


Kuhn Production System

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Kuhn Production System

Supplying material to the shop floor in an efficient way

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Executive Summary

In 2009 we, students of the University of Twente, started our thesis at Kuhn. Kuhn is part of the Bucher-Guyer group and manufactures a wide-range of specialized agricultural machinery. These machines are produced worldwide at eight facilities and distributed all over the world through a widely spread distribution channel. The mission of the organization is to design and manufacture specialized, innovative and high-quality products for agricultural use (1). With it all actions aim to provide the customer with superior service, maximum return on investment (ROI) and optimal long-term value. To achieve this mission the organization strives for a continuous development. This development is supported by all available values and contributed to the success and growth of the Kuhn brand over the last 181 years.

Today, Bucher-Guyer describes Kuhn as *“the world’s leading manufacturer of specialized agricultural machinery”* (2). With it a lot of responsibility and pressure is created. To cope with this and continuously improve the Kuhn brand, Kuhn realized in 2006 project CAP10 and implemented it under the appropriate name *“ONE”*. Through ONE Kuhn wants to unite all business units and make them work together to foster partnerships with both customers and suppliers (1). On top of that through their adherence to ONE each facility promises to involve employees, measure progress, develop synergies throughout the organization and continuously improve the performance.

Continuous improvement (CI) of the performances can be found throughout the organization. To structure these improvements and develop synergy throughout the organization, Kuhn implemented the strategic initiative "*Kuhn Production System*" (KPS) into ONE. KPS establishes a set of common manufacturing practices in order to achieve a world class manufacturing organization. One of these practices is supply management of which currently two pilots, at Kuhn Monswiller (MGM) and Kuhn Audureau (KAU), take place. Both these models focus on supplying material to the shop floor in a different way.

In order to optimally benefit from the two models Kuhn desires a detailed description, an analysis and a comparison of both models. This followed by rating the models’ performances regarding waste elimination and establishing a list of practical best cases. Through these steps Kuhn aims to achieve their goal, which we stated as:

> *“Kuhn’s goal is to combine theory and best practices to achieve the optimal production environment for their facilities. However each process is different and the required support is not everywhere the same. To cope with this Kuhn has currently divided the KPS into modules so that each site can apply the modules as desired. This resulted for each site in a unique setup that over time diverged even further by CI. Therefore to create structure and learn from each other Kuhn wants to describe the supply flows of both pilot sites and compare them so that the best practices can be incorporated in KPS. With it Kuhn strives for an optimal production environment that can be introduced at new facilities such as Kuhn Geldrop (the Netherlands).”*

With this report we want to contribute to Kuhn's goals. This by complying to the organization's need for a detail description of the current supply flows, a comparison of these flows and an illustration of their performance. By filling in these three blanks we hope to contribute to Kuhn's strive for perfection and provide them with recommendations that lead to waste elimination and improvement of the current supply flows. Additional to these main goals our secondary objectives are to provide some background information on both the organization and Lean Manufacturing (LM). The first is to get an understanding of the organization where this research is conducted and their perspective towards the future. The second is to increase the overall knowledge of the reader so that parts of this report can be understood better.

To achieve both Kuhn´s and our personal goals we stated six research questions. Through these questions we wanted to structure this research and present the results in an orderly fashion. The first step in this process was to provide the reader with background information on Kuhn and Lean Manufacturing (Research Question 1: *What is Lean Manufacturing (LM)?*). With this background information we advanced deeper into this topic by researching how Kuhn incorporated Lean in their KPS (Research question 2: *What is Kuhn Production System (KPS)?*). During this we saw that, like Toyota, Kuhn defines seven waste types. These seven waste types (Muda) are used to measure the performance of a supply flow and can therefore be seen as Kuhn's seven KPI (Research question 3: *What Key Performance Indicators (KPI) does Kuhn distinguish?*).

By answering this third research question we took our first major step towards satisfying Kuhn's need of rating the supply flow performances of both pilot sites. However in order to actually rate them, we first had to get familiar with these flows. This was easier said than done, because only parts of the supply flows were documented. To fill in the blanks we visited both sites multiple times and gathered information through observation and communication. By combining this tacit knowledge with the explicit knowledge of the available documentation, we created an elaborate description of how both sites manage and execute their supply flows (Research question 4). With it we aimed to satisfy Kuhn's need for a full coverage of these supply flows. On top of that with these descriptions we provided ourselves with an additional information source for the comparison and rating.

With Kuhn's first need satisfied we shifted our attention toward fulfilling their second need, namely that of illustrating the main differences between the pilot sites (Research question 5). As desired by Kuhn, we focused on highlighting the main differences on organization and strategical/tactical level. Once this was executed we choose to advance deeper and also provide a comparison on operational level. By doing so we wanted to provide Kuhn with some additional information and illustrate the impact that some processes have on the seven KPI.

By answering research questions three, four and five we established the necessary information pool to rate the supply flows' performances (Research question 6). However before we could actually rate them we still required two elements, namely a score card and rating system. The first of these two elements was easily created, because the scorecard should represent how well each pilot site (KAU and MGM) performs on the KPI. Therefore we set up a seven by two matrix (seven KPI by two pilot sites). Once this score card was created, the only obstacle remaining was the need of a rating system.

Due to the seven unique KPI and the differences in the supply flows we choose to develop our own rating system. This rating system is unique and both sites start with the ten-point maximum. From this, points are extracted depending on how well each site performs on the KPI criteria.

Apart from using the performance ratings for individual recommendations we also used it to create an overview of the practical best cases. By combining these practical best cases we formed our recommendation to improve the KPS. This is a combination of MGM's internal order creation (TDM) and order preparation (three-dimensional retrieval and multiple internal orders per retrieval route) with KAU’s internal order release (half a shift in advance) and methods of delivering internal orders to the shop floor (supply train plus improved carriers such as color-coded bins, picking chariots and rollers).

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Abbreviations

B.V.	- Besloten Vennootschap (= Private Company)
CAD	- Computer Aided Design
CEO	- Chief Executive Officer
CI	- Continuous Improvement
CM	- Continuous Movement
CV	- Customer Value
FGI	- Finished Goods Inventory
IE	- Industrial Engineers
ISO	- International Organization for Standardization
JIT	- Just in Time
KAU	- Kuhn Audureau (France)
KNL	- Kuhn Geldrop (the Netherlands)
KPI	- Key Performance Indicator
KPS	- Kuhn Production System
LM	- Lean Manufacturing
MGM	- Kuhn Monswiller (France)
MRP	- Material Resource Planning
NVAP	- Non-Value Added processes
PTS	- Physical Transformation Stream
R&D	- Research & Development
ROI	- Return on Investment
S.A	- Société anonyme (= public limited company)
TPS	- Toyota Production System
TT	- Takt Time
U.S.A.	- United States of America
VAP	- Value Added processes
VSM	- Value stream mapping
WIP	- Work in Progress

Definitions

Address Position	=	An article's storage location from where the warehouse employee can retrieved the desired quantity in order to fulfill shop floors demand.
Lean Manufacturing	=	A systematic approach that strives to maximize customer value while minimize waste in the production process
Picking	=	Retrieval of the exact quantity required by a workstation in order to complete the tasks at hand in a given time-bucket.
Random sampling	=	A method in which a fraction (control group) of the total quantity (sample space) is used to determine the overall quantity.
Replenishment	=	Restoring the inventory position of an address position from which an employee retrieves articles.
Retrieving	=	Collecting the desired articles stated on an internal order.
S-Shape walking pattern	=	Walking pattern that leads the employee in an S-shape through the warehouse, while passing all address positions in a continuous flow.
Storage	=	Storing of supplied handling units.
Waste or Muda	=	An excess that is not required to successfully execute and complete the tasks at hand

Preface

At the University of Twente it is obligated to finalize a master with a thesis. During this thesis the student shows that he or she is capable of putting the learned material to practice. This is done by working at least six months on a (literature) research at either a company of choice or the university. With this idea we came into contact with The Kuhn Group located in Saverne, France. After some correspondence by email we were invited to come to Saverne and talk about doing a thesis assignment there. During this meeting several projects were discussed, some more practical than others. One of these projects concerned improving the Kuhn Production System (KPS) and implementing it at the new Kuhn location, Kuhn Geldrop (KNL). This project seemed ambitious and promising. Therefore with the project in mind we returned to the university to request approval.

This approval did not come because according to the university some parts were too practical. Therefore the original project was unsuited as thesis and some adjustments were required. These adjustments concerned the implementation process at KNL. With this in mind we went back to Kuhn, where we and the project leader adjusted our role in the project. This resulted in the following problem statement and project.

"Kuhn Production System (KPS) establishes a set of common manufacturing practices in order to achieve a world class manufacturing organization. One of these practices is the supply management in which currently two pilots take place, namely at Kuhn Monswiller (MGM) and Kuhn Audureau (KAU). Both models focus on material supply to the shop floor in a different way. This makes them suitable for a wide range of situations, but each with its advantages and disadvantages. To optimally benefit from the two models, a description and analysis of both models is desired so that an overview of the practical best cases can be created. Based on these practical best cases can be decided what the best configuration is to implement at Kuhn Geldrop (KNL). Additionally it is necessary to investigate the possibilities of merging these practical best cases, so that an optimal model can be integrated within the KPS."

With the problem statement we returned to the university and there we received approval to start the thesis. This was realized on the 20th of May, 2009 when we started to work on the first desired deliverable namely a description of the current supply flow between warehouse and assembly line (IST-situation) at MGM. After this deliverable we also worked on the KAU's IST-situation, the comparison of both sites and rating of both systems in order to find the practical best cases and to improve the KPS.

Acknowledgements

A project like this is impossible to execute all by yourself because it requires a lot of knowledge about the organization and processes. Therefore to succeed you rely on colleagues and supervisors providing you with the desired information and freedom to observe the processes. Both this information and the room to freely maneuver were proved by the organization. For this I want to sincerely thank the Kuhn organization and its employees.

