The University of Manchester
Manchester Business School

DBA THESIS

"INTEGRATION OF LEAN PRODUCTION AND ENTERPRISE RESOURCE PLANNING IN THE AREA OF LOGISTICS AND PRODUCTION OPERATIONS OF AUTOMOTIVE OEMS"

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Abstract

This thesis deals with the integration of two apparently conflicting manufacturing improvement concepts; Lean Production (LP) and Enterprise Resource Planning (ERP). On the one hand, Lean Production aims at process excellence with a decisive focus on people, emphasizing standardization, material flow, quality and continuous improvement. On the other hand, Enterprise Resource Planning, largely focuses on Information Technology (IT) in order to improve processes and operations. Referring to these basic underlying paradigms, it appears that there are fundamental differences between these two concepts.

Based on a literature review in the field of operations and IS, the thesis identifies major differences, compares strengths and weaknesses and looks for theoretical synergies between the two concepts. In the light of the literature review findings, the thesis suggests a theoretical framework for integrating Lean Production and ERP, which is to be tested during the empirical part of the thesis. The theoretical framework is informed by two basic and partly contradictory assumptions, which could be viewed as contradictory research hypotheses.

The first assumption holds that due to the fundamental differences, conflicts between the concepts will prevent the application of an integrated framework combining ERP and LP. The second assumption presumes that there were synergies between ERP and LP, which could be utilizable within the application of an integrated framework combining ERP and LP.

Based on a detailed a case study, this research shows that the application of an integrated approach was possible in practice. In particular, the research identifies practical conflicts and shows how they could be overcome. In this respect, the involvement of the company’s top management turned out as a major success factor for overcoming general preoccupations of each side’s proponents against the other. Moreover, the research identifies practical synergies between the concepts and identifies how they could be utilized in practice. In this context, the case study suggests that, amongst others, the concept of LP benefits from ERP’s enterprise wide reach and the concept of ERP benefits from LP’s ability to attract top management attention. Moreover, there are several conceptual synergies, which could be revealed after removal of the general preoccupations. Eventually the findings are summarized in a new release of the integration framework between LP and ERP, informed by the empirical findings of this research.

Declaration

I hereby do declare that the work presented in this thesis has been carried out by me and has not been previously submitted to any other University / College / Organization for an academic qualification / certificate / diploma or degree. The work I have presented does not breach any copyright.

Word Count

Main Body: 79.848 words w/o references, figures and tables.

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Glossary

- Andon: Lean Production - status-display station in manufacturing
- BoM: Bill of Materials
- ERP: Enterprise Resource Planning
- Heijunka: Lean Production - leveling of demand and/or production
- IS: Information Systems
- IT: Information Technology
- Jidoka: Lean Production - process quality focus / route cause analysis
- JIS: Just-In-Sequence
- JIT: Just-In-Time
- KPI: Key Performance Indicator
- LM: Lean Manufacturing
- LP: Lean Production
- MPL: Master Process List
- MRP: Material Requirement Planning
- MRP II: Manufacturing Resources Planning
- OEM: Original Equipment Manufacturer
- SAP: "Systeme, Anwendungen und Produkte" Major ERP company and their software package
- TPS: Toyota Productions System
- WIP: Work-in-Progress

1 Introduction

1.1 Author's Background

The author has a fairly comprehensive academic background in the area of Operations Management, graduating as Industrial Engineer at Rosenheim University in Germany in 2000 and completing a postgraduate degree as Master of Science in Operations Management at the Manchester School of Management (UMIST) in 2001. Following his interest in the improvement of production and logistics operations, the author joined the supply chain management division of KPMG Consulting in 2001. In 2003, KPMG Consulting separated from the parent company KPMG and rebranded as "BearingPoint – Management and Technology Consultants". In 2009 the European sub-region's Managing Directors jointly conducted a Management-Buy-Out of all European BearingPoint practices. In August 2009, the new, independent and partner-led European was founded, employing some 3,500 staff all over Europe.

Holding the position of a Director, the author's main responsibilities include the management of consulting projects, acquisition of new business and managing a team of 10-15 direct reports consisting of consultants and managers. Throughout his career, he was concerned with the provision of consulting services in the area of logistics and production, specializing in clients in the automotive industry. In most of his client engagements he was primarily concerned with projects aiming at the design and implementation of manufacturing improvement initiatives. This thesis draws on the practical experience of the author's 10 years of intensive work within the global automotive industry, and that of his colleagues. In summary the thesis draws on more than 100 initiatives across the globe, most of which were based across Europe.

Despite a broad variety of manufacturing improvement initiatives, each of these initiatives in which I have been involved could be classified as either primarily business-driven with little or no use of information technology (IT) or as rather technology-driven with substantial use of IT and little or no operations management thinking. Though both eventually aiming at the improvement of corporate operations, the author has experienced that business- and technology-driven improvement initiates are usually pursued strictly separate from each other.

This led the author to develop his interest in the interface between business and technology driven improvement initiatives. What finally led to the topic of this DBA thesis was a large consulting project with the objective of integrating lean production (LP) with Enterprise Resource Planning (ERP). That is, integrating a primarily business-driven improvement concept with a usually rather IT-driven endeavour.

1.2 Research Area

Automotive OEMs are currently facing an exceptionally challenging business environment. On the one hand the global economic crisis led to dramatic slumps in demand and consequently high pressure on the revenue side of companies. On the other hand, the continuously high price levels of raw materials cause a financial strain for automotive OEMs procurement side.

Facing these external challenges, auto manufacturers are more than ever forced to work on internal factors within the enterprises' area of control. Probably one of the most important levers in this respect is the improvement of companies' core operations; that is, increasing efficiency and/ or taking out costs of internal business processes. In his respect, one of the key factors for Automotive OEMs is improving the efficiency of companies' production and logistics networks. More than ever, an efficient and flexible manufacturing and logistics network has become a source of competitive advantage in the global race for profits and shareholder value (Skinner, 1969, Christopher, 1992, Cooper et al., 1997, Dangayach and Deshmukh, 2001, Cagliano et al., 2006). In fact, there is a broad range of different concepts for improving a company's operational performance. On a high level, those concepts can be classified into two basic streams; a rather people-oriented and a rather technology oriented stream.

The people-oriented stream predominantly aims at improving a companies' operational performance by changing the behavior of the workforce and its management. Though recent decades have seen numerous approaches, Toyota's Production System (TPS) is probably the most famous example in this respect. Focusing on standardization, material flow, quality and continuous improvement, TPS aims at process excellence based on LP with a decisive focus on people (Sugimori et al., 1977, Shingo, 1981, Ohno, 1988, Monden, 1998, Fujimoto, 1999, Liker, 2004). Despite those first publications in English at the end of 1970s / beginning of 1980s, the interest taken in TPS by Western manufacturers was rather moderate until Womack et al. (1990) highlighted the performance gaps between Toyota and other car manufacturers in their famous book "The Machine that Changed the World". Pushing forward the notion of transferability of TPS to non-Japanese companies, Womack et al. established the term "Lean production" (LP) as the next paradigm of manufacturing (Hines et al., 2004, Lander and Liker, 2007). Despite some critiques throughout the historical development of TPS / Lean in the last couple of decades (Hines et al., 2004), the success of TPS is largely accepted both in academia and management, impressively underpinned by Toyota's recent take-over of the position of the world's largest car manufacturer (Swamidass, 2007, Krisher, 2008).

On the other hand there is the technology-oriented stream, focusing on Information Technology (IT) to improve processes and operations. Probably the most important development in corporate use of information technology is Enterprise Resource Planning (ERP) systems (Davenport, 1998). In the early days of ERP implementations, these initiatives were often viewed as pure IT implementation projects with the main intention of replacing legacy systems and integrating applications and underlying databases. However recent years have seen a shift in the perception of such initiatives towards a more comprehensive approach combining ERP implementations with initiatives aiming at improving, standardizing and harmonizing companies' operational processes (Huq et al., 2006).

It is interesting that the primarily technology-driven ERP is usually pursued separately from the people-centered LP, both in academia and practice. In terms of academia, Piszczalski (2000) held that the lean movement was almost anti-information systems (IS) in its stance. In a similar vein Nakashima (2000) claimed that, some lean proponents would even argue that ERP systems were the antithesis of lean production operations. Gill (2007) argued in a similar direction holding that lean manufacturing concentrated on pulling demand straight from the customer and operating to such requirements promptly and efficiently, whereas an ERP system was a more holistic approach focusing on the organization, effective movement of the data and forward planning. He concluded that Lean and ERP were not only different but also provided distinct outcomes. Masson et al. (2007)

analyzed interviews with more than 45 companies practicing lean manufacturing techniques about the use of Information Technology. He concluded that though lean production practices were fairly widespread, the penetration of lean software, that is software to support LP, was still low.

As far as practice is concerned, the author's practical experience supports the claims in the literature. Drawing on more than 100 manufacturing improvement projects in more than 10 years consulting experience, the author saw no practical attempts to combine ERP with LP elements into one integrated approach. This view is shared by the author's colleagues who have been doing similar projects in the last decade. In fact, the initiative serving as the case study for this DBA can be seen as the first holistic practical attempt to combine those concepts into a single integrated manufacturing improvement framework.

1.3 Motivation

This section sets out to explain why I consider it relevant to investigate an integrated approach consisting of a combination of LP and ERP. As mentioned above, most manufacturing improvement initiatives either focus at process improvement, for instance by implementing LP; or they predominantly aim at improving technology, for instance by implementing an ERP software package.

Figure 1 provides a simplified graphical illustration.

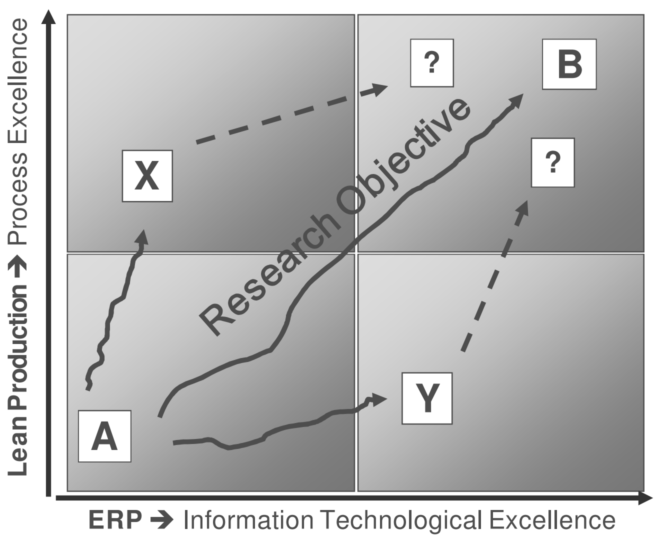

Figure 1: Process Excellence vs. Technological Excellence

The arrow from A to Y can be seen as a move towards technological excellence, whereas the arrow from A to X can be considered a move towards process excellence. However, many companies are neither completely satisfied with achieving point X, nor with reaching point Y. As a consequence companies often try to append a second step, either from point Y towards process excellence or from point X towards technological excellence. In contrast, this is an academic analysis of a project to attempt to simultaneously move towards technological and process excellence by combining LP and ERP into one integrated approach (path A to B).

The following sections briefly outline important arguments why an integrated approach is worth analyzing. After addressing issues with purely technology-driven or purely business-driven initiatives, I will briefly describe difficulties in sequentially progressing further from those points in a second step. Those arguments form the basis of the motivation behind the investigation of an integrated approach consisting of both ERP and LP.

1.3.1 Issues with purely technology-driven ERP initiatives

As far as point Y in figure 1 is concerned, unsatisfactory business outcomes usually originate from one of two different extremes; either a tendency towards simply reflecting existing processes in the new software on a 1:1 basis, or a predisposition towards simply following the processes pre-configured in an ERP on a 1:1 basis. According to the practical experience of the author and his colleagues, both extremes usually lead to unsatisfactory results from a business point of view.

First, regarding the tendency to copy existing processes, I realized that companies end up with processes reflected in a new ERP system; however these processes simply reflect the old processes on a 1:1 basis without improvements. In this respect, the entire ERP implementation initiative could be regarded as a wasted opportunity from a business perspective. In addition to that, I found that such attempts usually result in the development of large individual software enhancements in order to reflect complexity in streams that has grown historically. Apart from comparably high software maintenance costs, such individual enhancements hard-wire these processes and lead to inflexibility in terms of future process changes as well as hampering the ability to upgrade to new software releases.

Second, concerning the tendency to simply follow the processes preconfigured in an ERP, I realized that the outcome was often considered unsatisfactory from an operations management perspective. Even though this means at least some change of existing processes, it was actually the ERP defining the process instead of the process defining the IT. In this respect, these initiatives can be seen as turning the principle of IT supporting business operations upside down. Moreover, such projects can even be denounced as depriving operations management of their duty to design business process in line with an enterprise-specific operations strategy. In some cases, I found that this even led to a loss of competitive advantage for the sake of ERP process compliance.

1.3.2 Issues with purely operations-driven lean initiatives

Concerning point X in

figure 1, I have had the experience that pure operations improvement initiatives are often limited to specific areas within the enterprise. Such projects usually lead to local lean islands within the company, often restricted to single production lines, manufacturing cells, or even parts of it. In fact, within ten years of experience in the European Automotive industry, I did not come across a case in which lean production had been applied at the same and consistently high level throughout all logistics and production departments across an enterprise. Instead I usually found a rather fragmented picture consisting of local operational excellence islands next to areas which are far behind in their lean development. There are several other reasons for this. First, there are different organizational responsibilities for different organizational areas within the firm. However, the application of a rather “soft” topic like lean production depends on individual interpretations of the concept. In addition the applicability of lean production varies according to the operational context. For example, areas with high and steady production volumes and low product variety and complexity are often taken as pilot areas in order to derive quick wins. However when it comes to areas with more variation, I found that companies often struggle with the implementation.

Another issue with purely business-driven initiatives is a lack of sustainability. The application of lean production is very much a people driven phenomenon. However there is a natural tendency of human beings to fall back to old habits of doing things and there is no firm “corset” as provided by an ERP system, which forces people to do things in a certain way. Moreover workers tend to move jobs frequently in today's business environment. According to my experience these issues often lead to a lack of sustainability of lean production initiatives.

1.3.3 Difficulties with sequential implementations

In addition to the issues with purely business or technology driven initiatives, I have realized that companies often face difficulties in progressing further. This refers to both initiatives trying to implement LP after the ERP implementation (

figure 1, Y -> ?) as well as initiatives intending to implement ERP after the LP implementation (

figure 1, X -> ?).

With respect to implementing ERP after LP, I realized a strong and sustainable negative attitude of the employees towards ERP and/ or IT. In many of my past projects I found that this negative bias towards IT came from an association of IT/ ERP with push-based, deterministic MRP planning philosophies. It has often proven very difficult to sell the idea of implementing ERP in these existing LP environments. And, even if an ERP implementation can be launched, conflicts between LP and ERP representatives often arise since the ERP process templates do not always match with the already implemented lean processes on a one to one basis.

Regarding the implementation of LP after ERP, a major concern comes from the fact that the processes are already fixed by ERP prior to the start of the LP initiative. This makes re-design of processes difficult, since a change to a process is often not possible without adapting the ERP system. As a consequence, the lean changes often lead to costly and risky software adaptations, often resulting in the launch of new ERP project. In addition to that, conflicts between LP and ERP proponents are likely to arise since the ERP proponents tend to defend the processes they have previously implemented.

1.3.4 Coexistence of LP and ERP

Another point noticed throughout my practical career is that LP and ERP already coexisted within the same company or production plant, however they were implemented independently from each other. In these cases I encountered the issue that, instead of collaborating, the two concepts usually competed against each other. In this respect I encountered two major issues:

First, in areas which were controlled by lean production and ERP, the ERP inventory levels were often running out of control. The reason was that the physically triggered inventory movements in LP, often controlled by a manual Kanban systems, were not correspondingly booked in the ERP system. Quite often the ERP inventory posting was even viewed as non-value adding waste by the employees. However the communication to suppliers was usually done be EDI messages controlled by the ERP system. By this means the inaccurate ERP stock levels lead to wrong call-offs or forecast delivery schedules sent to suppliers, resulting in material shortages or excess inventories.

Second, LP was usually implemented only in certain areas characterized by ideal preconditions for LP. In other areas LP was not or only insufficiently implemented. However ERP, by definition, is to control an entire plant or even enterprise. In these cases there were usually many interfaces between LP and ERP, which were not or at least not clearly defined. As a consequence these interface usually did not work properly and the two concepts often worked against each other. For example this lead to LP pulling parts through certain areas and at the same time ERP pushing the parts according to deterministic principles in other areas, often downstream or upstream to the LP islands. Again, results were shortages or excess inventories. A similar example applies to batch sizes, which were often not in correspondence between LP areas and ERP areas, leading to avoidable repacking efforts.

1.3.5 OEM's Motivation

The OEM who conducted the project to be analyzed as the case for my DBA research is major manufacturer with many production plants across Europe. The company produces trucks and buses as well as engines and components and delivers them to customers all over the world.

The motivation of the OEM providing the setting for this research was very much in line with the issues described in the previous section. In the past, the OEM realized problems with both mainly IS-driven and mainly operations-driven initiatives.

On the one hand, the company carried out a range of mainly IS-driven initiatives before the integrated initiative was launched. These initiatives mainly focused on the replacement of old legacy systems, which could not be maintained any more. In these initiatives, the outcome was either completely negative or at best mixed. The IS side was at least partly satisfied with the outcome since at least some parts of the legacy system environment could be replaced, however often at the cost of additional system interfaces from the new ERP to the remaining legacy environment. However the operations side was mostly disappointed and claimed that they needed more people to operate the IT processes than before the implementation.

On the other hand, there were a number of purely operations-driven initiatives, for instance aiming at the improvement of specific sections of the assembly line or parts of the logistics operations. Even though the initiatives were often successful in improving operations in limited areas, the improvements often did not result in better overall productivity. The reason was usually that one area was improved on the detriment of other areas instead of considering the overall process flow. In fact, it was often the case that bottlenecks were only shifted from one area to another. Moreover, the improvements were often perceived as not sustainable.

Inspired by knowledge and reports about these above mentioned experiences of the OEM, the author and some of his consulting colleagues developed and suggested a new approach in which LP and ERP were combined into one integrated initiative. With the new approach I intended to combine the necessary replacement of old legacy systems with a holistic and sustainable improvement of operations processes in the production network. With the new integrated approach it was possible to convince the top management of the OEM to launch a feasibility study, which finally led to the project serving as the case for my DBA research. Both the financial results of the IS and the operational improvements were planned and regularly tracked in a financial business case evaluation for the overall initiative.

1.4 Aims of Research Questions

In the light of the potential and actual conflicts noted in the literature (for details see chapter 2), and observed in practice (for details see chapter 4), this thesis reports and analyses an integrated manufacturing improvement initiative in order to study the combination of LP and ERP in a practical case. The practical case is concerned with an enterprise-wide manufacturing improvement initiative of a European automotive OEM's production and logistics network.

The overall research theme deals with the question whether and how it could be possible to combine ERP and LP into one integrated approach. In order to address this question I primarily focus on two streams.

The first stream deals with conflicts between LP and ERP. In this respect I address the following questions:

- A1: Are there conflicting aspects between LP and ERP in practice, which can prevent the successful realization of an integrated manufacturing improvement initiative?
- A2: If yes, what are they?
- A3: How can they be overcome?

The second stream addresses synergies between LP and ERP in this practical research case. In this context I analyze the following questions:

- B1: Are there areas of synergy between LP and ERP, which can support the successful realization of an integrated manufacturing improvement initiative?
- B2: If yes, what are they?
- B3: How can they be utilized?

By analyzing the research questions, I provide a contribution with respect to two areas. First I expand the body of academic knowledge in the area of integrating LP and ERP with my empirical findings. Second, provide valuable insights for practitioners, who consider implementing ERP and LP simultaneously in one integrated manufacturing improvement initiative in practice.

1.5 Timeline

The following figure provides an overview of the timeline followed for the creation of the DBA thesis. I have divided the timeline into three parts, namely literature-based work, practical work and writing up the thesis. The practical work also reflects the major phases of the project to be analyzed in the empirical part of this research.

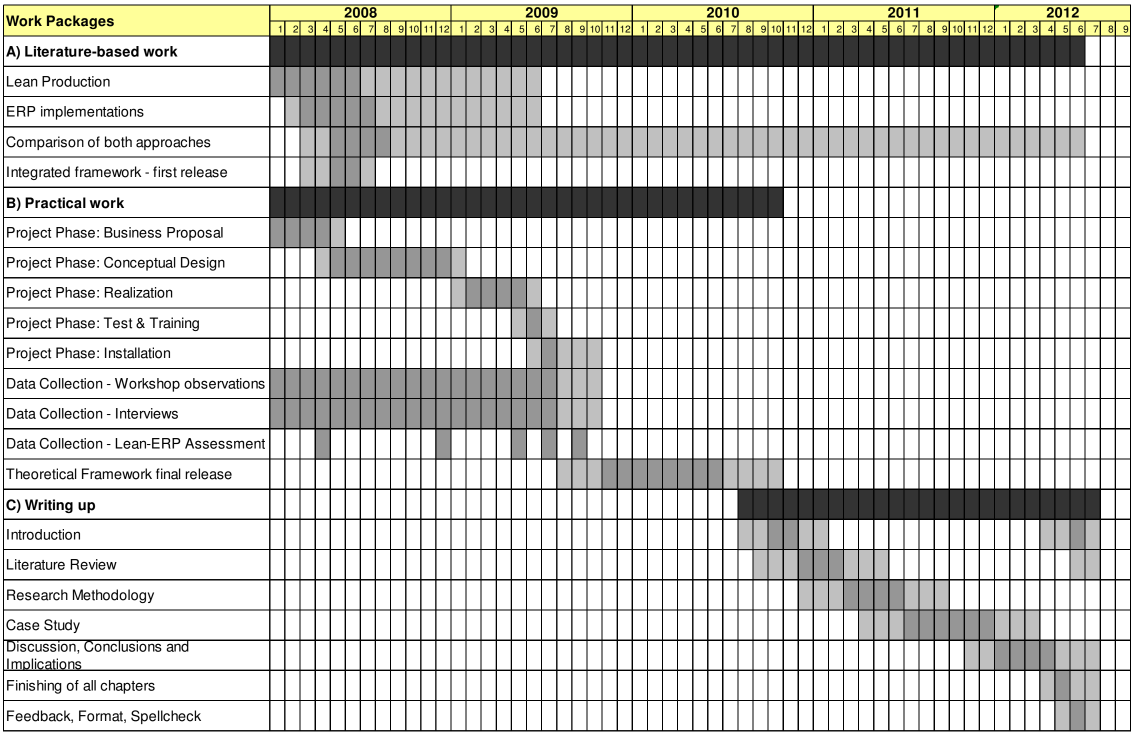

Figure 2: Timeline of DBA research

1.6 Main Findings

This thesis provides deep insights into the integration of two apparently conflicting manufacturing improvement concepts; Lean Production and Enterprise Resource Planning. Based on a detailed a case study, this research shows that the application of an integrated approach was possible in practice.

On the one hand, the research identifies conflicts and describes how they can be overcome in practice. The findings suggest that the conflicts can be clustered into two different levels:

- General Preoccupations
- Conceptual Conflicts

The general preoccupations can be understood as biases of each side's proponents against the other side. In this context my research shows that it is not unusual that ERP proponents consider LP as a management fad, based around simplistic common sense principles. On the other hand, LP proponents can regard ERP, with its strong IT focus and its high complexity, as in sharp contrast to the simple as possible lean philosophy. Particularly at the beginning of an integrated initiative, the research shows that it is possible that these preoccupations can only be overcome with the support and intervention of the top management. Later in the project, the general aversion decreases significantly in line with an increasing number of conceptual synergies identified and realized.

The conceptual conflicts are based on concrete conceptual differences between LP and ERP. One of the most predominant examples is ERP's deterministic MRP calculation logic, which is seen as in harsh contrast to LP's consumption driven pull principle. This apparent conflict can be resolved by applying a contingency approach consisting of ERP's new Kanban/ pull functionalities for high volume and low volatility parts and ERP's deterministic MRP logic for low volume and high volatility parts. Another predominant conceptual conflict was LP's focus on continuous improvement versus ERP's characteristic of fixing processes based on IT. The research shows that this conflict can be overcome mainly by demonstrating ERP's flexibility in terms of customization and parameterization and by contrasting it with the old and inflexible legacy system environment.

On the other hand, the research identifies practical synergies between the concepts and identifies how they could be utilized in practice. The synergies can be divided into two areas:

- General Synergies
- Conceptual Synergies

As far as the general synergies are concerned, the case study suggests that the concept of LP benefits from ERP's enterprise wide reach. In this respect, ERP can be said to equalize one of LP's main weaknesses, the difficulty to apply it on a holistic level. In fact, LP is often applied to specific areas of production lines or value streams, which are characterized by high volume and low volatility of the material flow. In contrast, the concept of ERP is usually applied on a plant-wide or even enterprise-wide level. My research suggests that by combining the two concepts, it is possible to spread out lean thinking and lean principles across all areas of logistics and production within a plant. Moreover, the other way round, I suggest that ERP benefits from LP's ability to attract top management attention and support. The combination of the two concepts leads not only to IT benefits but also to concrete business benefits for instance in terms of reduced inventory and/ or increased productivity. This case study shows that, on an enterprise-wide level, these benefits can accumulate to a level high enough to attract intensive attention of top executives.

Concerning conceptual synergies, the research identifies five major points amongst others. First, ERP's functionality in terms of electronic Kanban is well utilizable in a lean environment. Second, ERP's characteristic of standardizing processes actually works well in line with LP's element of standardization. Third, ERP's flexibility with respect to customization and parameterization serves as a facilitator towards Kaizen compared to old and inflexible individually programmed IT systems. Fourth ERP's demanding high requirement with respect to data quality is utilizable to support the LP element of quality first. And finally, ERP's ability to integrate data and processes throughout organizational barriers works well in line with LP's element of people and teamwork.

1.7 Structure of Thesis

This section briefly outlines the structure of this thesis. Chapter one deals with the introduction, summarizing the author's background, the research area and the motivation of the research. The chapter closes with the outline of the structure of the thesis provided in this section.

Chapter two reviews the literature relevant to this thesis. The first section focuses on the concept of lean production. After summarizing the evolution of the concept, I define the term lean production in the context of this research. The first section closes with a description of each of the main elements of lean production. The second section concentrates on the area of enterprise resource planning, providing a summary of its emergence and defining the term of ERP as I will refer to it during this thesis. Moreover the second section deals with the topic of ERP implementations, introducing various implementation models and discussing the role of business process reengineering (BPR) in ERP implementations. The third section brings together both topics describing differences, strengths and weaknesses as well as potential synergies.

Chapter three introduces the research methodology to be applied in this DBA research. After a description of the research strategy, I focus on the research design and the research methods. At the end of the chapter I discuss the strengths and weaknesses of the approach.

Chapter four is concerned with the empirical part of the research; that is, the case study. I first introduce the initiative which serves as the case for this thesis. Then I provide a section for each of the phases of the initiative, focusing on the course of action, the activities and the main findings of each phase.

In the fifths chapter I round up this thesis by providing a discussion, conclusions and implications. In this context I refer back to my research questions.

2 Literature Review

This chapter reviews the literature in two main areas. Section 2.1 provides an overview on the topic of Lean Production (LP), and section 2.2 reviews the subject of Enterprise Resource Planning (ERP). Section 2.3 compares LP and ERP to identify differences, strengths and weaknesses and potential synergies between both concepts. Finally section 2.4 provides a summary of the literature in these areas, highlighting gaps and research questions identified in and from the literature.

2.1 Lean Production (LP)

2.1.1 Evolution of Lean Production

This section sets out to provide a brief introduction to the concept of lean production (LP). After outlining the historical roots and briefly describing the evolution of LP, I will present two comprehensive definitions of the term LP.

Today there is general consensus that LP has its origin in Japan after World War II (Ohno et al., 1993). However, Henry Ford had already applied basic elements of today's LP principles in the 1920s. In his book "Today and Tomorrow" (Ford et al., 1926), Ford highlighted the topic of waste, which can be viewed as a central component of LP (Hines et al., 2004). In fact, he criticized the fact that they (the Ford company) spent too much attention on recovery and too little on avoiding issues in the first place. Furthermore he held that if they bought more material than required they were likely to decrease the value of the goods.

In contrast to Ford, the motivation behind the Toyota Production System (TPS) was the lack of economic resources after World War II (Reichhart and Holweg, 2007). According to Ohno et al. (1993), the budget for investing in new machines and inventory was extremely limited so the focus had to be on improving the efficiency of organizational procedures and processes as well as minimizing stock and work in process (WIP) inventory. Ohno claimed that after World War II, Toyota had adopted many of Ford's ideas, which no longer had much in common any more with the general production practices in the United States at that time. In a sense, one could hold that Ohno adopted Ford's ideas and developed them further into the Toyota Production System (Ohno, 1988, Monden, 1998, Fujimoto, 1999).

However despite the legitimate praise of the Toyota managers, it would be too simplistic to conclude that Toyota has not benefited from learning from other Japanese OEMs like Honda, Kawasaki or Nissan as well as from the teachings of Deming and Juran (New, 2007). In addition to that, Ohno (1988) holds that an important part of the inspiration for TPS actually came from visiting a US supermarket. In this context he refers to a business trip of a Toyota delegation led by Ohno in the 1950s to the United States with the objective to visit several Ford automotive plants. Ohno (1988) reports that the delegation was rather disappointed by the Ford processes, operating with large batch sizes and piling up huge amounts of inventory on site. However when the same delegation visited a US supermarket they were inspired by the consumption-driven reorder and restocking procedure in place (Magee, 2007). This consumption driven pull replenishment concept was transferred to Toyota plants and can be seen a predecessor to the prominent Just-in-Time (JIT) concept, which was later to become one of the two main columns of the Toyota Production System (Ohno, 1988).

Since the 1950s TPS has continuously evolved and spread, from engine manufacturing in the 1950s to vehicle assembly in the 1960s and the wider supply chain in the 1970s (Hines et al., 2004). It was during that period that the first supplier manuals were written and the principles of TPS were brought outside Toyota for the first time. The first substantial academic paper on TPS in the English language was published in 1977 by four Toyota managers in the International Journal of Production Research (Sugimori et al., 1977), who highlighted two underlying basic concepts of TPS: "Cost reduction through the elimination of waste" and "Full utilization of workers' capabilities". Cost reduction should be supported by applying Jidoka (machine design to automatically prevent production of defect products) and just-in-time production (comprising material pull systems, one-piece flow, leveling), the two pillars of what is today recognized as the TPS house (Liker, 2004, figure 2). Utilizing employees' capabilities should be achieved by establishing a system of respect for people underpinned by minimizing wasted movements of workers, ensuring safety and allocating greater responsibility by encouraging workers to participate in improving their work stations. In addition to Sugimori's paper, other early and often cited English publications on the topic of TPS comprise the books of Shingo (1981), Schonberger (1982), Hall (1983) and Monden (1983).

More than one decade after Sugimori's paper had been published, the term "lean production" was introduced as the next manufacturing paradigm beyond mass production by Womack et al. (1990) in their famous book "The Machine that Changed the World". In their MIT study comparing car manufacturing in America, Europe and Japan, they came across a concept they considered superior to the traditional concept of mass production, which was heavily deployed by Western automotive OEMs at that period of time. In fact, they presented a concept which appeared to solve the so far incompatible objectives of improving quality, improving productivity and decreasing delivery time. The authors referred to this concept as "lean production", in contrast to the then conventional "mass production" and claimed that they found the purest form of it in Toyota's TPS, which has been referred to as the best-known example of a lean production system (Lander and Liker, 2007). Furthermore, based on the assumption that automotive manufacturing issues were universal problems, the authors suggested a transferability of lean production by emulating it in environments beyond the context of automotive, manufacturing or Japanese-culture. Since this important milestone by Womack et al. (1990), lean has taken on a life of its own and has been applied by many organizations throughout the world.

Hines et al. (2004) hold that when applied to sectors outside the high-volume repetitive manufacturing environment, LP has reached its limitations. As a consequence other approaches have been developed in an attempt to cope with variability, volatility and variety. In this respect, agile manufacturing has received substantial attention and was even suggested as a potential successor of LP by some authors (Christopher, 1992, Goldman et al., 1995). Hines et al. (2004) maintain that in environments characterized by variability, volatility and variety, a lean-agile debate is appropriate for the trade-off between an agile or a lean strategy, or even a hybrid concept (Naylor et al., 1999, Christopher and Towill, 2001). However with reference to the distinction between a strategic level of lean and an operational level of lean, Hines et al. (2004) hold that agile manufacturing can be integrated on a strategic level without contradicting the core objective of lean thinking. In a similar vein, he also refers to other prominent approaches like Total Quality Management (TQM), Theory of Constraints (ToC), 6-Sigma, Total Productive Maintenance (TPM) and Enterprise Resource Planning (ERP).

2.1.2 Defining Lean Production

Today LP is often used by companies to promote ideas and products that have little similarity to the original ideas of Ohno's TPS. In this respect, lean production is frequently wrongly perceived as a tool box consisting of concepts, which can be applied separately and/or arranged individually. Due to that reason, Liker (2004) prefers to refer to the term The Toyota Way, so as to embed the tools and techniques into the overall Toyota philosophy, which is informed by an extraordinary corporate culture evolved through more than 50 years constant development.

According to Terell (1999), LP elements are often referred to as lean manufacturing, lean management or TPS. In terms of clarifying what is meant by LP, I present two comprehensive and different definitions of LP. The first one is a rather academic definition and was suggested by the Association for Operations Management (Cox, 2002, p.61):

> "Lean Production - A philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and dealing with the customers. Lean producers employ teams of multi-skilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes of products in potentially enormous variety. It contains a set of principles and practices to reduce cost through the relentless removal of waste and through the simplification of all manufacturing and support processes."

With the second definition I intend to present one out of numerous practical examples of defining Lean Production (Quest, 1999, p.ii):

> "Lean is used to describe an organization or process where the right things are done, at the right time and they are done well:
>
> - single items of work keep moving or flowing,
> - there is minimal work in progress, finished stock and raw material inventory; backlogs are low,

- everything works to a beat determined by the rate of customer demand,
- people work in self-managed, flexible teams to deliver a clear and complete output and
- the focus is on processes rather than functions."

Comparing the practical definition with the academic definition presented before, differences can be found. For instance, whereas the first definition accentuates the elimination of non-value adding activities and the removal of waste, the second definition highlights aspects like the focus on customer demand or single piece flow. This demonstrates that LP is a complex concept, which cannot be comprehensively described by a single definition. In order to provide a deeper overview of what constitutes LP, the following paragraphs break down the concept of LP by describing the main objectives, principles and the foundations. Hence the following descriptions can be seen as the detailed definition of LP, to which I will refer throughout this thesis.

As mentioned earlier, there are various applications of the term LP. The definition of LP for the purpose of this thesis will be used as broadly synonymous with TPS as is the case with many authors (Swamidass, 2007e.g.).

2.1.3 Elements of Lean Production

There is broad range of descriptions of LP / TPS. Liker (2004) describes 14 principles of TPS, Womack and Jones (1996) explain the five main steps for implementing LP and Ohno (1993) presents TPS from a rather biographic point of view. Fujio Cho, a student of Ohno, developed a clearly arranged illustration highlighting the main elements of TPS - the TPS-house.

The TPS house is structured into three different levels. The bottom part can be interpreted as the foundations, the middle part contains the main principles and the top part represents the main objectives. Figure 1 provides an overview of the TPS house as illustrated by Liker (2004).

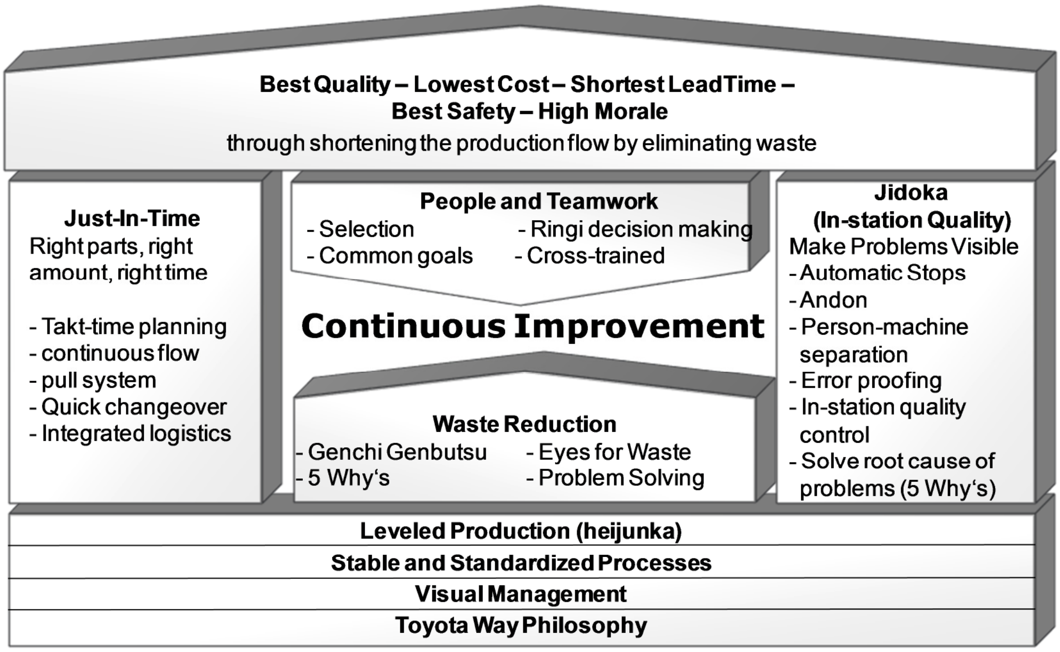

Figure 3: The Toyota Production System (Liker, 2004, p.33)

In order to provide deeper insights into LP, the following paragraphs briefly outline a selection of the important elements. The structure is based on the TPS-house as suggested by Cho and outlined by Liker (2004). Starting with the roof of the house, section 2.1.3.1 outlines the objectives behind LP. Section 2.1.3.2 addresses the two columns and the interior of the TPS-house, describing selected principles and tools. Finally, section 2.1.3.3 highlights the foundations of the TPS-house, explaining the main elements on which the LP concept is based.

2.1.3.1 Objectives

Cho has illustrated the objectives as the roof of the TPS-house (Liker, 2004). In this sense, these objectives can be interpreted as the basic guidelines that embrace all of the tools and techniques within the TPS-house.

LP is a practical improvement concept with one outstanding objective: increasing operational profit (Monden, 1998). In order to achieve this objective, LP follows two primary approaches: reducing costs and/ or increasing productivity. This is realized by the elimination of various kinds of waste, for instance the reduction of inventory or the downsizing of over-dimensioned machine capacities. However LP is not restricted to cost reduction in manufacturing but rather includes distribution costs, administration costs and even costs for capital lockup (Monden, 1998).

Although increasing profit and reducing cost by elimination of waste represents the primary objective of LP, there are lower level objectives which can be seen as prerequisites for the primary goals:

1. Demand leveling
2. Quality assurance
3. Respect for humanity

Demand leveling (Monden, 1998) aims at preparing the production system to cope with daily or monthly variations in terms of quantity and variety. The major objective of quality assurance is to make sure to deliver only flawless products and parts to the downstream workstations. Respect for humanity implies that only by providing respect to workers, it is possible to leverage the entire potential of the workforce, for instance in terms of motivation, improvement suggestions or take-over of responsibility. Though these three objectives are a necessary precondition for the primary objective, they cannot be followed independently from each other. The following figure describes the interaction between the various objectives of TPS.

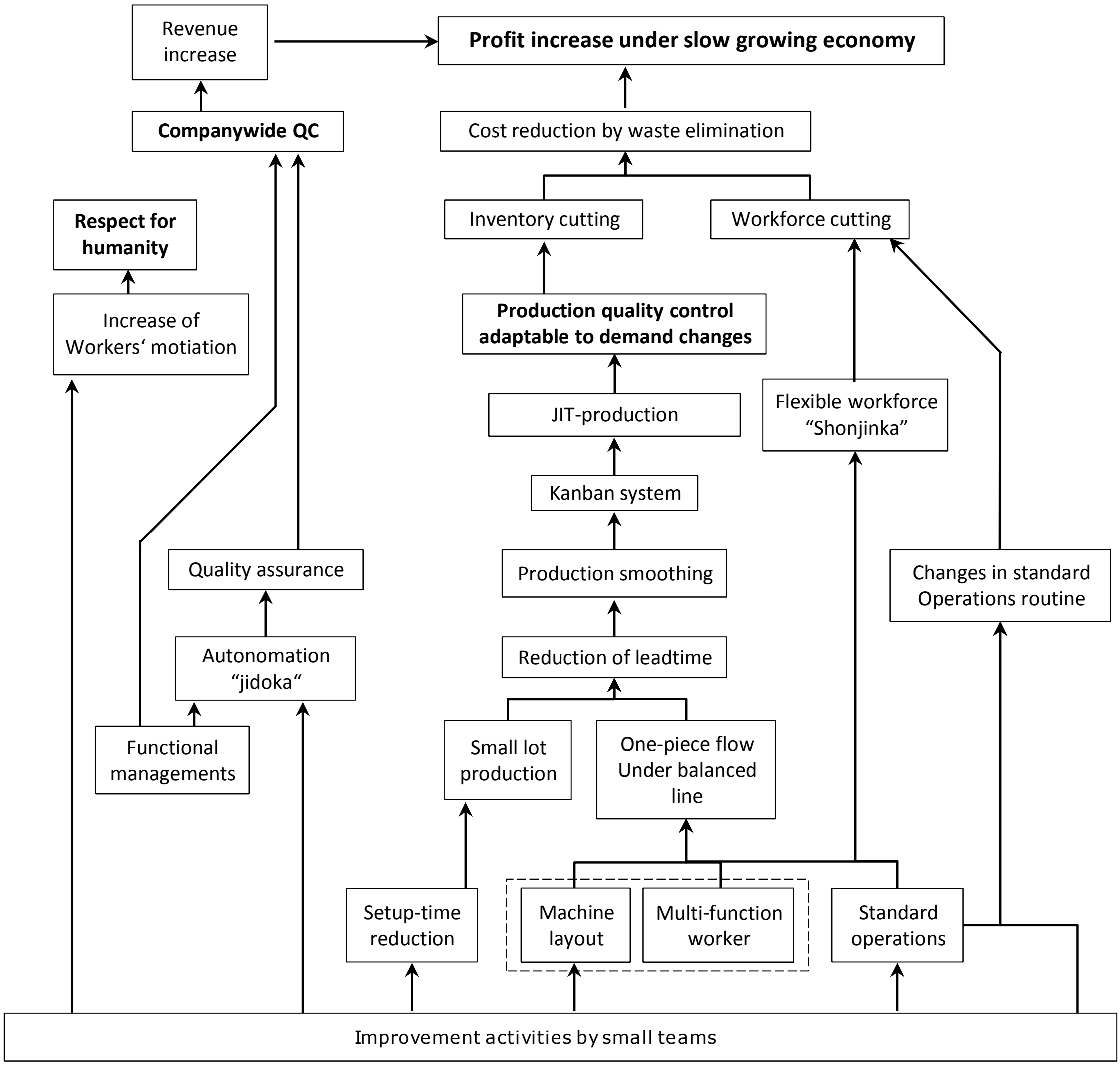

Figure 4: The Toyota Production System (Monden, 1998, p.4)

2.1.3.2 Principles and Tools

In this section I briefly outline the most important principles and tools of Lean Production. Those tools can be considered as the middle part of the TPS-house as suggested by Cho (Liker, 2004).

2.1.3.2.1 Just in Time

Just in Time (JIT) represents one of the two basic columns of the TPS house. JIT, which is also referred to as the pull-system, aims at a continuous flow of material and goods through production. Generally JIT means that the right amount of the right parts arrive at the assembly station at the right time. This leads to a significant decrease in stock and - in the ideal case - the inventory level comes close to the theoretical objective of zero. However considering a complex product like a vehicle consisting of thousands of different parts, the number of work-stations is extremely high and the various flows of material are extraordinary complex. As a consequence it is difficult to apply JIT systematically in all production activities (Ohno et al., 1993).

Within the JIT system, Kanban (Kanban = Jap.: card) is used as a major tool to control production as well as flow of parts and raw material. Kanbans are cards which carry information like part number, details about the means of transport and transport quantities as well as information about source and the target location. Production- and transport-kanbans, as the most predominant kinds, can be seen as the backbone of the JIT system since they support a consumption-driven production and material flow throughout the factory (Quarterman, 2008).

Reduction of set-up times is another important enabler of the JIT system. Set-up time means the period in which a machine cannot be used to produce parts because it needs to be prepared for the forthcoming activity. Whereas in mass production batch sizes where configured to be relatively large in order to reduce the number of set-ups to a minimum, Toyota managed to reduce most of their set-up times themselves to only a fraction of the initial times (Ohno et al., 1993). The method to dramatically reduce set-up times is often referred to as Single Minute Exchange of Die (SMED). SMED enables sequencing the production plan with plenty of machine set-ups. By this means, SMED supports the concept of One Piece Flow, which is often considered the ideal case of a JIT system (Ohno et al., 1993).

2.1.3.2.2 Jidoka

Jidoka can be considered to be the second column of the TPS house (Liker, 2004, Lander and Liker, 2007). It is also referred to as autonomous automation (autonomation); that is, automation with human characteristics (Ohno et al., 1993). This type of automation implements some supervisory functions rather than production functions. At Toyota this usually means that if an abnormal situation arises the machine stops and the worker will stop the production line.

Autonomation prevents the production of defective products, eliminates overproduction and focuses attention on understanding the problem and ensuring that it never recurs. By preventing defective parts from moving further to downstream operations, Jidoka supports the JIT principle to a great extent (Ohno et al., 1993, Kerr, 2006, Becker, 2006).

2.1.3.2.3 Elimination of Waste

LP evaluates all processes from a customer perspective. By this means, LP sets out to analyze which actions generate added value, for which the customer would be willing to pay money. All tasks which do not result in such added value are consequently considered as waste (Jap. Muda). Toyota identified seven elements of waste in business and manufacturing processes. One of the main objectives of LP is to avoid or at least reduce those kinds of waste as far as possible (Liker, 2004, Womack and Jones, 1996, Husby, 2007, Kerr, 2006). The following list provides an overview (Liker, 2004, Ohno et al., 1993, Cunningham and Jones, 2007):

- Overproduction
- Waiting time / idle time
- Unnecessary / too long transportation
- Poor organization of the working process
- Excess Inventory
- Unnecessary motion or movements
- Defects / failures

Overproduction summarizes all kinds of production of goods, which are not covered by an actual customer order. This kind of production is considered to lead to wasted capacity for work, excess inventory and unnecessary transportation efforts due to excessively filled warehouses. Waiting and / or idle times arise when workers are only there for monitoring machines or waiting for material supply. A poor organization means unnecessary or inefficient processes resulting from inappropriate tools or poor product design. Excess inventory comprises a high stock level of raw materials, work in progress, and finished goods inventory. Unnecessary motion or movements can result from searching for parts or poor assembly processes. Production of defective goods leads to repair efforts, scrap, replacement production as well as a need for quality inspection; all of those tasks can be considered non-value adding. Liker (2004) suggests an 8th waste category by summarizing all kinds of unused creativity potential like loss of time, ideas, improvement potential or learning potential due to the fact that improvement proposals of workers are not considered (Liker, 2004, Becker, 2006, Bell, 2006).

2.1.3.2.4 People & Teamwork

Another important element of LP is the principle of people & teamwork. Sugimori (1977) referred to respect for humans as one of two major themes of TPS. The main point of his argument is that TPS respects workers' dignity because the system makes full use of their capabilities and empowers them with the running and improvement of the plant. Referring to an analogy to sports, Ohno (1993) compares the teamwork required to assemble a product to, for instance, a soccer team, in which the team spirit and moral decide between victory or defeat. Similarly when manufacturing a good, the output in terms of quantity and quality depends on the work performed in the entire team, not on the quantity of parts treated by a single worker. Hines et al. (2004), for instance, highlights the importance of the human dimensions of motivation, empowerment and respect for people. Lean is often categorized as a bottom-up improvement approach with a strong focus on people, since the improvement itself is expected to be initiated by the workers on the shop floor (Magana-Campos and Aspinwall, 2003). This focus on people and bottom-up improvements can be seen as a distinguishing criterion from other improvement techniques like Business Process Reengineering (BPR), which are often induced top down with no or little worker involvement (Nolan et al., 2006, Williams et al., 2003, Johnston et al., 2001).

Many publications fail to consider adverse effects of LP on workers, such as those highlighted in Hampson (1999). For instance the occurrence of karoshi - death from overwork - was seen as evidence of the way `leanness' could cause stress to workers. However, as Pil and Fujimoto (2007) have establish, TPS has evolved and become more reflective and human over time, partly due to the difficulty of recruiting workers in the early 1990s.

2.1.3.2.5 Continuous Improvement

Continuous improvement is illustrated in the centre of the TPS house and can be seen as one of the basic principles of LP (Ohno et al., 1993). The expression of continuous improvement in the context of LP comes from the Japanese word

Kaizen. Literally translated Kaizen means change to the better (Jap.: kai=change, Jap.: zen=better). Kaizen is based on the conviction that every product, process and activity can be continuously improved and this improvement should be achieved by a defined procedure (Dickmann, 2007). This procedure sets a focus on direct on-site observation (Jap.: Genchi Genbutsu). In fact, Genchi Genbutsu is based on the philosophy that it is only possible to gain insights into a problem by direct on-site observation and self-verification of facts (Liker, 2004). Improvements are formulated as working hypothesis and subsequently realized and tested in the real working environment. The results are analysed, discussed and result in the creation of the next working hypothesis, which is in turn realized evaluated and further improved. This leads to a permanent improvement cycle consisting of planning, realization, monitoring and adjustment. Successful practices will be formulated as standard and rolled-out to the entire organisation.

In contrast to other improvement techniques like Business Process Re-engineering (BPR), LP is based on incremental but continuous steps to improve business processes (Williams et al., 2003). In order to make Kaizen work sustainably, however, it is required to go beyond the provision of tools and reward systems for encouraging workers to suggest improvements. It is rather required to induce a philosophical shift of the entire workforce towards a culture which is constantly questioning the status quo (Magana-Campos and Aspinwall, 2003, Black, 2007, Taylor and Taylor, 2008).

In this context, Deming encouraged Toyota to apply a systematic approach to problem solving, which became known as the Deming's Shewhart Cycle or Plan-Do-Check-Act (or PDCA) Cycle (Deming, 1986). Liker (2004) claims that the iterative four-step problem-solving process of Deming has become one of the cornerstones of continuous improvement. Whereas the Plan step comprises establishing the objectives and processes necessary to reach the expected output, the Do phase addresses the implementation of the new process, often on a small scale. The Check step is concerned with measuring the new processes and comparing the results against the expectation. Finally the Act step consists of analysing the reasons for differences and deriving potential areas of improvement, which leads again to step 1. In this way, the PDCA Cycle can be continuously repeated, leading to continuous improvements of operational processes and procedures.

Based on the philosophy of continuous improvement, Toyota is even questioning Kaizen and is moving towards other improvement concepts like innovation by quantum leaps (Jap.: Kaikaku). Another example is the tendency to supplement Kaizen through a version of Theory of Constraints in some areas (New, 2007, Hines et al., 2004).

2.1.3.3 Foundations

2.1.3.3.1 Leveled Production (Heijunka)

Leveled production (Japanese: Heijunka) is part of the TPS foundations because it is a basic prerequisite for the application of the JIT system and Kanban. Heijunka means balancing unsteady production plans in terms of production volumes and product variants / variant mix, respectively (Jones, 2006). The concept of production leveling leads to a reduction in waiting and idle-times for workers and operating facilities and, in parallel, to a reduction in work in progress inventory.

As explained before, in the JIT system every process receives from the upstream processes exactly the amount of parts required. In case of erratic demand fluctuation in terms of volume, variety or time, all upstream processes are forced to adjust to this volatility by either holding additional inventory and/ or additional capacities of workers and machines, which can be considered waste according to above description. Avoiding this phenomenon requires leveling the production plan in terms of volume and variation.

Heijunka requires the frequent change of tools and dies and a reduction of batch sizes down to an amount of one. Consequently, the entire set-up of machinery and/ or the production line needs to be trimmed to low batch sizes and high flexibility (Monden, 1998, Liker, 2004, Jones, 2006).

2.1.3.3.2 Stable and Standardized Processes

Standardized processes are part of the TPS-house’s foundations since they form the basis for continuous improvement and the delegation of responsibility to workers (Liker, 2004). There is no measurable improvement without a clearly described standard, which is the basis for the improvement. Standard worksheets posted at every workstation are often used as tools for describing the respective standard procedure. In particular, these standard worksheets illustrate the sequence of activities to be performed on each unit of operation. By this means differing job instructions should be avoided since every worker in every shift operating on the same machine has the same information available. The standard is being updated with every improvement suggestion, which will be realized. Apart from the standard worksheets, visible notices showing general information are often applied to illustrate output quantities or different kinds of defects.

2.1.3.3.3 Visual Management

Visual Management can also be seen as one of the fundamental elements of Cho's TPS-house (Liker, 2004). In this respect, Ohno (1993) holds that visual monitoring and control is applied in every Toyota plant as well as in every factory of co-operating firms.

One example can be seen in the standard worksheets hanging at every workplace with detailed and clear instructions on how to perform each operation. Furthermore there are Kanbans attached to every transport container, clearly indicating the content, quantity, source and destination of material transports. Another example is the Andon-display on top of each workstation. It gives the worker the ability to stop production when a defect is found. Common reasons for manual activation of the Andon are parts shortage, defect criterion or discovery, tool malfunction, or the existence of a safety problem. In modern systems, the alerts may be logged to a database so that they can be studied as part of a continuous-improvement program. In this regard, Parry and Turner (2006) hold that visual tools support process discipline by bringing transparency to the process and in doing so help to act as in-process metrics to aid resource allocation and scheduling.

2.1.3.3.4 Lean Philosophy

Despite the fact that principles and tools are important ingredients of LP, LP must not be misunderstood as purely a set of tools. What is even more important than the tools and techniques is the philosophy behind LP. Liker (2004) illustrates the importance of the LP philosophy impressively through a metaphor comparing LP with an iceberg.

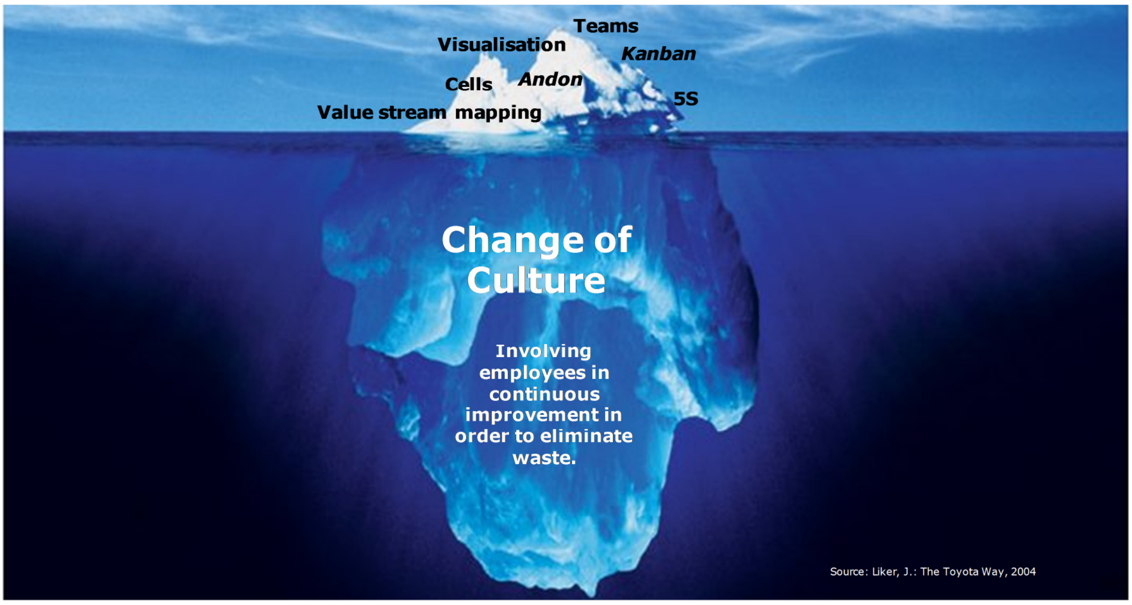

Figure 5: Iceberg model of TPS (Liker, 2004, p.298)

The larger part of LP, the change of culture, lies out of sight underneath the application of tools and principles. Unfortunately this is the part which has proven much more difficult to implement in practice, particularly for Western companies (Magana-Campos and Aspinwall, 2003). In fact, understanding LP as a basic philosophy instead of an accumulation of tools is what differentiates successful LP from less successful adoptions (Taylor and Taylor, 2008, Hines et al., 2004, Lander and Liker, 2007, Towill, 2007, Holweg, 2007).

2.2 Enterprise Resource Planning (ERP)

This section provides an overview of the topic of Enterprise Resource Planning (ERP). After outlining a brief overview of the history of ERP, I will define the term by considering three selected definitions. Finally I will outline the topic of implementation of ERP, particularly addressing the role of Business Process Reengineering (BPR).

2.2.1 Emergence of Enterprise Resource Planning (ERP)

In the early years of Information Technology (IT), software applications for businesses were entirely bespoke solutions, based on programs created by the manufacturer of the respective computer hardware. In the 1960s, the introduction of newly computerized reorder point (ROP) systems met the requirements of high-volume production, cost minimization and stable economic conditions. These systems used magnetic tapes to store master data as well as transactional data. The problem was that tapes are a one-dimensional medium, however projecting requirements of components based on the explosion of a complex bill of materials is a two dimensional problem (Jacobs and Weston, 2007). At the end of the 1960s, the availability of random access memory enabled a shift towards Material Requirements Planning (MRP), the predecessor of MRP II and ERP (Markus et al., 2000a). In this regard, MRP can be seen as the origin of today's ERP systems.

Though initial MRP solutions were big, clumsy and expensive, in the 1970s MRP was central to the creation of detailed plans for material needs in manufacturing (Samaranayake and Toncich, 2007). The development of faster and higher capacity disk storage enabled the development of more integrated business information systems. Roughly at that period of time, five former IBM employees founded a company called SAP – System Analysis and Program development – with the vision of developing standardized software applications for enterprises. The basic principle was to share the high development costs for financial accounting systems among several customers (SAP, 2009). Based on this principle, the idea of standard software for business applications was born. In 1975, Lawson Software was founded by Richard and Bill Lawson, who saw the requirement for pre-packaged enterprise technology solutions. Only two years later, Jack Thompson, Dan Gregory and Ed McVaney founded J.D. Edwards and Larry Ellison established the Oracle Corporation. In 1978, Jan Baan started the Baan Corporation with the aim of providing financial and administrative consulting services. In the same year, SAP released SAP R/2, a more highly integrated version of its software, which took advantage of the then current mainframe computer technology and enabled interactivity between modules as well as order tracking capabilities (Jacobs and Weston, 2007).

In the 1980s, the scope of functions as well as the integration of functional areas of business systems increased rapidly. In the beginning of the 1980s the term MRP was increasingly applied to MRP-encompassing functions like improved scheduling capabilities, capacity planning or cost reporting. Since the term Business Requirements Planning was already registered as a trademark, the term MRP II was coined in an attempt to distinguish the new capabilities from the original MRP system. By the late 1980s MRP II was increasingly referred to as Manufacturing

Resource Planning systems. Nevertheless any MRP II system was still based on the classic MRP logic for calculating material requirements (Helo et al., 2008).

However despite those rapid developments, in 1976 the industry still complained about an insufficient capability of business software. Even in 1982 there were voices claiming that the business customers’ requirements could only be met by individual developments. In parallel, the IT infrastructure within companies had been growing largely uncoordinated, leading to heterogeneous IT landscapes with accompanying problems like data redundancies and/ or inconsistencies, high number of interfaces and inflexibility (Jacobs and Weston, 2007, Michel, 1999).

With the invention of client/server architecture, standardized information technology became more flexible and hence interesting for businesses. Based on this technology, combined with a new graphical user interface, a new generation of standard business software emerged in the 1990s. Due to the fact that these systems were able to reflect and integrate nearly all main business areas of an enterprise, from production control, human resources, marketing and sales, distribution, and finance, this new generation was termed Enterprise Resource Planning (ERP) systems (Helo et al., 2008). As Davenport (1998) claimed, for organizations that adopted ERP almost all business transactions are entered, recorded, processed, monitored and reported in one central database. In this respect, ERP systems allow the replacement of a high proportion of individual legacy applications with one integrated system solution and one common data base. In addition to this, ERP systems are more flexible in terms of adjusting to different business processes than their predecessors. Michel (1999) holds that, formerly business processes often had to be adjusted to the system solution, which hardly makes sense for several reasons. One of the main points is the accompanying inflexibility to change and/or improve business processes, leading to a certain degree of stagnation in the continuous improvement process. However, there is also justified criticism of ERP systems. One of the major points in this respect is the continuously increasing range of functionalities, which often increases complexity of the system configuration and application to a considerable extent. However this topic has been addressed by most ERP producers, who have been continuously trying to improve the ease of operations. Another critical point is that the ERP’s material planning engine is still based on the old deterministic principles as in the former MRP and MRP II systems. This is probably the reason why ERP is usually considered to be based on a push-based or deterministic philosophy, despite the fact that today's ERP systems can also support consumption driven pull planning logic to some extent (Slack et al., 2007).

By 1999 the former dominance of IBM in the 1980s had shifted towards J.D. Edwards, Oracle, PeopleSoft, Baan and SAP. At the end of the century, the threat of the year 2000 (Y2K) date turned out to be a major catalyst of ERP growth, whereby many companies implemented ERP in order to replace legacy software that was not Y2K compliant. Following the crash of technology and dot com stocks at the beginning of the new century, software companies faced considerable pressure to downsize. Around that period of time, a vendor consolidation took place. First, in 2000 Baan had to be sold due to severe financial problems, and then in 2002 J.D. Edwards merged with PeopleSoft. And finally Oracle started the take-over of J.D. Edwards in 2003, which was eventually finalized in January 2005, leaving only two major players in the ERP market in 2005: Oracle and SAP (Jacobs and Weston, 2007)

In the light of the commercial breakthrough of the Internet, the use of conventional ERP systems was predicted to disappear. Nevertheless to date few companies use web-based ERP solutions but rather still run their conventional systems tailoring to the generation of ERPs. As Bayer (2009) points out, a quantum leap in terms of a new ERP generation, which is often referred to as ERP II, has still to be established.

2.2.2 Defining ERP

There are numerous definitions of ERP in the literature. The following three examples have been picked out in order to highlight that the magnitude and implication of ERP goes far beyond the pure bits and bytes of an IT system. In fact, the characteristic of combining and integrating various business functions and processes is reflected in many definitions of ERP. The following definition of ERP, as suggested by Duplaga and Astani (2003), stresses the aspect of an integrated system. In addition it highlights some of its key benefits, referring to a survey by Mabert et al. (2000) analyzing US manufacturing firms, as well as an article published by Bingi et al. (1999). In particular, Duplaga and Astani (2003, p.68) suggest the following definition:

> ”ERP systems are simply integrated information systems. They integrate processes, information, and people across functions, plants, companies, and geographic locations. This permits company-wide or enterprise-wide communication and coordination, using a common database available in real-time. The potential benefits of using an ERP system include quicker information response time, improved on-time delivery, lower inventory levels, better resource management, and improved interaction with customers and suppliers.”

Despite mentioning business improvements and integration, this definition still sticks to the view of regarding ERP simply as information systems. I consider this definition too narrow for the purpose of this thesis. A much broader definition of ERP can be found in the eleventh edition of the APICS Dictionary (Blackstone and Cox, 2005, p.39). In this ERP is seen as a framework for managing business:

> “ERP is a framework for organizing, defining, and standardizing the business processes necessary to effectively plan and control an organization so the organization can use its internal knowledge to seek external advantage”.

On the one hand this definition is much broader than the one from Duplaga and Astani (2003) by considering ERP as a framework for business processes rather than an IT system. On the other hand, not explicitly mentioning the IT aspects of ERP makes it appear to be too broad for my purpose. In fact, the definition is so broad that it could also be applied to many of today’s business improvement concepts.

Brislen and Krishnakumar (2007, p.1) suggest another definition which brings together both the IT and the business relevant aspects of ERP. On the one hand, the recognition of ERP as a set of activities, points out that ERP goes beyond being purely an IT system. On the other hand, in referring to ERP as software applications and accentuating the relational database their definition does not deny IT as the core element of ERP.

> “ERP (…) is an industry term for the broad set of activities that helps a business manage the important parts of its business. The information made available through an ERP system provides visibility for key performance indicators (KPIs) required for meeting corporate objectives. ERP software

applications can be used to manage product planning, parts purchasing, inventories, interacting with suppliers, providing customer service, and tracking orders. ERP can also include application modules for the finance and human resources aspects of a business. Typically, an ERP system uses or is integrated with a relational database system."

With respect to the context of this thesis, I understand ERP in the sense of the last definition, as suggested by Brislen and Krishnakumar (2007). I particularly share the view that even though at its core, ERP is an IT system, its business impact goes far beyond that. This particularly refers to the implementation of ERP, which is today often considered to be a business improvement initiative in itself.

