designing a controlling mechanism in the organization. This is done by including new actions, presented in figure 7.5, in the task list of the PTL, which is the daily head of operations.
Identify opportunities for standardization, integration and replication

The project could be an example for other communicational related problems or opportunities. The chapters of this report describes the different project phases clearly and also make clear how commitment should be created by involved stakeholder.

Because several units at Shell Pernis are dealing with deliveries (of raw materials) by truck, the monitoring methods to measure the performance, could be used by more units. By using one generic monitoring method for all units, this creates better insights in the performance of the suppliers and offers the opportunity to compare the performance at different units. Which is more effective for the senior buyers, who are responsible for the contracts with the suppliers.

When other units are experiencing same sort of problems related to the feedback of deliveries, this project and the measures taken can be used as an example. The measures taken probably need small changes, however using same methods, tools and background information, will increase the speed of the project significantly.

Confirm benefits

The pilot project provides insights in the benefits. However, the plan was set-up to create hard and soft benefits. The main focus of the project was on soft benefits. Communication improved in and around the process. This has a positive effect on the working environment. Less unexpected situations occur, which lowers stress and increases customer satisfaction. The hard benefits delivered by this project are the labor costs and demurrage. In the news situation unexpected situations are reduced, this also affects the extra labor hours; necessary hours spend to change the production planning. The second hard benefit is the decrease in demurrage. When unexpected production changes are diminished, this effects the delayed deliveries and thus demurrage time for ships and trucks.

Besides the soft and hard benefits which are directly related to the goals of the project, the project has delivered some indirect benefits. First of all it delivered process documentation for the new process, second results of the pilot project, thirdly an update on the involvement of the stakeholders, fourthly a project story and finally suggestions for standardizations and replication to apply similar methods on comparable problems.

Close project and recognize team

As explained, it is possible to evaluate all team members personally. However, the project was not really complicated, so the project performance is only overall evaluated during a last session. Several learning points are formulated, presented below:

- The speed of the project execution was positive
- The project documents were clear and provided good insights in the new process.
- Not all stakeholders were informed and updated at every stage of the project. Especially Shift 6 could have been involved more directly into the project. The idea was that this was done via the production administrator, however he was formally not part of Shift 6 anymore.
- The senior buyer should have been involved more directly into the project and from the beginning.
- Communication was now mostly executed indirectly via the project team lead. A forum for discussion should have created the opportunity for all involved stakeholders to directly address issues to all team members, instead of via the project team lead.

At the end of the evaluation session, the appreciation and recognition was communicated to the team members.
7.7 Conclusions

All five development phases of DMAIC are executed and presented in this chapter. The define phase stated the project goal as follows: Unnecessary production delays, caused by an unexpected shortage of raw materials, should be diminished. The first phase also gave insights in the current situation and set up a project team, consisting of a project team leader, logistics coordinator and the production administrator and shift 6.

The measure phase provided insights in the actor perspectives. It became clear that the communication between the production administrator and the logistics coordinator on one side and shift 6 on the other side, needed improvement. This phase also gave insights in the constraints, which provided insights in the agreements with the suppliers and working hours of shift 6.

The analyze phases provided insights in the problem situation and causes in more detail. The problem situation was divided into external and internal causes. Two main causes were identified; a lack of information sharing and disorganized deliveries of raw materials by the suppliers.

A solution was presented to improve the current situation. The solution was also internally and externally focused. It provided a new framework to improve the information sharing and it is started to monitor the current performance of the suppliers. Based on the monitored data, future actions are taken to improve their performance.

The control phase was also executed. Nine steps were taken to avoid failure of the project and described. A pilot project was started and implemented, based on the monitored results, improvements to the suggested solution were made. The new improved solution was implemented.

The execution and implementation steps, executed during the improve, are based on steps described by Kerzner (2008). The descriptions of these steps makes it possible to replicate these processes. The control steps taken, based on Shell (2008), are also presented in the chapter above and can also be replicated during other projects. Chapter 13, will evaluate the methodology in more detail, which makes it possible to learn from this project and replicate the improved development phases.
8. Project 2: Insights in tasks logistics coordinator

8.1 Introduction
This chapter explains and describes the five development phases of the DMAIC methodology for the second project. The second project is focused on the insights in tasks of the logistics coordinator. The same structure of the chapter is used as in chapter 7. However, not all project development phases were executed, because the project was not implemented. For this reason the chapter describes the define, measure, analyze and improve phases.

Paragraph 8.2 describes the define phase, paragraph 8.3 goes further into detail on the measure phase. Paragraph 8.4 and 8.5 describe respectively the analyze and improve phases. The control phase is described in paragraph 8.6 and finally paragraph 8.7 presents conclusions.

8.2 Define
This opportunity was the initial argument and trigger to start this research. During the last summer many employees of the CVP unit planned their holidays during the same weeks. The reorganization which took place earlier this year caused a parallel holiday planning by some persons executing critical functions. This created a situation in which the logistics coordinator was on holiday together with experienced operators, and where the tasks of the logistics coordinator couldn’t be replaced and executed properly by the production supervisor. Who was responsible to fill in his tasks during holidays. This created a need to define insights in the tasks of the logistics coordinator, so it is possible to replace this person when he is not able to perform his tasks.

The logistics coordinator is responsible to translate the production planning into a running planning. The production planning sent and created at SCE by the supply coordinators is used as main input. In consultation with the supply coordinators, the current situation at the units of CVP and other constraints of the units are taken into account in order to realize a achievable running planning. The logistics coordinator is beside this main task also responsible for the availability of the raw materials. The function of logistics coordinator is created years ago. The same person is fulfilling this function since the start. His focus was not on documenting his tasks which created a lack of documentation of his tasks. Next to that, the logistics coordinator is very experienced at CVP and has a lot of tacit knowledge. This enables him to solve many problems, but other people are missing this tacit knowledge when they have to replace him.

Important colleagues are the supply coordinators. In consultation with them they are together responsible for the creation of the production and running planning.

Documentation and visualization are necessary to define the tasks of the logistics coordinator. The knowledge is for a major part gained by the logistics coordinator, so one of the challenges will be to let him tell and explain his tasks and let him share his knowledge.

Summarized
The logistics coordinators fulfills a critical function in the supply chain of polyols. At the moment a lack of documentation of his tasks makes it difficult to replace this person in order to operate the units on a optimal level. Clear documentation and visualization of the tasks of the logistics operator should improve the insights in his tasks and avoid future problems replacing this function and person.

Project goal
Improving the insights in the tasks of the logistics coordinator by creating a structured visualization and documentation of the tasks of the logistics coordinator. The documentation makes it easier to replace the logistics coordinator when this person is not available. During the information gathering with the key stakeholders, attention is also given to possible points of improvement related to the tasks of the logistics coordinator.

**Project team**
Before it is possible to come up with solutions and recommendations it is necessary to set up a project team. All key stakeholders involved in this project should also be involved in the project team. This project team consist only of three members. The role of the project team leader should be performed by a extra person, because the logistics coordinator describes his own role and the production supervisor should test the documentation, based on his experience to replace the logistics coordinator. So the third person is necessary, to describe and document the tasks of the logistics coordinator.

- Project team leader
- Logistics coordinator
- Production supervisor

**Actor perspectives**
There are two main stakeholders involved in this project. The most important actor is the logistics coordinator. This person is extremely experienced at CVP. He gained, during many years of experience, a lot of tacit knowledge. From his perspective it is important to share this tacit knowledge and to make sure that his tasks are backed up when he is not available to execute his tasks. However it is difficult to share all his knowledge, because many tasks seems so logical because he has executed them for many years.

The second actor involved is the production supervisor. His main interest is to visualize and document the critical tasks performed by the production supervisor. His absence during the last summer made clear that insights in the tasks of the logistics coordinator is missing to execute all the critical tasks in a proper way when he is not available.

Besides these actors are also the supply coordinators involved. They have contact on a frequent base (daily) with the logistics coordinator and are aware of some of the tasks executed by the logistics coordinator. They can be used as information source, but are not part of the project team.

The actor perspectives are not conflicting, however they have both slightly different expectations. The challenge will be to gather enough information from the logistics coordinator to be able to document all the critical steps in a simple and clear way.

**8.3 Measure**
The previous paragraph defined the problem in more detail. The main question is how can future problems be avoided when the logistics coordinator is not available to perform his tasks? With focus on creating more insights in the tasks of the logistics coordinator.

**Constraints**
There is only one really important constrain which is related to the logistics coordinator. Because the success of this opportunity is depending on the input and information provided by him. His available time for this project will be important for the success of this project.

8.4 Analyze
Causes (problem situation)
The real causes for this problem situation are already previously mentioned and explained. The main cause will be shortly repeated. The reason is the lack of documentation on the tasks of the logistics coordinator. The function of logistics coordinator was created a couple of years ago. During the last years the logistics coordinator slowly developed his own working manners and tasks in order to make sure that the units are operating in a optimal way. Many years of experience created a lot of tacit knowledge, which is used to perform the tasks. A lack of documentation of this tasks makes it difficult to replace this function properly.

8.5 Improve
Solution
The improve phase describes the designed solution. The solution focuses on visualization and documentation of the tasks performed by the logistics coordinator. After performing several interviews with key stakeholders and performing some analysis on other comparable documentation and procedures of tasks of employees, is chosen to use process flow diagrams. The process flow diagrams make it possible to define the different tasks clear and simple in a schematic overview. Explanation per process step can be defined in more detail, which makes it also possible to define some complex tasks in a simple and clear overview.
Figure 29 presented below provides an overview of the main tasks executed by the logistics coordinator. Every step is explained in more detail in Appendix 10.
Advantages

-The schematic overview provides a good handheld to perform the repeating tasks of the logistics coordinator.

-It defines the exceptions which should be taken into account when steps are executed.
It makes it possible to perform all critical tasks of the logistics coordinator, which should enable optimal operations of the unit.

Disadvantages
- It is impossible to write down all the tacit knowledge gained by the logistics coordinator.
- Unexpected situations are hard to document. Only the normal routine tasks are captured in the documentation. When the logistics coordinator will be replaced definitively, it still needs some overlap time with the current logistics coordinator, to get feeling with handling some unexpected situations.

Process – project team
During this project there are only three persons involved of which one person is the real key stakeholder during the process; the logistics coordinator. The logistics coordinator contains the experience and knowledge which has to be documented and visualized by the project team leader. The role of the production supervisor is more an assessing role, this person is not directly involved in the project. So the core values are less of importance during this project, and mostly aimed at the cooperation between the logistics coordinator and the project team leader.

Openness: Openness is the key core value in this project. Because the logistics coordinator has to have the feeling that he can give insights in all his tasks. By being a critical listener as project team leader the best possible environment is created. Several meetings should be planned and progress on documentation should be shared. This way the logistics coordinator is constantly updated about the project and experiences a open environment.

Protection of core values: The logistics coordinator should be able to change the process, an exit option is not really possible because all stakeholders are necessary for the project. The documentation should only be send to other stakeholders when the key stakeholders agree on this.

Progress: The project team leader will ensure that there is enough progress and results are delivered. However it is important that there is a right balance of the total duration of the project. The project cannot be too short, because the logistics coordinator is not able to share all his tacit knowledge at once. But the project cannot take too long because the interest will lose. By splitting up the tasks the idea of quick wins is created.

Substance: The substance is safeguarded by the production supervisor. His experience and expertise will be used to check the content and can direct the project during when necessary.

Stakeholder involvement
This project is most of the time dealing with only one main stakeholders besides the project team leader. The commitment for the project was already created during earlier phases. Several involvement activities are organized to keep this involvement. The most important elements of the stakeholder involvement are hereunder described (Buhrmann unknown).

- When are the stakeholders involved
  The logistics coordinator is the key element in this project. He is involved at the start of the project. The production supervisor is only involved at the start of the project to define his interests and at the end to evaluate and assess the project results.

- Roles and responsibilities of the stakeholders in the project team
  The logistics coordinator only provide input and information. The project team leader is responsible to use the input to design a schematic overview of the insights in the tasks of the logistics coordinator. He is also responsible for the progress of the research and keep the
stakeholder updated of the progress. An important role in this project is to keep the logistics coordinator committed, because he is the key information holder.

- **Required skills**
The project team leader should be able to keep the progress going and he has to keep a right balance between quality, budget and the time constraints. The logistics coordinator has to be able to explain his tasks in detail.

- **Reporting procedures**
The project team leader is responsible to set up project team meetings which are used to report the progress. Only one finalizing meeting will be organized with the complete project team. Other meetings will be organized on frequent basis not periodically planned, but based on results and availability of the logistics coordinator.

The project meetings which are used to report the progress, are also used as involvement activities. One final meeting is planned, when the project is finalized and the results are secured, to evaluate the process. The involvement of the production supervisor creates an incentive for the logistics coordinator to stay committed.

When the control phase is not yet finished, the project lead could when necessary be handed over to the production supervisor. lead who will make sure that the project is finalized.

### 8.6 Control
The control phase is, as previously explained, not executed for this project. The project findings and project documentation is formalized and secured in the organization. During middle and/or long term periods of absence of the logistics coordinator, could the documentation be controlled.

### 8.7 Conclusions
Four of the five development phases of DMAIC are executed and presented in this chapter. The define phase stated the project goal as follows: In order to avoid future problems during absence of the logistics coordinator, insights in his tasks should be created and a clear documentation is necessary. The first phase also gave insights in the current situation and set up a project team, consisting of a project team leader, logistics coordinator and the production supervisor of manufacturing.

The measure phase provided insights in the actor perspectives and the constraints. It became clear that the logistics coordinator was a crucial link in this process and that the involved actors perspectives and interests were not conflicting.

The analyze phases provided insights in the problem situation and causes in more detail. During the last years the logistics coordinator slowly developed his own working manners and tasks to make sure that the units are operating in an optimal way.

To improve the current situation, insights were generated. The focus of the documentation was on clear visualization of the tasks performed by the logistics coordinator.

It was not possible to execute the control step, because this can only be done during middle or long term absence of the logistics coordinator. However, all project findings were transferred to the logistics coordinator and production supervisor. The production supervisor is in the lead during middle or long term absence to test the solution and make improvements when necessary.
9. Project 3: Delays of laboratory analyses

9.1 Introduction
This chapter explains and describes the five development phases of the DMAIC methodology for the third project. The third project is focused on the delays of laboratory analyses; target times vs. actual times. The structure of the previous two chapters is used again. Not all project development phases were executed, because the project is used as opportunity framing for the laboratory. For this reason the chapter describes the define, measure and analyze phases. The results of these phases are presented to the laboratory. After this presentation, the project including follow up actions, was transferred to the laboratory.

Paragraph 9.2 describes the define phase, paragraph 9.3 goes further into detail on the measure phase. Paragraph 9.4 and 9.5 describe respectively the analyze and improve phases. The control phase is described in paragraph 9.6 and finally paragraph 9.7 presents conclusions.

9.2 Define
This opportunity is selected because it has a high impact and it is related to opportunity 1. Necessary insights in the delays of the laboratory are required to be able to define the potential benefits of the first opportunity; changing the flexibility of the supply chain. But it is difficult to process this opportunity entirely, because of involvement of the laboratory. As defined in chapter 3, the laboratory is located on the edge of the scope of this research. Because the laboratory is a different, independent department with an own organization at Shell Pernis. CVP as chemical unit, is only responsible for a minor part of all the tasks of the laboratory. Another argument to not process this opportunity entirely is that the laboratory is also reorganizing at the moment.

For this reason, only the opportunity framing of this opportunity is executed. The analysis will be presented and some recommendations are given to improve the process in the future, or at least new targets are defined that could help to improve the performance of the laboratory to CVP. The analysis will also be presented to the focal point of the laboratory. However, a project team will not be formed, so this will be presented as a follow up action with the rest of the recommendations.

As already explained in paragraph 5.2, target times are used by the laboratory to define the expected time to deliver an analysis of a sample. In practice there is a difference between actual analysis time and target time of the analysis. But the exact difference between these times is unknown. When the analysis of a sample is delayed, this could have consequences for the entire supply chain. Because planned deliveries are experiencing delays, tanks are not emptied according to plan and several other parts of the supply chain are experiencing consequences caused by the delay of the analysis.

Necessary insights are missing at the moment to define the seriousness of the problem. Especially because the laboratory is an external unit, a thorough analysis of their results is necessary.

Summary
The laboratory is currently working with target analysis times instead of actual analysis times. This creates uncertainty within the supply chain of polyols and sometimes has negative effects on the performance of the supply chain. Necessary insights are missing to define these problems more precisely.
**Project goal**
Perform an analysis which shows the differences between target analysis times set by the laboratory and actual analysis times. Based on this analysis and created insights it should be possible to make recommendations to the laboratory and inform them. When necessary the project lead will be handed over to the focal point of the laboratory.

**Project team**
As previously explained is no project team set up for this opportunity. The results of the analysis will be communicated and presented to CVP and finally when necessary to the focal point of the laboratory. Below are the keys stakeholders involved listed, but they cannot be defined as project members:
- Intern who is performing the analyses
- Production specialist
- Laboratory focal point

**Actor perspectives**
It is very clear that there are two different actor perspectives. This involves out of the different interests of both stakeholders. The production specialist is interested in a sample analysis as quick as possible, but more important, as reliable as possible. This has two aspects, the first one is a quality aspect, which is not taken into account and the second aspect is a time aspect. Is the sample ready on the time that it is expected to be ready. The perspective of the production specialist is that the laboratory is a service, which should create no extra delays and/or problems.

The opinion of the laboratory focal point is that they are performing better than used to be and they are still working on improvements. By working with target times, they can offer the fastest services as possible, but not always. They have never seen an analysis that they are not performing well enough.

**9.3 Measure**
Paragraph 9.2 already explained the problem in more detail. The goal of this opportunity is slightly different than by the other opportunities, caused by the involvement of the laboratory which is explained in chapter 5.

The main question is: What is the current performance of the laboratory related to analyses done for CVP? At the moment involved stakeholders have the feeling that there is a difference between actual analysis times and target analysis times, but this is not based on data analyses.

**Constraints**
The laboratory has some hard constraints. The most important ones are capacity related, which is an argument why samples are not always delivered on time. The second one is a constrain related to CVP. CVP is one of the two chemical units at Shell Pernis. The chemical units are not as big as the oil units are at Shell Pernis. In other words, they are less important and have a much lower turnover rate. This creates a situation in which the interests and wishes of CVP are less important than the wishes of the oil units for the laboratory. Because sometimes decisions are necessary, they are often made in advantage of the oil units.

Other constraints are the delivery time of CVP and the operational hours of the laboratory. CVP is depending on their production progression and can only provides samples after the production is
Efficiency analysis of a planning process in chemical industry

finished and the tanks are circulated for on average 12 hours. The operational hours of the laboratory are from 07.00 a.m. till 17.30 p.m. Outside these hours, it is only possible to perform analyses of samples with the highest priority. Not all analyses can be performed during the night.

9.4 Analyze

Causes (Problem situation)
The problem situation is caused by a difference between target times and actual times of the analyses. The laboratory uses target times to provide a time indication for the suppliers of the samples. The different units are using these target times for their scheduling. However, in reality the target time is often delayed, which creates an unexpected difference in time between target times and actual times.

Based on data including 1916 processed samples for the CVP unit, between August 01, 2010 and December 10, 2010 an analysis is presented hereunder and in Appendix 7. This analysis provide a clear overview of the differences between target times and actual times.

The samples were categorized, based on their origin. The samples of categories 600, 6800 and 7500 are sales tanks. These are important to analyze, because these groups of samples are necessary before tanks can be set ready for sale and should be analyzed under time pressure. By the other categories of samples this is not necessary.

Because only the opportunity framing is done and no project is started, the advantages and disadvantages are not mentioned.