With this general gratitude expressed I want to address a few persons personally. The first two are misters Philippe Lang and Roland Rieger. I would like to show my appreciation to you both for the time you reserved to meet me and discuss the opportunities for a thesis at Kuhn. With this meeting the first step towards the realization of this thesis was taken. *For this I thank you!*

The second "person" that I want to show my appreciation to are the employees of Kuhn Monswiller (MGM). This is for providing me with information on their supply flow and the freedom to observe this flow. With this freedom I was able to see the flow in action and create my own opinion about it. However not everything could be understand by just observing. Therefore by communicating with the employees I gained information that would otherwise not be uncovered. With it I was able to fill in the remaining blanks. *For this I thank you!*

What applies for MGM also applies for KAU and especially for mister François Cazier. During my stay, even as short as it was, I was allowed to move around freely to observe the supply flow and talk to the shop floor workers. This freedom made it possible to establish a picture of the supply flow in just three days. This combined with the information I gathered during meetings with you, mister Cazier, and the information you send me made it possible for me to describe KAU's IST-situation. *For this I thank you!*

Furthermore I want to pay my gratitude towards three persons, namely misters Mathieu Palys, Lionel Kiefer and Laurent Froehlicher for the information you provided. With your information I was able to understand the Information Systems (IS) and information flows of both pilot sites. On top of that you provided me with data from ERPK and TDM, making it possible for me to conduct the rating. *For this I thank you!*

Additionally I want to pay my gratitude towards my neighbors of the design department. While this research did not have any connections to their department they received me with open arms and offered me a work place. Surrounded by their present and the contact we had, made me feel less of a stranger in a country abroad. *For this I thank you!*

With this said I want to turn my attention to the last, but certainly not least person at Kuhn, mister Jean-François Bablin. Under your supervision I conduct this research and found myself lucky to have you as my supervisor. Your knowledge of the processes at KAU and MGM were a beacon of light for me. Guiding me through the tough moments and providing me with a large quantity of information. On top of that with your knowledge on Lean Manufacturing (LM) you opened a new world for me. A world I will probably hear a lot about in the years to come, but due to you I will already have some basic knowledge on this topic. These two aspects together with your hospitality and especially your patience with me showed me that I was privileged to have you as supervisor, and mentor during this last phase of my education. *For this I thank you sincere!*

Besides my gratitude to the employees of Kuhn I want to also show my gratitude to my primary supervisor from the university mister Peter Schuur. After the research approval you received a request to act as a supervisor. This request you accept willingly and from our first meeting you showed a lot of interest towards this research and its progress. This interest did not fade over the course of time and each time we meet you showed your enthusiasm but also occasionally your concerns. However the way you highlighted your feedback I always experience pleasantly and it was an important source of information for me. With it I knew how to continue my report and where I had to focus on. On top of that during this long period of time in which I worked on this research your door was always open to me. This made it easier for me to turn to you when I required your expertise. *For this I thank you!*

The last person I want to thank is my second supervisor from the university mister Christiaan Katsma. After a long preliminary process with mister Schuur you were asked to step in and act as second supervisor. With it you had only a short period of time to get acquainted with this project and the results till so far. Still you were willing to take on this task and provide me with useful feedback before I handed in my final version. *For this I thank you!*

Enschede, August 10th, 2010

B.J.A. ten Doeschate

1. Introduction

In 2009 we, students of the University of Twente, started our thesis at Kuhn. During this period we want to contribute to Kuhn's goals. This by satisfying the organization's desired for a detail description of the current supply flows of their two pilot sites (Kuhn Audureau and Monswiller), a comparison of these flows and an illustration of their performance. By filling in these three blanks we hope to contribute to Kuhn's strive for perfection and provide them with recommendations that lead to waste elimination and the improvement of the current supply flows.

Additional to these main goals our secondary objectives are to provide the reader with some background information on the organization and introduce them to the world of Lean Manufacturing (LM). The first is to get an understanding of the organization where this research is conducted and their perspective towards the future. The second is to increase the overall knowledge of the reader and to provide the origin of methods and approaches used by Kuhn.

To achieve these goals we conducted both literature and practical research. The results of this lay before you. However before we start reporting our findings, we will first dedicate this introductory chapter to describe the problem, project, goals and research outline in more detail. To do this in a structured manner we divided this chapter into six sections. These sections are:

- *The introduction of Kuhn and their strive for perfection* *(section 1.1)*
- *The problem at hand* *(section 1.2)*
- *The goals of both Kuhn and ourselves* *(section 1.3)*
- *The research scope* *(section 1.4)*
- *The research questions* *(section* 1.5*)*
- *The research outline* *(section 1.6)*

1.1 Introduction

Since its origin in 1828 Kuhn developed from a small modest village forge into *“the world’s leading manufacturer of specialized agricultural machinery”* (2). To achieve this Kuhn focused on their four factors of success. One of these success factors is customer loyalty which reflects the customer’s appreciation for the delivered goods. Therefore a returning customer should not be recognized as another paycheck, but as a positive feedback on previous work. However customer loyalty does not come cheap and you harvest what you seed. This means that the more dedication the company has towards fulfilling the customer’s need, the higher the chance that customer satisfaction and with it loyalty are established. It is therefore important that all stakeholders have a common goal, namely to serve the customer as best as possible.

Customer satisfaction can be measure with the triangle of competition. This triangle consists of the three Key Performance Indicators (KPI) costs, delivery time and quality. Together these three KPI illustrate the relationship between what a customer is willing to pay for a product of certain quality and with a certain delivery time (lead time). In short: what the “*Value for Money*” is*.*

Value for money is influenced by several factors; two of them are supplier’s performance and the percentage in which the customer’s desire is translated into the product. Kuhn focuses on both factors by continuously expanding its product range and improving its business processes.

By expanding the product range, Kuhn provides the customer with more choice. With it increasing the chance of satisfying the customer's desires. To achieve this Kuhn obtained an active acquisition policy and it invested in its research and development (R&D) department. The result of this was on one hand multiple acquisitions of which Audureau S.A (1993) was one. On the other hand product range expansion and increasing demand led to the opening of a new assembly site named Kuhn Monswiller (2008). These two sites, Kuhn Audureau (KAU) and Kuhn Monswiller (MGM), were pointed out by Kuhn as pilot sites due to their ways of organizing the supply flows and will therefore be the places where we will conduct our research.

With an expanded product range, a wider range of customer need can be fulfilled. With it covering one of the two factors mentioned earlier. However for Kuhn it does not stop there and the through Continuous Improvement (CI) of business processes the company aims to reduce inconsistencies, eliminate waste and improve overall performance. To structure this CI Kuhn developed a production system called Kuhn Production System (KPS). KPS is a combination of tools, methods and approaches to structure processes. These processes are divided into three groups of which flow acceleration is one. This flow acceleration focuses on structuring the material flow and corresponding information flow. The goal of this structuring is to eliminate all waste and with it creating a "sterile" manufacturing environment which can produce better products with less resources. To achieve this, flows and underlying processes are continuously evaluated and when possible improved. This according to the principles of Lean Manufacturing (LM) as Kuhn redefined and incorporated in the KPS.

At both pilot sites takes flow acceleration through CI place on regular bases. This resulted in the IST-situations as we can observe today. However no situation is alike and due to unique circumstances it is possible that flows equal on paper can differ in practice. By highlighting these effects it is possible to compare the performance of both IST-situations. However in order to really learn from each other and improve as a complete organization it is vital that beside the effects also the underlying causes are highlighted. With it sites will not only learn from each other, but it makes it also possible for the Kuhn group to combine all best-practices in their KPS. By stating this we highlighted the purposes of this research, namely to describe both IST-situations and compare them so that the best-practices can be implemented in KPS.

1.2 Problem statement

Kuhn Production System (KPS) establishes a set of common manufacturing practices in order to achieve a world class manufacturing organization. One of these practices is the supply management in which currently two pilots take place, namely at Kuhn Monswiller (MGM) and Kuhn Audureau (KAU). Both models focus on material supply to the shop floor in a different way. This makes them suitable for a wide range of situations, but each with its advantages and disadvantages. To optimally benefit from the two models, a description and analysis of both models is desired so that an overview of the practical best cases can be created. Based on these practical best cases can be decided what the best configuration is to implement at Kuhn Geldrop (KNL). Additionally it is necessary to investigate the possibilities of merging these practical best cases, so that an optimal model can be integrated within the KPS.

1.3 The Goals

Kuhn’s goal is to combine theory and best practices to achieve the optimal production environment for their facilities. However as earlier described each process is different and the required support is not everywhere the same. To cope with this Kuhn has currently divided the KPS into modules so that each site can apply the modules as desired. This resulted for each site in a unique setup that over time diverged even further by CI. Therefore to create structure and learn from each other Kuhn wants to describe the supply flows of both pilot sites and compare them so that the best practices can be incorporated in KPS. With it Kuhn strives for an optimal production environment that can be introduced at new facilities such as Kuhn Geldrop.

With this report we want to contribute to Kuhn's goals. This by complying the organization's need for a detail description of the current supply flows, a comparison of these flows and an illustration of their performance. By filling in these three blanks we hope to contribute to Kuhn's strive for perfection and provide them with recommendations that lead to waste elimination and improvement of the current supply flows.

Additional to these main goals our secondary objectives are to provide some background information on both the organization and Lean Manufacturing (LM). The first is to get an understanding of the organization where this research is conducted and their perspective towards the future. The second is to increase the overall knowledge of the reader so that parts of this report can be understood better.

1.4 The research scope

Kuhn produces and assembles agricultural machinery at eight sites. Each site is a specialist within their product range and provides the customer with high quality machinery. To achieve this all sites continuously improve their current processes and with it eliminating as much waste (Muda) as possible from the supply flow. In this endless process of Continuous Improvement (CI) Kuhn currently appointed two sites, (Kuhn Audureau and Kuhn Monswiller) that they want to observe, describe and compare, as pilot sites. With this decision the first boundary of the research scope is set, namely that we only focus on how Kuhn Audureau and Monswiller organize, manage and execute their supply flows. Therefore we will leave the other six sites out of our research scope.

However with this boundary alone there is still a lot of work ahead and the time span of this research is limit. Therefore we set a second boundary, namely that we will focus on a part of the supply flow that we can actually compare. The result of this second boundary is that we will look at the supply flow part that leads from supply arrival through storage and directly to the shop floor. With it we exclude the supply flow parts that go through fabrication (KAU) and the paint workshop (MGM and KAU).

Through this boundary we prevent unnecessary time loss that would occur when we try to compare apples and peers. On top of that by instating this boundary we can spend more time on a certain supply flow part and with it looking deeper into it. By doing so, we aim for a larger benefit for Kuhn in their search for the optimal production environment.

Additionally we want to create an extra benefit for Kuhn by incorporating relevant parts of the information flow. By doing so, we are not only looking at how a supply flow is organized and executed, but also how it is managed and how internal orders are created and triggered. With this expansion of the research scope we want to cover all aspects relevant to successfully delivery supplies from storage to shop floor.

1.5 The research questions

During the execution of this research many questions will arise that need to be answered. However not all are equally important and the time to execute this research is limited. Therefore to structure the research the following research questions are setup to guide it. These questions are listed and described below.

What is Lean Manufacturing?

After some background information about the organization we will shift our attention towards the actual research. For this is basic knowledge of Lean Manufacturing (LM) required. Therefore the first research question that we define is: "What is Lean Manufacturing?"

To answer this question we are going to conduct a literature research during which we will use information from both the internal Lean database as well as external sources. The results of this literature research we will publish in Chapter 3: "Lean, a manufacturers religion".