2.2.3 Implementing ERP

This section sets out to provide an overview on the topic of ERP implementations. The issue of implementing ERP is of particularly relevance since the research presented in this thesis suggests an integrated approach, the structure of which primarily follows a typical ERP implementation procedure, however informed by conceptual elements of LP. Initially I will address the lifecycle of an ERP implementation by looking at different ERP implementation models as suggested in the literature. Then I will outline the role of BPR in an ERP implementation and vice versa. Finally I will provide a brief overview on results of ERP implementations reported in the literature.

2.2.3.1 ERP implementation Models

Robey et al. (2002) hold that for the implementation and maintenance of ERP systems it is important to have a structured approach, which is similar to systems development. Systems development theory uses the concept of stages in a lifecycle to describe the development of information systems (Pressman, 2004). A common theme in systems development theory is a strong focus on the development of the system itself with little or no attention to organizational implementation issues or post implementation stages. HoIver those aspects are particularly crucial in ERP implementations (Ehie and Madsen, 2005, Motwani et al., 2005, Ngai et al., 2008). In contrast to systems development theory, empirical research contributions on ERP implementations usually include an emphasis on organizational implications with respect to the implementation and post implementation phase.

In the following paragraphs I will introduce four renowned empirical models for ERP implementation. Though they do differ in terms of the number and exact naming of the phases, I will show that the first three in particular do not vary to a great extent in terms of the content they are covering. The fourth model, however, is different since it breaks down the implementation phase one level deeper into sub-phases. I will suggest that this more detailed level of breakdown is required for the suggesting an integrated model combining ERP implementation with LP elements in this DBA thesis.

First, Kwon and Zmud (1987) suggest a model that sets a framework to analyze the implementation of ERP in an organization. Cooper and Zmud (1990) hold that IT implementation is defined as an organizational effort directed toward diffusing appropriate information technology within a user community. Kwon and Zmud's (1987) model consists of 6 stages:

1. Initiation
2. Adoption
3. Adaption
4. Acceptance
5. Routinization
6. Infusion

In the initiation stage, organizational problems or opportunities as well as IT solutions are identified and analyzed and a pressure to change evolves. In the adoption stage, political negotiations take place to get support for the IT implementation and a decision to invest is made. The adaption stage consists of the actual implementation of the system including development, testing and installation as well as the training of organizational members. In the acceptance stage, the users are encouraged to commit to the usage of the IT application in their daily work. In the routinization stage, people get used to the new IT system in their normal working environment and finally in the infusion stage increased organizational effectiveness is obtained by applying the new IT system.

The second model to be introduced here was developed by Ross (2000). Based on 15 ERP implementation case studies Ross developed a model consisting of five phases:

1. Design
2. Implementation
3. Stabilization
4. Continuous improvement
5. Transformation

The design phase is primarily concerned with planning the ERP implementation and critical decision making. In this respect it is covers largely the content of Kwon and Zmud's (1987) initiation and adoption phases. Comprising the system's construction, testing, training and cut-over to go-live, the implementation phase is largely compliant to Kwon and Zmud's (1987) adaption stage. The stabilization phase encompasses the period of time after go-live in which system problems are solved and organizational performance successively improves. In this respect this phase is in many respects congruent to Kwon and Zmud's (1987) stages of acceptance and routinization. The phase of continuous improvement corresponds to a great extent to Kwon and Zmud's (1987) infusion phase, where functionality is added in attempting to further improve the processes and the system. Finally, the phase of transformation involves changing organizational boundaries, particularly with regard to the respective information technology. This phase has no directly corresponding stage in Kwon and Zmud's (1987) model.

The third model was developed by Markus and Tanis (1999). They suggest a model, which splits an ERP project lifecycle into 4 phases:

1. Chartering
2. Project
3. Shakedown
4. Onward and upward

The chartering phase is primarily concerned with creating the business case for the project, determining the project budget and schedule. This phase can be compared to Kwon and Zmud's (1987) initiation and adoption stage as well as Ross's (2000) design phase. The project phase deals with the configuration of the system, the integration with other business systems as well as testing, training and cut-over. The project phase is largely consistent with Kwon and Zmud's (1987) adaption stage and Ross's (2000) implementation phase. Consisting of the time from the go-live of the system until its normal operation, the shakedown phase covers similar aspects as Kwon and Zmud's (1987) acceptance and routinization stages or Ross's (2000) stabilization phase. Finally the onward and upward phase deals with ongoing maintenance and successive enhancement of the system and business processes, which is largely compliant to Kwon and Zmud's (1987) infusion stage and Ross's (2000) continuous improvement phase.

Several conclusions can be derived from the comparison of those three ERP implementation models. The comparison of the phases/ stages has revealed that the models do not differ to a great extent in terms of the content covered. First, all of those models include a phase concerned with planning activities prior to the actual implementation project. Second, all models suggest one or more post-project phases, in which the solution stabilizes and further improvements are made. Finally, and probably most important with reference to this thesis, all three models collapse the entire implementation procedure into one phase or stage. This is particularly interesting since the actual implementation procedure usually covers quite a period of time with many different activities to be carried out and milestones to be passed.

In this context, Parr and Shanks (2000) hold that there was justification for creating a project phase model (PPM) for ERP implementation, which is focusing on the discrete phases of the implementation project itself. Their model synthesizes the above models in that it recognizes the importance of the planning and post-implementation phases. The model's emphasis, however, is on the implementation project itself and the factors influencing a successful outcome at each of the phases of the implementation. Parr and Shanks's model can be considered a hierarchical model consisting of three upper level phases and 5 sub level phases. The following figure provides an illustration.

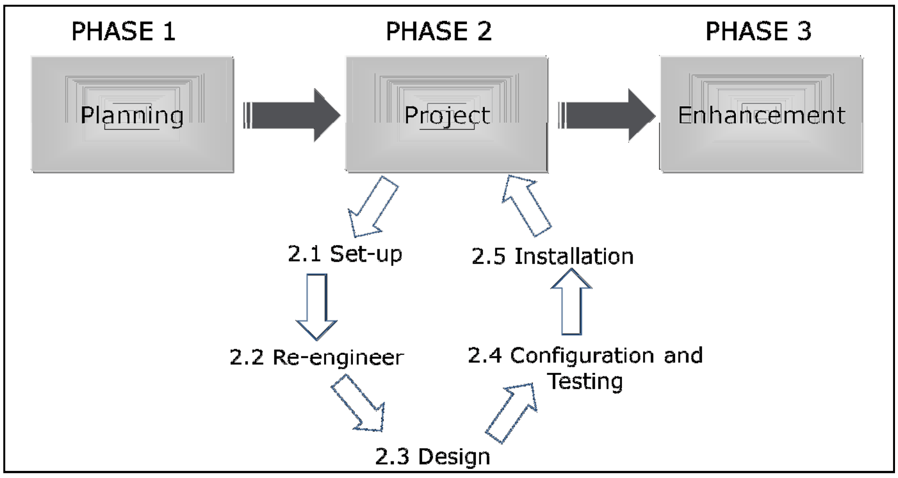

Figure 6: ERP implementation model (Parr and Shanks, 2000, p.292)

The planning phase is concerned with preliminary activities leading to the initiation of the actual project as well as preparation activities. Examples include the selection of an ERP package, assembly of a steering committee, determination of the broad implementation approach, and the determination of resource and budget requirements. Probably one of the most important activities in this phase is conducting a business case analysis in order to convince the top management of the economic value of the project.

The project phase encompasses all activities concerned with implementing the ERP solution, starting with setting-up the project and ending with installing the final solution. Since the project phase encompasses a broad range of different activities, it is broken down into five sub-phases:

1. Set-up
2. Re-engineering
3. Design
4. Configuration and testing
5. Installation

The set-up sub-phase includes the selection of the project team consisting of both technical and business-oriented experts. In addition to that, general guidelines and objectives of the project are being determined. The re-engineering sub-phase involves analyzing the as-is business processes as well as re-engineering business processes, mapping of the business processes with ERP functions and training of general ERP functionality. In the design sub-phase, the future processes and system functionality is designed and agreed by all stakeholders. This is usually accompanied by interactive prototyping and constant user communication. The configuration and testing sub-phase includes the actual system configuration, setting-up interfaces, writing reports and creating individually programmed enhancements. In addition, the integration of the modules with the system as well as the interaction with legacy systems is tested with real data. The installation sub-phase consists of the technical installation as well as managing user training and support.

Finally, the enhancement phase includes the stages of system repair, extension and transformation. In this respect, it reflects Ross' (2000) continuous improvement and stabilization phases and Markus and Tanis' (1999) onwards and upwards phases.

In conclusion I hold that Parr and Shanks' (2000) ERP implementation model comes closest to the requirement of my DBA thesis. The reason is that the hierarchical nature of their model allows covering phases adjacent to the actual project and, in parallel, sets a focus on the project phase by breaking it down into a number of sub-phases. Though I will not follow Parr and Shanks' model on a 1:1 basis for this DBA thesis, the suggestion of an integrated model presented in this thesis will be based on and informed by Parr and Shanks' model's structure.

2.2.3.2 Role of BPR

The review of the literature has confirmed the author's practical experience that the implementation process of an ERP system is best conceptualized as a business project rather than the installation of a new software technology. In fact there appears to be a broad consensus amongst academics emphasizing the importance of redesigning business processes in ERP implementation, whether it is referred to as business process engineering or business process re-engineering (BPR), process and/ or value stream mapping or process design (Cooper and Zmud, 1990, Markus and Tanis, 1999, Kumar and Van Hillegersberg, 2000, Koch, 2001, Duplaga and Astani, 2003, Chand et al., 2005, Botta-Genoulaz et al., 2005, Ehie and Madsen, 2005, Motwani et al., 2005, Nah and Delgado, 2006, Huq et al., 2006, Huq and Martin, 2006, Ma and Loeh, 2007, Peslak et al., 2007, Samaranayake and Toncich, 2007, Ngai et al., 2008, Helo et al., 2008).

2.2.3.2.1 Defining BPR

Despite the apparent agreement concerning the significance of engineering / re-engineering of business processes, there are different interpretations in terms of the type of connection between BPR and ERP. However before I can address this issue in greater detail, I need to define the term BPR. In this section I will briefly outline definitions as suggested by four of the most influential proponents of BPR, namely Michael Hammer and James A. Champy, D. Harvey and Thomas H. Davenport.

Hammer and Champy (1993) define BPR as fundamental rethinking of business processes with the basic aim of getting dramatic improvements in critical measures of performance, such as cost, quality, service, and speed. An important point is that those processes are treated independently of functional and organizational boundaries. Harvey (1994) emphasizes the focus on process management, claiming that BPR involved streamlining, reorganizing and integrating activities to create new ways of working to support a process management orientation. This typically involves redesigning information flows, their point of use and work-roles.

Davenport (1993) highlighted the role of information technology in his 1993 book with the title "Process Innovation: Reengineering work through information technology". He claims that BPR involves the envisioning of new work strategies, process design activities, and the realization of the change in its complex technological, human, and organizational aspects.

2.2.3.2.2 ERP to support BPR

As far as the connection of BPR and ERP is concerned, two main stances can be differentiated in the literature. The first regards ERP as kind of support tool for BPR or even considers ERP implementations as a type of BPR, whereas the second considers BPR as a kind of supporting methodology for ERP. This section will present arguments for the former point of view, whereas the following section will highlight major contributions of the latter.

On the one hand there is a stance in which ERP is seen as a supporting tool for BPR, in the purest form considering ERP even as a type of BPR initiative (Huq et al., 2006, Chiplunkar et al., 2003). The main argument for this is that ERP implementation projects reflect basic characteristics of BPR.

First, ERP and BPR aim at rapid changes. In BPR this is often as radical redesign or drastic improvement of processes (Hammer and Champy, 1993, Davenport and Stoddard, 1994, Huq and Martin, 2006). Similarly ERP implementations imply the sudden change of business processes by pre-defined milestones, at which either the new system or at least a bundle of new functionalities are made available for business (Ehie and Madsen, 2005, Peslak et al., 2007).

Second, BPR often emphasizes the use of technology to bring about changes (Hammer and Champy, 1993, Davenport, 1998). They argue that ERP fits well into this characteristic of BPR since ERP inherently consists of information technology. In this respect Davenport (1998) even considers ERP the most important development in corporate use of information technology.

And third, ERP and BPR both aim at improving business operations. As far as BPR is concerned, improvements can be seen as the core objective of the initiative (Hammer and Champy, 1993, Davenport, 1993). Regarding ERP, despite the fact that business improvement is not always recognized as the primary focus of ERP implementations, ERP projects do hold substantial potential for business improvements (Bingi et al., 1999, Mabert et al., 2000, Duplaga and Astani, 2003, Motwani et al., 2005). According to Huq et al. (2006), the biggest benefit comes from the use of one common database, resulting in data integrity, transaction reduction, reduction in cost of management and above all better customer service.

2.2.3.2.3 BPR to support ERP

There are several authors who look at BPR as a methodology or kind of tool for supporting ERP implementations or even consider it as one of the ERP implementation phases (Ehie and Madsen, 2005, Samaranayake and Toncich, 2007, Ngai et al., 2008, Parr and Shanks, 2000). In those contributions BPR is not applied in the original comprehensive form as presented in above definitions, but is rather boiled down to an activity or phase within or before an ERP implementation, in which processes are analyzed, mapped and designed or redesigned. As mentioned earlier in this section, Parr and Shanks (2000), for instance, have included a phase termed "re-engineering" in their ERP implementation model. In this respect they hold that in this phase current business processes should be analyzed in order to determine the level of business process re-engineering required.

Ehie and Madsen (2005) integrate BPR in the second phase of their 5 phase ERP implementation model. In their business blueprint phase, they suggest that existing business process should be analyzed in order to provide the background for system selection prior to extensive education and training to give the project team the insight needed to transform processes and map the new process design. In their factor analysis based study, BPR turned out to be one of the 4 most important factors to influence the success of ERP implementations. They point out that implementing ERP "is not a matter of changing hardware or software systems, instead it entails transforming the company to a higher level of performance through streamlined business processes" (Ehie and Madsen, 2005, p.554).

Similar to the first two contributions, Ngai et al. (2008) state that a certain level of BPR should be involved in an ERP implementation since the packaged software is usually not able to reflect the often historically grown business processes on a 1:1 basis. They further point out that an organization should re-engineer business processes to fit the software instead of trying to modify the software to fit the organization's current business processes. As indicated in the findings of a study by Mabert et al. (2000), in which most respondents reported minor customization, one could infer that companies already apply re-engineering so as to minimize expensive and risky efforts to enhance packages with non-standard functions. In this respect, Gattiker and Goodhue (2002) hold that ERP implementation projects have been found to result in process changes.

In contrast to the above authors who look at BPR as a part of an ERP implementation project, Samaranayake and Toncich (2007) consider the application of BPR to be a necessary prerequisite of ERP implementations. They hold that streamlined business processes are one of the key enablers of ERP implementations. Even though they appear to place BPR outside the ERP implementation project itself, they do agree with other authors that at least a certain level of BPR is required in order to successfully implement ERP in an organization.

2.2.3.2.4 The role of BPR in this thesis

I want to close the discussion on the role of BPR in ERP or vice versa by stating my view that there is no right or wrong stance as such but the two interpretations rather reflect different points of view. On the one hand there are the BPR proponents, who rather consider ERP as a tool in a comprehensive BPR initiative. On the other hand, from the viewpoint ERP implementers, BPR is rather viewed in a narrow sense as an activity to analyze and redesign business processes.

In my DBA thesis I consider this discussion not as either or decision, but rather as the two ends of a continuum of possible viewpoints. In this thesis I will take a position towards the ERP end of the continuum, despite respecting the viewpoint of BPR proponents. That is, I will consider BPR rather in the sense of a necessary and important activity in the ERP implementation project lifecycle, but not as an end to itself. The reason is that I am convinced that this better reflects the purpose of my research, since I intend to integrate LP with ERP, not with BPR.

2.2.3.3 Success and Failure of ERP implementations

This section will provide a brief overview of the success or failure of ERP implementations as reported in the literature. According to many contributions in the literature, the potential benefits of ERP appear to be remarkable. Bingi et al. (1999) suggest that ERP enabled companies to gain a holistic view of the business enterprise by utilizing one common database, one application and a unified interface across the enterprise. Similarly, Ehie and Madsen (2005) state that ERP systems provided companies with the means of integrating their business functions into a unified and integrated business process. Ngai et al. (2008) hold that many businesses believed that the ERP system can even deliver strategic competitive advantage and he concludes that this is one of the prime reasons for the high ERP adoption rate. In fact, there are several contributions reporting positive effects and benefits realized through the implementation of ERP in organizations. According to Teltumbde (2000) and Van Everdingen et al. (2000), ERP has been shown to provide substantial improvements in efficiency, productivity and service quality, and led to a reduction in service costs as well as more effective decision-making. Sweat (1998) presents the case of Earthgrains Company who report a net improvement in its operating margin from 2.4% to 3.3% and an on-time delivery rate of 99% as a result of its ERP implementation. Similarly it was reported that Par Industries improved its on-time delivery rate from 60% to 95% while reducing the lead time to customers from 6 to 2 days with an inventory drop of 60% (Appleton, 1997). Davenport (1998) refers to the case of IBM Storage Systems, who reduced the time to ship a replacement part from 22 to 3 days, and the time to perform a credit check from 20 minutes to 3 seconds. Other success stories include ERP's role in the Daimler-Chrysler merger (Wallace, 1998) and the integration of various Fed-Ex subsidiaries (Sweat, 1998).

On the other hand, there are many reports of failed ERP implementation projects and/ or negative results of ERP implementations. Markus et al. (2000b) suggest that many ERP adopters encountered problems in the complex exercise of implementing the ERP system. Ehie et al. (2005) take a similar view by claiming that ERP implementations are notorious for taking a longer time and costing more money than projected. In this context they provide several examples of failed ERP implementations with reference to prominent companies like Dell, Dow Chemical, FoxMeyer Drug and Unisource Worldwide. They point out that the failures were not due to errors in the ERP system but rather due to the companies failing to match the true organizational needs to solve the business problems. Helo et al., (2008) hold that despite an ERP history of nearly two decades there were still recent reports about implementation difficulties (Tsai et al., 2005, Lui and Chan, 2008). From a more general perspective, Somers et al. (2000) report a high failure rate of ERP implementations, which is underpinned by Zhang et al., (2003), who refer to a success rate of only 33% in western countries and even only 10% in China. According to Chakraborty and Sharma (2007), as many as 90% of all initiated ERP projects can be considered failures in terms of project management. Many of the failures have been reported in terms of complete cancellations or overruns in terms of cost and/ or time (Scott and Vessay, 2000, Kumar et al., 2002, Helo et al., 2008). In addition to issues concerning the actual implementation process of ERP, there are also contributions reporting cases in which ERP failed to meet business expectations. In this context, Okrent and Vokura (2004) hold that many organizations have not achieved the efficiencies and cost savings as originally planned. A similar view is adopted by Ehie and Madsen (2005), who claim that most ERP implementations have not lived up to their market and business expectations, and Helo et al. (2008) who point out that ERP implementations often did not achieve the organization's objectives.

To sum up, the literature shows a rather mixed picture in terms of success or failure of ERP. On the one hand, I have shown that ERP is reported to promise substantial benefits for both business and IT. In addition to that, the success of ERP in terms of its expansion is unquestionable. In this respect it was estimated that the worldwide investment in ERP added up to some $500 billion in one decade (Carlino and Kelly, 2003, Gefen and Ragowsky, 2005). On the other hand, there is a broad range of contributions reporting cases of failed ERP implementations. Many authors (Ehie and Madsen, 2005, Motwani et al., 2005, Davenport, 1998, Duplaga and Astani, 2003) refer to only partly unsuccessful attempts and / or high failure rates. And, there are several contributions claiming that even completed ERP implementations did not live up to their business expectations. In conclusion I hold that despite the mixed picture on the results of ERP implementations, it is quite likely that the expansion of ERP will continue, though not at the same pace as in the last decades. Apart from the benefits that ERP promises, a reason for that might lie in the fact that many companies simply will have no other choice than to adopt ERP, as their legacy systems become too difficult to maintain, and they often lack time and resources to develop their own new bespoke software packages.

2.3 LP versus ERP

This section compares and contrasts the concepts of LP and ERP based on the literature to examine potential synergies and conflicts. After addressing differences betIen the two concepts, I will identify relative strengths and weaknesses and identify potential areas of synergy.

2.3.1 Differences

Though Cagliano et al. (2006, p.1) refer to both ERP and LP as "manufacturing improvement programs", I have to recognize that there are differences between them. In the literature, the differences between LP and ERP are often seen as fundamental. In this respect, Piszczalski (2000) held that the lean movement was almost anti-information systems (IS) in its stance. In a similar vein Nakashima (2000) claimed that, some lean proponents would even argue that ERP systems were the antithesis of lean production operations. A bit more moderate, Gill (2007) claimed that lean manufacturing concentrated on pulling demand straight from the customer and operating to such requirements promptly and efficiently, whereas an ERP system was a more holistic approach focusing on the organization, effective movement of the data and forward planning. He concluded that Lean and ERP were different by design. The following citation can be seen as an example for the different perceptions of the concepts of LP and ERP (Bartholomew, 1999, p.25):

> "Lean emphasizes getting the manufacturing process right and then continually improving it; with ERP the emphasis is on planning. The former has the goal of eliminating all wasted time, movement, and materials; the latter seeks to track every activity and every piece of material on the plant floor. Lean is action-oriented; ERP is data-dependent. One has workers doing only things that add value to the product; the other has them recording data and bar-coding to keep track of inventory and labor."

Even though the above quotation could be seen as strongly biased in terms of highlighting only advantages of LP and providing only disadvantages of ERP, it should serve as an example to illustrate how fundamentally different the concepts are sometimes perceived to be. Throughout the literature review on both topics, I have in fact identified a broad range of differences as reflected in the table below:

CRITERION	**ERP**	**LEAN-PRODUCTION**
Origin	Originates from MRP-systems in the 1970s	Originates from post war Japan / Ford's production system in the 1920s
Material Planning Philosophy	Primarily historically-grown MRP-based push philosophy, deterministic planning/ Explosion of Bill of Material	Primarily consumption-driven pull philosophy, replenishment is triggered based on consumption of parts
Role of Technology	Focus on Information Technology to manage complexity	Focus on people and elimination of complexity (as little use of IT as possible)
Role of Data	Requires high amounts of data for processing transactions	Uses data as basis for improvement analyses
Organizational Driver	Initiatives often primarily driven by IS department	Initiatives predominantly driven by functional departments (operations)
Production processes	ERP focuses on the reflection of existing production processes	LP concentrates on the improvement and control of production processes
Trigger for production activities	Production activities initiated by production plans, based on received orders and sales forecasts *	Production activities are purely triggered by received customer orders or pull trigger of downstream processes (Kanban)
Production batch sizes	Components are produced in large batches in order to minimize overall set-up times*	Flexible production of components with rapid set-up times and low batch sizes (ideally batch size of 1)

CRITERION	ERP	LEAN-PRODUCTION
Transport batch sizes	Products are transported in batches, which are not moved before the batch is complete*	Material is moved to the next workstation after processing of each single unit so as to establish a continuous flow of material.
Role of Utilization	Focus on maximizing the utilization of each individual workstation*	Focus on maximizing the utilization of the entire line. Requirement for leveled production and takt synchronization
Basis for procurement	Procurement of parts based on demands derived from forecasts or planned production dates	Parts supply is based on actual parts consumption and manufacturing progress at the line
General areas of support	Supports planning, monitoring and reporting	Supports the production through a continuous flow and improvement principle.
Reactive vs. action oriented	Focus on reflecting all material movements (reactive)	Focus on triggering material movements so as to enable continuous material flow
Direction of improvements	Improvement of processes are triggered top-down	Improvement of processes are triggered bottom-up
Organizational Reach	The entire enterprise	often only local areas

Table 1: Differences between ERP and LP

(* based on historically-grown traditional MRP-philosophy)

At first, as shown in the previous chapters, LP and ERP have substantially different origins. Whereas the roots of LP can be found in the lack of resources in the Japanese post-war economy or even earlier in Ford's mass production concept of the 1920s, ERP's origins lie in the development of the first computer systems supporting MRP in the 1970s.

Moreover above table illustrates differences in terms of the basic philosophies underpinning each concept. Whereas ERP is primarily based on a deterministic MRP logic usually connected with a push-based material planning philosophy, LP applies a consumption driven pull-based material planning philosophy (Ma and Sun, 2012). Another example can be seen in role of technology and data; whereas LP is seen as primarily people-centered, ERP is predominantly classified as technology-focused and data dependent (Bartholomew, 1999, Bartholomew, 2003a, Bradford et al., 2001, Dixon, 2004, Dixon, 2008, Gill, 2007). In this respect, Ohno et al. (1993) stress respect for humans as a central theme of TPS. In addition to that they suggests that improvements should be generated by shop floor workers (bottom-up), for instance in small Kaizen teams, with as little use of IT as possible since entering data for processing transactions on IT systems is perceived as one form of waste. In contrast, even though nowadays ERP implementations are more and more seen as business process improvement programs, a major part of their benefits still comes from the virtues of an integrated IT system and database (Ehie and Madsen, 2005, Huq et al., 2006, Duplaga and Astani, 2003, Okrent and Vokurka, 2004). According to Davenport (1998), the business world's embrace of enterprise systems may in fact be the most important development in corporate use of information technology. In line with that, there are differences in terms of the organizational drivers for implementing the concepts. In fact, LP and ERP are often driven by different organizational entities; that is, whereas LP implementations are predominantly initiated and realized by production or logistics departments, ERP implementations are frequently driven by the Information Systems (IS) department (Ma and Loeh, 2007, Ngai et al., 2008, Helo et al., 2008).

Another area of difference is the basic attitude towards supporting production and logistics operations. On the one hand, ERP focuses on reflecting, planning and scheduling production still primarily based on the conventional MRP logic, which considers a mix of forecasted data and customer orders as basis for the demand of finished products (Samaranayake and Toncich, 2007). In a deterministic way, these gross demands are transferred to net requirements at component level through exploding a bill of material and considering system-based inventory levels. As a result, call-offs to suppliers as well as production of in-house parts or pre-assemblies are triggered by a deterministic approach. Batch sizes for both production as well as transport are usually relatively big in an attempt to optimize the utilization of each individual work-station through reducing the number of set-ups / transports (Jacobs and Weston, 2007, Bartholomew, 1999, Michel, 1999, Hong et al., 2010). In contrast, LP focuses on improving and driving production and logistics in a pull mode. Only actual customer orders are considered as basis for production. Material supplies as well as production in upstream workstations are purely triggered in a consumption-driven method, often supported by Kanban cycles. Batch sizes are made as low as possible in order to allow for continuous flow (Womack et al., 1990, Sugimori et al., 1977, Shingo, 1981, Ohno et al., 1993).

In addition to this, there is a major difference in the reach of both concepts. By definition, ERP has the objective of encompassing the entire enterprise. Even in large organizations with many plants throughout the world, ERP solutions are often designed in the form of process and system templates, which are rolled out sequentially to all production sites of the company. By that means, ERP provides a powerful framework for standardizing and aligning processes on a company-wide level (Ngai et al., 2008, Chand et al., 2005, Okrent and Vokurka, 2004). LP's reach, on the other hand, is often restricted to single factories, production lines, or even parts of production lines (Taylor and Taylor, 2008, Hines et al., 2004, Schonberger, 2007). One of the potential reasons for that might be the fact that LP is often wrongly perceived as a set of tools, which can be applied to local islands within the company. However as mentioned earlier, a successful implementation of LP requires a cultural shift of the entire workforce (Liker and Hoseus, 2008). It is exactly this shift, which is often seen as the most problematic area in implementing LP. In addition to that, LP does not provide a hard frame as compared to the case of an IT tool like ERP, which forces people to carry out processes in certain ways.

In summary, though both are aiming at improving business processes, the comparison of LP and ERP has revealed substantial differences both in philosophical and practical terms. It is not unlikely that these fundamental contrasts are one of the reasons for the shortage of combinations of LP and ERP in practice as well as theory.

Despite these differences, the question for many lean adopting companies is not whether but rather when or how to properly implement ERP in the area of production and logistics. The reasons for this include complex production environments, requirements for integration with financial reporting, or the requirement to replace old legacy systems which cannot be properly maintained any more (Duplaga and Astani, 2003). Therefore it is worth breaking down the differences one level deeper and exploring strengths and weaknesses of both concepts.

2.3.2 Strengths and Weaknesses

In the previous section I have summarized differences between LP and ERP. In order to lay a foundation for a potential combined approach, this section highlights primary strengths and weaknesses of each concept. There is a broad range of strengths and weaknesses in the literature. Taking into account that MRP is still the basic underlying logic for material planning functionalities in today's ERP, I have considered also relevant literature on MRP. Similarly, since JIT is the underlying material planning logic in LP, I have extended the scope to the JIT literature. I have identified a list of articles highlighting strengths and weaknesses or the two different concepts. The following table provides an overview of a selection of strengths and weaknesses of MRP/ERP on the one hand and JIT/Lean on the other hand. Table 3 contains the numerical key to the references.

MRP / ERP		JIT / Lean	
Strengths	Weaknesses	Strengths	Weaknesses
– Common database for supporting and integrating business processes 6, 9, 11, 13, 14, 19 – Long-term planning to support strategic business aspects 13 – Collaborative planning beyond the plant level (e.g. suppliers, plant-networks, logistics service providers). 13, 14 – Higher flexibility for supporting several different production types	– Mostly lack of support of improvement measures 6, 9 – Bottlenecks, blackouts of production facilities 9, 12 – High costs for maintenance 6, 19 – Slow execution tool, lack of sensitivity towards actual production situation 9, 11, 15, 19 – Unrealistic lead times 16, 19	– Stimulation of improvement measures 8, 23, 22 – Good support of production execution, consideration of actual production situation 2, 9, 13, 19 – Emphasizes simplicity of processes 8, 13, 14, 19 – Leads to low throughput times 8, 14	– Difficulties with adapting changes of demand or lead times 1, 7, 9, 10, 13, 14 – Lack of real-time information for integrating business processes 9 – Requires leveled production and low deviations 3, 10, 20 – Severe problems when applying in complex production environments 3, 7, 8, 9, 10, 13, 17, 21, 23

MRP / ERP		JIT / LEAN	
STRENGTHS	WEAKNESSES	STRENGTHS	WEAKNESSES
6, 9, 13, – Fairly well handling of production complexity 6, 9, 13 – ERP's reach encompasses whole enterprise 27, 28 – ERP automatically (re)enforces compliance to process changes and standards 27, 28	– Assumption of infinite capacities on each workstation 16, 19 – Lack of data accuracy 4, 11 – Poor real time coordination 11 – Complexity of ERP Software 5, 9, 20, 33 – Generation of unrealistic production plans 26 – ERP requires information non-value added activities like barcoding, or posting of inventory transactions 23	– Leads to low levels of inventory 5, 8, 14, 19	– Requires disciplined workforce 18, 19 – Difficulties when transferring into performance independent costs 3, 13, 22, 26 – Management of high volumes of data 24 – Lean is hard to apply to industries with long production cycles, throughput times of >= 90 days, requirement of batch production, long lead times for raw material as well as the generation of what-if scenarios 25
Numbers indicate the link to references in table 3			

Table 2: Strengths and Weaknesses of ERP / LP

The table above draws on the work of several authors. The following table provides a list with the references referred to.

Number in Table 2	**Reference**	**Page**

1	(Berkley, 1991)	2071
2	(Berkley, 1992)	393
3	(Bonvik et al., 1997)	791
4	(Ngai et al., 2008)	552
5	(Chu and Shih, 1992)	2574
6	(Flapper et al., 1991)	340
7	(Gstettner and Kuhn, 1996)	3253
8	(Hirano, 1993)	8
9	(Hodgson et al., 1992)	44
10	(Hopp and Spearman, 1991)	653
11	(Louis, 1997)	xviii
12	(Merrie, 1997)	3
13	(Nagendra and Das, 1999)	207-218
14	(Piszczalski, 2000)	26-28
15	(Prouty, 2000)	2
16	(Sheridan, 1998)	48
17	(Singh and Brar, 1992)	10
18	(Spear and Bowen, 1999)	97-105
19	(Hopp and Spearman, 2001)	529
20	(Spearman et al., 1990)	888
21	(Stockton and Lindley, 1995)	47-49
22	(Zipkin, 1991)	7
23	(Bartholomew, 2006)	25
24	(Bartholomew, 2003b)	54
25	(Gill, 2007)	20
26	(Liker, 1999)	30

27	(Chand et al., 2005)	559
28	(Huq et al., 2006)	70/81

Table 3: References in Table 2 "Strengths and Weaknesses of ERP / LP"

In summary, LP is considered superior to ERP in specific manufacturing environments. These environments usually consist of a moderate number of product variants, little demand volatility and limited throughput / cycle times. In turn, the weakness of LP is the difficulty to apply the concept in environments other than those characterized by the above mentioned attributes.

ERP, on the other hand, can be applied to many different production environments and has advantages in long term planning, collaborative planning as well as handling of complexity. However, applied with traditional MRP logic, ERP is considered less effective than LP in areas with high and steady demands and moderate product variability.

2.3.3 Potential Synergies

Despite the differences in many respects as outlined in the previous sections, this section will explore potential areas of synergy between LP and ERP. The section follows the structure of Cho's TPS house (section 2.1.3) and its main LP elements. Based on the findings in the literature as well as my practical observations gained in many consulting projects, I will illustrate potential areas of synergy for each of the LP elements.

2.3.3.1 Just in Time (JIT)

This section deals with potential to integrate ERP with the LP element "Just in Time". First I will address the applicability of MRP versus JIT and suggest that a combination of both planning and control systems could be a feasible option. Then I outline how Kanban could be realized and supported by ERP functionality.

2.3.3.1.1 Combining JIT and MRP

According to Karmarker (1991), the just in time (JIT) system is appropriate to flow production environments with high volume, low variety and little demand variation.

However JIT is considered less applicable to environments with low and unsteady demand, high variety and a complex material flow. The following figure qualitatively illustrates the applicability of JIT and MRP with relation to volume and variety (Slack et al., 2007).

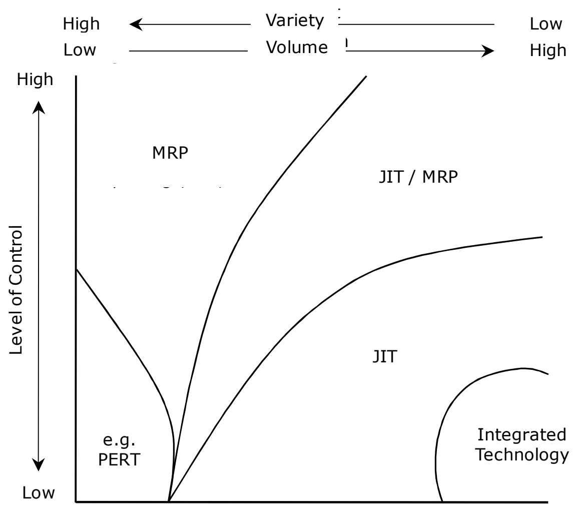

Figure 7: Volume-Variety and Level of Control (Slack et al., 2007, p.267)

There are two possible ways to apply JIT and MRP for an enterprise:

- Differentiation according to product type
- Differentiation according to process task

First, a company could differentiate by product type whether to apply JIT or MRP. Then, the more appropriate system could be applied depending on the characteristic of the product type. In this respect, Slack et al. (2007) suggest categorizing products into three different types depending on the typical demand characteristic. 'Runners' are products, which are produced frequently (e.g. daily), 'repeaters' are produced regularly, but at longer time intervals and 'strangers' are produced at irregular and unpredictable time intervals. Referring to this classification, JIT can be used for runners and repeaters due to the fact that a steady demand characteristic is suitable for consumption driven systems. However, due to the unsteady demand pattern of strangers, a consumption driven planning system is prone to lead to either excess inventory or to inventory shortages, depending on the determination of the pre-defined replenishment level. In a MRP system, material demand is broken down deterministically from the demand of the finished product by exploding the bill of materials. Therefore the replenishment of parts can be triggered specifically for the stranger, as soon as the finished product customer order is entered in the system.

Second, as the above figure suggests, there is an area in which both JIT and MRP are potential options. In this respect, there are authors who claim that that MRP and JIT can be combined in production environments (Karmarkar, 1991, Marques and Guerrini, 2012). In such an environment, ERP could be responsible for purchasing and material planning by creating the MRP-forecast, whereas JIT could be responsible for production control. Though a master production schedule (MPS) existed in this case, production control was executed via a pull-system triggered by JIT/Kanban. For balancing unsteady demands, the MPS is rescheduled with the support of a Heijunka box so as to ensure a levelled production program and consequently a levelled material flow. The following figure provides an overview.

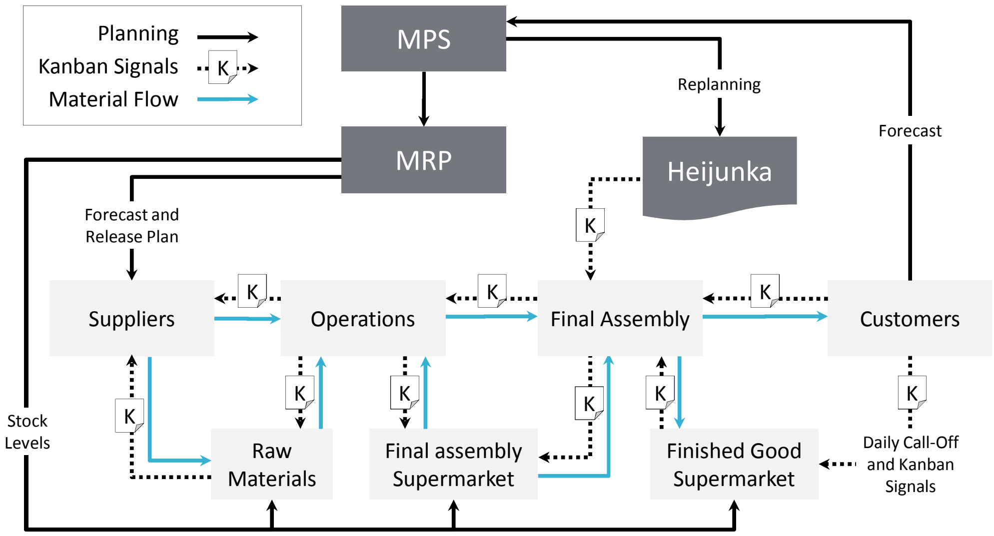

Figure 8: MRP and Kanban (Bell, 2006, p.150)

2.3.3.1.2 Electronic Kanban (E-Kanban)

In section 2.1.3, I introduced Kanban as an important tool for supporting material flow and production control in a consumption-driven way. Today's ERP systems provide functionality supporting electronic Kanban (E-Kanban). Nevertheless Powell et al. (2012) suggest modifications to the ERP system in the context of E-Kanban in order to better serve the company's pull system. As compared to manual Kanban, E-Kanban promises several advantages:

First E-Kanban supports the rapid calculating and adjustment of the Kanban sizing based on future demands. Particularly in the case of fluctuating demands and unsteady production volumes, Kanban sizes need to be adjusted regularly so as to fulfill the requirements of continuous material flow. In the case of manual Kanban, those calculations are often carried out manually or on spreadsheet applications. Today's ERP systems can carry out this step automatically.

Second, Kanban cards do not need to be reprinted and redistributed following changes; an update directly in the database is sufficient. By elimination of manual adjustments and replacement of lost Kanban cards, companies were reported to save up to 28 minutes working per employee per day (Carr, 2005).

Third, E-Kanban allows integration with other related IT-supported processes. An example is the integration of E-Kanban with handling unit management, which allows for a continuous tracking of boxes and containers throughout the plant network (Drickhamer, 2005).

Finally, E-Kanban can include business partners outside the factory, for instance through electronic transfer of Kanban production orders to external suppliers. Another example in this respect is the implementation of internal customer-supplier relationships with a plant network. In this case, a consumption driven pull signal triggers production and/ or dispatch of supplying plants, in contrast to push signals generated by a deterministic planning of a central system.

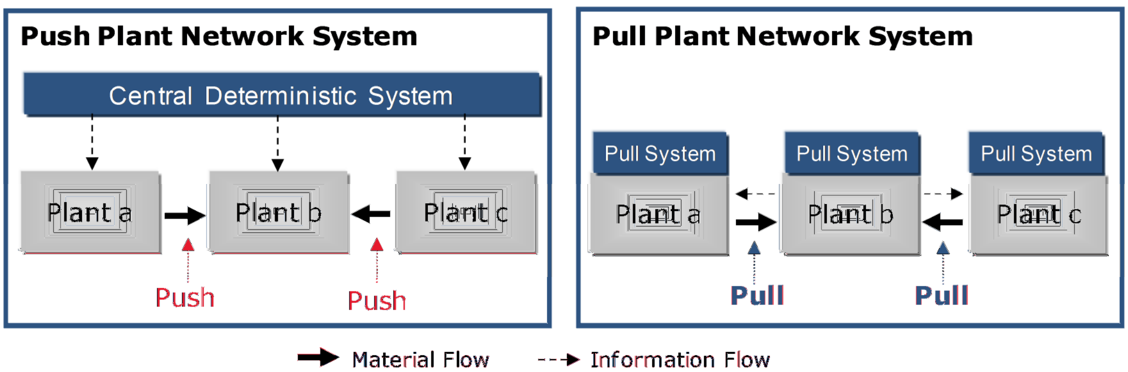

Figure 9: Push versus Pull in a Plant network (own figure)

The production and/or dispatch of the supplying plant are triggered only via consumption of the receiving plant. By this means, inventory levels within the plant network can be reduced since a sudden slow-down in production plant b (e.g.

vehicle production) automatically impacts on dispatch/ production of supplying plants.

2.3.3.2 Jidoka

As described in chapter 2.1.3, Jidoka can be considered one of the cornerstones of LP. One of the basic principles is to avoid, or at least detect and solve, quality problems at the point of emergence. Today, Jidoka can be supported by sophisticated monitoring software packages like Activeplants Performance Management System, which is able to inform workers about quality problems in real time (Duvall, 2006). In the area of the Andon Board, modern solutions allow the display of additional information like defect causes (Salescaster, 2008).

In fact, there are several potential synergies between ERP and Jidoka. First, plausibility checks in ERP systems can avoid future process problems. For instance, when transporting parts to a wrong destination area, the scan of the wrong destination location would be indicated immediately by an error message, which could make it impossible for the worker to carry out the next process. The same principle can be applied to the scan of a wrong Kanban label. In this sense, this can be treated as a modern form of the conventional autonomation, where a process would stop automatically in case of a problem (Ohno et al., 1993).

Second, the common database in ERP systems can be seen as a major contribution towards avoidance of errors. Whereas in a conventional environment, information is often saved in different information systems or even stored manually on lists or spreadsheets, ERP's central database provides the opportunity to reduce data redundancies and inconsistencies. Such inconsistencies can be one reason for poor process quality, for instance in the case of inconsistent shipping addresses, demand dates inventory levels, etc. By providing a consistent database, ERP contributes to a reduction of process errors, which is eventually reflected in improved service quality (Ngai et al., 2008).

And third, ERP stores respective user data for each process step carried. By this means, ERP increases the motivation of workers to carrying out the process according to standards. In case of wrong entries, users can be identified easily and, for instance, be given special training sessions. By this means, ERP can contribute to increasing the overall level of process quality in companies.

2.3.3.3 Elimination of Waste

Even though there are authors stating that ERP's requirements for transactions and data entries might be considered non-value added and consequently waste in the sense of LP (Bartholomew, 1999), most contemporary contributions do not go so far. In fact there are potential ways through ERP to support the LP element of waste elimination.

First, as mentioned earlier, ERP provides functionality to support Kanban. In this context ERP can reduce or even eliminate manual workload for tasks like calculating the number of Kanban cards per cycle, collecting or searching Kanbans as well as changing details on Kanban cards.

Moreover ERP can help to reduce non-value adding activities by the provision of one central database for all functional and cross-functional processes (Huq and Martin, 2006). The resulting data integrity helps to avoid tasks like searching for data across different applications, comparing data between different sources or even manual take-over of data from one legacy application to another. By this means, ERP reduces the number of necessary transactions for running operational business processes.

In addition to that, ERP provides one standardized platform for business processes across the company (Bazet and Mayere, 2007). This can decrease the requirements for basic training, particularly for employees who take-over new positions within the firm. The workers are already familiar with the general handling and navigation within the system as well as the basic terminology used. Moreover the often less productive settling-in period for the employee can be reduced by this means. Instead of dealing with issues like navigation through a new user interface, the employee can immediately spend the time getting to know the business processes behind it.

2.3.3.4 People and Teamwork

As mentioned earlier, in the past ERP implementations were often wrongly perceived as pure IS-projects. Today ERP implementations are increasingly considered as company-wide BPR initiatives with the ERP-system as the tool to re-cast business processes. Such ERP implementations often lead to fundamental changes within an organization's structure, culture and management process (Stebbins et al., 1998, Fowler, 1998, Al-Mashari and Zairi, 2000). In this respect, there are various contributions highlighting the management of people and change issues as one of the main critical success factors for ERP implementation projects (Motwani et al., 2005, Al-Mashari and Zairi, 2000, Huq et al., 2006, Huq and Martin, 2006, Bazet and Mayere, 2007, Ngai et al., 2008).

In fact, ERP implementations require strong collaboration and teamwork within and even across organizational boundaries. In this respect, Huq et al. (2006) claim that ERP's potential to integrate an enterprise can only be achieved if process owners from all functional departments affected and the respective IT personnel collaborate in a mixed team. One reason for this is that business processes do not stop at organizational boundaries. Another point is that workers rely on each other particularly when analyzing and evaluating current business processes, since the relevant knowledge is often widely spread in the organization. The same applies to the process design phase, where it is crucial to consider improvement suggestions of each employee in brainstorming mode. Later in the implementation project lifecycle when the processes are tested and trained, teams consisting of employees from different organizational departments are forced to collaborate with each other in order to make sure that the solution fits all organizational departments affected. In those respects, ERP implementations can support the LP element of people and teamwork by fostering teamwork not only within, but also across organizational boundaries.

Another important point supporting the LP element of people and teamwork is that ERP provides the possibility to speak the same language for all parties affected (McAfee, 2003, Koch, 2001). The ERP terminology provides a rich framework of business terms, which are clearly and uniquely defined. This fact can be extremely useful for supporting teamwork, particularly for collaboration between organizational units.

2.3.3.5 Continuous Improvement

Continuous improvement and ERP are often seen as contradictory since ERP is often considered as a tool to provide quantum leap improvements in a BPR context (Huq et al., 2006, Huq and Martin, 2006). However, apart from supporting improvement through once-off initiatives ERP has also potential to support incremental and continuous improvements.

One important aspect in this regard is that ERP allows for individual configuration of the software (Helo et al., 2008). As compared to individually developed business software, changes in business processes can be realized relatively quickly by changing the relevant configuration settings. By this means, ERP can often be adapted to process changes or improvements measures without the need for programming or external consultants. This is a major advantage compared to individually programmed software were most process changes cause the need for an IT resource to adapt the source code. Through the higher level of parameterization, ERP has the potential to support a philosophy of continuously improving the status quo. In this respect it is fair to state that ERP does not set things in stone like in the case of individual software, but rather supports flexibility and continuous change.

A commonly recognized drawback of Kaizen is that processes are often improved at a local level, but improvements are not or are only partly transferred to other areas or factories within a plant network. In this context, ERP can help to spread improvements on a company-wide scale, since an improved functionality will be available for all employees using the system. In that way ERP has the potential to function as a lever for continuous improvements (Masson and Jacobson, 2007).

Another area in which ERP could support continuous improvement is the issue of sustaining process improvement. In this regard, Ohno et al. (1993) stressed the importance to document process standards after improvements. However, sometimes improvements get diluted over time despite a thorough description of the process. Reasons for that can range from different interpretations of the descriptions to workers' attempts to decrease the workload. By providing a mandatory framework for carrying out processes and activities in certain ways, ERP can contribute to sustaining achieved improvements over time.

2.3.3.6 Leveled Production

Leveled production can be seen as a necessary prerequisite for the deployment of LP (Jones, 2006). Since information on sales orders are often directly entered in, or at least transferred to, the sales module of ERPs, the software naturally provides a central location for adapting those data. Modern ERP packages often provide possibilities to level demand data. An example can be seen in SAP's Lean Planning and Operations module (SAP LPO), which provides functionality to schedule and create a smooth material flow throughout a factory by leveling production of so-called pacemaker operations.

In contrast to the use of conventional Heijunka boards, production leveling in ERP has the advantage of a directly influencing production orders and consequently the basis for middle and long-term material requirements planning. In addition to that, production leveling functions of ERP packages provide the opportunity to make use of sophisticated mathematical algorithms, which would often be hard to apply on a manual basis.

2.3.3.7 Stable and Standardized Processes

Stable and standardized processes are an important part of the TPS-house's foundations (Ohno et al., 1993). As a matter of fact, this is probably the area where the synergies between ERP and LP are most obvious. ERP is often used as a tool to standardize and harmonize business processes on a company-wide level. In this respect, the standard processes available in industry specific ERP packages can often be used as a vehicle to bring back exotic and historically grown special processes to the standard.

In addition to that, ERP provides a mandatory framework for all employees to comply with process standards. As mentioned earlier, this fact not only forces compliance to standards across the company, but also increases the sustainability of process standards over time.

2.3.3.8 Visual Management

As far as visual management is concerned, potential synergies between ERP and LP originate from the fact that ERP provides a central database for a broad range of all transactional data. There is data directly available in ERP, which could be used as input for visual displays. An example could be the display of status information like the amount of current WIP inventory, material supply details like Kanban replenishments or the monitoring of vehicles statuses within the production line. In this respect, Parry and Turner (2006) present an example of how ERP outputs are communicated to a visual control board for shop floor operators to facilitate the process flow.

In addition to serving as the original data source, ERP could serve as an information hub for displaying data originating from applications outside ERP. Examples could be specific production scheduling tools or quality management tools, which are often interfaced to ERP.

2.3.3.9 Lean Philosophy

Putting into practice the philosophy of lean production is probably the most crucial and difficult aspect in implementing LP (Liker and Hoseus, 2008). Lander and Liker (2007) hold in this respect that there is a fundamental misunderstanding of LP in many companies by perceiving LP as a set of locally applicable tools instead of a enterprise-wide philosophy defined by guiding principles. They claim that in an attempt to implement Kanban or Heijunka, many companies fail to design a comprehensive framework that satisfies the basic principles of LP throughout the company. In a similar vein, Black (2007) holds that LP actually requires a substantial cultural change and that the lack thereof is one of the main reasons for the low success rate of LP in practice.

On the other hand, Huq et al. (2006) hold that ERP implementations lead to fundamental changes within an organizations culture and management practices. In a similar vein, Botta-Genoulaz et al. (2005) state that ERP enables deep changes in relationships, culture and behaviours, that can be crucial sources of advantage. McNabb and Sepic (McNabb and Sepic, 1995) suggest that changing a culture can only be achieved when employees learn new sets of behavior. Throughout ERP implementations, employees are forced to think along process streams instead of organizational boundaries. Understanding the entire business process value stream can have a massive impact on how different organizational entities collaborate within a company. In addition to that, Huq et al. (2006, p. 81) point out that "once established, the cultural transformation becomes pervasive, and the changed way of doing things takes roots".

Moreover, a key characteristic of ERP is its wide organizational reach (Chand et al., 2005). This applies to both the horizontal as well as vertical dimension of an organization. First, on a horizontal perspective, ERP reaches a wide range of departments. ERP systems are designed to integrate the all major business areas of an enterprise, reaching from sales and distribution to production and logistics operations, purchasing, finance and controlling as well as other indirect areas like HR. Second, a typical ERP implementation consists of phases such as process analysis, process design and training of process owners, key users and end-users. In all of these project phases, representatives of various hierarchical levels of an organization have to be involved. The reason is that the range of ERP supported processes reaches from shop floor activities up to functions like financial consolidation and reporting of profit and loss statements.

2.4 Literature Review Summary

The literature review has revealed a broad range of differences between LP and ERP. The material planning philosophies underpinning each concept can be considered different. Whereas ERP historically evolved within a deterministic MRP push philosophy, LP draws on a consumption driven pull philosophy. In addition to that, a major differentiator is the view towards information technology. In this respect, LP's respect for humans and its focus on manual tools and techniques can be seen as a contradiction to ERP, which inherently utilizes the benefits of modern information technology to improve processes. Another differentiating aspect is that ERP is based on rapid one-off improvements, whereas LP in its original form promotes incremental and continuous improvements. And finally, whereas ERP is primarily driven by IS departments often aiming at replacing old legacy systems, LP is usually driven by functional departments in an attempt to bring about concrete and measurable business improvements.

Presumably as a consequence of these general differences, ERP and LP are typically pursued separately from each other both in terms of practice and academia. In this respect, Masson et al. (2007) reports interviews with more than 45 companies practicing lean manufacturing techniques about the use of information technology. He concluded that though lean production practices were fairly widespread, the penetration of software that supports lean production principles was still low. In line with that the literature review has identified very few academic contributions addressing a combination of these two manufacturing improvement concepts. Moreover, most of these contributions only dealt with isolated synergies, usually considering ERP as a tool to realize single LP elements at an operational level.

Examples of these were discussed in section 2.3.3; particularly illustrative are the contributions of the application of Kanban, Heijunka and visualization functionalities in ERP.

However, with regard to forming an integrated implementation framework consisting of LP and ERP on a higher and more comprehensive level, very few academic contributions could be identified at all. In this context I conclude that there is very little academic knowledge on the construction of an integrated implementation framework combining LP and ERP, particularly with reference to the question of how such a framework would perform in a practical environment. Therefore those aspects form the territory for my research questions, which are addressed in the empirical part of this research work.

3 Research Methodology

This chapter provides an overview of the research methodology applied in the empirical part of this DBA. The relevant terminology in the field of research methodology is not applied consistently throughout the literature on management research (Cassell and Symon, 2004, Easterby-Smith et al., 2008, Creswell, 2008, Saunders et al., 2007, Bryman and Bell, 2007). In this context I want to point out that this chapter follows the terminology as suggested by Bryman and Bell (2007). However the overall research strategy and particularly the qualitative research design are mainly informed by Cassell's contributions qualitative methods in organizational research (Cassell et al., 2009, Cassell and Symon, 2004, Cassell et al., 2007).

The first section introduces the theoretical framework to be tested in the empirical part of this thesis. The second section introduces the research questions of my DBA research. In the following sections I address the topics of research strategy, research design and research methods. In each of the sections I explain the approach and outline the reasons for selecting the approach by briefly discussing the main advantages and limitations.

3.1 Theoretical Framework

This chapter suggests a theoretical framework for the integration of LP and ERP. The framework is based on a combination of the literature review and my practical experience from similar implementation environments. The intention of the theoretical framework is to illustrate a proposed relation between the concepts of ERP implementation and LP at a high level. The proposed framework will be tested in the empirical part of the research. The framework presented below has to be interpreted as a first release, since I develop the framework further in the light of the findings of the empirical part of my DBA. Representing the two manufacturing improvement concepts, the model consists of two parts:

- Lean Production => top part of the model
- ERP implementation => bottom part of the model

The following figure provides an overview of the first release of the integrated framework.

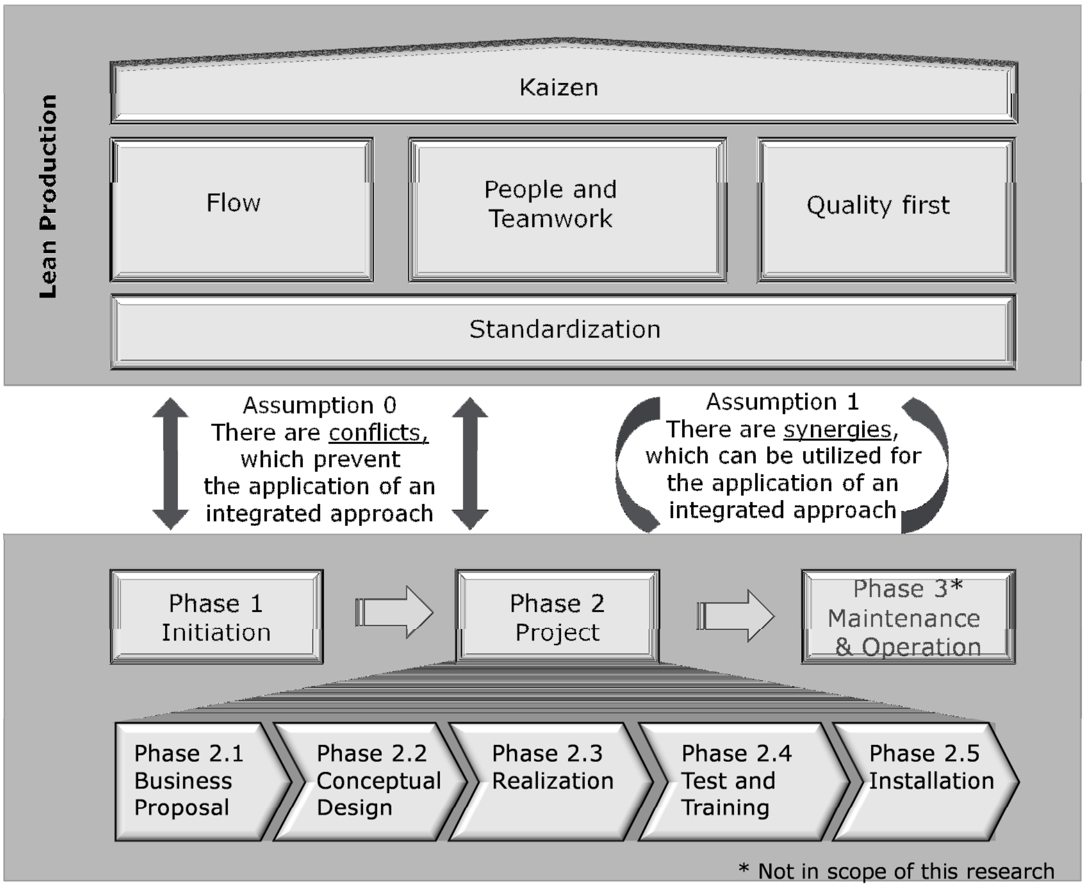

Figure 10: 1st release of integrated manufacturing improvement framework

The top part of the model reflects the concept of LP. Informed by the TPS house as suggested by Liker (2004, section 2.1.3), the LP part of the model was tailored according to the requirements of this research and practical initiative. First, whereas Liker allocated four terms to the foundation of the house, the foundation of the model's house was defined to carry only one term, namely standardization. However the other three elements of Liker's foundation of the house were not omitted but represented differently in the model. The "Toyota way" philosophy of Liker's model did not receive a separate representation since it was seen to be reflected in the overall model itself. The other foundation elements of Liker's house, namely visualization and Heijunka, were allocated to other LP elements as outlined below. Second, the left column wording of just-in-time was changed to the more generic term flow. Flow was defined to include not only the concept of just in time, but also other consumption driven concepts like Kanban, and other pull-based material supply methods. Moreover, the LP element "flow" was defined to also comprise Liker's element of Heijunka, allocated to the foundation of Liker's model. Third, the right column term Jidoka was translated to quality first as this wording was seen to be easier understood by all employees. Fourth, Kaizen was translated to continuous improvement and moved from the center to the top of the house. This move should symbolize the outstanding objective of LP to constantly progress in getting better. Finally, people and teamwork moved to the center in order to emphasize the top priority of employees to the overall initiative. Liker's element of visual management was also allocated to people and teamwork in the new model.

The bottom part illustrates my ERP implementation model, which was primarily informed by the model of Parr and Shanks (2000, section 2.1.3). In fact, I have adopted the basic structure and the hierarchical nature of Parr and Shanks' model. However I have adapted the content and naming of the phases so as to better reflect the purpose of my research as well as the author's practical experience in ERP implementation and LP projects. First, I replaced the naming of Parr and Shanks' planning phase with the phase named initiation. As described in Parr and Shanks' model, this phase did not only encompass the planning of the initiative but also the process to convince the top management to make the kick-off decision for the project. The reason for the name change was my intention to emphasize the initiation process, which is a more complex and difficult task according to my experience. Second, similar to Parr and Shanks' model, the project phase of my model consisted of five sub-phases. However I changed the naming and partly also adapted the content sub-phases so as to better fit my initiative and my practical experiences in ERP implementation projects. I will describe the content of each sub-phase in section 4.1.3. Third, I changed the enhancement phase of Parr and Shanks' model into a phase called operation and maintenance. This name should symbolize the phase after the hand-over of the project to the normal organization. This phase was not part of my research.

As mentioned earlier, the proposed framework in the figure above can be seen as a priori to the empirical part of the thesis. It will be tested via the empirical research described in the thesis. A refinement of the 1st release will be provided in section 2865.3 after and informed by the empirical findings

3.2 Research Questions

Based on the theoretical framework described above, I suggest research questions for the empirical part of the DBA. To some extent, the theoretical framework as suggested above can be seen as reflecting contradictory assumptions, which are to be tested in the empirical part of this DBA thesis. In this respect the first release of the theoretical framework suggests assumptions, which might be regarded to some extent as a null hypothesis and an alternative hypothesis.

- Assumption 0: Due to the fundamental differences between ERP and LP, conflicts between the concepts will prevent the application of an integrated framework combining ERP and LP.
- Assumption 1: There are synergies between ERP and LP, which can be utilized within the application of an integrated framework combining ERP and LP.

With regard to the fundamental differences between LP and ERP, a major focus of the empirical part of the study will be to analyse if and, if yes, to what extent the potential synergies may be realized in a practical environment. The research questions derived from the literature review can be divided into two hierarchical levels. The top-level research question deals with whether, and if yes how, it was possible to combine ERP and LP into one integrated approach. One level deeper, in accordance with the two assumptions outlined above, I suggest two streams. Whereas the first stream addresses conflicts between LP and ERP, the second stream is concerned with the utilization of synergies. These streams can be broken down into concrete subordinate research questions. The following list provides an overview.

Overall research questions:

- Is it possible to integrate ERP and LP into one integrated manufacturing improvement initiative?
- If yes, how?

Concrete research questions:

A) Conflicts

- A1: Are there conflicting aspects between LP and ERP in practice, which can prevent the successful realization of an integrated manufacturing improvement initiative?
- A2: If yes, what are they?
- A3: How can they be overcome?

B) Synergies

- B1: Are there areas of synergy between LP and ERP, which can support the successful realization of an integrated manufacturing improvement initiative?
- B2: If yes, what are they?
- B3: How can they be utilized?

With respect the questions under cluster 'A', chapter two has shown that the dominant position in the literature is that there are fundamental differences between the concepts of LP and ERP, which can be seen as suggesting that there are conflicts between the two concepts which can prevent the combination of LP and ERP in one single approach. Examples include the different stances towards information technology or the different underlying material planning philosophies of push versus pull (see section 2.4 for more details). However there is little literature addressing the question of how these conflicts could be overcome in practice.

Concerning the questions in cluster 'B', the literature review has shown that, when looking deeper into the potential synergies from a theoretical point of view, it is possible to identify potential synergies on a theoretical basis. However the literature neither provides a direct and comprehensive summary of synergies, nor does it provide an indication how such synergies could be realized in practice.

3.3 Research Strategy

Bryman and Bell (2007) consider a research strategy as the general stance a researcher adopts while carrying out his research. Though Bryman and Bell (2007) hold that important parts of the research strategy are determined by the researcher's position in terms of qualitative versus quantitative research, the research strategy can be further broken down into ontological, axiological and epistemological considerations as well as the role of theory within the research.

With respect to the distinction between quantitative and qualitative research, Creswell (2008) suggests the application of the term research paradigm. According to Kuhn (1962), paradigms are universally recognised scientific achievements that for a time provide model problems and solutions to a community of practitioners. Whereas the quantitative paradigm is based on the belief that the study of human behaviour should be conducted in the same way as studies conducted in the natural sciences, the qualitative paradigm is concerned with understanding human behaviour from the participant's own frame of reference (Hussey and Hussey, 1997). Although both can be viewed as the extremes on a continuum, most researchers adopt either a more quantitative or a more qualitative paradigm (Morgan and Smircich, 1980). For the proposed DBA research I would position myself rather towards the qualitative end of the continuum. The main reason for adopting a rather qualitative paradigm is that I intend to reach an in-depth understanding of the research area, taking into account the broader context including human and social issues. In particular, I intend to gain deep insights into the question *how* my integrated framework of LP and ERP performed in a practical environment, mainly through analysing the behaviour of human beings. According to Bryman (1988) and Meredith (1998), this kind of question lends itself to qualitative investigations. This is also supported by previous research into a related topic, in which the authors point out that the analysis of LP in a new environment has revealed a level of complexity, which cannot be sufficiently addressed with quantitative tools and techniques (Reichart and Holweg, 2007).

As far as my ontological, axiological and epistemological assumptions are concerned, my stance is largely in line with the rather qualitative paradigm as outlined above. In this regard, the underlying ontological assumption of my research is that access to reality is rather subjective. Though I hold that I am able to observe what I consider to be real, I am aware of the fact that what I observe is actually my interpretation of reality, realized through my subjective lens of experience, knowledge and values. Bryman and Bell (2007) termed this critical realism.

