LAPPEENRANTA-LAHTI UNIVERSITY OF TECHNOLOGY LUT
School of Engineering Science
Industrial Engineering and Management

Miikka Peltomäki

EFFECTS OF ERP IMPLEMENTATION IN A LEAN ENTERPRISE – A CASE STUDY IN AN ERP ENABLED BUSINESS TRANSFORMATION PROJECT

Examiners: Professor Timo Pirttilä

ABSTRACT

Lappeenranta-Lahti University of Technology LUT

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Miikka Peltomäki

Effects of ERP implementation in a lean enterprise – a case study in an ERP enabled business transformation project

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Keywords: ERP, lean, information management, lean enterprise, business transformation, data management, change management, business processes

In the core of lean enterprise is the idea of connecting the individual lean processes to create an improved flow of goods and value to the customer. ERP systems act as enablers in this, connecting all the units and internal organizations under common databases and system solution.

This thesis is conducted as part of a large ERP based business transformation project. Seeking to define and map the effects that the ERP implementation has in a lean enterprise. Conducted as a single case study the aim is to find and define the development areas of the system, related processes and the surrounding organization from lean management perspective.

Based on the findings of literature review and qualitative data gathered from conducted interviews, to enable improved lean information processes the emphasis should be on improving the item data management related tools, development of missing system concepts, and the alignment of the underlying organization with the new business processes and operational template.

TIIVISTELMÄ

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ERP-järjestelmän käyttöönoton vaikutukset leanissa organisaatiossa – tapaustutkimus ERP-pohjaisessa muutosprojektissa

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Hakusanat: erp, lean, informaation hallinta, lean organisaatio, muutosjohtaminen, prosessikehitys

Leanin organisaation ja yrityksen tavoitteena on yhdistää yksittäiset leanit prosessit ja yrityksen osat, jotta saadaan luotua yhtenäinen arvovirta kohti asiakasta. ERP-järjestelmät toimivat tässä mahdollistajana, yhdistämällä sisäiset prosessit ja niiden hallinnan yhden järjestelmän alle.

Tämä diplomityö on kasattu osana ERP-pohjaista liiketoimintaprosessien muutosprojektia. Tavoitteena on selvittää ja määrittää vaikutukset, jotka uudella ERP-järjestelmällä on leanissa organisaatiossa. Yksittäisenä tapaustutkimuksena toteutetun tutkimuksen tavoitteena oli löytää lean-ajattelun mukaisia kehityskohteita järjestelmästä ja siihen liittyvistä prosesseista, sekä ympäröivästä organisaatiosta.

Kerätyn aineiston perusteella uutta järjestelmää ja siihen liittyviä prosesseja voidaan viedä kohti pienempää hukkaa ja parempaa arvovirtaa kehittämällä tuotetiedon hallinnan työkaluja, kehittämällä ja määrittelemällä puuttuvat järjestelmäkonseptit ja linjaamalla organisaatiota uusien prosessien ja toimintatapojen mukaisesti.

FOREWORDS

After the long weekends, evenings and hours of work, I can finally say with confident that my studies in Lappeenranta are coming to an end.

The years studying and living in Lappeenranta have provided so much. LTKY Student Union, Kaplaaki and other organizations, and of course the friends made there have made the time spent studying unforgettable. Especially the Skinnarila spirit and the long days and nights spend in Kaplaaki's guild room and at the LTKY office working, studying and enjoying the company of friends I will be especially remembering fondly.

Special thanks also to friends, family and loved ones that have supported me during this process; sometimes providing input and support, by motivating and just by pushing forward to finishing this thesis.

Now, it's finally time to move onwards, towards new challenges in life – wherever they may take me, I can be confident that LUT and the time in Lappeenranta have provided me with the tools and knowledge to take them head on.

In Järvenpää

16.11.2019

Miikka Peltomäki

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Abbreviations

ATP	Available-to-Promise
BPR	Business Process Re-engineering
ERP	Enterprise Resource Planning
MRP	Material Requirement Planning
OTD	On-time Delivery
PDM	Product Data Management
RQ	Research Question
TPS	Toyota Production System
WTO	Way to Operate

1 INTRODUCTION

This master's thesis focuses on developing an understanding of the challenges and requirements that an ERP system has on a lean enterprise after a major ERP based business transformation project. The effects of the implementation on the organization are reviewed first through a literature review on the topic of lean information management in an enterprise setting and the impact and role of ERP systems have from the process perspective. Purpose of this study is to find answers, where the current issue areas are from a lean perspective and how the newly implemented information system processes could be improved.

1.1 Background

ERP systems are some of the most influential and critical systems used in modern enterprises and companies, forming the backbone for all business processes and operations throughout the organization by combining the information from different functions and operations under a single system. (Mayère, Grabot & Bazet, 2008, pp.1-11) Even though they promise a lot: improved process performance, reduced inventory and stock levels, and easier overall improved resource control by information sharing through the enterprise by connecting all parts of it, the results have been found lackluster and they often fail to meet the expectations. (Häkkinen & Hilmola, 2008)

Due to their role as the organizations operational enablers and backbones, the business and process transformations that are involved in the implementation of these systems are a major disruption to the daily processes. The transformation and re-engineering of processes to ensure a smooth transitioning to new system and ways of operating are critical for the success of the implementation projects. Covering both the information management processes and the ways of operating, the new system implementations should be handled as transformation and change management projects and not only as IT implementations. (Panayiotou et al., 2015; Hendricks et. al., 2007)

From a lean management perspective, ERP systems can poise major challenges for the daily operations and workflow in an enterprise setting. Lean management philosophy, built around processes that are flexible and can be constantly developed and improved to make the individual units flow better, seems to contradict with the rigid processes and operational models that ERP system implementations usually introduce with them to the organization. (Piszczalski, 2000)

From an enterprise level perspective, it is important to enable the lean thinking also on that level, ensuring that these ERP systems enable fluid sharing and flow of information between different units and organizations. To help organizations continuously improve and strive towards perfection, also these central information systems need to be developed to further support lean and more value-adding ways of working especially in the case of information management, ensuring the empowerment and support for information workers that rely on the data and information in their daily decision making.

1.2 Objectives

This thesis documents and present a case study conducted during an ERP implementation led global business transformation project done in an enterprise that has a strong strategic initiation towards lean development and continuous improvement. First, aim was to research the possibilities and challenges between ERP systems and lean management principles, ways how they could support each other and be applied to the information management processes in the newly implemented ERP system, focusing on the possible disruption in an organizational performance caused by the implementation of a new ERP system. To build understanding for this, we have defined our first research question, that we seek to answer during the research project and through literature review:

RQ1: What is the role of the ERP system in a lean enterprise?

Once we have the understanding and set definition of the role of the ERP systems and their role in an enterprise, this question of ERP systems role in a lean enterprise can then be further extended to cover their impact to the daily work and process performance in the case environment. This creates a basis for the second research question that seeks to answer the question of how newly implemented and transformed processes have affected the business process performance in the chosen business unit:

> *RQ2: How has the implementation of a new global ERP system affected the process performance in the case business unit?*

Last question that has been defined tries to seek answers to the challenges these new processes might poise to the daily work and process flow in the organization. The findings of the previous two questions can then be and defined how the lean principles should be taken to account in the future in the context of ERP system development, to enable improved support for lean process flow on an enterprise level between different units.

> *RQ3: What actions should be done to improve the information flow of the new business processes in the case business unit?*

These three research questions form the basis on which this thesis built on and which the research done seeks to answer.

1.3 Limitations

Most of the limitations of this study are due to the implementation and transformation project status in the case organization and business unit. Internally, the research has been limited to a single business unit that focuses especially to spare part sales to the end-customers as fast-flowing after-sales. This limitation to a single function also limits the organizational functions, processes and tasks under the ones that are most relevant to the specific unit. The process is also limited only to its logistics related parts. No financial or reporting related tasks or operations are considered as part of the thesis.

Second limitation on the thesis is due to the transformation project itself. Due to the ongoing rollouts and developments happening on the system side, there were incremental changes and new features introduced during the time period that this thesis was concluded, marking some of the earlier findings from the first interviews obsolete. Due to this volatile and changing nature of the system solution, the findings gathered and discussed have been limited to the ones that were not resolved during the research project. Also due to the time and resources it takes to take any changes to production, any of the suggested improvements could not be implemented during the thesis projects' timespan.

1.4 Research process

The research strategy used in this thesis is a qualitative research conducted as a literature review and as single case study conducted in a single business unit within the case company. Qualitative research methods are descriptive and interferential research methods that focus especially in evidence that enable the researcher to understand the meaning of what is happening and going on. Qualitative research can illuminate problems and provide explanations for the issues, and it enables the researcher to focus on the following points:

1. To carry out where other methods (quantitative) are not viable
2. Investigating little known situations about what is happening
3. Explore more complex topics that cannot be reviewed with a more controlled approach
4. Dig deep into the organization, to the informal data and part that can only be interpreted there
5. To view the case from the perspective of the people involved, inside-out
6. Carry research of the processes leading to the actual results, instead of focusing purely on to the results themselves (Gillham, 2000, pp.11)

The main method and the chosen research strategy to conduct the research are a literature review and single case study. While the literature review focuses on reviewing the current research and literature around the research area, a case

study is focused on researching a single phenomenon with different kinds of evidence and data that can be gathered. Case study seeks to answer research questions with a different range of evidence and different methodologies with the data and evidence that is available in the case setting through multiple sources. For this research, documents of previous assessments and work done, semi structured interviews and authors participant observation were utilized as part of the source data and evidence from the case environment. (Gillham, 2000, pp.1-5)

Semi structured interviews are a way of collecting data through open and/or closed questions. Interviewees are useful especially in cases where there is a small number of people involved, they are accessible, they are relevant to the case, the questions that they are presented with are largely open, and when the materials sensitivity is to be considered. Semi-structured interviews are a flexible way of gathering data through a clear structure or a format, that enables the interviewees to openly answer the questions. (Gillham, 2000, pp.59-65) The interviews were conducted as a cross-sectional study, where the particular phenomenon or case is studied at a particular or constrained time period, as opposite of the longitudinal study which is focused on change and development of the researched phenomenon over longer time period. (Saunders, et. al., 2016, pp. 200) The cross-sectional approach serves the research done in this thesis the best, since the limitations described in the previous chapter limit the execution of the thesis research only to a certain state and time of the system at a time of the thesis work when there is no longitudinal data available of the past performance due to the disruptive nature of the ERP implementation project itself.

Overall six interviews were conducted for this thesis. People ranged from different organizational areas, to different backgrounds. The interviewed consultant had vast experience from project management and change management area, while Managers A, B and C knew the operational landscape within the company and were also part of the implementing project

organization, while the specialist and engineer were end-users of the system and did not participate to the actual implementation project.

Table 1 Interviews conducted for this case study

Interviewee	Interview length	Area or responsibility
Consultant	86 minutes	ERP Project Management, Change management
Manager A	81 minutes	General operations
Manager B	92 minutes	General operations, Development
Manager C	67 minutes	Technology Manager, Production
Customer Service Specialist	36 minutes	Sales
Purchase Engineer	50 minutes	Procurement

All the interviews that were conducted during the project were recorded and transcribed in written format. Transcription is the method of representing data in a way that is usable and appropriate for the researchers use. Unfocused transcription can be used when the intended outlining and general meaning of the speech, without representing the detailed contextual characteristics. This method of transcribing the data and interviews is aimed to show what was meant to be said, and not what was exactly said, to support the analysis and make connections between the data and its representation. (Gibson & Brown, 2009, pp.116-120) The results and findings from the interviews and observations are presented in chapters 4.3 and 5 in more detail.

1.5 Structure of the thesis

The structure of thesis follows the traditional project report, which consists of introductory chapter with description of the research methodology, literature review, review of findings and results from the conducted study, discussion of

the research results and their implications, and from summarizing conclusions. (Saunders et. al., 2016, pp. 634) The thesis has been structured to correspond to the research questions developed in chapter 1.2. Chapters 2 and 3 consists of literature review done in the areas of lean enterprise thinking and in ERP systems. These chapters seek to answer and build and understanding relevant to the first research question, first focusing on their respected areas and then shortly discussing the application of both systems in unison on how to enable an ERP enabled lean enterprise.

After the literature review, the case company, research results and findings are described in detail. Chapter 4 focuses on the case business unit and the business transformation done there, describing the characteristics of the unit and also reflecting to the role of the ERP system in the daily operations and business processes, while chapter 5 focuses on describing the findings from the research process and clarifying the findings relevant to second research question. Based on these findings, suggestions for short and long-term development for improved and more value-adding information management are made in chapter six, focusing on the challenges poised in research question three. Lastly, the results are concluded in chapter 7 with the summary of results, an evaluation of the reliability of the study and implications of the results. Also, future research topics and extensions based on the findings and results from this thesis are presented also in chapter seven.

2 LEAN ENTERPRISE

Lean thinking and lean manufacturing have been one of the most influential management strategies and approaches over the last decades, covering multiple enterprises, public organizations and areas of business. (Staats, Brunner & Upton, 2011; Douglas, Antony & Douglas, 2015) Started and developed in the early 1970's in Toyota production facilities as a Toyota Production System (TPS), and thoroughly described and researched in the book "The Machine That Changed the World" (1990) by Womack, Roos & Jones. Lean management is a management principle, originating from the manufacturing industry in the 1970's. (Womack & Jones, 2003, pp. 12-20). Focused around the core principles of value and waste and improving the process flow overall.