What is Kuhn Production System?

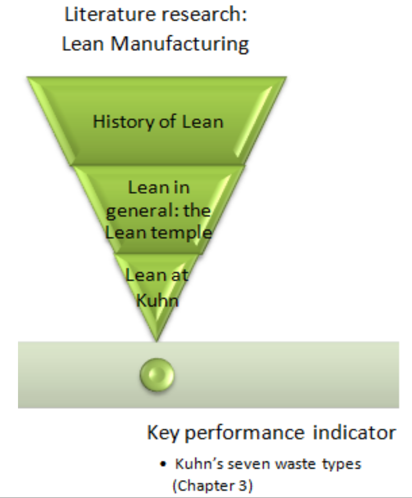
LM is developed by the Toyota automotive company to optimize its business processes. To achieve this optimization Toyota grouped and balanced several approaches and methods from all over the world. The result is the Toyota Production System (TPS).

Since then the TPS shown its effectiveness and efficiency time again and is nowadays the start point of many organizations that want to use LM to optimize business processes. This is not different at Kuhn. However Kuhn understood that TPS is tailor made for the Toyota Company and that you harvest what you seed. Therefore Kuhn knew that it had to adjust the TPS to fit the Kuhn group better. The result of this development we will describe in the second part of Chapter 1 when we try to answer the research question: "What is Kuhn Production System?"

What Key Performance Indicators does Kuhn distinguish?

When we look back at the problem statement we see that during this research two pilot sites are described. Once we described them we are going to compare and rate them. In order to do so, it is important that we first define aspects, criteria and indicators used for the rating and comparison.

Figure 1.1 – Research outline: LM



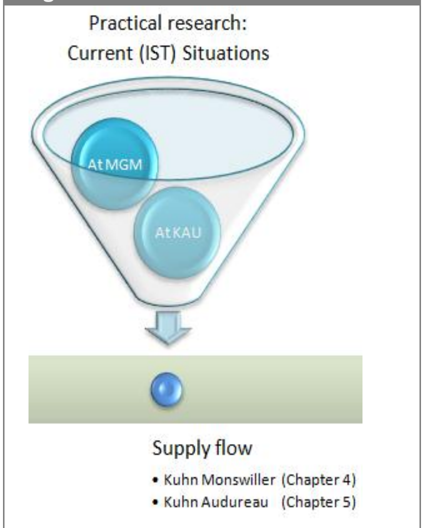
Kuhn indicated prior to the comparison and rating that it would like to see that their indicators are used. These indicators are incorporated in KPS, a system that is used to structure and optimize business processes. Therefore the logical research question before we look deeper into how both sites manage and execute their supply flows is: "What Key Performance Indicators (KPI)'s does Kuhn distinguish?" We will answer this question in Chapter 1 as well seeing it is in close relation with LM, TPS and KPS.

How do both pilot sites manage and execute their supply flows?

With the KPI defined we will conclude the theoretical framework and start our field research by describing the IST-situations of both pilot sites. During this we will focus on the supply flow from entrance gate through the warehouse to the assembly line. With this research we want to provide an answer on: “How do both pilot sites manage and execute their supply flows?”

This question is relevant to Kuhn because at the start of this research these flows were known but not yet described on paper. Therefore the aim of this research question is to provide a detailed and complete description of these supply flow.

Figure 1.2 – Research outline: IST



To answer this question we are going to visit the facilities in Monswiller and La Copechagnière (Kuhn Audureau). During these visits we will talk to employees and observe how currently the tasks are executed. This observation takes place from the sideline in order to not interfere with the daily processes and to prevent hazardous situations from occurring when participating. Additionally to the knowledge we gathered first handed we will execute a literature research using the internal available documentation. The results of these literature and field researches we will be described in Chapters 4 (MGM) and 5 (KAU).

What are the main differences between the pilot sites?

During describing the IST-situations it occurred that in general the same flows of delivery modes can be distinguished. However both sites manage and execute these flows in their own way. This difference in managing and execution affected the supply flows and caused differences between the flows. Therefore in our next research question we will look deeper into these differences when we are going to provide answer on: “What are the main differences between the pilot sites?”

Figure 1.3 – Research outline: Comparison

To answer this question we are going to compare the sites in three stages. In the first stage we are going to compare them on organizational level. With this comparison we aim for a better understanding of why both supply flows differ. From there we will advance to a comparison on strategical/tactical level and eventually on operational level. Through this approach we want to not only highlight the differences between the sites but also provide background information on why the facilities work as they do (IST-situations of Chapters 4 and 5). The results of this comparison can be found in Chapter 6.

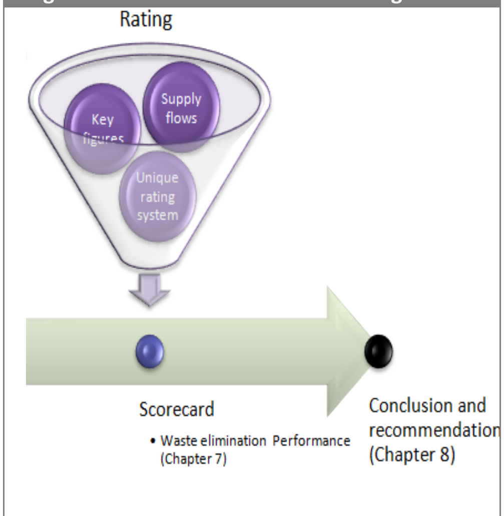
How do both pilot sites score on the Key Performance Indicators?

While both sites have a completely different background, the goal of this research is to learn from each other and to improve the KPS by combining the practical best cases. In order to do it is important to know how both pilot sites score according to the Kuhn KPI. Therefore we developed a rating system around these unique KPI.

Together this rating system and the information gathered during the previous research questions will form the tools that we are going to use to answer our next research question: *"How do both pilot sites score on the Key Performance Indicators?"*

The results of this rating can be found in Chapter 7, where we will first determine per KPI the scores of both sites. This followed by an overall scorecard at the end of the chapter, so that with one view the best practical cases per KPI can be determined. Based on this overview we will provide our recommendations concerning the improvement of the standard supply flow within KPS.

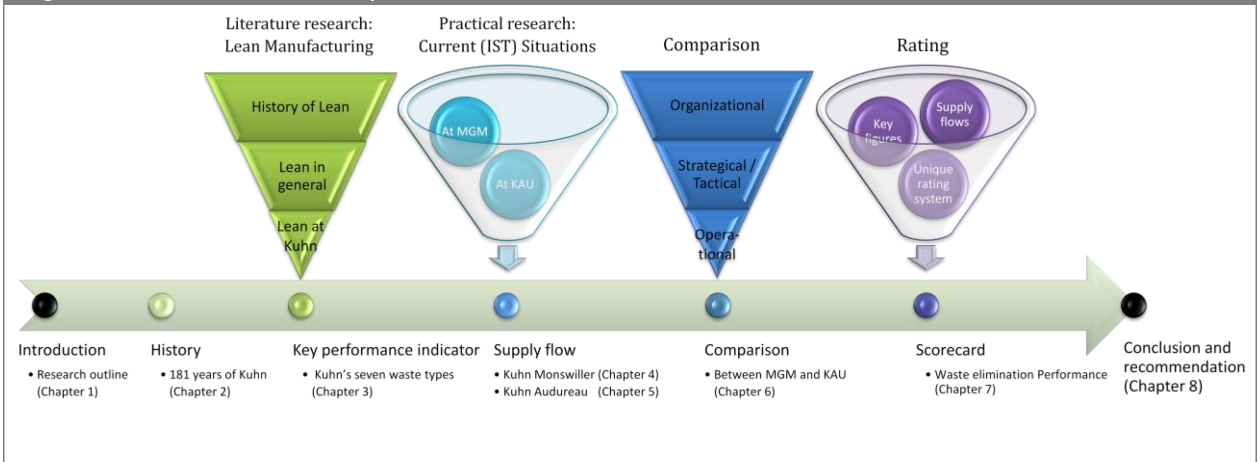
Figure 1.4 – Research outline: Rating



1.6 The research outline

In the previous section we defined six research questions. The goal of defining these research questions is to guide us through this research in a coordinated manner. Each of these research questions form a hurdle that we have to take in order to reach the finish line. Therefore to show the complete research outline in one overview we combined the contents of all six research questions in Figure 1.5. A stretched version of this illustration can be found in Appendix A.

Figure 1.5 – Research outline: Complete overview



With the outline set we will start the actual research with a short introduction of the company and the historical events that shaped it (Chapter 2). Through this we want provide the reader with some understanding of the company and its culture. Additionally with this background information we want to introduce three individual events from Kuhn´s timeline that will come together in this report. These events are the introduction of KPS, the acquisition of Audureau S.A. (KAU) and the realization of a new workshop called Kuhn Monswiller (MGM).

After the history we will advance to the second stage of this report (Chapter 1) where we will look deeper into KPS. As earlier described KPS is a model in which Kuhn structures its business processes. One of these processes is, the for this research relevant, flow acceleration. The goal of flow acceleration is to combine theory and best practices to achieve the optimal production environment for the Kuhn's facilities. To realize it Kuhn used as foundation similar elements as Toyota used for their successful Toyota Production System (TPS), namely the elements of LM. Therefore to provide a better understanding on Kuhn's flow acceleration we will dedicate Chapter 1 to provide some background information on LM. For this we will use a top-down approach (Figure 1.1) starting with the history of Lean, followed by Lean in general and Lean at Kuhn.

While the majority of Chapter 1 is informative our aim is to introduce the KPI used by Kuhn. These KPI play an important role in this research, because they are not only used in the scorecard but also as a (critical) third eye when observe and describe the current supply flows (Figure 1.2) of MGM (Chapter 4) and KAU (Chapter 5). The purpose of these two chapters is to show how both pilot sites currently manage and execute their supply flows. We therefore aim with these chapters to provide a detailed description of IST-situations at both pilot sites. During this process we will describe the flows as we observe them and from knowledge gather by talking to employees and studying the available documentation. At the end of each description we will elaborate on the actual flows, this by adding a section in which we look towards the IST-situation with our research perspective and through the critical third eye. During this we will highlight some aspects of the supply flow that we thought sprung out.

With a detailed description of both supply flows we will focus next on the comparison (Chapter 6). We divided this comparison into three parts using once more a top-down approach (Figure 1.3). These parts are a comparison on organizational, strategical/tactical and operational level. We use this approach because with each step taken more of the causes that shaped the current supply flows are revealed. Therefore our objective of this chapter is not only to highlight the major difference between the sites, but also to clarify why the flows are as they are.

Our second objective aim for this chapter is to introduce data about the use of delivery modes. By introducing this data during the comparison we not only want to connect cause and effect, but prepare for Chapter 7 in which we will use this and similar data for the performance rating of both supply flows.