With regard to the axiological assumptions, I consider the research to be at least partially value-laden and potentially biased rather than value-free and unbiased. However my intention was always to reduce bias as much as possible, for instance by cross checking my findings and interpretations within a larger group of consultants and clients.

From an epistemological point of view, my research adopts a rather interpretivistic stance (Bryman and Bell, 2007), taking into account the subjective meaning of social action in order to derive to a comprehensive account of the reality. Though I intend to act as objectively as possible throughout my research, I am aware of the fact that I will never be able to completely exclude subjectivity and bias from my analysis. In the empirical part of my DBA I endeavour to increase objectivity by verifying my analysis and the interpretations of the interviewees and relevant project participants. In addition to that, I discussed my observations and interpretations after each interview or workshop with my consultant colleagues and client representatives who attended the workshops.

As far as the role of theory is concerned, I refer to the distinction between deductive versus inductive research; that is, theory testing versus theory generating. As mentioned earlier I have formulated two contradictory assumptions in my framework after the literature review, which could be viewed as research hypotheses to some extent. In this respect one could argue that there is a deductive element in my DBA. However, looking at the type of research questions outlined earlier, the overall character of the DBA has to be characterized as largely inductive. Looking at the overall research question of how the conceptual framework performs in a practical environment, I rather intend to build and/ or enhance theory than to test it. This is reflected in my intention to develop the theoretical model further throughout the course of the empirical part of the research. The paragraphs outlined above describe various aspects of the research strategy. The following table provides a summary:

Aspects of research strategy	Research characteristic	Interpretation of characteristic
Overall Paradigm	Qualitative	Understanding human behaviour from participants own frame of reference
Ontology	Critical realism	Reality exists, but understanding of it is subjective and dependent on the researcher
Axiology	Value laden	At least not completely value-free and unbiased
Epistemology	Rather interpretivistic	People are different from physical objects, subjective meaning of social action needs to be considered
Role of Theory	Deductive aspects but primarily inductive	Theory testing on a high level, theory building on a more detailed level

Table 4: Components of the Research Strategy adopted

3.4 Research Design

3.4.1 Determination of the Research Design

As far as the research design is concerned, the DBA draws upon the findings of an in-depth case study, conducted in collaboration with a European truck manufacturer. Yin (2003) points out that a case study allows an in-depth investigation in order to provide a comprehensive account of the problem under investigation. In a similar vein, Robson (2002) defines a case study as a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context. With reference to this definition, the effects of applying an integrated framework of LP and ERP can be understood as the particular contemporary phenomenon to be empirically investigated. To be more precise, Yin (2003) furthermore differentiates between single and multiple case study strategies. In this respect, I will apply a single case study strategy in order to provide a holistic and consistent account of the benefits and conflicts of applying LP and ERP simultaneously in one project.

However there is another aspect I need to take into account with regard to my research design. In fact, the object to be researched will not be independent from, but rather will be influenced by, the action of the researcher since the researcher was working for the consulting company on the project to be researched. At first view, this fits well into the concept of Action Research (AR), which was first introduced by Lewin (1948). Due to the fact that the term AR has been interpreted in various ways since Lewin's first usage, Saunders et al. (2007) provide a summary of the four common themes of Action Research (AR). The following list provides an overview:

- Purpose is research in action rather than research about action
- Involvement with members of an organisation over a matter which is of genuine concern to them
- Implications beyond the immediate project
- Iterative research process consisting of diagnosing, planning, taking action and evaluating

First, the purpose of AR is research in action rather than research about action (Coghlan and Brannick, 2005), which fits to my proposed DBA research since I will be carrying out the research simultaneously while working in action on the project. Second, Eden and Huxham (1996, p.75) argue that the findings of action research result from "involvement with members of an organisation over a matter which is of genuine concern to them". In my DBA research, the "involvement with the organisation" is pre-defined through the researcher's role as the consulting partner in the project and "genuine concern" is present since the company intends to apply the integrated framework as a part of their operational strategy. Third, AR should have implications beyond the immediate project. In this respect Eden and Huxham (1996) stress the requirement for the development of theory. However with regard to consultants they point out that the implications beyond the project rather refer to the transfer of knowledge gained from one specific context to another. For my

DBA research project, particularly the generation of lessons learnt, as well as the suggestion of an improved approach, set out to meet this requirement. So far my research fits more or less into the themes of AR. Regarding the fourth theme; however, I hold that my research does not comply with the concept of AR. The fourth theme is concerned with an iterative research process consisting of diagnosing, planning, taking action and evaluating. However I hold that this iterative research process does imply a causal link between the phases and the intention of conducting research. That is, the theme presumes that the reason for taking action was the aim of conducting research, which means evaluating the results, carrying out further diagnoses and taking another action for the sake of doing research. Since the action taken for my DBA research will not be primarily carried out for the purpose of doing research, I do not consider my approach a case of AR. However I do notice that it does fulfil several aspects of AR. Therefore I conclude that this research is closest to a single-unit case study.

3.4.2 Critical Evaluation of the Research Design

The primary advantage of a case study research design is the possibility to gain in-depth insights into a certain "area of concern". In this regard, case studies allow a deeper understanding of both the contextual as well as the historical settings of the organisation under investigation (Easterby-Smith et al., 2008). Obviously this applies particularly to single unit case studies. Probably one of the most renowned examples of this strategy is Pettigrew's (1985) research on organisational development of ICI in Britain, in which Pettigrew was able to derive a profound understanding of the social processes by focusing on one single case over several years. The single unit case study approach suggested for my DBA research project allows us to analyse the implications of integrating ERP and LP on a relatively deep level over a longer period of time, partly allowing for the generation of historical insights.

Another advantage of the case study research design is its opportunity to generate and use data at first hand. This means that it is possible to gain direct access to people's behaviour, experiences and points of view including social contexts like the tone or gesture underpinning specific statements. In this regard, it is possible to generate rich qualitative data without having to rely on other people's judgement. Therefore, it can be argued that the collected data is less subjectively biased and richer in terms of the social context compared to other data collection like surveys or the use of secondary data.

Another important advantage of the case study research design is that it provides a vehicle for applying different data collection methods, which reduces the reliance on one single method (Bryman and Bell, 2007). This particularly applies to single case study designs, where the researcher can spend more time looking at one particular phenomenon from different angles. In addition to providing a broader and richer picture of the unit of analysis, the possibility of using a mix of methods can increase the reliability of findings, since different methods can also be used to check the plausibility of the results. With regard to the proposed DBA project, I applied triangulation by utilizing various data collection methods. These consisted largely of participant observations, and semi-structured and structured interviews. The empirical part of the DBA will be primarily based on observations in project meetings complemented with a selective use of semi-structured interviews.

There are several drawbacks associated with the case study method. One of the main points of criticism is that case studies lack external validity. In particular it is suggested that they rarely allow generalizations to be made from specific cases to the general population (Easterby-Smith et al., 2008). However as mentioned earlier, my position is rather informed by a constructionist epistemological stance. Instead of intending to generalize findings to a wider population, I am more interested in providing a rich picture of life and behaviour within the organisation. As Bryman and Bell (2007) suggest, the case is an object of interest in its own right and the researcher aims to provide an in-depth elucidation of the unique features of it. In addition to that, Siggelkow (2007) holds that even single cases may present very convincing tests of theory by referring to the well-known example of a talking pig. In this example, only one single case could break down the common theory that pigs are incapable of intelligent speech. In fact this principle also refers to this DBA research to some extent, in the event that I would be able to reject the commonly held belief of the apparently contradictory concepts of LP and ERP, which could not be applied together in an integrated project setting. Based on my experience in the automotive manufacturing improvement environment I am able to compare the specifics of my research setting to other settings, allowing us to derive claims about extrapolating my findings to other cases.

Another common critique is that case studies produce huge amounts of data, potentially allowing a researcher to make any interpretation they want (Saunders et al., 2007). This particularly applies when the boundaries of the unit of analysis are not clearly defined. But even when the organisation and rough area of undertaking of the study are largely determined, the unit of analysis does not exist in a vacuum but rather interacts with the world outside this area. These interfaces often make a clear delimitation of the study difficult. Concerning my DBA the delimitation of the unit of analysis is rather clearly pre-defined by a contractually agreed project scope, which is reflected in clear deliverables for the consulting company. Nevertheless, a certain degree of interaction with the world outside will be inevitable and will be considered accordingly in the evaluation of the research results.

Another critical point is that each organisation has a history which will influence the understanding of the present (Hussey and Hussey, 1997). Therefore, a major difficulty is to develop a sound understanding of the present situation without knowledge about events that happened in the past. In this research, the author will try to mitigate this by inquiring into the historically relevant issues of the organisation with long-term employees working in the relevant areas of the organisation under examination. The ability to gain historical insights at all is often considered a key advantage of the case study research design.

Finally, in terms of practical issues, Hussey and Hussey (1997) hold that the access to organisations is often difficult to negotiate. In my case, access is not a major issue since the researcher will be part of the team responsible for the management of the project forming the research case.

3.5 Research Methods

As mentioned previously, multiple methods for data collection will be used. According to Curran and Blackburn (2001), the choice of using a multiple method approach is increasingly advocated within business and management research, particularly when analysing a single case. The data collection methods for my DBA will mainly consist of participant observations in the context of project workshops or meetings, complemented with a selective use of semi-structured interviews. One of the main reasons for applying both types of qualitative methods allow for the generation of rich in-depth data (Bryman and Bell, 2007). Despite this broad common feature, participant observation and semi-structured interviews have slightly different characteristics, leading to slightly different advantages. As a matter of fact, some of those special characteristics of one method will help us to balance some of the downsides of the other technique and vice versus. Table 5 provides an overview comparing the advantages of both qualitative data collection methods as informed by Cassell (2004) and Bryman and Bell (2007).

Advantages of Participant Observation	**Advantages of Interviewing (semi-structured and unstructured)**
High and long lasting exposure to social setting	Enables focus on specific issues
Access to full, unfiltered picture	Access to issues resistant to participant observation
Naturalistic emphasis	Possibility to double-check / cross-check findings
Encountering the unexpected and flexibility	Less intrusive in people's organizational settings

Table 5: Advantages of Participant Observation vs. Qualitative Interviewing

3.5.1 Participant Observation

As mentioned earlier, participant observation in the context of project workshops and meetings will be the primary means of data collection for my DBA. There are several reasons for that. First, participant observation allows a high and long-lasting exposure to the social reality under investigation. As Bryman and Bell (2007) put it, the researcher's prolonged immersion in a social setting makes him or her better equipped to see as others see. Compared to other qualitative methods like interviews, the participant observer is in contact over a longer period of time and usually participates in many of the same kinds of activity as the members of the social settings to be studied. This extensive exposure to the social setting allows consideration of the context of people's behaviour. Moreover the long and intensive contact allows getting to know the special uses of terminology in an organisation, which is often crucial to understanding a context. Particularly in the environment of my DBA research topic, a high and long-lasting exposure to the project team appears to be absolutely essential in order to capture sufficiently rich and deep insights into the complex topic of applying an integrated framework of LP and ERP in a practical environment.

Another important advantage of participant observation is that it is possible to view the full picture; in contrast to interviews, which rely primarily on verbal behaviour. In addition, in the case of interviews the interviewee usually decides what he deems important, increasing the danger of omitting important facts. Moreover, as Whyte (1953) holds, few interviewees will be able to accurately recollect the dynamics of a meeting involving several people. In the context of my DBA research, I received a great deal of the information on how the application of the theoretical framework performed in practice to surface during project workshops and meetings. I am convinced that only through direct participation I was able to get full access to all aspects concerning the social dynamics of those settings.

Another advantage of participant observation lies in the fact that the position of the researcher in data collection is not as prominent as in the case of interviews. In this respect participant observation has the potential to come closer to a naturalistic environment. In addition to that, the less prominent role of the researcher contributes to the fact that the data derived from participant observation are less vulnerable to be politically biased than in interviews. Similarly, it is possible to uncover deviant or hidden activities resulting from participant's personal interests. Particularly in the environment of my DBA research, where a broad range of organizational and political issues are involved, the naturalistic setting of participant observations can be crucial to obtain unbiased first-hand information.

In addition, as a consequence of the unstructured nature of participant observations, one is more likely to come across completely new or unexpected aspects or issues. In contrast, this may be less likely in the case of semi-structured interviews, where the interviewee is usually guided by an agenda or the structure of pre-defined questions. Particularly due to the largely inductive nature of my DBA research, I expect this point as a major benefit of my approach.

A challenge for participant observation is often the question of how to document the proceedings and findings. With respect to my DBA research, voice recording or videotaping were not an option due to ethical reasons. Furthermore I did not want to cause an artificial atmosphere in the workshops; the participants should feel and behave like in any other normal workshop situation. As a consequence, I decided to collect my findings by taking notes. This happened in two ways; first during the workshop and second immediately after the workshops. For each of the workshops I defined the responsibilities for taking notes within the team of consultants. In addition to that, I was able to use the help of a team of 2-3 students for most of the workshops. The students were primarily responsible for taking notes. Usually immediately after each workshop we conducted a debriefing meeting with the consultants, the students and selected key members of the client organization. In these debriefing sessions I put together and discussed the findings. By this means, I was able to summarize the major findings and to verify the individual findings within a group of workshop participants including key members of the client organization. In addition, this procedure helped to clarify individual misunderstandings immediately after the meeting.

3.5.2 Interviews

In semi-structured interviews, the interviewer will ask a set of pre-defined open questions in order to address specific topics. One of the strengths of interviews is the possibility to focus on particular topics or issues. In this context I hold that semi-structured interviews fit nicely with the method of participant observation. Whereas the observations can be used to gain an overview of a broad range of various aspects, semi-structured interviews can be used to focus on specific areas. In this respect, semi-structured interviews could be utilized for instance, in order to explore an issue that came up during the observation on greater detail after the meeting. Other examples that can be foreseen are the possibility to ask questions about important background information that could not be explicitly explained during participant observation, or to clarify misunderstandings which couldn't be resolved during a meeting. In my DBA I intend to require this feature of interviews since I expect quite often situations in meetings or project workshops, which I cannot fully comprehend or interpret without further detailed background information.

Another advantage of the interview method is that it allows access to issues that are simply not amenable to observation. For instance people's thoughts or reasons for acting in certain ways can often only be accessed by interviewing the relevant person. Another example in this respect is the reconstruction of past events by asking interviewees to think back over how a certain series of events developed in relation to a current situation. I expect that I will need to consider those kinds of unobservable information also in my DBA thesis in order to provide a comprehensive representation of the social reality.

In addition to this, an advantage of interviews compared to participant observation is the possibility to allow for cross-checks / double-checks before the researcher draws a final conclusion. On the one hand, the researcher is able to paraphrase his understanding or formulate his conclusion in particular statements so as to double-check with the interviewee that his understanding or conclusion was correct. Similarly, statements of different interviewees regarding the same issue can be cross-checked. For my DBA research, I intend to make use of this characteristic of interviews in order to reduce the risk of misunderstandings and in order to increase the reliability of the findings.

A further often mentioned advantage of interviews is that they are held to be less intrusive in people's organizational setting than participant observation. One of the reasons is that in interviews the researcher usually spends less time with the people compared to participant observations. Bryman and Bell (2007) hold in this respect that there is a risk of disrupting the rhythms of work lives through participant observation. Despite the fact that I intend to take this issue seriously by trying to reduce the disruption to a minimum, the entire project of implementing a new manufacturing improvement framework will inherently require some disturbance of the usual work procedures.

In addition to semi-structured interviews, I also carried out unstructured interviews with client employees. This was done particularly in order to receive first hand feedback without the official character of semi-structured interviews. For instance lunch breaks turned out to be a valuable opportunity to receive direct and unfiltered feedback.

3.6 Assessing the Research Methodology

This chapter addresses the question which criteria will be applied in order to assess the quality of my DBA research. In contrast to rather uniformly defined criteria for evaluating quantitative research, the criteria to assess qualitative research vary within the literature. On the one hand there are authors like LeCompte and Goetz (1982) or Kirk and Miller (1986), who apply the quantitative criteria of reliability and validity in relation to qualitative research, but use the terms with somewhat different meanings. On the other hand, authors like Guba and Lincoln (1994) hold that it is necessary to specify different terms, because they are critical of the view that there are absolute truths about the social world. Assessing my DBA research, I position myself rather at LeCompte and Goetz's side of this continuum. I hold the view that a great deal of the social reality can be captured by qualitative research through concepts and theories. In this respect, I suggest the following criteria to assess the quality of my DBA research:

- External validity
- Internal validity
- Ecological validity
- External reliability
- Internal reliability

External validity refers to the degree to which research findings can be generalized. Generally, this is often seen as the primary weakness of qualitative research, due to the tendency to employ small samples or, as in my case, a sample size of one. In my DBA research, the primary intention is not to generalize the findings but rather to provide deep insights into one single case. However, as Siggelkow (2007) holds, even a single example of an anomaly can destroy a dominant theory. In this respect it could be the case that my research reveals that the widely-held differences between LP and ERP turned out not as invincible as expected in theory.

Internal validity refers to the question whether there is a match between the researcher's observations and the theoretical ideas developed. This criterion is often considered one of the strengths of qualitative research, particularly in the case of participant observation. The reason is that the participation over quite a long period of time entails a high level of congruence between observations and concepts (LeCompte and Goetz, 1982). This aspect corresponds particularly to the participant observation part of my proposed DBA research.

As far as ecological validity is concerned, I question whether my findings are applicable in practice; that is, in people's natural social settings. According to Cicourel (1982), ecological validity asks the question whether my instruments capture the real life conditions of those I study. In this respect, I intend to conduct my research without creating unnatural laboratory settings, thereby increasing the ecological validity of the findings.

External reliability is concerned with the degree to which my study can be replicated. Though I am aware that this will never be completely achievable since it is impossible to replicate a social setting, I intend to make my results as replicable as possible. For instance, I will be supporting external reliability by clearly describing the research setting and the detailed course of action applied.

By internal reliability LeCompte and Goetz (1982) refer to the question whether or not other observers would agree about what I have observed. In order to support internal reliability of my DBA research, I intend to have the collected data cross-checked by other observers of the interactions such as client employees.

4 Case Study

This chapter deals with the empirical part of the DBA research. As outlined in the research methodology chapter, I have chosen a case study research design. The case to be analysed consists of a manufacturing improvement initiative carried out in a practical environment of an original equipment manufacturer (OEM) in the automotive industry. The first section provides a basic introduction to the case and the approach adopted. The subsequent sections focus on the different phases within the initiative. For each of the phases, I present a description of major events relevant to my research questions as well as a summary of major findings for each of the logistics processes in the format of tables.

4.1 Introduction to Case Study

This section provides an outline of the practical environment in which I carried out my case study research. The case company is a European automotive original equipment manufacturer (OEM). The firm's production network consists of 9 vehicle production plants across Europe, complemented by several overseas manufacturing operations and co-operations. In order to increase efficiency and reduce cost of production operations, the OEM decided to re-engineer and standardize their business processes and systems in the area of production and logistics. In this respect the OEM launched a strategic initiative in the organizational division of production and logistics, which involved all 9 European production plants. Starting with the definition of the strategic cornerstones at the very beginning of the initiative, the author was deeply involved in the entire initiative acting as the consulting company's project manager.

4.1.1 Strategic Cornerstones of the Initiative

The initiative was designed along two equally important strategic cornerstones:

- Improving and standardizing business processes in the production network supported by SAP **ERP** Automotive
- Improving and standardizing business processes informed by the concept of **Lean Production** (LP)

Concerning ERP, improvements should be brought about by designing and implementing a new process and system template based on SAP. The usage of SAP was decided mainly due to two facts. First, SAP was already implemented in some parts of the company, e.g. finance and controlling, the spare parts business and even for some singular logistics processes in the production network. Second the dominant market position of SAP in Europe promised safety in terms of software maintenance and further development in terms of new functions.

With respect to the area of IS, the new initiative addressed two main objectives: First it intended harmonize the inhomogeneous system landscape by replacing a set of historically grown systems largely perceived as technically hard to maintain and inflexible. Second new functional features provided by a state of the art ERP software package should offer a platform to fulfill new and changing business process requirements. It deserves mentioning that the client company had done a couple of SAP implementation projects before the initiative under investigation, but the outcomes were largely perceived as non-satisfactory not only from the operations but also from the IS point of view. The reason was that these projects usually failed to realize above objectives to a satisfactory extent. Particularly the objective of IS harmonization could not be reached since only single processes were realized in SAP instead of realizing complete end to end processes. As a consequence, the number of IT interfaces increased, causing additional complexity to the IS landscape. With the new holistic approach of the new initiative, this problem should be solved. Furthermore, it was intended to utilize more new automotive specific functions than in past projects.

With respect to lean production, the initiative set out to comply with and put forward the OEM's lean production concept within the production network. The objective to promote the lean production philosophy as the client's major concept in the overall production network was a strategic decision made by the board several years ago. Even though several local LP initiatives have been launched in the past, there was still no fully standardized, comprehensive and sound LP standard in the production network. In fact, the degree of LP implementation varies not only from plant to plant, but also between different organizational areas within the plants. Often the LP state can be described as consisting of single local lean islands rather than an integrated and comprehensive lean process landscape.

4.1.2 Structure and Timeline of the Initiative

This section describes the structure and timeline of the initiative. In fact, the OEM's board decided to significantly change the course of action with the emergence of the economic crises at the end of 2008. The following two figures provide an overview.

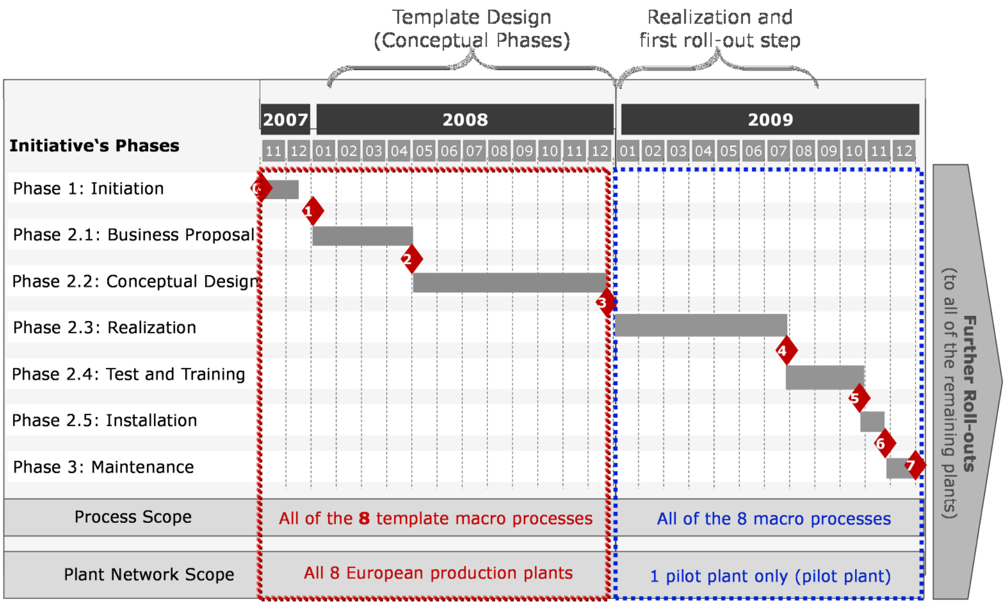

Figure 11: Initially foreseen course of action (board decision 12/2007)

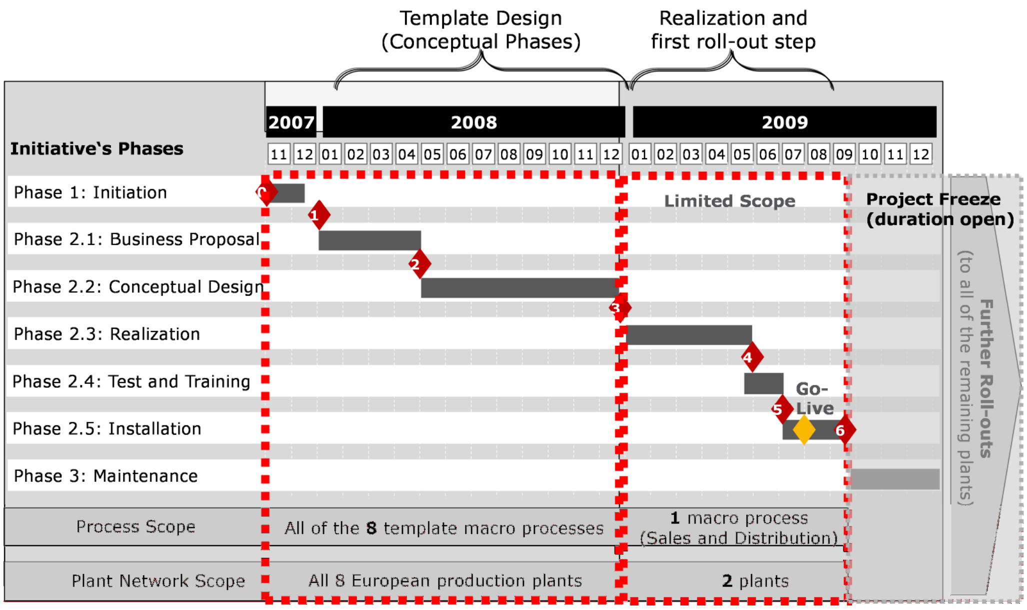

Figure 12: Actually followed course of action (board decision 12/2008)

In fact, due to financial constraints the board decided to either stop or freeze all of the larger company projects. With reference to my initiative, the board decided to significantly limit the scope as of January 2009 and to freeze the project as of October 2009. In this context it was decided to roll-out only one out of eight macro processes initially in scope, namely that of sales and distribution. As a consequence, the template design phases had been carried out for the entire process scope and for the entire European plant network, whereas the realization and the following phases where only done for one macro process and for two plants. The following figure provides an overview.

Work Stream	Macro Process	Initiation and Template Design (ph. 1; 2. 1; 2.2)								Realization Phases until 1st roll-out step (ph. 2.3 – 2.6)							
	Plants	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
PLANNING	Master Data Manage-ment	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Demand Planning	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Material Planning	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	In-house Parts Production	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
EXECUTION	Goods Receipt	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Warehouse Management	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Production Supply	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Sales and Distribution	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	N	N

Table 6: Scope of Initiative until first roll-out step = scope of thesis

In 2011 the company decided to proceed with the entire initiative in the originally foreseen process scope of all eight macro processes, starting a pilot roll-out at another production plant. However this new project had been started roughly 1 year after the empirical part of my research was finished. It could be an interesting object for future research.

4.1.3 Introduction to the Project Phases

This section provides a brief introduction to the project phases of the initiative. The details about the proceedings and findings in each of the phases are described in section 4.2 to 4.4. Furthermore section 4.1.4 provides an outline of the field of participant for the phases.

The initiative's general structure reflects my conceptual framework as suggested earlier in this thesis (see section 3.1). The following figure highlights the relevant project phases.

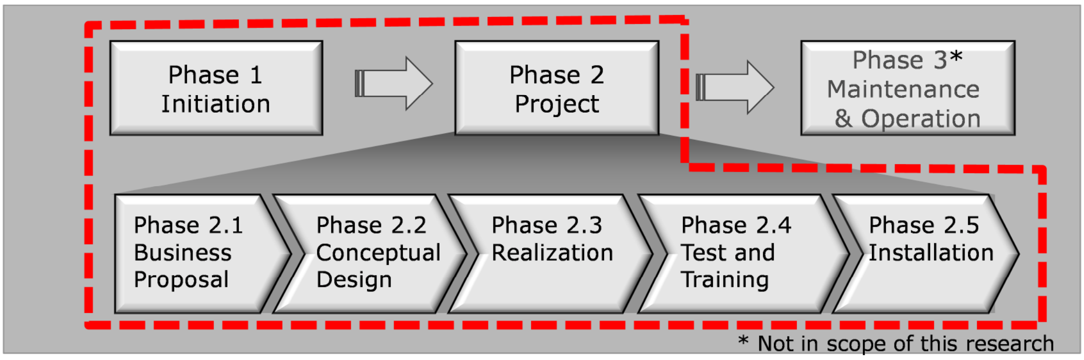

Figure 13: Overview of project phases

The initiative can be divided into the three main phases initiation, project and maintenance. The project phase can be further broken down into the sub-phases business proposal, conceptual design, realization, test & training and installation. In the following sections I provide a brief outline of each of these phases.

In the initiation phase, the OEM initiated a set of analyses and preparation activities leading to a comprehensive business case analysis, comparing the efforts with the potential savings of the improvement initiative. This phase can be considered a key challenge for the integrated manufacturing improvement initiative consisting of ERP and LP. A prime objective was to establish sufficient evidence indicating that such an initiative would be feasible and eventually produce bottom line results for the business. Assuming this could be established, another key challenge was to communicate the business case to the client's top management and to seek their commitment to launching the initiative.

The actual project was kicked-off after the successful completion of the initiation phase. In the first sub-phase, a business proposal was created, discussed and approved by the entire production network. Setting up the basic project structure leading to a so-called master process list (MPL), this phase formed the basis for the implementation phase. The actual business proposal document consisted of a macro-level process design for the entire production network. Throughout this phase, particular emphasis was set on the identification and consideration of potential synergies between LP and ERP. Those synergies had to be reflected in the macro process design and the initiative's business case accordingly. On the other hand, it was required to cope with apparent conflicts between both concepts.

Within the conceptual design sub-phase, all relevant concepts for the actual realization phase had to be created, agreed and approved by the entire production network. Amongst others, process flow charts were designed for all of the relevant business processes and a functional design concept was created describing the to-be business processes and requirements on a detailed level. Again, a major challenge was the integration of LP and ERP throughout all process levels. That is, the rough strategic improvement potentials outlined in the initiation phase had to be broken down into tangible operational improvements. As far as the IS perspective was concerned, important deliverables comprised the system configuration documents and the programming development specifications for system interfaces, add-ons, reports, or other types of standard enhancements.

The realization sub-phase comprised the actual realization of the processes as designed in the conceptual phases. Due to the economic crises in 2009, the scope of the realization and all subsequent phases was reduced to only one out of eight macro processes. The realization phase involved basically two parallel streams, a rather IS-relevant and a rather operations-relevant stream. Whereas the operations-relevant stream dealt with preparing the organization and the IS-surrounding operations processes, the IS-relevant stream was concerned with the set-up of the technical solution within the ERP system. With respect to my research topic, this phase allowed a first look at the new lean processes and IS functions. For my research it was important to note that the results of this phase had to be analyzed under the restriction of the reduced process scope. In particular it was likely that some improvements could not live up to the expectations raised under the premise of a full scope implementation.

The testing and training sub-phase comprised the testing of business processes and end-to-end business scenarios. The training activities comprised both ERP-supported processes as well as purely manual business processes. With respect to the combination of ERP and LP, this phase could be seen as the one in which the truth became apparent. By the testing the business scenarios, the operations people got harshly exposed to the advantages and disadvantages of the new processes. Also in this phase, the scope reduction had to be taken into account when analyzing the findings with respect to my research topic.

The installation sub-phase consisted of all activities concerned with the migration from the old process and system environment to the newly designed processes and systems. As far as the integration of ERP and LP was concerned, the installation sub-phase transferred the newly designed and realized lean business processes into real life conditions. This can be seen as the final transition from theory into an operational day to day practice.

Finally the maintenance and operations phase was mainly concerned with keeping the new process and system solution running at a stable and high performance level. Though it would be of some interest to analyze this phase in the context of my DBA, I have excluded it from the scope. The main reason for that was the lack of access, since the maintenance phase was not part of the consulting project.

4.1.4 Project Organization and Team

The core team of project members consisted of more than 120 people. Roughly one third were consultants from the consulting firm the author was part of. The rest were client representatives, around one third from the operations and another third from the IS area. The initiative was considered the largest project within the client organization at that period of time. The following figure reflects the project organization for the initiative.

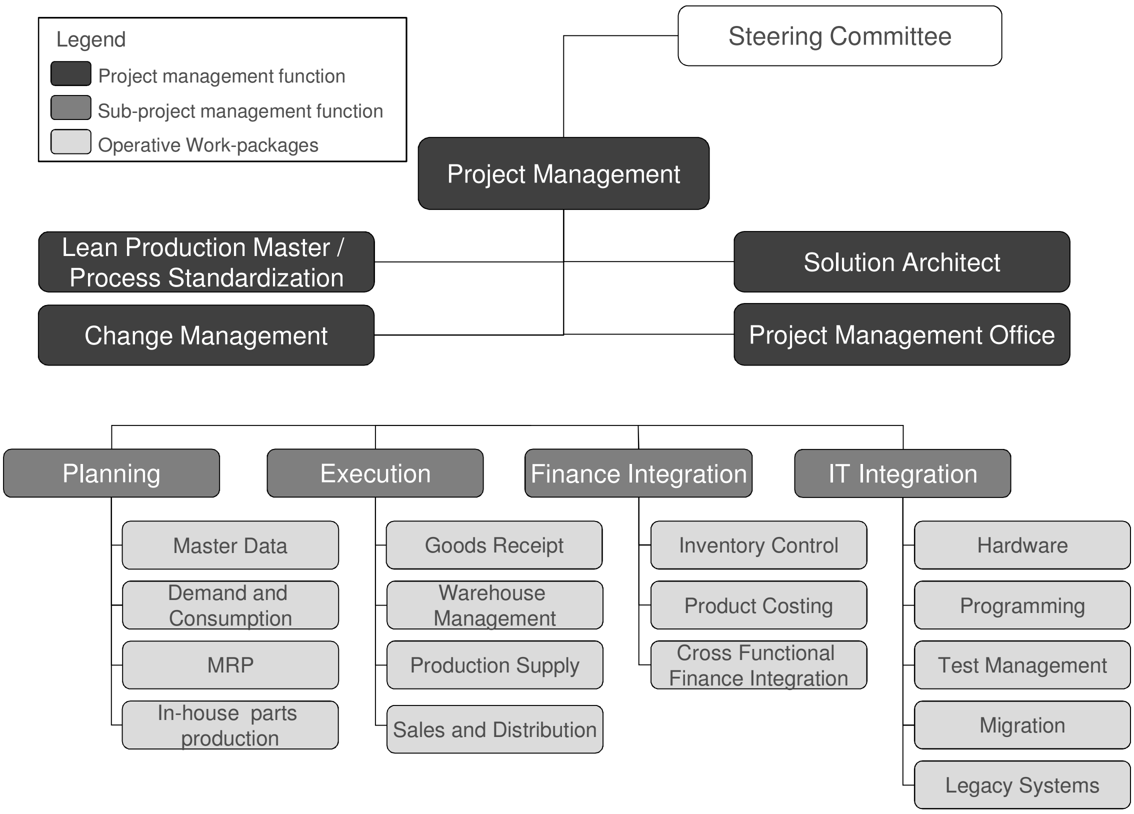

Figure 14: Project Organization

As above figure indicates, the project organization consisted of three layers. The first layer comprised the project management functions, the second layer reflected the sub-project management functions and the third layer included the operative work-packages. I considered organizational aspects as crucial for achieving the initiative's objectives and particularly for emphasizing the integration of the concepts of LP and ERP. In order to differentiate the initiative from a normal ERP implementation project, I decided to emphasize the lean- and process orientation within the project organization. I realized this by three different means.

- Composition of each instance in the organizational chart
- Process oriented project organization
- Special LP-responsible function within the program management

First, the importance of LP was reflected in the composition of each of the instances in the organizational chart. In fact, each of the instances was set-up in a triangular way so as to reflect the three different parties operations, IS and external consultants, whereby the external consultants came from the consultancy the author of this thesis is part of. Whenever one of the representatives of the three parties disagreed, the issue was escalated to the next higher hierarchy of the project organization; by this means, every representative of the three parties was given a kind of veto right. I expected this rule to contribute in producing more balanced decisions between LP and ERP on each level of the project organization. The following figure illustrates the general composition most of the instances in the project organization.

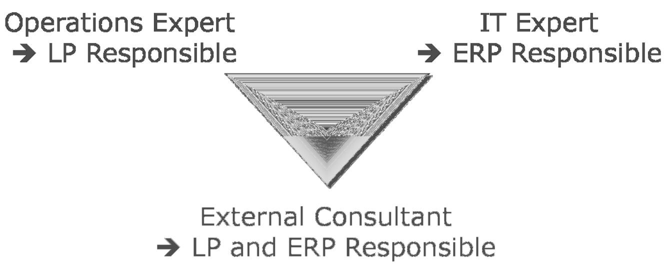

Figure 15: General composition of the project organization instances

Second, I set-up a process orientation project organization structure, instead of ERP module oriented structure like in many conventional ERP implementations. In fact, I set-up two process-oriented sub-projects, namely execution and planning, which were given a lead function above the other sub-projects. The teams below the two lead sub-projects were structured along a process orientation. The two lead sub-projects were by far the largest in terms of the number of participants. The two other sub-projects, namely finance-integration and IT integration, had been defined as kind of service functions for the lead sub-projects.

Third, I initiated a special function within the project management team, which was solely responsible for strengthening the realization of the LP principles within the initiative. This function was equipped with specific competencies in the design of processes. For instance, the function was equipped with a power of veto for all of the process designs worked out in lead sub-projects planning and execution.

As mentioned earlier, the initiative's core team consisted of more than 120 participants. In order to structure the field of participants, I have set-up a coding in the format of alphanumeric keys. The structure of the key consists of the following syntax:

<A> – <B> – <C>.

<A> indicates the participant's home location with a range from the value "0" for the central organization. The digits from "1" to "8" indicate the production plant where the participants were located.

<B> reflects the organizational division. I differentiate between the characteristic "O" for the operations division; that is, the division reporting to the COO. "I" for information systems division; that is the division below the CIO. "F" for the finance and controlling division; that is the division lead by the CFO. For the purpose of my research on the topic of LP and ERP, I am most interested in the distinction between the operations division and the IS division. For the further descriptions in this thesis I will simply refer to participants from these groups as the "IS group" and the "operations group".

<C> beaks down the type of organizational department into the actual department, indicated by a consecutive two digits numerical number. Apart from information about the exact department and home plant of any participant, this key allows us to differentiate between the group of operations- and IS-participants, which is crucial when it comes to analyse the people's behaviour with respect to the integration of LP and ERP. The key will remain constant during the descriptions of relevant activities and findings for this thesis, even if sometimes the persons holding the position was replaced during the course of the project.

The following table provides an overview of the field of core team participants of the initiative.

Phase 1	#	ID of	Position	Role in Project	Category
X	Ext	C-01	Senior managing consultant	Project manager - consultancy	Neutral
X	Ext	C-02	Managing consultant	Sub-project manager "planning"	Neutral
X	Ext	C-03	Managing consultant	Sub-project manager "execution"	Neutral
	Ext	C-04	Managing consultant	Sub-project manager "Finance Integration"	Neutral
	Ext	C-05	Managing consultant	Sub-project leader "IT-Integration"	Neutral
	Ext	C-06	Consultant	Macro processes "master data" & "demand planning"	Neutral
	Ext	C-07	Consultant	Macro processes "material planning" & "supplier integration"	Neutral
	Ext	C-08	Consultant	Macro process "in-house parts production"	Neutral
	Ext	C-09	Consultant	Macro processes "goods receipt" & "inventory management"	Neutral
	Ext	C-10	Consultant	Macro processes "warehouse management" & "line supply"	Neutral
	Ext	C-11	Consultant	Macro process "quality management"	Neutral
	Ext	C-12...C-29	Consultants / Junior Consultants	Functional Consultants	Neutral
X	Ext	C-30	Managing consultant	Lean production master	Neutral
	0	0-O-00	Member of board for production and logistics	Steering committee	Ops
	1	0-O-01	Central head of area for plant operations (reports to COO)	Steering committee	Ops
X	2	0-O-02	Central head of division for supply chain management	Temporary participation	Ops
X	3	0-O-03	Central head of department for logistics and supporting IT	Project manager - operations	Ops
X	4	0-O-04	Central head of department for plant network standardization and LP	LP master and process standardization	Ops
X	5	0-O-05	Central member of department for logistics and supporting IT	Project management office	Ops
X	6	0-O-06	Central team-lead of department for plant network standardization	Sub-project manager "planning"	Ops
X	7	0-O-07	Central team-lead of department for plant network standardization	Sub-project manager "execution"	Ops
X	8	0-I-00	Central head of company-IS	Steering committee	IS
X	9	0-I-01	Central division head for IS	Steering committee	IS
X	10	0-I-02	Central head of department for production relevant IT	Project manager - IT	IS
X	11	0-I-03	Central team lead for logistics systems	Solution architect	IS
X	12	0-I-04	Member of department for production relevant IT	Sub-project manager "IT integration"	IS
X	13	0-I-05	Member of department for production relevant IT	Sub-project manager "planning"	IS
X	14	0-F-01	Central head of department for product costing	Sub-project manager "finance integration"	Neutral
	15	1-O-01	Local head of plant 1	Temporary participation	Ops
X	16	1-O-02	Local head of division for plant 1 operations	Continuous participation	Ops
X	17	1-O-03	Local head of department material planning plant 1	Continuous participation	Ops
X	18	1-O-04	Local head of department material flow / warehousing plant 1	Continuous participation	Ops
X	19	1-O-05	Local head of department for vehicle assembly plant 1	Continuous participation	Ops
X	20	1-O-06	Local head of in-house parts production plant 1	Continuous participation	Ops
X	21	1-O-07	Local head of department for sales and distribution plant 1	Continuous participation	Ops
X	23	1-I-01	Local head of IS plant 1	Continuous participation	IS
X	24	1-I-02	Local head of department for production systems plant 1	Sub-project manager "execution"	IS
X	25	1-I-03	Local head of team for production systems department plant 1	Continuous participation	IS
X	26	1-I-04	Local team member for production systems department plant 1	Continuous participation	IS
X	27	1-I-05	Local team member for production systems department plant 1	Continuous participation	IS
	28	1-F-01	Local head of finance and controlling plant 1	Temporary participation	Neutral
X	29	1-F-02	Local head of controlling department plant 1	Continuous participation	Neutral
	30	2-O-01	Local head of plant 2	Temporary participation	Ops
	31	2-O-02	Local head of division for plant 2 operations	Continuous participation	Ops
	32	2-O-03	Local head of department material planning plant 2	Continuous participation	Ops
	33	2-O-04	Local head of department material flow / warehousing plant 2	Continuous participation	Ops
	34	2-O-05	Local head of department for vehicle assembly plant 2	Continuous participation	Ops
	35	2-O-06	Local head of in-house parts production plant 2	Continuous participation	Ops
	36	2-O-07	Local head of department for sales and distribution plant 2	Continuous participation	Ops
	37	2-I-01	Local head of IS plant 2	Continuous participation	IS
	38	2-I-02	Local head of department for production systems plant 2	Continuous participation	IS
	39	2-I-03	Local head of team for production systems department plant 2	Continuous participation	IS
	40	2-I-04	Local team member for production systems department plant 2	Continuous participation	IS
	41	2-I-05	Local team member for production systems department plant 2	Continuous participation	IS
	43	2-F-01	Local head of controlling department plant 2	Temporary participation	IS
	44	3-O-01	Local head of plant 3	Temporary participation	Ops
	...	....	...	...	
	90	8-F-08	Local head of controlling department plant 8	Temporary participation	Neutral

Table 7: Initiative's Core Team

Apart from initiation phase (see section 4.2.1), all employees of the table were involved in the project phases business proposal and conceptual design since the design was made for the entire production network. As of the realization phase, the two roll-out plants and the central area were more in the focus; the participants from the other plants reduced their level of participation to a role focusing on process verifications, sign-offs and support.

4.2 Initiation (Phase 1)

This section sets out to outline the initiation phase. The following figure illustrates the initiation phase in the context of the conceptual framework suggested earlier in this thesis (see chapter 3.1).

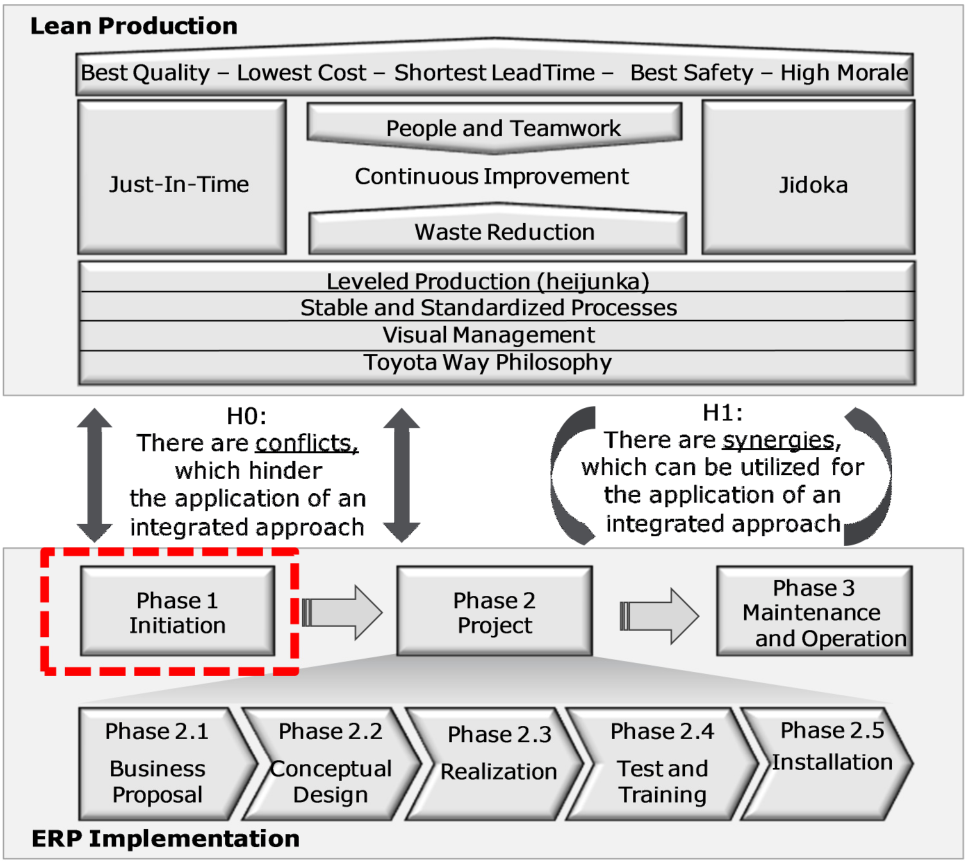

Figure 16: Initiation phase in the context of the conceptual framework

The duration of this phase was roughly one and a half months. As mentioned above, the phase mainly dealt with setting up the business case for the initiative and gain to top management commitment. At the point of time when this phase started there was no final decision made upon a potential realization of this initiative. In this sense, the phase could also be considered a feasibility study with the intention of analyzing whether such an initiative could be economically material.

4.2.1 Course of Action and Participants

On the one hand, this phase consisted of an estimation of basic project characteristics like the potential project scope, a feasible timeline, or a first estimate with respect to resource requirements. On the other hand the initiation phase encompassed activities leading to the launch of the project like winning and managing political support and top management commitment.

The approach consisted of an off-site period for preparation activities, an on-site period for data collection as well as a final off-site period for an evaluation of the findings. The following figure illustrates the course of action adopted in the initiation phase of the initiative.

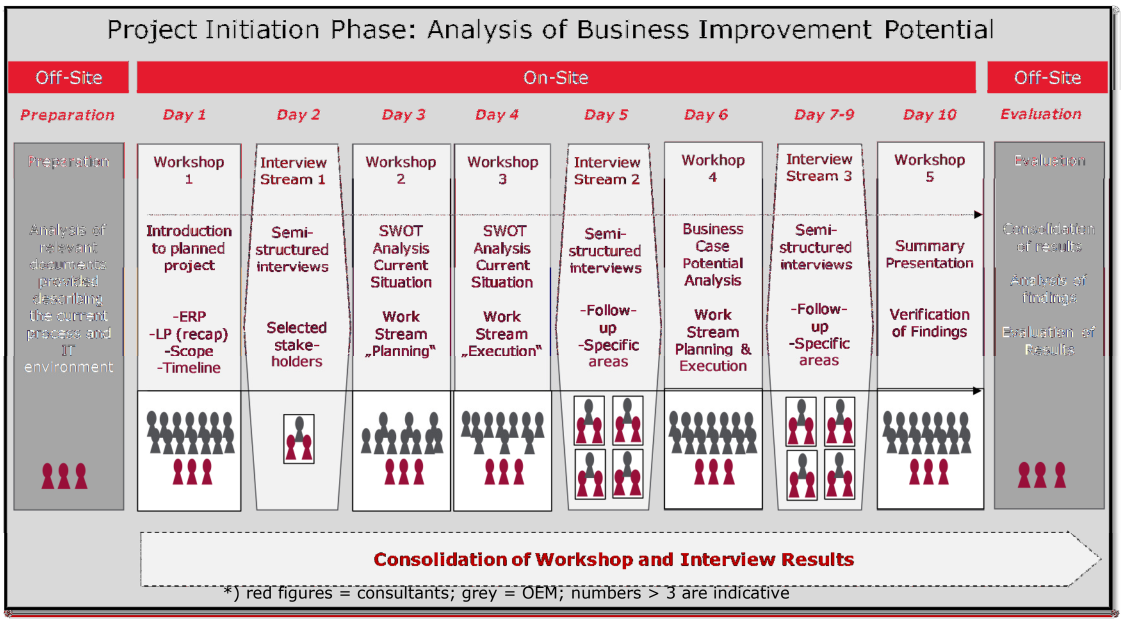

Figure 17: Procedure for Business Potential Analysis

Next to the four consultants from the author's consulting firm (C-01 to C-04, see table 7), the initiation phase comprised the central division representatives and the plant 1 representatives according to table 7. The other plants were not directly involved in the initiation phase workshops. The participants of the initiation phase are indicated with an "X" on the left column of table 7.

As indicated in the figure above, the actual on-site analysis consisted of following data collection elements:

- 5 interactive full-day workshops

- 9 semi-structured interviews

The first workshop set out to introduce the main objectives of the future initiative and mapped the potential scope on a high level with the local processes at the plant. Workshops 2 and 3 focused on an analysis of the logistics and production processes and systems currently in place at the local plant and aimed at identifying strength and weaknesses as well as opportunities and risks for the potential future initiative. Apart from further identifying potential future benefits, workshop 4 mainly intended to quantify those potential benefits as an important input variable for the set-up the initiative's business case. Finally, workshop 5 encompassed a verification of the results and a presentation of main findings.

Between the workshops, I constantly conducted interviews with the workshop participants. In summary I conducted 9 interviews in a semi-structured method. I applied this data collection method in order to make sure that I covered all relevant topics and, at the same time, left room for interviewees' individual interpretations, background information, or for the identification of new aspects. The first interview was conducted with the local head of plant 1 (1-O-01, see table 7) after the first workshop. Apart from the intention to provide background information on the planned project, major objectives were to capture the point of view in terms of strategic guidelines, focus areas and to agree on the rough approach for the upcoming workshops. Interviews 2-5 were conducted after the third workshop and focused on participants, who turned out to be specific experts with regard to important topics.

4.2.2 Findings

I analysed the initiation phase on a relatively detailed level. In order to keep the document size on a tolerable level, I decided to place the detailed activities and findings of this phase into the enclosure of this document.

In contrast, this section focuses on a summary of the main findings as relevant to my research topic. According to my research questions, I differentiated between conflicting aspects and synergies.

4.2.2.1 Conflicts

Particularly in the first workshops of the initiation phase I have observed a rather apprehensive and/ or even negative attitude of many participants towards the endeavour of combining LP and ERP. These attitudes can be divided into an IS-centred and a LP-centred point of view.

On the one hand, there was the rather IS-centred point of view. The representatives who took this view either came from a local or a central IS department. The point of view can be summarized as considering LP a management fad, which will soon be replaced by another concept. As representatives who are usually exposed to a rather quantitative environment, it was particularly hard for this group to appreciate the philosophical and the social aspects behind LP. A frequently expressed critique was that LP elements were basically only common sense rules, which were either already applied or should have been already applied without the need for a concept like LP. Many representatives have seen a significant conflict between the deterministic IS world they were familiar with, and the consumption driven pull principle of LP. The shift towards consumption driven pull was often considered a step backward due to an apparent loss of IS-control over the process. In addition, I often observed misunderstandings due to the different terminology the participants were familiar with in their daily work. An example can be seen in the word "system", which is usually used for an IT-tool in the IS environment, whereas it is used in a broader sense in the context of LP, for instance in the case of pull system.

On the other hand, there was the rather LP-centred point of view. In the purest form of critique against ERP, operations managers adopting the LP perspective questioned the requirement for an IT-system at all. The need to maintain data as well as the resource requirements for system processing were criticized as non-value adding activities. In addition to that, ERP was perceived as a deterministic tool with all its disadvantages. A commonly expressed critique in this respect was that ERP was only able to deal with theoretically calculated demand data derived from the explosion of an often inaccurate bill of material and the respective comparison with frequently inaccurate system-based stock levels. In addition to that, the deterministic system was not seen as being capable of dealing with short term changes of demands.

To sum it up, I observed a subliminal aversion of each side against the other one particularly at the beginning of the workshop stream. Particularly in this early period it was often hard to keep the discussions on an objective level and at least once the meeting was about to be broken off due to offensive arguing between the two groups. At that time the discussion could be brought back to an objective level only with the help of authority; that is, through intervention of the local head of the plant (1-O-01). As soon as the discussion was brought back to an objective and operational level, the first synergies could be identified, which enabled and supported the identification of improvement potentials and business case impacts. However during the entire course of the workshops, a strong moderation of the meetings was necessary in order to keep the discussion on an operational level.

I conclude that during the initiation phase I actually observed considerable social conflicts when applying the integrated manufacturing improvement framework combining LP and ERP. These conflicts did impede the successful realization of the initiation phase of the integrated manufacturing improvement project. However I have indication to assume that a great deal of the conflicts was based the different people’s legacies between the group of IS- and operations representatives. I draw this assumption primarily based on the fact that a substantial proportion of the conflicts could be resolved when it came to objective operational discussions.

4.2.2.2 Synergies

After the early disputes, I observed a slight shift in the attitude of many participants. This refers to both groups; those adopting a rather IS-centred point of view as well as those rather holding the LP perspective.

In fact throughout the course of the operational discussions, participants adopting an IS-centred point of view appeared to realize synergies between LP and ERP. Starting with the realization of obvious synergies like process standardization, which is a key element in LP as well as ERP, IS-representatives began to appreciate aspects of the LP concept. Moreover with an increasing number of synergies and improvement potentials identified, the IS-representatives increasingly appeared to develop a better understanding the concept of LP. In addition to that, I observed that some of the IS-representatives actually began to consider LP as a vehicle to attract attention and gain top management commitment.

Similarly, participants who adopted a rather LP-centred viewpoint started to recognize the possibilities of today's ERP functionality as soon as the workshop discussions could be boiled down on an operational level. In fact, LP proponents began to consider and appreciate ERP as a tool capable of supporting the concept of LP. I identified this occurrence with respect to three aspects: First, new functions supporting and improving lean processes could be identified. Second, the participants realized that ERP functions were able to support areas where the LP concept has its limitation. An example is the possibility to control low-volume and high variety characteristic parts. And third, representatives holding a LP-centred viewpoint started to appreciate the wide platform provided by the integrated approach. In this respect, the company-wide reach of ERP was increasingly valued as a vehicle for spreading the LP philosophy across the plant.

To conclude, despite strong initial reservations of the workshop participants towards an integrated approach, potential synergies between LP and ERP have been identified during the initiation phase. These synergies turned out to support the identification of improvement potentials leading to concrete business case impacts. Therefore I conclude that, during the initiation phase, potential synergies between ERP and LP facilitated the decision towards the launch of the initiative. However I hold that the synergies could be realized primarily on an operational level; that is, on the level of applying concrete LP elements.

4.2.3 Conclusion

As outlined above, I have observed areas of conflict as well as areas of synergy when applying an integrated approach consisting of LP and ERP in the initiation phase of the manufacturing improvement initiative under investigation. In the early stages, the conflicts jeopardized the success of this important phase. I found that much of the disputes appeared as a consequence of the different backgrounds of those participants adopting the IS-perspective on the one hand, and those adopting a LP point of view on the other hand. At a later stage of the initiation phase, the discussions centered more on an operational level and the participants started to identify synergies. As a consequence, improvement potentials could be identified and expressed in terms of concrete business case impacts. At the end of the initiation phase the participants committed to a level of savings and productivity gains, which positively influenced the business case to a great extent.

This aspect eventually helped to convince the board members to decide to release the budgets for the launch of the initiative.

With respect to the overall research question I conclude that in the initiation period of the initiative it was possible to integrate LP and ERP in one single manufacturing improvement initiative. I found that the launch of the project had not been possible without the improvement potentials identified through and supported by synergies between LP and ERP. However this was primarily enabled by a strong commitment of the top management throughout the entire initiation phase. In addition to that, intensive workshop moderation with a strong focus on operational aspects instead of generalizations was absolutely essential for identifying the improvement potentials.

For further details on the activities and findings of the initiation phase, please refer to the enclosure of this document as described in chapter.

4.3 Template Design (Phase 2.1 Business Proposal, Phase 2.2 Conceptual Design)

After the successful completion of the initiation phase, the launch of the project was approved by the OEM's board. As mentioned earlier, the combination of LP and ERP and particularly the business benefits accompanied with this approach have significantly facilitated the decision towards the launch the initiative. According to OC01, this board decision "had not been made solely based on an ERP implementation without the benefits promised by the concept of LP". The board decision encompassed the conceptual phases of the template design up and the realization and first roll-out. The sequence and timing of the subsequent roll-outs should be re-decided at a later point in time.

In this context, this section sets out to describe the conceptual phases; that is, the business proposal phase and the conceptual design phase. These phases are also referred to as the template design phases, since they encompass the creation of pre-defined processes functioning as a kind of process tool box for all of the plants in the production network. The following figure illustrates the business proposal phase and the conceptual design phase in the context of initiative's implementation model suggested earlier in this thesis.

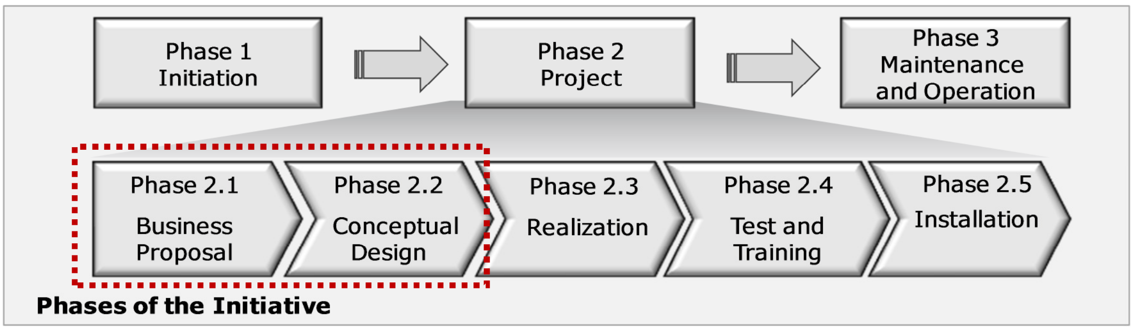

Figure 18: Business proposal and conceptual design phases

The completion of both phases encompassed 12 months, including all efforts from structuring the project up to the final sign-off of the entire documentation. The business proposal lasted for approximately 4 months and the conceptual design phase took approximately 8 months. The following figure illustrates the timeline of the conceptual phases, which are also referred to as template design phases in this thesis.

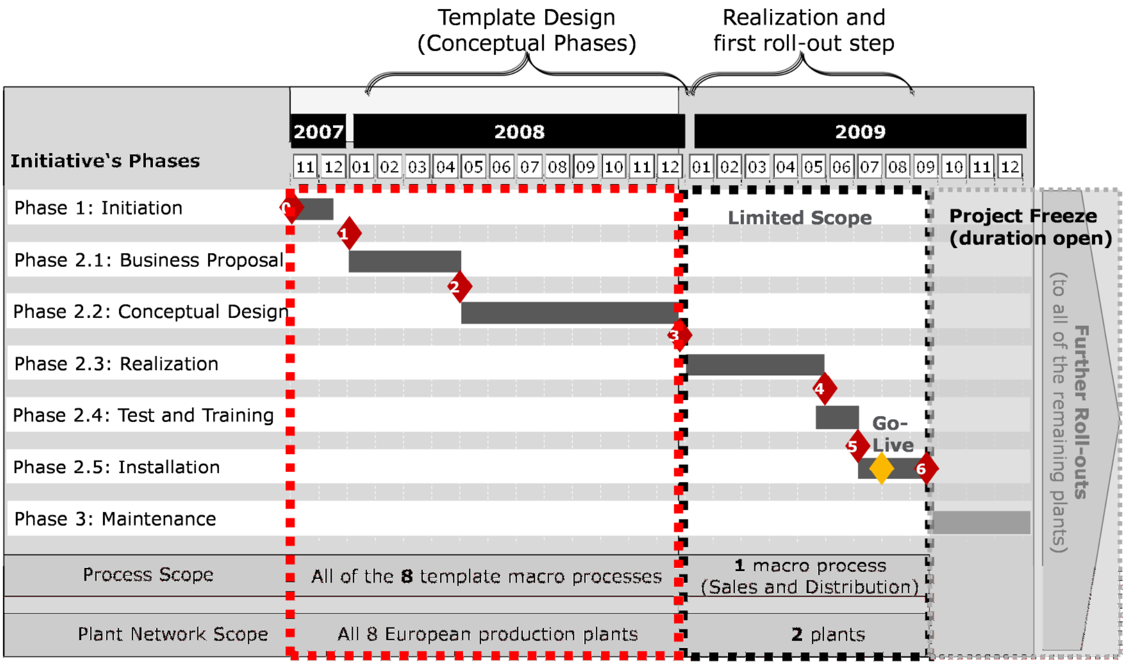

Figure 19: Initiative's timeline – template design

The main objective of the business proposal phase was to create the conceptual basis for the conceptual design phase. The expected outcome of these phases was a commonly agreed process template for the entire European plant network consisting of 8 plants in four countries, based on the combination of LP and ERP.

4.3.1 Approach and Timeline

As mentioned earlier, the main intention of the business proposal and conceptual design phases was to design a standardized logistics and production template processes informed by ERP and LP. In the business proposal phase, the main conceptual cornerstones should be defined and agreed before the detailed conceptual design work was launched. In fact, the major focus of the business proposal phase was the design of a commonly agreed big picture of the future group-wide production and logistics processes. Based thereupon, the conceptual design phase intended to break down the macro process designs from the business proposal phase into detailed operational processes and micro-processes. Consequently the main focus of the conceptual design phase was to create and sign-off all conceptual documents required for the subsequent realization phase on a detailed level.

As mentioned earlier, the combination of LP and ERP can be seen as the major strategic cornerstone of the initiative. I considered it crucial to develop a concept for anchoring of the LP principles in relation to ERP in the minds of all participants throughout the initiative. I applied a procedure for continuously stressing and highlighting the LP elements and principles in combination with the design of ERP processes as critical for both groups of participants. In this respect, I decided to focus on two different aspects:

- Deployment: Extensive emphasis on the combination of LP & ERP permanently throughout the initiative
- Control: Estimation of the degree of LP & ERP realization in the business processes at defined points of time

As far as the aspect of deployment was concerned, an extensive consideration of the combination of LP & ERP had to be induced and constantly refreshed throughout the initiative. First I did that by deliberately organizing the respective workshop sessions in a way to allow for LP thinking while defining ERP processes. For example, in the process design sessions we let the participants design an ideal lean process without any restrictions before starting to successively consider structural or legal restrictions. By this means, I intended to mentally distance the participants from their current as-is process. On the other hand, we continuously reminded the participants of the integration of LP & ERP by constantly stressing the topic during the workshop discussions. For instance, we regularly questioned if the newly designed to-be process really fulfilled the LP principles. I will refer to the aspect of applying the LP principles within the workshop discussions throughout the description of the relevant phases within this thesis.

Concerning the aspect of the control of LP & ERP consideration, I developed a specifically designed survey to assess the degree of LP & ERP consideration at certain points. I will introduce the details of the integrated LP & ERP survey at the beginning of the section describing the as-is analysis of the business proposal phase (see section 4.3.3.1). In order to generate a baseline for the process design, the participants were asked to assess the as-is situation in the first workshop stream of the business proposal phase. This baseline would then serve as a benchmark for the design and implementation of the future processes. During the course of the initiative, the integrated LP & ERP survey became the central tool for the assessing the goal of combining LP and ERP. In this respect we used it as a kind of direction check throughout the project.

4.3.1.1 Course of Action of Business Proposal Phase

We decided to apply centralized workshops as far as possible, bringing together the functional representatives of all plants of the same language area. The centralized approach promised two advantages. First, I considered the centralized option as quicker since this approach allowed defining the processes in one common discussion with all of the stakeholders instead of discussing the same process in each of the plants. Second, I considered the centralized approach superior in terms of fulfilling the overall initiative's objective of process standardization. In a large group of plant representatives I supposed that the group dynamic could contribute in convincing individual representatives that defining a common group-wide process could be superior to a local optimum in arguable cases. The following figure illustrates the approach graphically.