![Figure 30: Overview of delays of sample analyses](image)

<table>
<thead>
<tr>
<th>Current samples on time</th>
<th>63.64%</th>
<th>14.17%</th>
<th>3.21%</th>
<th>1.60%</th>
<th>2.94%</th>
<th>2.41%</th>
<th>2.14%</th>
<th>4.28%</th>
<th>5.61%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples delivered within 4 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Samples delivered within 8 hours</td>
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<tr>
<td>Samples delivered within 12 hours</td>
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<tr>
<td>Samples delivered within 16 hours</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Samples delivered within 20 hours</td>
<td></td>
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<td></td>
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<tr>
<td>Samples delivered within 24 hours</td>
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<td></td>
<td></td>
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<tr>
<td>Samples delivered within 48 hours</td>
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<td></td>
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<tr>
<td>Samples delivered after 48 hours</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Target samples on time 2011

100.00%
Figure 31: Overview of number of hours delay per sample

Figure 31 and 32 show an average on time delivery of samples (according or before the target time) of approximately 60%. The rest of the analyses are delayed.

Figure 32: Overview of delayed samples of CVP
9.5 Improve

Solution

A solution is not presented, because this analysis only provides a opportunity framing. Some conclusions and recommendations based on the analyses of the problem situation will be presented hereunder. The analysis will also be used as argument for the opportunity described below in chapter 10.

Based on results presented above and in appendix 7 can be concluded that the laboratory is performing on an average of 60% on time deliveries. 15% of the delays are within four hours. These results, based on their own data, can be used to set better targets. It makes it possible to monitor these goals and evaluate performance of the laboratory. It becomes possible to evaluate and compare their performances with historical results.

Process – Project team:

As previously explained will this opportunity not be approached as a project. The presented analysis creates insights in the current performance of the laboratory. It is possible to set up a project as follow up action. For this reason process design is not further explained. But it is important to mention that the (key) stakeholders involved in this project have different perspectives and also different interests. This makes a good process design even more important, because there is risk that the project otherwise fails.

Stakeholder involvement

As explained above is the stakeholder involvement of this project also less important. The commitment of the laboratory focal point was not yet created during earlier phases. Convincing him of two sides benefits convinced him to join the project (Buhrmann unknown).

- **When are the stakeholders involved**
  Both were involved from the start of the project. The laboratory focal point to deliver data and the production specialist to help set the goals clear.

- **Roles and responsibilities of the stakeholders in the project team**
  The stakeholders are involved during two presentations. The laboratory focal point was also responsible to deliver appropriate data, which could be analyzed. During the analysis, the production specialist had an advisory role to improve the analyses.

- **Required skills**
The project team leader should be able to analyze the data and come up with a solution. A balance between quality and time is necessary.

- **Reporting procedures**
  The project team leader is responsible to set up project team meetings which are presents the result and finally should convince the laboratory focal point of taking follow up actions. Two presentation are planned, one to present initial results and a second one to present more focused results.

As previously explained is the project lead could handed over to the laboratory focal point, who will make sure that the project is finalized.

### 9.6 Control
The control phase was not executed, because the project was executed as opportunity framing for improvements made by the laboratory. After presenting the results to the laboratory, the project was transferred to them.

### 9.7 Conclusions
Three of the five development phases of DMAIC are executed completely and presented in this chapter. The fourth and fifth are not executed, because this project was executed as opportunity framing for the laboratory. The laboratory is an independent operating organization at Shell Pernis. For this reason, the insights of the analyses are presented to the laboratory and they use it to take action and improve their performance.

The define phase stated the project goal as follows: Perform an analysis which shows the differences between target times and actual times set by the laboratory. The first phase also gave insights in the current situation and set up a project team, consisting of an intern, who performed the analyses, a production specialist of CVP manufacturing and the laboratory focal point.

The measure phase provided insights in the actor perspectives and the constraints. It became clear that two involved actors have different perspectives and different interests, although they have the same high level goal. The constraints of the laboratory are more complicated than expected. They deal with capacity constraints. They cannot process all analyses 24/7 and sometimes they are forced to make tradeoffs between the oil departments and chemical departments.

The analyze phases provided insights in the problem situation and causes in more detail. It analyzed a large data set of sample deliveries, which provided insights in the current performance of the laboratory and the differences between target times and actual times.

The insights created in the first phases of this project created a clear opportunity for improvement. However, as previously explained, the independent status of the laboratory made it impossible to implement a solution. For this reason, in combination with the complexity of the laboratory processes, the results were presented to the laboratory as opportunity framing. The insights gave enough detailed insights to improve the current performance. The involvement of the laboratory focal point and his commitment to the project in the first three phases, made it easy to transfer the project and give good confidence that this opportunity framing will result in future performance improvements.
10. Project 4: Optimal balance between inventory and flexibility of the supply chain

10.1 Introduction
This chapter explains and describes the five development phases of the DMAIC methodology for the second project. The fourth project is focused on an optimal balance between inventory and flexibility of the supply chain. To create this optimal balance, this project focuses on the potential to build in slack time in the supply chain. The same structure of the chapter is used as in chapter 7. However, not all project development phases were executed, because the project was not implemented. For this reason the chapter describes the define, measure, analyze and improve phases. Paragraph 10.2 describes the define phase, paragraph 10.3 goes further into detail on the measure phase. Paragraph 10.4 and 10.5 describe respectively the analyze and improve phases. The control phase is described in paragraph 10.6 and finally paragraph 10.7 presents conclusions.

10.2 Define
Figure 16 ranking of the opportunities defines this opportunity in box ‘plan to do later’ and classifies it as the one with the highest impact and with the lowest ease of implementation. This classification is first of all caused by the fact that many factors are influencing this opportunity and secondly because very elaborated analyses could be necessary to define the optimal balance between inventory and flexibility of the supply chain. A third argument is that performing these analyses is extra difficult, because the necessary data is hardly or not at all available.

Create extra slack in the supply chain
However, the balance between inventory and flexibility of the supply chain could also be improved without finding the optimal balance point between inventory and flexibility of the supply chain, but by searching for available improvements in the current system and methods. To be able to define improvements, more detailed insights of the current balance methods between inventory and flexibility are necessary. Special attention is given to the current flexibility of the supply chain, namely influenced by the planning process. Paragraph 5.3 already divided this opportunity in 1a and 1b. Where 1a was defined as create extra slack in the supply chain and 1b as finding the optimal balance between inventory and flexibility. In collaboration with key stakeholders is decided to focus on opportunity 1a.

The current situation can be explained as follows. The supply coordinators located at the supply department at SCE are responsible for the production planning process. They create an initial production planning in cooperation with the logistic coordinator of the manufacturing department at CVP. This production planning forms the basis for the running planning, which is used by the manufacturing department. The Customer Relation Center (CRC) located at SCE creates timeslots, based on (the production planning) the expected availability of products and the stock levels in the tanks. The CRC informs the customers/carriers of these available timeslots and is responsible for the contact about changes with the customer/carriers. The goal of the CRC is trying to maximize the number of pick up orders within an minimum amount of time. In other words, they try to minimize the inventory, by creating available time slots for the carriers as soon as possible.

The CRC is responsible to execute a strategy, set by the management of the supply and commercial department. To argue against this strategy, it is necessary to explain the consequences of this
strategy. The main consequence of this philosophy is that the supply chain is dealing with a very tight schedule. Under ideal circumstances, this is positive, because keeping inventory and producing more than direct necessary are two of the seven categories of waste defined in the lean manufacturing tool used by Shell; TIMWOOD (Shingo 1989). The tight schedule helps to keep the inventory as low as possible and tries to minimize over production. However, current operations proves that there are also some disadvantages of this philosophy, because the right balance is necessary and a too tight schedule could create problems and waste as well. These disadvantages occur when the ideal planned situation changes, caused by problems or delays in the production, analysis or filling and dispatch parts of the supply chain. TIMWOOD defines unnecessary movement and waiting times also as waste. For this reason a right balance is necessary.

Before the situation is described in more detail, it is important to understand the main steps of the manufacturing process. The production is executed at different units and different grades can be produced at each unit. Each grade defines a different product, with different characteristics. Not only sales characteristics etc., but also different batch cycle times, circulation times etc. The planning is based on the expected production time plus the circulation time of the tanks. When the production and circulation of the tanks are completed, a sample of the final product must be analysed at the laboratory before it is possible to start the filling and dispatch process. A visualisation of this process can be find at figure 12; value stream map.

After analyzing these processes presented above and performing interviews with stakeholders, it is now possible to conclude that two main processes are responsible for the majority of the problems and issues occurring in the supply chain. The first problem are caused by delays or product quality issues occurring during the manufacturing processes. The second main reason of issues is caused by delays or problems with the analyses of the samples.

Product quality related problems and specific production delays are not in the scope of this project, because they are too much focused on the production processes itself, instead of a focus on the planning process of the supply chain. It is always possible to improve the production process, because it will be impossible to reach a 100% reliable manufacturing process.

A second argument to avoid focus on the improvement of the production processes is that there are already people trying to improve these processes. There are two production specialists at CVP committed to the mid- and long-term improvements of the product quality and production processes of the units. Plus there is also a technology department, which tries to improve specific parts of the current manufacturing processes.

So this narrows our focus on the direction of improvements for this opportunity. In general there are two ways of solving problems as explained above. The first option is by eliminating the direct cause and secondly by minimizing the effects of the problems and issues occurring anyway. Eliminating the direct cause is very difficult because this is, as previously explained, highly related to the production processes. But minimizing the effects caused by the problems is possible. At the moment the supply chain is very sensitive to delays and other issues, caused by the strategy to apply a very tight planning in the supply chain. The planning is based on expected production times, circulation times and analyzing times. The sum of these times, including a small buffer, are the main input for the supply coordinators when they create a planning.
When the tanks are circulated and ready for analysis, a sample is taken and sent to the laboratory. The laboratory needs a certain amount of time to process a sample. This depends on the priority of the sample, determined by the responsible person at the CVP manufacturing department. This priority is based on the planning, or in other words the planned time of delivery. A higher priority costs extra money and it is impossible to send all samples with a high priority, because of the constrained possibilities of the laboratory. Because the priority is based on the planning, the priority is indirectly determined by the supply coordinators at SCE.

The laboratory is fully active during daytimes, from 07.00 till 17.00. The laboratory is the rest of the day and night only partly available to execute analyses. See appendix 8 for a overview of the tests which could be executed during the night.

These constraints create a situation where in the majority of cases, samples are brought to the laboratory during the morning. These samples with a normal priority are ready at 16.00 or earlier. So trucks and ships are planned on the same day as the analysis is performed, from 16.00 and onwards.

**Summarized**

When problems or delays occur during one of the necessary steps before the filling and dispatch process can be performed, this directly affects carriers or customers, because the scheduled delivery will be directly affected. In other words, during non-ideal circumstances the planning is too tight, which has directly negative effects on the carriers and/or customers. Because it is a highly complex process to produce and analyze polyols, the supply chain experiences many delays etc. caused by various reasons.

**Project goal**

This explanation creates the possibility to define the main goal of this project: In order increase the reliability of the polyols supply chain and diminish the number of issues experienced by the carriers and customers, slack time between the expected moment that tanks are freed for sale and the time that deliveries are scheduled, should be included in the planning process.

**Project team**

The first step to come up with solutions and recommendations, is as already explained, to set up a project team. All key stakeholders involved in this opportunity should also be involved in the project team. For this reason the project team consist of six member and one project team leader. The role of the project team leader can be performed by a extra person or by one of the six member of the project team:

- Project team leader
- Production specialists
- Product manager
- Logistics coordinator
- Supply coordinator
- Laboratory focal point
- Manager of the Customer Relation Center
**Actor perspectives**

The most important actors are already defined above and are part of the project team. However, the different actor perspectives can be divided into two main groups. First of all the actors involved at SCE, supply and commercial and the second group of actors involved at CVP.

The first group has two main interests: Minimize costs, maximize profit. Because keeping inventory costs money, they aim on low inventory and want to minimize the throughput time in the supply chain. However they are interested in a right balance between minimal costs and reliability. Because in the end it is also about the customer satisfaction. Higher inventory increases the reliability.

The second group are all actors involved at CVP. They want to produce the best quality and achieve their targets. So extra flexibility and slack time in the supply chain is welcome, because this reduces the stress and time pressure to produce and deliver polyols.

**10.3 Measure**

Paragraph 10.2 already explained the problem in more detail. The main question is how to diminish the effects, caused by delays in one of the necessary steps performed earlier in the supply chain. With focus on delays caused during the production or analysis phases.

**Constraints**

To improve the process, it is necessary to have insights in the current constraints. The four departments, explained in paragraph 10.2, have different interests. The constraints define the possibilities without opinions influenced by stakeholders interests.

- Customers demand products on short term. This creates a situation where the maximum amount of time between production and filling and dispatch is constrained.
- Customer and carriers are often using ‘day trippers’. These carriers arrive late on the day (after 16.00) to transfer the product the next day directly to the customer.
- Extra slack time in the processes and the planning process does not diminish the pressure on the system. Delivery of products is still demanded. However, it creates possibilities to solve issues on the short term, before the carriers and customer are necessarily informed and experiencing delays.
- The laboratory is responsible for the analyses of the samples. Some of the analyses can be performed 24 hours per day, but during normal circumstances the laboratory is only available during 07.00 and 16.00.

**10.4 Analyze**

**Causes (Problem situation)**

To come up with solutions, it is necessary to have insights in the issues and problems causing the delays. As already explained is it possible to define three categories of issues:

- Production problems, causing delays
- Product quality issues, causing delays and need follow up actions
- Sample analysis problems, causing delays, sometimes need follow up actions

Information on these issues is very scarce. However, figure 33 presents an overview of production problems, based on data material gathered by SCE – commercial department. Figure 33 shows the dependency of the polyols supply chain on a much broader supply chain. The polyols supply chain depends on the amount of EO and PO, which is delivered by Shell Moerdijk. Six categories of problems are mentioned, on which the grey one is related to production problems caused by the polyols units. This are the production problems and product quality issues stated above.
Figures are known, including impact in time of issues on the PO Derivatives performance in lost kiloton PO Derivatives. This information is based on analyses, interviews and email information. Impact is defined as time required to go back to normal operations. Not normal operations are noticed by SCE and Manufacturing staff (stress, additional work, etc) and by the customers (product allocations, uncertainty on product and quality, etc).

Figure 33 presents six categories of issues impacting the performance of the supply chain. Further research shows a significant share of polyols plant related issues. Especially the polyols plant related issues create delays at the end of the supply chain, which are, with the current tight schedule, directly noticed by the customer.

The significant share of polyols plant related issues, show the evidence that there are production problems causing delays, which legitimates a change of philosophy.

Based on the data gathered by SCE – commercial department, they already made some conclusions about the performance of Shell 2010. In 2010 CVP was not been able to supply products they wanted in quantities they wanted. Shell was not as reliable anymore, because they have been dealing with quality problems. And most important; they changed the delivery date of products very often (Ven 2010). This performance can be compared to the Shell Customer Proposition stated at their site: ‘We supply globally and reliably, good quality products’ (Unknown 2010).

After providing data and arguments on the production problem, the first two problem categories; production problems and product quality issues, are explained. The last category is about delays in the sample analysis. The laboratory is currently working with target times instead of real delivery times. Already defined as opportunity 10; delays of laboratory analyses. Figure 34 presents a overview of the delayed samples. The delays are compared to the target time set by the laboratory. The available data used starts at August 01, 2010 and ends at December 10, 2010. In total 1916 tests of samples were used as data set. Appendix 7 shows the results of this analysis. A remark is necessary, because the averages delays are higher caused by several analyses which were more days delayed, which is not comparable to reality. It is possible to delete these samples from the data set, but this was not necessary because the results were still useful enough to provide arguments to change the planning philosophy and build in slack.

The graph below presents the results for the samples 600, 6800 and 7500. These are the most important categories to analyze. Because this are samples taken from the tanks filled with products ready to use by the filling and dispatch department. The other analyses are not taken under time pressure. These three categories represents the analyses of the samples which are necessary at 16.00 o’clock.
Based on this data is proven that the samples are often delayed compared to the target times set by the laboratory. This is often around 16.00 o’clock and directly causes delays, because carriers and customers are scheduled from 16.00 o’clock onwards.

The data presented above provide enough information and arguments to start changing the philosophy and build in slack in the supply chain. Delays in sample analyses and production problems causing delays often create problems with deliveries at 16.00 o’clock.

### 10.5 Improve

#### Solution

The solution focuses on the possibilities to create slack time into the supply chain, in order to become less sensitive to delays and other problems occurring during the analyses and production phase.

After performing interviews with all key stakeholders and analyzing the key interests of the main stakeholders, it is possible to come up with the following solution. In the current environment the philosophy of the planners is to start with the filling and dispatch process at 16.00 o’clock in the afternoon. It is possible to change this philosophy and start with planning from 07.00 o’clock in the morning on the next day. This creates 15 hours slack time to solve issues and delays.

The graph presented hereunder shows the possible advantages and improvement that can be made by creating slack in the supply chain. This graph only shows the profit which can be made when four hours extra is calculated. In 14,17% of all cases are the deliveries not influenced by the delays of caused by the laboratory. However, this is the case when all samples should be ready at the exact target time of the sample. In practice sometimes there is a small buffer between sample delivery time and the scheduled loading time of trucks and ships.
Figure 35: Overview of improvement within 4 hours

Figure 34 shows the possible improvements that can be made when during the night (24 hours a day) till 04.00 a.m. not finished samples are analyzed till they are ready. The possible profit would be 14,17+3,21+1,60 = 18,98%. Also a laboratory improvement is adopted. Because a wider goal of this project is to convince the laboratory of the importance of on time delivery of analyzed samples. CVP is changing their production schedule, partly caused by the laboratory by creating more slack, but this also demands an improvement of the laboratory. However this is a long term goal and therefore the direct profit is 18,98%.

There is still a potential time margin left between 04.00 a.m. and 07.00 a.m. It is also possible to calculate the possible improvement till 08.00 a.m., this will be 21,93%. There is one remark on these figures, it is assumed that the laboratory is operational for 24 hours. In practice this is not true, so for that reason figure 33 shows a more reasonable increase.

Figure 36: Flexibility improves reliability

Creating extra slack in the supply chain offers advantages, but of course also disadvantages. These are presented hereunder:

Advantages:
- Creates possibility to perform an extra analysis (by off-spec issues, product quality issues)
- Reduces time pressure to start filling and dispatch
- During problems that cannot be solved, customers and carriers are much better available in the morning for making new appointments and agreements compared to the late afternoon.
- Pressure on loading slots reduces. Because trucks are no longer (or less) using a loading slot without getting products.
- Extra flexibility reduces the pressure on the involved employees, which reduces the stress factor. This advantage is related to HSSE and the work environment.
- The pressure of delivery shifts from moment of delivery to hours before delivery. Customers and carriers will not experience this pressure, so the perceived reliability of Shell increases.
- Carriers waiting on the site declare waiting cost. In the new situation waiting times on the site are minimized.
- Maximum production runs can still be scheduled, because the production planning does not change.
- Investments are not necessary. Only a change of philosophy and planning is necessary.
- Pre loading with high risks (by initial off-spec of product quality) are not necessary anymore.
- The laboratory can perform many analyses continue (also at night)
- During the night the Operational Team Leader can be made responsible to perform some necessary actions.
- It proves how seriously the problems with the laboratory are for CVP. It creates a possibility to demand improvements of the laboratory.

Disadvantages:
- At 16.30 p.m. day workers are going home. So the problems should be solved before people are leaving the office.
- The risk exist that problems and issues are transferred to the next morning, instead of using the slack time.
- The laboratory cannot perform all analyses continuously.

Process – project team
This project has many stakeholders and also the problem itself is very complex as previously explained. This increases the value of spending attention to design a proper process design. Again attention is given to the four core values.