Lean enterprise is one extension on the topic. Instead of focusing on the individual manufacturing processes, lean enterprise seeks to implement the lean principles and concepts throughout the whole enterprise, providing cost savings, improved process output and increased value to all the stakeholders throughout the enterprise by increasing and improving the enterprise value delivery as a whole. Lean management principles should be incorporated also on the strategic level in the enterprise, to corporate, business and operational strategies. Aim for all of this is to create more value to the stakeholders with the equal amount of inputs, making the lean enterprise also more sustainable in comparison to the competitors. (Hallam, 2005)

Bell (2006, pp. 37-70) also describe the lean enterprise as an extension and evolution of lean operations. While in lean operations the core of operational excellence I built and focus is on individual operations and processes in manufacturing, services, healthcare or other areas, lean enterprise focuses on the whole internal value stream and supply chain inside the company. This is shown in **Figure 1**. While lean operations are focusing on the material flow inside the company, lean enterprise also adds the cross-functional aspect and information flows to this, interlinking all the individual lean processes together to a value stream or network. Last stage of lean maturity as defined by Bell is then a lean network, where the lean thinking covers both the operational processes and internal value stream, but also the external partners, forming a lean network of suppliers.

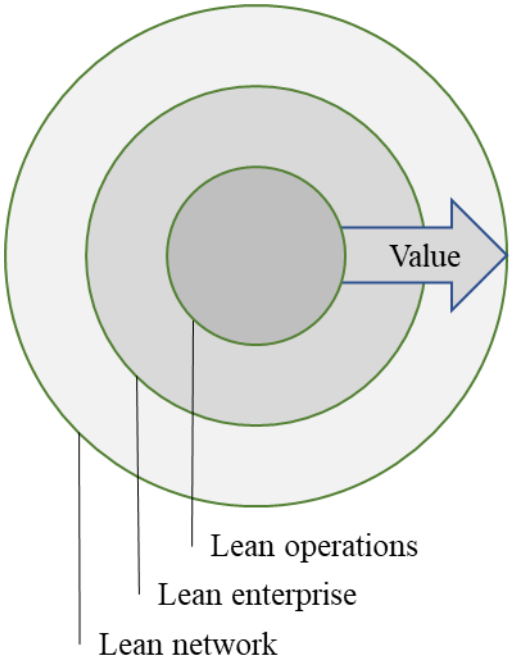

Figure 1 Three levels of lean maturity (Bell, 2006, pp. 68)

In this thesis, lean enterprise is considered to be an interlinking of different processes and operations between multiple business functions and units throughout the value chain, built on top of individual lean processes, interlinking them and creating an enterprise wide flow of materials, information

and services towards customer continuously seeking to improve and streamline them.

2.1 Basic concepts behind lean

The core concepts and main principles behind lean operations and thinking have remained the same for the past decades and can be implemented to a multitude of processes; manufacturing, services, healthcare and information management are all areas where the model has been extended and implemented to. In "Lean thinking" Womack & Jones (2003, p.15-26) present the five key principles, seen in **Figure 2** below, that should guide lean operations and processes development. Modig & Åhlstrom (2016, pp. 139-145) also describe the lean thinking and approach to strategy as the different means of values, principles, methods, tools and activities that focus on reducing, managing and eliminating the variations in processes that the organizations are daily working on. By focusing on the flow efficiency of the individual units in process instead of resource efficiency of individual operators, the enterprises are able to create more value to the end-customer and reduce any unnecessary and wasteful steps from the process.

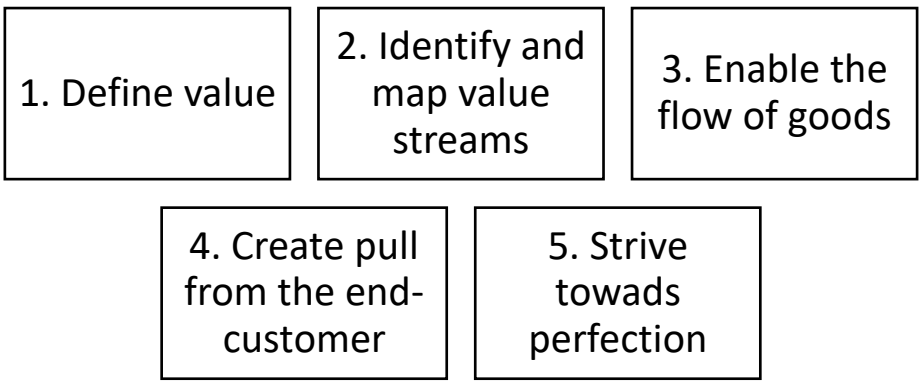

Figure 2 The key-activities in lean implementation process (Womack & Jones, 2003, pp. 29-98)

These core principles can be interpreted multiple ways, but the integral part of lean thinking is the elimination of waste, and through that enabling improved value creation and flow towards the end-customer. These two concepts, waste and value, can be considered the two most essential terms and ideas in lean thinking. (Huniche & Rahbek, 2011; Lyons et. al., 2013). Hines, Holwe & Rich. (2004) also support this proposal in their literature review of lean management. The authors suggest that the operational and strategic levels of enterprise should be linked to these concepts of value and waste: understanding value is the strategic aspect of lean management, while reducing and eliminating wastes and thus improving flow can be interpreted as the operational way of approaching lean management.

The tools and activities to reduce any of these wastes in the process are always dependent of the level of abstraction on which they are applied to. The lower-level the level of abstraction and closer to the actual daily operations, the more context dependent and specific the solutions should be. These solutions of removing wastes and variation in the processes are always dependent on the actual challenges and situations in the organizations own context, thus in general applicable to the specific operations and challenges within an enterprise. (Modig & Åhlstrom, 2016, pp. 139-145)

To move towards reduced waste and more effective value delivery, first these two need to be defined. Value definition itself should always come from the customer or the end-user of the produced service, product or other goods. These customers can be either the external end-customers or internal, meaning other parts or functions of the enterprise. This forces the lean implementers to focus on the whole process instead of individual phases or steps within it. This also allows a more complete look of the end-products value, sometimes providing important insights of the value that the manufacturer or producer hadn’t even considered.

Lastly, the strive towards perfection or continuous development highlights the strategic support that is required for successful lean implementation:

understanding the dynamic nature of operational environment and ever-changing world also requires that there is constant learning and development done also within the processes and organization itself. To reach this level of continuous development, processes should be well documented, stable and standardized, so that the actions done to improve them can be evaluated and assessed, as well as implemented successfully. (Modig & Åhlstrom, 2016, pp. 148-153)

2.2 Lean information management

Information as a term can be difficult to understand, since it is mostly non-tangible and hard to measure. It can be stored, used and presented in two formats: as tacit or explicit. Tacit information being informal, mostly undocumented and personalized information that is mostly shared between person-to-person interaction and has availability limited to the persons whom hold the information, while explicit information is the formally stored and codified information that can be reused by anyone. (Hansen, Nohria & Tierney, 1999)

Most common way of presenting and describing information is the data-information-knowledge-wisdom hierarchy. Presented in **Figure 3** this hierarchical model offers four different layers, starting from data, and explaining how it relates to information, knowledge and wisdom with each layer adding additional attributes to the previous ones. Data forms the most basic level in the hierarchy, in which turns in to information when added context. Knowledge is then the ability to use information in practice, while wisdom describes when and why to use knowledge. (Jifa & Lingling, 2014) Baškarada & Koronios (2013) also describe information as an aggregation of data that is shaped into a meaningful form which also adds value to its subject in their summarization of past literature, while Septer (2013, p.57-58) describes information as an abstract concept which is an understanding of the situation and context.

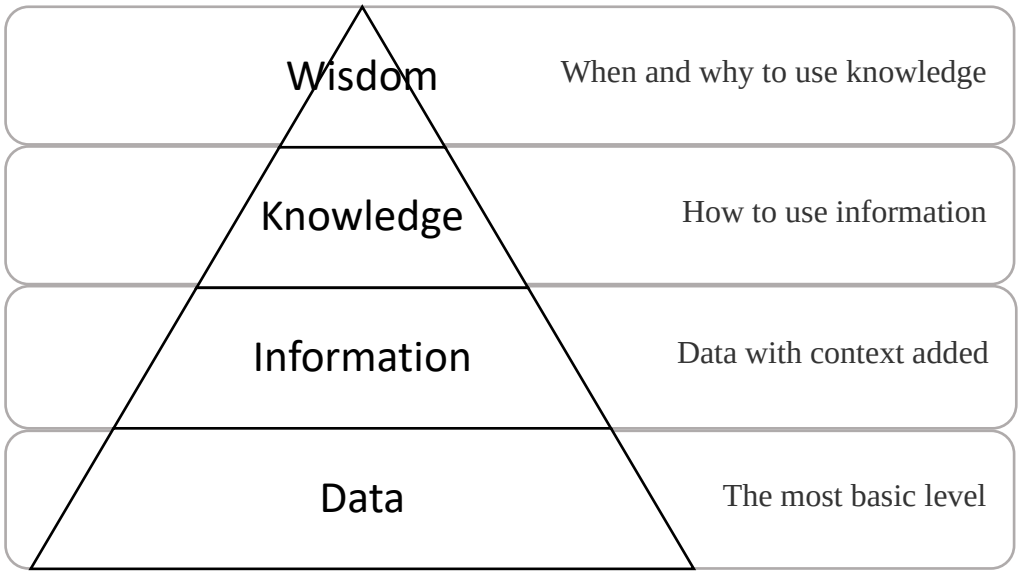

Figure 3 Information's relation to other similar terms in D-I-K-W hierarchy (Jifa & Lingling, 2014)

Improved and more efficient information management has been found to increase the process and performance management capabilities within companies (Mithas et. al., 2011), enhance individual and organizational problem-solving capabilities (Choo et. al, 2006) and to have an overall significant effect on productivity and customer satisfaction (Devece, Palacios & Martinez-Simarro, 2016).

To define the information waste, a closer look towards the original definitions of waste in lean context is required since waste and its reduction are the key concepts behind lean thinking. Originally waste was defined as "*any human activity which absorbs resources but creates no value"* by Womack & Jones (2003, pp. 15), tying it to the used resources and perceived value proposition. In physical production environment, this definition can be easier to interpret since tangible resources can most of the time be easy to quantify and measure, but in case of nontangible processes like service offerings and information management, this implication of waste can be harder to comprehend and understand.

One example of this nontangible process where lean thinking and principles were researched from an information waste reduction point-of-view, is the waste reduction done in product development process by Tyagi et. al. (2015). The results have been gathered in **Table 2** The authors state that since product development is very information-tense process which, instead of physical goods, has data and information moving between multiple team members and internal organizations, it is essential to ensure that there are no bottlenecks or wasteful steps within the process that might increase the time and other resources spent in already extremely time consuming, expensive and risky process.

Table 2 The eight different information wastes (Interpreted from Tyagi et. al., 2015; Bliljeven, Koelemeijer & Jaspers, 2017)

Waste	Description
Overproduction	Creating and processing too much of unnecessary information
Inventory	Having unused, obsolete and unclear or just more information than required
Extra processing	Processing information manually or in complex user interfaces more than required to get an indented output
Transportation	Moving information from one place to another place, either through email or between multiple systems
Waiting/queuing	Waiting for someone or something to process the information or waiting to get the information
Excess motion	Extra movement required to access the information, either by having to move between sources of information physically or on system level
Defect/rework	User, hardware, software and security related issues, errors, or mistakes that causes to redo the efforts to correct the problem
Underutilized people	The employees are either not assigned or have very limited roles. However, they are more skilled and capable to handle more if the process has been responsibly designed more effectively;

The value of any end-product, be it information or physical goods, is highly subjective and dependent of the end-user or customer of the said goods, the value should be defined on a case-by-case basis for every user or customer of the piece of information. Herrala, Leviäkangas & Haapasalo (2009) listed 16 different information value attributes that form and describe the characteristics of information: *accessibility, accuracy, availability, completeness, consistency, contents, cost, effectiveness, form, objectivity, relevance, reliability, reputation, timeliness, uniqueness, and validity*. These attributes can overlap with each other and have undermining components. For example, history of the information, media it is stored in, and its sheer volume are the components that all influence the perceived value and quality of information.

The potential value of information is also perishable, because information can become outdated and diffuse rapidly. Outdated and irrelevant information might even have a negative value if it leads to wrong and misaligned decisions (Manela, 2014). Therefore, it is beneficial to focus on information that can be considered to support the core business activities (Hicks, 2007). Since this might be extremely difficult and, in some cases, even impossible, it is better to focus on the value-adding steps than the end-value of the information itself, the latter being highly dependent of the context. Mapping the information management process and the flow of information within the organization to show all the activities required to process and present the information to the information consumer is important for effective management. (Taylor, 1982)

For process performance, it is crucial to have the right information available for the right user at the right time. Especially in an enterprise setting, where the information is used in multiple different functions and for different purposes. (Madenas et. al., 2015) Modig & Åhlstrom (2016, pp.128-139) also noted that for an effective flow of value, it is important to have an overall vision and comprehension of the value-chain and all the operations in it. They also noted that it is not enough to know what the requirements in the next step of the process or value chain are, but also look beyond that, through the whole enterprise and to all its parts.