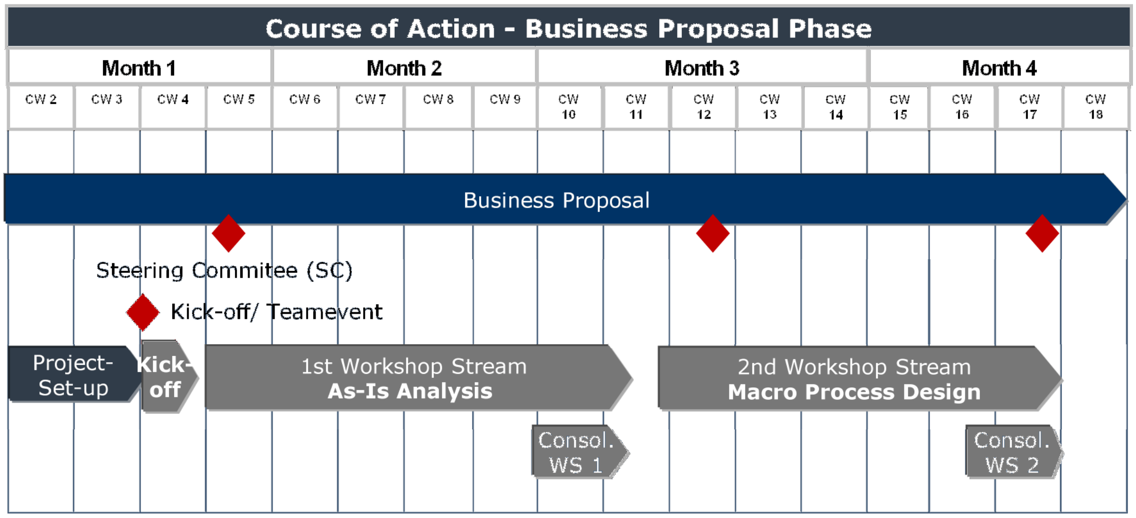

Figure 20: Course of Action for Business Proposal

After completion of the set-up period, we conducted a three days kick-off team event for the entire project team. I described the findings of this workshop in chapter 4.3.2 and chapter 4.3.3.

After that, the functional workshops were launched. As shown in the figure above, we decided to deploy two central workshop streams; that is, each of the processes was discussed twice with all of the plant representatives.

The objective of the first workshop stream was to carry out the as-is analysis. Based upon that we derived first rough improvement suggestions based on the combination of LP and ERP. The principles of LP played a major role during this phase since they served as the basic guideline for creating the improvement suggestions.

Similar to the first workshop stream, the second workshop stream allowed for a period of five weeks. In this stream, the future macro process template was drafted on the business proposal level and agreed among the plant representatives. In case of several potential alternatives, decision-making was primarily based on the criteria of LP. Deviations from the standard processes were only allowed in case of country-specific legal restrictions or in case of unchangeable structural differences between the plants. Such local processes had to be applied for in the form of a written document with a detailed explanation of the reason for the local deviation. The project management team, enhanced with special matter expert for the topic under discussion, made the decision whether or not to allow such a local deviation from the standard.

Since the business proposal phase set out to define the conceptual cornerstones of the future template processes considering both LP and ERP, it could be seen as one of the most crucial phases for the entire initiative. Many important conceptual decisions, particularly with respect to the integration of LP and ERP, were made during this phase. In the light of the experiences gained in the initiation phase, in which basically two opposing groups of participants emerged, I put particular emphasis on inducing a fair balance between the number of rather LP-oriented participants and the number of rather IT-centered participants. I expected that an unfair balance between these two groups would have led to a biased result when it comes to a trade-off between LP and ERP.

4.3.1.2 Course of Action of Conceptual Design Phase

The detailed modeling of processes and micro processes with the involvement of the entire plant network in workshops the same size as in the business proposal phase was considered not an option for the conceptual design phase. The reason was that on a detailed process level very detailed and often plant specific questions do arise, whereby the representatives from other plants often cannot contribute. Therefore, in contrast to the business proposal phase, the greatest part of the conceptual design was carried out by the respective sub-project management, central representatives and experts of one plant only; that was, the designated pilot plant. However, the objective of production network standardization was not abandoned in the conceptual design phase. In order to emphasize the network standardization aspect, we set up several specifically dedicated intensive production network workshops with the involvement of all plants. The following figure illustrates the course of action as planned for the conceptual design phase.

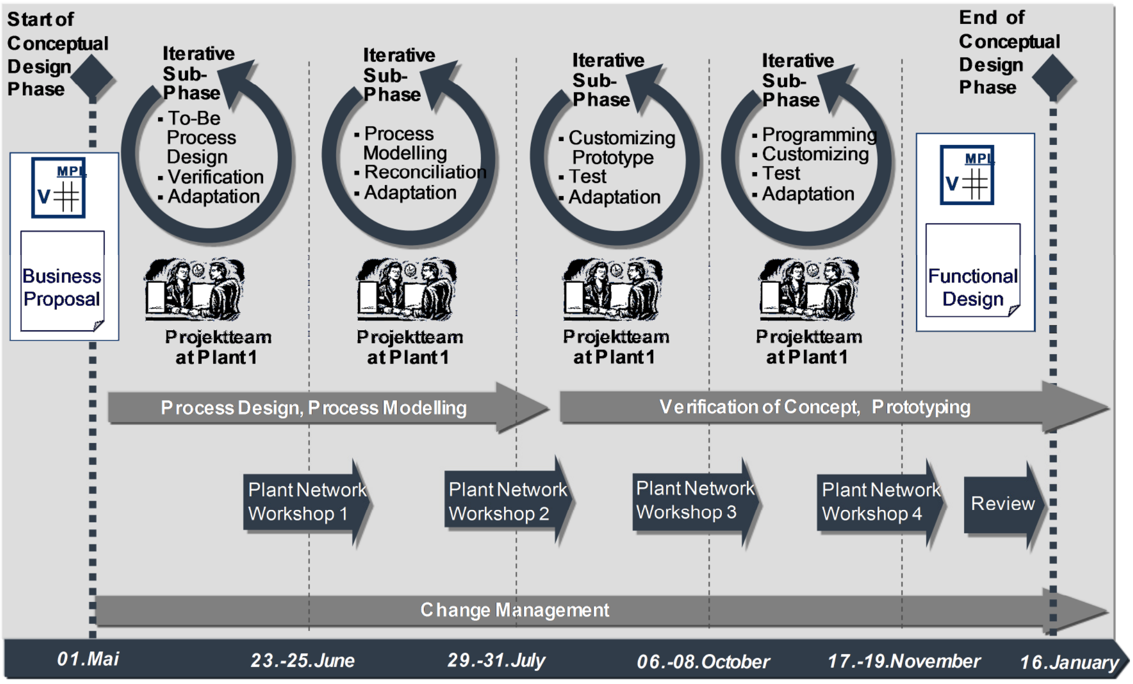

Figure 21: Course of Action for Conceptual Design Phase

As the figure above shows, the conceptual design phase started with a business proposal document describing the macro processes of the initiative and a master process list including the first allocation of macro processes in the plant network. These documents served as an important starting point for the conceptual design of the detailed processes.

The entire conceptual design phase of 8 months was divided into 4 sub-phases. The first two sub-phases were mainly concerned with process and micro process design and modelling. The last two sub-phases mainly dealt with the finalization and verification of the theoretical concept by setting up an ERP prototype. Each of the sub-phases was followed by a plant network workshop in order to mirror the conceptual designs with the requirements of all of the plants in the networks.

I was aware of the fact that the business proposal documents were still composed on a relatively rough level of detail, which left plenty of room for individual interpretations. In fact, I expected a high amount of controversial discussions when it came to the task of breaking down the macro processes into the level of detail required for the process and micro-processes design. Particularly when it came to the trade-off between LP excellence and information system excellence, I was convinced that controversial discussions were helpful in order to find a good compromise.

In order to allow for such controversial discussions, and in parallel, not to waste too much time to find a general agreement for each detail, we emphasized the aspect of iterative solution finding. By this means, the teams were given the opportunity to first draft the design a potential to-be process variant before it could be torn into pieces during the creation process. After a potential to-be process variant had been completely drafted by a specifically dedicated team, the process was verified by the entire process design team and all of the critical points were systematically noted. After that, the process design team adapted the potential to-be process and created a second release of the process. This second release was again verified by the process design team, followed by another adaptation phase. The procedure of modelling, verification and adaptation was repeated until the process design team finally agreed to the process.

Sometimes alternative process variants had to be designed because the process design team identified more than one feasible solution. In these cases, the above described procedure was applied for each alternative process variant until they were considered mature enough for a comparison. The comparison had to be done in the format of a benefit analysis with pre-defined criteria. In case the project design team was not able to agree on a commonly favourite, the final decision was made by the project management team with the respective power of veto of the LP function.

4.3.2 Activities and Findings Kick-off Team Event (Launch Phase 2.1)

This section outlines on the kick-off team event findings. The kick-off team event can be seen as the official launch of the entire initiative. The following figure indicates the kick-off team event in the context of the entire business proposal sub-phase.

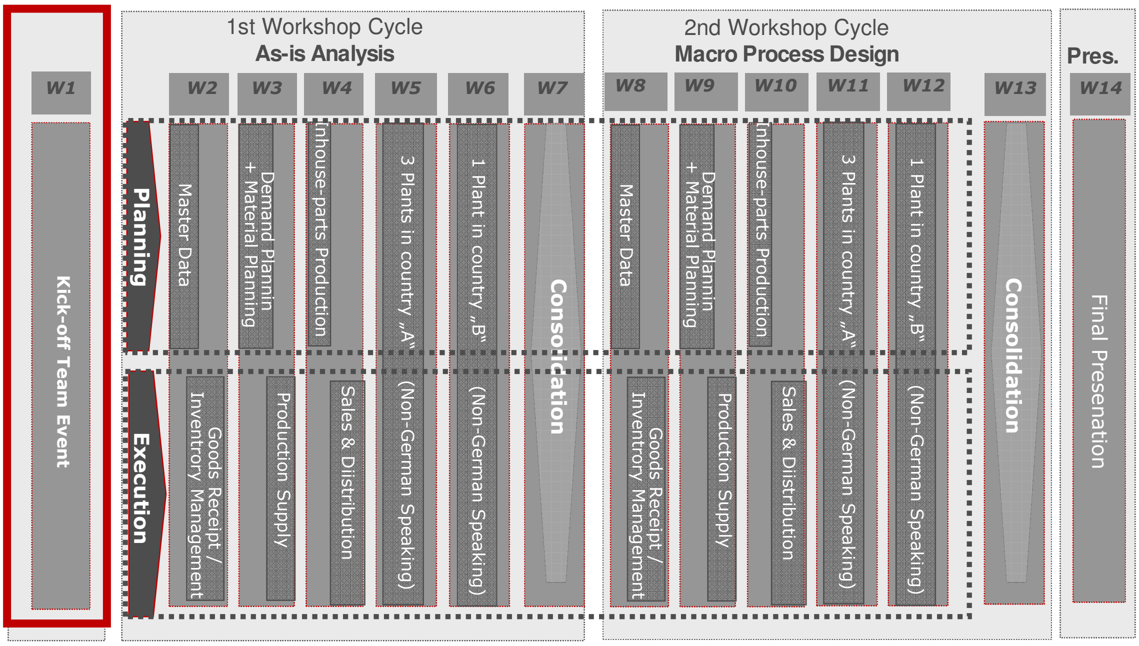

Figure 22: Kick-off Team Event in business proposal phase

As mentioned earlier, the kick-off team event was the first possibility to observe all of the initiative participants in one environment. Consequently I analysed the proceedings of this event on a relatively detailed level. In order to keep the volume of this thesis on a tolerable level, I placed the description of the analysis into the appendix of this document. The description in this section focuses on a summary the major findings.

I was particularly interested in the social aspects of the people involved in the initiative. In this context, I analysed the behaviour, gestures and verbal remarks of the participants towards the concepts of LP and ERP, with a particular focus on the organisational background; that is, differentiating between the group of IS-representatives and the group of operations representatives.

The findings revealed that there was a considerable gap between the mind-set of the IS group and the operations group with respect to the topics of ERP and LP (see survey results described the appendix). As far as ERP was concerned, the analyses have shown that the overall attitude of the operations group was primarily negative towards the concept of ERP. Most of the operations representatives have seen a strong contradiction between the basic idea of LP and ERP. In their eyes, one of the basic underlying themes of LP was to avoid deterministic IT-controlled material flow systems and to replace them by manual consumption driven concepts. On the other hand, the majority of the IS group was neutral or even positive towards ERP. They valued the advantages of one central database and the reduction of the amount of interfaces in the IT landscape.

With respect to LP, the IS group’s attitude was classified as neutrals to negative. Many of the participants were not experienced with LP at the beginning of the workshop. Their major critique point was that the concept of LP was perceived as a set of common sense rules instead of a manufacturing improvement system. They criticized that process re-engineering was not possible without the involvement of IT. On the other hand the operations group was primarily positive towards the concept of LP. Many of the participants had already gained at least some experience with LP. In particular, they valued the potential of LP for reducing inventory levels and throughput time though they also realized its limitations in low volume and high variety areas.

When it came to the combination of LP and ERP, both the operations and the IS group’s attitude could be classified as primarily sceptical. The major reason was the rather negative attitude of the operations group towards ERP and the same for the IS group towards LP. Though the intensive sessions of ERP and particularly the LP game helped to increase the understanding of the concepts, but it was not sufficient for a sustainable mind-set shift. On the one hand I observed that the presentation of the initiation phase results and the SWOT break-up sessions contributed to the realization, that an integrated concept promised strengths and opportunities at all. On the other hand, as the quantitative analysis of the SWOT sessions has shown, the participants saw still more weaknesses and threats than opportunities and strengths in an integrated initiative combining LP and ERP.

For both the course of the practical initiative and for my empirical research with respect to combining LP and ERP, the kick-off workshop revealed crucial findings.

The considerable gap between the IS group's and the operations group's mind-set towards the concepts of LP and ERP turned out to be a severe threat for the success of the initiative. Taking into account the positive outcome of the initiation phase, the results of the kick-off workshop were surprising for both the project management and the empirical research. Though a certain degree of resistance against this new idea was well expected (Burnes, 2000), the consistency and the magnitude of the resistance was unexpected.

One of the major lessons learnt for both the practical initiative and the research was that a three day workshop was considered as insufficient for inducing a sustainable turn-around of the deeply engraved prejudices of the participants. The findings suggest that it was rather required to constantly and intensively work on this topic in order to win the minds of the participants. I took this result as a strong indication that we were required to set-up an intensive change management function for the initiative and that the combination of LP and ERP needed to be an integral part of it. In addition to that I decided to spend more time on the topic at the beginning of the workshop cycles before launching the process re-engineering activities of the business proposal phase. For the set-up of similar projects in future I noted to take at least two weeks at the beginning of the initiative to intensively work on the topic of LP and ERP integration before starting the actual project work.

4.3.3 Activities and Findings of the As-is Analysis (1st Workshop Cycle of Phase 2.1)

This section focuses on the as-is analysis. The as-is analysis was conducted in the first workshop cycle of the business proposal phase. The following figure indicates the first workshop cycle by the red frame in the context of the entire business proposal sub-phase.

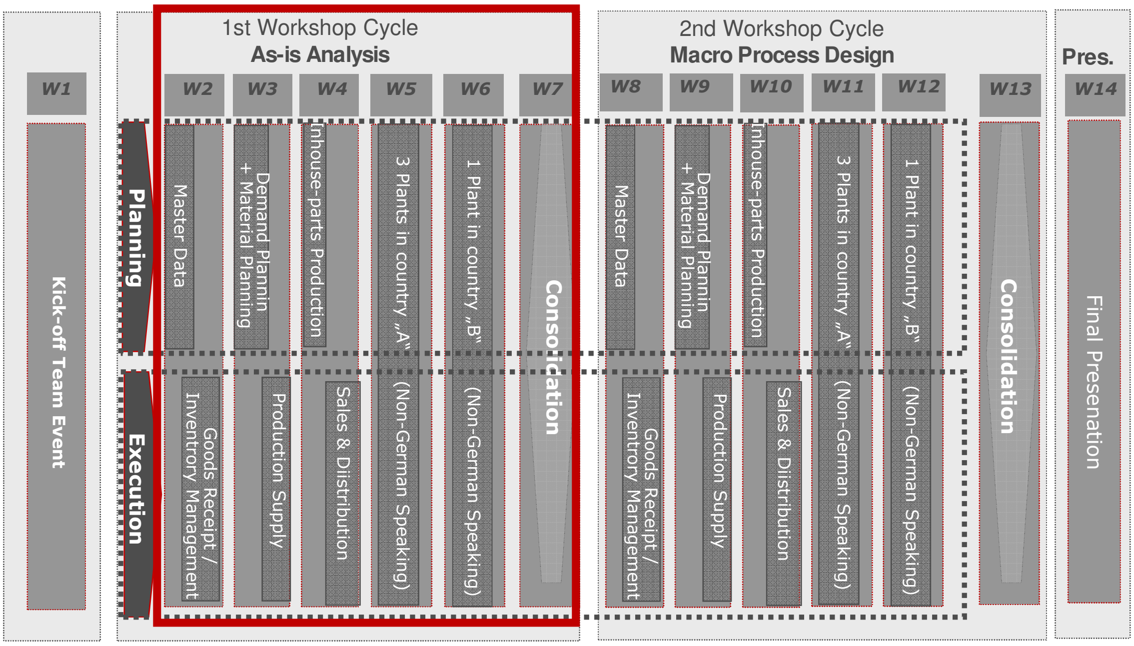

Figure 23: 1st workshop cycle of the business proposal phase

The plant network consisted of 8 plants. Week 2-4 involved German speaking plants. Week 5 dealt with the Polish language area and week 6 was concerned with the Turkish language area. By this means we made sure that every plant was involved in discussing all of the relevant process whilst in parallel, coping with language barriers and minimizing travel expenditures.

The field of participants in the workshop cycles varied with respect to the functional topic under discussion. Generally there was a certain core team of participants, who were taking part in all of the functional workshops. Referring to table 7, the permanent team included the project management team; that is, the consulting company's project manager C-01 and the change management consultant C-13, from the client's operations side the project manager for operations 0-O-03 and the LP master 0-O-04, and from the client's IS side the project manager for IT 0-I-02 and the solution architect 0-I-03. In addition to that, there were functional expert representatives of every plant involved both on the IS and the operations side.

Each of the workshops in the first cycle covered roughly the same main agenda points:

- As-is analysis (including LP survey)

- Identification of improvement potentials of LP and ERP

The first agenda point dealt with the as-is analysis. First the functional scope was defined and structured in a hierarchical way. This point was extremely important in order to set the boundaries for the analyses and to streamline the workshop discussions. Then the actual as-is analysis was started. We discussed each of the processes in detail. The format for the process analysis asked for the process input, the process itself, the process output, and the relevant IT systems involved. In addition to that, we discussed about current strengths and weaknesses of the processes. After the process discussions, we let employees fill in a LP survey in order to estimate the degree of LP consideration with respect to the current processes. For this purpose I developed the LP questionnaires as introduced in the section above.

The second agenda point dealt with the identification of improvement potentials with respect to the integration of LP and ERP. Bearing in mind the theoretical potentials as revised in the agenda point 1 and based on the process weaknesses identified in agenda point 2, the participants were asked to identify improvement potentials for the process under discussion.

After explaining the tool for estimating the Lean-ERP rating of the processes, the next sections provide a summary of the as-is analysis and the identification of improvement potentials for each of the macro processes under analysis. During the descriptions I set a main focus on the aspects relevant to my topic of integrating LP and ERP.

4.3.3.1 Lean-ERP Assessment

I was convinced that the assessment of processes with respect to a concept as rich and encompassing as the combination of LP & ERP cannot be done by measuring a set of quantitative key performance indicators. This is even more the case when it is required to assess processes at a design stage; that is before it can be observed under real conditions. Therefore I decided to design a survey to assess processes in terms of the degree of LP & ERP realization, referred to as "Lean-ERP assessment".

The survey should consider all processes under investigation by rating a degree of LP & ERP realization along a Likert scale. I have prepared questionnaires for each of the LP elements to be assessed. The questions were tailored towards an integrated LP and ERP initiative. Since I considered the realization of LP as the main challenge in the integrated LP and ERP initiative, I structured the questionnaires according to LP elements. In fact, I summarized the LP principles, tools and foundations as described earlier in this thesis (see section 2.1.3.1, 2.1.3.2 and 2.1.3.3) into five main LP elements. The following list provides an overview:

- People & Teamwork (incl. Visual Management)
- Flow (JIT and Heijunka)
- Jidoka (Right from me)
- Kaizen (Continuous Improvement)
- Standardized Processes

For each of these LP elements I have composed a questionnaire specifically designed for an integrated LP & ERP initiative. Each of these questionnaires consisted of 5 questions asking for the fulfilment of specific requirements. In order to allow a quantitative and comparable analysis, I have phrased the questions as closed questions allowing a yes or no answer only. Before conducting the survey with the entire core team, we carried out two pilots, one with the entire project management team and one with the central organization representatives as the respondents. With the feedback from the pilot survey's respondents, I was able to refine the questionnaires. The following tables provide an overview of the final versions of the questionnaires for each of the five LP elements.

#	Questions referring to the LP element of **People and teamwork** in the context of an integration with ERP
1	Simplicity and user-friendliness: Are frequently used process tasks and transactions designed as simple and user-friendly as possible?
2	Definition of procedures and responsibilities: Are tasks, procedures and responsibilities clearly defined in the process?

3	Balance of process requirements and employee skills: Are the employees capable of performing all required tasks involved in the process?
4	Control of human-beings: Is the employee under control of the process; that is, is the process compliant to the principle of "as little IT as possible as much as required"
5	Support of teamwork: Does the process support teamwork by contributing to the collaboration within the team?

Table 8: Questionnaire for the LP element of people and teamwork

#	Questions referring to the LP element of **Right from me (Jidoka)** in the context of an integration with ERP
1	Error prevention (Poka Yoke): Does the process prevent or impede the emergence of process and / or system errors?
2	Alert functionality: Does the process involve alert functions or tools, which make problems and errors transparent in order to enable quick reaction?
3	Error handling: Are procedures and responsibilities for systematic error handling and escalation procedures clearly defined in the process?
4	Internal customer-supplier agreements: Are the interfaces to process predecessors (internal suppliers) and process successors (internal customers) clearly defined?
5	Process and system stability: Does the process enable stability and performance of the process and system?

Table 9: Questionnaire for the LP element "right from me / Jidoka"

#	Questions referring to the LP element of **Kaizen** in the context of an integration with ERP
1	Process standards: Are process standards and procedures clearly defined order to provide a baseline from which to improve?
2	Key performance indicators: Are relevant process KPI's clearly defined and continuously measured in order to allow the measurement of improvements?
3	Employee capability for improvements: Is the employee educated, trained and motivated to continuously improve the process?
4	Process suitability for improvements: Does the process allow for continuous improvements; for instance through simple parameterization instead of hardwired procedures?
5	Procedure to define new standard: Is there a procedure to systematically document an improved procedure and to roll it out to similar processes?

Table 10: Questionnaire for the LP element of Kaizen

#	Questions referring to the LP element of **Flow** in the context of an integration with ERP
1	Demand leveling (Heijunka): Is the principle of demand leveling followed as far as possible in the process?
2	Customer demand: Is the process directly or at least indirectly controlled by real customer orders?
3	Pull principle (e.g. Kanban / JIT): Does the process apply pull / consumption-driven replenishment principles as far as possible for triggering the flow of material and/ or production?

4	Process synchronization: Are the processes integrated and synchronized in order to allow the flow of material and/ or information between the processes?
5	Switching between process variants: Does the process allow to switch between different process variants in order to react to changing business requirements?

Table 11: Questionnaire for the LP element of flow

#	Questions referring to the LP element of **Standardization** in the context of an integration with ERP
1	Modularity: Does the process fit into a modular process structure with standardized interfaces so that the process is universally applicable to similar business requirements?
2	Plant wide process standardization: Is the process standardized within the plant; that is, is the process carried out in exactly the same way within the plant whenever applicable?
3	Production network standardization: Is the process standardized within the production network; that is, is the process carried out in exactly the same way within whenever applicable in the production network?
4	Standardized customer-supplier relationships: Is the process compliant to the objective of standardizing internal and external customer-supplier relationships wherever possible?
5	Standardizing process documentation: Is the process documentation complete and in line with company-wide process documentation standards?

Table 12: Questionnaire for the LP element of Standardization

The participants were expected to assess the degree of fulfilment of the above requirements for each of the processes to be analysed. In order to derive comparable results, I had let these questionnaires unchanged during the entire initiative.

The participants were asked to rate their degree of agreement with the questions along a percentage scale. In order to limit the number of possible answers and hence to make the choices easier for the respondents, I allowed only six possible percentage values with an increment of 20%. The following table provides an overview.

%	Description
0%	The process fulfills the question's criterion to an estimation of 0%; that is, not at all => largest possible room for improvement
20%	The process fulfills the question's criterion to an estimation of 20%; that is, only to a very low extent => extremely large room for improvement
40%	The process fulfills the question's criterion to an estimation of 40%; that is, to a low extent => large room for improvement
60%	The process fulfills the question's criterion to an estimation of 60%; that is, to a moderate extent => considerable room for improvement
80%	The process fulfills the question's criterion to an estimation of 80%; that is, there are little gaps only => little room for improvement
100%	The process fulfills the question's criterion to an estimation of 100%; that is, it completely fulfills the question's criterion => No room for improvement

Table 13: Scale for the LP element rating

It is important to note that the questions had to be answered under consideration of the current given frame conditions. Frame conditions, which could not be influenced within the scope of the initiative, had to be considered as fixed and did not influence the evaluations. Such frame conditions could be infrastructure elements like the location of building and roads, the organizational structure of the company, or legal/ regulatory requirements for instance in the area of finance. In other words, if the process to be assessed was considered to completely fulfill the question's criteria within the given set of unchangeable frame conditions, it had to be rated with 100%, even if theoretically it could be further improved by changing frame conditions.

Concerning the group of participants to be considered in the surveys, I decided to include the voice of all of the workshop participants. Therefore we handed out the questionnaires to all of the participants and allowed for an anonymous vote. Having filled their questionnaire, the employees were asked to drop them into a box. I decided to do that because I was interested in an average estimation rather than in the opinion of few opinion leaders within the group. In addition to that, by considering all of the participants I automatically took into account the different hierarchical levels involved. In particular, I wanted to include also lower level employees, who actually applied the processes in their day to day work. If I had asked only the higher hierarchical levels, I could have received quicker results with less effort, however I considered the danger of receiving politically biased responses as too high.

4.3.3.2 Overview of all macro processes

The activity of the workshop participants was relatively high during the as-is analysis discussions. Most of the participants were willing to share their information about the current processes.

In particular when current process weaknesses were concerned, many operations participants seemed to consider the discussion as an opportunity to complain about current IS problems they were suffering from during their day to day operations. On the other hand the IS representatives often defended the current state. There were many voices from the IS side, which accused the operations side for requesting unfeasible or poorly described system adaptations.

After each of the as-is analysis discussions, I let the group carry out the Lean-ERP assessment of the macro process under investigation. As described in chapter 4.3.3, all of the workshop participants were asked to answer the questionnaires. By this means, I could ensure that every single participant's opinion was considered. As in the preceding analysis, I classified the participants into operations group representatives and the IS-group representatives.

The chart below illustrates an overview of the LP-average values for each the macro processes. The operations group's ratings are indicated in blue colour, the IS group's ratings are displayed in red colour.

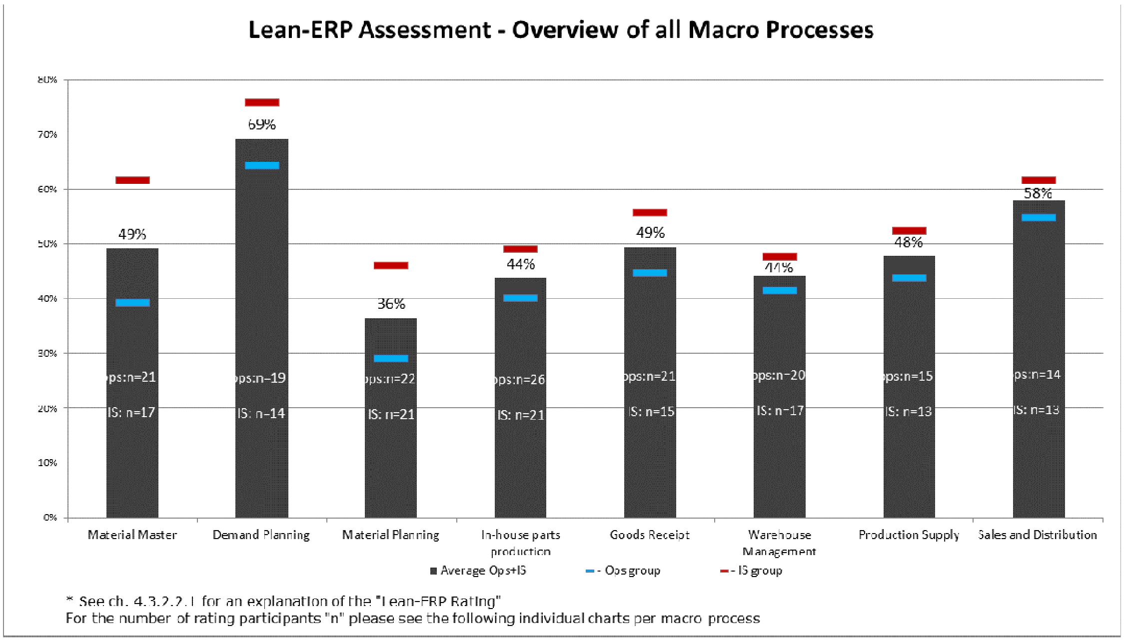

Figure 24: Lean-ERP Assessment – Overview of all Macro Processes

In general, the Lean-ERP assessment results indicate that the participants saw large to considerable room for improvement with respect to the as-is situation (see table 13 for the link of the percentages to the degree of improvement potential). Except for the macro process of demand planning with 78%, all macro processes' average ratings were below 60%. With 36%, the lowest rating was that of the IS group for the macro process of material planning. According to the qualitative discussion observations, most participants saw the reason in the current process not supporting pull-based material planning principles at all.

The macro process of demand planning received the highest rating with 69% on average. In this respect, the macro process of demand planning was defined to end with the data transfer of gross demands to the next macro process; that is, material planning. From the discussion observations I learned that most participants were pleased with the stability of the gross demand data generation and transfer. The main critical point mentioned was the push-based generation of gross demand data within the production network. The lack of pull principle support was mainly allocated to the macro process material planning, which explains the substantial difference in the ratings of these two macro processes.

Another important point with respect to the overview of the Lean-ERP assessment was the discrepancy between the ratings of the operations group compared to the IS group. The operations group evaluated the as-is situation worse than the IS group. In the average this general pattern was true for all macro processes and LP principles under investigation. This was in line with my qualitative observation, that the operations group often criticized the current processes due to the lack of proper IT-support, whereas the IS group tended to justify the current situation by describing the already existing functionality of the legacy systems. As we found out later through several interviews, there had been a long history of political battles between operations and IS due to above reasons. We interpret the discrepancy of the two group's ratings as a consequence of these arguments.

The following chart reflects another overview on the as-is analysis results. I generated the mean over all macro process ratings for each of the LP elements. The following figure presents the outcome.

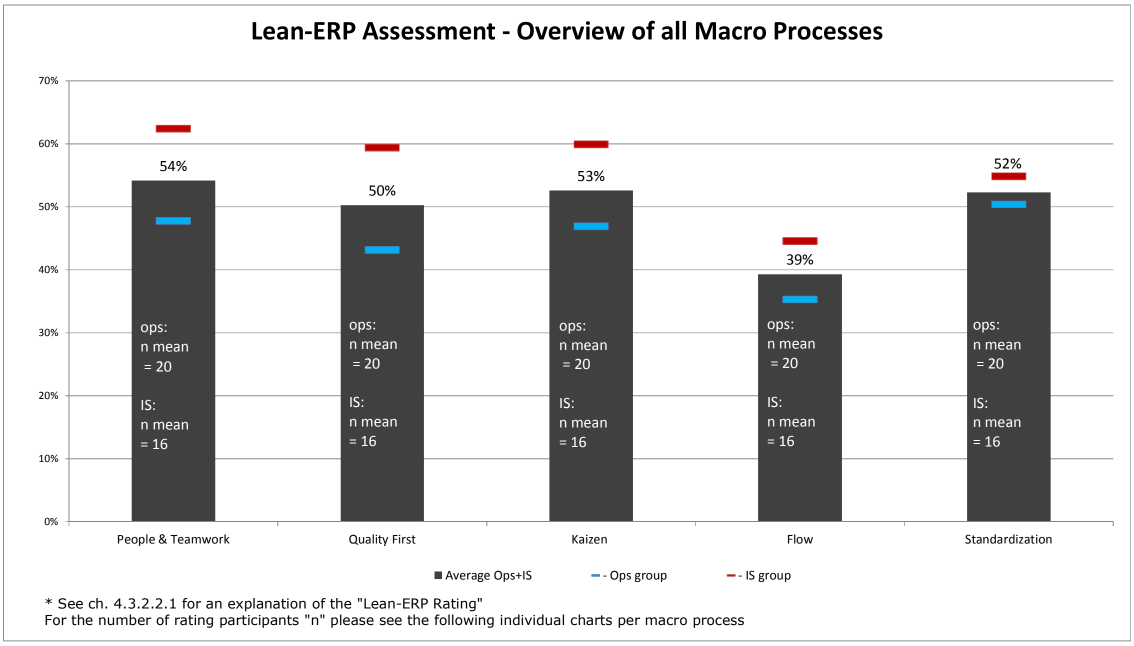

Figure 25: Lean-ERP Assessment – Overview of all Macro Processes

In general, the spread between the ratings of the operations group and the IS group also applied all of the LP elements ratings. Regarding the average ratings for Operations and IS representatives, the LP element of flow received the lowest ratings with 39%, indicating large room for improvement in this area. The other LP elements average ratings were between 50% and 54%, indicating a degree of improvement potential between large and considerable.

In order to analyse the findings in greater detail, the following paragraphs look at the survey results for each of the macro processes individually. This allows to display the ratings of each of the five LP elements for each of the macro processes.

4.3.3.3 Master Data

As we have seen in figure 24, the operations group's rating of the macro process master data was comparably low; in fact, the second lowest of all macro processes rated by the operations group. On the other hand, the IS group's rating of master data was the third highest of all macro processes rated by the IS group. The following figure illustrates the survey ratings for the macro process of master data for each of the LP elements under investigation. Again, I differentiated between the ratings of the group of LP and operations.

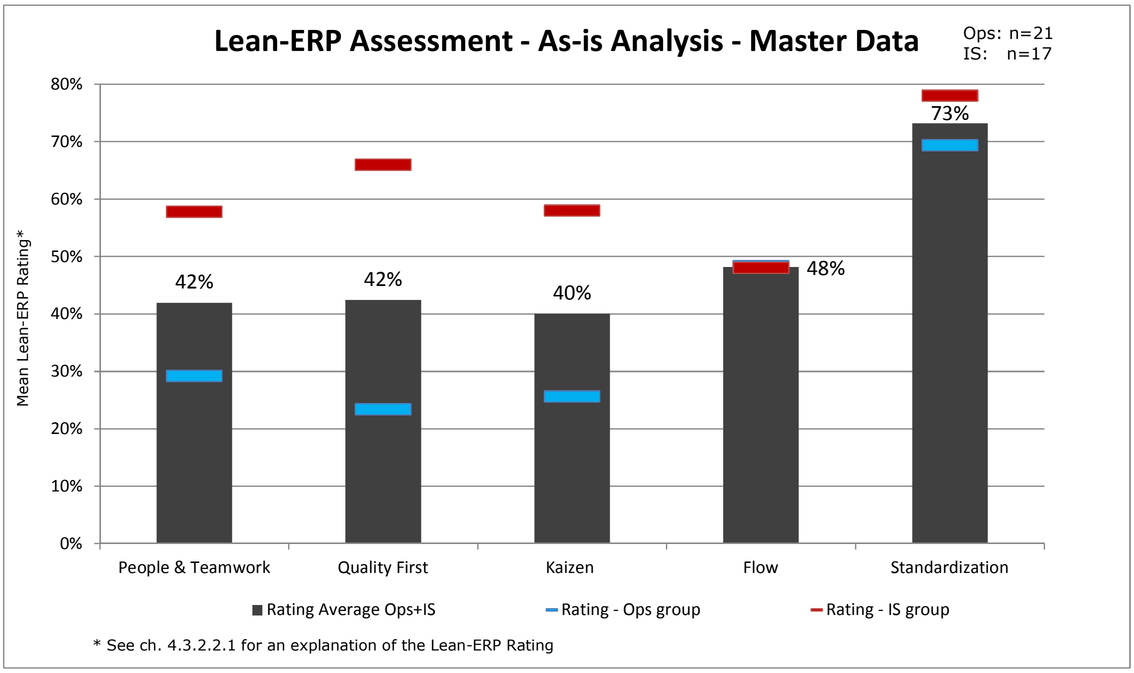

Figure 26: Lean-ERP Assessment – As-is Analysis – Master Data

With respect to the LP element of people & teamwork, the average rating was at 42%, whereas the operation group's rating was below 30%, the IS group's rating was at nearly 60%. That is, the operations group have rated the degree of improvement potential somewhere between large and extremely large (see table 13), whereas the IS group's rating can be interpreted as reflecting considerable room for improvement only (see table 13). From the qualitative discussion observations I have noted that the operations participants criticized the over-automatized processes for material master management, which did not allow for manual interaction. Therefore, they held that the master data processes did not encourage collaboration within the team. The IS representatives agreed only to some extent to the operations representatives' point of view. They held that there were several pre-defined process steps allowing for interaction, however these points required specific IT skills.

Concerning the LP element of quality first, the average rating of 42% was similar to the LP element before, but the spread between LP and Operations was even more extreme. The discussion observations have revealed that the operations representatives were particularly unsatisfied with the lack of quality check possibilities. Many operations representatives have seen the process as "non-compliant to the Jidoka principle", which states that problems should be identified and solved as early as possible in the process. Again, the IS fraction were more satisfied with the process. They claimed that there were several data consistency checks helping the IS responsible operator to make sure the process went right from the IS perspective. However they admitted that though the IS department could verify the technical correctness of all data creation procedures, they did not look at the correctness of the operational content of the data. As 4-O-02 puts it: "It might often be the case that all IT jobs went right, but the operations content of the data was wrong nevertheless. The IT department does not have the qualification to carry out operations quality verification".

The result for the LP element of Kaizen was comparable to the two elements described above. The operations side criticized that the largely automated processes made any kind of Kaizen improvements extremely difficult. The following statement raised by 1-O-03 can be taken as an example for many comments from the operations group: "The processes for initializing new material numbers in the system are like a black box for us. We hope that everything goes fine, but we have no influence at all. Quite often we realize that master data records were filled with wrong control data only because we have a missing part at the assembly. From my point of view, the black box does not allow for plausibility checks and a proper cooperation between the different teams responsible for setting the right control data." In contrast, the IS side claimed that even though the processes had potential for further improvement, the IS departments were already constantly improving the master data creation processes. For example, 2-I-02 held that the master data creation process included several functions, which came from improvement initiatives within the last year. He held that "only because we do not call it Kaizen does not mean we do not improve our processes."

With 48%, the average rating of the LP element was of flow was rated higher than the first three. Moreover it was rated equally high from the IS and operations perspective. Apart from the critiques mentioned above, the workshop observations have revealed that there were some aspects of pull in the current processes. 3-O-04 held that: "at least the trigger for creating new master data records is often based on preceding processes in the sales departments, which can be seen as a pull principle to some respect." The IS group rated this element a bit lower than the other LP elements. One of the negative points mentioned from the IS side was that the creation of new master data records led to errors in the IT processing due to the vulnerability of technical interfaces between systems. With respect to improvement potentials, the workshop participants suggested to increase the technical stability of the master data creation by applying state of the art technology for both the ERP system and the IT-middleware used for technical interfaces.

With 73%, the LP element of standardization was given the highest average rating in the master data category with a comparably low spread between operations and IS representatives. The discussions have revealed that the master data processes were seen as pretty much standardized within the plant. However the participants have seen improvement potentials with respect to the plant network standardization of the master data processes. The reason was that there were different legacy applications in place within the different plants of the production network.

The following table outlines the main qualitative findings of the as-is analysis workshop observations with respect to the five LP elements under investigation. I have differentiated between the main strengths and weaknesses, as well as the main improvement potentials with respect to combining LP and ERP.

LP Element	Current Weaknesses	Current Strengths	Improvement Potentials LP & ERP
People and teamwork	Automated process, only little possibility for manual interaction for operations representatives	Interaction possibilities for the IS group lead to some collaboration within the IS group	Pre-defined process steps for human interaction and system-based workflows for data maintenance
Quality First	"Black Box" - early quality checks not possible for the operations group	Some IT-related quality checks are foreseen in the current process	IT-supported consistency check tools for operations representatives
Kaizen	Lack of manual interaction possibilities makes Kaizen initiatives difficult for the operations group	Some interaction possibilities allow for continuous improvement from IS perspective	Parameterization possibilities in the ERP system for the master data creation, which can be controlled by operations representatives
Flow	Considerable technical problems in the IT interfaces between systems	Process triggered by preceding process in engineering department	Stabilization of pull based trigger
Standard-ization	Plant network standardization improvable	Process on a comparably high standardization level within each plant	Further improving the high standardization level by roll-outs of ERP into all production network plants

Table 14: As-is analysis: master data – qualitative observation findings

4.3.3.4 Demand Planning

In order to be able to interpret the survey results for this macro process, it is important to note what we exactly defined as demand planning and where we differentiated demand planning from the macro process material planning. For this initiative, demand planning macro process was generally defined as the process of creating gross demands for parts and components of vehicles by exploding the bill of material (BoM) of a specific vehicle configuration. This process can be differentiated into two different planning horizons; the short term and the long-term planning horizon. In the short term horizon, the BoM explosion is based on concrete customer orders with specific configurations for special options. In the long term horizon, the BoM explosion is based on so called "dummy orders" for presumably representative vehicle configurations. The long-term horizon is also called forecasting period. The important point is that the definition of the scope for the macro process of demand planning does not include any kind of material planning methods; that is, the macro process of demand planning ends with the generation of the gross requirements. The material planning methods; that is, the generation of net requirements and material call-offs was allocated to the scope of the macro process of material planning (see next section).

As we have seen in figure 24, the average rating of the demand planning process was the highest of all macro processes. Both the operations and the IS representatives have seen "little room for improvement" (see table 13). The following figure illustrates the survey ratings for the macro process of demand planning for each of the LP elements under investigation.

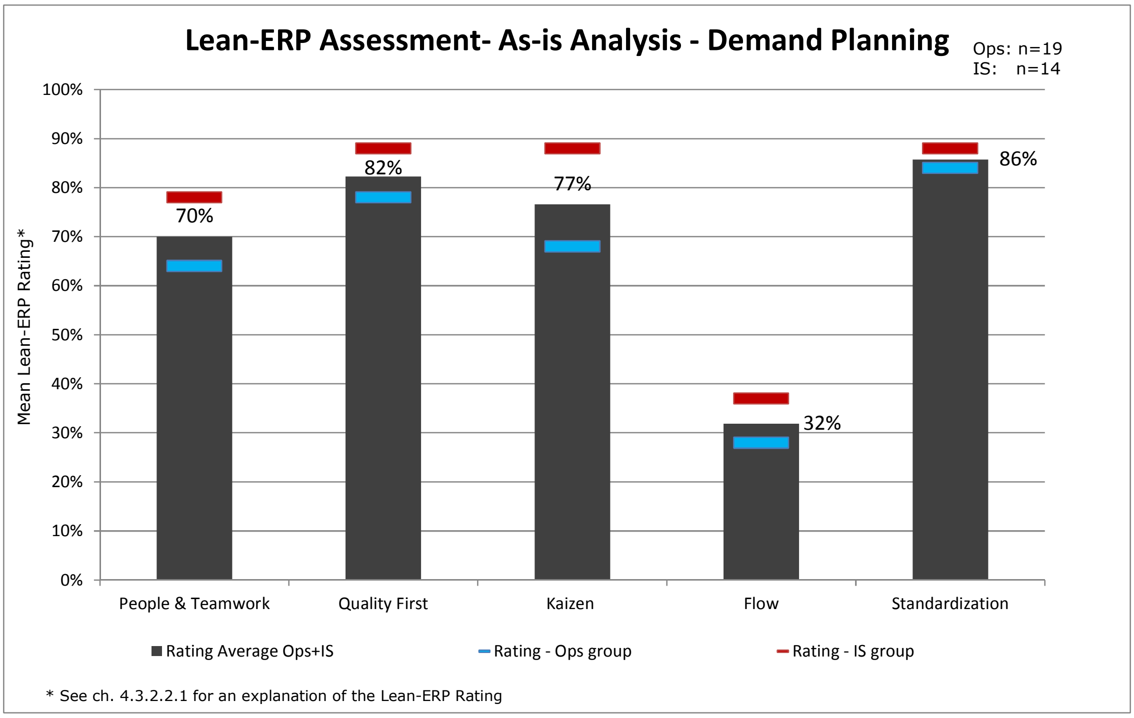

Figure 27: Lean-ERP Assessment – As-is Analysis – Demand Planning

Generally, the workshop observations can be interpreted as being in line with the quantitative survey results. Both the operations and the IS group were largely satisfied with the process of BoM explosion and gross demand generation. The participants were particularly satisfied with the stability of the BoM explosion process. However it is important to note that the participants have also mentioned heavy critiques for the lack of consumption driven material planning methods, but these were mainly allocated to the macro process of material planning in the surveys. The only exception was the LP element of flow, which received the lowest ratings due to the lack of pull-based production network internal demand generation.

Looking at the individual ratings of the LP elements, the ratings are relatively even distributed. Concerning the LP element of people and teamwork, the value of 70% reflected only between considerable and little room for improvement. The main critical point was the lack of collaboration possibilities since the process was largely automated. However most participants have seen the requirement for collaboration in this macro process as relatively low since it consisted of the rather technical process of BoM explosion. Therefore the rating reflected only between considerable and little room for improvement.

With 82%, the LP elements of quality first received the 2nd highest rating. Here the main theme of the discussions was the high quality of the data output, the continuous improvement possibilities for the BoM explosion methods and the high degree of standardization within the plants of the plant network. From the discussion workshops I learned, that one specific IT system had been defined as strategic building block in the client's IS landscape several years ago. By this means, the relevant competencies had been allocated around a specific IS team, which worked constantly together during the last couple of years. According to 0-I-02, the constant focus group of IS experts in this filed was "one of the main success factors for the stability and high quality of the technical processes around the BoM explosion".

Similarly, the macro processes ratings of the LP element of Kaizen received relatively high grades compared to the other macro processes. Again, the qualitative workshop observations had shown that most employees were pretty satisfied with the work of the IS team in this area. Several minor improvements could be realized in the past, which seemed to have contributed to this positive rating.

The LP element of flow received the lowest ratings within the macro process of demand planning. Mainly the operations participants but also the IS representatives criticized the production network internal generation of gross demands. They claimed that all internal demands are centrally planned by a legacy system, which is then transferring the demands on a daily basis to the single plants in the network. The problem with this method was that, according to 1-O-02 "the long lead time until the demands reach the supplying plant leads to the fact that the demand data are often not valid any more at the point of time when they reach the supplying plant. This often leads to obsolete inventory within the internal supply chain and missing parts at the receiving plants."

Finally, the LP element of standardization received the highest rating within the macro process of demand planning. As I have learned from the workshop observations, the process of gross demand calculation; that is, the BoM explosion was already standardized to a great extent in the current situation. This was valid not only within the plants, but also across the plants in the production network.

The following table provides a summary of the main points of the qualitative workshop observations on the macro process of demand planning. I differentiated between weaknesses, strengths and improvement potentials for each of the LP elements as far as applicable.

LP Element	**Current Weaknesses**	**Current Strengths**	**Improvement Potentials LP & ERP**
People and teamwork	Only some possibilities for manual interaction	Good collaboration within the IS focus group of demand planning	Increasing possibilities for cross functional collaboration during the BoM explosion process
Quality First	For the operations group, the quality check is performed after	Several early quality checks are done before the IS jobs are being started	Increasing possibilities for operations group to verify BoM explosion results by creating

	the process		specific reports
Kaizen	Lack of improvement possibilities for operations group due to the high degree of process automation	The IS focus group already continually improves the process, which leads to a high quality of the data output	Possibilities to reflect non-engineering, but assembly relevant requirements in the BoM (e.g. kit commissioning for part sets)
Flow	Central and deterministic generation of production network internal gross demands	Process triggered reliably by preceding BoM creation process in engineering department	Realization of pull principle within production network internal material flows
Standard-ization	-	Very high standardization level within plant network	Further standardizing the process for non-vehicle production plants (engines, etc.)

Table 15: As-is analysis: demand planning – qualitative observation findings

4.3.3.5 Material Planning

As shown in figure 24, with an average of 36% the rating of the macro process material planning was the lowest average rating of all macro processes. The same applies to the IS group's rating of 46% and the operations group's rating of 29%.

The following figure illustrates the survey ratings for the macro process of material planning for each of the LP elements under investigation. Again, I differentiated between the ratings of the group of LP and operations representatives.

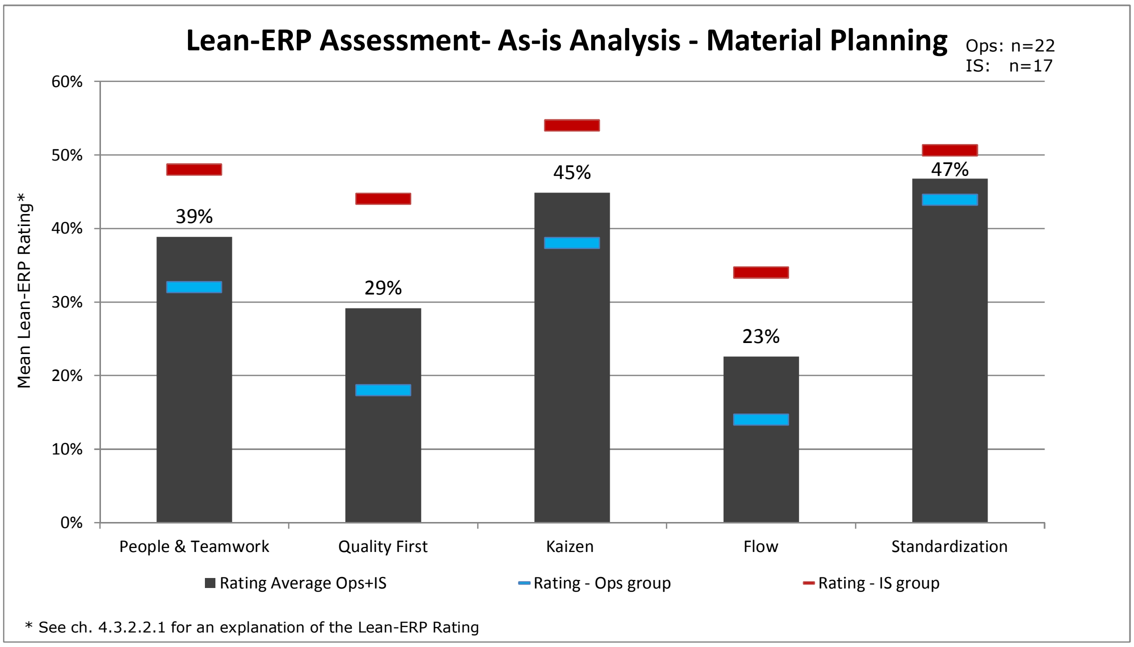

Figure 28: Lean-ERP Assessment – As-is Analysis – Material Planning

With respect to the LP element of people and teamwork, the average rating of 39% reflected a large improvement potential (see table 13). The workshop observations revealed that the operations representatives pretty much criticized the complexity of the material planning processes along several different IT systems. As a consequence, 6-O-02 claimed that: "we almost lack any kind of progressive collaboration in the area of material planning at all. The reason is that the system based net requirement calculation along our fragmented system landscape is not manageable for a normal material planner. The collaboration and teamwork is reduced to manual fire fighting activities in case of shortages." The IS representatives did not argue against this statement. Some IS representatives like 4-I-03 argued that the IT based demands serving as the input for material planning input could be categorized as extremely stable.

Even worse was the rating for the LP element of quality first with 29%. Along the arguments, the lack of check points and the quality of material planning reports were the most frequently mentioned critiques. 7-O-03 called for "the implementation of an early warning system as a support tool for the material planners." He further claimed that the reports generated for the material planners have to be customized to their specific requirements. Even though the IS representatives did not argue against the critique of the operations side, they assessed the Lean-ERP rating higher with an average of 44%.

With an average rating of 45%, the LP element of Kaizen was rated relatively high compared to the other LP elements of the macro process material planning. Nevertheless the operations participants saw large room for improvement for the LP element of Kaizen. The main critique point was that the current IT systems pretty much freeze the processes and thereby impede any kind of improvement initiatives. 1-O-03 claimed that: "even though we try to continually improve our material planning processes, we constantly are being stopped at the point at which we needed to change the operation of IT systems. We usually end-up with extremely high effort estimations and time consuming project schedules generated by the IT departments. However Kaizen lives from small and quickly realized improvements, what we have is actually the antithesis thereof." The IS-representatives claimed that there were constantly IT projects in place for realizing improvements. They mainly accused the complexity of the grown IS landscape for the lack of speed and the high change efforts.

With an average of 23% the LP element of flow received the lowest average ratings of the material planning macro processes. The same applied for both the operations and the IS side. Most frequently raised critiques were the complete lack of consumption driven planning methods. At the point of time, when the current system was programmed, people only cared about deterministic planning methods. As 8-O-03 put it: "our systems had been created so as to deterministically calculate the net requirement for every single screw in the plant. This not only causes a massive requirement for IT system resources, but simply generates excess inventory in the warehouses and at the production lines." The IS representatives appeared to largely agree to critiques from the operations side. At least I did not observe a positive statement, which could be interpreted as strength, with respect to the LP element of flow.

Concerning the LP element of standardization, the average rating of 47% can be categorized as expressing something between considerable and large room for improvement. Though most representatives agreed that there was a relatively high standardization level within each plant, the discussions have revealed that the standardization level of material planning processes and systems between the different plants was poor. This can also be derived from the fact that the representatives from different plants had severe problems to communicate to each other. The material planning terminology appeared to differ to a great extent between the various plants.

The following table summarizes the qualitative findings of the workshop discussions. I differentiated between weaknesses, strengths and improvement potentials.

LP Element	**Current Weaknesses**	**Current Strengths**	**Improvement Potentials LP & ERP**
People and teamwork	Lack of manual collaboration and teamwork due to complex and non-transparent deterministic MRP processes along several different IT systems	Input of gross demands relatively reliable (see demand planning)	Reducing complexity of material planning processes and IT system landscape. Implementation of simple consumption driven planning methods.
Quality First	Missing check points and reports for material planners	-	Implementation of an early warning system in the case of potential material shortages or quality problems. Implementation of high quality reports for the material planners.
Kaizen	Current IT systems freeze the flexibility of material planning strategies	Some initiatives for improving deterministic planning algorithms in place	High degree of freedom for material planning parameter settings (completely avoiding hard-wired system settings).
Flow	Lack of pull-based,	-	Implementation of consumption driven

	consumption driven material planning methods		material planning methods (e.g. Supplier Kanban)
Standard-ization	No standardized material planning processes and IT systems in the plant network	Standardization level of material planning processes within the plants is relatively high	Implementation of plant network wide standards for material planning strategies (common tool set)

Table 16: As-is analysis: material planning – qualitative observation findings

4.3.3.6 In-house Parts Production

The average rating for all LP elements for the macro process of in-house parts production was at 40% for the operations group, 49% for the IS group and 44% on average (see figure 24). The following figure shows the break-down into the different LP elements.

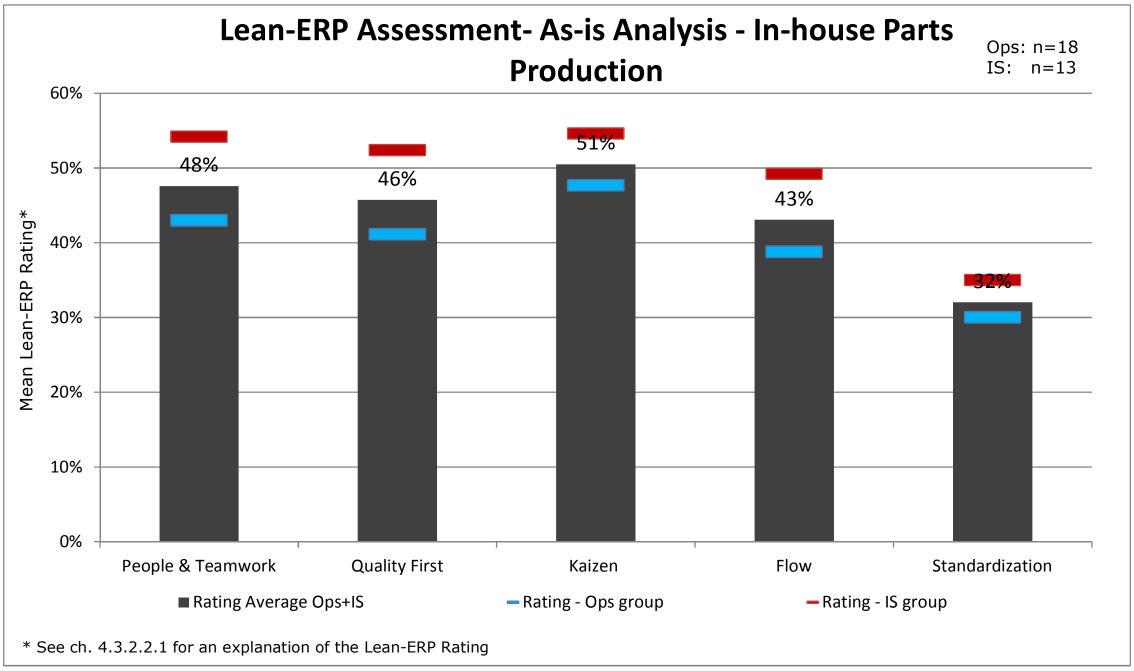

Figure 29: Lean-ERP Assessment – As-is Analysis – In-house Parts Production

Except for the LP element of standardization, the ratings were quite close to each other. The average ratings of the other four LP elements were between 40% and 50%.

For the LP element of people and teamwork, the main critique point was that the automated processes made manual human interactions difficult. Another point was mentioned by 7-O-06: "At the moment, our production is primarily function and batch oriented. The routing of parts through the production is following deterministically derived IT-based start and end dates as well as sequences. It is like having boundaries between the different functions at the shop floor." The main improvement potential derived from these discussions was the set-up of an ERP based process orientated production strategy, which is supporting cross-functional collaboration through increased spans of responsibilities for employees.

As far as the LP element of quality first is concerned, the ratings were on a comparable level to the ratings of people and teamwork. Operations representatives frequently criticised the lack of quality checks between single operation of a routing. The current process foresees only a final comprehensive quality check at the end of the last operation. This often leads to defective WIP in the production system and / or to process problems at downstream work stations. The only point discussed, which could be interpreted as strength of the current process, was the intensity of the final quality check after the last operation. The implementation of an ERP based process supporting an internal customer supplier relationship between operations was worked out as an improvement potential for LP and ERP. In such processes, the internal customers and / or the internal suppliers have to confirm right quality of parts, e.g. by a scan with the ERP system, when the parts move from one process to the next.

The average ratings of the LP element of Kaizen were the highest within the LP elements rated for the macro process of in-house parts production. Nevertheless, the rating still reveals that the improvement potential can be classified between a large and considerable potential (see table 13). As in most of the macro processes, the commonly shared critique with respect to the LP element of Kaizen was that the current IT landscape did not allow for continuous and rapid changes. Any kind of change in the IT system required a formal procedure and a large amount of time and effort. In addition to that, operations and IS representatives claimed that a realization of some changes was not possible at all due to a lack of programmers.

The only positive point was that there were already some continuous improvement initiatives in place, however they were limited to few, and completely manual processes steps. Again, the representatives called for increased parameterization possibilities, which could be performed without the need for IT experts.

The LP element of flow was rated at an average of 43%. Particularly the operations representatives have seen large room for improvement. 5-O-06 held in this respect: "We neither have IT support for consumption driven material replenishment, nor do we have support for consumption driven trigger of production process steps. The current IT system is only able to deterministically determine production start dates and material replenishment dates, which are often not accurate any more at the time they are fulfilled." The IS fraction agreed to the deterministic nature of the IT system, though they often did not see the problematic consequence. For instance, 6-I-02 questioned: "Isn't that what we want IT systems to do? Deriving planned requirement dates by exploding BoMs and looking at stock levels?"

Finally, the LP element of standardization was rated the lowest within the macro process of in-house parts production. The participants agreed that there was a lack of a plant-internal standardization, as well as standardization within the plant network. As a matter of fact, in some departments, the IT generated production dates have been ignored and even replaced by an individually crated spread sheet calculation. The IT system was only served like a shadow system in these departments. Other departments used manual standard work sheets in order to standardize the production sequence of processes within their department.

The following table provides a summary of the main points of the qualitative workshop observations on the macro process of in-house parts production. I differentiated between weaknesses, strengths and improvement potentials for each of the LP elements as far as applicable.

LP Element	**Current Weaknesses**	**Current Strengths**	**Improvement Potentials LP & ERP**
People and teamwork	Lack of transparency concerning	-	Increase of order status information and more detailed information on the

	production orders and inventory at the in-house parts production.		exact location of inventory and work in progress (WIP)
Quality First	Lack of quality checks between operations.	Precise quality check at the end of production.	Setting up internal customer supplier relationships between operations, supported by ERP-based quality checks.
Kaizen	Current IT-systems blocking continuous improvement initiatives.	Some continuous improvement initiatives in place at some specific areas	Setting up parameterization possibilities to be applicable for operations representatives.
Flow	No IT-support for consumption driven material planning or for triggering in-house parts production. Lack of value stream mapping initiatives.	-	Implementation of IT-support for consumption driven material replenishment or for consumption driven triggering of in-house parts production (e.g. e-Kanban). ERP support for value stream mapping initiatives / discrete event simulation
Standard-ization	No standardized in-house parts production processes in the plant network.	Manual attempts to standardize processes (use of manual operation worksheets)	Setting up ERP based plant network wide standards for in-house parts production

Table 17: As-is analysis: In-house parts production – qualitative observation

4.3.3.7 Goods Receipt

With an average along all five LP elements of 49%, the macro process of goods receipt was rated in the medium range of all macro processes (see figure 24). The following figure provides an overview of a break-down into the various LP elements.

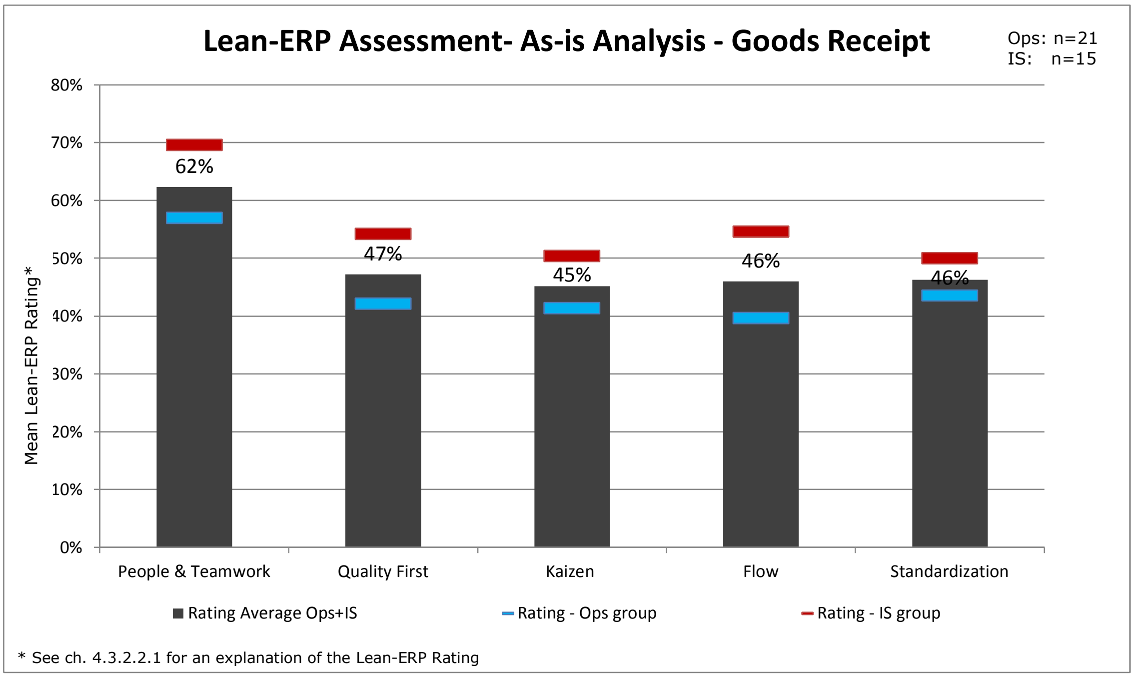

Figure 30: Lean-ERP Assessment – As-is Analysis – Goods Receipt

The LP element of people and teamwork received the highest rating within the macro process of goods receipt and inventory management. As I have observed in the workshop discussions, particularly the IS representatives held that within the goods receipt process there was a relatively intensive communication within the IS team, but also between the IS team and the operations team. However the reason for the relatively high level of communication was reported to be based on the poor quality advanced shipping notification (ASNs) received via EDI from the suppliers. Another point was that many suppliers were not able to electronically transfer ASN data at all. As a consequence, most plants had to found interdisciplinary task forces in order to maintain the relevant data during goods receipt. These task forces consisted of a mix of operations and IS representatives, who were commonly responsible for processing the inbound material flow. Although this helped to improve the collaboration, it took a massive amount of resources in order to perform repetitive jobs.