By highlighting the different use of delivery mode and the corresponding data a big step is taken towards the rating in Chapter 7. In this chapter we rate both supply flows on their performance of waste elimination. For this we use the seven waste types redefined by Kuhn, our own developed rating system and data from ERPK (Figure 1.4). With this rating we want illustrate how well both facilities score on the seven waste types in relation to the other side. This results in seven best practices, for each waste type one. By combining these waste types we aim for a recommendation that not only can improve both facilities individually, but also the KPS. This recommendation is stated in Chapter 8. However first up is the history of Kuhn.

2. The history of Kuhn

Kuhn is part of the Bucher-Guyer group and manufactures state-of-the-art machinery and vehicles. Bucher describes Kuhn as "the world's leading manufacturer of specialized agricultural machinery" (2). *These machines are produced worldwide at eight facilities and distributed all over the world through a widely spread distribution channel.*

The mission of the organization is to design and manufacture specialized, innovative and high-quality products for agricultural use (1). *With it all actions aim to provide the customer with superior service, maximum return on investment (ROI) and optimal long-term value. To achieve this mission the organization strives for a continuous development. This development is supported by all available values and contributed to the success and growth of the Kuhn brand over the last 181 years.*

In this chapter we will describe Kuhn's history and how the organization grew from a modest village forge into "world's leading manufacturer of specialized agricultural machinery" as Bucher describes Kuhn (section 2.1). During this description we will see that mutual loyalty between customer and company is one of the driving forces behind the company's success. Other driving forces are the contribution and strength of Kuhn's employees, the commitment and satisfaction of the shareholders and the respect for the environment.

Once we finished our journey through time we will dedicated the second section of this chapter (2.2) to summarize the historical events relevant to this research. With this summary we want to take the first step towards combining three individual historical events in one research. On top of that we want to use this section to provide a sneak preview of what can be expected in the upcoming chapters. By doing so, we aim for a better understanding of the origin of the two sites and Kuhn Production System (KPS), and the direction of the research.

2.1 Kuhn: 181 years of excellent craftsmanship

A small blacksmith that realized an opportunity

The journey through time takes us to Saverne (Alsace, France), 1828 (3). Here in the village's surroundings the small blacksmith Joseph Kuhn founded a modest village forge which he named Kuhn. At Kuhn weighing apparatus were manufactured and during the first 36 years of its existence the company turned into an early specialist in this area of expertise.

In 1864 France's exceptional prosperity was underlined by the opening of the Paris-Strasbourg-railroad connection. This railroad passed through Saverne and with it brought new opportunities to the region. Drawn by the opportunities Joseph Kuhn decided to move and together with his brothers purchased a lot next to the railroad. Here, on the same lot where Kuhn's headquarters is still located they started to produce agricultural machinery.

Profiting from the prosperity in France and the ability to receive supplies by train provided Kuhn with the stability it required to develop. During this development and even despite the railroad's extra advantages regarding distributing products over a larger area, Kuhn chose to be a regional company that worked essentially for Alsatian agriculture. This attitude did not change in 1871, when the region became German, and in 1918 when it was returned to France after World War I.

A period of ups but also downs

In 1921, three years after World War I, Kuhn built special workshops to accommodate assembly lines of threshing machines (3) (4). The quality of these machines was exceptional and soon after Kuhn's reputation for top quality products was established. This reputation led in seven years time to an average production of 1,000 threshing machines per year. With it, coloring Kuhn's 100th anniversary and triggering a decade of growth till it was brutally halted by the start of World War II.

During the five years of the war Kuhn received a severe blow and when the war ended in 1945 it lost many of its customers. Additionally the war financially weakened the company and in order to preserve Kuhn went in search of a partner. This partner was found in 1946 when Kuhn and the Swiss manufacturer of agricultural machinery Bucher-Guyer formed an association. Strengthened by this association Kuhn started to grow gradually and by converting to mechanical traction it became one of France's leading manufacturers of agricultural machinery. It marked the beginning of an era of tremendous development during which Kuhn became a reference trademark for innovation and quality.

While the company had one success after another it not all was sunshine. In 1965 a huge fire destroyed the machining tools and assembly workshops. This was a severe blow, but it also created a wave of solidarity when the workforce took on the reconstruction. With it, underlying contribution and strength of the employees as one of Kuhn's driving forces.

The world at its feet

Domestic market leader and one million machines sold (4), Kuhn was ready to sail out and conquer the world. This quest started in the 1970s with the export to countries all over Europe and overseas to Australia and the United States of America (U.S.A.). Through the expansion sales grew both domestically and globally. This increased the demand for spare parts and in 1972 the company opened a new spare part warehouse. However this was not the only change required to cope with the adventures abroad. Instead the foreign export routes marked the beginning of internal development. Three of these developments were the installation of 13,000 square meter storage and dispatch area (1980), a Research and Development (R&D) center (1982) and a centralized computer network (1983). Through this computer network factory data of all facilities could be accessed throughout the entire organization. Making it easier to share information and it provided headquarters the ability to access data from facilities outside the Saverne region. With it the efficiency could be improved.

The next phase of internal development took place in 1985 when Kuhn established a network of authorized dealer sales representatives. Through this network the communication lines between dealerships and the company became shorter. With it information could be exchanged faster and in a more structured manner. This network was expanded in 1986 with the launch of Minitel. Minitel is a service offered and operated by France Telecom. It consists of an information database that was accessible by authorized dealer and sales representatives in France. With a network between the company and externally towards the company's authorized dealerships was established.

Once the network was established and functioning as desired Kuhn focused on the further improvement of the R&D department. This was realized in 1987 by equipping the R&D with Computer Aided Design (CAD), a software package used to design products digitally.

The success of external expansion

In the same year, 1987, the effectiveness of the internal development and the ambition of Kuhn were proven when it merged Huard into the Kuhn group (4). Huard was a renowned manufacturer of ploughs and had established itself as one of Europe's leading plough manufacturers. This made the company well suited to help Kuhn expand its product range of mowers, tedders, tedder-rakes and threshing machines. Three years later the merger was rewarded when Kuhn was rewarded the gold medal for a Rotary Plough at SIMA.

The second external expansion took place in 1990 when Matelest Diffusion, nowadays known as Puissance Vert, was incorporated in the Kuhn group. This company was specialized in manufacturing garden and park equipment. With it Kuhn once more expanded its product range. This time an expansion that goes beyond agricultural machinery towards landscape development in a broader aspect.

The start of a new era

In 1992, after an era in which the company became domestic market leader, former Chief Executive Officer (CEO) Walter Reber) retired at Kuhn (5). With the settling of the new board, under supervision of new CEO Michel Siebert), a new ambitious objective was set namely becoming world leader in all offset markets. This meant that the company had to move into new areas for which an active acquisition policy was required. On top of that the deployment of a brand strategy on a global scale was required.

The first step towards achieving the objective was the acquisition of Audureau S.A located in La Copechagnière (France). This company was a specialized manufacturer of mixer feeder wagons, straw distributors and silage cutters. The second acquisition that was conducted by Kuhn was the acquisition of Nodet S.A which produced seed drills and sprayers. Together these acquisitions helped Kuhn to expand its product range even further and Kuhn started to become a company that could offer its customers a full coverage of agricultural and landscape machinery. Also internally success was achieved when Kuhn purchased in 1994 a lot of ten acres and built a 3,000 square meter storage site to increase the stock capacity. On top of that the new electrical paint coating unit became operational in 1996 and that year the foundry of Kuhn Saverne received an International Organization for Standardization (ISO) 9002 certification. With these last two developments Kuhn proved once more its excellent craftsmanship.

The last successes of the century were established in 1998 and 1999 with the successful realization of a new warehouse in Tennessee, Columbia (U.S.A) and the startup of the new Kuhn-Huard factory in Châteaubriant (France). This completed a century of tremendous growth in which Kuhn's excellent reputation for quality and its position as domestic market leadership were established.

The turn of the century

Refined throughout the 1990s and developed in the first decade of the twenty-first century Kuhn focused on further realization of its objective (5). This started in 2000 when Kuhn purchased a lot of 29.7 acres located in Monswiller (France). Here, under the smoke of Saverne, the new logistic platform would be realized. In 2001 the first phase of this project was completed when new spare part distribution centre called Kuhn Parts opened its doors. Meanwhile in the west of France another success was booked, when Kuhn Audureau (KAU) expanded its assembly hall and finalized the installation of a hedge and grass cutter testing site.

Kuhn's twenty-first acquisitions

Through the successful acquisitions in France Kuhn established the desired active acquisition policy and strengthened its position as domestic market leader (6). This however did not satisfy the ambitious hunger of the organization. Therefore in 2002 the first major acquisition abroad was realized by taking over the American family company Knight, located in Brodhead, Wisconsin (U.S.A). Through this acquisition Kuhn incorporated the American leader in mixer-distributors and manure spreaders. With it Kuhn's market share in America was signify increased and for the first time Kuhn set foot abroad to manufacture. This success was recognized abroad and in 2004 Kuhn and Kuhn-Knight received a regional performance trophy.

Through the successes in North-America the hunger for international expansion was reinstatement. This hunger led to South-America where the Brazilian company Metasa S.A was acquired in 2005. Metasa is a company specialized in designing and manufacturing direct precision drills for crops such as cotton and soya. While these crops are primarily produced in North- and South-America the design of direct precision drilling could also be applied to other crops such as maize. This created the opportunity to use the technology of manufacturing direct precision drills for markets all over the world.

With the acquisition of Metasa in 2005 Kuhn's hunger was still not satisfied and in 2008 and 2009 two more acquisitions were finalized. This time it concerned the French company Blanchard, located in Chéméré (France), and Kverneland Group Geldrop B.V., located in Geldrop (the Netherlands). By acquiring Blanchard, a specialized manufacturer of field and green area sprayers, Kuhn gained access to new technology. Also the products developed and manufactured by Kverneland Group Geldrop B.V. were not yet part of Kuhn product range and once more an acquisition led to product range expansion. This time it was expanded with fix and variable chamber round balers, big square balers, wrappers, rotary drum mowers, tedder-rake combinations and maize choppers.

Other milestones and achievement in the twenty-first century

The successful acquisitions that Kuhn made in the twenty-first century show the ambition of the company to realize the objectives set in 1992 (6) (7). However the acquisitions were not the only achievement and milestones since the turn of the century. In 2003 the company celebrated its 175th anniversary with a gold medal for the ACCURA precision coulter at the German Agritechnica show. That same year the HR-Venta seeding combination was elected as "machine of the year" in Germany and won a competitor from Normandy the French ploughing championship with a Kuhn machine. But the two greatest achievements that did not concern an acquisition were realized in 2006 and 2008.