Bortolotti (2012) suggests in their study that one possibility to increase the "leanness" of information heavy processes is through process and flow automation, especially in the context of services. But to reach this level of automating processes, they first need to be streamlined and as lean as possible first since automating unoptimized processes just automates the waste in the process also, turning the effort counterproductive.

2.3 Lean implementations and organizational effects

Implementing these lean management principles are not just the case changing individual process to match the five key lean principles to improve the performance and competitiveness of the organization. Lean implementation projects are also organizational change management projects, that should be supported by all the different levels of organization starting from the top management. To succeed, continuous training, active leadership and commitment from the management is required, as well as support from external resources and lean professionals during the implementation process, and the use of right lean tools in the right place. (Netland, 2016; Scherrer-Rathje, Boyle & Deflorin, 2009; Sreedharan V, et al., 2018)

Browning & Sanders (2012) also defined additional requirements for successful lean implementations. They separated lean developments to traditional lean where there are stable processes with routine operations and actions, and to novel and complex lean approach with unfamiliar and unstable processes that have low volumes and high volatility of workers. Browning & Sanders reason that the lean implementations are best done when there is the least amount of disruptions on the processes – as is the case in the first example of traditional lean - thus making the timing of the implementations important since the lean development itself will also destabilize the operations itself with the inherent changes. Also, the processes should be not improved in separate from each other and it is important to understand the complexity of the overall system before trying to implement any changes to it. This is required to prevent the "islands of excellence" where single functionality or part of the process may be lean, but

the impact is negative in other parts of the process, amplifying errors and overlooking parts that are important to other functions of the process.

In current academic research literature, top management support and organizations strategy alignment towards lean management have been deemed to be some of the most critical success factors in successful lean implementations. For lean implementations to succeed, there needs to be a clear organizational culture and employee commitment towards constant process and quality improvement throughout the whole enterprise. (Albliwi et al., 2014; Sreedharan V et al., 2018) The operational performance of the company after a lean implementation project does not grow in a linear fashion, but usually in an S-curve, as shown in **Figure 4**, where the gains are showing more slowly in the beginning, but increase with time as the organization gets more familiar with the continuous development principles of lean and matures together with the processes.

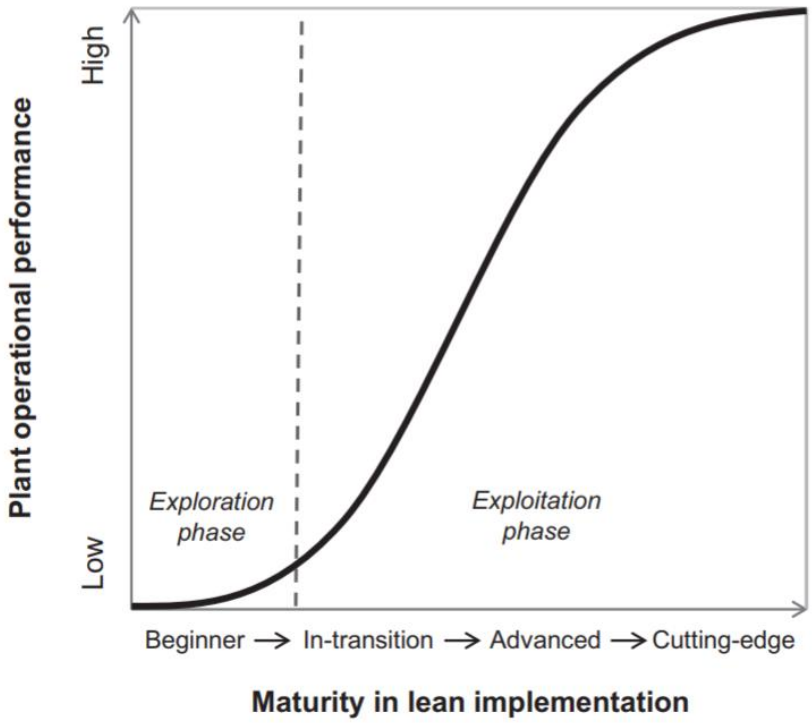

Figure 4 Maturity-Performance curve in lean organizations (Netland & Ferdows, 2016)

This also means that the investment in time, resources and money to reap the benefits of lean implementation are significant from the whole organization. Even though the cost savings gathered from the lean implementations are usually significant and greater than the investments to the implementation project (Dehe et al., 2015), the time, money and resources invested during the implementation are going to be significant on all organizational levels and the cost and process benefits can only claimed in the long term. (Hofer, Eroglu & Rossiter Hofer, 2012; Wempe & Fullerton, 2009)

3 ENTERPRISE RESOURCE PLANNING SYSTEMS

Enterprise resource planning (ERP) systems are commonly used enterprise wide software systems used for managing and tracking different business functions and to share the generated information and master data within the organization. (Hossain, Rashid & Patrick, 2002) They usually act as an organization wide backbone for most large and medium sized companies as information systems developed and implemented to ease and improve the acquirement, storing and distribution of information. These distributed systems are built to provide standardized processes and real-time information sharing capabilities by storing data from different processes and parts of the organization to a common database. (Mayère, Grabot & Bazet, 2008, pp.1-11)

These enterprise resource planning systems have a long history, where they have evolved towards the current widely extended and robust systems. Klaus, Rosemann & Gable (2000) describe the ERP systems in three ways: as a specific software package, as development objective or project of building and mapping processes to a unified and integrated structure, and third, as part of the infrastructure providing solution to a business to integrate processes and functions together. Davenport (1998) define these systems as a solution to integrate all the fragmented information that flows inside the company to a common platform, combining multiple layers together through the interfaces and solutions that enable process control of different internal functions.

ERP systems are based on old material requirement planning (MRP) and manufacturing resource planning (MRPII) software used already in the 1970’s and 1980’s. MRP was built around the purpose of enabling a better view and planning capabilities in the manufacturing environment and automating the material requirements calculations, while MRPII added functionalities like scheduling, enhanced demand planning and financial functionalities combining the materials planning and general ledger for improved tracking and control. (Klaus, Rosemann & Gable, 2000)

The modern ERP solutions are still built, and functioning around these planning functionalities, but in addition to just manufacturing they have been designed to cover the whole enterprises. Adding different modules and functionalities ranging from sales to project management and service functionalities, covering multiple front- and back-office modules have extended these system features to enterprise wide business critical solutions instead of focusing only on individual functionality or operational entities. (Klaus, Rosemann & Gable, 2000; Buonanno et al., 2005) Current ERP's seek to provide this sort of centralized enterprise functionalities, covering all the operations through a common user interfaces and shared databases within the enterprises different layers. Modern ERP platform try to unify and connect the different parts of the enterprise, also shown in **Figure 5**, by combining the different information systems to the actual business processes and enabling and supporting the actual users and organization in their daily work. Only when all three of these are working together in unified and fluent manner, can the enterprise wide benefits surface. (Davenport, 2000; Mayere, Grabot, & Bazet, 2008, pp.2-6)

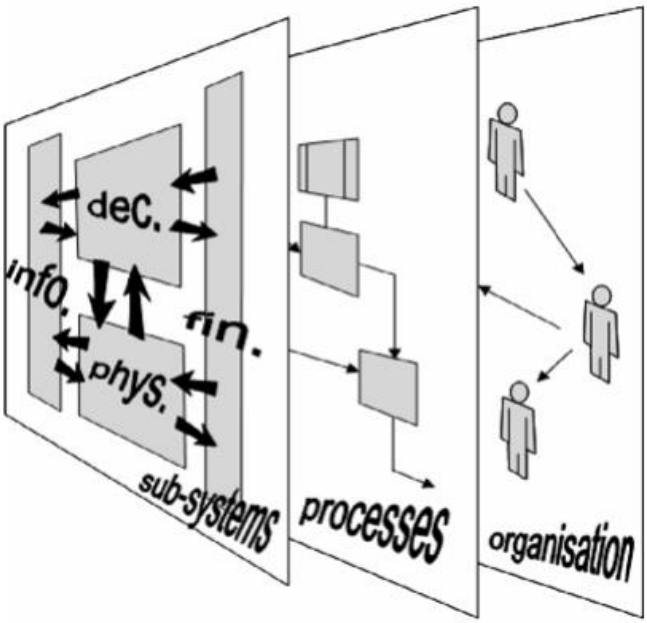

Figure 5 Three dimensions of enterprise that ERP system seeks to connect. (Mayere, Grabot, & Bazet, 2008, pp.6)

Because of this common, organization wide database solution, the ERP software allows common planning, scheduling, and material management capabilities that enable enterprises to control their material flows and resources throughout the supply chain. Designed to improve the visibility to these things, ERP's are designed to help organizations gain competitive advantages over their competitors by offering all the business processes and surrounding information systems in a single integrated package and taking to account the internal customers of information also. (Ganesh. et. al., 2014, pp.6-8) It is also common for ERP systems to have overlapping functionalities with other systems, in which case it is possible for them to act as supporting systems to each other. This allows a fluid exchange of data and information between the different parties, processes and systems with integrated interface setup through which they can interact automatically or manually with each other. (Frank, 2004; Elbanna, 2007) Besides the real-time sharing of information and data between different processes and stakeholders, other benefits that ERP systems seek to provide are improved efficiency and quality, standardized processes that are based on best-practices, and even increased productivity and profitability. (Ağaoğlu, Yurtkoru & Ekmekçi, 2015)

While most information systems are used as a supporting system for the daily operations and to connect the users with the information from processes and customers (Yusuf, Gunasekaran & Abthorpe, 2004), ERP systems also provide the ability to plan, control, and maintain the processes, as described in the earlier paragraphs. This is reflected in the ERP implementation projects, which are some of the largest information system projects conducted within companies. Besides time and money consuming implementation process, ERP systems require a noticeable amount of time and training before the system changes provide significant performance improvements, which might not necessarily even realize. (Nicolaou & Bhattacharya, 2006; Ripamonti & Galuppo, 2016)

3.1 ERP implementation project and organizational change

To further define the reasons why these promised improvements in the organization do not realize as process improvements and cost savings. Most of the literature and research on this area has been focusing only on the implementation projects and their success, while the post-implementation impact and long-term effects on organizational success have been few and far between. (Powell, 2013; Häkkinen & Hilmola, 2008)

ERP system implementation projects are some of the most intensive and complex projects any enterprise can decide to implement. In general, the ERP implementations should not be considered as a regular IT or implementation projects (Munir Ahmad & Pinedo Cuenca, 2013). To reduce the complexity of an ERP implementation, the project typically has three different well defined life cycle stages: Project planning stage, Project execution stage, and Go-live stage. Each of these consists of smaller phases, that are presented also in **Figure 6** below. (Ganesh et. al., 2014, pp. 37-47) In general, project planning phase consists of project definition and initiation, and requirement definitions, while the project execution is focusing on solution design, actual build of the software and system, and from system testing through system, system integration and end-user testing. Last, the go-live stage can be interpreted to consist of the actual production go-live after testing, of different system rollouts, and in addition some level of post-implementation support.

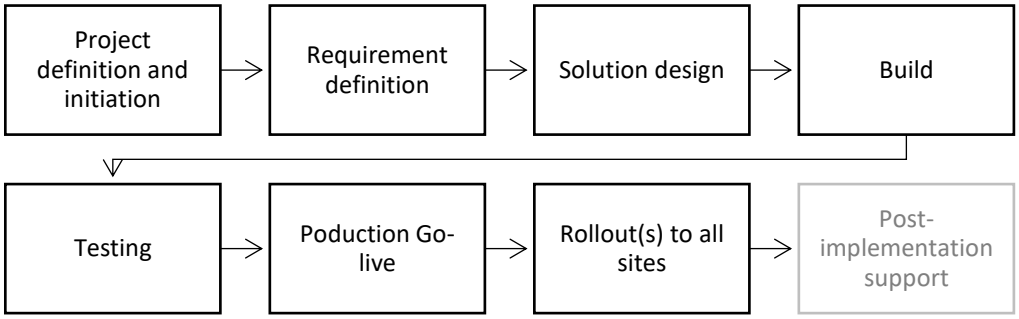

Figure 6 ERP implementation project phases (Interpreted from Ganesh et. al., 2014, pp. 37-47)

In large system projects these partial rollouts of new software to a certain set of functions is common, since it reduces the scope and complexity of implemented systems offering. (Velcu, 2010) Especially in case of global systems and implementation projects in multinational environment, there can be multiple rollouts of the same system solution. Since the implementation project usually ends in the system go-live and rollouts, most of the emphasis also in academic research and literature has been focusing on the successful implementations, with only minor focus being on the post-implementation effects and organizational development. Hendricks, Singhal & Stratman (2007) also recognized this their research, stating the following: "*…the research on enterprise systems should move beyond the key factors for successful implementation…*" One approach to this is to evaluate and research the possibilities the system provides for process development and if the promised benefits ever realize after the implementation of these systems.