Openness: Because many stakeholders are involved, it is the responsibility of the project team leader to keep all key stakeholders updated and committed to the project. Updates, by emails, telecoms or during personal meetings face to face are necessary to create openness and share the findings. It is necessary that all involved stakeholders can comment on these findings and that there is room for discussion between the different stakeholders. The first phase is to identify the interests of the stakeholders and try to find out what the possibilities are. This is already done in define phases in the paragraph 10.2. This paragraph, 10.4, starts analyzing. Before decisions can be made based on this analysis, everybody should be involved during a meeting in which the findings are presented and the direction of the solution is defined. This creates openness and makes sure all parties are involved.

Protection of core values: Because many stakeholders are involved in this project, it is very important that their core values are protected. The feeling should be created that nobody is forced to adopt a certain behavior to make certain choices against their will. This will be done by offering an exit rule. In other words, the stakeholders are asked to find out what the potential future possibilities are, but they can wait with cooperating definitively till the end of the project.

Progress: The project team leader is responsible for the progress and results. This is more difficult compared to the other projects, because many stakeholders are involved and they have different interests. The main challenge is to create early participation. By performing many interviews with all
stakeholders involved, early commitment is created. By splitting the opportunity in complex study to the optimal balance and building in slack, a win situation is delivered on the short term. Follow up analyses could define the optimal balance point of flexibility and inventory. By involving SCE at the start up phase of this project and get their support, it becomes possible to generate results. The analysis is performed and enough arguments are here to build in slack time, it is necessary to organize a meeting where everybody can share their expectations and constraints. Based on this meeting new deadlines are set to make sure enough progress is realized.

**Substance:** It is possible that the focus of the project shifts during the different phases of the project. Research and analyses of different parts of the supply chain are necessary to create a complete analyses and this urges sometimes focus on a certain part. Because many stakeholders on a management level are involved, it is important to visualize and argument the findings of the analyses strict and careful. Based on these findings follow up actions are required. Substance can be supported by the knowledge brought by all the involved stakeholders. It is not always necessary to create solutions, but to combine the ideas of the involved stakeholders. By doing so, the role of stakeholders is necessary and important and the project team leader creates enough substance by combining these inputs.

**Stakeholder involvement**

This project is dealing with several stakeholders. The commitment for the project was already created during earlier phases. Several involvement activities are organized to keep this involvement. The most important elements of the stakeholder involvement are hereunder described (Buhrmann unknown).

- **When are the stakeholders involved**
  After analyzing the data and when the problems were identified, all stakeholders were involved during individual meetings.

- **Roles and responsibilities of the stakeholders in the project team**
  All stakeholders are part of the process and should agree with the recommended project solution/planning philosophy. The project team leader is responsible to define the solution and create enough support to implement the new design.

- **Required skills**
  The project team leader should be able to keep the progress going and he has to keep a right balance between quality, budget and the time constraints. The most important skill of the project team leader in this project is stakeholder management.

- **Reporting procedures**
  The project team leader is responsible to set up project team meetings which are used to report the progress. Only one finalizing meeting will be organized with the complete project team. Other meetings will be organized individually and updates are send to the key stakeholders in this project.

The final project meetings is used to present the designed solution. The project lead could, when necessary, be handed over to the supply manager.

### 10.6 Control

The control phase is not executed for this project. The project findings and solutions to improve the current situation are presented and recommended to the involved team members. The project members take follow up actions and will execute the control phase when the decision is taken to
implement the recommended solution. The control phase will then start with a pilot project. Based on the monitored results of the pilot study, improvement are made or the decision is taken to not implement the proposed solution.

### 10.7 Conclusions

Four of the five development phases of DMAIC are executed and presented in this chapter. The define phase stated the project goal as follows: In order to increase the reliability of the polyols supply chain and diminish the number of issues experienced by the carriers and customers, slack time between the expected moment that tanks are freed for sale and the time that deliveries are scheduled, should be included in the planning process. The first phase also gave insights in the current situation and set up a project team, consisting of a project team leader, production specialists, product manager, logistics coordinator, supply coordinator, laboratory focal point and manager of the customer relation center.

The measure phase provided insights in the actor perspectives and the constraints. It became clear that SCE and CVP have different interests, although they have common high level goal. The constraints are limiting the delivery times and possibilities to build in slack time.

The analyze phases provided insights in the problem situation and causes in more detail. First insights are given in production and production quality related problems and secondly insights are provided in the performance of the laboratory and the effects on the reliability of deliveries of the polyols’ supply chain.

To improve the current situation, a solution is presented. This solution includes slack time from 16.00 hr till 07.00 hr the next morning. Slack time has many advantages, but also some disadvantages, for this reason these are both mentioned.

It was not possible to execute the control step, because it was not possible to implement the solution within the limited time frame. All project findings were transferred to the production supervisors and presented to all project team members. The production supervisor is in the lead to take follow up actions.
11. Project evaluation

11.1 Introduction

The previous four chapters described the five development phases of the DMAIC projects. Chapter 6 introduced and described the DMAIC methodology, added with some theoretical background which help to start projects. These methodologies are evaluated generically in chapter 13. This chapter focuses on the evaluation of the project results and other findings, not related to the methods, but worth mentioning.

Paragraph 11.2 till 11.5 evaluate the four project first individually. Followed by more general recommendations and conclusions related to the projects in paragraph 11.6. This paragraph first discusses the multi actor environment, secondly it spends attention to document the process for future use. The third sub-paragraph presents recommendations for future change and this paragraph ends with evaluation and recommendation of communication and documentation within the organization. Paragraph 11.7 sets the results in context, followed by conclusions in the final paragraph 11.8.

11.2 Project 1: Feedback of delivery of raw materials

This project is the most elaborated project of all, because it was the only project that was also completely implemented. Chapter 7 already discussed the results and findings of this project in detail in the control phase. The project proved that it was related to other problems. Fail in feedback of delivery of raw materials potentially results in production problems. However, solving these problems also directly showed other problems. For example improving and structuring the feedback process from shift 6 to the logistics coordinator shows that there are also problems with the performances of suppliers.

First some remarks are made on the stakeholder involvement. The pilot project executed in the control phase, provided insights in the result of the implemented solution. The logistic coordinator initiated this project during the workshop, which increased his commitment and support during the development phases. The production administrator was also committed, but less than the logistics coordinator. By frequently organizing meetings and showing the progress, it was tried to keep their commitment and support. The four core elements of a process design were used and applied during the meetings. Shift 6 was informed of the progress and steps made, but were not involved intensively. After executing the pilot project, it became clear that the senior buyer also played an important role in the process. She could have gave more insights in the performance of the suppliers and has the position to influence their behavior. If would have been better to involve her in a earlier stadium.

The results of the pilot study were satisfying. The steps were secured in the organization by adding them to checklists. This makes sure the necessary actions are executed every day. During the project it was necessary to set a clear scope, because the involved team members tended to include more problems. The project goal defined at the start of the project was useful to keep the scope.

All five development phases were executed during this project. The control phase is only executed in this project. However, the steps are described in a way that this project can be used to replicate the control phase in other projects. The nine phases makes it possible to replicate these. The other phases are also defined in a way it is possible to replicate these steps or apply the steps on similar projects.
11.3 Project 2: Insights in tasks logistics coordinator

A second project was started by providing insights in the tasks of the logistics coordinator. Because the results of this project can only be monitored and evaluated during nonattendance of the logistics coordinator for a longer term, the results of this project couldn’t be monitored and evaluated during the limited time of this research. By successful formalizing the outputs of the project in Shell procedures, it required an official control and approval of two assessors. The first long term nonattendance of the logistics coordinator provide possibilities to monitor and evaluate the current results of the project.

Although there is no monitored data available, the project process can be evaluated. Before the project was started, the management of Shell Pernis was already focused on the tasks related to the logistics coordinator. The logistics coordinator knew this fact and was really committed to make the research successful. During the project it became clear that the Logistics Coordinator is an important link in the web of CVP. He provides crucial information and makes decisions which affect the performance of CVP. It is remarkable that within CVP a situation is created in which one person communicates critical information with many people, but that insights in his task were almost completely missing.

The project was successful in creating these insights and secured these findings by formalizing them in official procedures. A constant trade off during the project was the level of detail. Defining and visualizing all knowledge of the logistics coordinator was not useful and endless, but certain insights in his tacit knowledge was critical for a complete overview. Finally this trade off was solved with help of other actors. It is necessary that they are able to perform the tasks of the Logistics Coordinator during his absence.

The process steps of this project are explained elaborately in chapter 8 and the methods are explained in chapter 6. However, replication of this particular project is more difficult, because it was really focused on one person. The majority of information was gathered during interviews with the Logistics Coordinator and it was not possible to standardize these conversations.

The projects also showed that by solving one problem, other problems come to light. Insights in tasks of the logistics coordinator were gathered, but during the project also new points of improvement became apparent. E.g. communication that could be improved, which is explained in more detail in paragraph 11.6.4. It was not possible to deal with these extra problems, the limited timeframe of the research made it necessary to focus on the problems within the defined scope.

11.4 Project 3: Delays of laboratory analyses

The third project was focused on the delays of samples handled by the laboratory. A difference between target times, used by the laboratory and actual times, relevant to CVP initialized this opportunity. An elaborate analysis of a large data set (1916) of actual sample times compared to target times, created clear insights and offered an opportunity for follow up actions. The independent status of the laboratory and the small influence from CVP on the laboratory made it impossible to finish this project. However the clear structured analysis, unambiguous results and a well received presentation of these results generated a nice opportunity for follow up actions in the near future initialized and lead by the laboratory.

This project was obviously more focused on analyzing data and needed less involvement of actors, compared to the other three projects. During the project, the laboratory was a very important stakeholder. This relation was different than other relations with actors that were directly involved with CVP, because the laboratory is an independent organization at Shell Pernis. The relation was
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built on creating benefits for both sides. The analyses presented at an early stage created useful insights for the laboratory and were well received, which created support and commitment during the rest of the project.

During this project more complexities were experienced than expected at the beginning. The project scope was even more important than with other projects, because the laboratory was on the edge of the research scope and could be perceived as an external party. Extra problems could not be changed and should not be dealt with. For this reason, this border was more strict and the project focused more on analyses of data. This resulted in a situation where other problems were less perceived and included, compared to the other three projects. The analyses are presented to the laboratory and follow up actions and improvements are expected from their site, because they now have good insights in the delays, which they didn’t expected.

The process steps are described in detail. The project steps taken can be replicated, because the data was delivered by the laboratory. This enables a situation in which data could be uniform delivered or used by other units at Shell Pernis, in order to create similar analyses. These analyses provides better insights in current performances and potential points of improvement.

11.5 Project 4: Optimal balance between flexibility and inventory

The final project was focused on the optimal balance between flexibility and inventory. Under normal circumstances was a minimum amount of time planned between production and delivery to trucks and/or ships. This created a critical time path in which production delays or analysis delays directly had consequences on the carriers and/or customers. The analysis executed at the previous project about samples delays, already provided a good argument to build in more flexibility. After consultation of all key stakeholders involved, a new planning philosophy was designed. This new planning method created more room between the end of production and the moment of delivery. This ‘slack time’ has a minimum negative effect on the availability of products and a significant increase in the reliability and performance of the supply chain. During normal circumstances deliveries were planned from 16.00 p.m. and onwards, in the new situation deliveries are planned from 07.00 a.m.. Which still makes it possible for day trippers to deliver the products on the same day as before, because they drive directly to the customers instead of the next morning. Because many stakeholders were involved in this complex project, it was not possible to complete this project given the limited research time. The new philosophy is agreed on with all stakeholders and recommended. However, time was too short to implement and evaluate the results, in order to evaluate and optimize the new planning method. The project team lead is transferred to the production specialist of manufacturing, who will take follow up actions and finalize the project when the results are available.

The project is not implemented during this project, which also makes it impossible to monitor the results of this project. However, it is possible to evaluate the project process. This was probably the most complicated project to create support on, because building in slack time in a supply chain is actually a philosophy that is against the Lean Six Sigma theory. Lean defines inventory as one of the seven wastes (Rother and Shook 2003), but the clear analysis presented in this document, together with support of many involved stakeholders showed insights in positive effects of slack time and an increased inventory. Within the limited time, the created support was not enough to start implementation of this project. Many stakeholders were involved and it was a too complex issue to realize the implementation within the limited timeframe of this project. It should be remarked that managing the stakeholders was at least as importance as developing the analysis during this project.
The different departments involved in this project all had different preferences, which made it more difficult to create alignment in time. However, the results and ideas are well received and supported, the project lead is handed over, so all steps are taken in order to implement the suggested measures in the near future.

The process of this project is explained in detail, but a big part of this project was related to stakeholder management. Stakeholder management is less easy to document. The previous chapters spend attention to this stakeholder management, by e.g. describing a process design, based on the four core elements, defining up front the actor field etc., but the soft skills are less easy to document. How to build up relations, how to use an independent position within an organization to bring actors together etc. is more difficult to map. For this reason the project steps can easily be replicated, but handling the relations and create support for the project outside the official described process design, will need soft skills that cannot be documented. And thus the results of similar projects like this, will also depend on the team lead and his/her position in the organization.

Before the evaluation of this particular project can be finalized, should be remarked that also during this project new problems came to light. Slack time changes the current planning method, which potentially demands extra steps and actions of the laboratory, e.g. working times at the laboratory and sample analyses constraints created new problems. Based on this project can be concluded that changes are often perceived as problems or that changes results in problems with the existing constraints of the current system.

11.6 Projects related research evaluation and recommendations

After elaborating in detail on the results of the four executed projects, it is also useful to spend attention to project related research evaluations and recommendations, which are not specifically related to one of the four projects. This paragraph addresses some major points of attention, which could be mentioned after executing the projects, but which are not directly related to one specific project.

11.6.1 Dealing with the multi-actor environment

A main element during the four projects, was to manage the involved stakeholders. In the second part of this thesis, an elaborated network analyses was executed to deal with the multi-actor environment. After executing the four projects, it is possible to evaluate the usefulness of this network analyses and to define possible points of improvements for future research.

Chapter three presented the elaborated network analysis and showed the multi-actor environment. This provided clear insights in the most important stakeholders. Based on these insights it was tried to create wide support by the involved stakeholders for the opportunities, which made it easier to create commitment for the individual projects. Several measures were taken during this research to optimize the stakeholder management. The SIPOC workshop was the first measure taken to create consensus on the processes of the supply chain. These stakeholders were also involved in the follow up phase, which defined the opportunities.

These opportunities were widely supported by the involved stakeholders, which made it easier to create commitment for the individual projects. These steps created the expected and satisfying results and are recommended to replicate during the future replication.

However, there were also some problems experienced related to the multi-actor environment. The network analysis showed four different departments, located at two different locations. During the research this was also experienced as a barrier. It was more difficult than expected at the start of the project, to create support at all four departments for implementation of a project. The focus of the
individual projects was at the CVP - Pernis location, which made it more difficult to get enough insights at the SCE - Rotterdam Alexandrium location.

After performing these four projects, some comments can be made on the organizational and formal chart presented in figure 8 and appendix 2. The organizational chart defines formal and informal relations, but in reality there are much more informal relations between the stakeholders. These relations are important, because project ideas and solutions are shared between these relations. If the project leader is not aware of these relations, it becomes more difficult to communicate effectively. This should be solved in the future by executing the network analysis iteratively, and by creating network analyses per project, at the start of a project, involving the project team members.

11.6.2 Document the process for future use
This thesis described the executed process steps of the four projects in more detail. First the methodology was explained in chapter 6 and secondly chapter 7 -10 applied the methodology on the four projects and described the project steps by step. The documentation of these process steps, makes the approach of this thesis universally applicable within comparable environments. Based on this research can be concluded that improving a planning process, with the goal to create a more reliable and predictable supply chain, is an ongoing process. The project started with the identification of opportunities and listed ten opportunities. Four opportunities were further processed in order to improve the supply chain, but six opportunities are still left. Other problems were encountered during the execution of the projects, showing elimination of opportunities does not result in a waste free supply chain without disruptions. Improving the performance of the supply chain will be an ongoing process. Now this research is executed once and all steps are documented clearly in this report, the process can be replicated in the future.

11.6.3 Recommendations for future change
The analysis phase defined ten opportunities. Four opportunities were used to start projects for improvement of the current supply chain. During the projects, it became clear that many of the problems in the supply chain are the results of other problems. In other words, many problems and thus opportunities are related to each other. This means that the effect of some of the minor problems may look small, but once analyzing and looking further it becomes clear that these small problems cause other problems, which again cause other problems, and so on. For this reason all opportunities should be taken seriously, because a small change can have big impact on the complete system. Although all opportunities could have a big impact, prioritizing the opportunities is useful, because limited time or resources can force a selection of the opportunities.

11.6.4 Communication and documentation
Findings related to two elements that are not directly linked to one of the four projects, but that are worth full mentioning are communication and documentation. These findings are presented below and are based on information gathered in part II – analyze and in part III, information gathered during the execution of the four projects.

Communication
• The most insights related to communication are gathered at the CVP departments and not at the SCE departments. Communication between actors within the organization is mainly formalized. In the current situation many reoccurring scheduled meetings should keep everybody updated and roles and responsibilities are very clear and formalized. However,
caused by this high standard of formalization, people try to keep the units running on an optimal way. Because the management is not always available and the formal way is time intensive, decisions are sometimes taken without informing the management as agreed on before.

- Critical information is shared between the logistics coordinator at CVP and one of the supply coordinators located at SCE. Together they decide on the production planning, which is based on a monthly handshake process. The production planning does influence all following processes and is a critical process in the whole system. The supply coordinators and the logistics coordinator have contact on a highly frequent basis. This means that they have several times a day contact by phone and also send each other many confirmation emails. When problems occur or changes seem necessary, they immediately get in contact and change plans, mostly on the short term. Because the threshold to get in contact with each other is almost zero, it is also easier to make changes. The effect is that changes are made frequently.

An advantage of this approach is that both employees are very experienced and reacting quickly, many problems are avoided by changing plans and keeping contact on a highly frequent basis. However, root causes of the problems are not mentioned, shared and/or diminished. So existing issues are not always solved.

By implementing a higher threshold to get in contact with each other, for example a maximum of two telecoms per day, a situation is created in which only really necessary changes are made. Not necessary changes are solved within time between the telecoms and issues are probably more frequently solved. This could improve the predictability of the planning of the supply chain.

- The logistics coordinator has a crucial role in the planning process of the supply chain. At the moment he is the daily link related to planning, between the commercial and supply departments at SCE, and the production department at CVP. Because this role is mainly fulfilled by one person, it is crucial that he communicates changes very clear to all stakeholders involved.

By sending emails to large groups of people, necessary information is shared. But does the information also reach the key stakeholders, because not everybody is reading emails instantly. The operators are not included in the emails, they are updated by a new hard copy production planning, hanged in the control room. However, it is not visual when the planning is updated. This could be improved by showing the time that the production planning changed. Sending emails could be improved by calling the key stakeholders and directly update them.

- The communication between SCE and CVP departments is not performing on a optimal level. There are restrictions between communication of the commercial department and the departments at CVP, because of potential conflicts of interests. But there are also natural restrictions, mostly created by the different locations of the departments of CVP and SCE. Because the different departments have different interests, openness between the actors is very important. The four core elements of a process design are explained in paragraph 6.3.3. These can also be used for the SCE and CVP departments. At the moment it is especially about openness, because it is not always clear what the interest of the other departments are. In the end, everybody has the same end goal, namely optimization of the performance of the complete supply chain. However, the main issue is that everybody has their sub-
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interests. By creating openness about each other’s interest and goals, the understanding is increased. This understanding creates commitment to each other’s projects. When information is not completely shared, actions are not always understood, which makes cooperation less likely.