The LP element of quality first was rated relatively low, indicating large room for improvement particularly from the operations side (see table 13). According to the workshop observations, this rating reflected the poor quality of advanced shipping notification. 7-O-04 stated in this respect: "Many of our suppliers, particularly the small ones, are not even able to send EDI messages. However even if we received ASNs, they often have to be corrected manually in order to be ready for processing. In our plant we have 2-3 employees only responsible for this job."

The LP element of Kaizen received similarly low ratings as quality first. In the workshops both the operations and the IS representatives complained that the level of continuous improvement was relatively low due to the fact that the people were too busy with their day-to-day operative tasks. As 1-O-04 claimed: "the high level of manual and repetitive tasks absorb the capacity and the creative potential of our employees. Whenever I intended to initiate improvement cycles, I always got stuck when it came to the question where to take the capacity from. It is like chopping wood with a blunt axe."

The rating of the LP element of flow can be interpreted as reflecting large potential for improvement (see table 13). An interesting point was that in the as-is situation there was only one central unloading point. This led to unnecessary material handling and material transports in the plant, only to transfer material from a central unloading point to the decentralized warehouses. The operations group tried to improve the situation by setting up decentralized unloading points for the trucks, however the current IT system did not allow for more than one unloading point per plant. Another critique observed in the as-is analysis workshops were missing status points in the material flow between the supplier's goods issue and the finalization of goods unloading within the client plant. As 1-O-04 held: "Currently the range from the supplier's goods issue until the truck was unloaded at our central unloading point is like a black box for us. This often leads to the fact that we have a shortage somewhere in the production and do not know that the parts are already inside the plant, somewhere on a truck which is just queuing somewhere in the middle of the waiting zone." Moreover, one commonly raised point was the lack of pull driven call-offs to suppliers and the consequence that the incoming material was delivered based on deterministic call-offs. It was reported by 1-O-04, 2-O-04 and 6-O-04 that this led to unsteady incoming material flow and consequently to accumulations of incoming deliveries and consequential traffic jams in peak periods. 1-O-04 reported that: "the reasons are often IT-system's demand date fluctuations or the fact that the IT-system's parameters like maximum call-off quantities were not set properly for some materials." Another critical point with respect to the LP element flow was that wrong of faulty deliveries were reported to block the unloading zones within the plant, which caused queuing of trucks and long waiting times within the plant. These waiting times were extremely costly for the company because the supplier contracts contained clearly defined maximum unloading times. If these times were exceeded, the supplier was able to charge extra money for their additional effort.

The rating for the LP element of standardization was on a comparable level to the three before. A major critical point heavily discussed in the workshops was the substantial difference of the goods receipt processes for material received from external suppliers and parts received from other plants in the internal plant network. In addition to that, there was no commonly agreed standard within the plant network.

The following table provides a summary of the qualitative workshop observations on the macro process of goods receipt. I differentiated between weaknesses, strengths and improvement potentials.

LP Element	**Current Weaknesses**	**Current Strengths**	**Improvement Potentials LP & ERP**
People and teamwork	Massive amount of manual transactions required in order to process the incoming material flow	Good level of collaboration within the goods receipt task forces	Increasing the number of suppliers able to electronically send advanced shipping notifications.
Quality First	Poor quality of incoming advanced shipping notifications decreases performance of the goods receipt process	-	Increasing the quality of electronically sent advanced shipping notifications (ASNs).
Kaizen	Potential and capacity for designing and realizing improvements tied up in	Idea to set-up improvement cycles already	Replacing repetitive manual tasks by automated processes

	daily operative work	existing.	(e.g. automatic ASN transmission)
Flow	Grey area in the material flow between supplier and unloading within the client plant Only one central unloading point and hence unnecessary goods handlings and transports Clarification of wrong or faulty inbound deliveries cause waiting times for other incoming deliveries. Deterministic call-offs cause unlevelled inbound material flows, which in turn lead to traffic jam of trucks before and inside the plant.	-	Possibility to reflect a status information when the trucks are being registered at the plant gate Implementation of a goods receipt process allowing for separate unloading points per plant Implementation of a two-step goods receipt process separating the administrative from the operative processing of inbound deliveries. Implementing ERP pull processes to level the material flow (e.g. Supplier Kanban).
Standard-ization	Different process for internal and external inbound deliveries. Lack of plant network process standardization	Relatively standardized process for receiving external deliveries	Standardizing goods receipt process based on state-of-the-art ERP goods receipt processes. IT-support of internal customer supplier relationships

Table 18: As-is analysis: goods receipt – qualitative observation

4.3.3.8 Warehouse Management

The macro process of warehouse management received an average rating of 44% across all five LP elements (see figure 24). The following figure provides a break-down into the various LP elements.

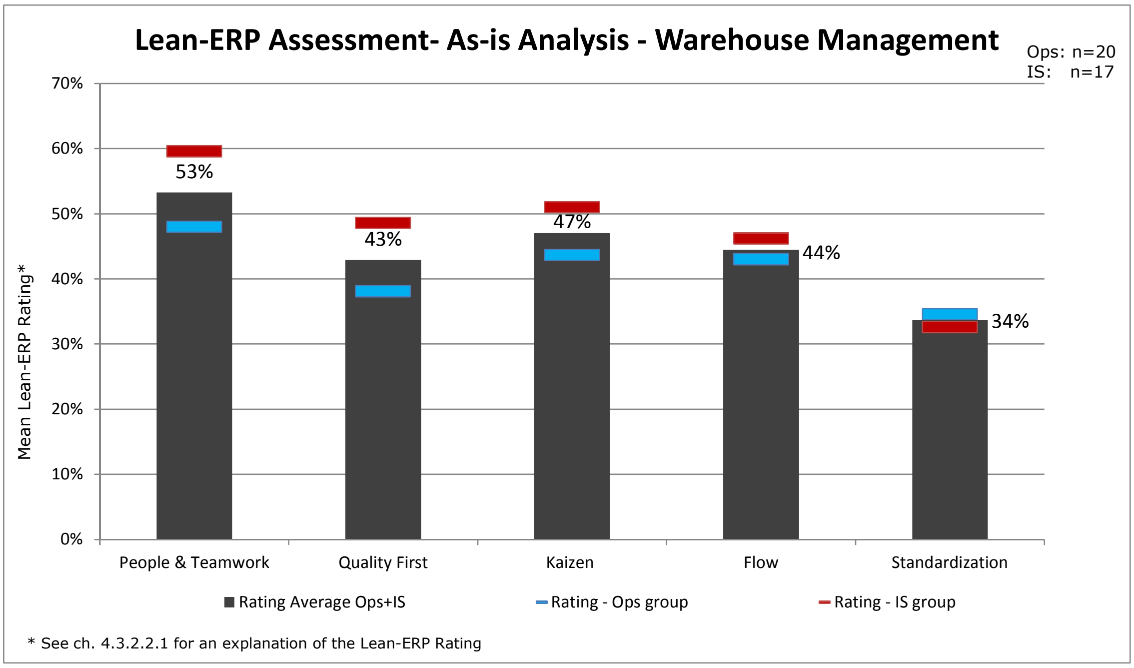

Figure 31: Lean-ERP Assessment – As-is Analysis – Warehouse Management

With respect to the LP element of people and teamwork, the average rating of 53% was the highest for the macro process of warehouse management. However, the level still indicates large to considerable room for improvement (see table 13). The most frequently mentioned critique was that there were too many interruptions in the process and information flows. The reason was that there was a heterogeneous IT-landscape for the warehouse management processes. As 3-O-04 claimed: "Communication and collaboration would be much easier, if we all looked at the same data. However this is obviously not the case in our current mess of IT-systems."

Regarding the LP element of quality first, the average rating was even lower compared to the LP element before. Participants criticized the poor data quality, inconsistencies and redundancies. The IS representatives accused the inhomogeneous IT landscape with the high number of technical interfaces for this problem. On the positive side they mentioned that there was a fully automatized warehouse management system in place, which was running relatively stable. The participants agreed that a new and integrated ERP platform would be beneficial for both increasing the data quality and fulfilling the LP principle of quality first.

In terms of Kaizen, the ratings also indicated large room for improvement. The interesting point observed in the workshops was that there were already some continuous improvement initiatives set-up in the warehouses. The problem was, however, that these initiatives were running without a standardized process basis and without central overview. This frequently led to suboptimal solutions. As 5-O-04 held: "Several times we faced the problem that warehouse departments repacked handling units according to their requirements in order to increase their warehouse utilization. However downstream processes had massive additional workload for separating the repacked items when supplying the parts to the line."

As far as the LP element of flow is concerned, the rating was in a comparable range to the ones before. The spread between the operations and IS group can be interpreted as comparably low for this LP element. The critique was based on the fact that the flow principle was not supported at all from current IT-systems and therefore not applied in the warehouse processes. As potential for the integration of LP and ERP, the requirements in terms of ERP-based processes were developed. As examples, consumption-driven principles like the so-called waterfall-replenishment or the Kanban principle were identified.

Finally, the average rating level of the LP element of standardization was the lowest of all five LP elements. The rating indicated an improvement potential between large and extremely large. The spread between the operations and IS group can be considered extremely low for this LP element. As mentioned above, the warehouse management processes and IT systems were characterized by an extremely heterogeneous landscape. Though some IT-systems were used in more than one plant, the processes reflected on these IT-systems had often nothing in common.

The following table provides a summary of the qualitative workshop observations on the macro process of warehouse management. Again, I differentiated between weaknesses, strengths and improvement potentials.

LP Element	Current Weaknesses	Current Strengths	Improvement Potentials LP & ERP
People and teamwork	Interruptions in the process and system flow make collaboration within and across the departments difficult.	High level of informal communication.	Integrated ERP system as a basis for encouraging teamwork and collaboration activities (all employees look at the same database)
Quality First	Poor data quality, data inconsistencies and redundancies between IT-systems. Problems in the technical interfaces between the IT-systems.	Fully automatized warehouse in place and running relatively stable.	Integrating automatized warehouse into the overall ERP system in order to decrease number of interfaces and to increase data consistencies. Quality checks early in the process, automatic stop of processing in case of wrong entries
Kaizen	Lack of centrally co-ordinated continuous improvement initiatives due to missing process standards. Departments improving themselves independently from the others.	Some continuous improvement initiatives in place, though on a fragmented level.	Set-up continuous improvement cycles based on enterprise-wide standardized warehouse processes. Implement highly flexible ERP processes, which can be easily changed by parameter settings, not IT-programming.
Flow	Flow principle not applied in current warehouse processes.	-	Set-up ERP based waterfall principle based replenishment processes and ERP Kanban control cycles in order to control the flow of material

			through the warehouses.
Standard-ization	Heterogeneous warehouse management processes within and between the plants in the production network	Several warehouse management systems used in more than one plant.	Implementation of ERP based standardized warehouse management processes within the entire plant network.

Table 19: As-is analysis: warehouse management – qualitative observation

4.3.3.9 Production Supply

With an average rating of 48% across all five LP elements, the macro process of production supply was on a medium range compared to the other macro processes (see figure 24). The following figure provides an insight into the various LP elements.

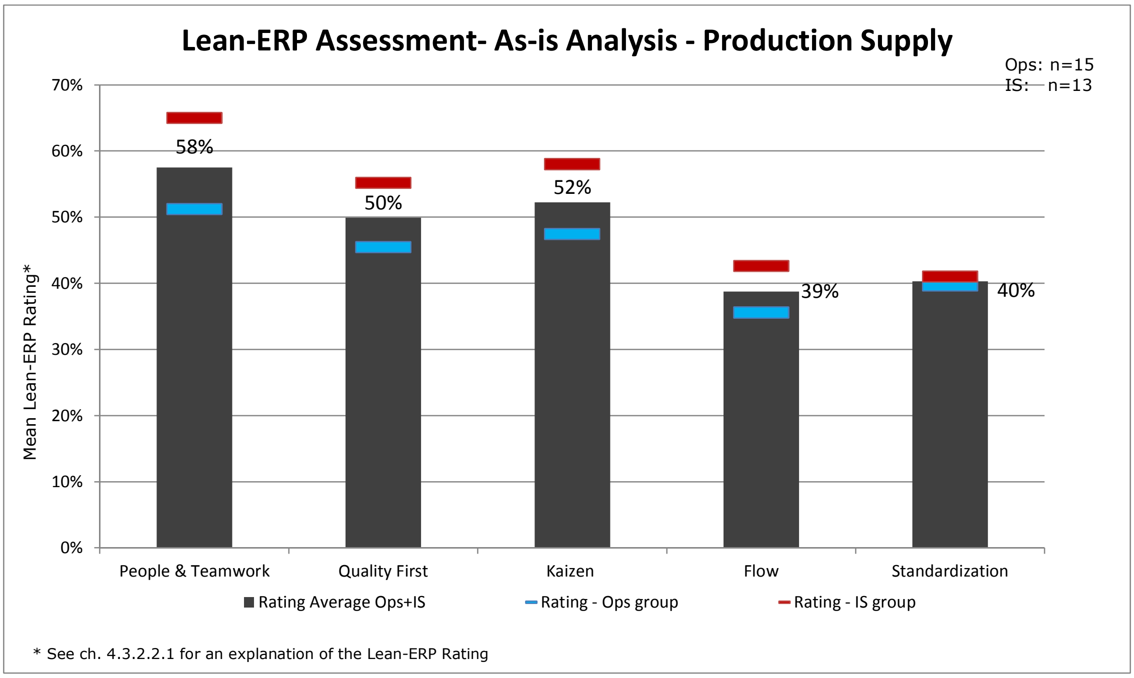

Figure 32: Lean-ERP Assessment – As-is Analysis – Production Supply

The average rating of 58% for the LP-element of people and teamwork was higher than the rating of the other LP elements for this macro process. Nevertheless there were plenty of critical voices particularly on the operations side. Particularly the operations representatives complained that the function orientation and the IT dependency of the whole production supply process does not encourage collaboration or teamwork. They claimed that people have to fulfil orders without being able to question what the IT system is telling them. The IS representatives did not comment on these critiques but held that the level of collaboration within the IS team was good. They have a regular meeting to discuss about improvements of the IT processes for production supply. The commonly agreed improvement potential was seen in an ERP system supporting more human and collaborative processes. As an example, the support of so-called "supermarkets" was mentioned several times. In this case, the human being picks and puts together pre-arranged part-kits for the assembly, triggered by the consumption driven pull principle.

Concerning the quality first principle, the main weakness mentioned was that the required parts are often not in the right quantity or in the right time to the assembly line. As 4-O-02 held: "This causes either excess inventory or shortages at the line. The shortage are usually covered by ad-hoc fire-fighting processes in order to avoid line stoppages." As improvement potential the workshop participants agreed on the requirement to set-up internal customer-supplier relationships for the process of production supply. ERP supported confirmation of delivery times and quantities can help to monitor the quality of line supply service degree.

The LP element of Kaizen was rated roughly on a similar level than the two LP elements described before. The major critique was heavily related to the critiques outlined in the LP element of people and teamwork. The high IT dependency made it difficult to carry out continuous improvement initiatives. It was criticized that such initiatives usually got stuck when it came to the need for changing parameters in the IT systems because of a relatively slow reaction time of the IS department. Most IS representatives did not agree to this accusation and raised examples of some minor improvements realized in the last year. However both sides agreed that more flexible and customizable processes were a substantial improvement potential for a future initiative combining LP and ERP.

With 39%, the LP element of flow received the lowest rating of the five LP elements for the macro process of production supply. The participants of the workshop discussions agreed that there was a lack of pull oriented line supply processes since the current IT-system was completely based on deterministic demand calculations. Problems like excess inventory and shortages as mentioned above were seen as a result of the deterministic processes, particularly by the operations representatives. However there was also strength in the current process. Vehicle dependent parts, that is parts with very unsteady demand patterns, could be handled on a tolerable level using the deterministic push principle based on bill of material demand data. Nevertheless the participants agreed that a shift towards consumption driven production supply principles could be noted as the major potential for integrating LP and ERP.

Finally, the standardization level of the production supply macro process has been rated at an average of 40% with almost no spread between operations and IS representatives. As I have observed during the workshop discussions, the participants of both sides agreed that the current processes can be considered extremely inhomogeneous. This referred to both the intra-plant as well as the cross-plant level. As a matter of fact, the enterprise-wide spread of an ERP was seen as the major improvement potential in this respect.

The following table provides a summary of the main workshop observations. As for the other macro processes, I differentiated between weaknesses, strengths and improvement potentials.

LP Element	**Current Weaknesses**	**Current Strengths**	**Improvement Potentials LP & ERP**
People and teamwork	Heavily function oriented and IT-based processes for production supply do leave only little room for teamwork. People fulfilling orders from the IT-system without questioning them.	Collaboration in the IS team was categorized as good.	Developing an ERP based processes-oriented work structure instead of function orientation. Process and IT-support for "supermarket" principle for the manual commissioning and sequencing of parts.
Quality First	Parts are often not at the right time in the right quantity at the	-	Setting up standard ERP-based internal customer-supplier relationships with

	production line.		IT-supported confirmation of delivery times and quantities (e.g. scan).
Kaizen	Continuous improvement initiatives difficult due to high dependency on IS department	Some improvements realized by the IS department	Implementing customizable line supply processes, which can be changed by the operations departments without IT support.
Flow	Production supply completely triggered by deterministic demand calculations	Vehicle specific demands can be processed through deterministic production supply method	Shift from deterministic assembly demand calculations towards consumption driven supply methods.
Standard-ization	Processes not standardized within the plants, nor in the plant network	-	Plant network wide production supply processes based on ERP and characterized by the pull principle.

Table 20: As-is analysis: production supply – qualitative observation

4.3.3.10 Sales and Distribution

The average rating of 59% for the macro process of sales and distribution was the second highest among all macro processes (see figure 24). The following figure provides a break down into the LP-elements under investigation.

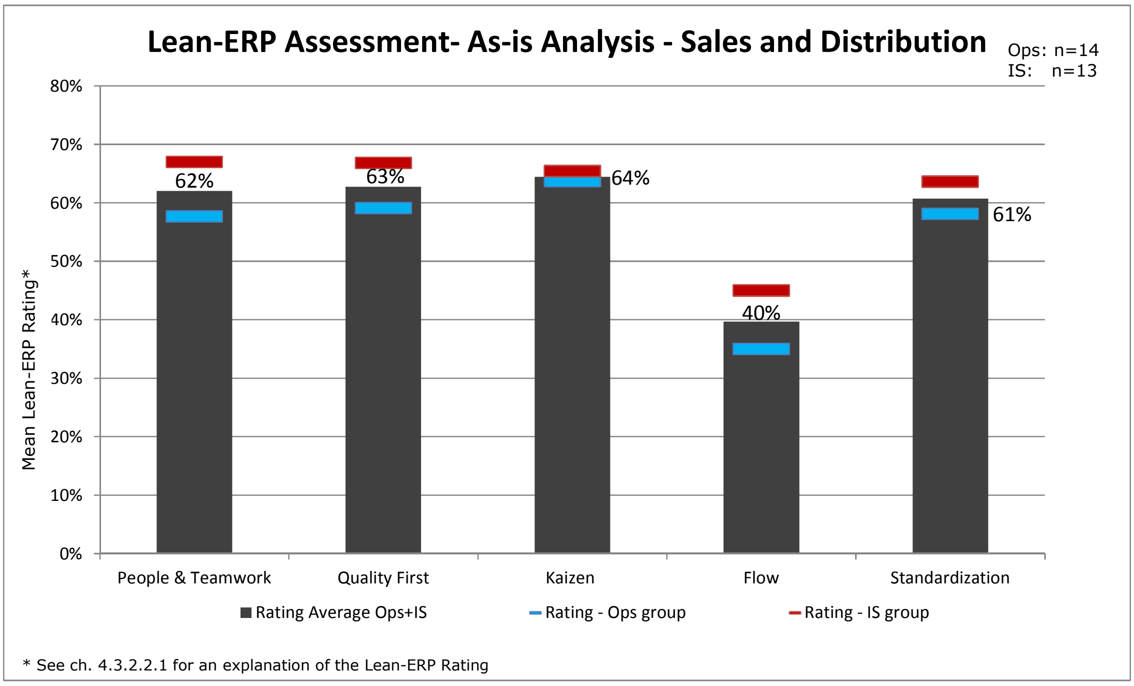

Figure 33: Lean-ERP Assessment – As-is Analysis – Sales and Distribution

The macro process of sales and distribution was to some extent different to the other macro processes. The reason is that these processes had been reflected already in an ERP system for three plants at the point of time when we started the initiative. These ERP implementations have been started with the primary intention to replace legacy system. Lean thinking did not play any role for these ERP implementations.

With respect to the LP element of people and teamwork, the average rating was 62%. Particularly the operations participants criticized that the collaboration to the other department, who were not working with the new ERP system was often difficult. 1-O-07 stated in this respect: "The process terminology of the new ERP system is completely different to our old systems. To some extent I feel like alienated within our plant." The IS representatives argued that the new ERP system and the accompanying standardized terminology has actually improved the level of collaboration within the IS team responsible for sales and distribution. This view was also shared by many operations representatives with respect to the functional sales department.

Regarding the LP element of quality first, the rating level was comparable to the LP element of people and teamwork described above. The main critique stated during the workshops was that there were still data inconsistencies between the sales and distribution department and the other departments, which did not have the new ERP system in place. As improvement potential, a plant-wide implementation of ERP was requested in order to remove all legacy applications and databases.

Concerning Kaizen, the average rating of 64% was on a comparable level as for the two LP elements described before. As a matter of fact, the participants criticized that most improvement initiatives get stopped when it came to collaborative processes with other departments. As 1-O-07 stated: "Most of our processes are integrated with other departments. If we want to really improve processes, we cannot stop at the border of our department. However, this is exactly what currently happens." The participants agreed on a LP-based implementation of ERP processes in the whole plant as the major improvement potential for a future initiative integrating LP and ERP.

In terms of the LP element of flow, the rating of 40% was the lowest of all LP elements for the macro process of sales and distribution. The participants agreed that the implementation of ERP was done without any particular consideration of LP elements in general and the pull principle in particular. In this respect, the implementation was largely seen as a lost opportunity at the operations side.

Finally regarding standardization, the rating of 61% was on a comparable range than the first three LP elements and can be interpreted as indicating considerable room for improvement. The workshop observation has revealed that though there was some standardization of sales processes in those plants with the new ERP system, there was a general lack of standardization between the plants in the production network. The participants agreed on the improvement potential of rolling-out the ERP solution in all of the plants with a stronger focus on standardization. The following table provides a summary of the main findings of the qualitative workshop observations.

LP Element	Current Weaknesses	Current Strengths	Improvement Potentials LP & ERP
People and teamwork	Collaboration with other departments difficult (due to new	Improved collaboration and teamwork within	Further roll-out of ERP will remove some of the boundaries for

	ERP terminology in the sales department)	the sales department	cross-department communication (e.g. terminology)
Quality First	Data inconsistencies between the sales departments' ERP and other departments.	-	Plant wide implementation of ERP in order to remove legacy systems and redundant databases.
Kaizen	Continuous improvement initiatives usually stop at the boundary of the sales and distribution department.	Continuous Improvement initiatives possible due to some parameterization flexibility	LP-based implementation of ERP processes in the whole plant instead of partial solutions.
Flow	Pull principle not considered when new ERP had been implemented.	-	Pull-based implementation of ERP processes in the area of sales / distribution.
Standard-ization	Lack of standardization between the plants in the production network.	Some standardization of sales processes in those plants with the new ERP.	Rolling-out the ERP solution in all of the plants with a strong focus on standardization.

Table 21: As-is analysis: sales and distribution – qualitative observation

4.3.3.11 Summary and Implications

The as-is analysis has turned out particularly crucial for my research of integrating LP and ERP in one combined initiative. I have seen two primary reasons for this:

- Establishing a benchmark for the Lean-ERP assessment
- Identifying improvement potentials for an integrated LP and ERP initiative

First the as-is analysis allowed us to establish an as-is benchmark for the Lean-ERP assessment of the processes under investigation. I designed and conducted a survey with a specifically designed questionnaire for estimating the improvement potential for an integrated ERP and LP implementation. Taking into account the activities and findings of the sections above, I can summarize the following main points:

- For 7 out of 8 macro processes, the workshop participants have rated the improvement potential for an integrated ERP and LP initiative between considerable and large. Only the macro process of demand planning was rated as holding only little room for improvement.
- The macro process of material planning was seen as the macro process with most improvement potential. The workshop participants frequently complained about the lack of pull-based material planning methods in this context.
- Generally there was a gap in the ratings of operations and IS representatives. On average, the IS group have rated the current processes better than the operations group for all macro processes under investigation.

Second, the participants were able to generate concrete functional improvement potentials for a combined LP and ERP initiative. This referred to all macro processes under investigation. I observed the following points as most frequently mentioned during the workshops:

- Realization of a pull-based flow of material and information throughout the entire plant as well as between plants in the production network (Flow)
- Process and system standardization and harmonization on both a plant and production-network level (Standardization)
- Improved teamwork and collaboration through a transparent and process orientated process and system landscape (People and Teamwork)
- Realization of improvable processes by allowing a broad range of process and system parameterization and individualization (Kaizen)
- Improving the overall process quality through forcing correct data entries at the earliest point in the process (Jidoka)

It is important to note that it was possible to relate the improvement potentials identified directly to the planned LP and ERP initiative due to one reason. The questionnaire was specifically tailored so as to only ask for questions directly related to the integration of LP and ERP. In fact, I only asked for improvement potentials which could be exploited by a combined LP and ERP initiative. Without this direct focus of the as-is analysis, we had not been able to apply the findings directly to our purpose.

4.3.4 Activities and Findings of the To-Be Process Design (2nd Workshop Cycle of Phase 2.1 + Phase 2.2)

This section focuses on to to-be process design. This to-be process design was conducted during two project sub-phases:

- Phase 2.1 Business Proposal - 2nd workshop cycle
- Phase 2.2 Conceptual Design - entire phase

The to-be process design conducted during the business proposal sub-phase was mainly concerned with the design of the future processes on a relatively high level. In fact, it focused the design of the macro processes based on the improvement potentials as identified in the as-is analysis. In contrast, the to-be process design conducted during the conceptual design sub-phase focused on a detailed process design. In this respect, not only the macro processes but also the process and micro process level was addressed.

In the following sections I present an overview of the results of the to-be process design and the Lean-ERP assessment for each of the macro processes under investigation.

4.3.4.1 Overview of all Macro Processes

Before focusing on the details of each individual macro process, this section provides an overview of all macro processes of the initiative. First, illustrating the process landscape, I outline a high level overview of the to-be macro processes of the initiative. Second, contrasting the overall average ratings per macro process and per LP element, I provide a high level overview of the Lean-ERP assessment results for the to-be process design.

4.3.4.1.1 To-be Macro Process Design Overview

This section outlines the rough macro process flow of the functional scope under investigation. The following figure provides an overview of the process landscape.

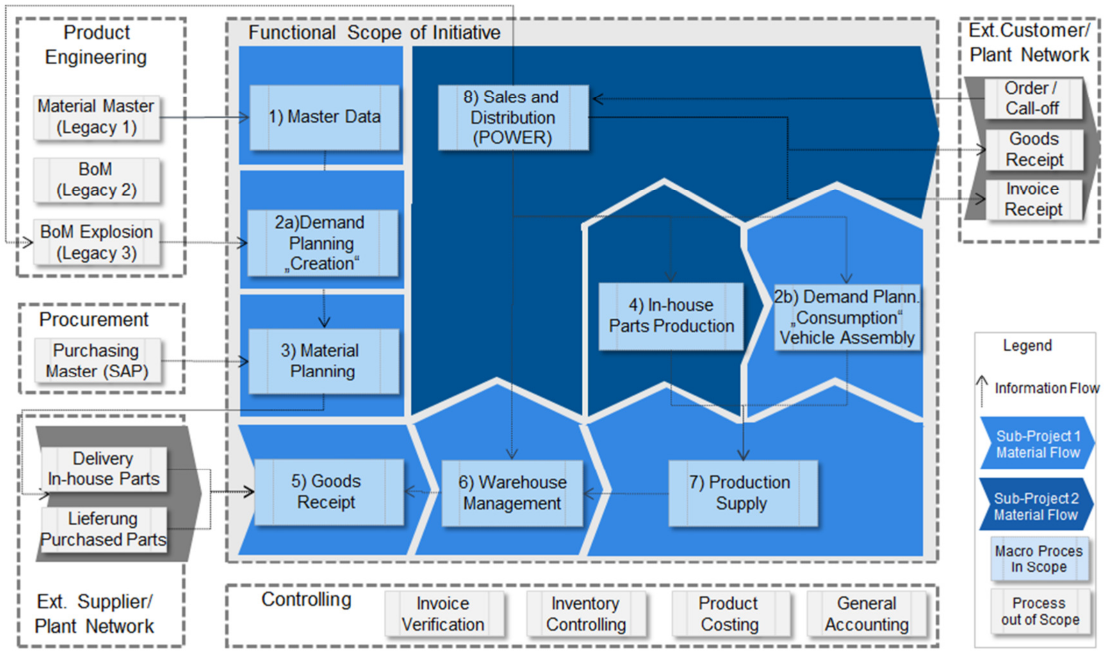

Figure 34: Process Landscape of the Initiative

The blue areas in the centre of the chart symbolize the 8 macro processes of the initiative. The initiative's scope is put into the context of the surrounding organizational units / entities. The main information flow links are illustrated by the black arrows. The material flow is symbolized through the bold grey and blow arrows in the background of the macro processes for which it is applicable. The following paragraphs briefly guide through the macro process flow.

On the left hand side, product engineering is producing the required material master records for all series part numbers; that is, for all parts which are eventually assembled into the vehicle. The initiative's macro process of master data takes over the raw material numbers, creates the master data records in ERP and is concerned with the maintenance of all necessary parameter settings for each part number. Amongst others, major improvement with respect to an integration of LP and ERP have been realized in to-be process design with respect to an avoidance of redundancies and improved flexibility in terms process and system parameterization. Section 4.3.4.2 will describe more details about Lean-ERP improvements, LP and ERP synergies as well as apparent conflicts in the area of master data.

In parallel, the bill of material and the explosion thereof takes place in a legacy system. The exploded vehicle BoM serves then as the main input for the first part of the macro process of demand planning. This process then generates the gross demand data for all part numbers. Even though the process was already perceived as relatively stable and secure, it has been further improved with respect to data consistency and in terms of implementing the pull-principle for internal demand generation between the plants in the production network. Section 4.3.4.3 will describe more details about the process improvements and the relation with LP and ERP integration with respect to the macro process of demand planning.

Based on the gross demand data, the macro process material planning generates net requirements by balancing gross demand and stock levels. As a result, the long term forecast is generated. Based on purchasing master data from the procurement department like vendors, frame contracts or incoterms, the long-term forecast is sent as a forecast delivery schedule to the suppliers. In addition to that, the macro process of material planning generates the short call-offs, which are delivery relevant for the suppliers. In contrast to the as-is situation, the short term call-offs are primarily created by consumption driven pull methods in the initiative, which has been seen as a major improvement in terms of reduction of inventory levels and material throughput time. Section 0 will go into further details about improvements, synergies and conflicts with respect to the integration of LP and ERP in the area of material planning.

The macro process of goods receipt is fed by advanced shipping notifications (ASN) for incoming parts sent by the suppliers. The process new consists of a two-step process. In the first step, the ASN data are processed and data discrepancies are clarified before the trucks arrive at the unloading point. Amongst others, urgent parts can be identified and the final route of the parts is calculated based on the stock requirement situation and other parameters. When the parts actually arrive, quantity and quality checks are done and the logistics and finance relevant goods receipt posting is carried out in the system. For more details on the macro process of goods receipt, please refer to section 4.3.4.6.

Based on the goods receipt data, the macro process of warehouse management is concerned with the put-away of parts into warehouses and/ or buffer areas like supermarkets. In addition to that the process deals with the picking of parts out of the warehouses, mainly based on pull signals based by other processes. Section 4.3.4.7 will describe more details about Lean-ERP improvements, LP and ERP synergies as well as apparent conflicts for the macro process warehouse management.

The macro process of production supply generates the triggers for pulling the material out of the warehouses and buffer areas. The material is then routed to the in-house parts production area and to the final assembly lines. Kanban principles are heavily deployed in order to generate the pull trigger based on the consumption of parts by subsequent processes. For more details about the macro process of production supply with respect to the integration of LP and ERP, please refer to section 4.3.4.8.

The macro process of in-house parts production reflects all production processes required for the manufacturing and pre-assembly of in-house parts. The process includes maintenance and explosion of the in-house parts' BoM, the maintenance of the relevant routings, the creation of work orders and the production steps including the consumption of components and the creation of new parts by the backflush postings. The material flow logic and the trigger for production are based on pull signals generated by the subsequent process of vehicle assembly or sales and distribution. Please see section 4.3.4.5 for further details on the as-is analysis findings with respect to the macro process in-house parts production.

The second part of the macro process of demand planning is concerned with the vehicle assembly processes. I have taken this process to the macro process of demand planning because the assembly of parts eventually leads to the reduction of gross demands and therefore closes the demand planning process. In this respect, section 4.3.4.3 covers also the vehicle assembly processes and the application of LP and ERP in this area.

Finally, the macro process of sales and distribution receives orders and / or call-offs from customers, processes them and transfers the resulting demand data according to the pull principle to other processes like demand planning, warehouse management, in-house parts production and the vehicle assembly, which is reflected by the second part of the demand planning macro process. Finally, the orders are commissioned, packed, prepared for delivery and are finally shipped to the customers, followed by the goods issue posting and the generation of the relevant invoices and delivery papers. Section 4.3.4.9 will describe more details about Lean-ERP improvements, LP and ERP synergies as well as apparent conflicts for the macro process sales and distribution.

4.3.4.1.2 Lean-ERP Assessment - Macro Process Overview

This section provides an overview of the Lean-ERP assessment results for the to-be process design. I have carried out the Lean-ERP survey at two defined points of time within the to-be process design phases. The first time at the end of the business proposal phase and the second time at the end of the conceptual design phase. For comparison reasons, I have contrasted these two rating results with the ratings of the as-is situation as described earlier in this thesis. I have composed two different charts for the Lean-ERP assessment overview:

- Break-down of the mean ratings per LP element
- Break-down of the mean ratings per macro process

The following figure illustrates the mean ratings over all macro processes for each of the LP elements analysed by the survey.

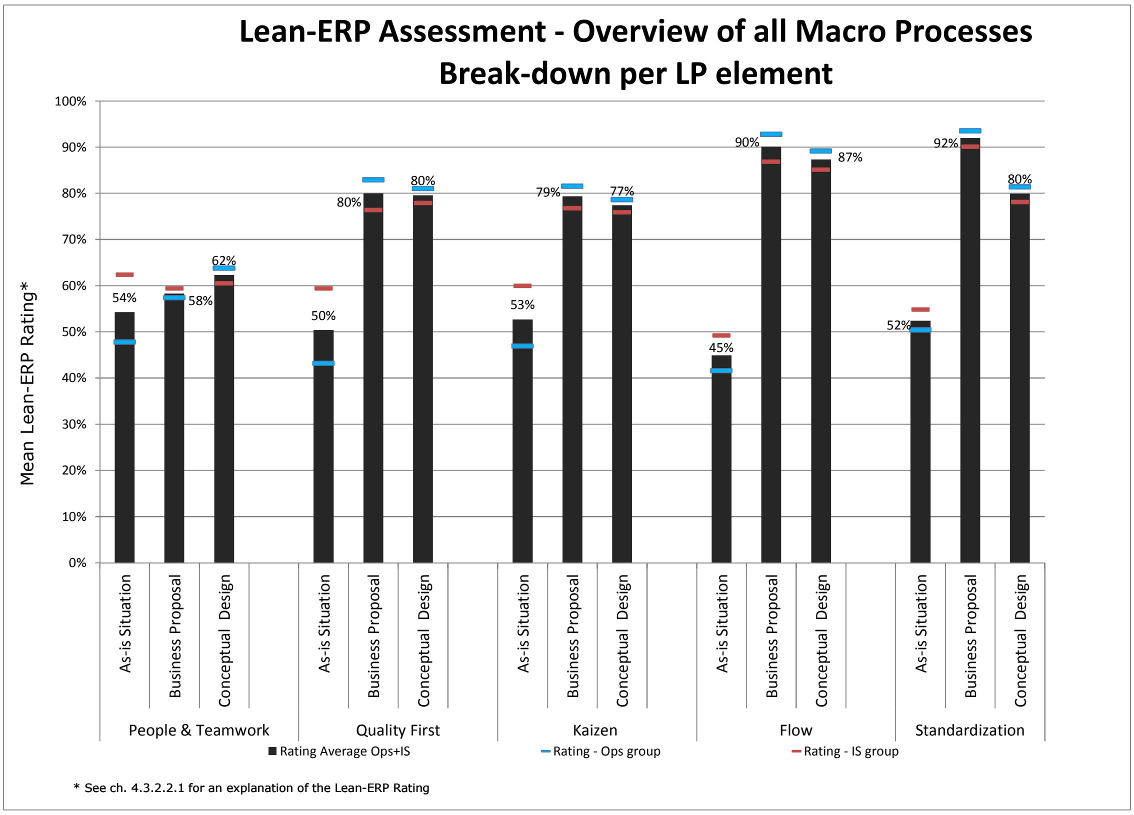

Figure 35: Lean-ERP Assessment – Overview of all LP elements

Looking at the survey results as summarized in the figure above, I established the following main points: First, for each of the LP elements the average rating of the as-is analysis was the lowest of all three ratings. In other words, the participants committed that the to-be process design improved the current business processes with respect to all LP elements, which I had defined for this initiative.

Second, there was a substantial rating improvement between as-is rating and the business proposal rating for 4 out of 5 LP elements, namely quality first, Kaizen, flow and standardization. In fact, for these 4 LP elements, there was a differences in the average Lean-ERP rating between the as-is situation and the conceptual design rating of minimum 24% in the case of Kaizen up to a maximum of 42% for the element of flow. Hence, for these 4 LP elements the majority of the participants stated that the integration of LP and ERP led to considerable improvements. Expressed in a qualitative way according to the classification in table 13, the average room for process improvement could be decreased from a range between large and considerable room for improvement for the as-is situation to a remaining range between little to no room for improvement for the to-be design stage. Only for the LP element of people and teamwork, the participants rated only 8 percent improvement between the as-is and the conceptual design rating. Hence the participants had seen a comparably low degree of improvement with respect to the LP element of people and teamwork compared to the other LP elements.

Third, for all LP elements except for people and teamwork, the conceptual design ratings were lower than the business proposal ratings. It appears that for 4 out of 5 LP elements, the expectations generated in the business proposal could not be completely realized in the detailed process mapping of the conceptual design phase. Only in the case of people and teamwork, the participants rated a minor improvement of the conceptual design phase compared to the business proposal phase, however on a comparably low basis.

Fourth, the spread between the average ratings of the group of operations representatives and that of the group of IS representatives became lower during the course of the project. For all LP element ratings there was a lower spread between operations and IS representatives in the conceptual design phase ratings compared to the as-is analysis ratings.

Fifths, the average operations group ratings were higher than those of the IS group for 5 out of 5 LP elements for the business proposal ratings and for all LP elements for the conceptual design ratings. This was in contrast to the as-is analysis ratings, in which the operations group rated all of the LP elements lower than the IS group.

The chart below illustrates an overview of the Lean-ERP assessment ratings for each of the macro processes under investigation. Again, I have differentiated between the as-is analysis ratings and the ratings after the business proposal and the conceptual design phases.

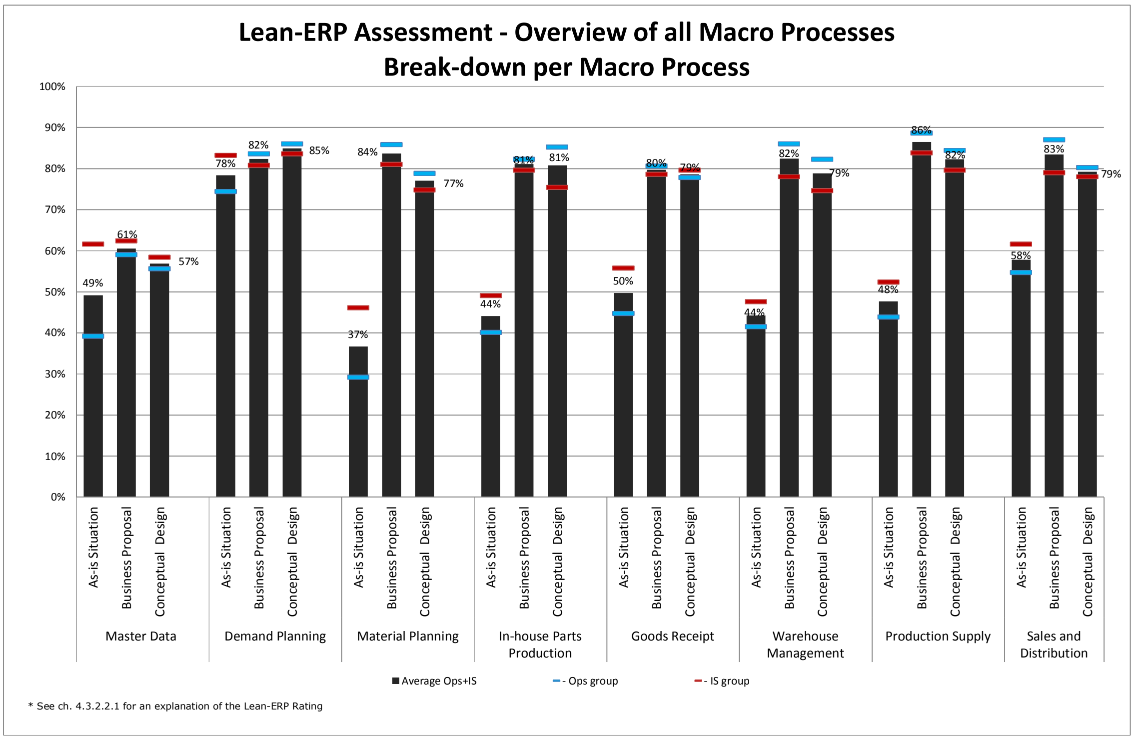

Figure 36: Lean-ERP Assessment – Overview of all Macro Processes

With respect to the figure above I can summarize the following main findings: First, similar to the break-down figure 35, the as-is situation received the lowest average rating of all three ratings for each of the macro processes. Hence the participants have seen a certain degree of improvement for each of the 8 macro processes. In other words, the improvements were not restricted to local areas but were based on a broad foundation.

Second, for 6 out of 8 macro processes there was an average rating improvement between the as-is rating and the conceptual design rating in a range of 21% for sales and distribution up to 40% in the case of material planning. For these macro processes, the average room for process improvement could be decreased from a between large and considerable for the as-is situation to a range between little to no room for improvement for the to-be design stage (see table 13). Exceptions were the macro processes of master data and demand planning, for which the improvements were rated 7% and 8% respectively.

Third, for all macro processes except for demand planning, the conceptual design processes were rated lower than the business proposal processes. Hence for 7 out of 8 macro processes, the expectations generated in the business proposal phase could not be fully realized in the conceptual design phase. Only for the macro process of demand planning the participants rated a minor improvement of the conceptual design compared to the business proposal.

Fourth, for most macro processes the spread between the average ratings of the group of operations representatives and that of the group of IS representatives became lower during the course of the project. In fact, for 6 out of 8 macro processes there was a lower spread between operations and IS representatives in the conceptual design phase ratings compared to the as-is analysis ratings. I take this as an indication, that the gap between the two groups' viewpoints became lower during the course of the initiative.

Fifths, the average operations group ratings were higher than those of the IS group for 7 out of 8 macro processes for the business proposal ratings and for 6 out of 8 macro processes for the conceptual design ratings. This was in harsh contrast to the as-is analysis ratings, in which the operations group rated all of the macro processes lower than the IS group.

I will carry out a more detailed analysis of the findings described above for each macro process in the following sections. In particular, I will analyse the survey rating results together with my qualitative observation findings. On the one hand, this allows us to cross check the quantitative findings with the qualitative ones and vice versus. On the other hand, I will try to establish causality between the quantitative rating results and the qualitative workshop observations wherever possible.

4.3.4.2 Master Data

This section describes the main findings of the to-be process design phases for the macro process master data. In this respect, the section summarises the main results of the business proposal phase and the conceptual design phase with respect to my topic of integration LP with ERP. I have split the section into two parts. First I provide an overview of the to-be process design and a qualitative assessment thereof based on the findings of the workshop observations. Second I present and discuss the results of the Lean-ERP assessment, comparing the business proposal phase and the conceptual design phase ratings with those of the as-is analysis.

4.3.4.2.1 To-be Process and Qualitative Evaluation

This paragraph sets out to provide a high level overview of the to-be process design and a qualitative evaluation of the macro process master data. The following figure graphically illustrates a rough overview of the macro process.

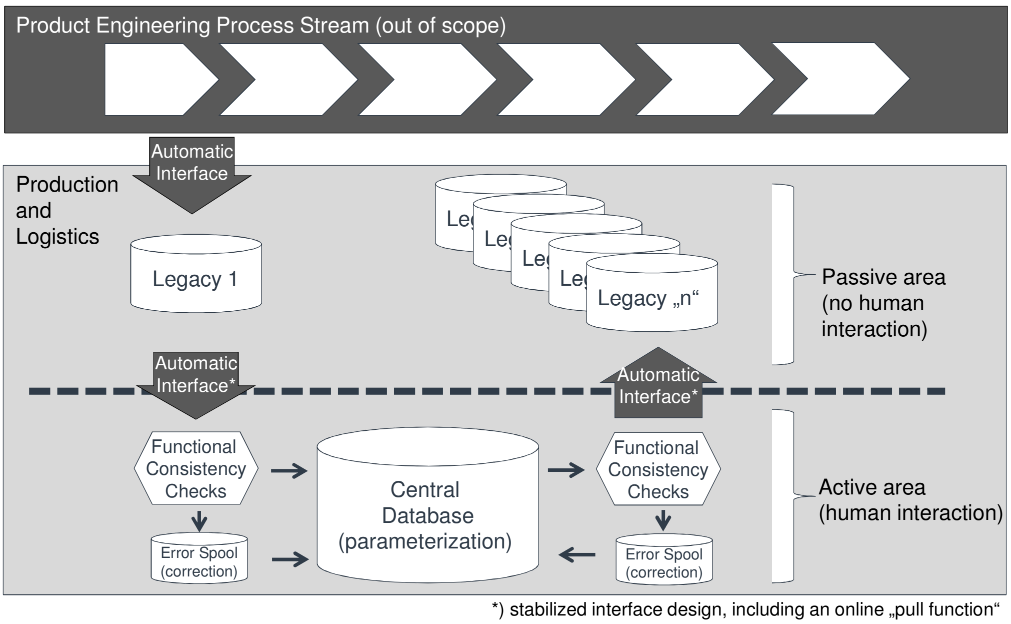

Figure 37: To-be macro process overview - master data

The macro process starts with the product engineering division. This division define the details of any new or changed product to be produced in the client’s production network. Based upon that, a newly designed interface transfers the relevant material master data to a legacy hub in the division of production and logistics.

After that, the data are transferred by an automatic interface to the central ERP database, whereby a new consistency check ensures the data consistency. Within ERP, the master data is being completed with all production and logistics process relevant parameter settings. After that, another consistency check is performed in order to reduce the risk of wrong parameterization. Only after a successful consistency check, the data can be used within ERP. Only correct data are transferred by another newly designed interface to other non-ERP applications.

The project team set out to realize improvement potentials through the integration of LP and ERP in the to-be process design as far as possible (see section 4.3.3.3). The following paragraphs briefly describe main improvement potentials and explain how and to what extent they could be realized in the to-be process design.

As far as the LP element of people and teamwork is concerned, the future to-be process was designed to maintain all relevant master data for the processes in scope centrally in the ERP data base, in contrast to the current inhomogeneous data bases. By this means it was possible to define human interaction steps in the ERP processes, which was a major LP & ERP improvement potential identified in the as-is analysis with respect to the LP element of people and teamwork. As the figure above illustrates, a passive and an active area had been defined. Data maintenance was only foreseen in the active areas within ERP. And, through the central interaction platform of ERP, the authorization management could be clearly defined and the parameterization possibilities were significantly increased by the new process design. The advantages as shared by the majority of the workshop participants can be exemplified by the following statement of 3-O-03: "By the possibility to clearly define who is allowed to maintain exactly which data at defined interaction areas in the system, the risk of data redundancies and inconsistencies can be reduced considerably. At the moment, redundant and inconsistent data are a major problem for all our logistics processes. Currently this leads to missing parts and/ or the requirement of Airfreight deliveries nearly every day."

Concerning the LP element of quality first, the to-be process contains several consistency checks for the new processes. Apart from all IT-relevant consistency checks for data formats etc., two main functional check-points had been defined. The first main functional check-point was designed after upload of the raw data from the legacy system. Amongst others, the consistency of master data like material master data, purchasing master data, BoM and routing data for in-house parts production could be verified in this step. The second main functional check-point was defined after the manual parameterization. During this step, functional parameters responsible for controlling the material flow throughout the plant were designed to be verified. I observed that the participants considered the new process as a step towards process quality improvement. An example can be seen in the statement of 6-O-04 who claimed in this respect: "Such systematic consistency checks can contribute significantly toward raising the quality of our business processes. For example, by comparing the parts' characteristic and the line supply methods, it is possible to identify whether an exotic slow mover part was wrongly parameterized as supplying it by the high-runner Kanban method. Though it appears unlikely, such things usually happen several times per month in our plant."

With respect to the LP element of Kaizen, enhanced parameterization possibilities had been designed as another improvement aspect with respect to an integration of LP & ERP. In the new to-be process design, the operations representatives were given more possibilities to change logistics and production relevant parameters. In the process design workshops, the participants had seen this as a major contribution towards realizing the Kaizen principle. As an example for the overall group's opinion, 4-O-02 mentioned raised the following statement: "The possibility to change parameters without the without the necessity to officially apply for a change request in the IS department should significantly support the continuous and rapid improvement of our business processes. For example, currently we need an IT change request to set-up a new material planning strategy. In the new processes design, we defined possibilities to adapt the material planning strategy independently."

Regarding the LP element of flow, the technical interfaces had been completely redesigned. For instance, next to the daily data transfer, individual pull-triggers for the interfaces were designed in order to provide the opportunity for sub-daily data transfers if required. By this means, required data updates could be pulled whenever required from a preceding IS system by a subsequent IS system. Moreover, the interfaces had been designed to be stabilized and standardized. In particular, the extremely inhomogeneous and old-fashioned existing middleware technology was designed to be replaced and standardized by a reliable up-to-date interface technology. This was seen as another contribution towards the LP element of quality first by the workshop participants in the process design workshops.

Finally, another important aspect of the to-be process design was consideration of the LP element of standardization of the processes within the entire plant network. As identified in the as-is analysis, the master data processes were still not standardized in the production network. There were still plants in the production network, which had created their own master data systems, partly redundant and partly as an extension to the central databases. The overall initiative's objective of realizing an integrating LP and ERP and particularly the LP element of standardization helped to convince the representatives of the necessity of a production network-wide standard. As an example we can take the statement of 7-O-03 who held: "One year ago, no-one could have convinced me that it really makes sense to change our locally optimized master data processes to a production network-wide standard. I considered and still consider our plant processes as unique, as we are the only engines assembly plant in the production network. However, the initiative's to-be process design approach to realize a plant-wide standard and, in parallel, taking care of our individual process requirements by designing modular enhancements has convinced me."

The following table summarizes the main improvements as define for the to-be process of the initiative. Moreover I have added the respective business implications in a separate column.

LP Element	**LP & ERP improvements reflected in the to-be processes**	**Business implications**
Flow	Redesign of technical interfaces so as to allow for online data transfer in addition to regular daily jobs	Abolishing technical restrictions for quick process adaptation requiring new master data => Reduction of manual data maintenance efforts => Reduction of the risk of data inconsistencies
People & team-work	Clear separation of an active and a passive data maintenance area Data maintenance only at pre-defined interaction points in ERP Improved authorization	Less redundancies of master data (e.g. integrating various databases covering similar content into one central master data repository) => Reduction of multiple data maintenance and reduction of manual

	management in ERP Design of ERP data maintenance workflows	data entry efforts
Quality First	Improved IT-related consistency checks Two operations related consistency checks, one before and one after system parameterization Use of standardized and stable state-of-the-art middleware technology for all IT interfaces	Increased accuracy of master data (e.g. reducing amount of wrong / missing data like weights, etc.) => Reduction of efforts for manual data correction, searches, reconciliation, etc. => Reduction of process errors due to data inconsistencies
Kaizen	Design of increased parameterization possibilities IS department only required in cases where programming is required	Increasing flexibility in terms of rapid process changes (e.g. simple change of procurement type from in-house to external part) => Rapid utilization of cost / quality advantages on a constant basis
Standar-dization	Full standardization of master data processes in the production network Consideration of individual characteristics by modular enhancements	Standardized master data maintenance processes throughout the plant network => Reduction of training efforts, less variants to provide IT-support => Reduction of manual efforts for data entry, maintenance, synchronization

Table 22: To-be process design improvements - master data

In addition to the improvements, I observed apparent conflicts between LP and ERP during the to-be process design. These conflicts turned out to impede the utilization of the synergies. The following paragraphs briefly outline the most important points in this respect.

A conflict mentioned several times by some operations participants was the contradiction of the macro process of master data with the LP rule as less IT as possible, only as much as absolutely necessary. In the extreme form, this argument was used to questioning the existence of the macro process of master data itself. However, if not interpreted in such an extreme way, the rule could be utilized even positively during the process design phases. I could actually use the rule quite often in order to respond to requirements, for which the relation between the realization effort and the business benefits was not satisfactory.

A commonly raised critique by operations representatives particularly in the early stages of the initiative was that the entire macro process of master data management was non-value adding according to LP. Some held a very extreme position like 3-O-05 by arguing that: "At the end of the day we get paid for producing vehicles and not for maintaining data in an IT system." I tried to utilize the positive aspect of such statements by replacing manual data entries by an automatic IT-based generation wherever an algorithm could be defined for automatically and correct derivation of the parameters. For the remaining few parameters where such an algorithm could not be correctly defined, we provided supporting IT tools for reducing the amount of time required, for instance with the help of mass data maintenance tools.

Finally, workshop participants claimed that the reduction of data redundancies was considered a standard IT objective, without the necessity for a concept like LP. Though this point was raised as critique, I hold that it was more a synergy than a conflict. It was relatively easy to react to such statements by pointing out that this initiative consists of an integration of both concepts LP and ERP. I argued that, if the reduction of data redundancies was an IT objective itself, it still made sense to consider the point for the to-be process design. The following table summarizes the apparent conflicts for the macro process of master data management.

LP element	Conflicts LP&ERP	Mitigation procedure
Overall	LP rule: "As little IT as possible, as much as necessary" – Master data are the prerequisite for IT	Simplification and reduction of IT processes as far as possible. E.g. pre-assemblies without IT support.
People and Teamwork	Data entries in ERP were considered as "non-value adding" according to LP The reduction of data redundancies was considered a standard IT objective, without necessity for LP	Replacing manual data entries by automation as far as possible, provision of support tools Stressing the argument that the integration of the two concepts considers positive elements of both LP and ERP

Table 23: LP & ERP conflicts and mitigation procedure – master data

4.3.4.2.2 Lean-ERP Assessment – Master Data

As we have seen in

figure 36, the macro process of master data received a relatively low average Lean-ERP rating for the to-be macro process design compared to the other macro processes in scope. In order to analyse the Lean-ERP assessment for the macro process of master data one level deeper, the following figure breaks down the Lean-ERP ratings of

figure 36 into the average ratings of the 5 LP elements. I have differentiated between the ratings after the business proposal and the conceptual design phases. For comparison reasons, I have also added the as-is analysis ratings.

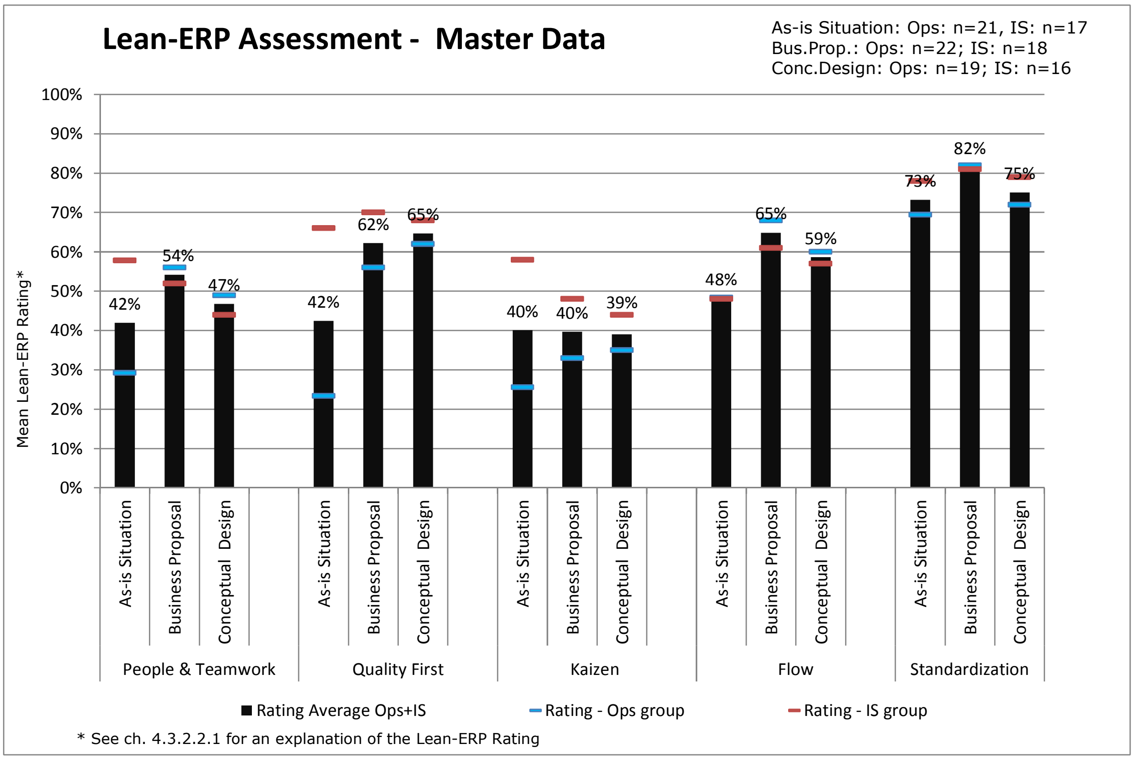

Figure 38: Lean-ERP assessment master data

The LP element of standardization received the highest ratings of all five LP elements. According to the workshop observations, the standardization level of the master data macro process was seen relatively high at the beginning of the initiative. However the high level could not be improved significantly during the course of the initiative.

The ratings of the LP element of Kaizen received the lowest ratings for the business proposal and the conceptual design phase. In fact, the rating even decreased slightly after the conceptual design. Looking at the spread between the operations and the IS group, one can realize that the spread became lower during the initiative. The operations group committed at least some improvement, whereas the IS group's rating became even worse during the course of the initiative. This is in line with the qualitative workshop observations in that respect, as the operations representatives designed an increased set of parameterization options for operations personnel in order to enable continuous improvements. However the still low percentage of below 40% for the operations rating was still surprising to some extent. It appears to reflect the commonly raised critique observed during the workshops that the process of master data itself was non-value adding in terms of LP and that LP requires as less IT as possible. On the other hand, the IS group's ratings even decreased during the course of the initiative. The additional parameterization options for the operations group appeared to have negatively influenced the IS group's opportunities for continuous improvement.

For the remaining three LP elements quality first, flow and people and teamwork the participants saw still considerable to large room for improvement after the conceptual design phase. To sum it up, the participants have committed some degree of improvement for the macro process of master data, however not on a comparable level to the other macro processes. From the workshop observations I have reason to assume that the general critique of the categorization of master data maintenance as non-value adding process contributed to these comparably low quantitative ratings.

4.3.4.3 Demand Planning

This section deals with the main findings of the to-be business process design for the macro process demand planning. The section summarises the main results of the business proposal phase and the conceptual design phase with respect to my topic of integration LP with ERP. I have split the section into two parts. First I provide an overview of the to-be process design and continue with a qualitative assessment of the improvements and conflicts. Then I present the Lean-ERP assessment.

4.3.4.3.1 To-be Process and Qualitative Evaluation

This section deals with the to-be process demand planning and the qualitative observation results thereof. Generally, this macro process can be divided up into internal demands which are generated by one of the plants in the client's production network and external demands originating from customers outside the company. Since a major improvement has been designed with respect to the internal demands, the following figure illustrates a graphical overview of the to-be process design for the internal demand planning processes.

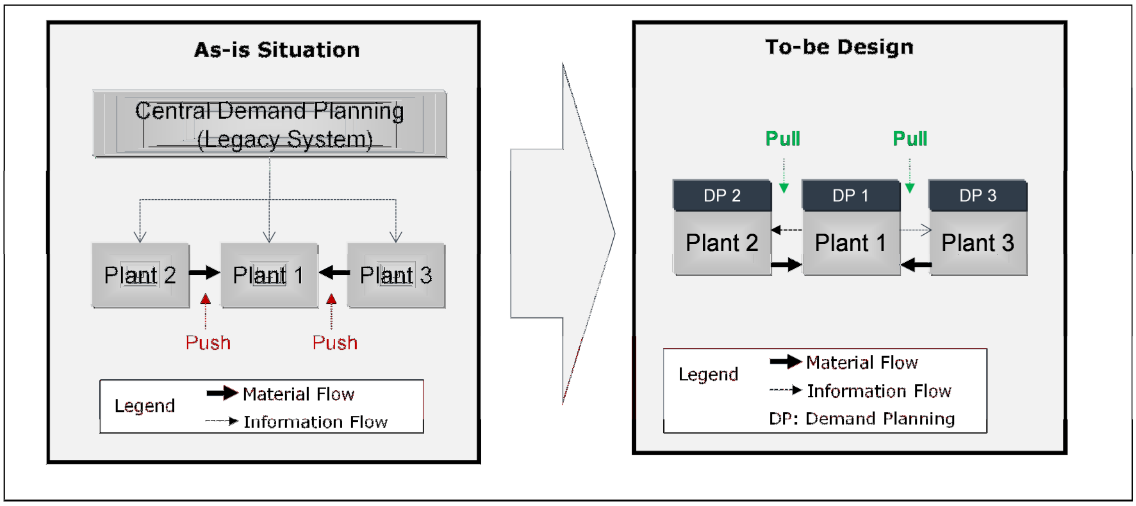

Figure 39: Process overview of demand planning within the production network

With respect to the LP element of flow the above figure illustrates that the traditional internal demand planning was based on the push principle. That is, a central system deterministically calculated demand dates and transferred them to the plants in the production network. The plants delivered according to the demand data received from the central planning system. As the as-is analysis had shown, this led to the fact that the centrally produced demand data did not reflect recent local changes within the receiving plants. In contrast, the to-be process had been design so as to support direct customer-supplier relationships within the production network. By this means, the pull principle had been realized in the to-be process designed, leading to a higher flexibility in case of short-term demand changes.

In terms of people and teamwork, the workshop observations have shown that the design of cross functional reports was identified as a synergy between LP and ERP. The possibility for other departments and even divisions to view gross demand data was mainly regarded as a means towards fulfilling the criteria of the LP element of people and teamwork. For example, 6-O-03 held in this respect: "The possibility for other departments to view our demand data is clearly a step towards increased transparency, which I would put into the category of people and teamwork. Amongst others, I definitely expect improved decision making as a main result." In addition to that, participants frequently mentioned an expected reduction of manual effort in composing specific reports responding to questions from other departments and divisions with the relevant searching and reconciliation efforts.

The design of plausibility checks to verify the results of the BoM explosion was seen as a contribution towards the LP element of quality first. The prime opinion observed in the workshops can be exemplified by 2-O-03 who claimed: "The possibility to separately display part-number changes, which occurred after the first data transfer constitutes a massive improvement for the quality of our demand data. Currently these changes cause massive problems because we have no possibility to realize them early in order to take countermeasures."

The to-be process design element of providing an opportunity to influence the result of the engineering BoM explosion for the sake of production and logistics processes was seen as a major contribution towards the LP element of Kaizen. By this means, changes like the reflection of a new BoM layer in order to accumulate specific parts for instance for the reflection of pre-assemblies or part-kits are possible. According to the majority of the participants this should fulfil urgent operations requirements. As 1-I-02 held: "This functionality eventually provides the answer to many requests raised by operations employees during the last decade." The participants saw the possibility for considerable gains in productivity through this new function.

Finally, the design of production network wide standard processes was seen as a major contribution towards realization of the LP element of standardization. As a result, the participants expected increased flexibility for the transfer of employees to other plants in the production network and hence increasing flexibility for the business. Moreover, IS representatives claimed that they expected reduced IT maintenance costs through economies of scale.