3.2 System and process alignment as part of ERP implementation

This move from implementation to recognizing the realized benefits after the systems are in use and to successful use of these enterprise systems. One reason for this is that ERP like enterprise systems and similar software implementations follow an S- curve, where the benefits should start showing slowly in the beginning but increase over time. In the beginning the implemented software has a bigger impact than the actual processes through new functionalities, improved information sharing capabilities or some other aspects. Increased benefits and performance should be achieved over time, when the actual processes and ways of operating are aligned with the systems that are being used. As presented by van der Lans (2013, pp. 104-110) in **Figure 7** over time the business process alignment with the existing systems provides better performance and enables system users to access, connect and interpret the relevant information in a way that allows the organizations to achieve competitive advantages through fluid information exchange and constantly improving processes.

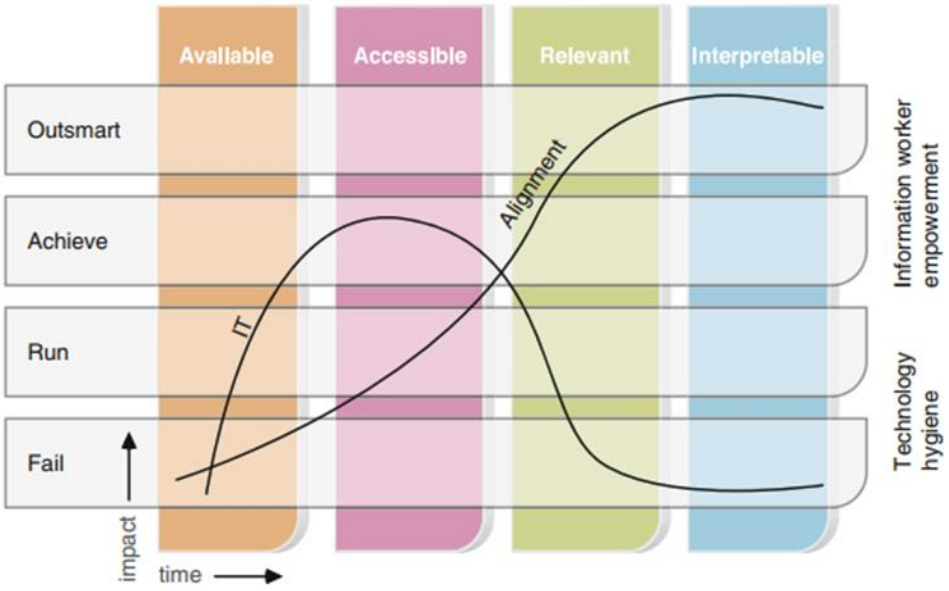

Figure 7 The impact of IT and process alignment on enterprise information management capabilities (van de Lans, 2013, pp. 106)

This model by van de Lans also shows the challenges that poise within the ERP implementation projects where the needs for process changes are almost inevitable, due to the nature of these systems. System implementation might disrupt the processes that are business critical, as they are needed to manage and track all the main business functionalities, and the performance returns are usually expected right after the implementation even though they rarely realize so early. This model is very similar to the lean implementation curve shown in **Figure 4**, where the impact increases over time.

One reason these performance improvements won't realize after the implementation is found in the fundamental ways of working with these ERP systems and how they are implemented. This covers the conflicts between local efficiency (best-practice processes) and global effectiveness (performance tracking, improved forecasting), which should be discussed in early age; both are not possible to achieve. Defining which one is more important for the organization implementing the system and its goals, be it better global visibility through operations or flexibility on local activities, should be defined before the

start of the actual implementation process since this will affect the whole system and application landscape architecture. (Mayère, Grabot & Bazet, 2008, pp. 47-51)

This lag between the results gained from ERP implementation and the actual go-live is mostly caused by the changes that these systems introduce to the daily operations. After the introduction of an enterprise system, the processes have become more formalized and constraining, limiting users' abilities to make any changes or alterations to the system and the underlying process itself. (Boudreau & Robey, 2005) This usually comes out as a resistance towards the new systems, making users avoid the use of new system, or even create new practices that do not comply with the implemented system. (Gilardi, Guglielmetti & Pravettoni, 2014) This resistance is also one of the reasons these system implementations fail to meet their expected results. (Kwak et al., 2012; Häkkinen & Hilmola, 2008) For example, Acar et. al. (2017), found out that even though expected, the bare use of an ERP system did not have a positive correlation with operational performance in a variety of different manufacturing companies. Instead there was a positive correlation when the ERP system implementation project is not handled as an IT implementation project, but as an organizational change management project (Hendricks et. al., 2007).

The organizational change management includes the re-alignment of organizations and also re-engineering of business processes. This business process re-engineering (BPR) and process alignment with the system functionalities is a requirement for an effective ERP system implementation and for a smooth transition (Panayiotou et al., 2015), but it might not be enough. Mayere & Bazet (2008, pp. 47-54) even argue that since ERP systems use one single central database and follow formal and imperative processes, the information and data within them needs to be so well predefined and in tacit form, which causes the companies to lose a significant proportion of the information along the way, gathered in previous legacy systems, supporting information management systems, in highly customized software or in other format. This formalization of processes doesn't necessitate that the user knows

who and where the next steps will be produced, or what the information will be used for, forcing them to generalize and thus making the information less suitable for decision making in complex situations.

Focusing only on two of the three areas of processes, technology, and people, is a root cause for issues. Focusing only on technology and people without processes usually translates to poor customer service and chaos where the systems can be used inefficiently. Tying processes and technology together and forgetting people causes estrangement from the system and its underutilization, while only focusing on people and processes and leaving the technology to the background, inefficiency and frustration of the system and underlying technologies will arise. (Bell, 2006, pp. 372-382)

Implementing ERP system to cover the whole enterprise and allowing it to mature over time is something that allows the main users to perform better in their daily operations and to make better decisions. This increase in operational performance is achieved through allowing real-time sharing and availability of information, process automation, and overall a better visibility of the company's operations. (Yusuf, Gunasekaran & Abthorpe, 2004; Chaabouni & Yahia, 2014). When considering the current goals of information management; to change the ways how people use information and allowing them to make better decisions, these new information systems are in key position, even though they are mostly used to collect, connect and disseminate information within the set business processes. The changes these enterprise wide systems introduce to the operational side and daily processes are so fundamental that they force users to change and adapt their ways of working to match the new systems introduced and re-engineered processes.

3.3 ERP systems as enterprise's strategy enablers

Since there is some process development and re-engineering required during the ERP implementation projects, they also have an effect on the Millet & Botta-Genoulaz (2008, pp. 157 - 169) discuss this user adaptation to the new processes

and how the used software system should mature with the users and organizations over time, allowing better control over the covered processes. Millet & Botta-Genoulaz propose a model with two axes: software maturity and strategy deployment. These two dimensions relate to the ability to use the information systems in the designed and intended way, and overall strategic and operational management of the enterprise. Both axes are split to three different phases, linking the strategy deployment with software maturity with each other. This maturity model, presented in **Figure 8**, defines three phases and maturity levels that the organization has to reach to get the best possible profit and benefits from an ERP system.

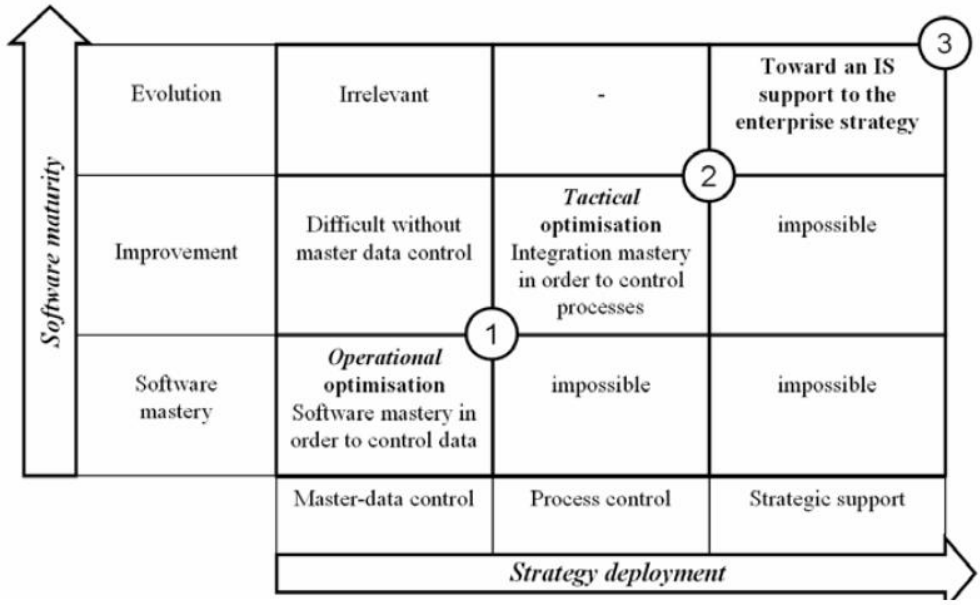

Figure 8 Linking strategic deployment with an enterprise wide ERP system (Millet & Botta-Genoulaz, 2008, pp. 166)

The first stage focuses on optimization of operations, the second to the optimization of strategies and third to the enterprise strategy development itself, based on the implemented and used system. During the first phase, the organization and the end-users need to learn to use the software and control the available master data. During this phase users' competences on the system utilization and usage is being built, which usually shows up as non-appropriate usage of the system, slow reaction times to system notifications, and as manual

corrections conducted afterwards due to lack of trust to the supporting system. After these issues have been cleared out, the organization should reach the first level of maturity (shown as number 1 in **Figure 8**) where the daily operations have stabilized, and the ERP system is an actual production tool and used as a central location for information broadcasting between users. (Millet & Botta-Genoulaz, 2008, pp. 164 - 169)

After the system software has been mastered by the users and the individual operations stabilized, should the focus be transferred to tactical optimization of internal processes through the integrated software. In this phase, the strategic deployment focus will move to process control, while software maturity focus will be on system improvements after the software itself has been mastered. To reach this level of operational prowess, management's strategic focus should move from individual tasks to the process level: finding the causes behind conflicts between users, processes and organizations functions. Resulting in suggestions for system improvement like automating activities and enhancing the user roles to simplify and better suit the daily workflows within individual processes. After this phase, the ERP system should fully support process control and integration of different functions instead of just enabling individual tasks and activities. To reach the highest level of strategic support, and to enable the best possible use of the enterprise resources, ERP should have become an actual tool used in strategic support, and the information provided by it is used in defining and driving the company's strategy forward. To reach this level external integrations, upgrades of the software version, further development of business intelligence systems, and changes in market and customer expectations as result of improved process control are usually required, in addition to the previous goals and developments. (Millet & Botta-Genoulaz, 2008, pp. 164 - 169)

This alignment of processes both with the IT and the workers has been found to have a positive correlation with the performance and value creation abilities throughout the value chain. Tallon (2007) found that the information technology and information system improvements mostly materialize at the process level,

and without the alignment of surrounding IT and information systems with the organizations strategy the results are suboptimal. In a further research Tallon (2011) also found that the alignment of processes causes a spillover of information, resulting in benefits and delivering both direct and indirect value to the interlinked processes within the value chain. These findings are supported by the theory presented also in **Figure 7** from van de Lans (2013).

There are different ways to reach these individual stages. According to Marcotte (2013) the second level of tactical optimization can be either reached through development of tasks, or automation of activities that process the information within the processes. These tasks and activities are the most basic form of information management: gathering, dissecting and transferring information within the workflow (Detlor, 2010). Activities are the steps that are usually conducted by the system after a certain prerequisite has been filled, and which can be automated. These support the tasks in the workflow, which require human input and actions before the outcomes can be moved forward in the process and workflow. Both should be considered already in the process design phase but can be also implemented later if necessary. Each business process can contain multiple interlinking activities and tasks, linking them to each other and allowing for the organization to decide which steps in system can be automated and which require human related tasks. Some examples of these requirement for human driven tasks decision making or skills not found within the ERP system. As Marcotte argues, while activities can be automated within the system, tasks require separate coordination in the form of predefined actors, allowing autonomy and introducing possible performance objectives for the system users. This allows development and improved management of these, opening possibilities of introducing further process improvements without necessarily touching and changing the surrounding ERP system.

DeLone & McLean (2003) offer one framework of assessing the information systems quality with their information system success model, presented in **Figure 9**. According to the two authors, information system success can be measured through the three quality aspects, that affect the overall user

satisfaction and the intended way of usage of the system. These affect the net benefits of the implemented system, either positively or negatively, which in turn also have an additional effect on the user satisfaction and the intended and actual use of the system – if the net benefits are interpreted as negative, also the user satisfaction and use of the system is affected, further lowering the benefits gained from the system itself.