In 2006 project CAP10 was implemented in the organization under the name ONE. Through ONE Kuhn strives for perfection by structuring work processes and fine-tuning them. This with the objective to serve the customer as best as possible by creating customer satisfaction and offering top quality products that fit the customer's needs. The Kuhn Production System (KPS), which we will describe in this report, is a strategic initiative of ONE.

The second great achievement that was realized was the new assembly site Kuhn Monswiller (MGM), located in Monswiller (France). Here the company started in 2008 with the assembling of hay and silage, seeding and Soil preparation machines. How this is executed we will describe in the report and compare it to the working methods of KAU.

The current Kuhn Group

As mentioned earlier the Kuhn Group currently consists, of eight production and/or assembly facilities (9) (8). These facilities are located worldwide in Brazil, the U.S.A, France and the Netherlands. Together these eight facilities produce and assembly a wide range of agricultural machinery that is distributed all over the world through the Kuhn network (Figure 2.1). This network has output ranging from Tahiti (French Polynesia) to Melbourne (Australia).

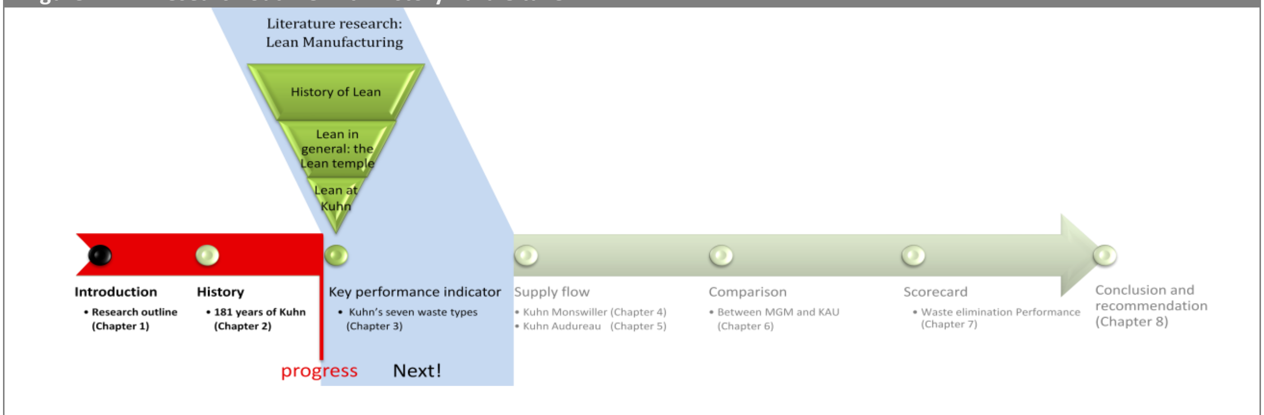
Figure 2.1 – Kuhn's distribution network (8)

2.2 Kuhn today

In the previous section we showed glimpses of Kuhn's rich history. A time in which Kuhn turned from weighing apparatus manufacturer into "*the world's leading manufacturer of specialized agricultural machinery"* (2). Off course much more happened in 181 years of Kuhn, but to prevent that we get sidetracked we had to limit ourselves to this small selection. However with this selection we wanted to create an understanding of Kuhn's organization and its culture. On top of that we wanted to highlight that even in 181 years Kuhn's objectives of striving for perfection, respect for the environment and mutual loyalty between customer and company customer satisfaction never changed.

With this state we end our journey through 181 years of Kuhn and return to the present where our report awaits. A report that till this point covered the introduction of the research and the history of 181 years of Kuhn (Red progress bar - Figure 2.2), but it has still a lot to reveal in order to achieve our personal goals and contribute to Kuhn's. Therefore we will leap over the history hurdle and move along the research outline towards the next chapter: Lean, a manufacturer's religion. In that chapter we will take a peek into the world of Lean Manufacturing using a literature research of both internal and external sources. The aim of this is to work our way from lean in general through Lean at Kuhn to Kuhn's seven KPI. These seven KPI are necessary in order to look critical towards current processes (Chapter 4 and 5) and rate the performances of both pilot sites (Chapter 6).

Figure 2.2 – Research outline with history hurdle taken

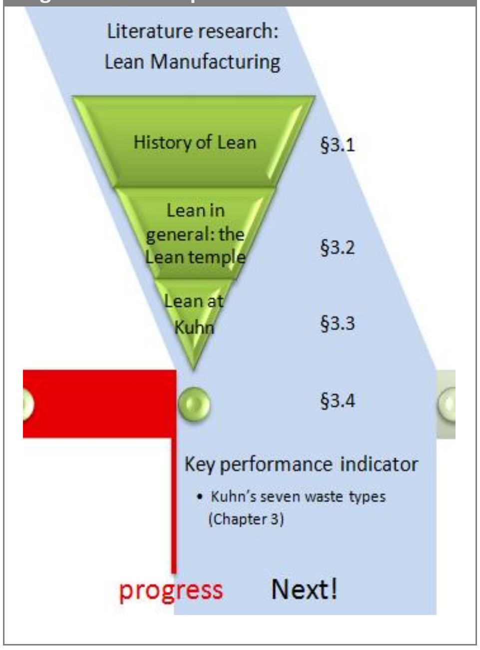


3. Lean, a manufacturer's religion

With the history hurdle taken, we provided some background information on Kuhn, its culture and some events that come together in this research. One of these events was the implementation of "ONE" (project CAP10). Part of "ONE" is the strategic initiative called Kuhn Production System (KPS). KPS establishes a set of common manufacturing practices in order to achieve a world class manufacturing organization. One of these practices is flow acceleration within supply management. Through this flow acceleration module Kuhn structures, manages and optimizes its current supply flows. In order to successfully optimize these flows Kuhn defined seven Key Performance Indicators (KPI) to measure the supply flow performance.

Like the complete flow acceleration module can the origin of these seven KPI be traced back to Lean Manufacturing (LM), Toyota's Production System (TPS) and in particular their seven waste types (Muda). Therefore we find it vital for the understanding of the flow acceleration module and its origin to incorporate a literature research on LM. During this literature research we used a top-down approach, starting with the history of Lean (section 3.1). Through this history we want to show that Lean is based on best practices from all over the world. Combined these practices form KPS' role model TPS.

Figure 3.1 – Chapter 3 outline



Once we provided background information on the Lean elements and their origin, we will advance to a more detailed level by describing Lean in general (section 3.2). To do so we will take a closer look at Toyota's Lean temple and in particular the element of Continuous Improvement (CI) or in Japanese "Kaizen". Especially this part of the Lean temple is important for our research, because it can be seen as the role model of KPS' flow acceleration that we will described in section 3.3.

With the flow acceleration and its origin described, the last step that we will take in this top-down approach is deriving Kuhn's seven unique KPI (section 3.4). This last step is vital in our research, because it provides the tools (a third eye) to observe the current supply flows critically (Chapters 4 and 5), compare them (Chapter 6) and rate their performance (Chapter 7).

3.1 The history of Lean

How old beliefs formed new minds

Lean is a well-known philosophy in manufacturing circles and has been adapted by companies all over the world. Many of these companies use the TPS as guideline because since its introduction in the early 1950s its effectiveness has been proven time again. Therefore when people talk about LM they directly associated it with TPS and its underlying JIT approach. However some of the concepts within LM are much older than the TPS. Therefore to give an idea about Lean's history and how it evolved over time into eventually TPS will we highlight some historical moments in time.

Our journey through time starts at the Venice arsenal in the early 1450s (10) (11) (12). As Europe's trading centre and route to Asia and Africa, Venice was a wealthy city that flourished by trade. However it was also a willing target for people that meant harm. Therefore to protect itself Venice was very well fortified and had a large arsenal. At this arsenal process thinking was part of the daily activities and used to optimize processes regarding the arsenal distribution. The Venice arsenal of the 1450s can therefore be seen as the first known moment in time that any form of Lean can be distinguished in a larger quantity.

While some other moments of rigorous process thinking can be pointed out since then, it took till almost the nineteen century before the second aspect of Lean was developed. This development came from the hand of Eli Whitney in 1799. At that year Whitney, renowned for his cotton gin, developed a way to perfection Honoré Blanc's interchangeable parts.

Interchangeable parts come in two forms, namely parts that are compatible with different configurations and parts that can be easily replaced. Through it operational costs (changeover time, downtime, and etcetera) could be reduced. Additionally it provided the ability to use machinery for different purposes by simply swapping certain (interchangeable) parts. Therefore interchangeable parts can be seen as one of the first ways of eliminating waiting time waste. On top of that by using a basic product setup with a few interchangeable components inventory waste can be eliminated and processes standardized.

Whitney's success triggered an attitude change towards technology and during the next 100 years continuous machine improvement was executed on a large scale. Covered by the smoke screen created through this attitude change the production process moved on in an old-fashion way till the late 1890s. At that moment Industrial Engineers (IE), such as Frederick W. Taylor and Frank Gilbreth, started to see through the smoke screen and focus on the worker-process relation rather than technology.

In his studies Taylor observed the individual worker and his working methods to execute the tasks at hand. The results of this study he named Scientific Management and it contains early concepts of Time Study and standardized work. Inspired by Taylor's Time Study and the desire to improve the efficiency of the bricklaying process, Gilbreth started to analyze motion within this business. During this study Gilbreth used a motion picture camera to analysis and describe the processes. This resulted in the concept of Motion Study in which the human motion elements are categorizes into eighteen basic components (Therbligs). Gilberth's Motion Study was such a success that he became a prominent builder in America and his findings were picked up by Taylor. Still perfecting his Scientific Management and impressed by Gilberth's work, Taylor decided to tribute his former fellow MIT student. This by incorporating an extensive coverage of Gilberth's works in his book "*The principles of Scientific Management*".

The second success that Gilbreth had was the use of a motion picture camera. By experiencing firsthand how great it worked, he decides to use it for documenting other processes. This was the birth of Process Charting, a method in which processes are charted to create a clear understanding of the relationship between processes. Also it turned out to be very useful to distinguish NVAP and VAP. Therefore it can be seen as predecessor of VSM.

The birth of flow production

In 1910 the manufacturing world trembled when Henry Ford realized in Highlight Park, Michigan U.S.A., his Ford system. In this system interchangeable parts (Whitney/Blanc) were combined with standardized work (Taylor), Process Charting (Gilbreth) and Continuous Movement (Ford). Continuous Movement (CM) is the uninterrupted movement from supplies to finish product. It could be achieved by placing process steps in sequential order. This results in a fast production flow from which almost all Work-in-Progress (WIP) inventories were eliminated. This was the birth of both flow production and one-piece-flow.