Documentation

- The logistics coordinator uses four different documents to create and update the production planning. The four documents are a load availability list, a production planning, a laboratory list including all samples with priorities and a raw materials planning. All documents provide necessary insights, however it is possible to connect or integrate them. Integration improves the possibilities to control the actions. This will be illustrated by the next example: At the moment the raw materials planning is based on the production planning. Based on this planning, and a combination of the tacit knowledge of the logistics coordinator, the raw materials planning is updated. This tacit knowledge enables the logistics coordinator to make estimations on usage of volumes of raw materials, depending on the production planning. However, integration between these documents is missing, so the correctness is also not controlled. An integration of documents makes it also more easy to replace the logistics coordinator. When documents are automatically coupled, they control each other, which increases the reliability and predictability of the planning process. Which was the main goal of this research. Besides this advantage the tasks of the logistics coordinator become more transparent which makes it also easier to replace the logistics coordinator, which was a sub goal of this research; create better insights in this tasks.

- This recommendation is the most generic recommendation of this research and more focused on the work environment at Shell Pernis or even Shell worldwide. Almost every task at Shell is described in procedures. It is often necessary to fill in a pre-described and/or formalized document to approve or get approval for a certain process step or action. The reasons for this formalization of process steps are highly related to safety measures and the gigantic dimensions of the company. They are most of the times necessary and serve their goals, however there should be a constant focus of the management team of CVP to monitor and evaluate the degree of this formalization. During many interviews signs were received from employees about an environment which is dealing with over-formalization. This creates an environment in which behavior starts where people try to avoid these rules and legislations.

11.7 Results in context

It is now possible, after a elaborated evaluation on different aspects of the research projects, to set the results in context. The results of the research project can be split into several parts; results of the analysis, individual project results, general recommendations and a less measurable result, which can be defined as a certain consciousness created at the organization, caused by the execution of a research executed by an independent person. The results of the analyses are discussed in this chapter and not in a previous part of this research, because it was necessary to executed the four projects, before the usefulness of the analyses became clear.

The results of the analysis phase is surprisingly useful. The phase brought different departments together and provided insights in their common goal and all process steps executed in the complete
supply chain. Besides the detailed description, the insights created better understanding between the different departments. It offered the opportunity to improve certain aspects and successfully realize change. Also on the long term, when this project is finished, could this common understanding of the processes be helpful in order to start improvement projects, which are overlapping two or more departments.

The individual projects resulted in concrete results. The implemented project already proved its benefits, but also the other projects presented useful analyses which could improve the performance of the supply chain in the near future. The insights in the tasks of the logistics coordinator help to increase the reliability of the supply chain, because problems to replace this function are now intercepted by using the schematic flow diagrams. The analyses of the delays of lab samples help the laboratory to more specifically improve their performance. Although the project is not implemented yet, it already created support at the laboratory. This was an unexpected result of this research, because at the start of the project the laboratory was defined as an external stakeholder, on the edge of the scope of this research. The final project resulted in a new presented planning philosophy, which already has support in the organization. Unfortunately it is not implemented yet, but if the recommendations are implemented, this will be an unexpected good result. Unexpected, because it has a significant impact on the whole supply chain, and not only on one aspect or department. However, the fact that three of the four projects are not implemented or monitored yet, set the results also in context. Although there is confidence that these project are finished in the near future, the results would have been more worth full when they were all implemented.

Next to these concrete results, also less measurable results are gained during the research. Some recommendations provided on documentation and communication are useful. However, at the beginning of the project it seems that everything and every process could be improved. During the project it became clear that all processes are related and linked to other processes, which creates many constraints and made it not so easy to create changes as it was on first sight. By executing projects in intensive cooperation with some stakeholders, they learned at least a bit to apply some methods and theories. For example creating insights in the tasks of the logistics coordinator and visualizing them with help of schematic flow diagrams, was also useful for the Logistics Coordinator. Next to that, a different and independent viewpoint is provided and shared with them during six months. This independent viewpoint confronted the organization with their current performance and ideas. Sometimes it forced them to explain their methods and provide arguments for it, but probably more important, at the same time they evaluated the usefulness of these ideas and methods.

11.8 Conclusions and recommendations

This chapter evaluated the projects results and findings in detail on a low aggregated level. The second, third, fourth and fifth paragraph evaluated the four projects. It evaluated the stakeholder involvement, experienced complexities, results and the replication possibilities of the projects. Where possible it provides advices for improvements and does suggestions to organize follow up meetings, to finalize or monitor the project.

Paragraph 11.6 presented projects related research evaluation and provided recommendations where possible. It started to describe how to document the process for future use, then it provide recommendations for future change. It also focused on two more general elements of the organization, namely documentation and communication. After evaluating these elements, four
recommendations related to communication, and two recommendations related to documentations are described.

Paragraph 11.7 set the results of the project in context. It is concluded that only one out of four projects, was successfully monitored and implemented.
12. Transfer knowledge to the organization

12.1 Introduction

The previous chapters focused on the five development phases of the four individual projects and evaluated the results of these project. Project 1 was implemented and the control phase was executed for this project. Eight steps were taken to finalize the project and ensure it became successful. The results of these projects and more general findings gathered during the research, should be transferred to the organization. This paragraph focuses on steps and methods to transfer the knowledge to the organization.

Paragraph 12.2 describes the knowledge transfer to the organization, paragraph 12.3 presents and describes the knowledge transfer model and the last paragraph 12.4 presents the conclusions.

12.2 Knowledge transfer to the organization

The first step of transferring knowledge is taken in chapter 7, by executing the control phase and close out of a project. These steps can be applied on all projects which are in the control phase. The limited timeframe forced this research to define follow up actions, because it was not possible to bring all projects to the control phase and finalize them. The nine described steps (Shell 2008) are possible to replicate and enable the implementation of the projects. Finally they will come to the control phase, which makes sure that the results are ready to transfer to the organization. This chapter describes the steps necessary to transfer the knowledge gathered during the research to the organization. Information is not confused with knowledge: Information might be thought of as facts or understood data; however knowledge has to do with flexible and adaptable skills (Stake 2005).

Argote and Ingram (2000) define knowledge transfer as “the process through which one unit (e.g. group, department) is affected by the experience of another”. How well knowledge remains broadly accessible within a firm, depends upon the nature of that knowledge: from where or whom it comes, who gets it and the organizational context within which any transfer occurs. Szulanski (1996) compares and refers to Stickiness, a concept that derives from the difficulty of circulating fluid around an oil refinery, including effects of the fluid’s native viscosity.

Blackler (1995) defines five knowledge types, which are useful to define the best method to transfer the knowledge: embrained, embodied, encultured, embedded and encoded knowledge. Embedded, encoded and embodied knowledge are the most important knowledge types generated during this research, which should be transferred to the organization. Embodied knowledge is action orientated and consists of contextual practices. It is more of a social acquisition. How individuals interact and interpret their environment, creates this non-explicit type of knowledge. Embedded knowledge is explicit and resides within systematic routines. It relates to the relationships between role, technologies, formal procedures and emergent routines within a complex system. Finally encoded knowledge could be useful to formalize and transfer specific knowledge to the organization. This type of knowledge deals more with the transmission, storage and interrogation of knowledge.

The first necessary step before the knowledge gained during this research can be transferred, is to identify the knowledge holder(s). The knowledge holders of this research are known. The key stakeholders involved during the four individual projects, are up to date on all decisions taken and arguments to take these decisions. These project members are used by the independent researcher, which has the lead in this research and is the key knowledge holder, to transfer knowledge to. The project supervisor also has certain knowledge, but this will not be directly used during this
transferring process, but she can be used when project members have questions or problems that they cannot be solved by themselves.

The second step is to get the involved people motivated to share the knowledge. By convincing the knowledge holders that transferring the knowledge also is beneficial for them, creates enough motivation. The key knowledge holder in this research has self interests to share the knowledge, because this is one of the research demands. The knowledge gathered must be made explicit. The second argument is that the purpose of this research is to improve the current supply chain, for this reason this person is highly motivated to share the knowledge at the end of the research, because this increases the results of the research.

During the third step the mechanism to facilitate the transfer is designed. This is a slightly more complex step and directly followed by the fourth step; executing the transfer plan. These steps are described under figure 36, which provides the knowledge transfer plan.

The fifth and sixth consist of measuring the transfer and applying the knowledge transferred. These steps should be executed by the key stakeholders involved in the project and are presented as follow up action. These persons and roles are included in the knowledge transfer model, presented in figure 37. For this research, these steps are less important, because the limited time makes it impossible to complete these steps.

The knowledge transfer model presented in figure 37 is focused on the transfer of knowledge gathered during this research project. It avoids that knowledge contained at one person is lost when this person leaves the organization at the end of this research.

### 12.3 Knowledge transfer model

The knowledge transfer model presented below covers all phases described above. After all steps presented in this model are executed, the necessary knowledge is transferred to the organization. Three phases are defined, but the main focus is on the first two phases, because the limited amount of time makes it impossible to monitor, evaluate and revise the transfer of knowledge to the organization, actions defined in the third phase.

![Knowledge transfer model](image)

**Figure 37: Knowledge transfer model - Adapted from (Landon 2001)**
Phase 1: Knowledge Loss Risk Assessment

This phase is focused on the identification of all relevant knowledge gathered during this research, which should be transferred to the organization or otherwise experiences consequences of loss. Next to this it is also necessary to define the key persons where critical knowledge lost is most imminent. The essential knowledge gathered during this research will be listed hereunder and sequentially presented, based on the sequence of the appearance in this report:

- Elaborated network analysis
- Detailed description and overview of all relevant steps in the planning process of the supply chain. A result of an interactively executed workshop.
- A list of five opportunities, as a direct result of the SIPOC workshop
- A list of ten opportunities, as a result of the SIPOC workshop and several interviews performed during the research. Including a ranking of the opportunities, based on ease of implementation and impact on the organization.
- Four projects which are started, based on the opportunities.
  - Feedback delivery raw materials
  - Insights in tasks logistics coordinator
  - Delays of laboratory analyses
  - Optimal balance between flexibility and inventory
- Communication
  - Formalized procedures
  - Information sharing between logistics coordinator and supply coordinators
  - Production planning update
  - Communication between departments of CVP and SCE
- Documentation
  - Four different documents used by Logistics coordinator
  - Work environment; procedures
- Replication
  - Process description to enable replication of the research
  - Description of process improvements

The following key persons should be updated with the findings of this research. Only the management functions should be updated on all findings. The other functions can only be updated with knowledge related to their function:

- Management team of CVP (Manufacturing and Filling and Dispatch)
  - Production Unit Manager
  - Production supervisors
  - Production specialists
- Management of SCE
  - Commercial: Product manager
  - Supply: Supply manager
- CVP Operational
  - Logistics Coordinator
  - Production Administrator
  - Head operation Projects & TA Support
  - (Senior Buyer)
Efficiency analysis of a planning process in chemical industry

- SCE Operational
  - Supply coordinators
  - Focal Point Customer Relation Center
- Laboratory
  - Laboratory focal point

The knowledge transfer method presented above, also prescribes to assess the consequences of loss of knowledge. Trade offs were made before, during the creation of the list. So, all information is necessary to transfer to the organization.

**Phase 2 – I: Develop a Knowledge Retention Plan**

The second phase uses the information presented in the first phase to determine the approach to capture the critical knowledge. It is necessary to transfer all knowledge which is gathered during this research and which is presented above. However, the results of the four individual projects contain the majority of the key information.

This thesis already documented all findings and most of the time the findings are also visualized with help of figures or tables. Under normal circumstances knowledge can be classified as either explicit or tacit. Tacit knowledge is what we know, but it has not or cannot always be articulated. The visualization used in this research makes it easier to transfer the tacit knowledge and redefines tacit knowledge in explicit knowledge. Explicit knowledge can be readily transferred to others (Landon 2001). Figure 38 presented below describes different knowledge transfer practices. Difference practices are used for explicit and tacit knowledge.

![Figure 38: Knowledge transfer; explicit vs. implicit and tacit. Based on (Landon 2001)](image)

This research also dealt with different sorts of knowledge. E.g. creating insights in the tasks of the logistics coordinator could also be renamed as creating insights in the tacit knowledge of Logistics Coordinator. This thesis already described and visualized most of the findings. Visualized findings can be transferred as explicit knowledge. The measures presented below are not specifically focused on transferring implicit and tacit knowledge, because during the research most tacit knowledge was, as already explained, visualized. Only point 5 is using tacit knowledge. Because this point is assuming that the tacit knowledge contained by the project members is enough to finish the projects. These capabilities are more difficult to define and the steps that should be taken to process the projects are for this reason not exactly defined.
To be able to retain or at least diminish the loss of knowledge, the following measures are taken and together form the main input for the knowledge retention plan:

1. All findings are described and presented in this thesis document. However, this document is too elaborated to transfer the knowledge purposefully.
2. A management summary is created, to make sure that key knowledge is shared. This management summary will be send to all stakeholders involved on a management level.
3. The projects are all summarized and presented in project charters, which are added to the appendix. These project charters are commonly used by Shell, which minimizes barriers to read them and understand the findings.
4. Process flows schemes are used in the majority of cases to visualize processes. Because process flows schemes are also commonly used by Shell, it minimizes the barriers to understand the results.
5. Project teams are set-up, in order to transfer the lead of the project before the project is finished. Other team members are fully informed and capable of finishing the project.
6. Results of finished projects are secured in formal procedures (BBS3 procedures).
7. Extra tasks and actions, which are a result of the research, are secured in task lists of operational team leaders.
8. All critical stakeholders mentioned above are invited to join the final presentation, which includes a summary of the most important research findings which is necessary to share.
9. All analyses, findings and results are iteratively shared with the key stakeholders. So all results are expected, which avoids unexpected resistance of stakeholders.
10. All these measures are more successful when the knowledge is shared by the involved stakeholders to a larger group of people. Spreading the knowledge with enthusiasm and carry out the message of success will increase the group of informed people (Shell 2008).

Phase 2 – II: Implement Knowledge Retention Plan
The stakeholders that should be involved in the knowledge transfer are known. The knowledge that should be transferred is also known, and the steps necessary to transfer the knowledge are described. So only one question is remaining, how could the knowledge retention plan be implemented? This thesis already describes the steps taken and the methods used to transfer the knowledge. The measures taken to transfer the knowledge described above are hereunder sequential presented. This figure represents the different implementation steps to transfer the knowledge to the organization. Four different phases are defined; the research findings are described first, then these are summarized and visualized in formats that are commonly used within the organization, the results and new process steps/ actions are secured in the organization and finally all is presented in a final presentation. The final presentation also explains the knowledge retention plan, making sure all key stakeholders are informed about the availability of the information.
Phase 3: Monitor, Evaluate and revise

Due to the limited timeframe of the research project, it was not possible to monitor, evaluate and revise the knowledge transfer. For this reason, these steps are also not presented in the knowledge retention plan or presented as measure that should be taken. By not only transferring the knowledge to the organization, but also handing over the lead of the complete projects, a situation is created which makes it possible to monitor, evaluate and revise the knowledge transfer for specific projects in a later stadium. The management of the different departments should monitor, evaluate and revise the complete impact and success of the knowledge transfer to the organization after several weeks. Where necessary they should improve the presented plans to gain optimal results in the future during replications.

12.4 Conclusions

Chapter 6 presented the nine necessary steps taken to execute the control phase. Chapter 7 executed these steps in project 1. These nine steps make sure that the control phase of this project is properly executed. After finalizing the control phase, the project is finished. However, it is important that the information is secured in the organization and knowledge losses must be avoided. Paragraph 12.2 described and provided methods to transfer the knowledge gathered during the research.

A knowledge transfer model, presented in paragraph 12.3, provided three phases which are applied on the implemented project to make sure the knowledge is not lost. The three phases are:

- Phase 1 - Conduct a knowledge Loss Risk assessment
- Phase 2: Part I - Develop a knowledge retention plan to manage this risk
- Phase 2: Part II – Implement knowledge retention plan
- Phase 3: Part III – Monitor, evaluate and revise
Only the first two phases of this model were executed and gave satisfying results. The third phase couldn’t be executed yet, because this includes long term actions and monitors, evaluates and revises the knowledge transfer plan after 2 till 3 months. At the moment, the knowledge transfer is just finished, so the results of this knowledge transfer are not known. For this reason, the fourth phase is defined as a follow up action and will be executed by the project team.
13. DMAIC methodology evaluation

13.1 Introduction
Chapter two introduced the Lean Six Sigma theory as leading methodology during this research. This decision fitted perfectly to the work environment at Shell Pernis. Since the FFO Shell Pernis focuses on Lean Six Sigma thinking. Lean Six Sigma methods are well known at middle and higher management of Shell Pernis and employees on an operational level are also familiar with Lean Six Sigma projects and tools. This made it more easy to apply these methods (Shell 2008).
To structure the four individual projects, the classical Lean Six Sigma structure called DMAIC was applied. After executing the four projects and evaluating the results, it is now possible to evaluate the pros and cons of DMAIC.
This chapter evaluates the methodologies used during the DMAIC projects. Obviously this evaluation is focused on the DMAIC methodology, but the three theories that helped to start the projects and create successful performance improvement changes, are also evaluated.

Paragraph 13.2 evaluates the theoretical methods and paragraph 13.3 presents conclusion based on the evaluation of the DMAIC methodology.

13.2 Evaluation on the theoretical method
Chapter five started with preparation steps in order to set up the four DMAIC projects. The ten opportunities were identified and ranked. The ranking was based on information gathered by stakeholders and analyses performed. The input of stakeholders was very important in this research and the limited timeframe of the research prohibited to apply an extensive MCDA method. This made it more difficult to define exact weights on stakeholders’ opinions. However, the involvement of the stakeholders during these preparations steps, resulted in a high initial commitment and support to start four DMAIC projects.

Chapter six introduced and explained the DMAIC methodology, which was applied on the four projects in chapter 7 till 10. The underlying assumption of DMAIC, that problem solving follows predictable steps (Schroeder, Linderman et al. 2008), is confirmed during this research. During the four projects, the five development phases went naturally from one phase to another. The DMAIC phases helped to guide this process, but without DMAIC structuring the processes similar steps would have been executed as well. DMAIC helped to explain the current step of the project, but even more important, it especially provided insights to the involved project members and other stakeholders in the next steps. Although the five steps are logical steps, the DMAIC structure helped to avoid jumping to conclusions and ensured an adequate search for alternative solution to a problem (Harry 1994).
The DMAIC method places emphasis on integrating specific tools into each step of the method (Schroeder, Linderman et al. 2008). By adding additional steps from other methods and theories during start up, improve and control phases to the four projects, they were less focused on integrating specific tools into each step of the DMAIC method. However, all projects still applied DMAIC tools, which delivered useful results.
DMAIC normally involves different organizational members at different steps in the method (Schroeder, Linderman et al. 2008). The four projects executed in this research were relatively small. This created a situation in which all project team members were involved in the majority of the project meetings and project development phases. This could have been executed more efficiently,
especially in the fourth project, by splitting the project team during project meetings. It was clear that during the measure, analyze and improve phases, the process owners were more involved in the project compared to the define and control phase. In these phases, employees on a management level were more involved.

This is not the only remark about the DMAIC method related to stakeholder participation (Kwak and Anbari 2006). DMAIC does not exactly prescribe how to involve the stakeholders during the different development phases of the project. DMAIC is not focused on stakeholder participation. During the projects, two theories were used to deal with stakeholders. First the theory of de Bruijn, Heuvelhof et. al (2003), which defines the key elements of a proper process design. A process design was developed for every project, which spend attention to the four core elements. The four core elements of this process design were presented during the first meeting of a project and helped to keep the stakeholders committed to the projects. By discussing these four elements, it became clear that everyone was interested in the same high level goal; overall performance improvement. It also made sure that core values were protected, which is a benefit for everyone and diminished the chance that stakeholders leave the project and stop supporting it. Secondly, six steps for guidance for stakeholder involvement (Buhrmann unknown) were used, to make sure the stakeholders were involved in the projects in a proper way. This also helped to keep them committed to the projects.