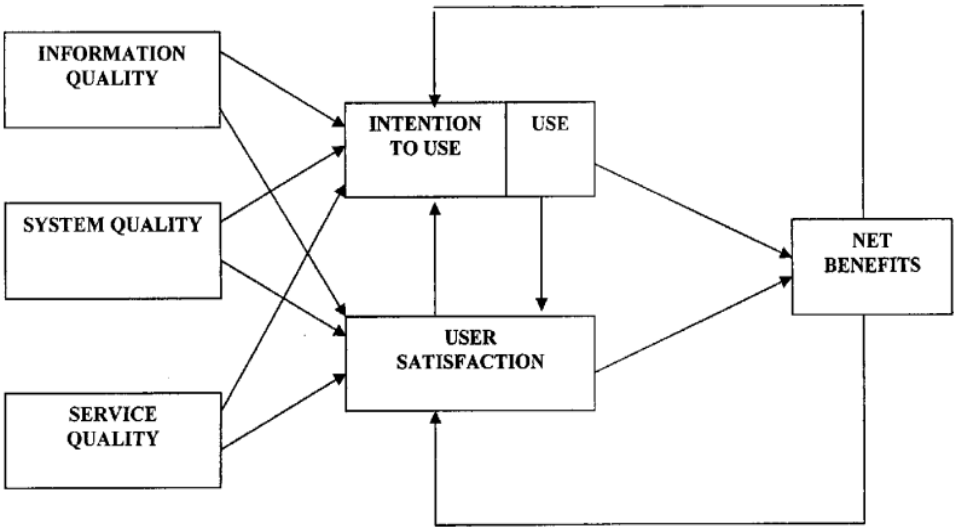

Figure 9 Information system success model (DeLone & McLean, 2003)

Within the information management process, there are set to be activities and tasks that create more value for the company and information users, but also steps that are not necessary but still mandated either by the systems or the accompanying processes. To better increase the informational value and reduce waste, these enterprise wide resource and information systems can also be used to facilitate lean thinking in real life and information management process (Haque & James-Moore, 2004), opening ways to more effective process control and extended lean enterprise.

3.4 Challenges in building ERP enabled lean business processes

In literature, there has been a lot of discussion about the concurrent application of ERP systems and lean thinking, because of the differences in their nature. Piszczalski (2000) describes how "Manufacturers are torn between two opposing camps. In one control is lean manufacturing. In the opposite camp is computer-based planning and control systems." Where the ERP systems are based on standardized, rigid and difficult to alter processes that are mainly used to support managerial decision making, lean management has been founded on the idea of constant improvement of processes that should be facilitated and applied from the bottom-up, starting from the shop-floor level activities. In literature and in industry interest, the application of lean principles and concept to these sort of information systems and management processes has been expanded.

Applying the lean principles and thinking to information management can be considered a rather new area of interest. The fundamental change that has been introduced by the enterprise wide information systems and their management processes' have seen since the early 2000 has been drastic. Transforming them from pure services and bare necessities to strategic business enablers like in the case of ERP systems. Since lean thinking has also matured and the concepts behind it are becoming more widely known and applied to other industries besides manufacturing, it has become possible for information managers and IT professionals to optimize their IT systems and processes to better support the core activities and main business processes. (Costello, 2011)

When discussing the simultaneous application of both ERP systems and lean management principles, academia and research literature seems to be lacking on the area. Like discussed earlier in chapter 3.1, research on the area of ERP implementations is mostly focused on implementation success, and not in evaluating the long-term success factors and impacts. As Powell (2013) notes in his literature research "ERP systems in lean production: new insights from a review of lean and ERP literature" regarding the topic, much of the earlier

research has only been focusing on the implementation and not on evaluating the effects of concurrent application of lean and ERP systems. Some authors have researched the challenges and differences between the two, even suggesting that ERP systems can be considered to have a negative effect on the previously implemented lean processes and changes, even though opposite results have been found by Ward & Zhou (2006) when the internal integration of IT has been implemented on top of lean operations, stating that "*Firms will benefit from reduced lead times due to IT integration when the process improvements generated by lean/JIT practices are in place.*"

Halgeri, McHaney & Pei (2011) mention that in real life, companies have been combining both ERP systems and lean processes already on many levels. The main differences between in thinking and attributes are shown in **Table 3** below. While academia has been focusing on these issues and ideological conflicts, there are multiple cases of lean and ERP systems working concurrently in different industries. After all, other is only a software system used to track the enterprise wide resources and execute planning, while the other is a management method that focuses on individual process development, reducing quality defects, and in enhancing operational excellence. As written about the differences between the two by Bartholomev (1999): "*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*". Based on the lean enterprise thinking, ERP systems should support the lean enterprise and its operations as a whole by guiding the management and the system users in their daily work and operations, offering improved flow of information and centralized data for all the users to utilize.

Table 3 Differences in attributes of Lean thinking and ERP systems (Halgeri, McHnaey & Pei, 2011; Bell, 2006, pp. 13)

Attributes	**Lean**	**ERP**
Implementation method	Incremental, continuous development	Single implementation project with clear start and end.
Goal of implementation	Continuous process improvement, cost reduction	Planning, scheduling and tracking of all company operations and resources
Approach to planning	Pull-based, just-in-time delivery	Push-based, MRP planning based on forecasted demand
Processes	Flexible, constant development towards perfection	Fixed, difficult to alter due to costs and requirements
Training	Process flow focus	Individual task/operation focus
Level of focus	Operational - Shop-floor, single process	Strategic - Top management, enterprise wide information collection
Orientation	Individual actions	Data dependent
Implementation approach	Bottom-up	Top-down

Halgeri, McHaney & Pei (2011) also argue that implementing an ERP system might increase the amount of inventory on hand, focus on push based planning, and slow-down the internal processes of the company. Topics which are all in conflict with the lean principles. Even with these challenges, according to the authors, this combination of lean processes and ERP systems is feasible and even necessary especially for small and medium sized companies to improve their competitiveness, even though there might be some hindrances when combining the rigid processes of ERP with the nimbleness of lean.

Nauhria, Wadhawa & Pandley (2009) expand the topic of concurrent application of ERP systems and lean manufacturing in their article "*ERP enabled lean six sigma: A holistic approach for competitive manufacturing*" where the authors explain how the common application of ERP and six sigma tools benefits the organizations in their work, by supporting each other and even arguing that "*A well implemented ERP system is the foundation on which an effective lean six sigma program can be built.*" Since lean six sigma puts emphasis on reducing the process outcome and product variability, and ERP system offers predictable and repeatable processes that provides information about the actual performance and operations, they can and should be utilized in unison, supporting each other.

Framework for concurrent application of lean production and ERP systems, providing a combination of ERP implementation best practices with lean production concepts and tools has also been developed by Powell et. al. (2013), providing a toolset for parallel application of both new ERP systems and lean toolsets. Authors also suggest that the ERP implementation can be used as a catalyst for implementing also lean production principles, which in turn provides benefits when comparing to a case in which both are implemented independently. Challenges this concurrent application of both new ERP systems and lean management principles may also provide. For example, a successful lean implementation requires stable and non-disrupted processes since the implementation of lean itself will cause some disruptions and changes to the process. (Browning & Sanders, 2012) This is in clear conflict with the effects

of an ERP implementation, which itself is a major disruption to the existing processes and takes time to stabilize after the implementation project.

Common for both, ERP and lean implementations, are the strategic and operational changes needed in the current ways of operating. Like Millet & Botta-Genoulaz (2008, pp. 164 – 169) describe, ERP system should not be treated just as an IT software or project, but it should be tied into the enterprise strategy with the support of the whole organization, enabling better execution through improved information and process control within the company. Similar requirements can also be associated with the implementation of lean management tools and principals, where significant support throughout the organization, starting from the top management and strategic alignment is needed for successful implementation. (Huniche & Rahbek, 2011; Losonci, Demeter & Jenei, 2011)

Bell (2006, pp. 364-373) also raise the concern for Lean IT thinking, that is required to support the endeavors of lean enterprise. Lean IT should be built around an agile, manageable, team-based organization that needs to focus on incremental and continuous changes, while executing operations within cross-functional teams. The aim of this lean IT is to focus improvements on value streams and processes as a whole and thus provide overall value and improve flow in the whole organization. Like Bell notes in his book: *"For breakthrough results and lasting change, the Lean Enterprise and Lean IT must work hand in hand"*. This means that there is strategic support also needed for all functions within the enterprise, not just the core functions that are delivering goods to the customers but also to supporting functions.

Based on the findings presented also in **Table 3** earlier, there should be no direct conflicts between lean thinking itself and the ERP systems even though they might have different approaches to similar problems. These differences between the two may seem to conflict from each other's at least in some areas, especially in how the demand planning and ordering should be handled according to lean purists. Major differences are the training and implementation focus, where lean

tools should be implemented and developed from process optimization perspective, while ERP implementations usually focus on improving the individual tasks and operations within the enterprise. This combined with the differences in strategic approach of the two, where the lean has more operational and process task level focus, while ERP systems seek to support the strategic decision making and process handling.

Even though there are conflicts and differences between the two. Each is trying to tackle different areas, with the goal outcome of improved process performance and ways of working, that result in cost savings and more efficient organizations overall. Even though, the real examples from how the two can be combined so that the ERP system supports the lean enterprise seem to be few and far between, and this thesis seeks to extend these requirements for implementing an ERP system that could both supports and benefit a lean enterprise. Based on the literature review, there are no blockers to implement both the ERP system and lean management principles in unison, and even the ERP enabled lean processes can be reached when the role of the ERP system in an enterprise is understood. Focusing on the surrounding and supporting functionalities, enabling the constant development of the system and support for lean delivery of new solutions and enhancements. Focusing on the processes as a whole enables the movement from organizational islands and siloes towards a leaner and unit flow focused business processes.

4 INTRODUCTION TO THE CASE STUDY

In this chapter, a comprehensive view of the ERP transformation project and its scope is given, explaining the extend and coverage of the business transformation that the company is ongoing, as well as a more detailed description of the business unit which was chosen to this research. In chapter 4.3 the ERP systems role in the specific case unit is opened in more detail, with the basic end-to-end process of operations.

4.1 ERP transformation project within the case company

The case company the research was conducted in is a Finnish high technology company that operates in multiple business areas globally in a competitive environment. The case company offers different process technology, automation, and service offerings to multiple industries in over 20 countries. Services, process technology and machinery are offered on different technological areas to pulp, paper, and energy industries, ranging from new machine development and build, to servicing and mill or process line improvements. The aim of the company is to be the preferred partner and supplier of technology, automation and service solutions in the chosen market sectors.

The company is split to four separate business lines, covering different business areas, customer sectors and solutions. The first business line is built around offering maintenance operations, spare parts, and other services both for own machinery and for competitors' solutions. Majority of the revenue is coming in from this area, bringing in over on third of the total revenue to the whole enterprise. The service operations can be described as high volume operations with lots of smaller projects and assignments, and with a high amount of transactions happening annually through sales and service orders. Besides service offerings, the company also provides technologies and solutions for energy, pulp, and paper industries starting from individual process equipment deliveries and individual machine lines, all the way to complete mill and energy

plant builds. This area of business can be characterized as very project oriented business with a small number of annual projects that are high in value and long lasting. Lastly, one business line is focused on delivering automation solutions from full line and process automation solutions to single measurement unit implementations, assigned somewhere between the two previously mentioned business lines, focusing on smaller projects and service and spare part sales with a medium amount of transactions happening every year.

Strategically the case company is focusing the development of customer relations, technology development and process improvement. To support these strategic goals, lean manufacturing and thinking has been a real focus point both strategically and operationally in the past years, on the whole enterprise level. Examples of the efforts done towards reaching this status are continuous lean trainings to employees, additional reward system that encourages quality improvements and continuous development, and close collaboration with partners focusing on lean development and consulting.

Part of this strive towards excellence and ability to gain competitive advantage the case company is performing an ERP transformation project during which the research for this thesis was conducted. With multiple operational locations and a global presence in every continent, the need for enterprise wide resource visibility and unobtrusive enterprise wide information systems is essential, given that the old solution has also reached the end of its lifecycle. To answer the growing competition, reduce costs through reduction of multiple different overlapping software, and to improve the global visibility of operations and resources within the company, a business transformation towards transferring operations to a unified and global ERP system was started.

Earlier system architecture was based on individual system solutions, which varied between different business lines and locations. Each of these was a separate entity with local customizations, processes and policies, making the global visibility extremely difficult. This lack of visibility within the company alongside with multiple overlapping systems which were getting rapidly

outdated were the main motivations behind the implementation of single ERP solution. The goals of the project were to introduce standardized ways of working throughout the company; a common way of working towards the customer, focus on value adding activities and to free resources through automation of different activities. To enable this transformation towards harmonized and common ways of working, a common template blueprint of processes was developed that could be rolled out to all locations and business lines, covering the different business processes. The different organizational parts and processes are shown in **Figure 10**.