Ford did not stop there and soon he started to line up complete processes rather than process steps. During this Ford used special-purpose machines and when possible gauges to trigger a task. With these gauges the supply flow of components was regulated. This means that as soon as the gauge indicated a go the component was moved to a designated area at the assembly line just a few minutes before to assembly. With it WIP is reduced and with it is prevented that preassemblies and fabrications clubbing up the system.

The Ford system was revolutionary in and due to the flow it was possible to turn inventories within the entire organization every few days. However the Ford system had also a big disadvantage, namely variety. So was the system incapable of providing any form of variety, meaning that on the assembly line only one model could be produced in one specific setup and color. This left the customer with only one possible choice, namely choosing between one of the five bodies. A variety that was possible merely because the bodies were delivered by external suppliers as a single unit and mounted at the very end of the assembly line.

Falling back on old customs

At first Ford's fast way of production made up for its lack of variety. However over time the customers started to get demanding and desired more variety and shorter product life cycles (less than the 19 years of the Model T). This was impossible for the Ford system at that time. On top of that Ford himself did not want to change the system setup. Therefore other car manufacturers were invited to jump into the gap that Ford left unfilled. They responded willingly by offering the customer a large variety of models options and colors. The negative side-effect was that the production systems had to cope with this large variety, resulting in changeover times. The changeover times increased the cycle time and reinstated, like in the time between Whitney (1799) and Taylor (1890s), the focus on improving machines to run faster and against lower operational costs.

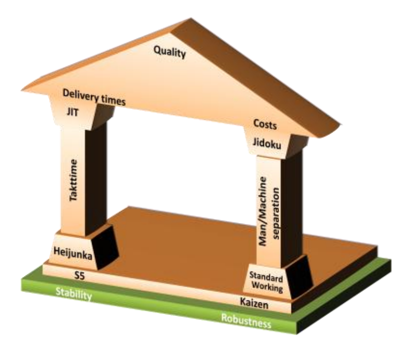
A second negative side-effect was that inventory levels kept on increasing. On top of that the large variety caused time lags between activities and required more sophisticated Information Systems (IS) in order to successfully route complex parts. This last resulted in Joseph Orlicky's Material Requirements Planning (MRP) system in the 1960s.

Sunrise in the east

While the first roots of Lean in the West sprang in the 1450s it took till 1897 before it sprang in the East (13) (14) (15) (16). In that year Sakichi Toyoda invented a loom that did not only operate automatically but also contained the human intelligence to recognize snapped thread. By recognizing an error it could shut itself down. With it preventing the finished product quality from declining. Also this mechanism provided the ability to have a single operator for several machines because the machines can automatically signal the operator when they are in need of attention. Therefore Toyoda called this process Jidoku, which is Japanese for Automation with a human touch.

The second development regarding Lean in Japan took place in the early 1930s and after World War II. At that period Kiichiro Toyoda and Taiichi Ohno started to revise the Ford system and combining it with Jidoku. During this process the people of Toyota discovered that when right-sizing machines to the actual demand you could reduce the Finished Goods Inventory (FGI) and with it the inventory costs. On top of that Toyota believed that the costs could be further reduced when incorporating Jidoku in the production process without dropping the products' quality level.

Figure 3.2 – TPS' lean temple



By combining Jidoku and the Ford system the foundation for the TPS was set. However to cope with other challenges Toyota knew that still some processes had to be arranged and stability had to be created. This resulted in the development of JIT, a combination of One-piece-flow (Ford), Takt Time (TT) and Pull system (Kanban). By combining these three aspects Toyota created a flow in which you produce and deliver the right amount, with the highest quality at exactly the right time. This resulted in the second pillar of the Lean temple (Figure 3.2) and together Jidoku and JIT form the temple's backbone that uphold the Triangle of Competition.

However the Japanese also understood that to have a straight backbone you require a good stable surface of structure and discipline. Therefore Toyota described a few ways in which structure and discipline can be achieved.

3.2 Lean in general

3.2.1 Lean Manufacturing and its temple in a nutshell

Lean manufacturing (LM) is a systematic approach that strives to maximize customer value while minimize waste in the production process. The ultimate goal of this is to create a product which is perfectly aligned with the customer's desires. This product produced in a manufacturing environment that consists of primarily Value Added Processes (VAP) in which no waste can be distinguished.

In order to achieve both, understanding of customer value (CV) is up most important. CV is based on three criteria namely cost, delivery time and quality of a product. According to these three criteria the customer values a product and decides if it is a good investment. Therefore it is important for good sales numbers that a product scores well on these three criteria. This point of view was underlined by Toyota when it included the Triangle of Competition in its Toyota Production System (TPS).

By illustrating the Triangle of Competition as roof (Figure 3.2) of its Lean temple, Toyota indicated that all methods and approaches within the TPS has a common goal namely to create a solid structure that upholds the Triangle of Competition. This starts with creating stability and establishing robustness so that the organization is less vulnerable against internal and external disturbances. Stability is influenced both internally and externally. An example of an external factor is consistency of supply deliveries. When these deliveries are inconsistence it causes instability within the organization, leading to problems and waste. By moving into an environment with more stability these problems are prevented.

However closely related to stability is robustness. Robustness indicates the toughness of an organization to withstand treats and overcome problems. Together these two elements are the ground on which every organization has to build because without it, it is a matter of time before everything goes wrong. Therefore to illustrate (Figure 3.2) this we adjusted the Lean temple and colored the level of stability and robustness green, the color of a healthy lawn.

Once stability and robustness are realized the next step in LM is to create structure. Creating structure has two objectives, namely structuring both the workplaces and processes. To structure the workplace all unnecessary elements at the workstation have to be eliminated. This can be achieved through Toyota's 5S (Seiri, Seiton, Seiso, Seiketsu and Shitsuke). Each "S" stands for a phase in the cleaning process, starting with sorting (Seiri) and ending with sustaining the principle (Shitsuke).

Besides workplace structuring is process structuring an important part of LM. This focuses on eliminating all Non Value Added Processes (NVAP) from the physical transformation stream (PTS). By eliminating these NVAP no unnecessary work is executed, leading to lower costs and shorter delivery times. Therefore process structuring contributes to offering better value-for-money to the customer. To achieve NVAP and waste elimination, Toyota introduced a cycle of continuous improvement (plan, do, check, and act) called Kaizen. This Kaizen is based on Frederick Taylor's Motion Study and Frank Gilberth's Process Charting.

Continuous Improvement (CI) or Kaizen has two primary objectives namely to maximize value for the customer and to minimize waste in the production process. To achieve this a five step Lean cycle is created. This five step Lean cycle starts with identifying value, followed by Value Stream Mapping (VSM). Through these two steps information about the CV and how that value is currently established is gathered. Once this information is known, improvements can be introduced. During this it is important that flow is created (step 3) and pull established (step 4). By doing this a manufacturing environment can be created that uphold one of the Lean temple's pillars, namely the pillar of Takt Time (TT) and Just-in-Time (JIT). The result of this is that you produce the exact quantity of the highest quality products at exactly the right time. So not before or after the due date!

As indicated in the history is this not the only pillar that holds up the triangle of competition. Instead there is also a pillar based on Jidoku, meaning automation with a human touch. This pillar focuses on the man-machine separation by standardizing work and the use of "smart" machines that notify an operator when they need attention. Through this multiple machines can be operated by a single employee and with it advancing from the old believes of one machine, one operator.

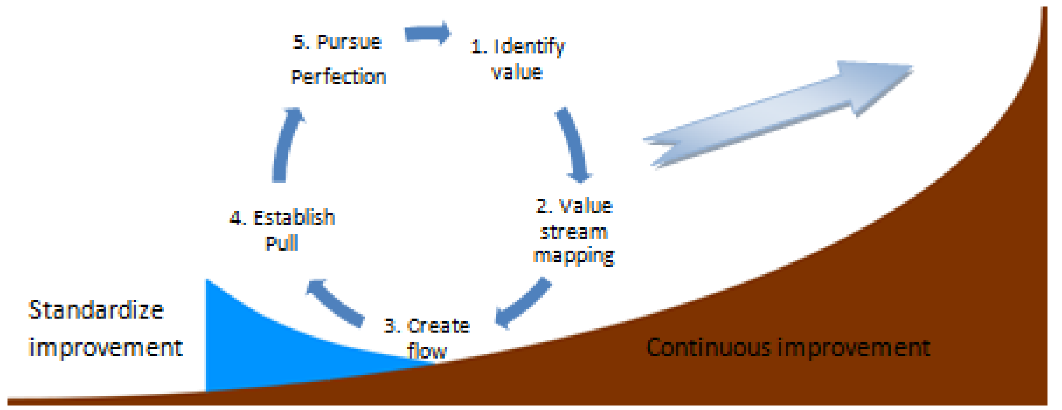
With this said we cover in a nutshell the basics of the Lean temple. Off course this is just a fraction of LM and large quantities of books can be written on each of temple element. However the time of this research is limited and therefore in the next section we will only highlight the element that is closed related to KPS' flow acceleration and our goals, namely CI. Through it introducing the basics on which of KPS' flow acceleration is built and creating a bridge towards Lean at Kuhn and more important Kuhn's KPI.

3.2.2 Continuous Improvement: The five step lean cycle

With the origin of LM and TPS briefly described in the previous section we covered the question of "What is Lean Manufacturing?" During this description we highlighted approaches and methods that can be distinguished within the TPS. So we mentioned that stability and robustness are required to build up. Also we described that the two pillars are on one side JIT and on the other Jidoku. In this section we will advance further into LM and focus on how to achieve LM's ultimate goal of creating the perfect product without any waste in the production process. For this we will look at the five step Lean cycle because it has much resemblance with Kuhn's way of continuously improving its business processes.

In the Lean cycle five steps are defined. The first two steps focus on establishing awareness of both product (identify value) and process (VSM). Once this awareness is established improvements can be made through creating flow and establishing pull. This pull is important because it indicates that you produce for an (internal) customer rather than producing from your own perspective. The last stage of this approach is pursuing perfection. This can be achieved by standardizing proven situations and improve from there by starting a new Lean cycle. We illustrated this process in Figure 3.3 during which with each cycle taken future improvements will become harder to spot and take.