Based on the four executed projects could be concluded that both methods were useful during the project meetings and created an open situation between the project leader and the other project team members. It created and kept the support and commitment of the stakeholders to the projects. During future replications of similar projects it is advised to gather extra information on stakeholder management and/or stakeholder involvement methods and theories. These could probably be combined with the DMAIC structure and increases the results.

After evaluating general aspects of the DMAIC method, it is possible to evaluate the DMAIC method step by step.

The define phase introduced the project, described the project goal and created a project team. The analyses executed in the first part of this research helped to start up the projects. As previously stated in the evaluation of part II – analyses, a SIPOC workshop is recommended to execute again. SIPOC created initial support and commitment to start the individual projects.

The ranking of the opportunities legitimated the decision to start the projects. Most stakeholders were already involved during the first part of the research, which made it easier to get their support and commitment.

During the define phase, DMAIC tools were used. Process flow schemes created insights in the current situation and processes. Process flow schemes were useful to share findings to the complete project team or explain problems during interviews (Harry 1994). In projects where process flow schemes were not used, it was more difficult to keep within the scope of the project.

The measure phase analyzed the project in more detail. It focused on the actor perspectives of the involved stakeholders and it defined the constraints of the current process per project. The analyze phase used the input of the previous two phases and defined the problem situation, by identifying the causes of the problems. It was not always clear where the measure phase ended and the analyze phase started. According to the theory should the measure phase be used to gather data and quantify the problem/opportunity. The analyze phase should find the root cause by delving into details (Yeh, Cheng et al. 2007). In practice, data was gathered and analyzed, which most of the times indirectly showed the root cause of the problems. The transition point was not always clear. The
DMAIC development phases of the four project were similarly presented in this report, which made it even more difficult to split the measure and analyze phases. The research did not apply specific tools in the measure phase. These were all included in the analyze phase, but these phases were not always perfect split. The analyze phase used several tools to present and analyze data and information. Tables and histograms were used to show insights in the performance of the systems. The tools or similar tools are recommended in these phases of projects. The improve phase developed solutions to diminish or eliminate the defined problems. It identified advantages and disadvantages of proposed solutions. For one project it also described how the project should be executed and implemented. Nine, more practical focused aspects (Kerzner 2008), were taken into account to structure the execution and implementation of the project. Support and commitment are very important in this phase of the project. Changes are necessary to realize improvements, and they can only become successful when the proposed changes are supported by the key stakeholders. During the four projects it was possible to involve the key stakeholders often, because the project teams were small enough. Project 4, which had a larger project team, showed that it is almost impossible to keep everybody directly updated during the project if project team are bigger. It is recommended to apply tools to deal with this issue. These tools can be used to involve stakeholders more directly, by e.g. organizing a workshop (Harry 1994). When the solution is designed, it is recommended to involve all project team members in this process. A similar method could be applied as during the identification of the opportunities. This results in more support and commitment when the changes should be implemented and executed.

The control phase, which was only executed for the first project, tests and makes the solution robust. It used nine steps to avoid failure of the project during this phase (Shell 2008). These nine steps were essential to realize successful changes. The pilot project was a crucial step during the control phase of project 1. It showed that the solution was not perfect and that new problems come to light, when other problems are solved. The earlier defined scope and project goal were used to keep the scope strictly and determine the new problems as ‘out of scope’ problems.

The four projects were not all finished and implemented during this research. However, it was possible to transfer the project lead after finishing one of the five phases. The involved project members are able to take follow up actions and realize successful changes in the near future. DMAIC helps to transfer the lead, because DMAIC does not focuses on the people (Bevan, Westwood et al. 2005), but on the processes. It is possible to replicate the projects. Based on the described DMAIC methodology in chapter 6, the described execution of these steps in chapter 7 -10 and the evaluation of this method in this chapter, it is also possible to make improvements to the future processes.

13.3 Conclusions
This chapter evaluated the DMAIC methodology, including theories and steps which were added to the DMAIC method during one of the five development phases. The evaluation was based on insights gathered during the execution of the four DMAIC projects. The first part of paragraph 13.2 focused on more general related elements of the DMAIC methodology. It spend attention to the benefits and challenges related to the structure DMAIC provides, the tools of DMAIC and to the stakeholder involvement in combination with DMAIC.

The second part of this paragraph evaluated specifically the five development phases. It draw the following conclusions: The preparation steps before the define phase were useful to start the
projects and create support and commitment. The measure and analyze phase were not always strictly divided. Support and commitment are especially important during the improve phase, when change is necessary. DMAIC tools could help to keep or get the support and of the involved stakeholders. Finally the control phase was useful. Based on nine practical focused aspects, improvements to the designed solution where made. It also helped to critically reflect on the earlier defined scope, when new problems come to light during the execution of a pilot project.
Part IV - Conclusions and recommendations
14. Conclusions and recommendations

14.1 Introduction

This final chapter draws conclusions on the complete research. Chapter 11 already evaluated the project results and chapter 13 the DMAIC method. This chapter uses this information and other input gathered during the research to answer the main research questions, provide general conclusions, reflect on the research and provide recommendations for future research and replication.

The first paragraph provides answers on the main research questions and draws conclusions on the concrete results generated by the individual executed projects. The second paragraph spends attention to the research conclusions and recommendations, followed by the third paragraph which describes general conclusions and recommendations. Paragraph 14.4 describes the effects on the organization. Paragraph 14.5 goes further into detail on possibilities to replicate the complete research. Paragraph 14.6 reflects on the process and paragraph 14.7 provides as last paragraph of this thesis, recommendations for future research.

14.2 Research conclusions and recommendations

A planning process is a crucial factor within a supply chain. In a supply chain all process steps are somehow depending on a previous process step and at the same time they are essential input for a subsequent process step. A planning tries to optimize the sequence of these process steps in order to realize a maximum performance of the supply chain. This performance can be defined in volume, profit, but also in reliability or another performance indicator. The performance indicator can vary per supply chain. It is even possible that several indicators are important.

The supply chain of polyols at Shell Pernis, on which the research was performed, included four main departments: Commercial, Supply, Manufacturing and a Filling and dispatch department. These four departments are located at different offices on different locations and all have different perspectives and perceptions on the current performance of the supply chain. At the start of the research only a fuzzy overview of the processes of the supply chain was available. It demanded cooperation between the four departments to create a complete overview of all process steps. Identification of the perspectives, interests and perceptions of the stakeholders involved helped to define this detailed overview.

All this information is necessary to answer the first main research question: What are the main factors affecting, positively or negatively, the planning process of the defined supply chain (of CVP and SCE) and what is the impact of these factors? To be able to answer this question, three sub-questions were defined, which combined provide the answer on the first main research question.

1. What are the relevant state of the art theories and practices to analyze supply chains and to identify waste and disruptions within organizations and supply chains?

The answer on the first sub-question is extensively provided in chapter 2. Six Sigma and Lean manufacturing theories were combined into the so called Lean Six Sigma approach, which was leading during this research. This theory provided several tools, e.g. SIPOC, process flow diagrams, value stream map, DMAIC and waterfall graphs. Other performance improvement methods and theories, which are focused on supply chain management, were added to this Lean Six Sigma approach. These theories formed the basis to analyze the supply chain and identify the waste. In the third part of this research four projects were started. These projects applied other theories and frameworks as well, to clarify certain aspects in more detail.
2. Which processes being performed within the commercial, production and transportation part of the supply chain are relevant for the planning process?

To answer the second sub-question, an interactive SIPOC workshop involving all key stakeholders, was organized and created a clear overview of the complete planning process. A seven steps process flow scheme was created and formed the basis to make a ten steps detailed description of the most important planning processes, including suppliers, inputs, outputs and customer. The seven steps process flow scheme is presented hereunder.

Process flow – Planning process of the supply chain of polyols

![Process flow diagram]

Figure 40: Process flow of the planning process

3. What are the most significant disruptions and waste within the processes of the CVP commercial, production and transportation unit and which causes can be identified?

The results explained and partly presented above, answered the second sub-question and created the possibility to answer the third sub-question. In an early stage this research defined four categories of problems related to planning and scheduling activities within the supply chain of polyols at Shell Pernis; changes in production plan, (non-)availability of raw materials, production problems and problems related to delivery to customers. A complete overview of the critical processes on which consensus was created during the SIPOC workshop, together with the categorization of potential problems, formed the basis to define the most significant disruptions. Disruptions affecting, positively or negatively, the planning process of the supply chain.

During the same workshop with all stakeholders involved, the five most important opportunities were listed. Further analysis and input gathered during interviews created a second list of five opportunities. These opportunities are directly related to the most significant disruptions, but are presented as chances for improvement of the supply chain. The list presented hereunder is showing the ten most relevant opportunities and completes the answer on the first main research question.

- Optimal balance between flexibility and inventory
- Feedback delivery of raw materials
- Responsibility and monitoring stock levels ‘in house’ produced raw materials
- Product quality related issues
- Reporting time vs. tonnage
- Insights in tasks of logistics coordinator
- Content and goals of monthly hand shake process
- Temporarily process of acidification of polyols
- External demand of samples
- Delays of laboratory analyses

This list is necessary input in order to answer the second main research question, which will be done hereunder. The second main research question is: Which solutions and/or recommendations can be formulated to make the planning process of the supply chain (of CVP and SCE) more predictable and reliable (robust) and how should these findings be implemented?

The ten defined opportunities were all analyzed in more detail. However, the limited timeframe of the research project made it necessary to make a selection of these opportunities. A four boxes model was applied in order to rank the ten opportunities, based on impact and ease of
implementation. The ranking enabled a selection of four opportunities, which were processed in more detail. These opportunities are: optimal balance between flexibility and inventory, feedback delivery of raw materials, insights in tasks logistics coordinator and delays of laboratory analyses. These four opportunities were used to provide answer on the fourth sub-question:

4. Which recommendations and possible solutions can be generated to improve the planning processes of the commercial, production and/or transportation division and eliminate waste?

In order to answer the fourth sub-question, project teams were set up per opportunity to improve the planning process. The project structure contained five phases; Define, Measure, Analyze, Improve and Control (DMAIC). Extra attention was given to the stakeholders involved by creating a process design which focused on four core elements; openness, protection of core-values, progress and content.

The most important findings of the four projects are presented hereunder per project:

**Project 1: Feedback delivery of raw materials**

One project is completed during this research, namely the project called: delivery of feedback of raw materials. The project goal was to diminish and finally eliminate the unexpected shortages of raw materials, caused by a lack of feedback of deliveries, which created a negative effect on the production planning. By focusing on short term internal solutions, new communication structures and standards were defined. The key stakeholders; the logistics coordinator, production administrator and Shift 6, were committed to the project from the start and were closely involved during all project phases. Several evaluations sessions optimized the solutions. Since the start of the project, delays and non-deliveries are monitored, which creates better insights and make it possible to execute follow up actions. These follow up actions are more externally focused and could create long term improvements.

**Project 2: Insights in tasks logistics coordinator**

A second project was focused on creating insights in the tasks of the logistics coordinator. Because the results of this project can only be monitored and evaluated during nonattendance of the logistics coordinator for a longer term, the results of this project couldn’t be monitored and evaluated during the limited time of this research. The outputs of the project are successfully formalized and secured in Shell procedures, which required an official control and approval of two assessors. The first long term nonattendance of the logistics coordinator provide possibilities to monitor, evaluate and improve the current results of the project.

**Project 3: Delays of laboratory analyses**

The third project was focused on the delays of samples processed by the laboratory. Differences between target times used by the laboratory, and actual times relevant to CVP, initialized this opportunity. An elaborated analysis of a large data set (1916) of actual sample times compared to target times, created clear insights and offered an opportunity for follow up actions. The independent status of the laboratory and the small influence from CVP on the laboratory, made it impossible to finish this project. However, the clear structured analysis, unambiguous results and a well received presentation of these results by the laboratory, generated a nice opportunity for follow up actions in the near future. These actions should be initialized and lead by the laboratory. Possible improvements can be expected on the midterm.

**Project 4: Optimal balance between inventory and flexibility of the supply chain**

The results of this third project were not only used as opportunity framing to improve the performance of the laboratory, the results of the actual analysis times of the samples were also a direct argument used in the fourth project. This project was focused on the optimal balance between
flexibility and inventory. Under normal circumstances a minimum amount of time was planned between production and delivery to trucks and/or ships. This created a critical time path in which even short production or analysis delays, directly negatively affected the delivery to the carriers and/or customers. The analysis showing the differences between target times and actual times was also a significant argument to make the supply chain more flexible. After consultation of all key stakeholders involved, a new planning philosophy was developed. This new planning method created more room between the end time of production and the moment of delivery, with a minimum negative effect on the availability of products, and a significant increase in the reliability and performance of the supply chain perceived by the customers. During normal circumstances deliveries were planned at 16.00 p.m. and onwards. In the new situation deliveries are planned the next morning at 07.00 a.m. But, it still is possible to deliver the products on the same day as before using day trippers. In the new situation day trippers drive on the same day to the customers, instead of the next morning. It was not possible to implement and complete this project given the limited research time, mainly caused by the involvement of many stakeholders and the complexity of the project. The new philosophy is supported by the stakeholders involved. However, time was too short to implement and evaluate the results, in order to optimize the new planning philosophy where necessary. In order to get the project implemented, the project team lead is transferred to the production specialist, who will take follow up actions to finalize the project.

The results of the projects and the solutions presented above provide answers on the fourth sub question and also partly on the fifth sub-question. It is important to remark that the lead of the projects is handed over to project team members. The project charters defined in appendix 13, were used to hand over the project properly. The fifth sub-question is presented below.

5. What steps are necessary to implement the solutions and recommendations and how could these processes be replicated?

The explanation presented above already described the status of the projects. This described the implementation steps partly and defined where necessary follow up actions per project to finalize the implementation.

To complete the answer on sub-question five, the gathered information should be transferred to the organization. A knowledge retention plan divides knowledge into explicit and implicit knowledge. Four phases, containing eight steps are defined to transfer the knowledge to the organization and avoid knowledge losses. Chapter 11 and 13 evaluated the complete research and provided insights in points of improvement and strong aspects of this research. The most important conclusions are that the Lean Six Sigma method fitted perfectly to the organization and the interactive SIPOC workshop created significant results and maximized the benefits of stakeholder participation. However, the ranking method of the opportunities and the management of stakeholders should be improved next time. These recommendations, together with the described analyses and project steps, make it possible to replicate the complete research. These findings together provide an answer on sub-question 5.

The answer on sub-question 5, combined with the answer on sub-question 4, answers the second main research question. Although the research questions are answered, there are still 6 other opportunities defined which are only presented as opportunities for improvement. This research defines these opportunities as potential improvements of the supply chain of polyols at Shell Pernis.
14.3 General conclusions and recommendations

Based on the findings done during the research, it also possible to draw some general conclusions and recommendation. The previous paragraph focused on more concrete results; the output of the individual projects. The four projects delivered the most concrete results and recommendations. However, during the research also more general insights were created and more general focused analyses were executed. This makes it possible to draw some general conclusions and recommendations, which are not directly related to one of the four projects.

Many stakeholders of the polyols’ supply chain were interviewed during the past six months. Their input, together with the experience gathered during training days and other experiences, make it possible to draw conclusions and come up with recommendations for improvement.

First three recommendations are made related to the process of the research, followed by content related recommendations.

The first recommendations is related to stakeholder management. Next time, the network analyses should be performed iteratively during the research. This makes it possible to start performance improvement project earlier. And this makes sure that all formal and informal relations are captured and the project leader is aware of these relations. This enables optimal communication between project members during the execution of the individual projects.

The second recommendation is related to several steps which were taken to deal with the multi-actor environment and resulted in satisfying results. The following three steps are recommended during replication of a similar project; first an interactive SIPOC workshop should be organized to create stakeholder participation and define the processes. Secondly the stakeholders should be involved in defining opportunities and finally the stakeholders should be involved at the start of the individual projects.

The third recommendation is to change the location where the research is executed more often. This creates varying insights from different departments and increases commitment to realize changes by all stakeholder involved.

The following recommendations are more content related. The fourth recommendation is related to the function of the logistics coordinator. The logistics coordinator is a crucial link in communication related to the planning of the supply chain and in the communication between CVP-P and SCE supply. This crucial role is currently fulfilled by one person. In cooperation with the supply coordinators the planning is created and more important, changed when necessary. Continuously information sharing between the logistics coordinator and the supply coordinators during working days, create a situation in which barriers do not exist anymore to make changes in the planning. These changes have serious consequences for the performance of the supply chain and affect many stakeholders.

Continuous updates and information sharing between these stakeholders can be prohibited or diminished by implementing a minimal barrier to contact each other. This forces the supply coordinators and logistics coordinator to start searching for other options, before changes are made to the production planning.

A fifth recommendations is related to the previous problem. The communication to the operating teams about changes in the production planning, coming from the logistics coordinator should be made more obvious. In the current situation these changes are not actively shared with the operators. A clock in the control room, defining the moment of the last update, makes this information sharing more clear.
A sixth recommendation is also related to communication and focuses on information sharing. Updates which contain necessary information for other involved stakeholders are now sent by group emails. This is not a specific problem of one employee, but more a general problem at Shell Pernis. Emails and especially group emails containing important information are sometimes not read, because employees are dealing with an overload of email traffic. Forums and central storage facilities are introduced, but not used in a proper way at the moment. The higher management should promote these facilities, because at the moment information sharing of key information is suboptimal.

A final recommendation related to communication is about the relation between SCE and CVP. One of the four core elements of a process design is not applied properly. Sufficient openness is missing, partly caused by a lack of knowledge about each other’s interests and tasks. Openness creates understanding of each other’s actions and creates commitment to help solving problems from both sides.

Two recommendations can be added related to documentation. The first recommendation is related to the tasks of the Logistics Coordinator. Currently this person is using four individual data sheets to create necessary insights in the production planning. These four related documents should be integrated into one Excel file. This makes it easier to replace the logistics coordinator and automatically controls the executed steps.

The second recommendation has a more generic focus and is related to the formalized communication at Shell Pernis. Safety standards are very important at Shell Pernis. To realize a high level of safety and in order to keep the company manageable, all actions and tasks are formalized. During the research it became clear that it is essential that the higher and middle management constantly try to find an optimal balance between the safety policy and the ability to perform the tasks properly.

14.4 Effects on the organization

The previous paragraph discussed and answered the main research questions and provided more general research recommendations. This paragraph describes in more detail the effects of the research on the organization.

The project started six months ago, initiated by the fact that insights were missing in the processes of the complete polyols’ supply chain. The logistics coordinator was seen as an important element in the supply chain, but specific insights in his tasks were missing as well. Six months later, insights in the processes of the supply chain were created with involvement of key stakeholders working at four different departments of the supply chain. These insights were visualized and made the key stakeholders more conscious of the fact that the four different departments all have the same high level goal, although they have different low level interests.

The network analysis provided for the first time an interdepartmental overview of the stakeholders’ relations and positions, including informal relations. This also helped to make the involved stakeholder more conscious of the importance of communication and cooperation between the departments.

The SIPOC workshop illustrated the benefits of stakeholder participation in performance improvement projects. The SIPOC workshop created initial support and commitment, which made it easier to start the individual projects.
Ten opportunities were defined which could improve the performance of the supply chain. Four of them were processed as individual projects. The concrete results of these projects are already discussed, however the projects also created less concrete results which affected the organization.