During this transformation and system improvement project, the case company will move to a unified and standardized platform throughout all its functions and operations, by standardizing the basic processes throughout different locations. The case company took a technology-driven approach to the new ERP implementation, where the system was chosen based on the initial requirements set by the organization. After this, the to-be-transformed and aligned internal processes and system concepts were developed in the beginning of the project, and enhanced during the implementation process and system development, based on the currently used processes and through the introduction of best practice processes to the organization. (Panayiotou et al. 2015)

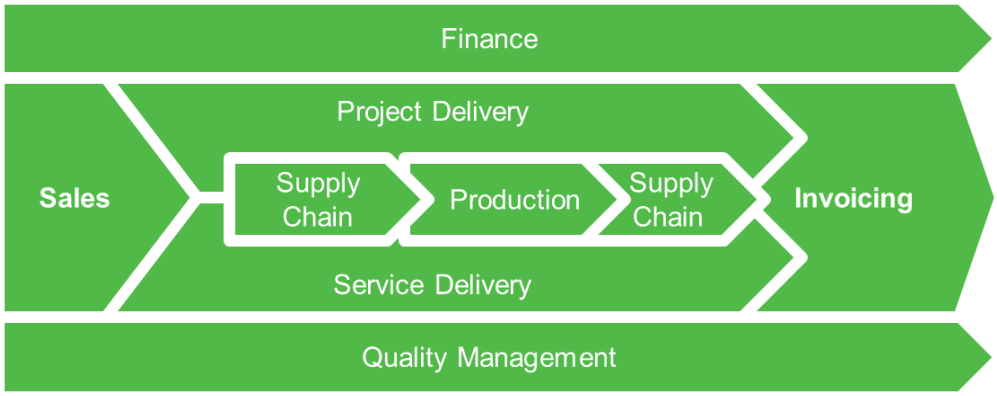

Figure 10 Internal business process areas in scope of the transformation project

The implementation project within the case company started with mapping of the future processes based on the requirements and user input from business unit

representatives. Since the processes being mapped were based on multiple locations and business units, some compromises were made within the processes to introduce all the requirements defined by the business functionalities and best practice methodologies. It should be noted that no enterprise wide ways of working or as-is processes had been introduced or mapped earlier, and those were defined either locally, on a country level, or on a business unit level. This best practice approach to process and information system implementation meant that a majority of the internal processes and ways of working will be changed or adjusted in one way or another, introducing changes to all business units.

From information management point-of-view, this offers new possibilities and challenges. The implementation of new information systems, like the ERP system in the case company, is not only about the introduction of new software. The changes in the enterprises working environment also require management of change. New business processes and development of existing operations for business benefit are required for a successful implementation. Earlier in the case company information management, ERP, and other supporting systems were only assigned and used by a certain business area or location, limiting the visibility and information sharing capabilities, while increasing the amount of overlapping systems used. The standardized processes being globally implemented with the new software system were designed to create a unified way of working, improved value delivery for the customer and reduce obstacles between communication.

Like described in chapter 3, this ERP implementation was expected to and has caused major concerns regarding the conflicts between local efficiency and global control, especially between different business lines. The lean process development done in individual business lines and locations, specific to their needs, there is a major fear that the new ERP system will have a negative impact on both internal and external efficiency and competitiveness.

4.2 Introduction to the case business unit

The case study documented in this thesis was conducted inside a single business unit in the case company. As part of the services business line, this unit focused on spare part business and deliveries to customers and related projects through different order types in the ERP system. The customers require precise information about the availability and pricing of the parts, due to the need of production line and factory shutdowns to perform any maintenance. This also translates to needs for accurate forecasting and ability to promise precise delivery dates.

The business unit can be characterized as having a high amount of annual transactions going through the system: in 2018, this accounted for 60 000+ individual transactions of different order types, to 1700+ customers globally resulting in over 100 individual shipments each day. There are an estimate 300 end-users currently using the current ERP system, majority of them in Finland, but also in other satellite offices globally. In general, the following characteristics apply to the business unit which was focused during the research of this thesis:

- Most customer demand are after-sales based on installed base of the earlier projects and delivered machinery
- Fast turnover of orders and products, lots of transactions
- High volatility and margin on products
- Items delivered are very customized and, in most cases, not standardized, translating to multiple new spare parts and items created annually
- Customers require quick response times and offers for spare parts, thus the ability to respond to quotation requests in time very critical
- Price estimation accuracy for new purchased parts critical so that the costs are kept in check
- Forecasting accuracy of supply and demand needs to be high

Most of the suppliers are located in the Nordic area, with some of the materials being manufactured within the company in Northern Europe or in Asia, while most others are sourced globally from preferred suppliers. Items in general, even though they have a high turnover, have quite long lifecycle

The new ERP system was implemented in two waves for the business unit. First wave was done in May 2018, covering only two production units in Finland and their daily operations. The remainder of the business had their go-live to the new system in November 2018 as a phased go-live where the old ERP system was still in use for some open orders and for project cases where there were concepts missing for the new system, but the majority of the daily operations was transferred successfully under the new system. At the point of this thesis and conducting this research, the users have had experience for over 7 months of daily use.

4.3 ERP systems role in the case business unit

As raised during the interviews, ERP systems can be used in different ways in different companies – in some cases they only act as an information warehouse that is used to store some financial data while all the process control is handled externally, while in others ERP system forms the backbone of the company upon which all operations are based on. The case company and business unit are focused on using the system with the latter part in focus, meaning the newly implemented ERP system should act as a medium of process control and as a supporting tool for executing the daily operations and strategy. As already mentioned in the earlier chapter 4.1, the implementation project was not only an ERP implementation but a business transformation project towards global and unified ways of working and operating in the business processes. This also means that there are certain barriers given for the ways to operate, that should be followed, a few of them noted down below:

- Sales order created, available-to-promise (ATP) check done for the possible delivery date when out-of-stock based on available resources

and estimates provided, as defined in the master data. Promised delivery dates based on this.

- All purchasing must happen inside the system. Purchase price quotations required in cases of new items, as well as price estimates need to be maintained to provide best estimates of prices. Purchasers are responsible for different product families (e.g. bearings, seals, blades, etc.). Some purchasers also allocated specific supplier responsibilities in cases of larger suppliers.
- Only standard items that are globally used are allowed, no more project or customer specific items created in the system.
- Materials are automatically linked and committed to projects but not to any other orders.
- Production execution should happen on task level, and all the materials and hours should be reported in the system for accurate reporting and material management.

The basic end-to-end process is shown in Appendix 1, presenting the process from the system functionality point-of-view. Since in the case business unit the ERP system acts as the backbone of all the daily operations, the support for lean principles and ways of working was highlighted as a major strategic success factor throughout the implementation project.

> *”The previous system we had had been developed for 20 year. In the beginning it was very incompatible with our business and it was built over the years to support our core business. In our spare part business area, the engine that moves the whole daily operations is the ERP system. It is the soul of the daily operations and barely any process development happens without accompanying system development.”*
>
> - *Manager A*

The system by design should provide additional value and improve flow of information and materials through the core enterprise, by reducing waste and defects when implemented correctly and successfully, as mentioned by the

interviewees. At the same time this should also support the lean ways of operating through more efficient processes that have less wasteful operations and defects, and through increasing the flow of the value-stream to the end customer through improved visibility and more accurate forecasting.

> *"Even if we had taken our current basic processes that we have been built as lean and improved from there, then we would have taken a leap forward in the operational excellence. Now [I feel like] we went back in time full 20 years and start from scratch."*
>
> - *Manager A*

Raised during the data gathering process were also the two underlying differences on how to measure the leanness of the processes: through efficiency of operations which translates to reduced amount of waste and defects in the deliveries or through additional value creation to the stakeholders either within or outside of the core enterprise throughout enabling the improved value-stream and flow. ERP system should be able to support in both sides, guiding the users in their day-to-day workflow, making their life easier and information sharing between different units easier.

While the common systems have also been previously used in the same business unit, the change to the global system architecture application landscape has been recognized to bring some benefits and also challenges in the daily work and business processes, affecting the performance of some of the local units significantly. For example, the on-time-delivery (OTD), one of the key performance indicators, has dropped significantly from almost 95% to below 60% in a single location.

"[In our business unit] speed is the key as fast response times, which in turn requires that the process needs to be also fast and responsive from all of its elements. Starting from master data management, through order management and all the way to the involved management and bureaucracy. The whole process needs to be responsive and fast. If we are not able to respond to the customer in time, we will miss the sales.

- *Manager B*

The consultant A especially highlighted that the possibilities and additional value-add that the ERP system can provide should not necessarily focus only on the customer facing processes and delivery of goods, but in the internal operations that can be more cross-functional and strategic. New strategies, development and improvement of internal ways of working, removing old and out-dated systems and replacing them with new ones and integrating all the systems and platforms under single solution and architecture are the main value that the new system brings after implementation. One highlighted area was the reporting, which is always an integral part of the ERP's and used to track all the orders, projects, and other functions through the common general ledger and accounting. The benefits brought by the new ERP platform and solutions that combine all the operations to a single system, especially when comparing to the previous system architecture with separate ERP systems which took a lot of manual effort to gather and maintain.

When going through the current process during interviews by focusing on different areas and the issues there affecting current performance on each area, there were 27 individual issues and open topics that had an effect to the capabilities of developing the most value through the end-to-end process to the end-customer, as presented also at **Figure 11**. These issues and development points gathered through interviews, observations and documentations were documented in an excel format and split in to three main areas: conceptual issues in how the delivery process in the system is working and designed as a whole: if it has been poorly optimized or missing parts all together. People related

issues to the organization that are required to enable the enterprise wide lean thinking, if it is not aligned with the system and new processes. And to technical issues within the actual system solution and architecture where individual functions do not work and operate properly or are sub-optimized for current use. Some of the problems that were raised during the interviews and the writing of this thesis may also be combination of the two, like in cases where some sub-optimal and only partly optimized decisions made on the system solution earlier are causing issues in the process flow of individual flow units.

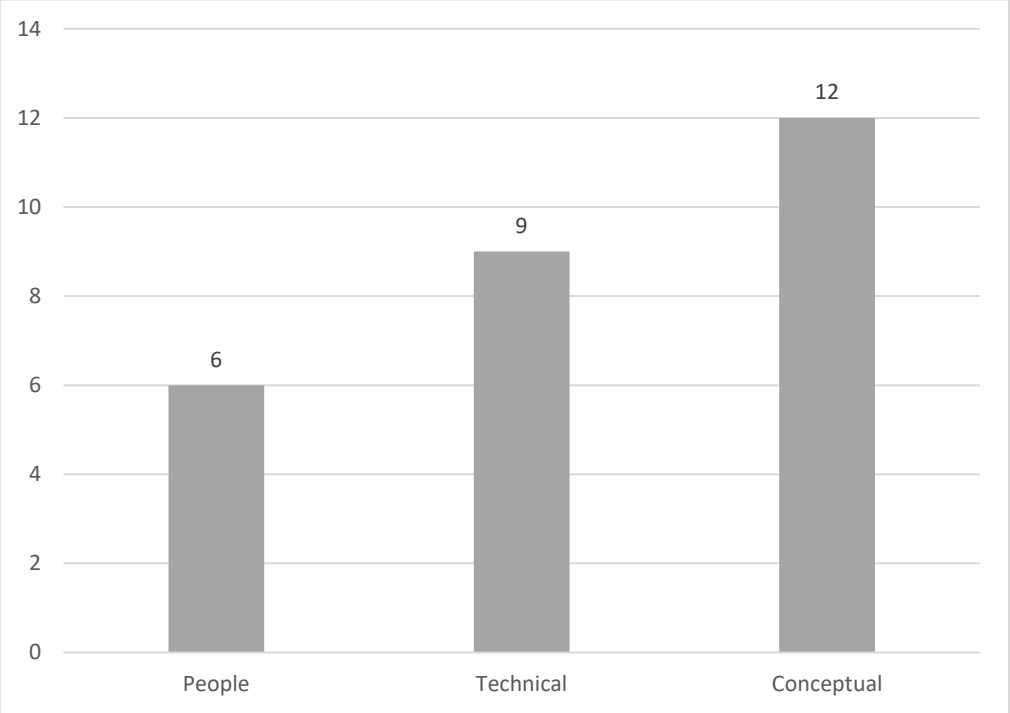

Figure 11 Issues found on different areas in the enterprise

From this total list of development topics, the most critical ones were chosen based on the interviewed people and their impact to the daily process performance. These are opened in more detail in the next chapter, where the main development points from each area are highlighted, their impact described to the processes and suggestions for their development made.

Not included on these findings are clear one-time technical, user or other issues that were recognized during the data gathering. Examples of these are times when the ERP system is not available due to unexpected downtimes, parameters

and master data that need to be set one-time but have been missed during the time or when there have been clear user errors against the trainings and instructions given. It can be argued that these are issues and defects related to the actual implementation and delivery of the system to the end-users and to supporting services.

5 ISSUES HINDERING THE NEW BUSINESS PROCESSES

The spare part process by default is rather simple demand-fulfilling delivery process, where the demands coming from customer are fulfilled with sourced or manufactured materials. Like mentioned in previous chapter, the ERP system is a crucial part of the whole organization acting as the backbone and central platform for all operations, orders and resources moving through the enterprise unit

> *”If you ask from me what would be the correct lean way to operate, to me it is making sure that the flow of goods and materials is uninterrupted, secured and well designed. Right now [8 months after the go-live] there is no sign of this.*
>
> - *Manager A*

During the interviews there were multiple different issues and problems raised that effect negatively the delivery process and functions, causing wastes in multitude of ways. First, the system concept related issues that link the system to the real business processes and the issues on that area reviewed, while the latter two chapters focus on the technical challenges that had been recognized and to organizational changes that were highlighted during the research project.

5.1 Conceptual issues

Lean enterprise thinking should not focus only on lean operations or individual processes, but also interlinking of these processes between all organizational units and functions, creating a fluid flow of goods and materials throughout the organization. From an ERP perspective, the system processes should connect the surrounding software and different system modules to each other, to the actual users through the common business processes and ways of operating by guiding and supporting them to perform better in their daily work. Building working concepts that can be applied to all three levels: system, processes and organizations is required to achieve this level of operational excellence, as highlighted by several interviewees.