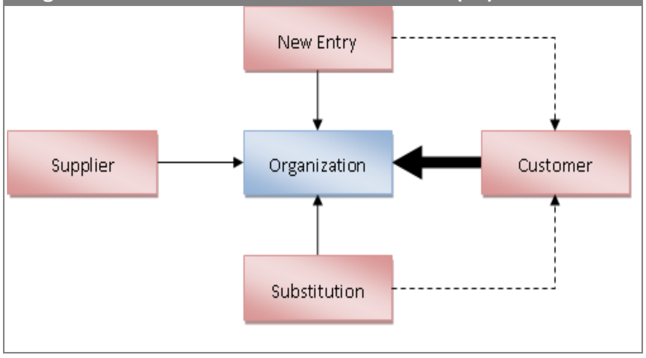
Figure 3.3 – CI according to the Lean cycle



Identify the value

As Lean focuses on creating the perfect value for the customer it is no surprise that improvement of your processes start with identifying and specifying the value for the customer. In this step the value of a commodity, service or both (the product) can only be determined and defined by the customer or desired offset market. Simply because it is the customer who decides what he/she wants to buy and not the company that creates the product? During identifying and specifying the value of a product the customer uses the three criteria of the Triangle of Competition (costs, delivery time and quality). However it is important to keep in mind that the product value can change over time due to different influences within the market (Michael Porter).

Figure 3.4 – Porter's five forces framework (17)



Influenced by the moment of the market it is necessary to express product value in terms of a *specific product according to customers' requirement at a certain place, at a certain time and for a certain price*. To identify the value of a product it is therefore required to thoroughly evaluate the market by conducting market research. During this market research the focus is on what the customer wants without letting this process be influence by any other stakeholder, such as shareholders or management, involved. Simply because the number one priority is: to satisfy customer demand!

Eventually identifying and specifying the value of a customer provides an idea of what a customer desires. These desires should be incorporated as much as possible within the production process. Therefore it is a very important part of forming and improving the value stream.

Value stream mapping (VSM)

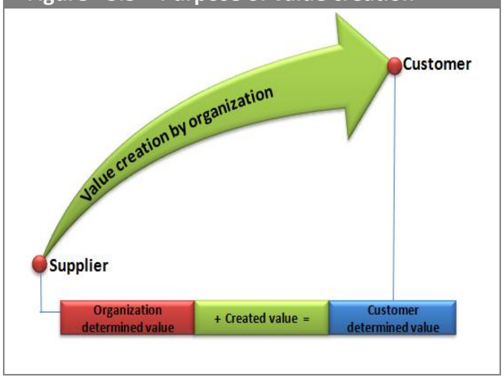
The second step of the Lean cycle is the VSM. VSM is a tool that focuses on visualizing current process flows throughout the organization, while highlighting and eliminating both waste and underlying causes. Off course many different flows can be distinguished throughout the organization and each of them contain waste. To map all of these flows you would need a lot of time and in many cases the flows do not directly tribute to the actual value creation for the customer. Therefore a distinction is made and VSM focuses merely on the production process flows, which are for a factory:

- Material flow (Transportation)
- **Information flow**
- Labor flow (Motion)

Physical Transformation Stream

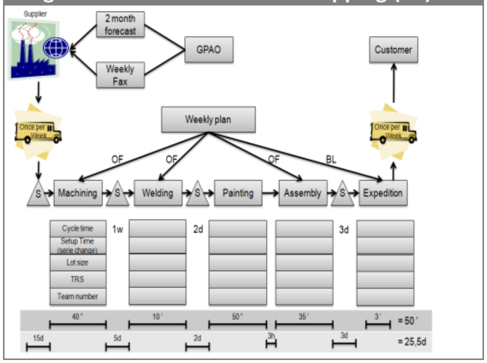
Of these three flows two are highlighted, namely the material and information flow. These two flows are especially of interest to the VSM, because they have the highest impact on creating value for the customer. So describes the material flow the physical flow from start to end. During this flow resources are processed and turned into the end-product.

Figure 3.5 – Purpose of value creation



The information flow represents the information movement through the organization. This flow is used to structure and support the material flow.

Figure 3.6 – Value Stream Mapping (18)



VSM's goal is to visualize the value creation (Figure 3.5) and describe the information and material flows necessary to realize this value creation. This process is executed for each product family. During it all identified waste is highlighted and eliminated with its underlying causes. Therefore VSM is a great tool for seeing the flow, its waste and origin of the waste while creating a base of discussion on the total production process scope (Figure 3.6). Also it helps creating an alignment between Lean activities and a construction plan for the organizational target.

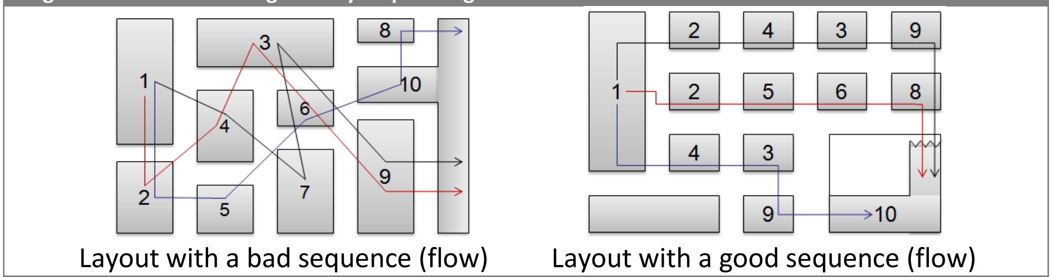
Part of VSM is the identification and elimination of waste, in Japanese Muda. Waste is something you pay for but does not tribute to the value creation process one way or another. Therefore they are undesired elements in value streams and should be eliminated. To successfully highlight and eliminate waste from a value stream Toyota categorized seven waste types. We summarized these waste types in Figure 3.7 but for a more elaborate description we would like to refer to Appendix B A.B where they are listed and described with some of their causes mentioned.

Figure 3.7 – TPS' seven Muda

Creating flow

The third step of the Lean cycle is creating flow. Creating flow means smoothing the production in such a way that the value creation steps occur in a tight sequence. This process can be executed once the value stream is identified and the waste is eliminated using VSM. With the waste eliminated the VSM provides a clear overview of the processes in the value creation. According to these processes the layout of the site should be setup. With it preventing unnecessary motion and transportation from occurring. To illustrate this we incorporated two layouts with each three flows (blue, black, red). In the left layout no flow is yet established. Therefore the flows go through each other and randomly through the site. In contrast of this is the second layout in which a decent flow through the site is established.

Figure 3.8 – Establishing flow by sequencing the workstations in a work cell



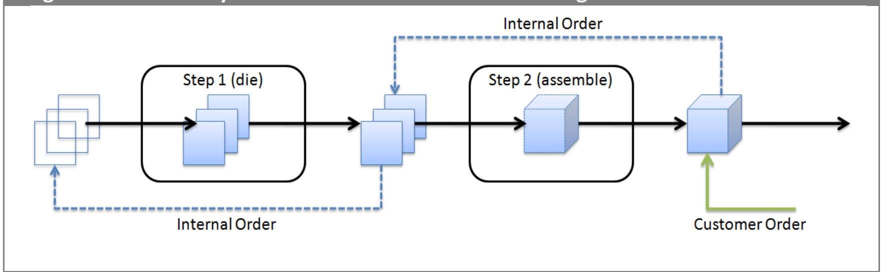
For this process it is essential that all parties involved undergo a fundamental change where individual goals become subordinate to the common goal, namely the value creation. So should the material flow be setup in such a way that it optimally copes with the processes required for the value creation. Furthermore the information flow has to be set up to optimally coexist with the material flow. In this process the material flow is leading with the information flow in a supportive role.

Establishing pull

The fourth step of the Lean cycle is establishing Pull. Pull imply that a product is pulled from the organization by a customer when and how the customer requires. This means that the value creation process is executed merely when a customer order arrives and not before that. Therefore according to this order the production process is triggered and executed so that the right quantity is delivered in time and against the desired quality. This equals the purpose JIT.

While JIT applies for customer orders, it also applies for internal orders. Each time a customer order is received it triggers a chain of internal orders. This chain travels upstream through the supply flow. Starting at the customer and ending at the supplier. Each actor in this chain creates an (internal) order for its predecessor. This process is illustrated in Figure 3.9

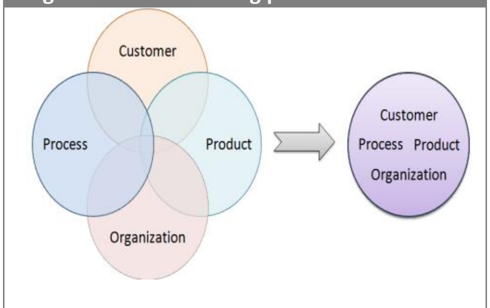
Figure 3.9 – Pull system as used in Lean manufacturing



Pursuing Perfection

Pursuing perfection is the last but ongoing process during Lean. In this process all executed improvements of the previous steps are set to standard. With it preventing relapse when trying to fine tune even further. This is an important step towards pursuing perfection. Also it contributes to the ultimate goal of creating a product in which the customer, organization, process and product are one. This means that customer and organization come together which results in the perfect product, while process and end-product come together resulting in a production process that perfectly matches the VAP. Figure 3.10 is our representation of pursuing perfection.

Figure 3.10 – Pursuing perfection



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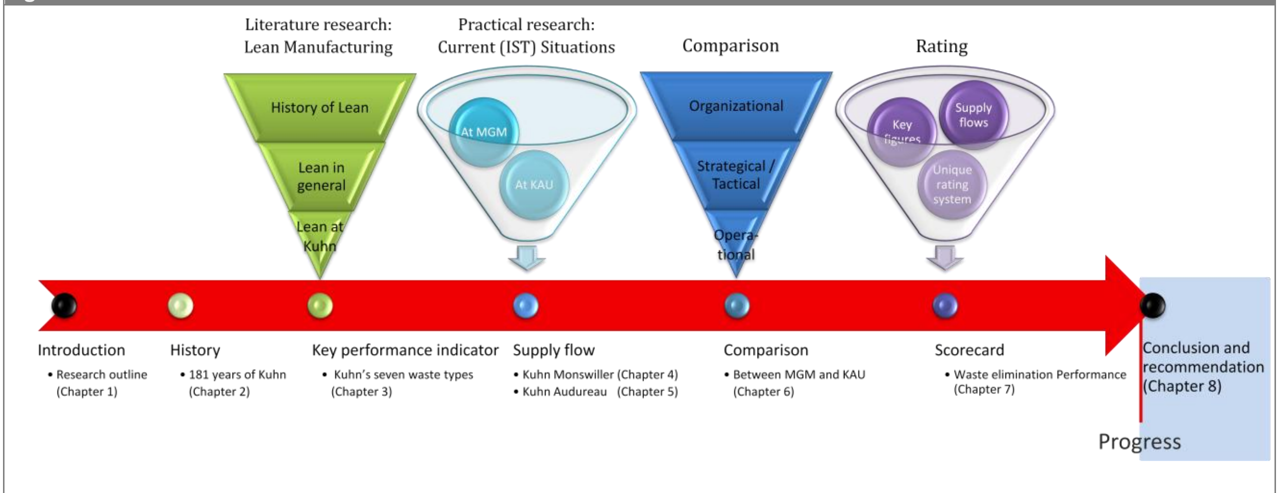
8. Conclusion and recommendation

In the previous chapter we rated the supply flows' performances of both sites. For this we combined our unique rating system with the information provided through chapters 2 till 7. By doing so, we took the last hurdle within our research outline and with it remain only the conclusion and recommendation unanswered (Figure 8.1*).*

Figure 8.1 – Research outline: Conclusion and recommendation are next



In this chapter we will fill in these blanks by drawing our conclusions (section 8.1) and providing our recommendations (section 8.2). During this process we will look back on our research and connect the intented goals to our results. By doing so, we aim to achieve our personal goals and contribute to Kuhn's. Once the conclusion is completed we will finalize this research by providing our recommendation. This recommendation is divided into three parts, namely an recommendation to structure the KPS (section 8.2.1), a recommendation to improve MGM's current flow (section 8.2.2) and a recommendation to improve KAU's current flow (section 8.2.3).