The following table provides a summary of the main improvements as defined in the to-be process design of the initiative. In addition to that I have added the respective business implications as expected by the workshop participants.

LP Element	LP & ERP improvements reflected in the to-be processes	Business implications
Flow	Design of internal customer-supplier relationships, supporting the realization of the pull principle within the production network Design of demand levelling functionality(e.g. balancing the average production program by shifting specific orders) as basis for consumption driven material planning methods Design of a state-of-the art performance saving two-step backflush functionality	Internal customer supplier relationships enable the triggering of production and shipments only if really required => Reduction of finished goods inventory, reduction of potentially wasted production and logistics efforts More even demand patterns allow the extensive usage of consumption driven pull methods => The increased deployment of pull systems like Kanban leads to lower average inventory levels and throughput times Reduction of system processing time for part consumption => Increased productivity through rapid system performance
People & teamwork	Design of reports allowing all relevant departments of the production and logistics division to view the gross demand data Access for division of engineering to the gross demand data of the division of production and logistics	Increasing transparency with regard to vehicle demand, production progress and inventory of finished goods (e.g. SAP's vehicle management system) => Reduction of manual efforts for co-ordination (e.g. inquiries by phone or email), searching, verifying, etc. Easier decision making based on transparent and up to date data => Increased likelihood of making business decisions with positive impact
Quality First	Design of plausibility checks to verify the results of the BoM explosion, for instance by separately displaying	Higher quality of demand data and early identification of potential BoM or BoM explosion errors

	part-number changes after the first data transfer	=> Reduced risk for subsequent processes
Kaizen	Definition and design of a kind of "production BoM" for reflecting only logistics relevant BoM related aspects like a specific sub-structures for pre-assemblies or kit commissioning) Increased interaction possibilities to adapt the upload of an exploded BoM for the operations group	Increased flexibility for the production and logistics division in terms of changing and improving pre-assembly, assembly and logistics processes => Possibility to improve the productivity of production and logistics processes
Standard-ization	Further roll-out of the standard production network process, also to non-vehicle producing plants in the network	Production network wide standard processes => Increased flexibility for the deployment of personnel => Reduced IT maintenance costs

Table 24: To-be process design improvements – demand planning

Along with the improvements and the consequences thereof as described above, I also observed conflicts between LP and ERP during the workshops. The following paragraphs outline the main points.

During the course of the to-be design workshops, I observed that ERP was often equated with deterministic material requirement planning strategies with only limited possibility for human interaction. It is likely that this point of view came from ERP's roots in MRP / MRP II (see section 2.2.1). For example, 6-O-05 held in this respect: "I am still not convinced how a deterministic IT system like ERP could possibly support the LP element of people and teamwork. Isn't that two different worlds clashing together?" Though we could not completely abandon this kind of critical thinking for every participant, we found that the provision of concrete counterexamples best helped to reduce such general prejudice. As one example we explained the ERP Kanban process, which requires manual scan for triggering the next material replenishment cycle.

A critical point with respect to the LP element flow was the danger of over-engineering with respect to data processing and data requirements due to an attempt to increase quality of inventory figures in ERP. Particularly in the assembly area, operations representatives often call for a high amount of IT-reflected status points for the assembly lines, hoping that this could increase the inventory accuracy at the assembly lines. However the more status points, the more postings are required in ERP. As a consequence, the data processing times increase and the data is often not up-to-date when completely processed. And, the more status points, the more data maintenance has to be done properly beforehand for the process to work correctly. Initiating a separate workshop stream including all relevant operations and IS representatives was required in order to commonly agree on a fair trade-off.

Another critical point regarding the LP element flow in general and the prerequisite of demand leveling. In particular workshop participants questioned the necessity for IT supported demand leveling while operating with manual Heijunka boards. However the proponents of the IT supported demand leveling process argued that this function will not replace but rather support the manual Heijunka boards. As 1-O-03 held: "The demand leveling suggestion as generated by ERP is not foreseen to be automatically realized. It should only serve as a valuable source of information for the manual Heijunka boards. Only after manual fine-tuning and manual release, the demand data is being updated with the respective impact to all dependent functions like material planning, line supply, etc.

Another conflict was the fact that representatives of bus producing plants raised different demand planning requirements compared to truck producing plants. In contrast to truck production, bus production consists of strong elements of engineer to order requiring a high flexibility for changing the exploded vehicle BoM. 7-O-03 claimed in this respect: "At the point of time when we put the bus on the assembly line, we do not even know the final configuration of the bus. We need the flexibility to process configuration changes at any time, because it is our daily business".

The following table provides a summary of the major conflicts and the mitigation procedure applied for the macro process of demand planning.

LP element	Conflicts LP&ERP	Mitigation procedure
People and Teamwork	ERP often perceived as automatic tool supporting deterministic "make to forecast" strategies	Exemplifying pull-based ERP processes with the possibility for manual interaction (e.g. ERP-based

	without possibility for human interaction	Kanban with manual scan as trigger)
Flow	Danger of IT over-engineering with a high amount of data requirements and data processing not in line with the element flow. Manual (Heijunka board) versus IT supported demand levelling	Defining a fair trade-off between the number of status points and the time for data processing and data maintenance Using IT-based demand levelling reports as input data for a manual Heijunka board
Standard-ization	Conflicting demand planning requirements of bus production compared to truck production	Expansion of template with specific bus production relevant processes

Table 25: LP & ERP conflicts and mitigation procedure – demand planning

4.3.4.3.2 Lean-ERP Assessment – Demand Planning

As

figure 36 revealed, the macro process of demand planning received a high average lean-ERP rating of 82% for the business proposal and 85% for the conceptual design. The following figure breaks down the lean-ERP assessment of

figure 36 into the average ratings of the 5 LP elements In order to analyse the Lean-ERP assessment for the macro process of demand planning one level deeper. Again, I have differentiated between the ratings after the business proposal, the conceptual design and the as-is analysis ratings.

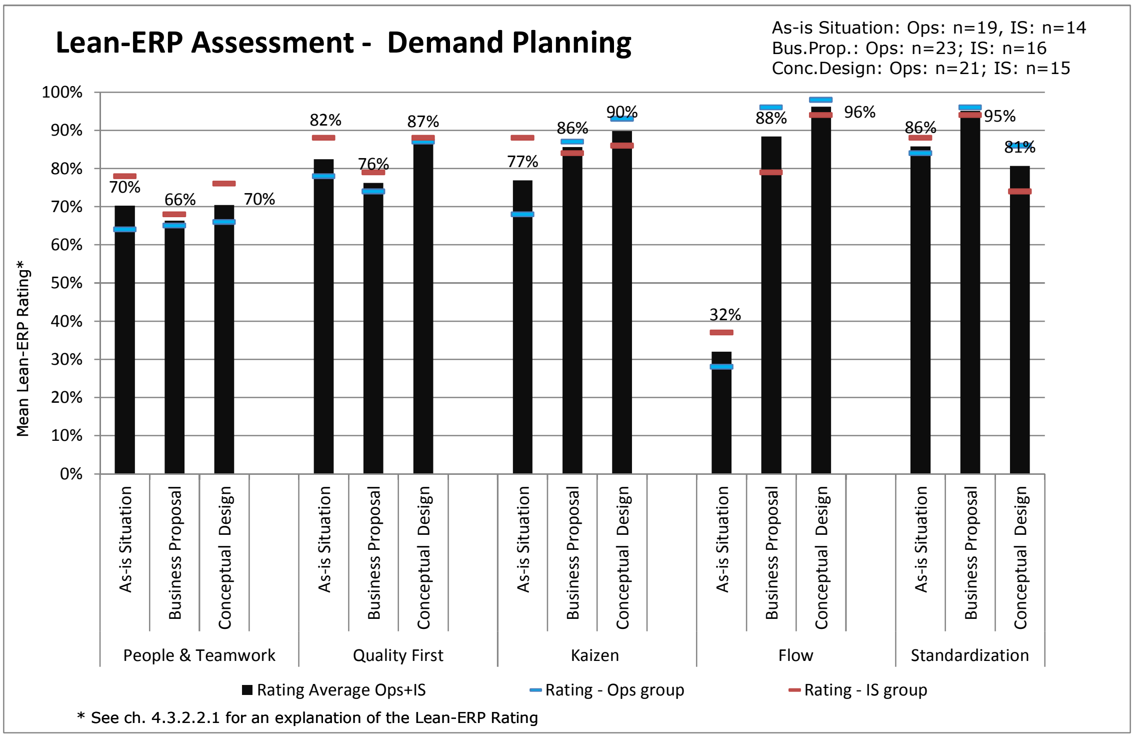

Figure 40: Lean-ERP assessment demand planning

With 96%, the LP element of flow received the highest value of the to-be process ratings after the conceptual design phase. In addition to that, the spread between the as-is situation ratings and the business proposal / conceptual design ratings is particularly high for the LP element of flow. This spread reflects the improvements identified in the qualitative observations. Particularly the pull principle for the production network internal supplies was seen as a significant improvement for the business, which was generated by the integration of ERP and LP. The high improvement rating was based on the fact that the cross-plant material transfers reflect a major proportion of the overall logistics value flow since the parts shipped between plants like engines, axles, vehicle bodies are relatively expensive. From my observations I derived that the participants had realized that the implementation of a consumption driven material planning process supporting the LP element of flow was not possible without a company-wide reach of ERP. In addition to that, the demand levelling processes were interpreted as a major contribution towards optimizing the logistics material flow. The ratings expressed the fact that the participants considered levelled demands as seen as a major prerequisite for pull material planning methods.

The LP element of people and teamwork received the lowest to-be design ratings of the demand planning macro process. This was in line with the qualitative observations of a deterministic perception of ERP with only limited possibility for human interaction. The countermeasures of exemplifying pull-based ERP processes appeared not to have an impact to the LP ratings.

Another point worth mentioning is that the LP element of standardization was rated very high in the business proposal phase but relatively low in the conceptual design phase. As I learned from the workshop observations, the high expectation with respect to demand planning could not be fully met in the conceptual design. During the detailed process definition within the conceptual design phase, the template processes had to be enhanced with bus specific variants in order to cope with the specific requirements of bus plants. Amongst others, this fact appeared to have contributed to a slight decrease of the standardization ratings of the conceptual design phase.

The LP elements quality first and Kaizen ended up with relatively high LP assessment ratings after the conceptual design phase. The ratings can be interpreted as symbolizing a potential between little and no room for improvement.

4.3.4.4 Material Planning

This section summarizes the findings of the to-be business process design for the macro process material planning. As for all of the macro processes, I have split the section into two parts; an overview of the to-be process design qualitative evaluation thereof, and the Lean-ERP assessment results.

4.3.4.4.1 To-be Process and Qualitative Evaluation

This section focuses on the to-be process overview and the qualitative evaluation of the macro process of material planning. The following figure provides an overview of an important part of the to-be process design of the macro process material planning.

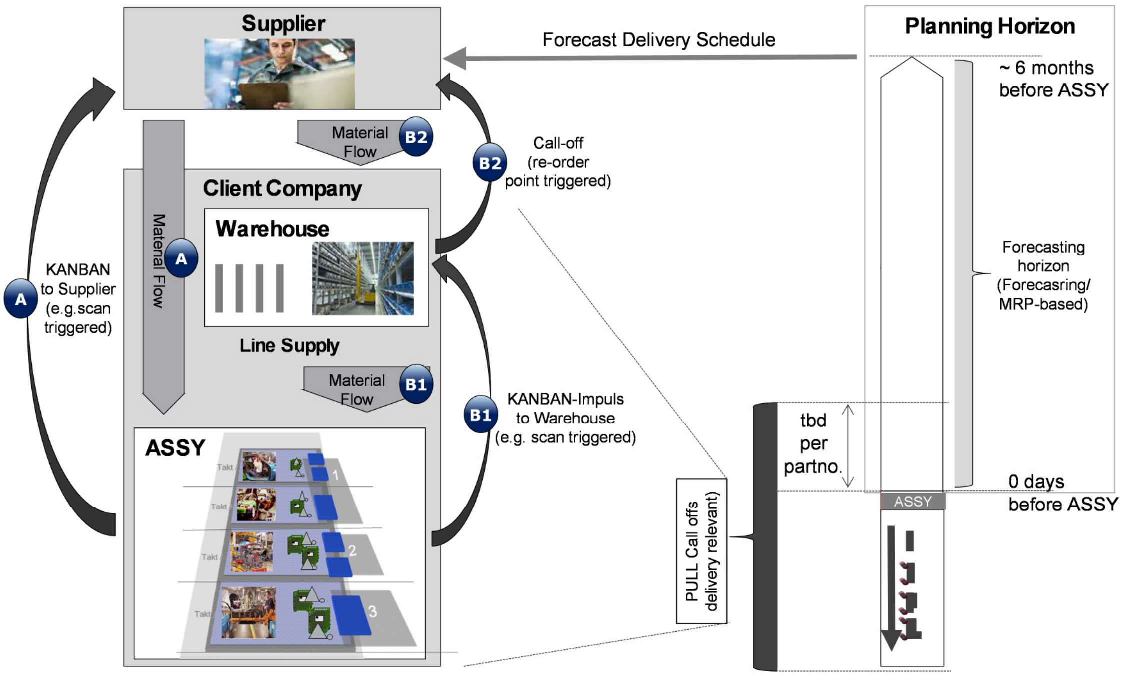

Figure 41: Process overview material planning

The figure above illustrates the connection of delivery relevant call-offs and forecasting-relevant delivery schedules. This process can be allocated to the LP element of flow. The supplier regularly receives two types of information. The forecasting information covers a horizon of assembly start up to 6 months into the future. Depending on the demand pattern of the part-number, it is generated by forecasting algorithms or by classic MRP calculation based on gross demands from an exploded vehicle BoM. The delivery relevant call-off is generated by consumption driven pull methods. The figure displays two options. In the first option, the pull signal can be forwarded directly from the assembly to the supplier. In this method, the parts are being directly shipped to the assembly without any warehousing function in between. This type is also referred to as classic Just-in-Time (JIS) procedure. It had been applied primarily for expensive parts, for which the supplier's plant is relatively close to the client's plant. In the second option, the pull signal is routed from the assembly to the warehouse first and the warehouse sends the call-off to the supplier, for instance triggered by a reorder point procedure. The second option was defined for parts which require a certain amount of safety stock and/ or for parts which are used in many different locations across the plant. In general, the majority of the workshop participants were extremely satisfied with the new process design. For example, 2-O-03 made the following point: "I actually expect a dramatic improvement from the new material planning processes. The pull methods should have strong positive impact on our average stock levels and the average material throughput time. And the flexibility allows us to further make improve without necessity to contact the IS for every little thing."

With respect to people and teamwork, the design of consumption-driven planning was expected to reduce the material planning complexity. In fact, many operations and IS representatives even expected increased collaboration and teamwork due to the increased data transparency in only one IT system. 2-I-02 held in this respect: "Having all required data centrally in ERP will definitely avoid misunderstandings and misinterpretations of employees from different departments. Currently this is a major issue; employees from different departments often use different IT-based terminology and often even look at different figures when talking to each other."

Concerning quality first, I observed that the design of an early warning system appeared to be the most important improvements according to the workshop participants. In fact, the to-be design included a sophisticated range of coverage calculation with consideration of quality relevant information for all types of material. 1-O-05 explained it that way: "If we knew early enough which parts might become scarce in the near future, for instance due to quality problems or other delivery-related issue, we can proactively react instead of the fire-fighting we are doing right know most of the time. This should lead to a decreased number of missing parts at the line and, in consequence, less line stoppages."

For the LP element of Kaizen, the major point observed were the parameterization options for the material planner. Particularly the operations representatives paid particular attention that they were allowed to carry out changes as far as possible without the requirement for the IS department. As 1-O-03 explained: "We expect considerable productivity gains through the increased material planning flexibility. With the additional options and the possibility to rapidly change parameters, our continuous improvement teams are able to carry out improvements at a completely different pace compared to the current process, in which they sometimes need to wait for months in order to get something realized by the IS." Another important point observed was the support of a rapid switch between external and internal processing of activities. With the support of a standard ERP process, the newly designed to-be process was designed so as to enable a change from one day to the other in case of capacity constraints. As 1-O-03 held: "The legacy systems require a lead time of several weeks in order to carry out a cut-over from internal to external processing. During that time, capacity constraints can lead directly to a decreased daily output of trucks."

And finally, for the LP element of standardization, the workshop participants most frequently raised the design of standardized material planning processes and system in the production network. The consequential reduction of heterogeneously grown processes and systems was expected to reduce efforts for maintaining software solution or manual workarounds. As 0-I-02 held: "I am convinced that through running less IT system in parallel, we will be able not only to reduce our costs of second and third level IT-support, but also to realize a positive impact for the training efforts of operations and IS representatives. I think operation representatives would call this economies of scale, right?"

The following table provides a summary of the main improvement points as observed in the business proposal and the conceptual design phase. In addition to that, I have added the respective business implications in a separate column.

LP Element	**LP & ERP improvements reflected in the to-be processes**	**Business implications**
Flow	Support of consumption-driven material planning strategies (e.g. initiating procurement proposals	=> A properly deployed pull system leads to a reduction of inventory and throughput time

	triggered by Supplier Kanban functionality for extending the pull principle to external suppliers (e.g. SAP JIT-Outbound functionality based on Kanban technology) Design of Just in Sequence (JIS) functionality for calling-off Vehicle Identification Number (VIN) -specific parts / part groups (e.g. SAP sequenced JIT call functionality) Reduction of deterministic MRP functionality to a minimum (e.g. using MRP to create long-term supplier forecasts for planning only; the delivery relevant call-offs are generated outside MRP	=> Reduced inventory / throughput time by applying a VIN-specific pull based JIS call-off => Reduction of push based material planning leads to a reduction of wrong material orders
People & teamwork	Reducing complexity of material planning processes and IT system landscape. Implementation of simple consumption driven planning methods. Reflection of all demand and stock levels in one system.	=> Increased collaboration and teamwork due to consistent and for all transparent data and through simpler processes => Reduction of manual search / verification / coordination efforts and reduced time required to switch between different applications
Quality First	Design of an early warning system for detecting potential material shortages or quality problems.	=> Decreased number of shortages at the assembly line, and in-house parts production areas.
Kaizen	Reducing complexity and enable parameterization of supporting system by the material planner instead of the IT department) Supporting a switch between external and internal processing of activities through applying a standard ERP process (e.g. SAP external processing functionality)	=> Increased productivity through rapidly improving / adjusting planning parameters and reduced effort for co-ordination with the IS department => Increased productivity and reduced costs by rapidly adjusting make-or-buy decisions

Standard-ization	Design of standardized material planning processes and system, in the production network. Reduction of heterogeneously grown processes and systems	=> Reduction of efforts for deploying and maintaining individual solutions/ manual workarounds (e.g. training efforts, system maintenance, helpdesk support, etc.)

Table 26: To-be process design improvements – material planning

However there were also conflicts between LP and ERP, which I observed during the workshops. The following paragraphs outline the most important points.

A frequently raised critical point with respect to the combination of LP and ERP was the questioning of the necessity for MRP at all. Mainly operations representatives argued that MRP impeded the application of simple and manual controllable methods like supplier Kanban. For instance 6-O-03 held an extreme position which, if less extreme interpreted, can be taken as representative for many operations group participants. He claimed that: "We should get rid of MRP at all. Otherwise I fear that many employees will misunderstand MRP as more comfortable than manually triggered supplier Kanban because with MRP the IT system appears to do the work for them. However the system is often wrong or not up to date as we know from our own experience. I think we need to make a clear cut here for our employees to understand the difference." In order to cope with this issue, we asked the question how to operate with parts with extremely unsteady and low volume demand patterns. Since these discussions revealed no feasible alternative method to some kind of deterministic MRP calculation, most participants accepted the need for at least some MRP for a limited group a part-numbers.

Another ERP and LP conflict was the fact that IS representatives denied that the operational employees were capable of the right system parameterization. For example 1-I-03 put it that way: "As long as we run IT systems here in the plant, operations employees relied on the IS department for properly setting the system parameters. I really doubt that the operations departments do have the proper personnel to suddenly take care of these partly technically sophisticated tasks." Similar arguments were also raised by IS representatives from other plants. We responded to this point by planning specific and sophisticated training streams for system parameterisation, guided by IS representatives and external consultants. Moreover, we set-up a number of prototyping sessions, in which the parameterization and customization possibilities could be experienced by the workshop participants. I found that particularly the practical experience of prototyping a process provided a significant contribution towards understanding the ERP's flexibility in terms of process adaptations or even larger process changes.

With respect to the LP element of flow, the most frequently discussed conflict between LP and ERP was that of applying consumption-driven methods for part-numbers with low volume and high variety demand patterns. Operations as well as IS representatives argued that for these part-numbers, consumption-driven methods could even lead to an increase of average inventory levels, or at the other extreme to material shortages. 8-O-05 made the following statement: "we do not have the space to store a minimum quantity for every theoretically potentially occurring part-number. Some parts are extremely exotic; they are required once or twice a year only. We could impossibly cater for these part numbers with a reorder point method or with a simple Kanban system." We reacted to this often and heavily discussed conflict by repeatedly stating that this point was one of the prime arguments for an integrated initiative combining both LP and ERP. Moreover the problem of call-offs with vehicle sequence, the so called just-in-sequence (JIS) process, was discussed heavily and was often seen as a conflict between LP and ERP. It was critically mentioned that the implementation of a just-in-sequence (JIS) process for calling of a group of vehicle related parts meant very complex non-standard IT programming in ERP. On the one hand, the process was often criticized as non-compliant to the LP element of flow. As 1-O-03 claimed: The JIS kits can't be simply called-off through a Kanban procedure. We need the detailed vehicle relation to be kept during the entire process from call-off to the receipt of an ASN, up to the receipt and line supply in our plant. In addition to that, we do not simply call-off single part numbers but a specific unique group of parts. Therefore we need a kind of header variable for the call-off. I do not see this as compliant to the flow procedures we discussed so far." On the other hand, participants have seen such a comprehensive IT-programming development as non-compliant to the LP element of people and teamwork, because it was not simple to maintain and not compliant to the initiative's objective of "as little IT as possible". After an intensive analysis comparing different realization alternatives, the decision was made to buy a specific software solution outside ERP for this functionality, which would be fully integrated into the ERP solution. However the trigger for the call-off was designed to be based on ERP's actual assembly line progress of the vehicles. By these means, we realize the pull principle while, in parallel, avoid the programming efforts and the consequential IT-maintenance issue. Most participants were pretty pleases with this new to-be process design and claimed that it meant a significant improvement for the business.

The following table provides a summary of conflicts and respective mitigation procedures for the macro process of material planning.

LP element	Conflicts LP&ERP	Mitigation procedure
People and Teamwork	LP representatives questioning the requirement for MRP at all	Exemplifying the case of forecasting and call-offs for parts with unstable and vehicle dependent demand patterns
Kaizen	IS representatives have considered the functional employees as not-capable of adjusting the proper parameters	Extensive training sessions and prototyping sessions for operations employees for all new parameterization possibilities
Flow	In case of low volume and high variety parts, consumption-driven methods could lead to additional inventory / shortages IT Requirements for implementing an "OEM JIS-Outbound" solution is rather complex and not available off-the-shelf available	Detailed workshop stream for an analysis of the historic demand patterns of all part-numbers. Integration of a separate standard tool for handling JIS outbound call-offs

Table 27: LP & ERP conflicts and mitigation procedure – material planning

4.3.4.4.2 Lean-ERP Assessment – Material Planning

Figure 36 has illustrated that the macro process material planning was rated relatively low for the as-is situation with 37%, but relatively a high with an average lean-ERP rating of 84% for the business proposal phase and 77% for the conceptual design phase. This was by far the highest spread between the as-is and the to-be ratings for all macro processes in scope. The following figure breaks down the lean-ERP assessment of

figure 36 into the average ratings of the LP elements.

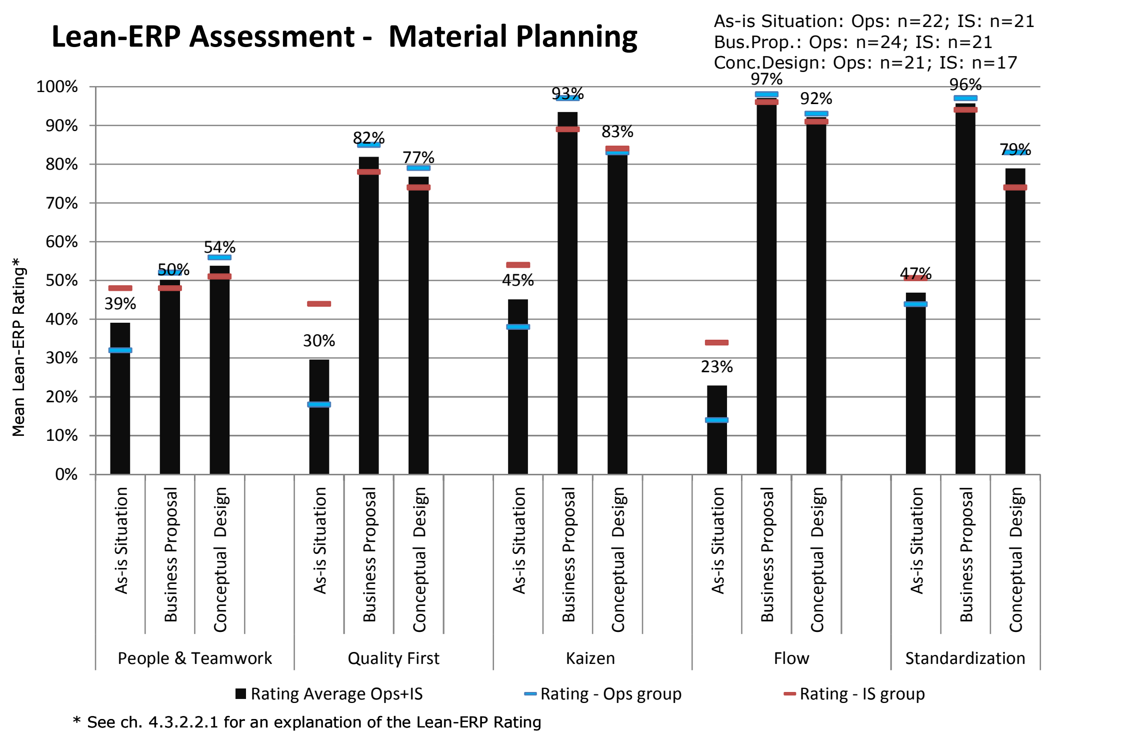

Figure 42: Lean-ERP assessment material planning

On the one hand, the LP element of flow was given the highest average to-be design ratings of all LP elements for the macro process material planning. This was particularly interesting because this LP element received the lowest as-is analysis ratings. In fact, the discrepancy of 69% between as-is analysis and conceptual design rating was the highest of all the LP elements for all macro processes in scope. With reference to my qualitative workshop observations, this rating was in-line with the discussions in the to-be process design workshops. The current IT systems appeared not to support any kind of pull based material planning processes. According to unstructured interviews with 1-O-02, 1-O-03, 1-I-01 and 1-I-02 I found that both the operations and the IS representatives considered the step towards pull oriented material planning processes reflected by ERP as a major synergy between LP and ERP and a significant business improvement potential. In this respect, 1-O-02 made the following statement: "The shift from push to pull cannot be emphasized high enough. It means a quantum leap for the entire plant logistics. ERP helps us to roll-out and manifest the pull principle in the entire plant."

On the other hand, the LP element of people and teamwork received the lowest to-be design ratings, though there was a slight improvement trend between the as-is situation, the business proposal and the conceptual design ratings. Referring to the qualitative observation results as described in the section above, I deduced that the low ratings reflected the apparent conflict, which was seen between ERP-based material requirements planning processes and the LP objective of replacing complex IT with simple manual procedures. Despite the fact that we explained the necessity for IT calculation by frequently exemplifying the case of part-numbers with low volume and unsteady demand patterns, the participants still saw considerable room for improvement after the conceptual design phase with respect to the LP element people and teamwork.

All of the other LP elements' to-be design ratings were on a relatively high level. According to table 13, the to-be design ratings could be interpreted to display a range between little and no room for improvement.

Another point worth mentioning is the difference between the business proposal and the conceptual design phase ratings, particularly for the LP element standardization with a drop of 17%. According to the workshop observations, the participants often realized during the conceptual design phase that not all of the high standardization objectives could be put into practice on a one to one basis. As an example we can take the case of the engines production plant. Apart from series engines for trucks and buses, this plant also produced engines for the marine sector. The marine engines were not only bigger and technically more complex, their demand patterns were also characterized by a higher product variance and a lower volume compared to the series engines. Moreover, the throughput time of a marine engine could be up to 2-3 weeks, whereas a series engine was produced within several hours. Another point was that the customers for marine engines often brought in late configuration changes. As a consequence of all these differences, the material planning for this part spectrum could not be handled similar to that of the series engines. In particular, supplier Kanban and reorder point-based call-offs were only applied for a very limited part spectrum and instead, deterministic MRP planning had to be applied for an extensive part-number spectrum in the case of marine engines production. During the business proposal phase, the detailed requirements of the marine engines production were not analysed on such a deep level. It can be assumed that it was due to effects like the one described above, that the conceptual design phase ratings for standardization were at a lower level than for the business proposal phase.

4.3.4.5 In-house parts production

This section deals with the to-be business process design for the macro process in-house parts production. Again I have split the section into an overview of the to-be process design and a qualitative evaluation thereof, and the Lean-ERP assessment results.

4.3.4.5.1 To-be Process and Qualitative Evaluation

This section outlines a to-be process overview and the qualitative evaluation of the macro process in-house parts production. The following figure illustrates a graphical overview of the in-house parts production in the context of the material flow from the warehouse to the vehicle assembly.

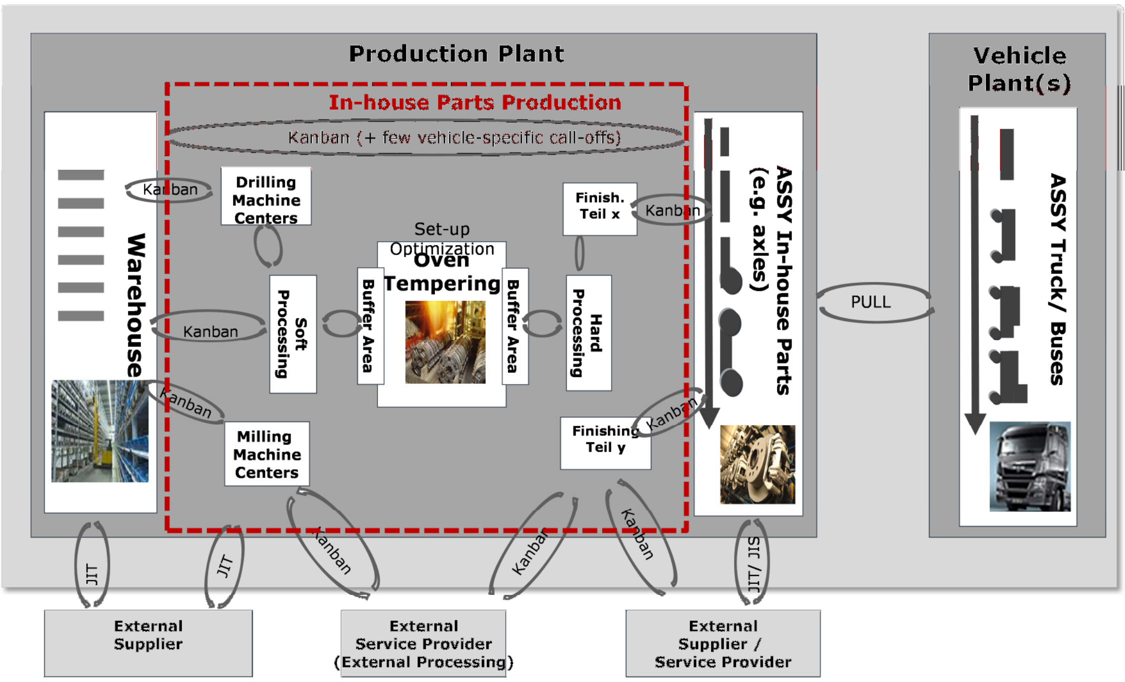

Figure 43: Process overview in-house parts production

The figure above relates to the LP element flow with respect to macro process in-house parts production. The entire material flow to, from and throughout the in-house parts production was designed towards pull orientation. The in-house parts production is split between a so-called soft-processing area before tempering in an industrial oven and a so-called hard-processing area after tempering. Starting on the right hand side, the vehicle assembly triggers the assembly of in-house parts based on an order related pull signal. The in-house parts assembly is connected via control cycles to the in-house parts production. In fact the in-house parts assembly triggers the hard-processing of the required in-house parts; either based on the drop of assembly buffer levels below re-order points and/ or based on manual scans of Kanban cycles. Then the parts consumption during the hard-processing triggers the goods issue of parts from a buffer area after the industrial oven. In this context it is worth mentioning that the processing areas are decoupled from the industrial oven by buffer areas in order to decouple the small batch sizes of the processing areas from the relatively large batch sizes of the industrial oven. Then the drop of the inventory levels in the buffer areas triggers the tempering and, in turn, the soft-processing of parts in order to feed the industrial oven. Finally the consumption of parts during soft-processing triggers the picking processes in the warehouse, again based on pull signals generated by manual scans or the drop of stock levels below reorder quantities. In addition to that, external suppliers and service providers are linked into the pull system by connecting them via JIT / JIS call-offs. By this means, the ERP system has been designed to generate or process manually generated pull triggers and forward the signals to the preceding work centers or buffer areas. For the entire material flow ERP keeps track of the flow inventory throughout the various work centers and buffer areas. I observed that the majority of both operations and IS-representatives appeared to be satisfied with the new process design and particularly with the possibilities brought about by the integration of LP and ERP. In this context 1-O-06 made the following statement: "The new process design is really a huge step in the right direction towards LP, supported with the tools of ERP. Before this initiative I was not aware of the possibilities ERP offers for realizing lean processes. Particularly the pull oriented functions like ERP Kanban control cycles and just in time should bring significant improvements for our day to day operations."

As far as the LP element of people and teamwork is concerned, the to-be processes were designed to support an increased transparency of the in-house parts production. In this context an in-house parts production cockpit was designed, in which all relevant data could be viewed in one place. On the one hand, this referred to the status of production orders. Through an increase of so called backflushing points after the various activities, the status of each production order could be tracked. On the other hand, more backflushing points led to higher inventory accuracy because the ERP-based consumption of parts was more in line with the real consumption. Moreover manual scans for initiating material replenishments and inventory movements were expected to lead to more detailed and accurate inventory records compared to the as-is situation.

With respect to the LP principle of quality first, the participants designed ERP supported quality checks at certain predestined points in the processes. For instance after tempering the parts in the industrial oven the parts were designed to be checked more systematically than in the as-is situation. ERP supported this process through triggering quality checks based on sampling rules and statistical procedures. In this context, 6-O-06 held that: "ERP helps us to realize Jidoka by supporting reliable quality checks within the processes. Moreover the system cannot be cheated; that is, it won't allow you to continue without entering the quality check results. In addition to that, with entering the quality check results the user-ID is automatically saved into a database table. This is exactly what was required in order to force more discipline into this process."

Regarding Kaizen, the possibility to manually switch from batch oriented production to repetitive manufacturing strategies was frequently raised as a possibility towards supporting continuous process improvements. The repetitive manufacturing process for in-house production can be described as a relatively lean process with only little master data and IT posting requirements. It was developed for high volume parts with very similar processing steps and a steady demand pattern. 3-O-06 put it that way: "Even though we do not use it intensively at the moment because our products are too diverse, repetitive manufacturing will definitely become a lean option for the future. With respect to the current modular product engineering strategy, it is very likely that we will have fewer variants of in-house parts in future. The new process allows us to move into the direction of repetitive manufacturing part by part."

With respect to the LP element standardization, I observed very similar discussions as for most of the other macro processes. The most frequently raised improvement point was the design of standardized processes and systems in the production network. The background was that the in-house parts production processes were turned out as extremely heterogeneous along the production network. As for the other macro processes, the participants expected economies of scale in terms of education, training and IT maintenance, as well as improved flexibility to deploy workers across the production network.

The following table summarizes the main LP and ERP improvements for each of the LP elements as observed in the process design workshops. Furthermore I added the main business impact expected by the participants.

LP Element	LP & ERP improvements reflected in the to-be processes	Business implications
Flow	Design of pull principle between activities within one routing (e.g. consumption-driven trigger of downstream activity) Pull principle for triggering the start of production for in-house parts (e.g. using ERP supported Kanban)	=> Reduced inventory and throughput time through applying pull for high-runners => Reduced inventory and throughput time through applying pull for high-runners
People & teamwork	Increasing transparency of in-house parts production in terms of production orders and material flow (Implementing an in-house parts production cockpit)	=> Reduction of manual search efforts for shortage parts by displaying all kinds of information required in one screen => Intensified and more target oriented interaction between employees
Quality First	Design of ERP-supported quality checks between activities aiming at the design of internal customer supplier relationships	=> Earlier detection of quality problems leads to lower correction efforts / scrapping costs
Kaizen	Application of ERP-based repetitive manufacturing strategies for in-house production of high-runners	=> Reduced efforts to maintain the requirements for and process individual costing (e.g. efforts for preliminary and final costing on individual vehicle basis)
Standard-ization	Design of ERP based plant network wide standards for in-house parts production	=> Economies of scale for training and increased flexibility for employee deployment

Table 28: To-be process design improvements – in-house parts production

In addition to the above mentioned improvements, I also observed conflicts between LP and ERP. The following paragraphs outline the main points.

Mainly concerning the LP element people and teamwork, participants were generally questioning the need for ERP support for in-house parts production. They claimed that the interaction and cooperation between the employees would be higher without ERP because people were forced to talk to each other if they wanted to do their job. We reacted by initiating a workshop stream for planning an IT-free in-house parts production including operations, IS and finance representatives. Starting from an IT-free production and adding step-by-step only the necessarily required IT functions.

With respect to the LP element flow, the required scans for material flow tracking turned out as a conflict area between LP and ERP. Particularly IS representatives had interpreted the necessary scans as non-value adding activities because the scans did not add any value for the customer. Moreover 1-I-02 argued that: "it is better to omit the IT reflection of a status point instead of setting up a status point for which the required scans cannot be carried out consistently. As a matter of fact, according to the author's experience many clients tend set-up too many tracking points in the design phase only to realize during the live operation that the additional scans really mean additional workload for the employees. Moreover, the required discipline to properly carry out all scans is often an issue for companies. We reacted to this apparent conflict by advising a reduction of the scans to an absolutely necessary minimum. Many workshops with both operations and IS employees were necessary in order to derive a final definition of status points for each material flow throughout in-house parts production.

Another flow related issue was conflict between the LP objective of low batch quantities and the still traditional objective of increased machine utilization. We reacted to this commonly raised issue by referring to the results of the LP game played in the kick-off workshop. We particularly presented the results which had shown that a lower batch size can contribute to higher output of finished goods while piling up less WIP inventory.

And, operations participants like 1-O-04 criticized that the time required for ERP-based quality checks could slow down the flow of material and, in consequence, increase the average throughput time. We reacted by commonly defining the number and scope of ERP-based quality checks together with operations and IS representatives. As in the case of the status point scans, we recommended a limitation of the quality checks to an absolutely necessary minimum according to the principle as few as possible and as many as necessarily required.

The following table provides a summary of conflicts and respective mitigation procedures for the macro process of in-house parts production.

LP element	Conflicts LP&ERP	Mitigation procedure
People and Teamwork	Questioning the need for ERP support at all for in-house parts production, particularly for high runner parts.	Initiation of a workshop stream for discussing the effects of reducing the amount of IT support for in-house parts production.
Flow	Required scans for material flow tracking interpreted as waste / non-value adding. One peace flow - costs of lower machine utilization due to consumption driven pull. Time for ERP-based quality checks can impede the proper flow of material and increase the average throughput time.	Reduction of required scans to an absolutely necessary minimum, definition in a joint workshop with operations and IS employees. Reference to LP game played during the kick-off workshop. Commonly defining the number of ERP-based quality checks together with operations and IS representatives.

Table 29: LP & ERP conflicts / mitigation – in-house parts production

4.3.4.5.2 Lean-ERP Assessment – In-house Parts Production

According to

figure 36 the macro process in-house parts production was given a similar LP assessment pattern as the macro process material planning. The average as-is analysis ratings can be considered as indicating large room for improvement and the average ratings after the business proposal and after the conceptual design left only little room for improvement. The following figure breaks down the lean-ERP assessment of

figure 36 into the average ratings of the LP elements.

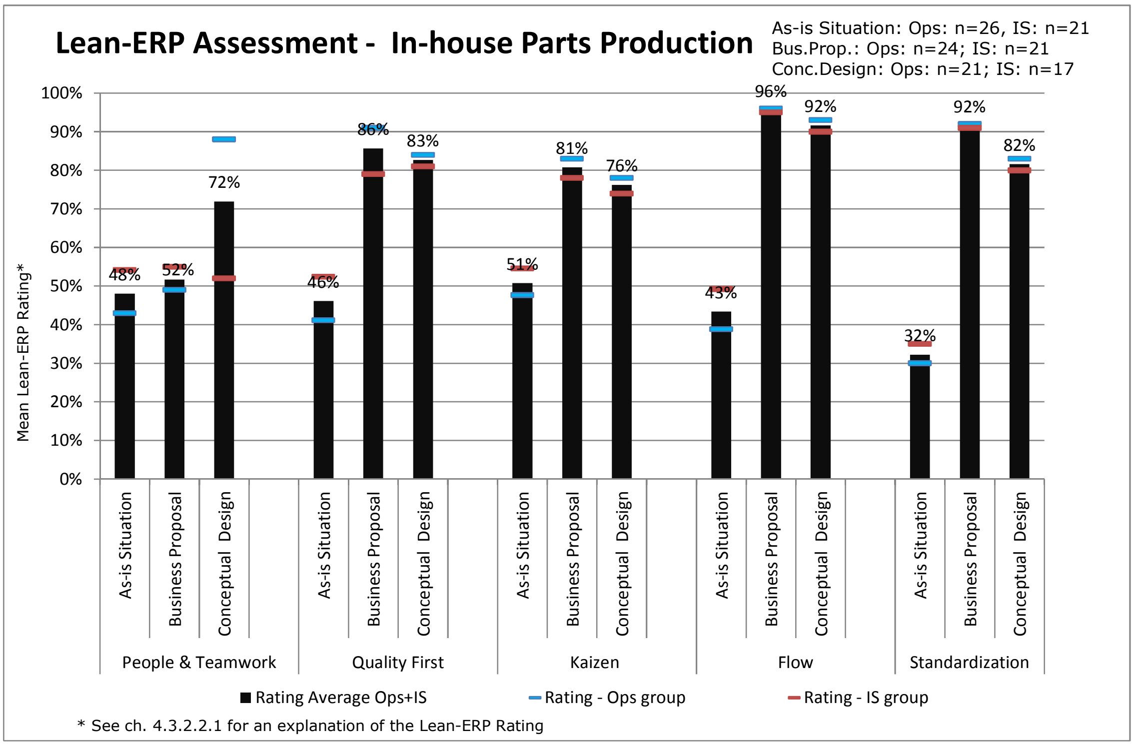

Figure 44: Lean-ERP assessment in-house parts production

The LP element flow received the highest ratings for the to-be process design regarding both the business proposal and the conceptual design phase. Also the spread between the as-is and the to-be situation reflected relatively high improvement step. These results are corresponding with my qualitative workshop observations as described in the section above. The design of pull-oriented processes was the most commonly discussed to-be design improvement, which could be realized through the integration of LP and ERP. Not only the triggering of material replenishments from internal warehouses and via JIT/JIS from external suppliers, but also the triggering the start of production orders according to the pull principle were the most commonly mentioned improvements in this area. According to the workshop observations, I have reason to assume that these were the major improvements, which led to the comparably high ratings. The conflicts as mentioned in the previous section appeared not to have a considerable impact for the to-be design ratings. As I learned from a couple of unstructured interviews after the lean-ERP assessment the intensive workshops to define the number of ERP reflected status points and the refreshing of the LP game as argument for lower batch sizes had a positive effect on the ratings. For instance, 1-O-04, 1-O-

06, 1-I-02 and 1-I-04 pointed out that they would have given a lower rating without these measures.

The lowest to-be design ratings were given to the LP element people and teamwork. As outlined in the section above, participants tended to question the need and the value of ERP with respect to teamwork and collaboration. Many participants like 1-O-04, 6-O-04 and 7-O-04 saw a conflict between the IT related processes and the human improvement cycles and manual production control like the Andon Board in LP (see chapter 2.1.3.3.3). After the business proposal phase we set-up a specific workshops series to discuss the effects of decreasing the amount of IT support for in-house parts production (see section above). Though this has contributed to an improved rating after the conceptual design phase, the rating of 72% was still the lowest amongst the LP elements. Looking at the spread between operations and IS representatives, the improved rating between business proposal and conceptual design only applied to the operations group. From unstructured interviews after the lean-ERP assessments with participants like 1-O-04, 1-O-06 , 1-I-02 and 1-I-04 I found out, that whereas the operations representatives were very satisfied with the workshop series, the IS representatives appeared not like the discussions about a reduced IT support.

Looking at the trend in the evaluation after the business proposal and the conceptual design phase, apart from people and teamwork all LP elements realized a slightly lower ratings after the conceptual design phase. With a decrease of 10%, the LP element standardization realized the highest drop. I observed that for some processes the high standardization levels could not be maintained for the entire production network. An example is the engines production plant, which had specific requirements for the material planning of equipment and tools. The reason was that the engines plant had by far the highest amount of in-house parts production. The respective planning of tools and could not be handled manually as in the other plants. Therefore a separate IT-tool had to be linked-up for this local requirement.

4.3.4.6 Goods Receipt

This section focuses on the to-be business process design for the macro process goods receipt. First I provide an overview and a qualitative evaluation of the to-be process design. Then I deal with the lean-ERP assessment results.

4.3.4.6.1 To-be Process and Qualitative Evaluation

This section focuses on the to-be process overview and the qualitative evaluation of the macro process goods receipt. Figure 45 presents a comparison of the to-be process design with the as-is situation for the macro process goods receipt. The as-is situation is illustrated on the left hand side. As symbolized by the grey area, the material flow before the unloading zone is in the as-is situation not reflected in any IT-system. Moreover, there was only one central unloading point, unsteady incoming deliveries and occupied unloading zones due to the clarification of delivery deviations when unloading. These points were already summarized in the as-is analysis sessions (see section 4.3.3.7).

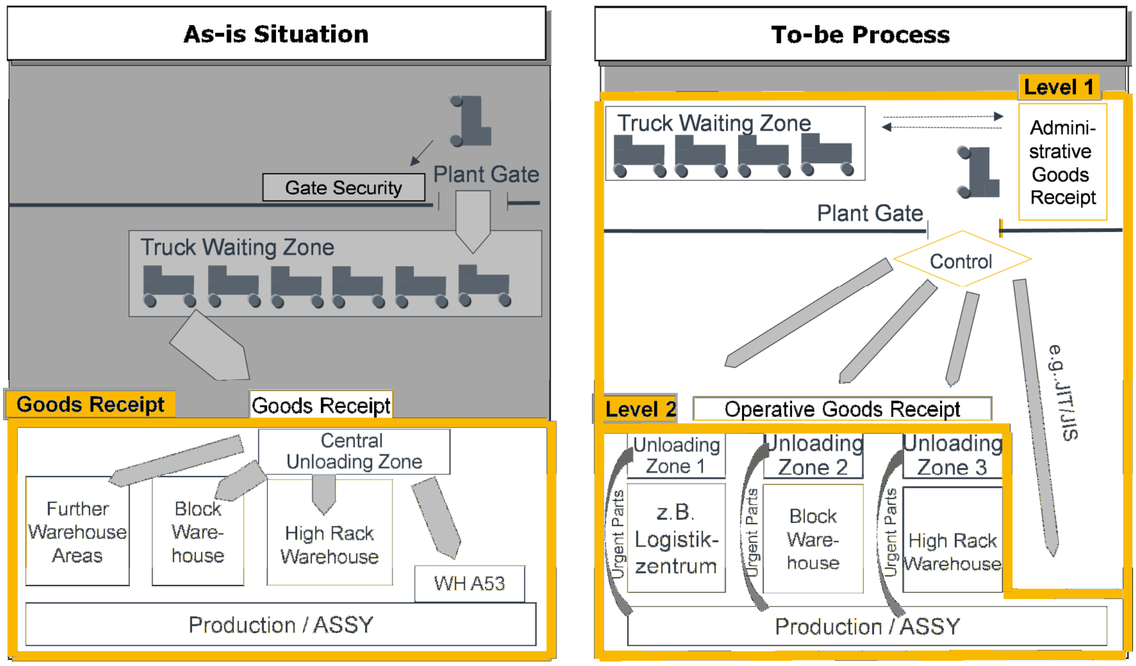

Figure 45: Process overview goods receipt

The to-be process, on the right hand side, consisted of a two-step goods receipt process. The first step is being carried out at the point of time when the truck arrives still outside of the plant. The driver needs to register at the plant gate and the first step, the so-called administrative goods receipt is being performed right there. The delivery papers and / or ASN data are compared with the actual call-offs. In case of deviations, the truck was not allowed to enter the plant. Apart from that, the administrative goods receipt finally determined the decentralized unloading points, checked the goods for urgent parts and makes a posting in the system in order to change the status of the goods to “in plant” in ERP. At that point of time, everyone in the plant could actually see in ERP that the parts received the plant but were not yet unloaded. After that, assuming the checks were successful, the truck was allowed to directly go to the first unloading point. Depending on whether the truck contained urgent parts, which were defined by the material planners, the truck was either routed directly to the production area where the urgent parts were required or to one of the unloading points at the warehouses. The unloading of the truck was equivalent to the second step of the goods receipt process, also referred to as operative goods receipt. After quantity and quality checks, the goods receipt posting was carried out. This step eventually led to an increase of the inventory records of the plant in ERP and triggered the put-away process, which was allocated to the warehouse management macro process.

Concerning the LP element of flow, I observed that the participants appeared to be largely pleased with the new processes. As 1-O-04 pointed out: "If we manage to realize also the required organizational changes like enlarging the plant gate building, the new processes will improve almost all of our current material flow weaknesses. I expect even a decrease of missing parts at the assembly lines due to the warehouse bypassing function for urgent parts." Moreover, 3-O-02 claimed that: "The process might cause addition workload at the administrative goods receipt. But I am convinced that these efforts will be more than balanced by the logistics savings through direct routing of the trucks to decentralized unloading points. In addition to that, I expect less traffic in the plant." According to my observations, not only the other operations representatives but also the IS group appeared to agree to these statements.

Concerning the LP element of people and teamwork, the main improvement topic discussed with respect to combining LP and ERP was increased the material flow transparency through two-step goods receipt process. Particularly the additional status "in plant" was considered to decrease the grey area in which the employees did not have information of the status of incoming shipments. In this respect, 1-O-04 made the following statement: "If we make proper use of the additional information, we should even be able to reduce the number of missing parts at the assembly or in-house parts production. In case of a shortage we can find out whether the truck is already at the plant premises. If yes, we can adapt the sequence of trucks to be pulled into the plant in favor of the truck with the missing parts." This view was shared amongst most of the participants in the workshops.

With respect to the LP element of quality first, I observed that the participants saw a connection between the ratios of electronically received advanced shipping notifications (ASNs) and the quality of the data on the inbound material flow. 3-O-04 explained it that way: "If we do not receive an electronic ASN we have no other choice than to manually enter the data of the delivery note into the system. However this is an extremely error-prone process which often leads to issues at downstream processes like the warehouse put-away." Moreover it was established during the process design workshops that ERP and the LP element quality first generated a business benefit through statistically supported quality checks at goods receipt. With the use of sophisticated statistical algorithms, it was expected that the inbound quality checks could be carried out more target oriented. As a consequence the quality control effort was expected to decrease while the impact of the quality checks was supposed to remain constant or even to improve. According to the predominant viewpoint of the participants in the design workshops, the number of non-conforming parts in the plant was expected to decrease as a result. 1-O-04 explained: "At the moment we do not have the resources to manually calculate the statistics for sample audits for each material number several times a year. Instead, we often create a best guess rule based on our experience with the supplier. There must be a massive potential to allocate our quality audit personnel more target oriented on such part-numbers and/ or suppliers, where we really face severe problems. If ERP provided the mathematical tools to sharpen the scope and target of our quality inspections, we should be able not only to reduce our effort, but also to increase the average quality of parts inside the plant."

With respect to Kaizen, the to-be process improvement in terms of enlarging the proportion of electronically sent advanced shipping notification (ASN) can be summarized as the major point according to my observations. Currently the entire goods receipt team is heavily under strain, not at least through a big proportion of manual data entering for suppliers without electronically sent ASN data. Many plant representatives argued that due to this workload they actually lacked the necessary capacity for improvement initiatives. Now the expected improvement in the to-be process was that the capacity currently tied-up in dull data entering for inbound deliveries could be relieved from this work through increasing the proportion of electronically transferred ASNs. In this respect, a web-supported supplier portal was designed in order to link up suppliers delivering too little volume to justify setting up an EDI connection. 1-I-03 made the following point in this respect: "Our biggest problem is the 80% of suppliers who are delivering only 20% of the goods received in one year. The volumes are often so low that the set-up of an EDI Link would not make sense. The supplier portal is the perfect tool to tackle this issue. We can force the suppliers to either enter the shipped data or to pay an additional fee for our goods receipt staff to do that. I am convinced most suppliers will take the first option."

Concerning the LP element standardization, I have observed that apart from the production network standardization as for most of the macro processes, business benefits were also expected by standardizing the goods receipt processes within the plants. The reason was that in the as-is situation there was a massive difference between the process for internal deliveries from plants of the client's production network and for deliveries from external suppliers. As 3-I-02 explained, the process differences came from different IT systems reflecting the internal and the external inbound deliveries. However, 2-O-04 held that another reason was that the formal quality check procedures for internal inbound deliveries were defined to be less strict and encompassing as for external inbound deliveries. He further claimed: "ERP should be the right tool to set-up one standard process valid for all kinds of inbound deliveries. Why should we support two different processes if we talk about internal customer-supplier relationships all of the time. In this context ERP could support the LP element standardization by forcing the adherence to the new process in the entire production network. The danger of falling back to old processes can be excluded with the newly designed standard ERP process. The reason is that you simply do not have another choice than to follow the standard process if you wanted to proceed with the next process." 1-I-01 continued: "Furthermore we must not forget the reach of ERP for all our plants. Without this enterprise wide reach the compliance to the standard process could be hardly guaranteed by manual means."

The following table provides an overview of the main LP and ERP improvements for each of the LP elements as observed in the process design workshops. In addition to that I added the main business impacts as expected by the participants.

LP Element	LP & ERP improvements reflected in the to-be processes	Business implications

Flow	Implementation of a goods receipt process allowing for separate unloading points per plant Administrative goods receipt in order to carry out all system and paper based checks before the truck enters the plant Implementing ERP pull processes to level the material flow (e.g. Supplier Kanban).	=> Reduced logistics efforts due to direct routing of trucks to decentralized unloading points => Shorter average unloading times, less queuing at the unloading points and reduced truck traffic in the plant => Smoother material flow throughout the plant with less queuing at the bottlenecks
People & teamwork	Increased material flow transparency through two-step goods receipt process with additional status "in plant"	=> Reduction of manual efforts for determining the detailed location of goods => Increased material availability due to possibility to react earlier
Quality First	Increasing the ratio of suppliers electronically transferring an advanced shipping notification (ASN) via EDI ERP supported quality checks at goods receipt	=> Reduction of efforts to correct process errors in downstream processes => Increased quality of purchased parts in the plant and sharpened efforts for quality insurance measures
Kaizen	Increasing the ratio of suppliers electronically transferring an advanced shipping notification (ASN) via EDI or through a newly designed web-based supplier portal	=> Reduction of efforts for manually entering data in the goods receipt process leading to free capacity for Kaizen improvement cycles
Standard-ization	Standardization of goods receipt process for external and internal shipments from other plants in the production network	Synergies and economies of scale for the goods receipt processes

Table 30: To-be process design improvements – goods receipt

Next to the improvements as presented above, I also observed conflicts between LP and ERP. The following paragraphs provide an outline for the macro process goods receipt.

In terms of the LP element people and teamwork, the participants mainly criticized the fact that the procedures carried out in the first step of the newly designed goods receipt process was likely to require a larger headcount at the plant gate office, which was seen as waste according to LP. We have actually confirmed the appropriateness of this critique because it was in line with our own experience for similar cases. However the majority of the workshop participants expected that the savings of efforts in downstream processes would more than compensate for the additional workload at the administrative goods receipt. As 6-O-04 pointed out: "All the issues we need to clarify in the first step of the new process are things we would have to clarify anyway, at the latest at the point of unloading the truck. However at that point of time the clarification causes much more disturbance that when the truck still waits outside the plant. If you ask me, we only talk about a shift of effort from the unloading zone to the more appropriate location of the plant gate." For the to-be process design, we have outlined an organizational measure to actually shift personnel from the unloading zone to the plant gate office.

Another point which was seen critical with respect to combining LP and ERP was the issue of ERP supported and strictly forced quality checks. Participants like 3-O-04, 2-O-02 and 2-O-04 feared that in case of crises, for instance line stoppages due to material shortages at the assembly line, such strictly forced quality checks might further delay the line supply. They argued that in such a case, the parts simply needed to be transferred to the line as quickly as possible, in emergency cases also without a quality check. The group reacted by setting-up an emergency scenario, in which only the head of department or his deputy were allowed to overrule this strict quality check procedure.

And, finally participants argued that standardized processes for internal and external deliveries might impede the possibilities for improvements. As 7-O-04 pointed out: "Whereas in the past we could make improvements to the internal goods receipt independently, we now need to consider also the impact on the external goods receipt process. I fear that this will decrease the speed of our continuous improvement initiatives." Other participants generally agreed to this point even though they also saw an advantage in the argument. As 1-O-02 pointed out: "On the other hand, if you have only one common process between internal and external inbound deliveries and you consider both the impact for internal and external suppliers, any improvement you make should have a double impact. This is also a contribution towards LP and efficiency, isn't it?"

The following table summarizes the main conflicts as observed for the macro process of goods receipt. In addition to that I have outlined the mitigation procedures.

LP element	Conflicts LP&ERP	Mitigation procedure
People and Teamwork	More personnel required for the first step of the new process; the administrative goods receipt	Shift of personnel from downstream processes to the administrative goods receipt
Flow	ERP forced goods receipt checks could lead to blocking of the inbound material flow	Design of a possibility to bypass the quality checks in a severe crises, however only for the head of department
Kaizen	Standardized processes for internal and external deliveries were expected to decrease the possibilities for improvements because of interdependencies	Encouraging improvement cycles to consider both the internal and the external case when searching for improvements

Table 31: LP & ERP conflicts and mitigation procedure – goods receipt

4.3.4.6.2 Lean-ERP Assessment – Goods Receipt

Concerning the overall ratings as illustrated in

figure 36, the macro process goods receipt was given a to-be design rating, which can be interpreted as indicating only little room for improvement. For comparison, the as-is analysis rating was indicating between large and considerable improvement potential. In other words the participants have committed a noticeable degree of improvement between the as-is situation and the to-be design, though not exactly on the same level as for the macro processes of material planning and in-house parts production. The following figure breaks down the lean-ERP assessment of

figure 36 into the average ratings of the LP elements.

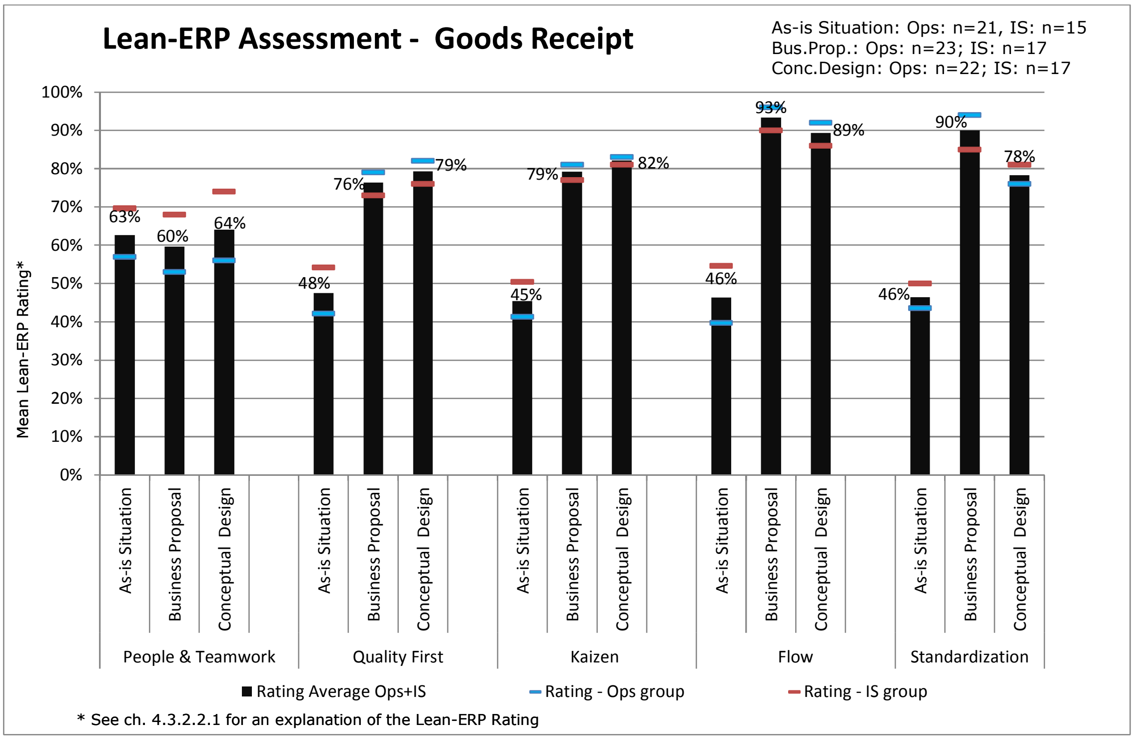

Figure 46: Lean-ERP assessment goods receipt

As for the two preceding processes, the LP element of flow received highest average to-be design ratings amongst the 5 LP elements. This result mirrored the qualitative observation results as described in the section above. According to the workshop observations and the findings of unstructured interviews with 4 workshop participants from the operations and 4 from the IS group, we have reason to deduce that particularly the routing of trucks directly to decentralized unloading points and the administrative goods receipt at the plant gate had remarkably contributed to this massive improvement step from 46% to 93/89% respectively. The LP and ERP conflict of the quality checks as described in the previous section appeared not to have a significant impact on the ratings. As I have realized during the workshops, the designed mitigation method of allowing overruling the strict quality check requirements in ERP has eased the fear of material flow interruptions.

Again the LP element people and teamwork received the worst to-be design ratings. In fact there was no substantial difference between the assessment of the as-is analysis and the to-be design with respect to this LP element. In summary, the fear of increased capacity requirements for the additional tasks at the plant gate office appeared to balance the advantage of increased transparency of the material flow through the additional status "in plant".

The LP elements quality first and Kaizen received relatively similar lean-ERP assessment patterns. There were noticeable improvements between the assessment of the as-is situation to the to-be design, but almost no change between the business proposal and the conceptual design assessment. For both elements, the point of increased electronic data exchange from suppliers to the client played a major role in the assessment.

Finally the LP element standardization received the second highest to-be design ratings after the business proposal phase and dropped slightly after the conceptual design phase. As I have learned from the process design observations, the processes between internal and external inbound deliveries could be adapted to each other, but they could not be made equal completely. The reason was specific accounting requirements for the posting of internal inbound deliveries, which had a certain impact on the logistics processes. According to my workshop observations I have reason to assume that this was at least part of the reason for the lower conceptual design ratings.

4.3.4.7 Warehouse Management

This section deals with the to-be business process design for the macro process warehouse management. Again I have split the section in two parts. In the first part I provide an overview and a qualitative evaluation of the to-be process design. In the second part I focus on the lean-ERP assessment results.

4.3.4.7.1 To-be Process and Qualitative Evaluation

This section describes the to-be process and the qualitative evaluation of the macro process warehouse management. The following figure illustrates a graphical overview of the macro process, focusing on the material flow.