Most of these missing system concepts that are translated to process related issues are due to the technical debt and issues in the current solution and system architecture, preventing uninterrupted flow and visibility of information and goods between the different parts of the business. During the implementation project, the focus has been on each operational area separately, and the focus had been on individual solution development and definition on each operational area within the organization. The focus has not been on the delivery process overall, but the system development has been done in siloes in different areas, negatively impacting the possibilities of interacting between other units and functions and making information exchange hard and not well thought-out from the unit perspective. This is critical especially in this case where the ERP system should be the central system and control tool for all operations and business processes.

> *"Previously it was possible to purchase and source materials also outside of the ERP system, but nowadays now that they need to be create through the purchase requisitions in the ERP which in turn generate the purchase orders that are allocated to the project. From that [procurement] sense, the processes are more ERP central than they used to be before the implementation of the new ERP system."*
>
> - *Manager C*

Especially in cases of ERP systems which should offer the global visibility of information throughout the supply chain, this development of individual functions instead of the whole process has been seen as a suboptimal solution at least for the case unit, when the decisions have been made only from single perspective and not taking all the other process parts to account, resulting in technical and organizational debt on different areas. One issue especially raised was how the new processes and overall operational template has been defined and developed as part of the implementation project team, without including people from the daily operational business. This lack of co-creation with the business users and implementation team caused this sort of process and concept

gap in the solution, as especially highlighted by manager B, where all the possible process variants were not mapped and designed but came out as a surprise to the implementation team that didn't have understanding of the then current ways of working and challenges.

These missing system concepts that were raised during the research like how to handle certain customer order types, keeping track of purchase price estimates and their success rate or forwarding in the system not only cause extra work daily, they also require the use of multiple process variants that differ from the goal of centralized operations under a single system that is used to control and manage the business processes. Even though the underlying business cases might vary a little bit, there should be a common and standardized way of handling them as highlighted the interviewed consultant, to reduce unnecessary actions and keep the new processes harmonized and standardized not only in the case unit, but also across all the business lines and units.

As of now, it was made clear that the requirement of information visibility through the supply chain does not realise in the daily work. Especially between the different parts of the organization, like sales and purchasing, sales and logistics and purchasing and logistics there are issues in the handover-points that cause a lot of manual and extra work in all parts of the organizations, starting from order management and tracking. Simplified presentation of this is shown in **Figure 12**. For example, there is no clear way for warehouse workers to connect the warehouse receipt and shipment lines to the sales order that they were supposed to be part of without special workarounds and extra work if asked so by the sales or purchasing team in case where for example the deliveries have not been shipped in time. And the purchasers need to spend lot of time manually keeping track of the orders and their assigned delivery dates, ensuring the visibility of information of any delays also the to end-customer. Also, confusion and extra time processing had to be spent since the terms and names used in the ERP and other surrounding systems are not aligned – an example of development that has been done in functional siloes and not from more end-to-end process flow perspective.

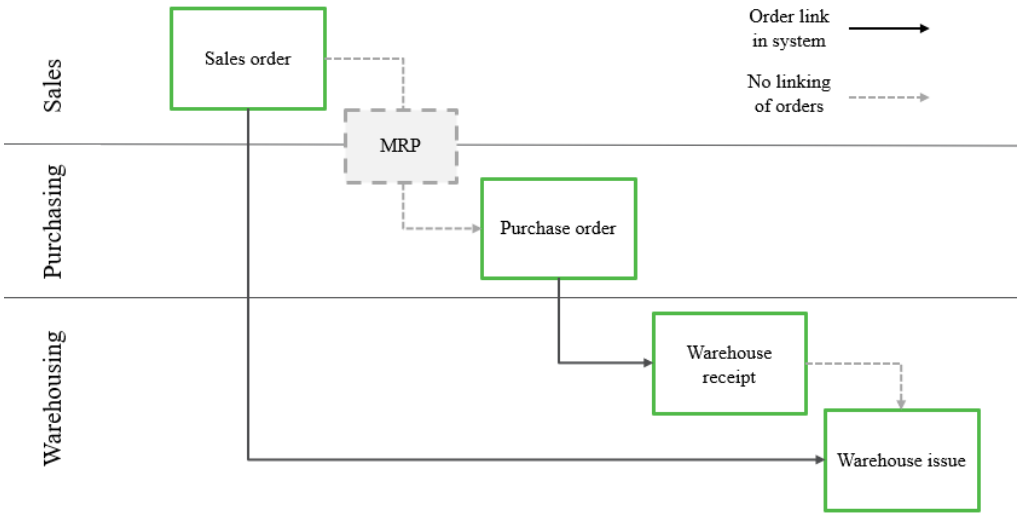

Figure 12 Organizational siloes and gaps in information processing between different enterprise functions within the ERP system

Since the development of the system has been done more and less in siloes focusing in each individual area, there can be seen these sort of "islands of excellence" that were highlighted during the interviews, where some functions and parts of the system have been optimized just from that single operations or functions perspective, causing issues in the latter parts of the process. From lean perspective, these solutions have been focusing more on the resource efficiency instead of unit efficiency and flow. Especially with a global system which is always balancing between the local flexibility and global visibility (Mayère, Grabot & Bazet, 2008, pp. 47-51), these sort of issues have a major effect in the daily operations.

Besides the focusing on individual of different siloes without an end-to-end process focus, the exclusion of businesspeople whom knew the processes and ways of working has also resulted in missing some processes and system concepts even during the go-live of the system. These concepts of how to handle specific order types, process variations and other processes has been one of the biggest source of issues in the operational side, forcing users to rely on legacy systems, working in multiple systems at the same time depending on the process variation. Even nearly one year after the initial go-live, there are still missing

some basic and complex processes and concepts how to handle for example internal trade and common contracts between different business units and inventory management of variably sized items like pipes, wires and sheets of metal that can't be only summed up in stock but the actual lengths of individual pieces need to be also known. Like mentioned by the interviewed purchase engineer, this also causes a lot of extra work for sales, purchasing and warehousing, when the actual amounts need to be checked each time manually from the warehouse, or stored in some other place other than the ERP system.

These missing processes and concepts are more related to the actual implementation project and delivery of the system solution than to the actual business processes themselves, but they are the cause for lots of extra and manual work needed in the daily operations side. It also poses a challenge for the successful implementation of the system, as raised by three interviewees. When the solution is not stable and processes not known, the change management and understanding the implications to real-life operations on the organizational level are not possible, threatening the performance of the daily business and the implementation of the system itself. Manager B for example evaluated that the pareto principle or 80/20 rule applies in this area, where the missing 20% of concepts generate 80% of the additional and wasteful work currently existing.

The problems with the solution itself and how it functions, as well as the current status of the implementation project where the system is under constant development are preventing the processes and ways of operating from fully stabilizing, providing extra challenges with their development and improvement. Larger software releases have been consisting of new 20 to around 60 new functionalities and several hundreds of bug fixes, meaning that even though the issues and concepts are consistently worked on, informing the end-users about these changes is not currently working as supposed to. As raised by multiple interviewees, this constant updates from the system side require also training of not only the upcoming users but also the current end-users. Currently this process of training and informing the end-users of the upcoming changes

has not been working, since the changes have come as a surprise, basically preventing the processes from stabilizing on their ways of working and in correct form.

5.2 Technical problems

The technical issues found mainly cover individual parts and functions in the system that are affecting negatively the daily work of the employees in a single part or function of the system. Since in best case the ERP system and its functionalities can provide additional value when utilized properly. Some of these value-adding functionalities that have had a positive impact on the daily work have been for example enabling improved handling of lot controlled and expiring materials. When earlier it was up to the individual warehouse worker to keep track of the expiring materials, some of the stock was always going to waste due to not being able to use and keep track of the expiry dates. With the newly implemented ERP and in the short time it has been used, there have been cost savings due to the ability keep more detailed track of the expiring materials and using those in production when they are still valid and useable.

Of course, the newly implemented system was not without technical problems either. For daily use, the current roles and navigation menu used in the system have found to be confusing and hard to navigate as they are currently implemented. Based on the best practice roles from the system provider, they contain many roles and functionalities that are not used currently by the case unit, making the overall process handling and assignment of system roles and access rights difficult. For example, in the sales module of the system splitting the sales quotation and order handling process under separate system roles that need to be opened separately have been found very confusing since in the case business units organization there are no such separate roles just for quotation and order management and it is all managed by single person whom are responsible for maintaining client specific relations. Also, the titles and names of the roles and processes in the system are not the same as are used in the actual organization, making the search for different operations and processes a bit

more time-consuming, and users easily mix the different purchase, sales and warehousing specific roles with each other. Aligning the system roles and responsibilities with the real organization alongside with the naming would already benefit the users when they don't need to spend time searching for the correct roles. Expanding the roles also to cover the whole end-to-end process, instead of just single function or task would benefit the visibility of information in the system and enable more fluid use experience when the users are able to do material issuing and production order hour accounting from the same process.

> "*System itself is well-liked and received, but the implementation of it and how it has been handled was raising concerns and an issues. It was unclear what kind of changes and actions would be needed on the business side.*"
>
> - *Manager A*

> "*The ERP system is a good tool and platform, the improved visualizations make daily tasks easier, and the tools for searching and filtering data and information are very good. The ability to copy texts in the system itself is a clear benefit, something that was not possible in the earlier system.*"
>
> - *Purchase Engineer*

One major technical issue and problem was found out to be the planning functionality in the system that is used to control and plan the material requirements based on the actual demand existing in the system. Since most of the materials are ordered based on the planned orders coming from the system, traits like trustworthiness and predictability should be applied to it. Currently, that is not the case.

There were multiple issues raised during the interviews that relate to the way that the MRP functions. As per the current setup and configuration in the system, the created orders are not linked to the demand existing in the system,

except for projects, meaning that since there is no hard links existing between the sales orders and planned purchase orders in the system, it is possible to use or “steal” the ordered materials on some other order that might’ve been created later but have a delivery date that has been set earlier. Without the linking of ordered materials to specific customer orders, there is a risk that even though the materials and goods have been ordered on time some other order consumes them and it is not possible to get new materials in time due to the supply lead time for example. This requires lots of time from the purchasing side to keep track of the existing orders and demand in the system, which increases the manual work and time consumed tracking each individual order and that all the goods can be delivered in time.

Besides the issue of material linking and allocation, also a problem with the safety stocked items has been recognized, especially when they have a minimum order quantity defined in the system. Even though the system does not link the materials to other order types, it creates the linking in case when there are materials ordered to a specific project. How the current solution is implemented and developed in the system, has caused lots of issues with excess orders and materials in inventory, especially in cases when there is a safety stock and minimum order quantities defined on the item that need to be fulfilled. In case when there are material shortages in the warehouse from where the goods are shipped to the project, MRP creates two separate orders, one of which is assigned only to the project and one which is allocated to the warehouse in general.

These duplicate orders are causing major issues in cases when there are minimum order quantities and safety stocks defined for two reasons: The ordered quantities rarely match with the real-life demands of the project, and in the system the materials that are ordered to the specific project are going to be always linked to that project, making it not possible to use them to fulfil other orders without manually updating the item data and stock allocations in the system. This takes additional work to adjust and extra work also during the purchasing process when the purchasers need to keep track of the already

existing and created orders in the system, increasing manual handling and work needed to process the system planned purchase orders, and even as financial losses as excess stocks and materials ordered when the planned orders have been processed without going through all the orders and warehouse transactions in the system. But also, this was found to cause the drop in overall trust to the system and lowering the value and trustworthiness of the information due to its lack of timeliness, validity, and accuracy due to wrongful content and lack of coherent consistency.

Since the global system acts as a central database and business process control tool in the company, this puts much emphasis and requirements on the master data also. Since the ERP implementation has been designed to cover the whole supply chain and material flow in the system, this also means that the material related master data should be in good order to take the best benefits out of the system. From the lean perspective, the main flow unit that is moving through the process are individual items and spare parts that should be supplied to the customer, focusing in the requirements that the system sets for them and the related master data is one focus point that should be covered, especially from the item data management perspective where the ERP system is the main system for logistics related data, while the integrated PDM systems are the main sources for technical item data.

In the current process, the item enrichment in the ERP system side was raised as a point that takes significant amount of time to do especially with the current volumes when there are tens of thousands new items created and used annually. As evaluated by the interviewed end-users, currently to make sure that the items can be used and sold to the customers and making sure that all the related master data is in place, the users need to go through almost 20 different sessions and views, entering each one separately by clicking and ensuring that the item related master data is in place. Since this forms the basis of the system processes and any information it generates, it is utterly important to get it setup both in good quality and in mannerly time.

As highlighted by the sales engineer, since the item enrichment is the first step of the process it crucial that it is done as fluently and efficiently as possible. Currently it was seen as a bottle neck, due to the time and resources needed to get the items in to state that makes them usable and fully functioning in the system processes.

Estimated to take around three to five minutes in the system currently to go through all the sessions and maintaining the master data on the system required level based on item type, reducing the lead time this takes through further development of more centralized views and tools could reduce the time to make each individual item usable significantly, especially when the annual quantities are on the defined level of 60 000 transactions created annually.