8.1 Conclusion

In the introduction of this chapter we showed the research outline (Figure 8.1) once more. This layout was based on the problem statement that we and Kuhn defined preliminary to this research. Therefore we will refresh the mind a little by stating the actual problem statement before drawing our conclusions and providing our recommendations (section 8.2). As recalled this problem statement (Chapter 0) was:

> "Kuhn Production System (KPS) establishes a set of common manufacturing practices in order to achieve a world class manufacturing organization. One of these practices is the supply management in which currently two pilots take place, namely at Kuhn Monswiller (MGM) and Kuhn Audureau (KAU). Both models focus on material supply to the shop floor in a different way. This makes them suitable for a wide range of situations, but each with its advantages and disadvantages. To optimally benefit from the two models, a description and analysis of both models is desired so that an overview of the practical best cases can be created. Based on these practical best cases can be decided what the best configuration is to implement at Kuhn Geldrop (KNL). Additionally it is necessary to investigate the possibilities of merging these practical best cases, so that an optimal model can be integrated within the KPS."

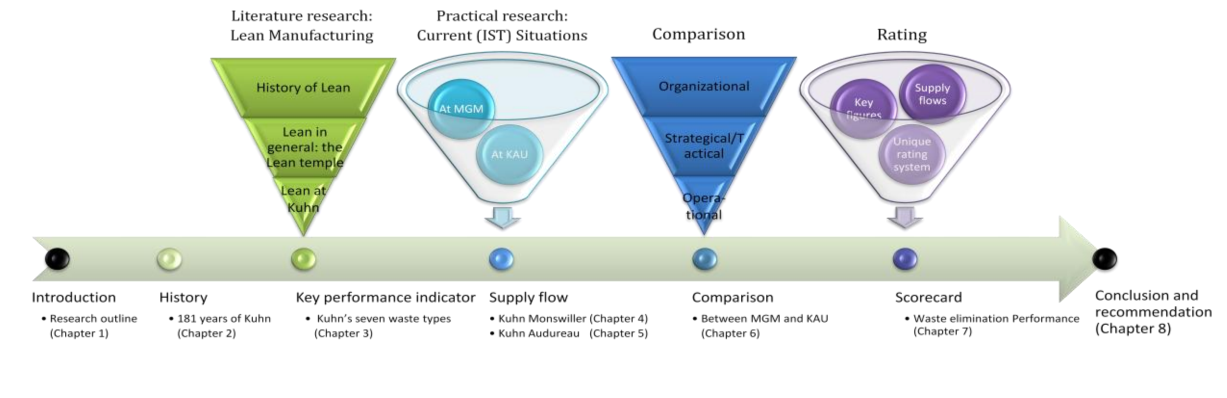
With the problem statement it became clear that Kuhn wants to use their best practices as foundation for future improvement. However the organization has a load of documentation available but none describing the complete supply flows of the two pilot sites. Therefore Kuhn desires these two descriptions, together with a comparison of both sites on organizational and strategical/tactical level. With these descriptions a new source of information becomes available that can be used to rate the sites' performances and combine the best practices in a single model. By combining these needs we formulated the goal that we think Kuhn aims for. To refresh the mind we will restate Kuhn and our personal goals (section 1.3):

> *"Kuhn's goal is to combine theory and best practices to achieve the optimal production environment for their facilities. However as earlier described each process is different and the required support is not everywhere the same. To cope with this Kuhn has currently divided the KPS into modules so that each site can apply the modules as desired. This resulted for each site in a unique setup that over time diverged even further by CI. Therefore to create structure and learn from each other Kuhn wants to describe the supply flows of both pilot sites and compare them so that the best practices can be incorporated in KPS. With it Kuhn strives for an optimal production environment that can be introduced at new facilities such as Kuhn Geldrop.*
>
> *With this report we want to contribute to Kuhn's goals. This by complying the organization's need for a detail description of the current supply flows, a comparison of these flows and an illustration of their performance. By filling in these three blanks we hope to contribute to Kuhn's strive for perfection and provide them with recommendations that lead to waste elimination and improvement of the current supply flows.*
>
> *Additional to these main goals our secondary objectives are to provide some background information on both the organization and Lean Manufacturing (LM). The first is to get an understanding of the organization where this research is conducted and their perspective towards the future. The second is to increase the overall knowledge of the reader so that parts of this report can be understood better".*

Together the problem statement and goals illustrate the scope of this research. To cover this scope we formulated six research questions. Through these research questions we wanted to bring structure to the research so that it can be executed as smooth as possible. These research questions and layout (Figure 8.2) were:

- What is Lean Manufacturing (LM)? (Sections 3.1 and 3.2)
- What is Kuhn Production System (KPS)? (Section 3.3)
- What Key Performance Indicators does Kuhn distinguish? (Section 3.4)
- How do both pilot sites manage and execute their supply flows? (Chapters 4 and 5)
- What are the main differences between the pilot sites? (Chapter 6)
- How do both pilot sites score on the Key Performance Indicators? (Chapter 7)

Figure 8.2 – The research outline defined at the introduction



Using these research questions we set up a research outline (Figure 8.2) that lead from the introduction to the conclusion and recommendation. During this travel we formulated several hurdles, starting by providing some background information on Kuhn and Lean Manufacturing (Research Question 1). With the background information we looked deeper into how Kuhn incorporated Lean in the acceleration flow of the KPS (Research question 2). This resulted in seven unique KPI (Research question 3) that are based on Toyota's seven Muda.

Together these seven KPI formed a critical third eye while observing and describing the current supply flows (Research question 4) of Kuhn Monswiller (Chapter 4) and Audureau (Chapter 5). With it Kuhn's need for these descriptions is fulfilled.

Once this need was satisfied, we continued by comparing both sites on organizational and strategical/tactical level (Research question 5). This comparison was executed in Chapter 6 and in Chapter 7 we combined its information with the information of the current situations in order to make assumptions and rate the performance of both sites.

Due to confidentiality are the pages 92 – 95 removed.

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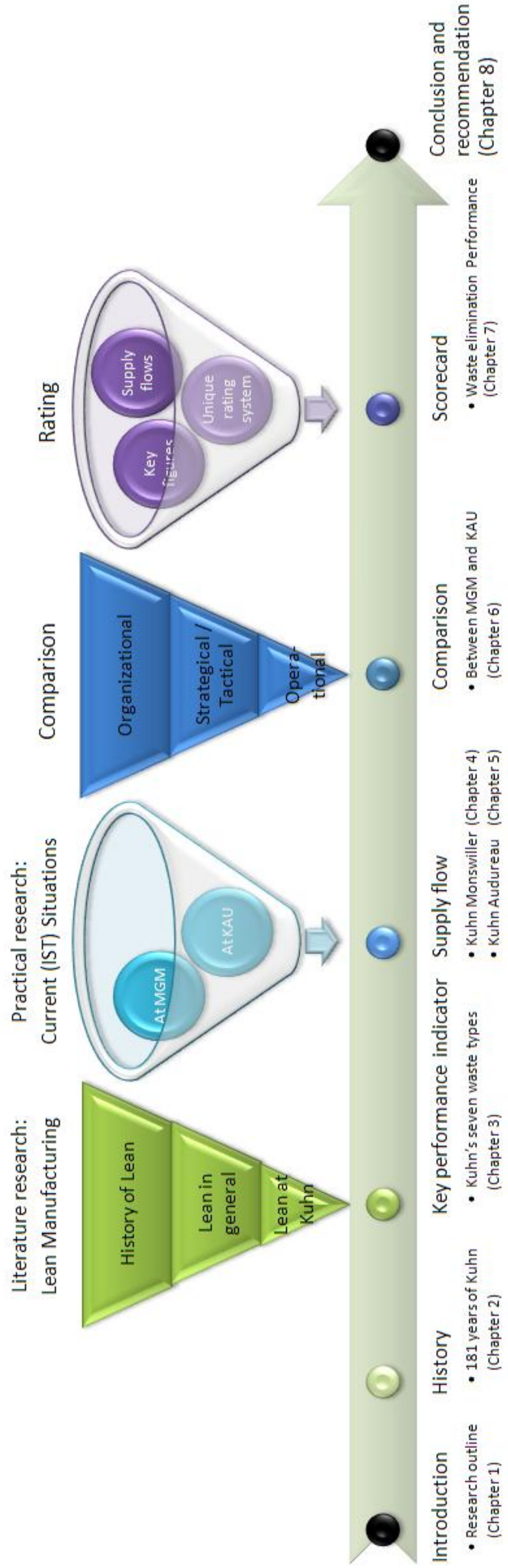
Appendix

A. The research outline



B. Seven waste types (19)(20)(21)

Waste (Muda)	Definition	Causes
Defects	Defects are products or services that are not up to the specification or customer expectations. This results in scrap or rework.	Process failure Batch process Inspect-in-Quality Incapable machines
Inventory	Inventory is the excessive amount of supplies additional to the amount required to fulfill the demand. This includes raw materials, Work-in-progress and finished goods.	Supplier lead-time Lack of Flow Long set-ups Long lead-times Lack of ordering procedure
Motion	Motion is the excessive movement of employees and equipment due to inefficient process layout, defects, reprocessing, overproduction or excess inventory.	Workplace disorganization Missing items Poor workstation design Unsafe work area
Over-processing	Over-processing is the excessive amount of operations that are conducted within the value stream without contributing to it. This can be rework, reprocessing, storage & retrieval.	Delay between processing Push system Customer voice not understood Designs
Over-production	Overproduction is the excessive amount produced additional to what is pulled by the (internal) customer. This results in excessive finished-product stock.	
Transportation	Transport is the unnecessary movement of materials such as inventory and work-in-progress. This movement can be between storage locations or unnecessary movement between one operation and the other.	Batch production Push production Storage Functional layout
Waiting time	Waiting or queuing is the idle time that occurs when an upstream activity (predecessor) does not deliver on time to the downstream activity (successor).	

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