**Project 1: Feedback delivery of raw materials**
The first project increased the reliability of the supply chain, by diminishing the chance on unexpected shortages of raw materials. New communication structures and standards were designed and secured in the organization to improve the feedback on deliveries of raw materials to the logistics coordinator and production administrator. Besides the concrete realized improvements, it made operational employees conscious of the importance of monitoring results. Monitored results are necessary to change behavior of external parties, e.g. suppliers. The project also illustrated that even small issues can have significant effects on the total performance. The involved project members were enthusiastic to take follow up actions. By transferring the lead of the project to the logistics coordinator, he has the possibility to illustrate his capability of executing Lean Six Sigma projects.

**Project 2: Insights in tasks logistics coordinator**
The second project created insights in tasks of logistics coordinator and formalized these tasks. This increased the reliability, because his tasks can now be executed during periods of middle and long term absences. The detailed description also defines the constraints, that should be taken into account when the production planning is created and when production is monitored. A recommendation for future improvement is already provided in paragraph 14.3. Besides the concrete results, less other results were gathered during this project, mainly because the project team was small and the project was focused on one person. However, process flow schemes were used to describe tasks. This method was well received by employees acting on all levels and could be used as an example to describe other functions in the future. All insights were shared with the production supervisor and supply coordinators. These persons deal on a frequent basis with the logistics coordinator and can use the insights to improve processes or communication between each other.

**Project 3: Delays of laboratory analyses**
The third project framed an opportunity to the laboratory to improve the performance related to sample analyses of CVP samples. It showed that only 64% of the current samples is on time at the moment, and 14% is ready within 4 four hours after the target set by the laboratory. The insights were presented to the laboratory. Although there are no official actions taken by the laboratory at the moment, involved stakeholders noticed improvements of the laboratory. Since the presentation of the results, the laboratory directly informs CVP when samples are delayed. The project also showed that data analyses can provide unexpected insights. The results of the data analyses surprised the involved stakeholders. This also illustrated an important learning point that information gathered during interviews always is coloured.

**Project 4: Optimal balance between flexibility and inventory**
The final project involved all departments of the supply chain. The analyses showed that including slack time in the supply chain would significantly increase the perceived reliability of the supply chain. This could create a performance increase of 16%, without affecting deliveries of day trippers.
Potentially this percentage could be increased to 85%, but this depends on possibilities of the laboratory to perform sample analyses during the night. At the start of the project, many skeptical opinions did not believe that it was possible to realize agreements between the different departments. By involving all departments in one project, it showed that it is possible to create consensus between the departments. It also demonstrated the organization that an increased collaboration between the departments could lead to performance improvements.

It is now possible to summarize the effects on the organization. The four departments involved in the Polyols supply chain experienced benefits of the increased insights in the processes of the supply chain. The research increased the consciousness that all departments have one high level common goal. The results of the four projects were useful and already have impact on the current performance of the supply chain or will have impact in the near future, after executing some follow up actions. The performed research could be used as example to illustrate the potential of small Lean Six Sigma projects. This fits perfectly into the new improvement performance strategy at Shell Pernis; to motivate operational employees to initialize and start small individual performance improvement projects.

### 14.5 Reflection on theoretical methodologies

The previous paragraphs answered the research questions and presented some general recommendations and conclusions. Before reflecting on the complete research and going into more detail on possibilities to replicate the research, the theoretical methodologies are evaluated. This paragraph only evaluate the leading theory and two methods or tools used in this paper. First Lean Six Sigma as leading theory is evaluated. Secondly the paragraph goes in more detail on the benefits and challenges of the SIPOC workshop, finally DMAIC is evaluated. DMAIC was already elaborately evaluated in chapter 13 and SIPOC in paragraph 4.4. For this reason only the most important conclusions are repeated.

Chapter two introduced the Lean Six Sigma theory as leading methodology during this research. This decision fitted perfectly to the work environment at Shell Pernis. Since the FFO Shell Pernis focused on Lean thinking, Lean Six Sigma methods are well known at middle and higher management of Shell Pernis, which made it more easy to apply several methods, because they were understood. The project applied in first instance a Lean Six Sigma approach based on Bevan, Westwood et. al. (2005) to define four major phases during the complete research. In a later phase the classical Lean Six Sigma structure called DMAIC was applied, because this was a common applied approach at Shell Pernis (Shell 2008).

The combination of Lean Manufacturing and Six Sigma was useful in this research. The focus on quality improvement and speed both delivered benefits during this research (Bevan, Westwood et al. 2005). The limited timeframe of the research forced to focus on speed, but major parts of the research was focused on quality related problems. The applied tools were already evaluated. Tools originated from Six Sigma and Lean manufacturing showed significant results. Other methods or theories can be easily added to the leading Lean Six Sigma method, which is valuable benefit. During the execution of the projects, these extra methods were useful.
Challenges of the Lean Six Sigma method became apparent during the execution of the projects and when the SIPOC workshop was organized. These challenges are included in the evaluations on the DMAIC and SIPOC methods. Tools/Methods which are part of Lean Six Sigma.

The SIPOC workshop created successful results. It maximized the benefits of stakeholder participation in the research. Several steps were added to the normal SIPOC method. This used the benefits of stakeholder participation and minimized the challenges. These steps avoided an overload of divergent information generated by the stakeholders and resulted in an useful platform to define opportunities on. The involvement of the stakeholders this early in the process created support and commitment, which was useful during the execution of the projects.

DMAIC was useful to structure the projects and commonly used by Shell. The five development phases made it easier to explain the steps to the involved stakeholders. Although the steps are following a logical sequence, which are almost automatically processed. By adding theories helpful to start projects and using DMAIC/Lean Six Sigma tools, DMAIC was successful and delivered significant results. Next time the measure and analyze phase should be more strictly split up.

14.6 Replication
The previous paragraphs presented conclusions and defined strong and weak elements of this research. Based on these conclusions, added with some more details on the replication steps, should it be possible to replicate this research.

It is possible to divide replication of the research into four main parts; part 1; introduction, part II can be defined as; the exploration of the processes of the supply chain, the third part can be defined as; using the defined opportunities to improve the current planning process of the supply chain and finally the last part is focused on transferring the information and defining the most important research conclusions.

This report explains all process steps in detail, which makes it more easy to replicate the research. The first phase defines the problem situation and discusses the methodology and theory used. The methods and tools applied can also be used in replicated projects. The second part of this research can be replicated by performing interviews, but the most important results are generated during a SIPOC workshop. All chapters do not only describe the process steps in detail, but they also provide sources which refer to elaborated explanations on the steps, e.g. applying the SIPOC tool in small and large groups, interactively and non-interactively.

The third part of the research is focused on four projects. By applying the same DMAIC structure on all projects, it becomes easier to replicate these processes. Again the sources refer to more elaborated explanations on the steps taken. This makes it possible to replicate the process steps which are less elaborately explained. For example to develop a process design, including the four core elements.

The fourth part goes further into detail on transferring information to the organization and avoiding knowledge losses. Several frameworks and standardized steps can be replicated to gain similar results.

So far the research is very good replicable and the methods and tools explained in the chapters can be applied in order to replicate similar projects. However stakeholder involvement and getting their commitment is more difficult and differs per project. Stakeholder involvement also depends on many soft factors which are not the same for every research. The four core elements of a process design helped to deal with stakeholders and to be able to involve them in projects. E.g. during this research
the work environment was very open and most people were ready to put in time and effort, because this was presented as core element in an early phase. However, it will always depends on the stakeholders involved. These soft skills are less easy to define. For this reason stakeholder management should always be a point of attention, when a similar research or parts of the research are replicated.

14.7 Reflection
Till this moment on, this chapter mainly summarized the research results and answered the main research questions. However, reflection on the research itself is also necessary to maximize the output of this research. Even though the research presented some promising results in defining opportunities and starting and executing projects in order to improve the supply chain, also some critical remarks regarding the process can be made here.

The research was constantly dealing with a limited time frame. The time constraint influenced many decision during the project. E.g. the number of processed projects. Next time, the analyses should be executed faster or iterative. This creates more time to process opportunities. On the other hand, arguments can also be provided that the time spend on these first tasks is justifiable, because understanding a new environment and a completely new industry takes a lot of time. It took three months before the analysis phase was finished and improvement projects started. During the first weeks the output produced was lower than during the rest of the research. New procedures, new processes and a new environment took time to adapt and understand. This was extra difficult because many stakeholders were involved, all with different opinion and interests.

Stakeholder management and management of expectations of these stakeholders need improvement. Many stakeholders were involved and put effort into the project, however they also demanded output and results. Updating these stakeholders on a more frequent level could have been useful to show the progress and results of the research, in order to create more commitment. The network analysis performed in chapter 3, showed this involvement and provided insights in the roles and interests of these stakeholders. If these insights were gathered earlier, this could have made it less difficult to manage the stakeholders and diminished the ‘scope creep’ during the first months.

A subsequent planned second workshop was cancelled and followed up by more focused project meetings with less stakeholders involved. The results of the new approach were satisfying, however it could have saved a lot of energy when this approach was designed up front and the second workshop was not planned. On the other hand, a more concrete approach working towards results during the time in between the workshops, could have created a situation in which it was not necessary to cancel the workshop.

The scope of the research narrowed, as a result of the first workshop. The first workshop narrowed the scope of the research in order to maximize the results and to avoid the involvement of too many stakeholders during one workshop. Due to a limited timeframe and satisfying results of this first workshop, the scope was kept narrowed and less time was spend on issues and improvements at the filling and dispatch department. This is not a big issue, when it is properly communicated. However, communication and management of stakeholders related to this issues could have been improved.

After finalizing the analysis phase, ranking the opportunities was the next difficult step of this project. A trade off was necessary between creating output as fast as possible and presenting clear arguments to rank the opportunities. Finally a balanced approach was found by using a four boxes
model, but more time could have been spent on the analysis, the input gathered during interviews with key stakeholders was, because of a lack of a grounded analysis, of vital importance. The final difficulty perceived, is related to the implementation of the individual projects. Before the project solutions could be implemented, support of the stakeholders was of vital importance. By applying process theories of de Bruijn and Heuvelhof (2008) and using other theories, a well structured approach was defined. However, the research project did not succeed to realize implementations of the four projects. It was too complicated to create enough alignment by all key stakeholders to implement the projects within the given time constrain.

The most satisfying part of the project was the interactive SIPOC workshop. During a morning session, attended by all key stakeholders involved, the preparations and information gathered during interviews came together, resulting in a detailed overview of the complete processes and several points of improvement. The created motivation of the stakeholders and other preparations done up front, together with a clear and structured designed workshop based on methods and literature, all perfectly came together during one session, which produced very satisfying results. The essential preparations up front, made it possible to understand the input and lead the workshop in the direction which was determined up front.

14.8 Future research

After evaluating, concluding and reflecting on the complete research, it is now possible to define recommendation for future research.

An important recommendation is to execute the defined follow up actions of the four projects. Significant effort is put into the analysis and start of the project, minor future efforts can realize implementations of these projects and increase the current performance of the supply chain. Secondly, attention should be given to the six remaining opportunities. The origin of these six opportunities is explained elaborately and also background information on the opportunities is provided. These opportunities should be processed as individual projects. The project lead should be handed to involved stakeholders per opportunity, possibly to stakeholders on operational levels. Furthermore some extra effort can put into the project of the delayed samples. The data on the delays of the sample analysis are accurate, however it does not shows the differences compared to a deadline of 16.00 o’clock and the actual time. These insights are an improvement and better insights than the current analysis, however a tradeoff between input and benefit is necessary.

Besides future research related to the performance improvement projects, it is also possible to perform future research on the possibilities to involve stakeholders in project where Lean Six Sigma is applied as leading methodology. This research illustrated that a SIPOC workshop could deliver significant and satisfying results. It described the steps taken in detail and provided benefits and challenges of these methods. Future research should be executed on the possibilities to increase stakeholder participation, which is qualitatively focused, in the quantitative focused Lean Six Sigma methodology (Kessler 2004).

The final recommendation is to frequently use students to execute a research project at Shell Pernis. An independent opinion and independent executed research is very useful within the current environment at Shell Pernis. It provides new insights and could for example critically evaluate one of the points of attention mentioned in this chapter.
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Appendices

Appendix 1- schematic overview production units

CVP has three units producing polyols: Phoenix, Flexibles and the Sannest. Polyols can be divided into Polymer polyols, case polyols, rigid and flexible polyols. Figure 41 presents an overview of the production units. This creates insights in the different products delivered by the different units.
## 2.1 – stakeholder analysis

<table>
<thead>
<tr>
<th>Actor</th>
<th>Interest</th>
<th>Aim</th>
<th>Problem perception</th>
<th>Causes</th>
<th>Solution directions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Management</strong></td>
<td><strong>Production Unit manager</strong></td>
<td><strong>Continuity and efficiency of Production Unit. Realize targeted goals.</strong></td>
<td>Decrease the sensitivity of disruptions, decrease cost. Clarity of responsibilities and tasks.</td>
<td>Performance can always be better.</td>
<td>Planning complexity, production complexity, responsibility complexity. Increase robustness of supply chain, by increasing insights and decreasing sensitiveness to disruptions.</td>
</tr>
<tr>
<td><strong>Management CVP – production</strong></td>
<td><strong>Continuity and efficiency of Production unit</strong></td>
<td>Decrease the sensitivity of disruptions, decrease cost.</td>
<td>Production process is too sensitive of disruptions. Not robust enough.</td>
<td>Planning complexity, production complexity, responsibility complexity. Increase robustness of supply chain, by increasing insights and decreasing sensitiveness to disruptions.</td>
<td></td>
</tr>
<tr>
<td><strong>Management CVP – filling and dispatch</strong></td>
<td><strong>Continuity and efficiency of filling and dispatch unit. Maximize satisfaction by customers/carriers.</strong></td>
<td>Decrease the sensitivity to disruptions, decrease cost.</td>
<td>Production process is too sensitive of disruptions. Not robust enough.</td>
<td>Planning complexity, production complexity, responsibility complexity. Increase robustness of supply chain, by increasing insights and decreasing sensitiveness to disruptions.</td>
<td></td>
</tr>
<tr>
<td><strong>Management SCE - commercial</strong></td>
<td><strong>Continuity and efficiency, maximize customer satisfaction and maximize profit.</strong></td>
<td>Maximize customer satisfaction, maximize turnover, maximize flexibility, minimize costs and maximize profit.</td>
<td>Production process is too sensitive of disruptions. Not robust enough.</td>
<td>Planning complexity, production complexity, responsibility complexity. Increase robustness of supply chain, by increasing insights and decreasing sensitiveness to disruptions.</td>
<td></td>
</tr>
<tr>
<td><strong>Management SCE - supply</strong></td>
<td><strong>Continuity and efficiency. Maximize satisfaction by customers/carriers.</strong></td>
<td>Maximize customer satisfaction, minimize sensitivity to disruptions.</td>
<td>Production process is too sensitive to disruptions. Not robust enough, which creates a lot of extra work.</td>
<td>Planning complexity, production complexity, responsibility complexity. Increase robustness of supply chain, by increasing insights and decreasing sensitiveness to disruptions.</td>
<td></td>
</tr>
<tr>
<td><strong>Executive employees Polyolene</strong></td>
<td><strong>Team leader (PTL)</strong></td>
<td><strong>Produce the order list within the given timeframe</strong></td>
<td>Increase the performance of the polyols production (their unit).</td>
<td>The polyols production can perform better, e.g. small batch sizes.</td>
<td>External influences (Lack of raw materials, quality issues raw materials, inefficient machines) Increase machine reliability, always have enough raw materials, larger batches.</td>
</tr>
<tr>
<td><strong>Operators</strong></td>
<td><strong>Maximum output of their part of the production process.</strong></td>
<td><strong>Maximum output of their part of the production process.</strong></td>
<td>Their part of the production can be higher, caused by e.g. small batch sizes.</td>
<td>Too often quality related issues or production related issues.</td>
<td>Bigger buffers in the production line, higher storages, better maintenance.</td>
</tr>
</tbody>
</table>
### Efficiency analysis of a planning process in chemical industry

<table>
<thead>
<tr>
<th>Role</th>
<th>Task</th>
<th>Associated Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Planner</td>
<td>Produce the order list within the given timeframe and maximize continuity and efficiency.</td>
<td>Planning is changed too frequently. Decisions based on knowledge, not on procedures etc. Tacit knowledge instead of procedures etc.</td>
</tr>
<tr>
<td>Executive employees</td>
<td>Realise the order list within the given timeframe and maximize continuity and efficiency.</td>
<td>IT systems are not integrated, communication lines are not clear. Minimize queues by number of orders by forecasting and planning tools. Minimize trucks on the site.</td>
</tr>
<tr>
<td>Traffic Office</td>
<td>Increase performance by reducing time on site and queues.</td>
<td>Bigger buffers in the production line, higher storages, better maintenance.</td>
</tr>
<tr>
<td>Operators</td>
<td>Maximum output of their part of the production process.</td>
<td>Bigger buffers in the production line, higher storages, better maintenance.</td>
</tr>
<tr>
<td>Team leader (PTL)</td>
<td>Produce the order list within the given timeframe</td>
<td>Increase machine reliability, always have enough raw materials, larger batches.</td>
</tr>
<tr>
<td>Customer relation center (+ Team leader)</td>
<td>Optimize customer satisfaction and optimize contact with the customer.</td>
<td>Increase machine reliability, always have enough raw materials, larger batches.</td>
</tr>
<tr>
<td>Executives</td>
<td>Optimize communication and coordination between order and order delivery.</td>
<td>Increasing machine reliability, always have enough raw materials, larger batches.</td>
</tr>
<tr>
<td>Coordinators supply chain</td>
<td>Maximize customer satisfaction and profit.</td>
<td>Better coordination, less often changing of production planning and better insights in effects of changes in planning.</td>
</tr>
<tr>
<td>HSSE supervisors</td>
<td>Optimize safe work environment. Clarity about life saving rules.</td>
<td>Better coordination, less often changing of production planning and better insights in effects of changes in planning.</td>
</tr>
<tr>
<td>Managemen</td>
<td>Continuity and Decrease Production Planning Increase</td>
<td>Better coordination, less often changing of production planning and better insights in effects of changes in planning.</td>
</tr>
<tr>
<td>Stakeholder</td>
<td>Issue</td>
<td>Goal</td>
</tr>
<tr>
<td>-------------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>t of Shell Pernis</td>
<td>Efficiency of the site. Maximize satisfaction by customers, maximize profit, minimize disturbance to neighbours and minimize accidents.</td>
<td>costs, maximize profit, maximize customer satisfaction, minimize accidents.</td>
</tr>
<tr>
<td>Reliability engineer</td>
<td>Continuity and reliability of Production unit</td>
<td>Decrease number of breakdowns and total breakdown time of disruptions.</td>
</tr>
<tr>
<td>Maintenance engineers</td>
<td>Perform preventive and reactive maintenance as fast and good as possible.</td>
<td>Minimize turnaround time and total breakdown time of disruptions.</td>
</tr>
<tr>
<td>External parties</td>
<td>External Raw Materials Suppliers</td>
<td>Produce and deliver on time, with the lowest costs.</td>
</tr>
<tr>
<td>Carriers</td>
<td>Maximize volume, minimize cost, maximize flexibility of Shell, maximize time slots.</td>
<td>Maximize profit and customer satisfaction.</td>
</tr>
<tr>
<td>Customer</td>
<td>Minimize product prize and on time delivery.</td>
<td>100% on time delivery against lowest prices.</td>
</tr>
<tr>
<td>Refinery of Moerdijk – EO/PO Supplier</td>
<td>Continuity and efficiency. Produce and deliver on time, with the lowest costs and right quality.</td>
<td>Deliver on time with the lowest costs.</td>
</tr>
<tr>
<td>Local government</td>
<td>Compliance from Shell and partners of the laws and regulations.</td>
<td>Zero violations of the permits or law.</td>
</tr>
</tbody>
</table>