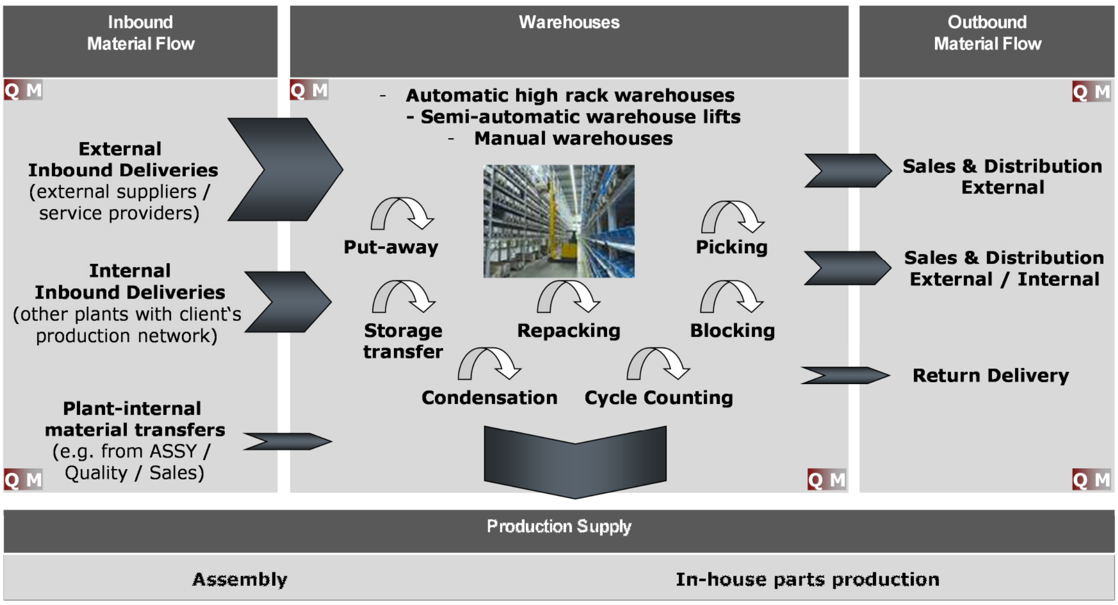

Figure 47: Process overview warehouse management

The material streams can be differentiated between the inbound material flows, movements within the warehouses, and the outbound material flows. The major inbound stream is inbound deliveries from external suppliers, followed by the stream from other plants within the client's production network and finally the plant-internal stream. Within the warehouses, processes like put-away, transfer of parts between warehouses and / or warehouse locations, repacking, cycle counting, blocking of storage units and picking had been designed. Moreover the process of condensation was heavily discussed within the workshops. By condensation the workshop participants understood the maximization of the warehouse utilization degree by filling-up partly filled stock-keeping units with parts stored somewhere else in the warehouse. The proponents of condensation like 1-O-04, 4-O-04, 5-O-04 and 8-O-04 argued with respect to the enhancement of the overall warehouse capacity, which was supposed to save investments into new warehouses. On the other hand opponents like 0-O-03, 1-O-01 and 3-O-01 argued against the process due to the additional goods movements and handling efforts required for the condensation processes. They considered the additional efforts as a contribution towards avoiding waste in terms of LP and held that normally the parts should not be repacked or refilled at all within the plant. If this was the case, they argued that the packing sizes from the suppliers had to be adapted. However the proponents pointed out that it was not always possible to change the delivery packing sizes and that for some part-numbers we needed different packaging sizes within the plant. The IS representatives did not express a strong meaning on this issue. After long and intensive discussions, the compromise was to apply system-based condensation processes in the fully-automatic warehouse areas only, but to omit this process in all semi-manual and manual warehouse areas. The other warehousing processes had been designed according to the pull principle as far as possible. For instance all of the replenishment transactions from central to decentralized warehouse areas were triggered by pull signals, as well as most of the outbound material flows (see section 4.3.4.8). In summary the majority of the participants expressed that they were satisfied with the to-be process design in terms of realizing the LP element of flow.

Concerning the LP element people and teamwork, the participants saw integrative LP & ERP improvements for employees through the support of manual processes. As an example, the participants most commonly referred to spreading out the use of scanner technology. 2-O-04 put it that way: "Currently we have many warehouse areas in which the warehouse staff manually notes warehouse movements on paper and then someone in the office enters the data into the system. This is surely all but lean. Apart from the avoidable manual efforts, we face many errors not only when making the manual notes, but also when entering the notes into the system. Often the back-office staff just have problems to properly interpret the handwriting. This is one of the points, whereby the new ERP systems with its certified interfaces to state-of-the-art scanner technology can support us to get rid of the wasteful manual transactions and to improve our productivity." Another improvement heavily discussed and considered in the to-be process design was the unique database as an enabler for encouraging teamwork and collaboration activities. Participants expected that the potential of misunderstandings and the productivity of communication and collaboration were much higher. 1-O-04 held that: "Instead of clarifying misunderstandings due to inconsistent databases, the communication can focus on the actual issues on the shop-floor."

With respect to the LP element quality first, the full integration of all warehouse management relevant processes in one central ERP system was considered as one of the major improvements in this area. In fact even external automatic warehouse management systems could be fully integrated in ERP. As a consequence of the high level of integration, the number of interfaces between warehouse and inventory management systems decreased considerably. Since these interfaces have proven as the primary error sources in the current situation, the workshop participants expected less data inconsistencies and therefore improved process quality in the warehouse and in the subsequent processes. Moreover an increased number of consistency checks in ERP were also considered to contribute to this improvement. The interruption of ERP processes in case of wrong data entries or data other inconsistencies as early as possible in the process was interpreted as a means to realize the Jidoka principle by many operations representatives. 6-O-04 explained in this respect: "If you ask me, the employees will damn the system for the strict data entry requirements at the first place. But I am definitely convinced, taking the broader view, this will contribute significantly to improve our overall process quality."

As far as the LP element Kaizen was concerned there were three main points discussed in terms of process improvements supported by the integration of LP and ERP. First the participants considered the utilization of ERP supported heuristics for warehouse storage structure improvements in order to reduce the average time for storage transfers. Another point was the design of flexible and easy to change warehousing processes in order to allow for a quick realization of Kaizen improvements. And the participants emphasized the multiplier effect for realized improvements through company-wide standardized processes. For instance, 4-O-04 claimed in this respect: "Having realized a process improvement for one plant in ERP, it is immediately available to eight plants in the production network. This means a multiplying factor of 8 for the cost reductions or productivity gains associated with the improvement. To me this is one of the clearest synergies between LP and ERP."

Concerning the LP element standardization, apart from the usual point of production network standardization, the integration of inventory management and warehouse management turned out as the main to-be design improvement as designed by the participants. 1-I-03 explained it that way: "Currently we are using two different systems in order to reflect our inventory. First we have a so-called inventory management level, which is connected to the finance applications for all finance relevant posting associated with material movements like goods receipts of goods issues. And we have the more detailed level of warehouse management, which is not connected to the finance applications and reflects the goods movements on a bin location level. These two levels are currently reflected by two completely different IT systems, which are connected to each other through very complex interfaces. In the new process design we have these levels integrated in one standard ERP tool. This leads to massive improvements due to the elimination of efforts for synchronizing stock levels and maintaining data in two systems."

The following table summarizes the main LP and ERP improvements as observed in the process design workshops. Moreover I have enclosed major business impacts as expected by the participants.

LP Element	**LP & ERP improvements reflected in the to-be processes**	**Business implications**
Flow	Pull-oriented warehouse internal material replenishments ("waterfall principle"). Outbound material flows also primarily based on pull signals from production, assembly or sales areas	Reduction of average inventory levels and reduction of average warehouse throughput times
People & teamwork	Increasing the degree of process automation (e.g. utilization of RF-scanning technology) Integrated ERP system as a basis for encouraging teamwork and collaboration activities (same	=> Increased processing productivity through automation of activities Fewer sources for misunderstandings, easier communication and teamwork

	database for all employees)	
Quality First	Full integration of automatic WMS with all other warehouse areas and inventory management locations reflected in ERP Increased number of consistency checks, automatic stop of processing in case of wrong entries	Decrease number of interfaces and to increase data consistencies Improved process and data quality of the warehouse operations and downstream processes
Kaizen	Use of tools to improve the warehouse storage structure (e.g. utilize operations research heuristics to suggest preferable bin locations) Implementation of flexible ERP processes, which can be adapted without need for programming. Continuous improvement initiatives based on standardized warehouse processes.	=> Reduction of transport ways for put-away and picking and improved utilization of storage space Lower hurdle to actually realize improvements High leverage for the improvements measures, because utilizable in the entire production network
Standard-ization	Integration of inventory management and warehouse management processes and systems Standardizing warehouse management processes and system across the entire plant network	=> Elimination of efforts for synchronizing stock levels and maintaining data in two systems => Reduction of efforts for deploying and maintaining individual solutions => Increased flexibility of warehouse staff to work in different locations

Table 32: To-be process design improvements – warehouse management

During the workshop observations I also realized conflicts between LP and ERP. The following paragraphs outline the main conflicts observed with respect to the macro process warehouse management.

With respect to the LP element people and teamwork, the participants mainly faced two conflicts between LP and ERP. First participants were questioning the requirement to deploy an IT supported warehouse at all. 0-O-02 explained: "If we radically realized LP in its core, we should shut down all automatic warehouses and replace them by much smaller and manually driven buffer areas. I know that this is not realistic since we still depend on many non-JIT suppliers with long shipping periods because their factories or delivery centers are far away from our plant. But I want us to bear in mind that any warehouse and particularly any kind of automatic warehouse is not compliant to lean thinking and should only be a last option if everything else fails." There was a long discussion, in which particularly the warehouse responsible operations managers and IS managers like 3-O-04, 4-O-04, 6-O-04, 7-O-04, 1-I-03, 4-I-02 argued very emotionally that automatic warehouses actually contributed to increasing the productivity because it replaced manual workload by automatic machines. Another critical point mentioned by participants like 1-O-02, 3-O-02 and 8-O-03 with respect to the LP element of people and teamwork and the integration with ERP were apprehensions in terms of a loss of manual control over the warehousing process in case of over-automation. In fact, this point was considered as another argument against an extensive use of automatic warehouses. After several longer discussions the misunderstanding could be finally clarified and everyone agreed that an automatic warehouse was still required in the near future, but its deployment should be gradually reduced as far as possible. For the conceptual design phase, an analysis was carried out for the entire parts spectrum and roughly 15% of the parts were designed not to flow through automatic warehouses in future but to be operated via buffer areas like supermarkets.

As far as the LP element flow is concerned, the process of condensation was frequently interpreted as waste according to LP. As mentioned earlier in this section, this process was criticized because it meant material transfers and often also manual handling efforts which do not add value to the end product. However as explained above, the process had been restricted to automatic warehouses and the intention was to avoid condensation as far as possible by re-analyzing the packing sizes called-off by the suppliers.

And, regarding the LP element standardization the participants raised concerns for delaying the improvement process due to production network standardization. An example can be viewed by the comment of 3-I-02: "I think that it will take a long time to derive an agreement between all 8 plants in the production network. This could significantly delay the improvement realization rate from the perspective of a single plant." After several sessions the response to this issue was the set-up of a change control board, which was presenting requested process changes on a weekly basis to the production network. The longest time period from initiating a change to the decision was determined to two weeks. Clear escalation procedures were defined in case the production network did not come to an agreement. Though this was still seen as delaying the process slightly, others argued that it could also be seen as an additional quality loop preventing from the realization of quick and dirty or even dangerous solutions.

The following table summarizes the main conflicts as observed for the macro process of warehouse management. In addition to that I have outlined the respective mitigation procedures.

LP element	**Conflicts LP&ERP**	**Mitigation procedure**
People and Teamwork	Questioning the requirement to deploy warehouses and particularly IT-supported warehouses at all Fear of loss of manual control over the process in case of over-automation	Agreement to reduce warehouse management to an absolutely unavoidable minimum Setting up user-friendly monitoring cockpits for the material flow throughout all warehouse areas.
Flow	Process of condensation was frequently interpreted as waste according to LP	Re-analysing packing sizes for part call-offs from suppliers. Applying the process only in automatic warehouses
Kaizen	Concerns of delaying the improvement process due to production network standardization.	Setting-up a platform for regularly and frequently discussing change requests in the plant network.

Table 33: LP & ERP conflicts and mitigation – warehouse management

4.3.4.7.2 Lean-ERP Assessment – Warehouse Management

As illustrated in

figure 36 the macro process warehouse management received a lean-ERP assessment pattern, which can be interpreted as ordinary compared to the majority of macro processes. Referring to table 13, the as-is analysis rating can be considered as indicating large improvement potential and the to-be design symbolizes only little improvement potential. The following figure breaks down the lean-ERP assessment of

figure 36 into the average ratings of the LP elements.

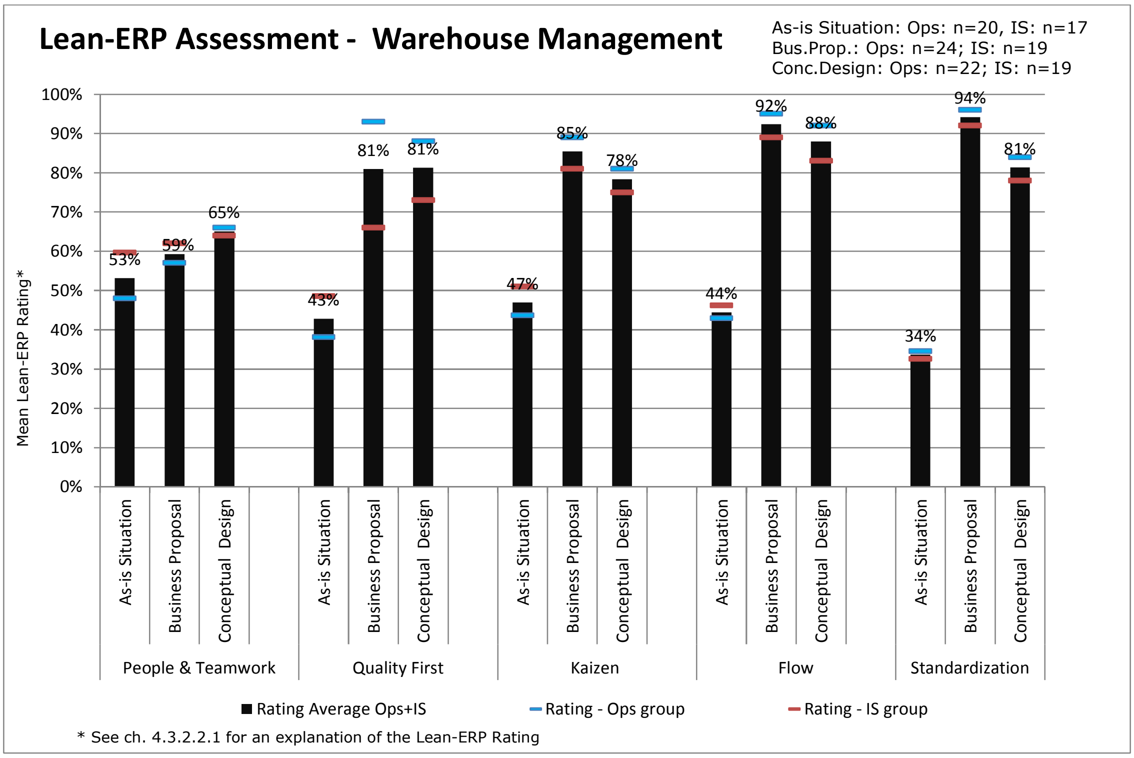

Figure 48: Lean-ERP assessment warehouse management

For the warehouse management macro process, the highest to-be design ratings were given to two different LP elements, depending on whether we look at the business proposal or the conceptual design ratings. Concerning the business proposal ratings, the LP element of standardization was the leader with 94% and concerning the conceptual design phase the LP element of flow had the lead with 92%.

With reference to my qualitative findings as described in the previous section, I found that the high business proposal results for standardization were generally in line with the improvements identified. The macro process was warehouse management was the macro process with the largest amount of users in the production network wide users. Therefore the LP element standardization appeared to have a large impact on the business. On the one hand the employees saw a considerable potential for savings due to synergies in the area of IT maintenance, support and training. On the other hand, due to the plant network standardization any further improvement automatically had a large multiplier and consequently a huge business potential across the production network. The drop to 81% for the conceptual design phase is very likely to be related to controversial discussions about processes on a more detailed level. An example was the process of cycle counting, for which plant from different countries turned out to have different regulatory requirements to fulfil.

For the LP element flow the values also dropped between the business proposal and the conceptual design phase, though on a much lower level. Finally the conceptual design ratings of flow received the highest average ratings amongst all LP elements. Taking into account my qualitative observation results as outlined in the previous section, the design of pull-oriented material flows was seen as the primary benefit in the context of flow. The participants committed relatively large savings due to a considerable decrease of warehouse stock and material flow throughput time.

As for most of the other LP elements, people and teamwork received the lowest to-be design ratings. Looking at the observations as described in the section above, I realized that the participants connected the general discussion about the necessity of automatic warehouses with the LP element people and teamwork. The automatic warehouses were seen to stand in contradiction to the requirement of manual control of human beings. These qualitative observation results suggest that there was a connection between this contradiction and the low quantitative ratings for the LP element people and teamwork.

4.3.4.8 Production Supply

This section summarizes the findings of the to-be business process design for the macro process production supply. I split the section into two parts. First I present an overview and a qualitative evaluation of the to-be process design and second I focus on the lean-ERP assessment results.

4.3.4.8.1 To-be Process and Qualitative Evaluation

This section focuses on the to-be process and the qualitative evaluation of the macro process production supply. Figure 49 provides a graphical illustration of the macro process. Different process types for supplying goods to the production areas had been designed. First, internal ERP-supported Kanban is used to supply the in-house production, the supermarkets and the final assembly. The supermarket is a buffer area near the assembly, in which manual commissioning processes take place. This process type is applied for the majority of part-numbers. Second, supplier Kanban was designed to be launched for a smaller part-number spectrum consisting of some 20-30 part-numbers with high volume and low variability demand patterns. It was planned to successively increase the proportion of supplier Kanban as soon as the process has stabilized for first group of part-numbers. Third, vehicle demand related call offs were defined for a small group of part-numbers consisting of less than 100 parts with a demand pattern characterized by low volume and high variability. And finally manual Kanban without IT support had been foreseen for goods movements from of the supermarkets and the sequencing areas to the assembly.

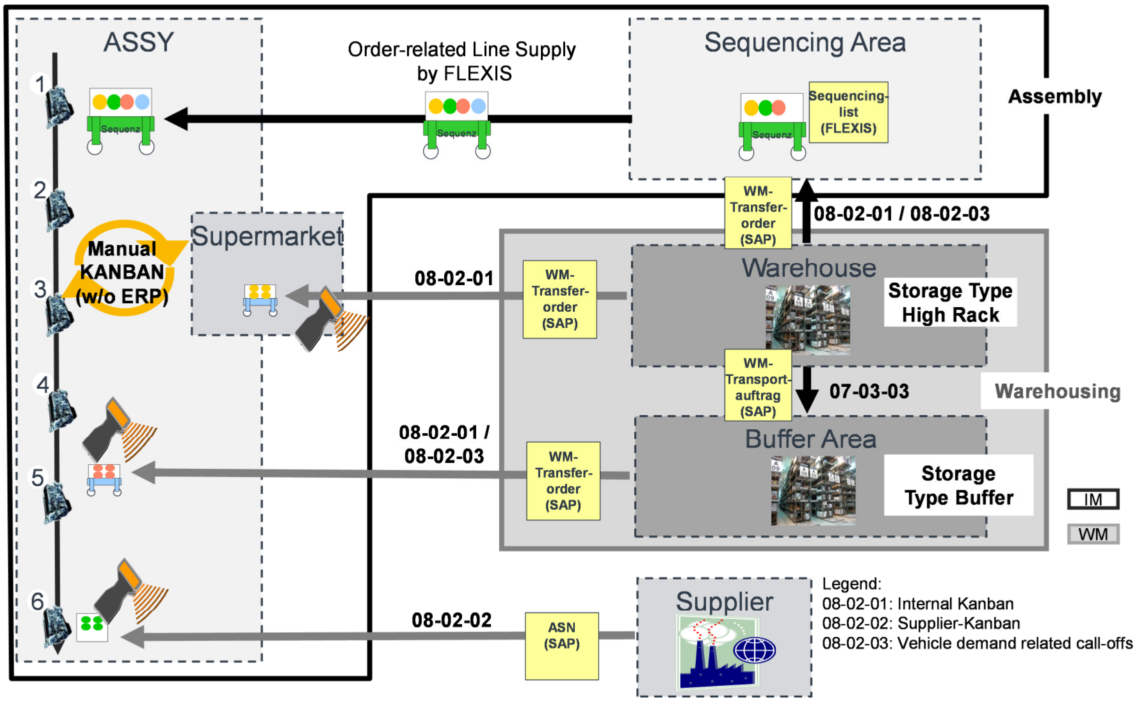

Figure 49: Process overview production supply

Regarding synergies between LP and ERP, most of the benefits were identified and realized with respect to the LP element flow. A predominant point was the fact that ERP supported Kanban control cycles were designed as primary process type for production supply. As visualized in the figure above, this refers to plant-internal control cycles and to external control cycles in the form of supplier Kanban. During the workshops I observed that the participants expected considerable improvements based on these pull-oriented processes. An example can be seen in the following statement from 1-O-02: "In fact, the macro process production supply should benefit most from the general shift towards consumption driven material supply. Apart from positive impacts in terms of decreasing inventory levels, I also expect less effort for the material managers for firefighting and shortage management." We observed that this view was shared by most of the participants, on the one hand by interpretation of the positive gestures like nodding and on the other hand by the fact that there were hardly any contradictory statements raised by the field of workshop participants. The only exception was the question whether ERP support was necessarily required to realize the pull-driven processes, which will be addressed in the paragraphs describing the conflicts realized. Another synergy between LP and ERP in the area of flow was the possibility to prioritize competing production supply orders. This was considered an extremely important point for the operations representatives since the as-is process did not allow for such a prioritization option and this often led to wrong avoidable shortages of production areas.

Concerning the LP element of people and teamwork, the design of manual buffer and commissioning areas was seen as primary improvement based on the integration of LP and ERP. The main reason was seen in the fact that these elements allowed the deployment of manually controllable processes and in parallel, using ERP for the repetitive tasks like material replenishments into these buffers and commissioning areas. As 6-O-04 pointed out: "Instead of developing a complex algorithm and technical automatic commission system for bringing the material to the employee in the right order, the new processes are based on the employee going to the material in order to do the commissioning of parts, just like a housewife shopping in a supermarket. It is simple and transparent and the human being is in full control of the process. The IT system can be perfectly used for the repetitive task of automatically refilling the buffers" There was broad agreement amongst the participants during the conceptual design workshops.

With respect to the LP element quality first, the set-up of standard ERP-based internal customer-supplier relationships was realized and discussed as a synergy of LP and ERP. Particularly the ERP supported confirmation of delivery times and quantities per scan were seen as a contribution towards increasing the process quality. It could be discussed if it did not better belong to the LP element flow since it aimed at increased parts availability. However the process design consisted of internal customer supplier relationships with quality checks before handling the goods to the internal costumer. Therefore we left the allocation to the LP element quality first as observed during the process design workshops.

As far as the LP element Kaizen is concerned, the participants' emphasis was on a successive further increase of the proportion of part-numbers supplied in a pull oriented process to the production. Particularly the case of supplier Kanban was expected to promise considerable room for further expansion. The general opinion observed in the to-be process design workshops can be exemplified by the following statement of 4-O-04: "For the initial phase we plan to link-up a very limited number of suppliers with the supplier Kanban process. However, as soon as we get more confident I am positive that we can increase this number significantly since the majority of parts procured externally are characterized by high and steady volumes. We can use continuous improvement cycles in order to support this successive expansion. This should result in less workload for the material planners and lower inventory levels."

Finally, regarding the LP element standardization, the primary synergy between LP and ERP was the expectation that ERP's company-wide reach helped to standardize the new processes in the entire production network. As for most macro processes, the participants expected positive effects in terms of reduced IT maintenance efforts and increased flexibility for deploying workers in different plants as a possibility to equalize varying plant utilizations. In this respect, the statement of 1-O-01 was particularly interesting: "I remember times when the bus plants had a boom while the truck plants were running on 50% capacity. On the other hand we had years in which we were not able to produce enough trucks while the demand for buses was lower. In such phases it could be an extremely valuable benefit to know that we could shift workers from one plant to another and the employees could work productively with the same processes and systems without an extensive settling period.

The following table puts together the main LP and ERP improvements as observed in the process design workshops. Moreover I summarize the major business impacts as expected by the participants.

LP Element	LP & ERP improvements reflected in the to-be processes	Business implications
Flow	Design of ERP supported internal Kanban and supplier Kanban control cycles as basic principle for production supply Possibility for prioritization of competing production supply orders	=> Reduced inventory levels and throughput time by applying the pull principles => Reduced manual efforts for calculating Kanban parameters and for printing and searching for physical Kanban cards => Increased parts availability in shortage areas due to possibility to prioritize line supply orders
People & teamwork	Design of manual buffer and commissioning areas like supermarkets	Simple and transparent production supply process with increased sphere of human influence.
Quality First	Setting up standard ERP-based internal customer-supplier relationships with IT-supported confirmation of delivery times and quantities (e.g. scan).	=> Increased parts availability at the production areas
Kaizen	Successively increasing the proportion of pull orientation (e.g. supplier Kanban) for high volume low variety part-numbers	=> Reduction of throughput time and stock levels through continuously improved Kanban parameters
Standard-ization	Roll-out of new processes to the entire production network	Reduced IT maintenance efforts, reduction of training efforts and increase of flexibility for deploying workers in different plants

Table 34: To-be process design improvements – production supply

On the other hand, I also observed conflicts concerning the integration of LP and ERP during the to-be process design workshops. The first conflict was that participants were questioning the advantages of IT-supported Kanban versus the use of manual Kanban cards. As I learned during the workshop discussions and from unstructured interviews with workshop participants like 1-O-02 and 1-O-04, there were some areas in which manual Kanban was already in place after the realization of a LP implementation wave several months before kicking-off of the initiative described herein. During this local LP implementation wave great emphasis was put on manual processes. The use of IS was considered negative because it was seen as deterministic tool which was in contrast to the pull orientation of manual Kanban. I found that it were particularly these participants who contributed in this LP wave who were negative towards the ERP supported Kanban process. As a countermeasure we decided to implement a prototype process as a showcase example. I put particular attention on comparing the manual Kanban process with the ERP supported process realized in the prototype. After that we let the participants discuss about the advantages and disadvantages of these two processes. The participants identified advantages like the automatic calculation of the number and sizes of Kanban containers or the lack of printing and searching manual Kanban cards. In fact I observed that the prototype contributed to changing the minds towards the use of ERP supported Kanban. This can be exemplified by the statement of 1-O-05 who claimed that: "Actually at the beginning I was not very positive towards the use of ERP for Kanban. Experiencing the advantages of the ERP supported process in has really changed my mind."

Another conflict discussed was again the trade-off between plant-wide process standardization and the flexibility to rapidly improve a process locally. Participants like 1-O-06 and 1-I-03 expressed the fear that production network wide discussions required in order to get an approval for a process improvement could slow down the speed of improvements significantly. However proponents of production network standardization like 0-O-03, 0-O-04 and 0-I-02 responded by emphasising that this might be the case, but the leverage of process improvements was a factor of up to 8 higher when all plants could benefit from the improvement. In addition to that they held that the discussion in the production network could be seen as an additional quality check for the improvement suggestion.

The following table summarizes the main conflicts for the macro process of production supply.

LP element	Conflicts LP&ERP	Mitigation procedure
People and Teamwork	Questioning the advantages of ERP supported Kanban versus classical	Prototyping workshops for presenting the process of ERP supported Kanban and comparing it with the manual

	manual Kanban	Kanban process
Kaizen	Contradiction between plant-wide standardization and continuous improvement	Emphasising the leverage of process improvements when concerning entire plant network. Presenting the impact to the overall business case.

Table 35: LP & ERP conflicts and mitigation procedure – production supply

4.3.4.8.2 Lean-ERP Assessment – Production Supply

Figure 36 indicated that the macro process production supply had been assessed in a comparable pattern to most of the other macro processes. Referring to table 13, the as-is analysis rating can be interpreted as indicating large room for improvement whereas the to-be design ratings have improved, leaving only little improvement potential. The following figure breaks down the lean-ERP assessment of

figure 36 into the average ratings of the LP elements.

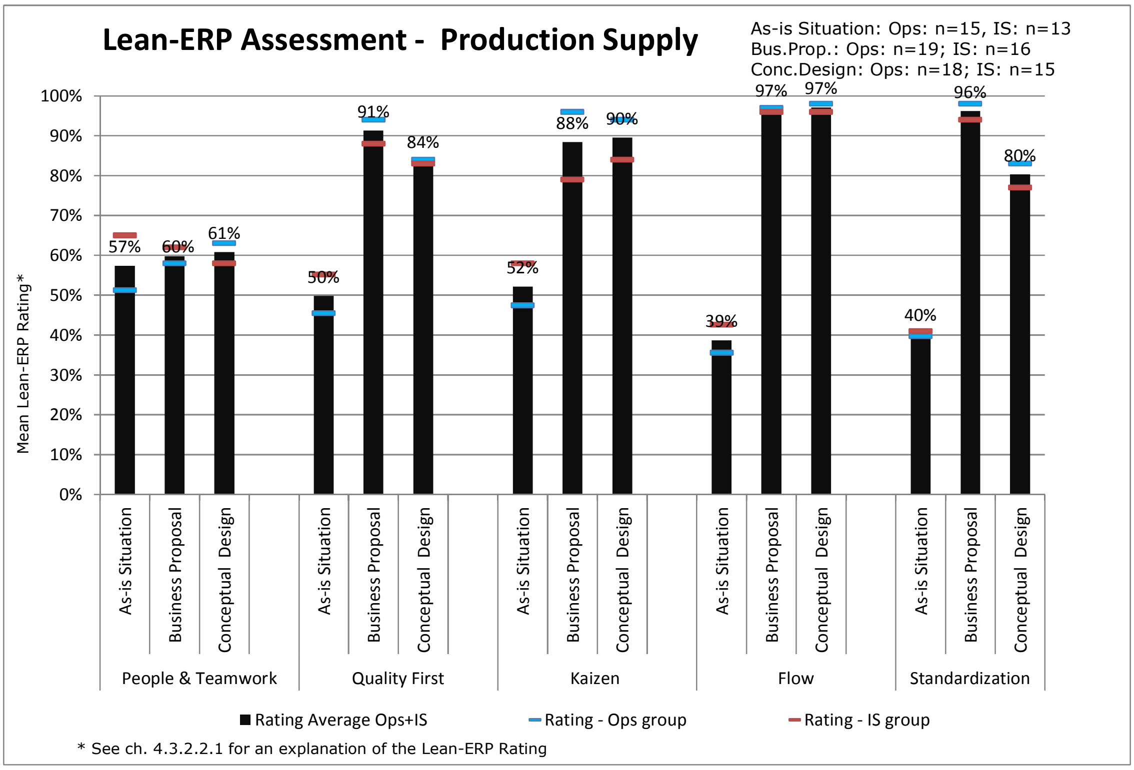

Figure 50: Lean-ERP assessment production supply

As expected from the qualitative observation results, the LP element flow has realized the largest improvement comparing the as-is rating with the business proposal and conceptual design ratings. In fact, the as-is rating was given the lowest ratings of all LP elements whereas both to-be design ratings were assessed with the highest scores of all LP elements. Taking into account the workshop observation results this pattern was not a surprise due to two reasons. First the macro process production supply was by definition concerned with material flow to a great extent which was reflected by the time the participants spent on this element during the workshop discussions. And second I learned from the workshop observations that the current system provided almost no support of the pull principle whereas the to-be design was primarily based realizing the pull principles with the support of ERP. However, the level of the to-be design rating was unexpectedly high with 97% for both the business proposal and the conceptual design. As I learned from unstructured interview with 5 workshop participants (1-O-02, 1-O-04, 3-O-04, 1-I-02, 2-I-101) I found that they saw the subject had been exhausted and they saw almost no further improvement potential if not changing frame conditions like the bill-of-material structure. However according to the definitions in chapter 4.3.3.1, such changes of frame conditions were not to be taken into account for the assessment. Nevertheless there was a contradiction between the extremely high ratings of flow and the qualitative observation results of the LP element Kaizen since the participants did see room for further expanding pull processes like supplier Kanban for Kaizen initiatives.

Looking at the ratings for the LP element Kaizen, the ratings were in line with the qualitative observations results. In other words, the participants did see room for further Kaizen improvements while they did see almost no potential for improvement with respect to the LP element flow. When I tried to find out more on this contradiction, I initiated a separate meeting in order to analyse this issue. The participants argued that in their flow rating they did not see any potential for further improvements for the launch of the processes, resulting in the high rating of close to 100%. However after a phase of qualifying additional suppliers, they did see further improvement potential, which could be realized with the support of Kaizen initiatives.

The LP element people and teamwork received the lowest to-be design ratings. As I learned from the qualitative workshop observations, the participants often questioned the need for IT-supported process, particularly expressing doubts that this could help to increase collaboration and teamwork. Though the participants were more positive after considering the prototyping results with respect to ERP Kanban, there was still a certain degree of skepticism amongst the participants, which appeared to have reflected in the assessment results.

4.3.4.9 Sales and Distribution

This section outlines the findings of the to-be business process design for the macro process sales and distribution. First I present an overview and a qualitative evaluation of the to-be process design and second I focus on the lean-ERP assessment results.

4.3.4.9.1 To-be Process and Qualitative Evaluation

This section focuses on the to-be process and the qualitative evaluation of the macro process sales and distribution. The following figure provides an overview of a major part of this macro process; that is, the JIT/JIS link-up of an internal plant with an internal customer, whereby internal refers to plants within the client's production network.

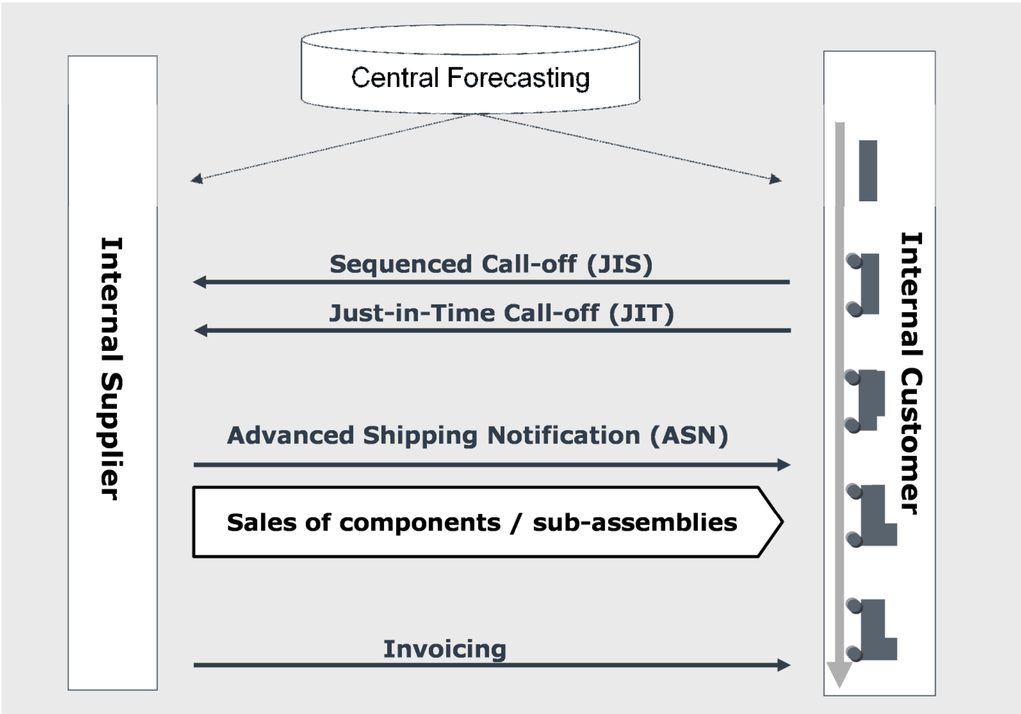

Figure 51: Process overview production supply

The central long-term forecasting is performed centrally for the entire production network and then broken down and transferred to the individual plants. However these centrally planned figures are not delivery relevant but serve as source for the long term disposition of the components and the production capacity. The delivery relevant orders are received directly from the customer plant in the form of just in time (JIT) and/ or just in sequence (JIS) call-offs.

With reference to the figure above and the LP element flow, the major improvement based on a combination of LP and ERP was seen in the ability to support the receipt and further processing of incoming just-in-time (JIT) and just-in-sequence (JIS) call-offs. Since the current systems did not support these processes, the participants expected business improvements in terms of reduced manual workload and / or workarounds to support this process. In this respect, the following statement of 1-O-07 can be seen as reflecting the opinion of the majority during the process design workshops: "I have currently 4 people only taking care of manually supporting JIT and JIS processes. Depending on the customer, we currently receive these call-offs per email, fax, or even by phone calls. We currently use Excel spreadsheets and other manual tools in order to track and monitor the process. I expect massive improvements when we implement the automatic ERP process. And we can use the free capacity in order to link up more clients via JIT / JIS processes." In this respect, 0-O-02 commented: "Moreover, this is a major driver for expanding the range of potential customers, since many of today's clients simply expect us to deliver in a JIT / JIS mode. I would even say it is a necessity if we want to stay in business on the long run." These views were shared not only amongst the majority of the operations but also amongst the IS representatives. Another significant improvement was the design of Kanban control cycles between the warehouses and the dispatch areas as well as between the in-house parts production areas and the dispatch areas. With the application of Kanban control cycles, the average stock levels in the dispatch areas were expected to be reduced. 1-O-07 explained it that way: "Currently we are triggering our material supply based on planned delivery dates in sales orders. As soon as a delivery date is being postponed, the stock levels in our dispatch areas become too high. Unfortunately this is not an exceptional case but rather occurs several times per day. With the ERP based Kanban would not care about postponed sales orders. The replenishment is only triggered as soon as the box is scanned as empty or the stock level falls below a certain limit."

With respect to people and teamwork, the most frequently mentioned synergy was that the roll-out of the initiative was expected to break-down some of the boundaries for cross-department communication. A good example for this can be seen in the following statement raised by 2-O-07: "Currently one of our core problems is the difficulty to communicate between different organizational units due to the heterogeneous process and IT landscape within the plant. The people just do not seem to speak the same language. A plant wide or even production network wide rollout of ERP should improve this situation dramatically. Therefore I expect that the new initiative allows us to actually increase our level of collaboration and communication." I observed broad agreement amongst the workshop participants. In particular, similar points were raised by 1-O-07, 0-O-4 and 1-I-02.

Regarding the LP element quality first, the major theme observed during the process design workshops was the fact that a plant wide implementation of ERP would remove legacy systems and redundant databases. The consistent database was expected to lead to a higher data quality. As a result, the overall quality of the business processes was presumed to increase. The following quote from 1-O-07 can be seen as an example for the mainstream perception during the process design workshops: "For me, a synergy between ERP and LP with respect to the LP element quality first lies in the consistent database of ERP and the consequence of less data redundancies and inconsistencies. As a consequence I expect a better quality of our processes particularly in the area of dispatch. An example for that can be seen in the various sources for the weights of parts, sub-assemblies and packaging material in the current situation. The weights are often not maintained at all, or there are inconsistencies between the various sources. The worker often manually enters the wrong weight, which sometimes leads to dramatic delays during customs processes or to penalty payments to logistics service providers. A consistent database for weights will definitely improve the quality of our dispatch process."

Concerning the LP element Kaizen, the most prominent synergy between LP and ERP was seen in the ability of ERP to provide a standardized company-wide process platform, which was considered a key enabler and multiplier for continuous improvement. The following statement of 1-O-07 can be considered representative for the majority of the workshop participants: "Currently we have an extremely inhomogeneous process and IT landscape. We often do not even know with which process to start from when we set-up continuous improve initiatives. In future we can start from a common standard process. And the improvement should even pay off for every organizational unit where the process is applicable."

Finally the reflection of a standardized sales and distribution process flow without system breaks was also seen as the main improvement with respect to the LP element standardization. In particular the standardization of niche processes was seen as a significant improvement to the business. As 1-O-02 pointed out: When we take the Completely Knocked Down (CKD) process as an example, we have 3 plants in the network which run the process, but every plant does it with different IT support and with completely different processes for commissioning, packing and shipping the parts to overseas manufacturing plants. Our new standard process based on ERP will allow us to roll it out to all these plants and finally end up with one process and one system for all CKD processes in the whole production network. The savings in terms of reduced IT support and the additional personnel flexibility should bring a significant benefit to the business."

The following table provides a summary of the main improvements for the macro process sales and distribution as identified during the process design phases.

The following table provides an overview of the main LP and ERP improvements as observed in the process design workshops. In addition to that I summarize the major business implications as expected by the participants.

LP Element	**LP & ERP improvements reflected in the to-be processes**	**Business implications**
Flow	Implementing a process and supporting IT-functionality for receiving and processing incoming JIT / JIS call-offs (e.g. SAP JIS Inbound functionality) Set-up of Kanban control cycles for material supply into the sales areas	Reduction of efforts for deploying individual manual tools and techniques and for controlling this process manually throughout various systems Expansion of the range of potential future clients
People & teamwork	Further roll-out of ERP will remove some of the boundaries for cross-department communication (e.g. terminology)	Employees from different departments start speaking the same language, which improves communication and collaboration, resulting in higher productivity and less efforts for the clarification of misunderstandings
Quality First	Plant wide implementation of ERP in order to remove legacy systems and redundant databases.	Consistent database leads to higher data quality which, in turn, increases the business process quality
Kaizen	ERP providing a plant-wide platform as a proper basis for continuous improvement initiatives.	Any implementation of an improvement pays out several times; that is, for every single division / plant running the same process
Standard-ization	Reflection of a standardized sales and distribution process flow without	Reduction of efforts for continuously maintaining system interfaces,

	system breaks (e.g. Implementing an integrated state-of-the art ERP system) Standardizing niche processes like the Completely Knocked Down (CKD) process or the return delivery process (e.g. developing template processes and rolling them out to all plants)	increased productivity and customer service of the sales team through the possibility to deploy all sales processes in one system Reduction of efforts for deploying individual tools and techniques supporting different processes in different locations

Table 36: To-be process design improvements – sales and distribution

Apart from the benefits, the process design workshops for the macro process sales and distribution also revealed conflicts concerning the integration of LP and ERP. First with respect to the LP element flow, it was remarked by several participants that the high level of data quality required in ERP might slowdown or even stop the logistics process flow. The following statement of 4-O-07 can be seen as representative for many other participants: "Maybe the high requirements of ERP in terms of data quality are good with respect to the LP element quality first, but we have to be aware that this could lead to a break-down of the material flow in case of poor data quality. And taking into account our low inventory levels in the warehouses and buffer areas, we would have a stop shipping parts after a maximum of 1-2 days." We took this critique absolutely serious because we wanted to avoid the expansion of this fear to the entire field of participants. We reacted by setting up a workshop in order to go through every single data object required in ERP for the proper material flow and compare it to the data requirements of the old legacy system supported process. By this means we found that the data requirements of ERP were not more compared to the legacy systems. The difference was that for many data objects ERP would cause an error message at a defined point early in the process, whereas the legacy systems would cause the error message at an undefined point within the process flow. However the result would be the same, the process could not be carried out until the proper data was maintained. Though this workshop required a high amount of time, I have considered it extremely important for the acceptance of the entire initiative. Another point was that we designed tools to support the tracking and improvement of the data quality on a constant basis.

Concerning the LP element people and teamwork, participants argued that over-automation might lead to a weaker level of communication and collaboration amongst employees. This was a fear which was also mentioned with reference to other macro processes. As a reaction and mitigation strategy we decided to pay particular emphasis on the design of processes that provide a fair balance between automation and manual control. Quite often we decided against the fully automated solution and in favour of the manually controlled process. An example can be seen in the prioritization of demands when it comes to shortages of components. Instead of letting the system make the decision, we provided an ERP supported cockpit for the sales responsible employees, which allowed to easily manually deciding which order to prioritize in case of shortages.

Moreover there was apprehensiveness of participants concerning the LP element Kaizen. Several participants raised the fear that ERP could fix the newly implemented processes and that these fixed processes could make continuous improvement initiatives impossible or at least more difficult. We reacted by analysing the flexibility of the old legacy supported processes with that of the newly designed ERP supported processes in the area of sales and distribution. Comparing the parameterization possibilities of the old processes with the new processes in detail, I found that the new processes were actually by far more flexible. In fact, the ERP standard processes allowed for great range of parameterization and customization possibilities. The reason was that ERP, by definition, has to be applicable to a broad range of different enterprises and consequently to different processes. Demonstrating these possibilities to the workshop participants helped to convince the critical participants of the possibility to carry out continuous improvement initiatives after the ERP implementation.

The following table summarizes the main critical points as described above. I have outlined the mitigation procedure applied in the initiative for each of the conflicts.

LP element	**Conflicts LP&ERP**	**Mitigation procedure**
Flow	The high level of data quality requirements of ERP could lead to a slowdown or even stoppage of the logistics process flow	Analysing all data objects required in ERP and comparing them to the legacy system landscape. Design of processes for permanently monitoring and improving the quality

		of the required data for a proper sales and distribution processes
People and Teamwork	Fear that over-automation might lead to a weaker level of communication and collaboration amongst employees	Paying particular emphasis on the design of processes that provide a fair balance between automation and manual control.
Kaizen	Reservation of participants that ERP might fix the processes and impede continuous improvement initiatives	Emphasizing the possibility of parameterization and customization of processes during the process design phases

Table 37: LP & ERP conflicts and mitigation procedure – sales and distribution

4.3.4.9.2 Lean-ERP Assessment – Sales and Distribution

Figure 36 has revealed that the macro process sales and distribution received the highest as-is situation rating of all macro processes. Referring to table 13, the as-is analysis rating of 58% can be interpreted as leaving only considerable room for improvement. As mentioned earlier, this macro process was the only one, in which ERP had been already implemented in a part of the production network before start of the new initiative. Nevertheless the to-be design ratings were assessed higher than the current situation. The following figure breaks down the lean-ERP assessment of

figure 36 into each of the LP elements for the macro process sales and distribution.

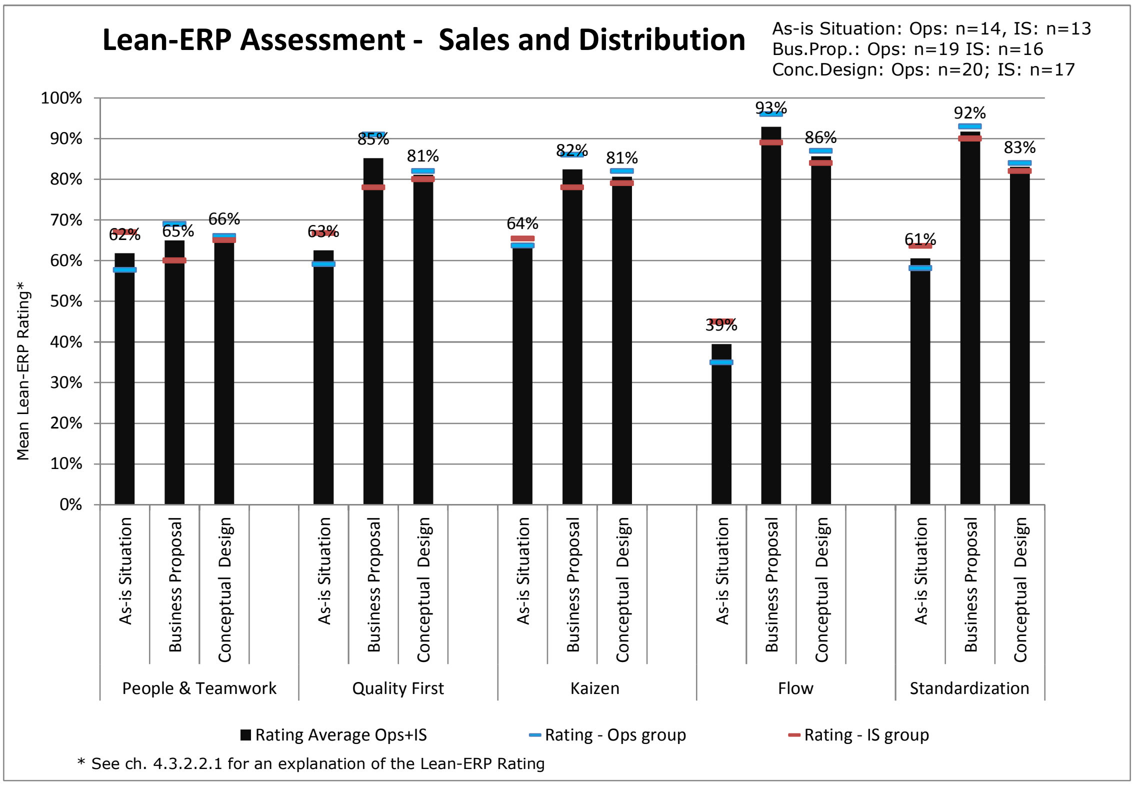

Figure 52: Lean-ERP assessment sales and distribution

As for most of the macro processes, the LP element flow received the highest level of improvement between the as-is situation and the to-be design ratings. Moreover, it was given the highest absolute to-be design ratings of the 5 LP elements for both the business proposal and the conceptual design rating. As I have learned from the workshop observations, the possibility to receive and process just in time and just in sequence call offs was seen as a key enabler for supporting a pull-oriented material flow. Another point mentioned with respect to pull was the possibility to supply parts via Kanban control cycles to the sales areas. Observing the workshop discussions and based on several semi-structured interviews after the assessments (1-I-02, 1-O-07, 3-O-07, 5-O-07) I have strong indication that the JIT/JIS and the Kanban support were the main reasons for the high to-be design ratings of the LP element flow. As for most of the ratings, the conceptual design was assessed lower than the business proposal. In this context I observed that during the detailed conceptual design, the participants have realized that JIT/JIS and Kanban could not be applied to the same extent as expected in the business proposal. The high level design of the business proposal appeared to be not detailed enough to consider all of the different part categories.

Again as for most of the macro processes, the lowest to be design ratings were given to the LP element people and teamwork. As I have learned by the workshop observations as described in the previous section, there was the fear over-automation within the field of participants. As a consequence some participants argued that this might lead to a less communication and to a worse collaboration amongst employees. Though we had been extremely careful during the moderation of the to-be process design to remind the participants not to over-automate, there was still a level of apprehensiveness which could not be completely removed.

The other LP elements quality first, Kaizen and standardization have been assessed in a comparable pattern. The as-is situation ratings were on a relatively high level compared to the other macro processes and the to-be design ratings were on a comparable level between 81% and 92%.

4.3.4.10 Summary and Implications

In section 4.3.2.3 I analyzed the to-be process design of all of the macro processes in scope on a relatively detailed level. My main focus was on all aspects relevant to the integration of LP and ERP. For each of the macro processes I divided my findings into two parts; a rather qualitative part summarizing the main workshop observations and a rather quantitative part presenting and interpreting the lean-ERP assessment results. Taking into account the activities and findings of the sections above, I can summarize the following main points.

4.3.4.10.1 Overall Summary

Referring to the criteria of the lean-ERP assessment introduced in section 4.3.3.1, the workshop participants considered the new process design substantially better than the current situation. This refers to both the average LP element ratings for all eight macro processes in scope and to the average macro process ratings for all of the five LP elements under investigation (see figure 35 and

figure 36). This quantitative assessment result can be seen as confirmed by my qualitative workshop observations. Though the participants also raised several critical points, I can conclude that the large majority of the comments were positive towards the new process design consisting of an integration of LP and ERP. It appeared that after a first phase of getting used to the idea of combining LP and

ERP and particularly after the proponents of LP and ERP got to know and trust each other, a positive group dynamic developed and grew during the course of the workshops. At the end of the workshop streams, the participants appeared to even enjoy identifying and designing LP and ERP improvements.

Another general point was that the gap in the ratings of operations and IS representatives decreased and even reversed. Concerning the as-is situation, the IS group have rated the processes better than the operations group. In contrast with respect to the to-be processes, the operations group was slightly more positive than the IS group for most macro processes. In the to-be design workshops I observed that the operations representatives appeared to be more proactive when it came to commenting on improvements based on a combination of LP and ERP. However there was not a substantial difference between the proportion of positive versus negative comments between the representatives of operations and IS.

4.3.4.10.2 Viewpoint of Macro Processes

Looking at the macro processes, material planning was assessed as the macro process with the highest improvement comparing the to-be process design with the as-is situation. Based on the qualitative workshop observations I have strong indication that the realization of pull based material planning scenarios like ERP supported supplier Kanban and JIT / JIS processes were a main reason for the high ratings of the new process design. This conclusion becomes even more credible when I reconsider the as-is analysis, in which the participants heavily complained about the lack of pull support of current processes and systems.

However the participants also realized also a considerable level of improvement for the macro processes in-house parts production, goods receipt, warehouse management, production supply and sales and distribution the participants. For all these macro processes the qualitative workshop observations revealed that the ERP supported pull-based material flow was regarded as a key improvement with respect to combining LP and ERP. Moreover, process standardization based on ERP’s enterprise wide reach and Kaizen supported by ERP’s flexibility in terms of parameterization and customization were seen as a key improvements for these macro processes.

Finally, comparing the as-is ratings with the to-be assessment for the macro processes of master data and demand planning, there was a minor level of improvements in relation to the other macro processes. Both master data and demand planning can be seen as comparably IT-intensive macro processes. Master data, by definition, consist of a high extent of data maintenance. As I have learned from the workshop observations, data maintenance was often considered a non-value adding activity from the viewpoint of lean production. Moreover, participants were frequently questioning the compliance of a macro process like master data with the LP objective of as little IT as possible. This explains the comparably low level of all of the ratings for this macro process. Though for demand planning the degree of improvement was also rated comparatively low, it was on a distinctly higher level compared to material planning. The workshop observations have shown that the participants were largely satisfied with the as-is process of BoM explosion and gross demand generation. Therefore the room for improvement was limited. Nevertheless, considerable LP improvements supported by ERP could be realized in terms of demand levelling and the set-up of customer-supplier relationships within the production network.

4.3.4.10.3 Viewpoint of LP Elements

Summarizing the results from the viewpoint of the LP elements, I conclude that the LP element flow was seen as the most predominant lever for improving the processes along the combination of LP and ERP. On the one hand the lean-ERP assessment indicated the highest level of improvement for the LP element flow compared to the other LP elements (see

figure 36). On the other hand, the qualitative workshop observations have revealed that almost all of the macro processes benefited from the newly designed ERP processes supporting various types of pull processes. Particularly the ERP-based pull processes like internal Kanban, supplier Kanban, just in time and just in sequence or a combination of them could be applied for most macro processes. Though manual Kanban was frequently seen as an alternative to the ERP-based version, the majority of the participants considered the ERP-based process superior due to higher process stability and less dependency on paper-based cards. Another important point with respect to flow was the ERP supported process for warehouse bypassing in case or goods receipts for shortage parts.

The lean-ERP assessment has resulted in standardization as the LP element reflecting the second highest improvement between the as-is situation and the to-be design. Though the high expectations in terms of standardizing processes along the production network as envisaged during the business proposal could not be completely transferred to the details of the conceptual design, the to be design ratings left only little room for further improvement. Looking at the qualitative investigations of each of the macro processes, I observed one pre-dominant aspect with respect to improvements supported by the combination of LP and ERP. In this respect it was the company-wide reach of ERP, which turned out to balance one of the key weaknesses of LP; that is, the difficulty to spread the concept across the entire plant / production network. The as-is analysis has shown that LP was implemented on a high level only in single local islands within the plants, which are characterised by high volumes and low variability. However the overall picture within the plants and even more in the production network was extremely fragmented. In this respect, an enterprise encompassing concept like ERP was identified as a perfect spreader for the concept of LP production across the production network.

With respect to LP element quality first, the lean-ERP survey indicated an improvement of 30% comparing the as-is situation with the to-be design. According to table 13, this leaves only little room for improvement for the to-be process design compared to an improvement potential between large and considerable for the as-is situation. The qualitative workshop observations have shown that the predominant improvement theme with respect to integrating LP and ERP in the area of quality first were ERP supported early quality checks. On the one hand this applied to the high data quality requirements in ERP, which were considered to decrease the risk of downstream process errors. On the other hand, this applied to ERP-supported quality checks for parts and components during goods receipt and within internal customer-supplier relationships.

The average lean-ERP assessment rating of the LP element Kaizen was comparable to that of the LP element quality first. During the qualitative workshop observations I found that the participants have considered ERP's flexibility in terms of parameterization and customization as the major improvement with respect to combining LP and ERP. Allowing for quick process adaptations without need for source code programming, the high flexibility of ERP was identified as a key enabler of Kaizen. Nevertheless in contrast to that, there were also participants who expressed the fear that the newly designed processes might be fixed through the reflection in ERP. They argued that though ERP might be more flexible than the old legacy systems, ERP based processes are still not as flexible as completely manual processes.

Finally, the LP element people and teamwork was assessed as the worst of all five LP elements. Though the ratings reflected a slight improvement comparing the to-be processes to the as-is situation, the average conceptual design rating of 62% can be expressed as leaving considerable room for improvement according to table 13. The qualitative observations have revealed that the participants have seen a general conflict between the IT-oriented ERP and people-oriented collaboration and communication between employees. Though the participants also realized that factors like the common database and the common terminology helped to improve communication and collaboration, the general conflict between IT and communication was seen with respect to a most macro processes in scope.

4.4 Realization and Roll-out (Realization, Test & Training , and Installation Phase)

This section describes the realization phase, the test and training phase and the installation phase. In contrast to the template design phases as described in the section above, these phases are concerned with the actual realization and implementation of the processes as designed in the previous phases. The following figure illustrates these phases in the context of initiative's implementation model suggested earlier.

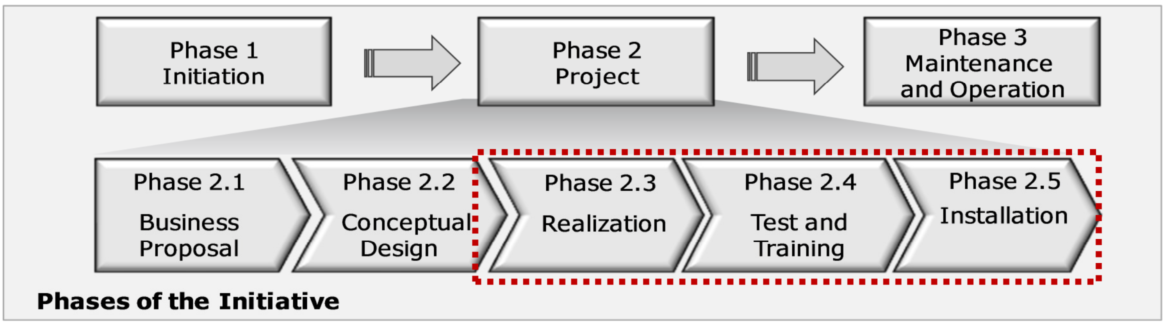

Figure 53: Realization, Test & Training and Installation Phases

As mentioned earlier in this thesis, due to financial constraints the board decided to significantly limit the scope of the initiative as of January 2009 and to completely freeze the project as of October 2009. In this context it was decided to roll-out only one out of eight macro processes initially in scope, namely that of sales and distribution. Moreover, it was decided to conduct only the first roll-out step, which was defined to consist of two plants. The following figure provides an overview of the limited scope of the phases 2.3, 2.4 and 2.5 in contrast to the template design phases 2.1 and 2.2.

Work Stream	Macro Process	Template Design (ph. 1; 2.1; 2.2)								Realization Phases until 1st roll-out step (ph. 2.3 – 2.5)							
	Plants	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
PLANNING	Master Data Management	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Demand Planning	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Material Planning	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	In-house Parts	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
EXECUTION	Goods Receipt	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Warehouse Management	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Production Supply	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	Sales and Distribution	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	N	N

Table 38: Limited scope for phases 2.3, 2.4 and 2.5

The following figure illustrates the timeline of the conceptual phases in relation to the overall timeline of the initiative.

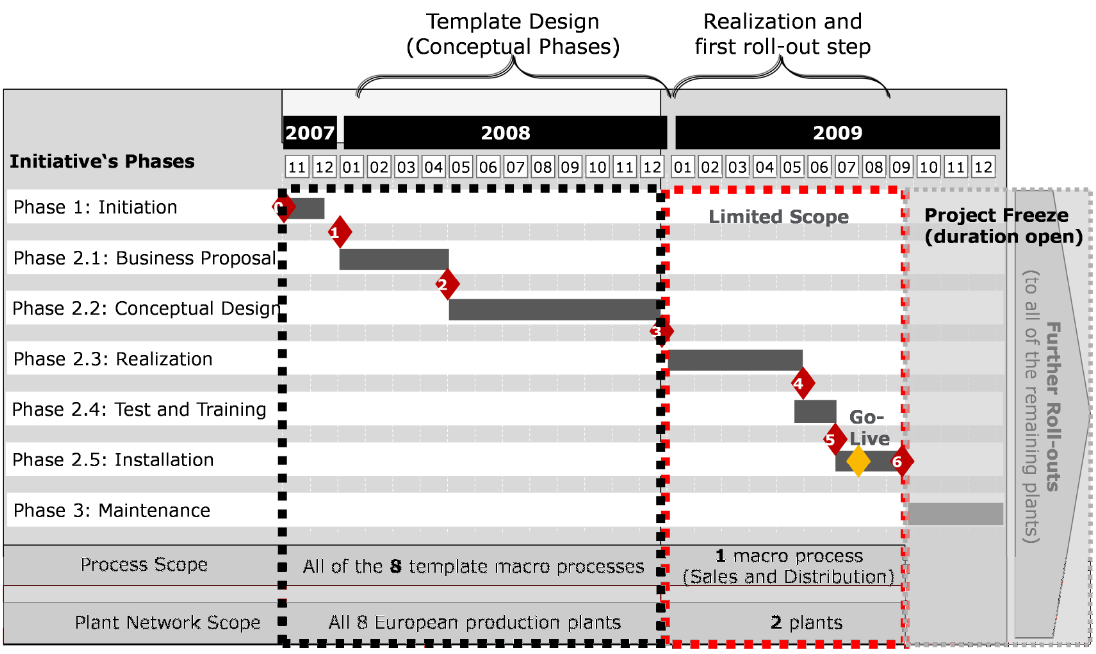

Figure 54: Initiative's phases 2.3; 2.4; 2.5

4.4.1 Course of Action

Since the realization comprised only one out of 8 macro processes, the time frame for the rollout was relatively short. In fact, the time span between start of the realization phase and the end of the installation phase took nine months. The go-live of the new processes in the two plants was planned after 7 months after start of the realization. The go-lives of the two plants were realized in a big-bang scenario; that is, both plants went live at the same point of time. The following figure breaks down the rough project plan into a more detailed plan.

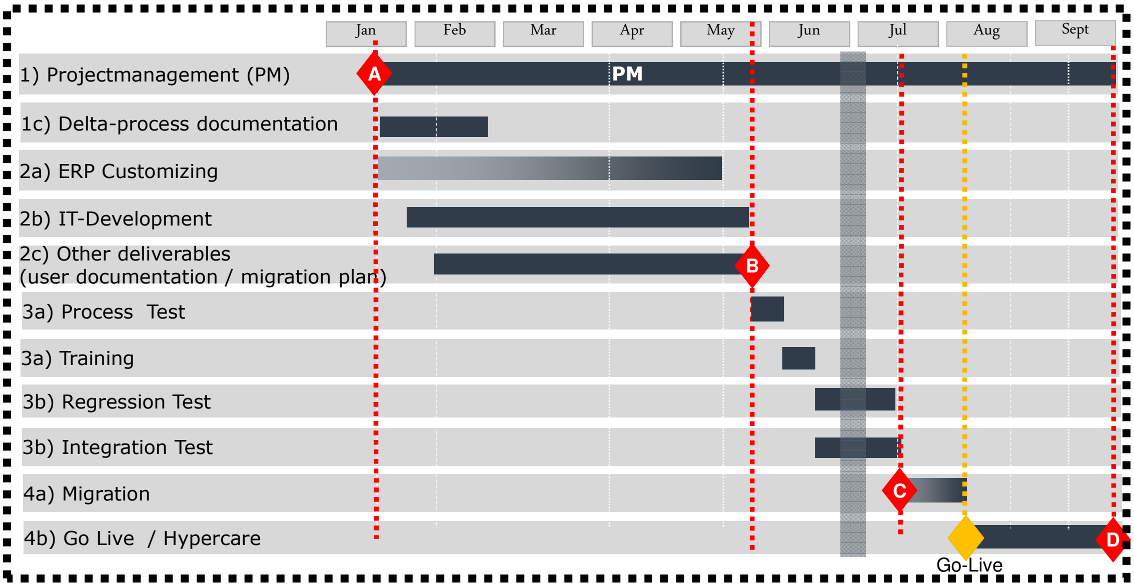

Figure 55: Detailed course of action for phases 2.3; 2.4; 2.5

Apart from project management activities, phase 2.3; that is the realization phase, started with the so-called delta process documentation. In this 6 weeks long step, the template processes were compared on a detailed level with the existing processes in the two plants of the first roll-out step. In parallel, the first activities to customize the ERP system started slowly and continued with increasing intensity until middle of May. Largely in parallel, the necessary IT development activities were carried out. Starting two weeks later but also largely in parallel, other deliverables like the user documentation and the migration plan were created.

After milestone B was passed at the end of May, phase 2.4 test and training was launched. As far as testing was concerned, this phase comprised of the process tests, the integration tests and the regression tests. In the process tests, singular processes were tested in terms of input, process and output. In contrast, integrations tests aimed at testing entire business scenarios consisting of a series of processes. And regression tests had to be done in order to make sure other entities running on the same ERP system like the aftersales processes were not influenced by the new processes. With respect to training, we applied the train the trainer concept. That is, the project team trained a number of selected so-called process champions, who were then responsible to train all employees affected by the new processes.

Milestone C marked the entry of the last phase; that is, the installation phase. It consisted of all activities required to finally set up the newly designed processes. The phase consists of the migration, which was concerned with the preparation of the ERP system as well as the preparation of the physical processes and the organisation. After that, the newly designed ERP system and with it, the newly designed lean processes went live and the hyper care period started. During this period, the entire project team supported the organisation in deploying the newly designed processes and ERP system. After a period of almost two months, the new processes were running on a stable level and the project ended by passing the final milestone D.

4.4.2 Activities and Findings

4.4.2.1 Qualitative Evaluation

This section provides a summary of the observations made during the realization, test and training and installation phases for the macro process sales and distribution. Before looking at the findings with respect to the LP elements, it deserves mentioning that the decision to realize only one out of eight macro processes had far reaching implications. In fact, this decision removed one of the main advantages of ERP; that is, the integration of different macro processes.

4.4.2.1.1.1 Flow

With respect to the LP element flow I observed that the project team intended to apply pull processes wherever possible but faced difficulties in realizing them in the full scope. Particularly during the realization phase the project members started to realize that this objective was much more difficult when considering the sales and distribution processes in isolation. Even though the team was able to design ERP supported Kanban cycles within the area of sales and distribution, they faced severe problems when trying to set-up ERP-supported Kanban processes from the sales areas other areas like warehouses or production, which were excluded from the realization scope. For instance, 4-O-07 put it that way: "The warehousing IT systems are simply technically not able to receive the ERP Kanban messages. Moreover, even if we enabled the warehousing IT systems to receive the calls, the processes in the warehouses do not foresee sub-daily processing of transport orders. We need a complete process re-engineering initiative in the warehouse areas in order to fulfill these requirements."

This statement included two main issues the project team faced due to the decision of the isolated realization of one macro process. First there were the technical interfaces between ERP and the legacy system reflecting the areas of warehousing and production. Since the old system did not support current middleware technology, the link-up was extremely complex and time consuming. In fact, most of the realization and testing effort ran into the embedding of this one ERP-based macro process into the legacy world.

Second, there was the issue of process synchronization between the new lean sales and distribution processes and the old processes in the surrounding area. During my observations I learned that the current warehouse processes where designed in a way that transport orders were transmitted to the warehouses within IT-jobs during night. Consequently the material transfers could be carried out during the next business day at the earliest. A similar situation was given for the link-up of the sales areas to the production areas. Nevertheless despite the restriction that incoming call-offs could only be processed during the night in the warehouse and production areas, we set-up a pull logic for generating the call-offs based on minimum stock quantities wherever possible in the sales areas. Though this pull process was not as efficient as Kanban logic with sub-daily call-offs, it was still perceived as superior compared to the old push-based material replenishment process by the project team members. In addition to that there were other process flows within the sales departments, in which a standard ERP-based Kanban process could be applied. This referred to buffer areas between the production and sales areas which were within the responsibility of the sales departments. In fact, these sales buffer areas were linked to the packing and dispatch areas via standard ERP Kanban with sub-daily call-offs.

To sum it up, the decision to realize the macro process sales and distribution in isolation turned out to lead to two main issues. First, there were major technical challenges through the requirement to realize a high number of technical interfaces between the ERP-based sales and distribution processes and the legacy systems of surrounding areas. Though these challenges could be eventually solved, the effort in terms of manpower for programming and testing was much higher than expected. Second, the objectives concerned with the LP element flow could not be completely met. In fact, ERP based Kanban with sub-daily material call-offs could not be realized for most process flows in the macro process sales and distribution. Instead the project team set up a pull-based logic which was only able to react via night. Though this pull logic was seen as superior to the old push based material replenishment logic, it did not allow exploiting the full potential of the LP element flow.

4.4.2.1.1.2 Kaizen

Concerning the LP element of Kaizen, the major improvement expected during the process design phase was a standardized process platform within the plant network, from which to commonly drive continuous improvement steps. During the realization of the sales and distribution processes for the two plants, the participants tried to keep the high level of standardization in the plant network as far as possible. However it turned out that this objective could not be completely realized. The reason was that due to the inhomogeneous process and system landscape in the plant network concerning adjacent macro processes like warehouse management or in-house parts production, the standardization of the warehouse processes could not be realized to the full extent. 4-O-07 explained it that way: "Since the warehousing processes and systems in the various plants work differently, we are not able to standardize our commissioning processes in the plant network to the extent could have done it in the case of the original project scope."

Nevertheless, my observation was that most participants saw a better platform for Kaizen activities after the process realization compared to before. An aspect observed was that the employees of the two plants already used their at least partly common process platform to discuss about improvements even during the realization phase. 5-O-07 explained it that way: "Since employees from the two plants suddenly speak the same language. The newly set-up improvement cycles consisting of process experts from both plants develop an enormous momentum when trying to continuously develop process improvements. We can visualize that when looking at the high number of process improvement requests generated during the realization and testing phase."

My conclusion is that the expectations from the conceptual design phases could not be fully met due to the realization of only one single macro process. However we are convinced that new processes already revealed the high potential of the plant network wide standardized ERP processes in terms of the LP element Kaizen.

4.4.2.1.1.3 Quality First

As far as quality first is concerned, the qualitative observation of the phases realization, test & training and installation has revealed that the project team frequently criticized the missed opportunity to improve the data quality by reducing the dependency from processes supported by legacy systems. This was particularly the case with respect to a specific legacy IT system responsible for quality management, but also to other linked legacy systems like warehouse management systems or production. Though the sales processes themselves were replaced by the new lean ERP processes, the interfaces to other systems remained and had a considerable impact on data quality. This led to critical comments among the project members. For instance, 5-I-03 made the following statement in this context: "We might have realized some process quality improvements because of ERP's hard data quality requirements. But frankly speaking, from an IS perspective, my team and I are kind of disappointed from the new processes. Instead of getting rid of all these data redundancies and inconsistencies between the various IT systems, we have simply replaced one system with another and the interfaces remained. From an IS perspective, this was a lost opportunity to significantly improve the data quality".

A partly critical point of view was also taken amongst the group of operations representatives. The lack of process and system integration appeared to significantly limit the range of potential process improvements. The following statement of 5-O-07 can be taken as an example: "If we had involved the initial scope of the lean ERP initiative, we could have increased the process quality to a great extent. However the singular implementation of the sales & distribution process does not allow us to take full advantage of the new processes. An example is the poor integration with the macro process material planning. Currently we face severe process problems due to an unstable interface between the ERP based sales processes and the legacy IT system responsible for material planning. This leads to material shortages and late deliveries."

I conclude that despite some improvements in terms of data quality, the high expectations raised in the conceptual design phase could not be fully met. From my observations and the comments made by the project team members I have a strong indication to believe that the prime reason for that was based on the decision to implement only one singular macro process without the others. It turned out that a consistent data base across all business process appeared to be a significant precondition in order to significantly improve the process and data quality in the area of sales and distribution.

4.4.2.1.1.4 People and Teamwork

With respect to people and teamwork, the major expectation raised during the conceptual design phase was the removal of functional barriers between different departments. Due to the decision to realize and implement the lean ERP solution in one macro process only, this objective could not be reached by definition.

Nevertheless I observed that the project members of the two production plants concerned committed benefits from the project implementation, which can be allocated to the LP element people and teamwork. Particularly the functional terminology appeared to have a considerable impact to the collaboration between the employees from the two plants. For instance, the following statement made by 4-O-02 can be taken as representative in this context: "Actually I do realize a positive influence with respect to the level of collaboration between employees from the two plants. In the past, the IT systems and the processes were everything but homogeneous. As a consequence these employees from the two plants did not even speak the same language. Joint collaborative process initiatives were almost impossible. With the new processes, we can not only carry out joint training and testing sessions, we even formed mixed realization teams consisting of employees from both plants."

Having observed the realization, test and training and the implementation phase, I can state the following point. Though the expectation in terms of cross functional collaboration could not be met, I have seen improvements in terms of the collaboration of sales and distribution employees between plants. These improvements were well recognized among the employees concerned.

4.4.2.1.1.5 Standardization

Regarding the LP element standardization, I observed a similar general picture to the LP elements described above. Though the objective of standardization within the macro process sales and distribution could be achieved to a great extent, a standardized integration to adjacent macro processes turned out as a major obstacle towards fully meeting the expectations raised in the conceptual design phase. The reason was that the two plants ran different legacy systems in the macro processes around sales and distribution. As a consequence the interfaces between systems and processes in the two plants could not be standardized. Examples for such inhomogeneous macro processes to be linked up were the macro processes warehouse management, material planning and in-house parts production.

The statement of 4-I-03 can be taken as a representative example to the perception of the majority of the project team: "The processes of packing, creating transports, dispatching and creating delivery documents like the bill of lading, shipping notifications, invoices and customs declarations are pretty much standardized with the new lean ERP processes. We were able to take advantage of this fact during the realization, testing and training phases of the project. The teams of both plants worked together extremely close during these phases. However, the processes of commissioning parts and components out of the warehouses and the in-house parts production areas, and the link to material planning for instance for carrying out the availability checks differ to a great extent from one plant to the other." Similar comments were made by other project participants like 4-O-07: "When I ask my team members, they do recognize and appreciate the standards within the sales and distribution area. However at the same time they are disappointed because we were not able to realize this high level of standardization within the interface processes to adjacent macro processes. They are afraid that there will be no follow-up project in the near future and state that this rollout might be a lost opportunity for the plant."

I conclude my qualitative observations of the macro process standardization by holding that the improvement potential of standardization could be revealed to a great extent. However, similar to the other macro processes, the full potential of the lean-ERP initiative could not be exploited due to the singular realization and rollout of only one out of eight macro processes

4.4.2.2 Lean-ERP Assessment

The following figures illustrate the lean-ERP ratings of the macro process sales and distribution for the phases of realization, test and training and installation. For comparison reasons, I have added the ratings of the as-is analysis, the business proposal and the conceptual design phase as displayed in the previous chapter. Whereas the first figure illustrates the average lean-ERP assessment ratings across all five LP elements, the second figure breaks down the ratings into each of the five LP elements.

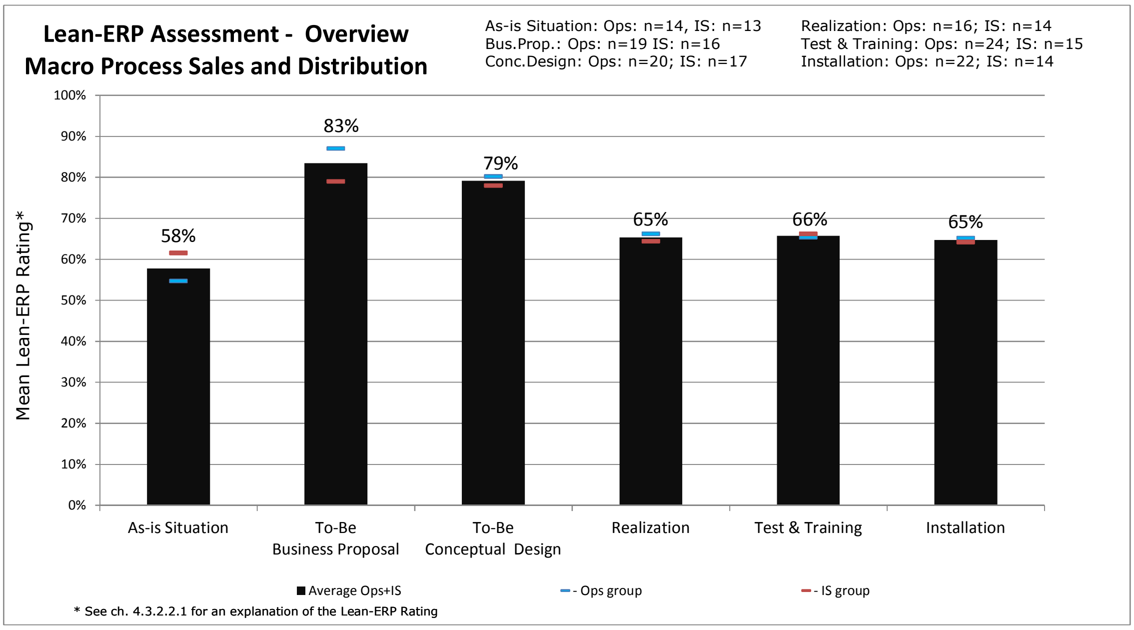

Figure 56: Lean-ERP assessment sales and distribution – all phases

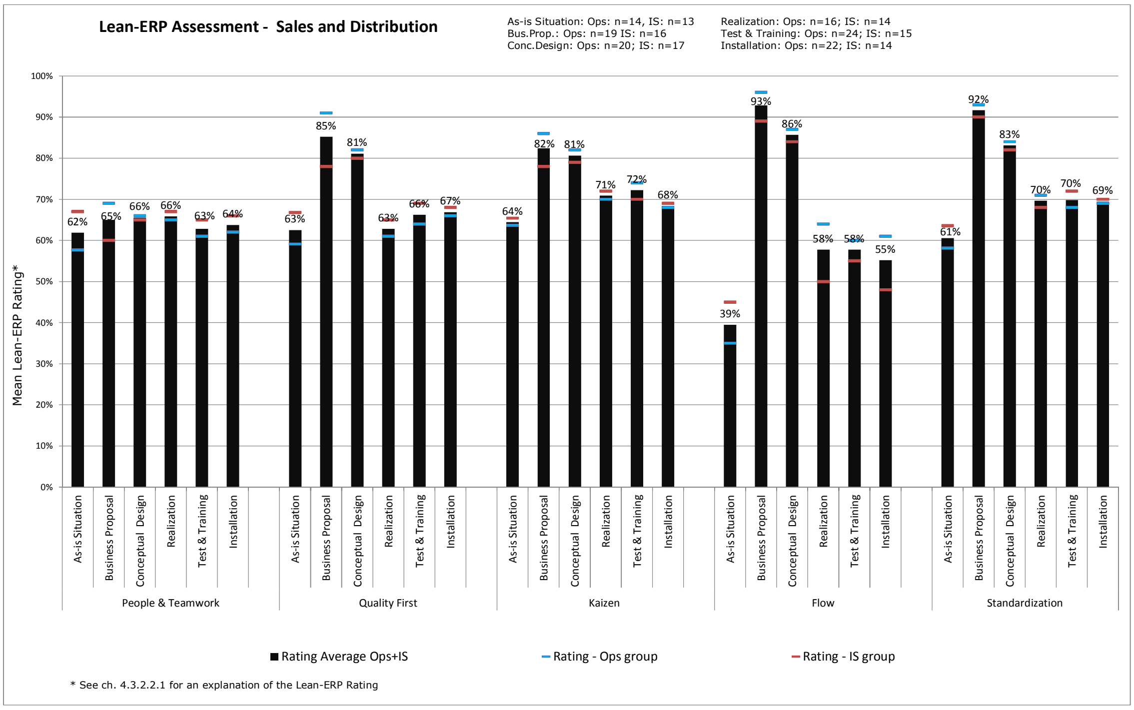

Figure 57: Lean-ERP assessment sales and distribution – all phases

The ratings of the overall concept of the first three ratings was based on the concept of a complete lean-ERP initiative comprising all 8 macro processes as described in the initiation phase, the business proposal and the conceptual design phase. The realization, test and training and the installation phases refer only to the individual project for the macro process sales and distribution. Due to this difference in the basic set-up, the concept designed in the phases 1, 2.1 and 2.2 could not be realized on a one to one basis in the phases 2.3, 2.4 and 2.5. This refers particularly to the areas of interfaces between the macro process of sales and distribution and adjacent macro processes.

Concerning the average ratings across all 5 LP elements, the quantitative analysis illustrates that the average ratings of the phases of realization, test and training and installation were somewhere in between the as-is analysis ratings and the conceptual design ratings. And, the average ratings of the phases realization, test and training and installation was extremely constant. In order to analyse these findings on a deeper level, I looked at the ratings of each individual LP element. In this context, the following paragraphs outline the main aspects of the lean-ERP assessment for each of the LP elements.

Regarding the LP element flow, the drop between the conceptual phases and the realization and onward phases was the highest of all LP elements. However comparing the as-is analysis rating to the realization and onward phases, the level of improvement was the highest of all LP elements. Looking at my qualitative observation findings as described in the previous sections, I found that the decision to realize the macro process sales and distribution in isolation lead to issues in terms of technical and process-based issued in the interfaces between the newly designed processes and systems and the environment they had to be embedded. This lead to the fact that the pull principle could not be realized as designed in its purest form, for instance with sub-daily material replenishment call-offs from the warehouses. This has led to frustration within the project team, leading to a considerable drop from the conceptual design to the realization phase rating. On the other hand, the project team realized pull based scenarios within the area of sales and distribution, for instance for calling of parts from sales buffer areas to the dispatch areas. And, for the material replenishment out of the warehouses and in-house production areas, the team set up a consumption driven pull-based replenishment logic on a daily basis. Though this was not comparable to the originally designed sub-daily replenishments cycles, it was still seen as a massive improvement to the traditionally deterministic call-off, which were perceived as inaccurate and too inflexible to react to sudden demand changes. Taking into account both the improvement compared to the traditional situation and the delta between the ideal scenario as designed in the conceptual phases, I conclude that the quantitative rating expresses my qualitative observations pretty well.

Concerning the LP element Kaizen, the pattern also indicates a drop from the template design to the realization, test and training and installation phases. However the drop was lower than for most of the other LP elements. I hold that this rating was in line with my qualitative observations. On the one hand the employees complained about the missed opportunity to implement enterprise-widely standardized processes, from which to start with when setting up continuous improvement initiatives. On the other hand, the team members valued the opportunity to speak the same language when discussing process improvements within the area of sales and distribution between the two plants, which was extremely difficult before the project. The employees agreed to regularly carry out a process benchmarking analysis between the plants. The results could be used to trigger new continuous improvement initiatives.

Concerning the LP element quality first, the lean-ERP rating pattern reflected a drop in the realization phases compared to the design phases. This general pattern can be seen as in line with my qualitative observations described in the previous section. Due to the lack of breadth in terms of macro process involvement in the realization, test and training and installation phases, the expectations of the design phase could not be met. An example can be seen in the failure to reduce the fragmented databases to one common database. As a consequence, the objective of less data redundancies and inconsistencies and, in turn, the improvement of the overall process quality could not be fulfilled. I conclude that these issues materialized in a generally lower rating level of the phases realization, test and training and implementation. The deviations between the phases realization, test and training and installation remained relatively low. I interpret this as a sign that though the level of improvements was lower than expected; the improvements could be could be put into place in the practical environment.

The LP element people and teamwork reflected a relatively even pattern across all phases. In contrast to the other LP elements, the level of expectation raised during the conceptual design phases was relatively low. As I have shown in the previous sections, many employees saw a general contradiction between the IT aspects of this lean-ERP initiative and the emphasis of human interaction without IT according to the LP element people and teamwork. The fact that the ratings of the realization and onward phases kept a relatively stable level compared to the design phases was not completely in line with my qualitative observations described above. The objective of removing functional barriers for collaboration between organisational units could not be reached because of the realization of only one macro process. Therefore I would have expected a lower ranking in the realization, test and training and installation phases compared to the design phases. However, the qualitative observations revealed that the objective of improved collaboration of sales and distribution employees between plants could be fulfilled to a great extent. With the new processes the employees suddenly appeared to speak the same language, which materialized in joint realization, test and training sessions. I have reason to assume that these collaborative experiences helped to reduce the general apprehension against the IS aspects of the project. From my findings I have reason to conclude that it was this reduced general apprehension, which has balanced the lack of removal of cross functional barriers, eventually leading to the even level of the lean-ERP ratings.

Finally with respect to the LP element standardization, the general rating pattern was comparable to most other LP elements. Again, we have seen a remarkable drop between the conceptual phases and the realization and onward phases. The average level in the phases realization, test and training and installation remained relatively stable and on a higher level compared to the as-is analysis ratings. I take this result as a confirmation of my qualitative observations outlined above. The participants have committed an improvement in terms of process standardization compared to the situation before the initiative. This improved standardization referred particularly to the processes within the macro process of sales and distribution, which explains the higher level compared to the as-is situation. However due to the isolated realization of only one macro process, an overall plant-wide process standardization was not possible and the expectations raised in the conceptual design phases could not be met, which is reflected in the rating drop of the realization and onward phases compared to the conceptual design phases.

4.4.3 Summary and Implications

Referring to all of the findings of the realization, test and training and installation phase as described in the sections above, I conclude the following main points.

First, the expectations of the business proposal and conceptual design phases could not be fully reached. On the one hand this conclusion is based on the qualitative findings with respect to each of the five LP elements as describe in the previous chapter. On the other hand, this conclusion was generally underpinned by the results of the lean-ERP assessment.

Second, I hold that the primary reason for the lower than expected level of process improvements was based on the isolated realization of one out of eight macro processes. My qualitative observations have revealed that the project members identified the lack of process harmonization and integration between the macro processes as the most important critical points for each of the LP elements.

Third, though the level of improvement was lower than expected the newly implemented processes were considered superior compared to the old as-is situation. I derive this conclusion from both my qualitative observations and my quantitative lean-ERP assessment results. Concerning the former, I have shown that the participants frequently explained actually realized process improvements with respect to the combination of LP and ERP for each of the LP elements. Regarding the latter, both the average lean-ERP ratings and the individual LP elements ratings of the installation phase were above the as-is situation.

Fourth, with respect to the differentiation between the IS group and the operations group, I could not establish a pattern of any kind. Neither in the workshop observations, nor in the lean-ERP assessment did I make out a remarkable general difference in the overall behavior or in the judgment of the processes. It appeared that the fluctuations in the lean-ERP ratings were rather random than following a general pattern. I take this as an indication that the initial general gap in perception towards the initiative between the IS group and the operations group participants disappeared or at least decreased during the intensive collaboration throughout the run of the project.

5 Discussion, Conclusions and Implications

This chapter concludes this research by discussing the results of the empirical part of this thesis described in chapter four in the light of the enfolding literature of chapter two and the research questions as stated in chapter three. Based on the literature review and the author's practical experience in the automotive industry, I introduced a first release of a theoretical framework in section 3.1 emphasizing two contradictory assumptions. Whereas the first assumption suggested that there were conflicts between the two concepts preventing the application of the integrated framework, the second assumption suggested that there were synergies utilizable in the application of the integrated framework.

Based on the two assumptions I defined the research questions for this thesis in section 3.2. In my overall research question I asked if, and if yes how, it was possible to combine LP and ERP in one integrated manufacturing improvement initiative. One level deeper I followed up on each of the two assumptions and looked at two different streams. In the first stream I asked the concrete research question if there were conflicting aspects between LP and ERP in practice and, if yes what they were and how they could be overcome. In the second stream, I asked if there were synergies in practice and, if yes what they were and how they could be utilized.

In the following paragraphs I will address the research questions of each of these two streams in a separate section. In this context I will compare and contrast the empirical findings of the case study analysis with the theoretical findings of the literature review. In this context I will discuss the research implications of my findings.

Then, merging the conclusions of both streams, the third section provides a second release of the integrated framework, based on and informed by the empirical part of this research. Eventually I will address the overall research question stating if and how it was possible to combine LP and ERP in one integrated manufacturing improvement initiative and suggest further research work.

5.1 Conflicts between LP and ERP

According to the findings described in chapter four, I can conclude that in practice I did find differences between LP and ERP causing conflicts which had the potential to prevent the deployment of an integrated initiative combining LP and ERP. In this respect, my practical findings are in line with the theoretical findings in the literature.

The following paragraphs will describe these conflicts and explain if and how these conflicts could be overcome in practice. I divided the relevant aspects into general preoccupations and conceptual aspects. Whereas the general preoccupations deal with conflicting aspects in terms of the general attitude or biases of the people, the conceptual category is mainly concerned with conflicting aspects with the operational aspects of LP and ERP.

5.1.1 General Preoccupations and Countermeasures

The following table puts together major general preoccupations as observed in the empirical part of the thesis. In this context I compare and contrast my findings with the literature review presented earlier in this thesis. The general preoccupations can be summarized to two main points:

- General aversion between operations and IS representatives
- Basic scepticism towards combining LP and ERP

5.1.1.1 General Aversion between Operations and IS Representatives

Particularly at the beginning of the initiative, I observed a latent but noticeable general aversion of the group of IS representatives against the group of operations representatives and vice versa. The intensity of the aversion was at the highest level in the early phases of the initiative and decreased throughout the further progression of the initiative. Particularly in the initiation phase workshop discussions often turned into subjective arguments. At least once the workshop stream looked like it would come to a halt and we had to intervene through the involvement of the plant's top management. Actually during the entire course of the initiation phase, an intensive moderation of the meetings was necessary in order to keep the discussion on an operational level. Based on my empirical findings I found that there were various reasons for the general aversion between the two groups. I found that one of the outstanding reasons was the lack of standardized communication and collaboration between the two groups before start of the initiative. In the daily business, the operations group was solely responsible for formulating IT requirements and handing them over to the IS departments. The IS departments were solely responsible for realizing the IT requirements. In this context the LP and ERP representatives can be described as working in separate silos and the lack of communication in this process led to frustration on both sides. A large amount of the frustration on the IS side was based on the view that many of the IT requirements handed over from the operations side made little or no sense from an IT perspective or were even considered as not realizable at all. On the other hand, the operations group's frustration originated to a great extent from their perception that the realization of the IT-requirements generally took too much time and often failed to meet the defined requirements.

With respect to the literature I found some contributions hinting towards a general aversion between operations representatives driven by the idea of lean production and IS representatives. An example can be seen by Piszczalski (2000) who claimed that the lean movement was almost anti-information systems (IS) in its stance. However what surprised us in my empirical observations was the level of intensity and the sustainability of the aversion, particularly at the beginning of the workshop series. Though I would not state that this high level of aversion recognized in this case will be necessarily found in all other attempts to integrate LP and ERP, I maintain that this case has shown that the issue of aversion should not be underestimated in initiatives like ours. According to the author's practical experience, the poor collaboration and the lack of communication between operations and IS departments observed in this case was anything but an exceptional cases in the industry.

In practice we applied the countermeasures in response to the general aversion as summarized above. First, we ensured the commitment and if required the intervention of the top management. Particularly in the early phases of the initiative, the commitment of the top management turned out to be absolutely essential for the success of the overall endeavour. I am convinced that without the frequent presence of the top management in the workshops an objective discussion would rarely have been possible. As soon as a top management representative participated in the workshops, I realized a massive improvement of the discussion quality mainly in terms of objectivity. Moreover selective top management intervention was necessary in order to avoid a lack of workshop progress in cases of unconstructive arguments. From time to time, individual top management coaching sessions with selected opinion leaders helped to improve the workshop productivity.

Second, we set-up cross functional team event workshops with the main objective of encouraging collaboration between IS and operations representatives. For instance at the beginning of the initiative we set up a large-scale kick-off workshop involving more than 100 people over three days. We designed the workshop mainly in order to foster communication and collaboration between the group of IS and operations representatives. In this respect we conducted an interactive LP game, in which both IS and operations representatives worked together in teams in order to optimize a simulated production line according to lean principles. We applied the instrument of team event workshops several times throughout the initiative, particularly at the transition periods between project phases. I found that such events contributed to some extent in reducing the general biases of the two groups and for encouraging team work throughout the initiative. However I also conclude that such events, even when encompassing several days as in this case, were not sufficient for sustainably or completely reducing the general aversion or scepticism I observed in this case.

Comparing this empirical finding with the literature I suggest that both above-mentioned countermeasures have been addressed in the mainstream of the operational improvement literature (Shingo, 1981, Ohno, 1988, Womack et al., 1990, Liker and Hoseus, 2008). This refers mainly to the importance of top management commitment, but also to the encouragement of cross functional team collaboration. In terms of top management commitment, this case can be interpreted a key example for impressively demonstrating the significance of top management commitment. Moreover I believe that top management commitment has even turned out as the most important key enabler for the practical realization of the idea to integrate LP and ERP. In this regard my findings not only confirm the long track record of the significance of top management commitment in the literature of operational improvement concepts, but even strengthen its importance for unconventional cases like the combination of apparently conflicting concepts.

5.1.1.2 Basic scepticism towards combining LP and ERP

In line with the general aversion described above, I observed a generally sceptical or even negative attitude of most participants towards the idea of combining LP and ERP. The sceptical attitudes can be divided into an IS and an operations dominant point of view. The dominant view of the IS representatives was to consider LP as another temporary management fad. I observed that it was particularly hard for the group of IS representatives to appreciate the philosophical and the social aspects behind LP. In addition to that, the consumption-driven pull principle of LP was often even misinterpreted as a step backward compared the traditional deterministic IT-driven demand calculation. As a consequence, the IS representatives considered a combination of ERP with LP as a dilution of the concept of ERP. On the other hand, there was the rather LP-centred point of view. In the most extreme form, operations managers questioned the need for IT-systems at all. The need to maintain data as well as the resource requirements for system processing were criticized as non-value adding activities. Moreover ERP was perceived as a deterministic tool incompatible to the LP idea of consumption driven flow.

With respect to the literature I suggest that the empirically observed aversion and the sceptic attitude towards the idea of combining LP and ERP was generally in line with the overall literature theme. In this respect Nakashima's (2000) contribution can be considered a representative, which held that some lean proponents would even argue that ERP systems were the antithesis of lean production operations. Though there are also less drastic contributions in the literature, I maintain that from the mainstream of the contributions one could deduce that an integration of lean production and ERP would raise some concerns particularly amongst the hardliners of LP or ERP proponents. However what could not be expected based on the theoretical contributions was the level of intensity and the sustainability of the scepticism observed in practice. Though I am aware that my findings are not generalizable on a one to one basis, I believe that my observations of the basic scepticism enhanced the general body of knowledge in the area of integrating two apparently conflicting concepts.

As a response to this basic scepticism we deliberately induced a shift of the process design discussions away from an abstract level to an operational shop floor related level. In this context we split each macro process into lower level processes and divided the large group of participants into smaller process-oriented focus groups with the relevant experts from each side. As a consequence, each of the lower level processes could be discussed on an operational shop floor level. During the operational discussions I realized a slight but continuous reduction in the general aversion between the IS and operations group. Moreover I realized that the more the discussions were driven by functional experts on an operational level, the more synergies could be identified between LP and ERP. I found that with increasing objectivity in the workshop discussions, the individual participant's contribution gained more and more importance over the organisational origin.

5.1.2 Conceptual Conflicts and Countermeasures

In addition to general preoccupations as described above, I have identified a number of rather conceptual conflicts. I am convinced that, if not addressed properly, these conflicts had the potential to considerably disrupt the course of this initiative. The following table summarizes the major conceptual conflicts together with the respective countermeasures applied.

LP Element	ERP Characteristic	Outline of Conceptual Conflicts	Countermeasures
People and Teamwork	Focus on Information Technology	Fear that ERP's automation potential could lead to a reduction of human process control, communication and collaboration	Setting up user-friendly cockpits for monitoring the information and material flow and allowing for human intervention
Flow	MRP logic	Apparent contradiction between ERP's deterministic MRP logic versus consumption driven pull	Exemplifying and showcasing ERP's support of pull processes, e.g. ERP supported Kanban
Flow	Data Quality Requirements	The high level of data quality requirements of ERP could lead to a	Design of processes for permanently monitoring and improving the quality of the

		slowdown or even stoppage of the logistics process flow	required data for a proper sales and distribution processes
Kaizen	Focus on Process Standardization	Contradiction between production network wide standardization through ERP and the flexibility required for Kaizen in LP	Setting up prototyping sessions demonstrating ERP's flexibility. Installation of a platform for discussing and deciding about change requests on a weekly basis

Table 39: Major conceptual conflicts between LP and ERP

5.1.2.1 LP Element People and Teamwork versus ERP's Information Technology Core

One of the major conflicts observed in practice was the apparent contradiction between the LP element of people and teamwork and ERP's information technology focus. In fact I observed the fear of workshop participants that ERP's information technology potential could be used to increase automation and to reduce of human process control, communication and collaboration. In fact, this point was raised frequently with respect to many of the macro processes under discussion. This empirically observed conflict corresponded to the literature review findings as described in section 2.3.1 and 2.3.2, in which LP was characterized as people-centered whereas ERP was predominantly classified as technology-focused (Bradford et al., 2001, Dixon, 2004, Gill, 2007).

As a countermeasure we set-up a basic rule to reduce IT automation to a minimum, which was applicable for all processes and all phases in this initiative. This basic rule can be summarized as the requirement to install as little IT automation as possible in the design of processes, leaving as much control as possible to the human being. In areas in which automation was necessarily required or brought significant benefits to a process, it was required to set-up a minimum of a monitoring functionality allowing human beings to monitor the process and to intervene if required. By making these rules and guidelines a firm cornerstone for all process design workshops we managed to cope with the conflict of LP's element of people and teamwork versus ERP's information technology core. In this respect I believe that even though it was not possible to completely remove this conflict, we were able to reduce it to a level tolerable for the purpose of an integrated LP and ERP initiative. Since the literature review did not reveal academic contributions on how to cope with this conflict, I suggest that my empirical findings can be considered a contribution to the body of knowledge in this area.

5.1.2.2 LP Element Flow versus ERP's MRP logic

Another major conflict realized was an apparent contradiction between ERP's deterministic MRP logic versus LP's consumption driven pull philosophy. Throughout the course of the to-be design workshops, ERP was often viewed as solely supporting deterministic material requirement planning processes without support of consumption driven pull processes. This finding was in correspondence with the literature review, in which I have shown that there are several contributions considering ERP as representing a deterministic MRP logic (Jacobs and Weston, 2007, Michel, 1999, Samaranayake and Toncich, 2007) compared to LP focusing on pull logic (Womack et al., 1990, Sugimori et al., 1977, Shingo, 1981, Ohno et al., 1993). I posit that the reason for this view came to a great extent from ERP's roots in MRP / MRP II (see section 2.2.1). In this respect I maintain that my empirical results have shown that this simplistic and theoretical conflict was actually still deeply anchored inside the minds of many employees. I state that this theoretical conflict contributed considerably to the general preoccupations as described in section 5.1.1.2.

Though we could not completely abandon this kind of critical thinking for every participant, I found that the provision of concrete counterexamples helped best to reduce such general prejudice. As one example we frequently explained and showcased the ERP supported Kanban pull process. I observed that the more the participants were able to realize the lean ERP processes in the form of practical examples, the more the apparent contradiction between LP and ERP was replaced by the question how the advantages of both approaches deterministic MRP logic and consumption driven pull, could be utilized in parallel. Eventually the participants found that both pull and MRP could be used in parallel to complement each other. Since there were only few academic contributions describing a parallel coexistence of pull and MRP, I consider this empirical finding a relevant contribution to the academic mainstream thinking.

Another major conflict with respect to the LP element flow was the high level of data quality requirements of ERP, which could potentially lead to a slowdown or even stoppage of the logistics process flow. This fear was also in line with my literature review findings, in which ERP is generally characterized as data dependent, trying to track every piece of material in the plant (Bartholomew, 1999, Bradford et al., 2001, Dixon, 2008, Gill, 2007). Also according to my consulting experience, this point had to be taken seriously. In fact, a major problem in many ERP installations was the lack of a proper data quality, which can in fact lead to a break-down of the entire process chain.

We reacted by commonly defining the number and scope of ERP-based quality checks together with operations and IS representatives. We recommended a limitation of the quality checks to an absolutely necessary minimum. In addition to that, we conducted data quality improvement initiatives in the early phases of the project and maintained the intensity of these initiatives until the installation phase. These measures helped to reduce this conflict to a level at which the advantages of better data quality were estimated to exceed the potential risk of process stoppages caused by data non-conformance. In this respect, I state that I was able to demonstrate the possibility to reduce or at least deal with ERP's data dependency in an integrated initiative combining LP and ERP.

5.1.2.3 LP Element Kaizen versus ERP's supposed Characteristic of Fixing and Standardizing Processes

One of the main conflicts observed was with respect to the LP element Kaizen and ERP's characteristic of fixing and standardizing processes. Concerning the aspect of fixing processes, the concern observed was that once implemented ERP would set things in stone by deploying a corset of IT reinforced mandatory procedures and process step sequences. Moreover with respect to standardization, there was a major conflict in people's perception of a contradiction between process standardization through ERP and the flexibility required for Kaizen according to LP. In fact there was a fear that time consuming discussions for defining a common standard could completely prevent improvements or at least slow down the speed at which improvements could be implemented. In fact, I suggest that these apparent conceptual conflicts between Kaizen and ERP turned out to impede the realization of this integrated initiative in practice. Comparing these findings with the literature, I state that the suppositions described above can be interpreted as in line with the literature review results, in which a lack of flexibility was reported as one of ERP's weaknesses (Flapper et al., 1991, Hodgson et al., 1992). To this extent I demonstrated that I was able to confirm this theoretical conceptual conflict between LP's Kaizen and ERP's supposed characteristic of fixing procedures through process standardization.

However I further suggest that these empirically confirmed conflicts mainly referred to people's biases and preoccupations and not so much to actual conflicts when defining, implementing and deploying processes. I come to this conclusion by my observation that these apparent conflicts decreased the more the participants focused on functional processes on an operational level. In addition, I was able to significantly decrease these biases by applying several countermeasures.

First we responded by initiating prototyping sessions, in which we informed particularly the participants from the operations group about ERP's flexibility in terms of process adaptations. We emphasised the fact that, compared to the old legacy applications, processes in ERP could be changed along a huge range of parameterization and customization options without the need for time consuming source code programming. Demonstrating the massive customization options in concrete practical process examples, we were able to reduce the bias about inflexible ERP to a great extent.

Second we set-up a production network platform and procedure for rapidly deciding on process change requests on a regular basis. We applied this procedure during the entire course of the initiative. The longer the platform was in place, the more accepted was this instrument in the entire production network and decisions could be made relatively quickly. I realized that with progression of the initiative, advantages of production network standardization were more and more acknowledged by the employees. I refer to these advantages in section 5.2.2.3 as conceptual synergies between LP and ERP.

To sum it up, I maintain that based on my findings I was able to put the theoretical accusation of ERP paralyzing LP's Kaizen element into a different perspective. Moreover, I claim that I was able to extend the body of knowledge on the matter of Kaizen versus ERP through my practical illustrations on how we responded to above described conflicts.

5.2 Synergies between LP and ERP

In section 2.3.3 I established potential synergies primarily based on the literature. Based on my empirical findings, I conclude that I was able to actually identify synergies between LP and ERP. I further claim that these synergies could be well utilized in the practical environment of this integrated LP and ERP initiative. In this respect, the following paragraphs briefly summarize these synergies and outline how they could be utilized in practice. Furthermore I will set the practical findings in relation with the theoretically established synergies in section 2.3.3. First I describe the area of general synergies, in which general characteristics of one concept have positive influence on the other concept. Then I address the area of specific conceptual synergies.

5.2.1 General Synergies

This section focuses on synergies on a general level. The general synergies can be allocated to two main points:

- LP's top management popularity supporting ERP
- ERP's reach supporting LP

5.2.1.1 LP's top management popularity supporting ERP

I found that ERP benefited to a great extent from LP's ability to generate the interest and commitment of the top management. Pure ERP projects often suffer from a lack of top management commitment. Based on its historical roots in MRP and MRP II, ERP implementation is often wrongly perceived as a pure IT implementation project, which can be conducted mainly by the IS organization alone. I suggest that this view comes from the history of ERP projects, in which ERP systems had often been implemented in order to replace a bunch of legacy systems without or with little process improvement ambitions.

On the other hand LP with its focus on operational excellence is often placed within the top range of the CEO / COO agenda. In this initiative described in the empirical part of this thesis I found that by combining ERP with LP it was possible to gain a high and sustainable level of commitment from top executives. Moreover by combining the positive effects of LP with ERP, I was able to create a positive business case for the entire initiative. I maintain that, in turn, the positive business case helped significantly to encourage and maintain the commitment of the top management on a high level throughout the initiative.

Setting these findings in relation with the literature review as described in section 2.3.3, this general synergy was not expected from a theoretical point of view. Though a certain degree of top executive commitment towards the concept of LP was well expected based on its long and deep underpinning in management literature (Shingo, 1981, Ohno, 1988, Womack et al., 1990), the possibility to transfer LP's popularity to an integrated initiative with ERP was not expected. I suggest this point as a contribution to the body of academic knowledge in the area of combining LP and ERP.

5.2.1.2 ERP's enterprise wide reach supporting LP

Another general synergy identified on an empirical basis was that ERP's enterprise wide reach could be used to support the concept of LP. In fact, I realized that ERP's reach contributed in spreading lean thinking across the entire company.

One of the major issues of LP is the critique that it is often implemented in local areas which fit well to the concept. Such areas are usually characterized by high volumes and low variation. In other areas with less ideal characteristics the concept is often not or only partly implemented. With the combination of LP's improvement potential and ERP's reach, an entire vehicle production plant could be improved in one project. In this initiative, I was able to address an entire production network consisting of eight plants in the conceptual phases. This helped significantly to spread the LP elements, principles and lean thinking into all of the plants concerned.

Setting my empirical findings in relation to the literature review as described in section 2.3.3.9, I claim that I was able to confirm that the organization-wide reach of ERP (Chand et al., 2005) could be utilized practice in an integrated initiative combining LP and ERP. In this context I was able to use this strength of ERP to cure one of LP's main issues as suggested on a theoretical basis in chapter 2. I consider this finding a relevant contribution to the academic body of knowledge with respect to combining LP and ERP.

5.2.2 Specific Conceptual Synergies

I identified a relatively high number of conceptual synergies compared to the number of conflicts encountered during the initiative. In this respect, the following list outlines only the most important and predominant conceptual synergies utilized during the course of this initiative.

LP Element	**ERP Characteristic/ Functionality**	**Outline of Conceptual Synergy**	**Utilization / Business Impact**
Flow	ERP supported Pull functionalities Parallel support of Push and Pull logic	Applying ERP supported consumption-driven pull methods and combining them with deterministic MRP	The consumption-driven pull logic led to a reduction of inventory levels and material throughput time
Standardi-zation	ERP's process standardization potential and organization reach	Design of standardized logistics processes and systems in the entire production network	Reduction of efforts for deploying and maintaining individual solutions
Kaizen	ERP's flexibility towards process changes	Comparably high flexibility of ERP with respect to process changes through parameterization and customization	Increased productivity through rapidly improving / adjusting material planning parameters
Quality first	ERP's demanding data quality requirements	High data quality requirements lead to significantly improved data quality	Higher data quality leads to higher operational process quality
People and Teamwork	ERP's ability to integrate data and processes	Reflection of all relevant logistics processes and data and in ERP in one consistent	Increased collaboration and teamwork due to consistent data and

		database.	standard terminology.

Table 40: Major conceptual synergies between LP and ERP

5.2.2.1 LP Element Flow and ERP supported Pull Functionality

One of the most predominant conceptual synergies between LP and ERP was the application of ERP supported consumption-driven pull methods for material planning and supply. These pull methods could be applied for a broad range of business scenarios. First, for the material call-offs from suppliers, for which I was able to utilize ERP supported just-in time (JIT) processes like supplier Kanban. Second, for material call-offs within the company's production network, ERP supported just in sequence (JIS) processes could be applied. Third, for material replenishment within the plant, internal ERP supported Kanban control cycles were installed. And fourth, ERP supported Kanban could be utilized for triggering in-house parts production.

Moreover, by complementing above mentioned pull methods with deterministic MRP functionality in ERP, it was possible to provide also a solution for material with low volume and high variation characteristics. And, it was possible to provide long term forecasts to external and internal suppliers in parallel to the pull-oriented short-term call-offs. In summary, I suggest that this case has shown the practical applicability of several synergies in the area of pull.

Referring to the theoretical findings based on the literature, I maintain that I did identify theoretical potential for synergies with respect to pull as described in section 2.3.3.1. However comparing this theoretical potential with the empirical results, I conclude that the practically realized synergies in the field of pull even exceeded the potential synergies foreseen on a theoretical basis.

Based on the literature I predicted mainly the complementing of just in time with ERP's MRP logic (Bell, 2006, p.150) and the case of electronic Kanban (Drickhamer, 2005, Carr, 2005). However the applicability of Kanban for external suppliers' call-offs or the integration of Kanban for directly triggering production orders for in-house parts was not foreseen in the academic literature. Moreover, the scope and acceptance of E-Kanban applicability for normal line supply was even higher than expected based on the theory. With respect to realizing pull for internal plant to plant relationships, the theoretically foreseen potential synergies can be seen as fully confirmed by my empirical findings.

Apart from these findings, I believe that I was able to describe the applicability of realizing the LP element of pull in an integrated LP and ERP approach on a more practical and deeper level compared to the existing academic literature.

5.2.2.2 LP Element Standardization and ERP's Process Standardization Potential

Another major conceptual synergy between LP and ERP was the element of standardization. In my practical observations, LP's element standardization went largely hand in hand with ERP's inherently strong standardization potential.

In particular, I observed that it was possible to utilize ERP's organizational reach to standardize processes. As mentioned earlier, the design and implementation of standardized logistics processes in the entire plant and even across the production network can be seen as a major strategic cornerstone of the initiative described in the empirical part of the thesis. In this context ERP with its characteristic to address processes at a plant or even enterprise level turned out as enabling the expansion of process standardization from a line section level as often the case in LP towards plant-network wide process standardization. An example can be seen in the design and implementation of standardized customer-supplier relationships within the plant network as described in section 4.3.4.3.1.

Moreover ERP's ability to standardize processes on a sustainable level was seen as a major benefit in terms of LP. The reason for this was that in pure LP initiatives, human behaviors supporting the newly designed processes were often reported to fall back to the old patterns after a while. ERP's characteristic to force certain behaviors based on pre-defined IT procedures was realized as a contribution towards weeding out LP's weakness in terms of sustainability.

In fact, operations representatives valued the unique basis from which to start further Kaizen activities. Moreover, any further improvement of a process could be utilized in all of the plants in which it was applied. By this means it was possible to multiply the return on investment for further process improvements. An example can be seen in the standardized goods receipt process as described in section

4.3.4.6.1, for which the benefits of any improvement are likely to be applicable for all plants in the production network.

Setting my empirical findings in relation to the literature review as presented in chapter 2.3.3, I maintain that the empirical results generally confirmed the theoretically suggested synergy of LP and ERP with respect to the element of standardization. This refers to the aspect of ERP's organizational reach for process standardization and to the related aspect of enabling leveraging developed and implemented process improvements across the entire production network as theoretically inferred from the contribution of Masson (2007). Moreover ERP's ability to reinforce the coherence of processes with the help of pre-defined IT procedures (Chand et al., 2005, Huq et al., 2006) has turned out as a considerable utilizable synergy in this empirical case.

However the fear of fixing processes in the ERP software as described in 5.1.2.3 has to be seen as serious concern in this context. This empirical finding of the necessity to emphasize ERP's parameterization and customization flexibility can be seen as a contribution towards practical knowledge. I particularly address this point in the following section with respect to the LP element Kaizen.

5.2.2.3 LP Element Kaizen and ERP's Flexibility towards Process Changes

A further empirically observed conceptual synergy was the LP element Kaizen and the flexibility of ERP with respect to process changes. In fact, LP's Kaizen and ERP's supposed characteristic of fixing processes was originally considered as a conflict as summarized in section 5.1.2.2.

However, with ongoing project time and increasing participants' understanding of ERP's possibilities supported by applying specific countermeasures (see section 5.1.2.2), I demonstrated that this apparent conflict turned into a synergy. In this respect ERP turned out as much more adaptable to process or organizational changes than the traditional legacy system landscape. The higher flexibility turned out have two aspects

First, ERP has proven to be a tool with considerable possibilities for operations employees to adapt process settings without the involvement of the IS department. By demonstrating ERP's high flexibility by prototyping specific processes in the system and demonstrating these possibilities to the participants, it was possible to provide a flavor of ERP's powerful parameterization options. Particularly compared to the old legacy systems in which even minor adjustments often required source code adaptions, the operations participants welcomed this broad option set as massive increase in process flexibility.

Second, in case of required process changes beyond the parameterization options, I was able to demonstrate and make use of ERP's extensive customization possibilities. In a specific prototyping session we introduced customization as a layer below the level of parameterization, which allows change or set up of new processes through an extensive range of settings. I further demonstrated how this layer enabled a pre-defined group of employees to carry out far reaching process adaptations without source code programming. In contrast to the case of parameterization, the customization layer provided not only a higher range of options, but rather was realized as completely new by the participants. Since source code programming of the old legacy systems usually involved long periods of time for coding and testing, I observed that the participants valued the possibilities of customization as an accelerator for installing new or changed processes.

Referring to the findings of the literature review, I claim that my findings confirmed the theoretically foreseen synergies an outlined in section 2.3.3.5. As I have shown based on the literature, ERP allows for individual configuration of the software (Helo et al., 2008). It was this aspect, which has turned out to be a major advantage of ERP and a major synergy between ERP and LP's element Kaizen in a practical environment. Moreover, I was able to show that apparent conflicts between Kaizen and ERP could be overcome in practice as illustrated in section 5.1.2.3. I suggest that these aspects provide a contribution to both academic and practical knowledge.

5.2.2.4 LP Element Quality First and ERP's Data Quality Requirements

Another major synergy between LP and ERP was identified with respect to the LP element quality first and ERP's high data quality requirements. The LP element quality first was used as synonym for the Japanese term Jidoka because it was supposed to be easier understood by the majority of the employees.

With respect to this initiative described in the empirical part of this thesis, I observed that in the early phases ERP's high data quality requirements were often seen as an obstacle towards project progress. In particular, the participants complained about the effort and time spent on data improvement measures (see also section 5.1.2.2). In order to improve the data quality for this initiative, I defined two major areas. The first area referred to the preparation activities for the data migration. This step focused on the consistency of master data like material master data, purchasing master data, BoM and routing data for in-house parts production on an extremely detailed level. In this initiative I found that there was massive room for data quality improvement. The second area was designed to be applicable constantly after the manual parameterization of any functional process. Functional parameters responsible for controlling the logistics flow throughout the plant had to be constantly verified with respect to consistency. I observed that the systematic consistency checks contributed considerably toward raising the quality of the overall business processes.

Applying these measures over a period of several months, I observed that the confidence of the participants in the quality of the data improved considerably. Moreover conducting the first testing activities the employees started to realize the massive impact of the data quality improvement measures to the overall quality of the processes. Though there was still plenty of data quality errors detected in the testing sessions, I observed that the participants realized that, once the early detected data quality errors were resolved, the process tended to run through smoothly without interruption. This was seen as an important improvement compared to the old situation, in which such errors occurred at any point within the process.

I believe that the above described principle of detecting and sorting out potential errors as early as possible in the process fully supports the main principle of the LP element quality first (Ohno et al., 1993). Though this theoretical synergy was predicted based on the literature review findings in section 2.3.3.2, this case provided deeper insights into the practical implications of the synergy between LP's quality first and ERP's high data quality requirements. An example is the necessity to carry out data quality improvement initiatives in order to utilize the full potential of this synergy.

5.2.2.5 LP Element People and Teamwork and ERP's Ability to Integrate Data and Processes

Moreover I identified a major synergy with respect to ERP's ability to integrate data and processes and the LP element people and teamwork. This refers to ERP's ability to reflect a broad range of the logistics processes in one IT application system. Whereas in the old legacy environment several heterogeneous applications were responsible for processes in the area of physical logistics, material planning, production, purchasing, finance and controlling, ERP unifies all of these processes in one integrated application suite. I observed that this aspect was seen as a major contribution towards improving the cross functional collaboration between different organizational departments.

In correspondence with this finding was largely in correspondence to the theoretical contribution of Huq and Martin (2006) who addressed ERP's potential to integrate an enterprise as described in section 2.3.3.4 of our literature review. However the extent to which ERP contributed towards the LP element people and teamwork was larger than expected. In fact I observed that representatives of certain different departments actually appeared to discuss process integration issues, which actually turned out to have existed for several years. An example of that was the issue of the logistics department transferring parts from the in-house production department to assembly in a sub-optimal way. Due to the lack of communication, the issues had been considered as non-changeable by the assembly department. I am convinced that this joined LP and ERP initiative forced the representatives of both departments to commonly discuss and define the future processes and, in this context, to solve such long existing issues.

In addition to that I found that the combination of ERP and LP led to a common standardized functional terminology used by operations and IS representatives. I observed that this fact also contributed significantly towards communication and collaboration particularly between the IS and operations group.

And there was ERP's characteristic to integrate all data in one common database. As a consequence, the central database led to fewer inconsistencies and redundancies as compared to the bunch of old legacy systems. This in turn made the communication, collaboration and teamwork across departments or plants much easier than before.

I conclude by claiming that all of the above described aspects led to an increased level of collaboration and cooperation of employees, one of the key elements of LP. In this respect my empirical findings generally confirmed the synergies theoretically derived from the literature review. With respect to the positive impact on cross functional collaboration, I maintain that the findings even exceeded my level of expectations derived from the literature as described in 2.3.3.4.

5.3 Integrated Framework and Overall Research Question

In section 3.1 I introduced a first release of a manufacturing improvement framework for integrating LP and ERP in one initiative. This first release was based on assumptions derived from the literature review presented in chapter 2 combined with the practical experience of the author in more than 10 years consulting in the Automotive Industry.

In order to close the research loop, this section introduces a second release of the manufacturing improvement framework for integrating LP and ERP. In contrast to the first release, the second release is informed by the empirical findings as presented in chapter 4. Instead of highlighting theoretical assumptions, the second release of the framework illustrates only actually observed interdependences between LP and ERP.

For comparison reasons, the following two figures present both releases of the framework. Whereas the first figure shows a copy of the first release as presented in section 3.1, the second figure illustrates the second release.

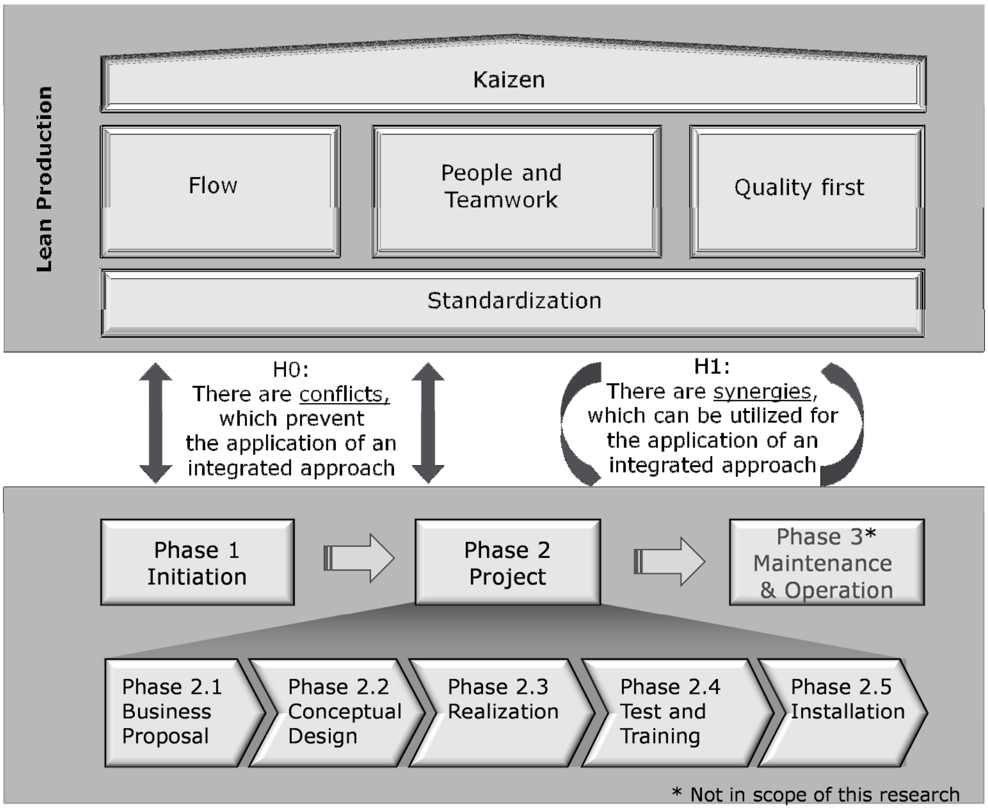

Figure 58: 1st release of the integrated manufacturing improvement framework

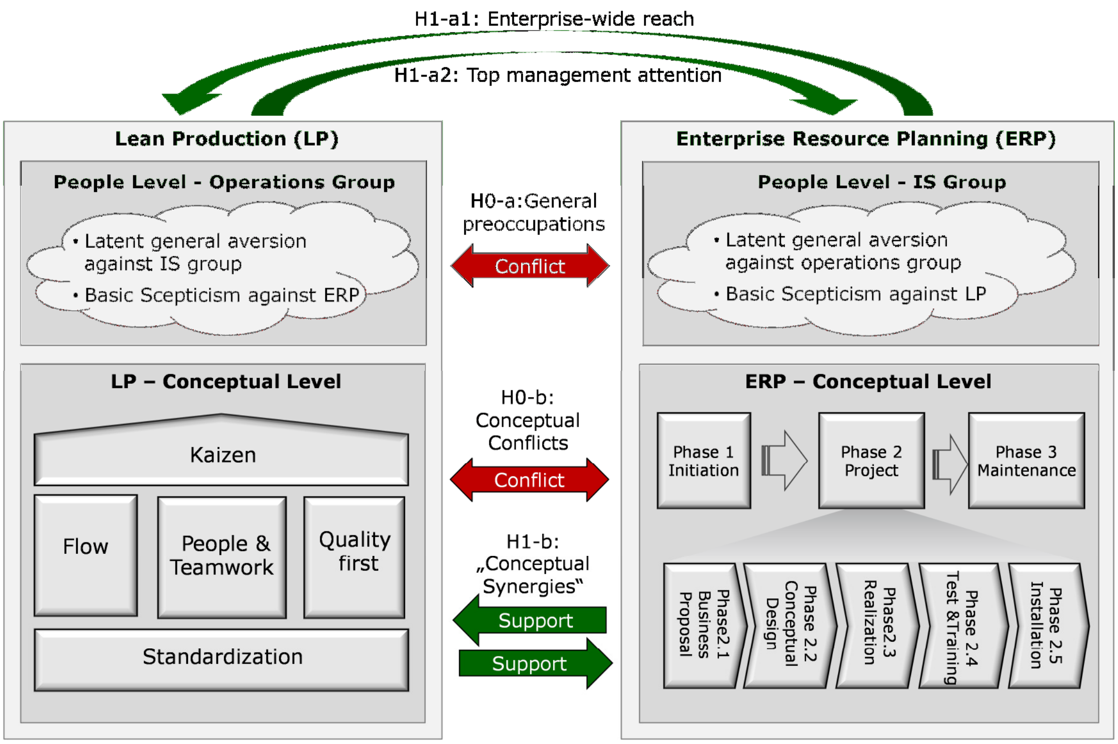

Figure 59: 2nd release of the integrated manufacturing improvement framework

Comparing the two releases, we can see that the first release of the framework was generally at a higher level compared to the second release. The first release highlighted assumptions. Whereas the first assumption suggested that there were conflicts preventing the application of an integrated approach, the second proposed that there were utilizable synergies.

In contrast, the second release of the integrated manufacturing improvement framework replaces each of these two assumptions with several more precise interdependencies as observed in this practical case. Moreover the second release differentiates each of the concepts into a people level, a conceptual level and a general level, which is indicated by the outer LP and ERP boxes.

With respect to the general level, I observed mainly synergies between the two concepts. On the one hand ERP supported LP with its enterprise wide reach (H1-a1) as described in section 5.2.1.2. On the other hand I found that LP supported ERP on a general level by its ability to attract top management attention and commitment (H1-a2) as summarized in section 5.2.1.1.

Regarding the people level, I observed that there were conflicts, which could be summarized as general preoccupations (H0-a). These people related conflicts could be broken down into a general aversion between operations and IS representatives as outlined in section 5.1.1.1 and basic scepticism towards combining LP and ERP as summarized in section 5.1.1.2.

As far as the conceptual level is concerned, I found both conflicts and synergies. The conceptual conflicts (H0-b) as outlined in section 5.1.2 turned out to be surmountable by proper countermeasures with progression of the initiative as. In contrast, the conceptual synergies (H1-b) as summarized in section 5.2.2 tended to increase positive effects after the initial phases of the initiative.

In response to my overall research question as stated in section 3.2, overcoming the conflicts and utilizing the synergies, it was possible to combine ERP and LP into one integrated manufacturing improvement initiative. Based on the business case analysis as described in chapter 4.2.3, I found that the potential to combine LP and ERP in one integrated initiative promises a higher return on investment than applying one of the two concepts in isolation.

5.4 Research Implications and Limitations

This section discusses the implications and limitations of my DBA thesis. In contrast to the discussions in above sections of chapter five, this section discusses these issues on an overall level addressing the general research design.

As mentioned in chapter 3, I decided to conduct an in-depth case study to empirically analyse the applicability of an integrated manufacturing improvement concept combining LP and ERP at a relatively deep level. In correspondence to the criteria suggested in section 3.6, I assess the research implications and limitations according to the following criteria:

- External validity
- Internal validity
- Ecological validity
- External reliability
- Internal reliability

As explained earlier, external validity refers to the degree to which research findings can be generalized. On the one hand, my primary intention was not to generalize my findings but to provide deep insights into one single case. I found that through the high level of access to the research case I was able to fulfil this intention. In this respect I am convinced that my detailed observations increase the body of academic and practical knowledge in the research area of integrating LP and ERP into one initiative.

However I found that, in contrast to a major stream of the literature review, my research has shown that the conflicts between LP and ERP could be overcome in practice when taking the right countermeasures. In this respect I state that I am able to reject the dominant theory. I further claim that this very aspect, the finding that I was able to show that it was *not* impossible to combine the two concepts, can be interpreted as generalizable. Since it was possible to integrate LP and ERP in this case, I can reject the believe that such an integrated endeavour was not feasible in general.

I further conclude that I was able to achieve a high level of internal validity through my detailed workshop observations over a long period of time. According to LeCompte and Goetz (1982), the participation over quite a long period of time entails a high level of congruence between observations and concepts. In the case under investigation, the revision to the conceptual framework as suggested in section 5.4 was purely informed by the findings of my empirical in-depth case study observations and findings.

As mentioned earlier, ecological validity asks whether the instruments applied captured the real life conditions of those studied (Cicourel, 1982). As far as this case was concerned, I conducted my research without creating unnatural laboratory settings but in a real large industry initiative. Moreover, I was not acting as researchers but as consultants for the participants of the initiative under investigation. Therefore my setting was in fact a practical case and consequently my findings were applicable in practice by definition.

With respect to external reliability, on the one hand I am aware that it is generally impossible to replicate a social setting. As a matter of fact this also refers to my case. In this respect, a further issue decreasing external reliability of this case is the fact that the functional scope of the initiative was reduced during the course of the project. After successful completion of the conceptual phases, the number of macro processes actually realized was reduced to one out of eight due the economic situation of the company in this period of time. However in order to increase external reliability I made my results as replicable as possible by clearly describing the research setting and the detailed course of action applied. My detailed descriptions could support researchers or practitioners in creating an intervention, which could be relatively comparable to ours.

As far as internal reliability is concerned, I am aware that in a case like ours with more than 100 participants, it is not possible that all observers draw exactly the same conclusions. However I am convinced that most of the other observers would agree to the findings I have described. In order to increase internal reliability I applied two main strategies. First, I had all relevant findings cross-checked by a group of 5 employees of the client company, who also participated in the workshops. The feedback has been considered immediately after the workshops. Second, I have shown my entire thesis to selective client managers deeply involved in the initiative. The feedback has been considered in the thesis particularly with respect to chapter 4 and 5.

To close this section, I state that one of the drawbacks of my research was that the functional scope under investigation was reduced during the course of the initiative. After the conceptual phases were completely resolved for all macro processes, the scope for the realization was cut to 1 out of 8 macro processes due to conditions in the wider economy. This lead to the fact that only a proportion of the entire positive potential could be exploited. The reason for that is that many improvements required the precondition of a full Lean-ERP implementation throughout the entire logistics process chain for unfolding the whole potential. As a consequence, the Lean-ERP assessment ratings were not as high after the partial implementation compared to the ratings after the complete conceptual design. However despite that, the overall ratings were still on a rather high level compared to the as-is analysis. From the survey results in conjunction with the qualitative findings, I deduce that the integrated initiative did not even exploit its whole potential; that is, it would have been even more successful when fully implemented.

5.5 Further Research

This section briefly addresses the question of further potential research arising from this DBA thesis. In this regard I suggest four main areas.

First, in relation to the last paragraph of the previous section, it would be worth analyzing if the realization of the not implemented macro processes also lived up to the potential found in the conceptual design phases. Moreover, it would be interesting to analyze if the overall satisfaction level would even increase to a higher level when implementing the full process scope.

Second, it is worth analyzing whether other attempts to apply LP and ERP in parallel in the automotive industry could also be successful. Though I was able to reject the assumption, which suggested that conflicts would prevent the application of an integrated initiative, I am aware that it is problematic to generalize my findings. In this respect, other examples would provide further valuable evidence.

Third, it would be interesting to analyze the applicability of my approach in a manufacturing company outside Automotive. Though LP has been becoming increasingly popular in industries beyond automotive and ERP is being implemented across many sectors, Though LP has been increasingly becoming popular in industries outside Automotive and ERP is being implemented across many industry sectors, it would be a practically and academically interesting question whether the combination of LP and ERP was also applicable in different environments.

Fourth, further expanding the point above, I suggest that the applicability in cases outside manufacturing could be another field worth analyzing. For example, lean has been becoming increasingly popular in the growing services sector, so this would be an interesting area in which to test the integration with integrated data systems.

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