Table 5: Stakeholder analysis
Efficiency analysis of a planning process in chemical industry

2.1 – stakeholder analysis

2.2 Formal card of involved stakeholders

[Diagram showing formal card of involved stakeholders]

Figure 42: Formal card of involved stakeholders
<table>
<thead>
<tr>
<th>Actor</th>
<th>Resources</th>
<th>Replaceable</th>
<th>Recourse importance</th>
<th>Critical actor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>Production Unit manager</td>
<td>Formal highest authority; central position; end responsibility</td>
<td>Not on short term due to education and experience.</td>
<td>Big, Yes</td>
</tr>
<tr>
<td>Management</td>
<td>Management CVP – production</td>
<td>Formal authority; central position; end responsibility</td>
<td>Irreplaceable</td>
<td>Big, Yes</td>
</tr>
<tr>
<td>Management</td>
<td>Management CVP – filling and dispatch</td>
<td>Formal authority; central position; end responsibility</td>
<td>Irreplaceable</td>
<td>Big, Yes</td>
</tr>
<tr>
<td>Management</td>
<td>Management SCE - commercial</td>
<td>Formal authority; central position; end responsibility</td>
<td>Irreplaceable</td>
<td>Big, Yes</td>
</tr>
<tr>
<td>Management</td>
<td>Management SCE - supply</td>
<td>Formal authority; central position; end responsibility</td>
<td>Irreplaceable</td>
<td>Big, Yes</td>
</tr>
<tr>
<td>Executive employees Production</td>
<td>Team leaders (PTL)</td>
<td>Tacit knowledge; Operators trust; Education</td>
<td>Not on short term due to education</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Executive employees Production</td>
<td>Operators</td>
<td>Tacit knowledge; education</td>
<td>In relative short term</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Executive employees Production</td>
<td>Logistics planner</td>
<td>Extreme amount of tacit knowledge concerning the planning; planners trust; operators trust</td>
<td>Almost irreplaceable (currently)</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Executive employees Filling and dispatch</td>
<td>Traffic Office</td>
<td>Tacit knowledge; education</td>
<td>Not on short term due to education</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Executive employees Filling and dispatch</td>
<td>Operators</td>
<td>Tacit knowledge; education</td>
<td>In relative short term</td>
<td>Medium, Yes, on short term</td>
</tr>
<tr>
<td>Executive employees Filling and dispatch</td>
<td>Team leaders (PTL)</td>
<td>Tacit knowledge; Operators trust; Education</td>
<td>Not on short term due to education</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Executive employees Commercial</td>
<td>Customer relation centre (+ Team leader)</td>
<td>Tacit knowledge; education</td>
<td>In relative short term</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Executive employees supply</td>
<td>Coordination planners</td>
<td>Tacit knowledge; education</td>
<td>Not on short term due to education</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Cross organization parties</td>
<td>HSSE supervisors</td>
<td>Tacit knowledge; education</td>
<td>Irreplaceable</td>
<td>Medium, No</td>
</tr>
<tr>
<td>Cross organization parties</td>
<td>Management of Shell Pernis</td>
<td>Formal authority; central position; end responsibility</td>
<td>Irreplaceable</td>
<td>Medium, Yes</td>
</tr>
<tr>
<td>Cross organization parties</td>
<td>Reliability engineer (CVP)</td>
<td>Tacit knowledge; education</td>
<td>Not on short term due to education</td>
<td>Medium, No</td>
</tr>
<tr>
<td>Cross organization parties</td>
<td>Operational Maintenance coordinator</td>
<td>Tacit knowledge; education</td>
<td>Not on short term due to education</td>
<td>Medium, No</td>
</tr>
<tr>
<td>External parties</td>
<td>Local government</td>
<td>Permits needed to produce</td>
<td>Irreplaceable</td>
<td>Medium, Yes, on short term</td>
</tr>
<tr>
<td>External parties</td>
<td>Raw materials suppliers</td>
<td>Materials needed to produce</td>
<td>Irreplaceable for PO; others almost irreplaceable</td>
<td>Big, Yes, on short term</td>
</tr>
<tr>
<td>Carriers</td>
<td>Transport needed to sell products</td>
<td>In relative short term</td>
<td>Big</td>
<td>Yes, on short term</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------</td>
<td>------------------------</td>
<td>-----</td>
<td>--------------------</td>
</tr>
<tr>
<td>Customer</td>
<td>Money needed to make profit</td>
<td>Irreplaceable</td>
<td>Big</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 6: Stakeholder analysis - Resources
Appendix 3 – SADT analysis

3.1 Interaction ‘as is’

3.2 Interaction ‘to be’

Figure 43: Interaction ‘as is’

Figure 44: Interaction ‘to be’
3.3 SADT

Figure 45: SADT - A0
3.4 A0 planning process

Figure 46: SADT – A0 Planning process
3.5 A1 Commercial

2 timelines

Figure 47: SADT - A1 Commercial
3.6 A2 Supply

Figure 48: SADT - A2 Supply
3.7 A3 Production

Figure 49: SADT - A3 Supply
3.8 A4 Filling and dispatch

Figure 50: SADT - A4 filling and dispatch

3.9 A5 Transportation

Figure 51: SADT - A5 transportation
## Appendix 4 – SIPOC (Suppliers Inputs Process Outputs Customers)

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Inputs</th>
<th>Process</th>
<th>Outputs</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product managers</td>
<td></td>
<td>1 Demand and capacity forecast</td>
<td></td>
<td>Production specialists; Maarten Steenbakker and Kelvin Cheng</td>
</tr>
<tr>
<td></td>
<td>Seizonyality: based on history</td>
<td></td>
<td>Output DF: [kt/grade]; flex, case, san; [per year and per month]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expected customer demand (strategy, growth expectations, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expected availability; Production and Swap/toll buy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production specialists;</td>
<td>Input CVP: Demand forecast [kt/grade] and [g/month]</td>
<td></td>
<td>Output CVP: Technical availability based on grade slate --&gt; translated [kt/day]</td>
<td>Supply Manager; Rik Onrust</td>
</tr>
<tr>
<td></td>
<td>Input CVP: Reliability performance (incl. turn arounds) [%]</td>
<td></td>
<td>Output PO/EO; Technical availability [kt/yr] PO</td>
<td></td>
</tr>
<tr>
<td>Reliability engineers</td>
<td>Input PO/EO Moerdijk: Reliability performance (inc. turn arounds) [%]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Demand forecast
2. Production planning Monthly
2.1 Enterprise optimisation modelling (GMOS)

2.2 Hand Shake review; commercial, supply, manufacturing

3 Production planning daily
Efficiency analysis of a planning process in chemical industry

Supply coordinators;
Demand (of SCE)
Input by phone, email and excel

Inventory (daily)

3.1 Production planning SCE
Production planning; batches and grades/day

Customer SCE; Logistics coordinator; Wolter Donker

Production planning; batches and grades/day

Actual performance of the units

RNS maintenance

Running planning

Inventory (daily)

3.2 Running planning CVP
Laad/los beschikbaarheid

Customer CVP; Operation and RLP

Shift 6

Order list; raw materials, excel (bestellijst)

Logistics coordinator;

Production (running) planning

4 Order adjuvants and raw materials

Inventory raw materials

Recepis

delivery time

4.1 Order adjuvants and raw materials

Logistics coordinator;

Production supervisor;

Operators

Production planning; Excel, daily updated

5 Make products

Resource planning

Raw materials

5.1 Make products

Product in tanks, ready for analysis

CVP; Production Supervisor, Giel Kempers

6 Analysis (take sample)
<table>
<thead>
<tr>
<th>CVP operations</th>
<th>Sample (+ analysis)</th>
<th>6.1 Tank analysis; RLP</th>
<th>Sample result visible in Lims</th>
<th>CVP: Production supervisor, Giel Kempers</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCE (priority setting)</td>
<td>Sample priority</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLP (Laboratory)</td>
<td>On spec result (GSAP)</td>
<td>7 Product on-spec (free tanks)</td>
<td>On-spec Product available in tank</td>
<td>CVP: Filling and Dispatch, Production supervisor, John Gillesen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 5 – Overview of the opportunities

This appendix presents an overview of the ten opportunities partly defined during the workshop and partly defined during follow up meetings.

<table>
<thead>
<tr>
<th>Point of improvement</th>
<th>Opportunity</th>
<th>Input</th>
<th>Key stakeholders</th>
<th>Priority</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insight in tasks logistics coordinator</strong></td>
<td>Integrate raw material planning with production planning</td>
<td>a) Current files, constraints and recipes of process</td>
<td>Logistics coordinator</td>
<td>Low</td>
<td>Technical (Excel)</td>
</tr>
<tr>
<td></td>
<td>Integrate four different documents into one document, create targets.</td>
<td>a) Create more opportunities for taking decisions by PTL and operators</td>
<td>Logistics coordinator - PTL and operators</td>
<td>Low</td>
<td>Technical (Excel)</td>
</tr>
<tr>
<td></td>
<td>Insight in steps to create production planning and constraints.</td>
<td>a) Overview of valves, pumps and pipes</td>
<td>Logistics coordinator - Production supervisor</td>
<td>Medium/High (Reason to hire an intern)</td>
<td>Organization and technical</td>
</tr>
<tr>
<td><strong>Balance in flexibility of production and minimal inventory</strong></td>
<td>Define optimal stock level.</td>
<td>a) Costs demurrages and delays in delivery</td>
<td>Production specialist – Supply manager –</td>
<td>High impact, complex, possibly difficult to change?</td>
<td>Technical; analysis is technical, implementation or recommendation is communication, organization</td>
</tr>
<tr>
<td></td>
<td>b) Costs of higher inventory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Production planning and storage constraints</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Feedback (non) delivery of raw materials</strong></td>
<td>Formalize feedback processes of ‘Shift 6’ to production planner and supply coordinators</td>
<td>a) Identify current feedback process</td>
<td>Logistics coordinator - Supply coordinators - Operators - Shift 6</td>
<td>High → easy solution, medium impact.</td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td>b) Analyze possible incentives of delays in deliveries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Responsibility and monitoring stock of ‘in house’ ingredients</strong></td>
<td>Define and formalize responsibility of in house ingredients. Ppg 315, md30-08, g800 (s2000 en mpg cat).</td>
<td>a) Current responsibilities and overview of current process. b) Current problems.</td>
<td>-Logistics coordinator -Supply coordinator</td>
<td>Low</td>
<td>Communication, organization</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Quality related issues (off-spec production)</strong></td>
<td>Need more information on this subject</td>
<td>Waiver procedure (off-spec production) or? Waiver already site wide.</td>
<td></td>
<td>Could be high and complex</td>
<td>Technical, communication, organization</td>
</tr>
<tr>
<td><strong>Reporting time vs tonnage</strong></td>
<td>Different interest by commercial and production. Create uniform reporting style. Less discussion of setting and monitoring targets.</td>
<td>a) Current reporting. b) Interests and constraints.</td>
<td>-Product manager – Production specialist – Supply manager –</td>
<td>Medium</td>
<td>Communication, technical possibilities</td>
</tr>
<tr>
<td><strong>Content and goals of hand shake process</strong></td>
<td>More possible than current output. Also a possible evaluative function.</td>
<td>a) Current process b) Interests and goals of stakeholders c) Develop new format.</td>
<td>-Product manager – Production specialist – Supply manager –</td>
<td>Low/medium</td>
<td>Communication, organization</td>
</tr>
<tr>
<td><strong>Acidify ‘Aanzuring’</strong></td>
<td>Time is critical during this process. Not monitored enough. (A temporarily measure, till Staircase project is finished.)</td>
<td>a) Define current problems and causes. b) Define responsibilities</td>
<td>-Production specialist – Logistics coordinator – PTL and operators</td>
<td>Low – focus on production process</td>
<td>Technical, organization</td>
</tr>
<tr>
<td><strong>External demand of samples</strong></td>
<td>External demand creates instantaneous extra work.</td>
<td>a) How often does this happen? b) Is it necessary?</td>
<td>-Logistics coordinator – External Shell locations (Amsterdam)</td>
<td>Low</td>
<td>Communication, technical possibilities</td>
</tr>
</tbody>
</table>
### Efficiency analysis of a planning process in chemical industry

**Appendices**

<table>
<thead>
<tr>
<th>Lab analysis; delays</th>
<th>Target times are used instead of actual times. Also other causes can create long delays</th>
<th>a) How often does this happen? b) Is it possible to use actual times?</th>
<th>Laboratory Focal point - Logistics coordinator</th>
<th>Low – laboratory on the edge of my scope</th>
<th>Technical; constraints and causes, organization target setting.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delays of hauliers; ships and trucks</td>
<td>External causes; Out of scope.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 8: Overview of the opportunities*
Appendix 6 – Ranking the opportunities
The analyses presented hereunder support figure 13 in paragraph 5.3 and present the ranking of the ten opportunities defined in chapter 5. The analysis is based on a Multi Criteria Analysis. Which makes it possible to compare different criteria together. Because it is too difficult to define ease of implementation and the impact of the opportunities without reference or additional criteria, this analysis is used.

Based on three different criteria for success, namely: flexibility of the supply chain in general, frequency of occurrence and quality of forecast and evaluation is the impact determined of the opportunities. Based on the time, costs and resources is the ease of implementation determined. Comparing different criteria and summing them up in one category is always a bit of problem. Because this makes the weighting of the factors arbitrary. For this reason four categories are used. By using these boxes it is only necessary to define the two axes; impact and ease of implementation, as high or low. By using these four boxes, presented in figure 27 and figure 13, can be dealt with the disadvantage of the MCA and comparing different criteria without weighing the criteria.

![Figure 52: Legenda of boxes](image)

![Figure 53: MCA total overview](image)
### Figure 54: MCA group 1 - success factor based on frequency of occurrence

<table>
<thead>
<tr>
<th>Success Factors</th>
<th>Time</th>
<th>Costs</th>
<th>Resources</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback (delay)</td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Responsibility</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>Product quality</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Sales strategy</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

### Figure 55: MCA group 2 - success factor based on forecast and evaluation quality

<table>
<thead>
<tr>
<th>Success Factors</th>
<th>Time</th>
<th>Costs</th>
<th>Resources</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production time</td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Lead time</td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Flexibility</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

### Figure 56: MCA group 3 - success factor based on flexibility of supply chain in general

<table>
<thead>
<tr>
<th>Success Factors</th>
<th>Time</th>
<th>Costs</th>
<th>Resources</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production time</td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Flexibility</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
Appendix 7 – Overview of delayed samples

This part of the appendix is deleted for reasons of confidentiality
Overview of all samples

<table>
<thead>
<tr>
<th>#</th>
<th>on time</th>
<th>&lt;1</th>
<th>1-4</th>
<th>4-8</th>
<th>8-12</th>
<th>12-16</th>
<th>16-20</th>
<th>20-24</th>
<th>24-48</th>
<th>&gt;48</th>
<th>Total</th>
<th># delayed samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>174</td>
<td>13</td>
<td>18</td>
<td>7</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>13</td>
<td>248</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average delay per group</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0.38</td>
<td>2.17</td>
<td>5.32</td>
<td>10.05</td>
<td>14.18</td>
<td>17.76</td>
<td>22.11</td>
<td>37.75</td>
<td>294.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.41</td>
<td>39.11</td>
<td>37.21</td>
<td>20.11</td>
<td>85.11</td>
<td>124.30</td>
<td>88.43</td>
<td>151.01</td>
<td>3828.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1.42</td>
<td>2.14</td>
<td>2.53</td>
<td>4.05</td>
<td>5.86</td>
<td>7.00</td>
<td>9.02</td>
<td>59.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>70.16%</td>
<td>24%</td>
<td>7.26%</td>
<td>2.82%</td>
<td>0.81%</td>
<td>2.42%</td>
<td>2.82%</td>
<td>1.61%</td>
<td>1.61%</td>
<td>5.24%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#</th>
<th>on time</th>
<th>&lt;1</th>
<th>1-4</th>
<th>4-8</th>
<th>8-12</th>
<th>12-16</th>
<th>16-20</th>
<th>20-24</th>
<th>24-48</th>
<th>&gt;48</th>
<th>Total</th>
<th># delayed samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>28</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>60</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average delay per group</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0.50</td>
<td>1.82</td>
<td>5.01</td>
<td>0.00</td>
<td>15.33</td>
<td>0.00</td>
<td>22.11</td>
<td>34.71</td>
<td>291.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.01</td>
<td>16.39</td>
<td>10.01</td>
<td>0.00</td>
<td>46.00</td>
<td>0.00</td>
<td>22.11</td>
<td>138.86</td>
<td>875.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1.13</td>
<td>1.50</td>
<td>1.50</td>
<td>3.23</td>
<td>3.23</td>
<td>3.98</td>
<td>8.22</td>
<td>34.81</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td>46.67%</td>
<td>16.67%</td>
<td>15.00%</td>
<td>3.33%</td>
<td>0.00%</td>
<td>5.00%</td>
<td>0.00%</td>
<td>1.67%</td>
<td>6.67%</td>
<td>5.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#</th>
<th>on time</th>
<th>&lt;1</th>
<th>1-4</th>
<th>4-8</th>
<th>8-12</th>
<th>12-16</th>
<th>16-20</th>
<th>20-24</th>
<th>24-48</th>
<th>&gt;48</th>
<th>Total</th>
<th># delayed samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>36</td>
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<td>3</td>
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<td>2</td>
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<td>5</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>Average delay per group</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0.26</td>
<td>2.51</td>
<td>4.60</td>
<td>10.33</td>
<td>14.01</td>
<td>17.02</td>
<td>21.63</td>
<td>38.51</td>
<td>274.14</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>22.62</td>
<td>49.41</td>
<td>44.67</td>
<td>45.39</td>
<td>145.88</td>
<td>43.26</td>
<td>143.30</td>
<td>642.04</td>
<td>3511.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>11.31</td>
<td>24.01</td>
<td>19.45</td>
<td>16.21</td>
<td>25.67</td>
<td>25.09</td>
<td>29.09</td>
<td>45.46</td>
<td>154.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>54.55%</td>
<td>3.03%</td>
<td>1.52%</td>
<td>4.55%</td>
<td>6.06%</td>
<td>3.03%</td>
<td>3.03%</td>
<td>4.55%</td>
<td>12.12%</td>
<td>7.58%</td>
<td>100.00%</td>
</tr>
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</table>
## Overview of delayed samples

<table>
<thead>
<tr>
<th></th>
<th>&lt;1</th>
<th>1-4</th>
<th>4-8</th>
<th>8-12</th>
<th>12-16</th>
<th>16-20</th>
<th>20-24</th>
<th>24-48</th>
<th>&gt;48</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># samples</strong></td>
<td>13</td>
<td>18</td>
<td>7</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>13</td>
<td>74</td>
</tr>
<tr>
<td><strong>Average delay per group (Hours)</strong></td>
<td>0,38</td>
<td>2,17</td>
<td>5,32</td>
<td>10,05</td>
<td>14,18</td>
<td>17,76</td>
<td>22,11</td>
<td>37,75</td>
<td>294,49</td>
<td></td>
</tr>
<tr>
<td><strong>Total hours delay</strong></td>
<td>4,91</td>
<td>39,11</td>
<td>37,21</td>
<td>20,11</td>
<td>85,11</td>
<td>124,30</td>
<td>88,43</td>
<td>151,01</td>
<td>3828,41</td>
<td></td>
</tr>
<tr>
<td><strong>Average total delay</strong></td>
<td>0,38</td>
<td>1,42</td>
<td>2,14</td>
<td>2,53</td>
<td>4,05</td>
<td>5,86</td>
<td>7,00</td>
<td>9,02</td>
<td>59,17</td>
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</tr>
<tr>
<td><strong>% group</strong></td>
<td>17,57%</td>
<td>24,32%</td>
<td>9,46%</td>
<td>2,70%</td>
<td>9,46%</td>
<td>5,41%</td>
<td>5,41%</td>
<td>17,57%</td>
<td>100,00%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>&lt;1</th>
<th>1-4</th>
<th>4-8</th>
<th>8-12</th>
<th>12-16</th>
<th>16-20</th>
<th>20-24</th>
<th>24-48</th>
<th>&gt;48</th>
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<tr>
<td><strong># samples</strong></td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td><strong>Average delay per group (Hours)</strong></td>
<td>0,50</td>
<td>1,82</td>
<td>5,01</td>
<td>0,00</td>
<td>15,33</td>
<td>0,00</td>
<td>22,11</td>
<td>34,71</td>
<td>291,86</td>
<td></td>
</tr>
<tr>
<td><strong>Total hours delay</strong></td>
<td>5,01</td>
<td>16,39</td>
<td>10,01</td>
<td>0,00</td>
<td>46,00</td>
<td>0,00</td>
<td>22,11</td>
<td>138,86</td>
<td>875,58</td>
<td></td>
</tr>
<tr>
<td><strong>Average total delay</strong></td>
<td>0,50</td>
<td>1,13</td>
<td>1,50</td>
<td>1,50</td>
<td>3,23</td>
<td>3,23</td>
<td>3,98</td>
<td>8,22</td>
<td>34,81</td>
<td></td>
</tr>
<tr>
<td><strong>% group</strong></td>
<td>31,25%</td>
<td>28,13%</td>
<td>6,25%</td>
<td>0,00%</td>
<td>9,38%</td>
<td>0,00%</td>
<td>3,13%</td>
<td>12,50%</td>
<td>9,38%</td>
<td>100,00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>&lt;1</th>
<th>1-4</th>
<th>4-8</th>
<th>8-12</th>
<th>12-16</th>
<th>16-20</th>
<th>20-24</th>
<th>24-48</th>
<th>&gt;48</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># samples</strong></td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td><strong>Average delay per group (Hours)</strong></td>
<td>0,26</td>
<td>2,51</td>
<td>4,60</td>
<td>10,33</td>
<td>14,01</td>
<td>17,02</td>
<td>21,63</td>
<td>38,51</td>
<td>274,14</td>
<td></td>
</tr>
<tr>
<td><strong>Total hours delay</strong></td>
<td>22,40</td>
<td>49,19</td>
<td>44,61</td>
<td>45,38</td>
<td>145,81</td>
<td>43,23</td>
<td>143,27</td>
<td>641,96</td>
<td>3510,97</td>
<td></td>
</tr>
<tr>
<td><strong>Average total delay (Hours)</strong></td>
<td>11,20</td>
<td>23,86</td>
<td>19,37</td>
<td>16,16</td>
<td>25,62</td>
<td>25,04</td>
<td>29,05</td>
<td>45,43</td>
<td>154,89</td>
<td></td>
</tr>
<tr>
<td><strong>% group</strong></td>
<td>6,67%</td>
<td>3,33%</td>
<td>10,00%</td>
<td>13,33%</td>
<td>6,67%</td>
<td>6,67%</td>
<td>10,00%</td>
<td>26,67%</td>
<td>16,67%</td>
<td>100,00%</td>
</tr>
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</table>
Appendix 8 – Overview of analyses performed 24/7

This appendix is deleted for reasons of confidentiality
### Appendix 9 – Overview of the interviews, training days TU Delft meetings

<table>
<thead>
<tr>
<th>Interviews</th>
<th>Function</th>
<th>Location</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Production specialist - CVP filling and dispatch</td>
<td>CVP (SC 12)</td>
<td>Introduction, transport of products and kick-off document</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>CVP (SC 12)</td>
<td>Organizing a workshop; sharing SADT</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>CVP (SC 12)</td>
<td>Organizing a follow up workshop: Focus on points of improvement</td>
</tr>
<tr>
<td>2</td>
<td>Section POLG - Coordinator graduation students</td>
<td>TU Delft - TBM</td>
<td>Introduction involving organizational theories and network analysis</td>
</tr>
<tr>
<td>3</td>
<td>Production planner</td>
<td>CVP-Production</td>
<td>Insights in steps to create a production planning</td>
</tr>
<tr>
<td>4</td>
<td>Production specialist - CVP production polyols</td>
<td>CVP (SC 12)</td>
<td>Introduction in supply chain and communication between departments</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>CVP (SC 12)</td>
<td>Organizing a workshop; sharing SADT</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>CVP (SC 12)</td>
<td>Organizing a SIPOC workshop</td>
</tr>
<tr>
<td>5</td>
<td>Production supervisor</td>
<td>CVP (SC 12)</td>
<td>Expectations of the responsible person of the production unit.</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>CVP (SC 12)</td>
<td>Prioritizing the opportunities</td>
</tr>
<tr>
<td>6</td>
<td>Supply Manager SMPO</td>
<td>SCE</td>
<td>Delineation, goals of SCE and introduction with Rik</td>
</tr>
<tr>
<td>7</td>
<td>Junior supply manager caradols</td>
<td>SCE</td>
<td>Insights in complete supply chain. Nelke has experience at CVP and SCE.</td>
</tr>
<tr>
<td>8</td>
<td>PU-Manager CVP</td>
<td>CVP (SC 12)</td>
<td>Shell mentor; Finalizing and communicating research proposal</td>
</tr>
<tr>
<td>9</td>
<td>Process Improvement Program Manager</td>
<td>Telecom</td>
<td>Black belt (Lean Six Sigma), manager of improvement projects recent years, sharing information and sources.</td>
</tr>
<tr>
<td>10</td>
<td>Supply chain coordinators</td>
<td>SCE</td>
<td>Insights in supply chain and supply and planning processes at SCE</td>
</tr>
<tr>
<td>11</td>
<td>Supply chain coordinators</td>
<td>SCE</td>
<td>Insights in supply chain and planning processes at SCE</td>
</tr>
<tr>
<td>12</td>
<td>Logistics optimizer</td>
<td>SCE</td>
<td>Sharing information, also from a SEPAM background.</td>
</tr>
<tr>
<td>13</td>
<td>Administrative Support Traffic Office</td>
<td>TO</td>
<td>Information about LOLA, planning and scheduling trucks and ships</td>
</tr>
<tr>
<td>14</td>
<td>Traffic office team lead</td>
<td>TO</td>
<td>Information about Time on site, queues, procedures TO</td>
</tr>
</tbody>
</table>
Efficiency analysis of a planning process in chemical industry

<table>
<thead>
<tr>
<th>Table 9: Overview of performed interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Who</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 10: Overview of training days</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Who</strong></td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>17</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>19</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>
Appendix 10 – Insights in tasks logistics coordinator

**Figure 57: Insights Logistics Coordinator - Subtask 1**

1. Check monsters in Lims
   - Check monsters for the correct person
   - Check monsters for the correct location
   - Check monsters for the correct time
   - Check monsters for the correct lab

2. Check monsters Monsters
   - Check monsters for the correct person
   - Check monsters for the correct location
   - Check monsters for the correct time
   - Check monsters for the correct lab

**Figure 58: Insights Logistics Coordinator - Subtask 2**

1. Aanmelden, tussentijds checken en update pro’s monsters
   - Aanmelden check
   - Tussentijd check
   - Update pro's monsters

2. Aanmelden monsters
   - Aanmelden monsters
   - Update pro's monsters
   - Check monsters
   - Update pro's monsters
Efficiency analysis of a planning process in chemical industry

Figure 59: Insights Logistics Coordinator - Subtask 3

Figure 60: Insights Logistics Coordinator - Subtask 4
Figure 61: Insights Logistics Coordinator - Subtask 5

Figure 62: Insights Logistics Coordinator - Subtask 6
Figure 63: Insights Logistics Coordinator - Subtask 7
Checken analyses en tanks geplande verkoop en reserves (GSAP)

Ja

Nee

Voldoende stock aanwezig?

Ja

Nee

Voldoende stock vrijgegeven?

Ja

Nee

Analyses uitstaan LIMS?

Ja

Nee

Oplossen; contact met Lab

Ja

Nee

Off-spec?

Ja

Nee

Off-spec traject starten

Ja

Nee

Verschil Lims en GSAP schadelijk?

Ja

Nee

Off-spec traject starten: Probleem escaleren.
Appendix 11 – Monitored data
The table below presents monitored data on the deliveries of raw materials at CVP-P. It provides data based on three monitored weeks.

This appendix is deleted for reasons of confidentiality

Table 11: Monitored data - deliveries raw materials
## Appendix 12 – List of abbreviations

The table presented below defines all abbreviations used in this report:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBS</td>
<td>Bedrijfs Beheers Systeem (Company Administration System)</td>
</tr>
<tr>
<td>CRC</td>
<td>Customer Relation Center. Located at SCE and responsible of information sharing with customers</td>
</tr>
<tr>
<td>CVP</td>
<td>Chemische Verladingen Polyolen (Chemical, Filling and Dispatch, Polyols)</td>
</tr>
<tr>
<td>DMAIC</td>
<td>Define, Measure, Analyse, Improve, Control</td>
</tr>
<tr>
<td>FFO</td>
<td>Flexible Flexship Organisation</td>
</tr>
<tr>
<td>GAME</td>
<td>Global Asset Management Excellence</td>
</tr>
<tr>
<td>MCA</td>
<td>Multi Criteria Analysis</td>
</tr>
<tr>
<td>Shift 6</td>
<td>Team of operators, working at the production site of CVP. They are responsible for deliveries of raw materials and a particular part of the filling and dispatch, which is outside the responsibility of the CVP-filling and dispatch department.</td>
</tr>
<tr>
<td>VSM</td>
<td>Value Stream Map</td>
</tr>
</tbody>
</table>

*Table 12: List of abbreviations*
# Appendix 13 – Project Charters

## Chart: Insights in tasks logistics coordinator

<table>
<thead>
<tr>
<th>Business Case</th>
<th>Project problem (Pain/Frustration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insights in tasks of logistics coordinator (LC) should be improved in order to avoid future planning related production problems at CVP, during middle and long term absence periods of the LC.</td>
<td>The LC is responsible for the production planning. The production planning is a crucial element in the polyolefin supply chain. During the last years the LC slowly developed his own working manners and tasks in order to make sure that the units are operating on an optimal level. Many years of experience meant a lot of task knowledge, which is now used to perform the tasks. A lack of documentation of this tasks makes it difficult to replace the LC and execute the tasks properly. This negatively affects the performance of CVP production, during middle and long term absences of the LC.</td>
</tr>
</tbody>
</table>

## Scope

<table>
<thead>
<tr>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>All tasks of the logistics coordinator which are somehow related to the production planning.</td>
<td>All other tasks</td>
</tr>
</tbody>
</table>

How valuable was an aspect not mentioned in this scope? What is missing/missing in it & how makes it worse? |

## Project Goal

Improvement of the current insights in tasks of the LC, by developing flow diagram which visualizes and document these tasks in detail. This makes it easier to replace the LC during middle and long term absence, and diminishes planning and production problems during period of absence. The tasks are secured in BBS3 procedures.

## Expected benefits

Not possible to quantify, but benefits are expected during middle and long term periods of absence of the LC. Production planning is during absence of LC not a constraining factor anymore. Stress is reduced.

## Project Schedule

<table>
<thead>
<tr>
<th>Start</th>
<th>Finish</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define 1-nov-10</td>
<td>20-nov-10</td>
<td>DMA phases are executed</td>
</tr>
<tr>
<td>Measure 1-nov-10</td>
<td>30-nov-10</td>
<td></td>
</tr>
<tr>
<td>Analyze 20-nov-10</td>
<td>2-nov-10</td>
<td></td>
</tr>
<tr>
<td>Improve 1-dec-10</td>
<td>20-dec-10</td>
<td></td>
</tr>
<tr>
<td>Control 20-dec-10</td>
<td>8-jan-11</td>
<td></td>
</tr>
<tr>
<td>Handover 14-feb-11</td>
<td></td>
<td>Finalizing project is possible after middle or long term absence of LC</td>
</tr>
</tbody>
</table>

## Project Team/Resources

<table>
<thead>
<tr>
<th>BLT/PMT Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics Procurement Manager CVP</td>
</tr>
<tr>
<td>Project Leader/Project Manager</td>
</tr>
<tr>
<td>Management Agent/MER</td>
</tr>
<tr>
<td>Team Members (Team CVP, Logistics Coordinator CVP and Production Supervisor (Controlling function))</td>
</tr>
</tbody>
</table>

Figure 65: Project Charter - Insight in tasks LC
**Charter: Feedback of delivery raw materials**

**Business Case**
Improving the communication between shifts and the Logistics Coordinator (LC) and Production Administration (PA) improves the reliability of the supply chain, because unexpected shortages of raw materials are eliminated. Money related investments are zero, effort of stakeholders is needed.

**Project problem (Pain/Frustration)**
Deliveries of raw materials are disrupted by the supplier, delays or no deliveries are an exception. Lack of information sharing between shifts and the Logistics Coordinator and/or production administrator delays necessary insights in deliveries of raw materials, which primarily lead to necessary changes in production planning and result in production problems.

<table>
<thead>
<tr>
<th>Scope</th>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>All deliveries of raw materials at CVP</td>
<td>All other deliveries</td>
<td></td>
</tr>
</tbody>
</table>

**Project Goal**
The first step is to diminish the unexpected shortages of raw materials by implementing an internally focused new control and feedback structure. The second step is to eliminate the unexpected shortage of raw materials, by taking externally focused actions, based on monitored data, to increase the performance of the supplier.

**Expected benefits**
It is impossible to quantify the benefits because of a lack of monitored data. However, it will improve the reliability and performance of the supply chain because unexpected shortage of raw materials are eliminated.

**Project Schedule**

<table>
<thead>
<tr>
<th>Start</th>
<th>Finish</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>1-nov-10</td>
<td>1-dec-10</td>
</tr>
<tr>
<td>Measure</td>
<td>1-nov-10</td>
<td>31-dec-10</td>
</tr>
<tr>
<td>Analyse</td>
<td>1-mar-10</td>
<td>31-mar-10</td>
</tr>
<tr>
<td>Improve</td>
<td>1-apr-10</td>
<td>20-may-10</td>
</tr>
<tr>
<td>Control</td>
<td>20-may-10</td>
<td>20-may-10</td>
</tr>
<tr>
<td>Handover</td>
<td>15-juin-11</td>
<td>Project lead is transferred to LC</td>
</tr>
</tbody>
</table>

**Project Team/Resources**
- SMP: Sponsor
- Logc: Process Engineer
- Intern CVP
- Project Lead/Presentation
- Improvement Agency/MEB
- Team Members: Intern CVP, Logistics Coordinator, Production Administrator, Shift B. Second part, externally focused: senior buyer is also involved.

---

**Figure 66: Project Charter - Feedback delivery of Raw Materials**
## Figure 67: Project Charter - Delayed samples analyses CVP

### Charter:

**Delayed sample analyses CVP**

### Business Case

Results of sample analyses delivered after the expected target time negatively affect the performance of the Polyolefins supply chain. Insights in the current performance of the laboratory is necessary information to convince the laboratory to improve the current performance of CVP’s sample analyses, or change the current target times.

### Scope

<table>
<thead>
<tr>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory results and sample analyses</td>
<td>Other issues related to the times of CVP samples.</td>
</tr>
</tbody>
</table>

- **What were we not on?**
  - What is missing in the plan and how can it be improved?
- **What are we aiming for?**
  - What is the expected performance in the future?

### Project Problem (Pain/Problem)

The laboratory uses target times to provide a time indication for the supply of the samples, in this case CVP. These target times are used by CVP in their production and delivery scheduling. The current situation often deviates from these target times, which negatively affects the performance of CVP. However, insights are missing to prove these deviations and make action.

### Project Goal

Create deeper insights in target times set by the laboratory to analyse samples and actual sample analysis times. Based on the results are recommendations provided to the laboratory focal point, potential understanding and support of laboratory is generated to realize performance improvements.

### Expected Benefits

The benefits depend on support of the laboratory and results of the analyses. A significant improvement is possible, new target times are set or current system of target times is changed.

### Project Schedule

<table>
<thead>
<tr>
<th>Phase</th>
<th>Start</th>
<th>Finish</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>1-Dec</td>
<td>14-Dec</td>
<td></td>
</tr>
<tr>
<td>Measure</td>
<td>1-Dec</td>
<td>14-Dec</td>
<td></td>
</tr>
<tr>
<td>Analyze</td>
<td>15-Dec</td>
<td>31-Dec</td>
<td></td>
</tr>
<tr>
<td>Improve</td>
<td>1-Jan</td>
<td>14-Jan</td>
<td>Project results and recommendations are handed over to laboratory</td>
</tr>
<tr>
<td>Control</td>
<td>15-Jan</td>
<td>14-Jul</td>
<td>Project results and recommendations are handed over to laboratory</td>
</tr>
</tbody>
</table>

### Project Team/Resources

- **Technical Support**
  - Lab Analysts: Intern CVP
  - Project Lead/Process: Intern CVP
  - Improvement Analyst: Intern CVP
  - Lab Analysts: Intern CVP, Laboratory focal point for CVP, Production Specialists of CVP
**Charter: Optimal balance between flexibility and inventory**

**Business Case**

The current supply chain of physicians is subject to delays. These delays are directly noticed by the carers (and customers) and affect their perceived performance and reliability of the supply chain. Long planning leadtimes in the planning of the supply chain could probably have more positive effects than negative effects, and will increase the perceived reliability and performance of the supply chain.

**Project problem (Pain/Frustration)**

Three sets of problems: production problems, product quality issues, and supply delays, are causing delays in the supply chain. These delays are directly noticed by the carers (and customers), because the current planning method does not include slack time. These delays affect the perceived reliability of the supply chain.

**Scope**

<table>
<thead>
<tr>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>The research focuses on the benefits of slack time and does not provide an exact optimum based on an extensive detailed analysis.</td>
<td>All elements which are related to an exact optimum between flexibility and inventory.</td>
</tr>
</tbody>
</table>

**Project Goal**

Slack time, between the expected moment that items are ready for sale and the scheduled deliveries, should be included in the planning process, in order to increase the reliability of the supply chain, which is perceived by the carers and customers.

**Expected benefits**

It is not possible to quantify the expected benefits. Perceived reliability is increased and stress for employees is reduced. Slack time of 4 hours will at least generate a performance increase of 14%.

**Project Schedule**

<table>
<thead>
<tr>
<th>Start</th>
<th>Finish</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>1-Nov-10</td>
<td>22-Nov-10</td>
</tr>
<tr>
<td>Measure</td>
<td>1-Nov-10</td>
<td>22-Nov-10</td>
</tr>
<tr>
<td>Analyse</td>
<td>22-Nov-10</td>
<td>31-Nov-10</td>
</tr>
<tr>
<td>Improve</td>
<td>1-Dec-10</td>
<td>23-Dec-10</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handover</td>
<td>14-Feb-11</td>
<td></td>
</tr>
</tbody>
</table>

**Project Team/Resources**

- **STFMT Scrum**: 1
- **Local Process Manager**: Intern CVP
- **Project Lead Process**: Intern CVP
- **Team Member**: Intern CVP, Production Specialist CVP, Product Manager, Logistics Coordinator, Supply Coordinator, Laboratory Focal Point, Manager of Customer Relationship Center

Figure 68: Project Charter - Optimal balance between flexibility and inventory
Efficiency analysis of a planning process in chemical industry

Literature


Efficiency analysis of a planning process in chemical industry


Rother, M. and J. Shook. Learning to See: Value-Stream Mapping to create value and eliminate muda.


Wiesenfelder, H. and M. McDonough (2010). "Introduction to DMAIC." Bright Hub - The Hub for Bright Minds.