The technical capabilities and individual functionalities of the system are the base on which the actual processes and requirements should be built on. Any technical issues causing discrepancies between the system and users and the intended way of running and using the system due to any technical limitations are about to reduce the benefits brought by the implementation but also affect the intended use of the system, affecting the other parts in the process also as well as the net benefits as shown earlier by the information system success model in **Figure 9** presented earlier in chapter 3.3.

5.3 Misalignment of organization and new processes

Since ERP system implementations are not only IT implementations but also organizational change projects, requiring changes in the processes but also on the roles of people and their daily workflow. Since the employee's resistance to change is one key factor in realizing the operational benefits of the newly implemented system, there is a requirement to align also the employees with the newly engineered business processes (Hendricks et. al., 2007). This is also the key-requirement from the lean perspective, which by default is relying on the input and commitment of all employees throughout the organization to try to recognize the improvements in the ways of working.

The issues raised on the organizational change and people management were highly linked to the actual project implementation model, and how the implementation project itself was concluded, starting from the solution design and development, all the way to testing, and supporting the rollouts and go-lives as defined in the implementation model. Raised by the people whom participated in to the actual implementation project and development of the system, the technical capabilities and functions were not introduced during the start of the implementation project, but the focus was too much on the development and review of processes which is now causing problems as inefficiencies in the system use and high costs of operating the daily operations and causing frustration. The implementation was done with the project schedule first, which in turn meant that the implementation teams and key users failed to recognize the needs that the new system was going to introduce to the local organizations – this also reflected to the missing system concepts and processes that were not mapped or known even before the go-live.

> *”If the ERP system is not implemented as change management projects first, then according to my experience they will fail --”*
>
> - *Consultant A*

> *”Recognizing the changes that the system introduces is the most critical part here when taking a new ERP system to use. What is the current situation in the current organization, what it requires from the implementation team and people involved in there, understanding this change is the most critical part of the successful implementation. That you understand the system logic and functionalities, or the business logic and requirements overall, that unfortunately is not enough.”*
>
> - *Manager B*

As an example of this requirement to maintain the organizational alignment throughout the processes and all parts can be considered in a case where one user who does not understand the use and role of the ERP system skips on some

inputs or is not able to use the system at the same level of excellence with the others. This will cause unexpected and invisible value loss within the whole process, due to an issue in training and recognizing the necessary changes that the system might have in the ways of operating, as raised by the interviewed consultant and all the managers. For example, let's consider a person who is responsible for receiving and placing the materials within the warehouse. If this person receiving the goods can't use the system and places the received goods to a location not being defined correctly into the system, can there be expected to be further wasteful and extra steps when the material location in the system does not match the one that it is placed in real life, resulting in additional work, wasted time and defects that require fixing either in system or in stock floor level.

New roles that came with the added requirements of not using project specific items that could be customized and quickly setup by single project or purchase engineer, like master data specialists and planners that would only focus on maintenance of master data and product lifecycle. The failure to recognize these roles that should be added or clearly assigned within the organization, causes issues still over six months after the implementation and go-live of the systems. Even though people have been getting familiar with the system and the new processes, some people still don't have clear understanding of their current roles and responsibilities and there are overlapping work done in different parts of the organization causing additional waste in the organization. Other issue was also that the end-users of the system, even though already familiar with the basic functionalities, do still not know how to use the system to their benefit, or are still on the learning curve about the functionalities and how they should be using them. This is especially critical since the current system is not yet the most optimized for the end-to-end customer deliveries, but only as individual functions and is still under development.

This still continuous development of the ERP system was also raised as problematic due to three reasons: the supporting functions are not on the required level of supporting actual lean operations, there is a clear gap between

the co-creation of development team and the end-users that could translate the business requirements to system functions, and the continuous changes are not necessarily transferred to the end-users. The latter part is due to cause confusion with the end-users, when there are changes and updates done in the system. The continuous development would also require continuous training and informing about the changes done on the system level, but currently the supporting functions are not seen to be on the required level of providing instructions and trainings on the required level, and the information about the changes are not visible to the end-users.

The system architecture and global level of operations is also subject to limit the commitment level of people and their ability to affect their own work. The idea of continuous development requires also support from the supporting organizations and the capability to deploy and release system updates and customizations quickly, but the as of now the implementation project team and the supporting functions like IT are not on the required level themselves to actually enable the actual continuous development of system and processes even though there would be demand and understanding of the system changes. Current development and implementation models are seen as way too bureaucratic to support the actual lean development of the daily operations. To get some minor change that takes the developed four hours to implement and test might take over nine months, with the added approvals needed from multiple people and multiple rounds of testing before it can be included in larger system update. With such long lead times even for small system changes, the problems and wastes in the daily operations are escalated further, and in worst case end-user requesting the changes might disappear making all the time and resources spent developing some solution obsolete – the same time that could’ve been used to develop some other solution that has a larger impact on the daily operations and an actual improvement on the workflow.

Overall, more of this kind of co-creation with the daily business users and system developers was wished during the interviews. There still a clear gap between the daily business users and the actual implementation team, where the

business requirements are not successfully translated to development topics and system requirements that could be implemented. Developing this kind of understanding both in the business and supporting organization was seen as a critical success factor for the future development of the processes, enabling the development of both the system according to the business requirements as well as organizational alignment with the system, offering better process alignment.

6 MOVING TOWARDS ERP ENABLED LEAN ENTERPRISE

In this chapter findings of the interviews, and their implications on the organization are discussed further, and suggestions for development are made based on the information gathered. Based on the interviews and materials collected after the go-lives, current situation in the case company is that the current solution has many gaps between the individual functions and processes at handover points, for example between sales and logistics, for this sort of cross-functional value gain to realize. These issues and gaps in the end-to-end process flow of information prevent the any of the benefits from realizing, especially since there is still a major amount of technical debt existing in the system that prevents even individual functions from performing on their best possible level.

Due to the status of the solution implementation, constant development of the software and organizational understanding, the development of the delivery process as a whole cannot be seen as feasible – automating and streamlining unstable and changing processes has no function, and can even be considered harmful if done without understanding the whole system process and the effects the decisions have not only on different parts of the process but also on global level on other business units and countries. As described earlier in chapter 2.3, the requirements for successful lean development of operations is not fulfilling currently while the processes are not stable, and there are lots of disruptions with the ongoing development happening. The current understanding of the system architecture, solution complexity and the ways of operating are also preventing the development of end-to-end processes, risking further siloing of different functions and amplification of errors between them.

Due to these reasons currently most of the wastes show up as waiting times when waiting for support, as defects in the process when there are not sufficient instructions and processes developed, quality issues in the information flow between different units an even as excess orders and materials in the order

handling/purchasing process because to the system planning and how it functions based on the master data setup.

Focus of development should be on parts that are either stable enough so that they can be maintained and improved, or to enable the support for lean operations on enterprise level. Based on this information gathered from the interviews and the current solution situation, the suggestions for improvement and steps needed to take steps towards ERP enabled lean enterprise have been gathered below under three short-term and one long-term development points. The focus in general should be in improving the already stable parts of the process and solution that are not subject to be changed, while ensuring the ability to support the continuous development of system and operations in the long-term without altering the current system solution architecture.

6.1 Improving the data flow for more accurate information

For timely, valuable and valid information, good quality master data is required to be managed and delivered for information users in time. Acting as the base for any information related activities, be it reporting, purchasing, sales, or other information system related abilities, the master data and the ability to manage it in a manner that enables the lean operations on all levels. Especially in ERP system, where the master data on the system level is used to perform the material requirement planning based on the existing information and object related master data. Especially in the currently used system solution, which requires for example the maintenance of item related master data in almost 20 separate sessions.

Improving this in the system side would be a move towards more lean way of operating. Current solution on item master data enrichment is based on resource efficient way of operating, where one person could be responsible for maintaining the data related to a single are or functionality like production, procurement, warehousing and sales. Moving towards more flow unit focused approach, where all the necessary data is collected under a single session or

view in the system and could be easily maintained from there. This would have a positive impact on the item enrichment process and reduce the overall lead time that is critical with high volumes and fast response times that are characteristics of the business unit, while also allowing for example purchasers to focus on more business critical cases instead of ensuring that the master data is enriched properly in the system side.

Further software and solution development is needed to reach the required level of process control that the ERP system can enable, as shown also earlier in **Figure 8**, where data management capabilities and software development done based on this both play key roles in reaching the next level of operational excellence and value provided by the ERP system. Reducing this enrichment and checking time required by individual item even by a minute could already save over 41 days of working time annually in the researched case unit. This development of item data management tools also supports the competitive advantages and decrease the response times on quotation when the new items could be setup faster. Developing the capabilities and tools on this area would bring benefits already in the short-term, when the system requirements for each item could be met faster and more efficiently from the flow unit perspective.

Due to the global role extensibility and role of the system, this development could also be utilized in other organization and business lines, making the savings in time and cost even more substantial.

6.2 System role updates

Unifying this item enrichment functionality and process phase under a single role also makes it possible to remove some of the processes and roles that are currently available in the system, making the navigation also easier and less time consuming for the end-users. Updating and simplifying the list of roles used and moving away from the software suppliers “best-practice” model that is split to very limited siloes and functionalities permits also aligning them with

the business responsibilities and moving towards more flow-unit focused system processes instead of resource focused ones.

Current mixing of different managerial, operational and view roles are hard to navigate and seem to work against users' intuition when the authorizations for different approvals and functions need to be applied to separately. Combining the different functions and roles under a more process oriented categories would support the end-users in their daily work and reduce the time spent searching the system for the correct sessions and views. It would also make the responsibilities of people clearer, when the actual organization would match the ERP system and prevent the realization of any gatekeepers or bottlenecks where only individual people have the correct authorizations and needed licenses.

6.3 Developing the missing concepts and removing variants

As raised during the data gathering process and raised in the chapter 5.1 the challenges related to the conceptual issues, the remaining business processes and variations which are missing from the current solution template can be considered a blocker for enabling further lean development of the actual processes, especially from the end-to-end perspective, since currently there have been found clear issues especially in the handover points of the process between different functions. Reducing these variants in ways of working and in systems simultaneously used enable harmonized and standardized processes within the scope of the ERP system. Removing the bottleneck from the master data maintenance and item data handling helps, but over time moving onwards from the level of operational optimization and master data control defined by towards more tactically optimized level where the system can be utilized more thoroughly for process control as defined by Millet & Botta-Genoulaz (2008), this standardization and stabilization of processes under single system enable further development of operations also from a lean perspective. After all, this standardization of processes helps make continuous improvements both on system and on ways to operate possible.

Missing processes and ways of operating required are required to ensure that the excess systems, workarounds and other process variants outside of centralized ERP can be removed. This in turn enables the processes to be documented in full and stabilizing the solution and operations for improvement ensuring that the changes and development done in the system and their impact can be fully assessed. This also aids with alignment the of organization with the new processes or removing this sort of "organizational debt" that has been accumulated during the implementation project. Since the changes and weak spots in the organization have not been recognized before taking the system to daily use, there are still inefficiencies and unclarities in the organization about the responsibilities, and roles. This kind of "continuous interim phase" where the end-users are waiting for solutions that could replace their old systems and help them centralize their work and changes under single system solution also helps remove the wastes that might be caused by the misalignment of processes and ERP platform.

Doing any further development without this stabilization also otherwise risks that the development done can be counterproductive and cause amplifying of errors through a whiplash effect. Since the goal is to develop long-lasting processes that support also operating on a more local level, it is not enough that the to-be processes are defined by the implementation team. As raised in chapter 5, this co-creation of concepts is needed together with the business representatives and system and IT professionals from the development team side. This notion also complies with the lean principles and strategies where the approach for any development should start from bottom-up, or from "shop-floor-level" where the actual operations and work is done. This co-creation of operations and system concepts can also be utilized in both ways – the implementing and developing team understands the real-life business challenges, while the business representatives also gain the understanding of any possible changes needed in the local organization or in the ways of working.

To reach this goal of stabilizing the operations and understand the requirements from local perspective still while the constant development and rollouts are

ongoing is challenge, especially since the organizational support is not yet on the required level: especially for the long-term development, building the lean IT capabilities and delivery models is critical for any further development on a process level.

6.4 Building lean organization and delivery models

The previous points of improving the flow of data through streamlined item enrichment process, updating the system roles to match the real-life processes and organization, and developing the missing concepts that keep from removing overlapping systems and possible workarounds can all be reached even in short-term, if it wasn't for the barrier and bureaucracy required to get all the changes and updates approved for development. To fully reach the state of ERP enabled lean enterprise, also the supporting organizations and delivery models need to be aligned with lean delivery model and IT.

Also highlighted in the interviews by the consultant, implementation project is only used to get the system running but the actual development of operations and processes both within the organization and in system starts from the day-one when the system is actually taken to use – opposite of what is usually the approach with the ERP transformation projects. This development and transition towards lean IT should be considered part of continuous improvement and supporting services, and not just as a single implementation as is usually the case with ERP implementations.

Since the successful implementation and utilization of lean principles requires it to mature over time to gain the most benefits and reach high operational performance illustrated also by Netland & Ferdows (2016) in chapter 2.3, building and improving the internal capabilities of system development over time is critical to reach the state of ERP enabled lean enterprise. Especially acquiring the people who can act as "translators" or system specialists that have the understanding of the end-to-end processes in the system and can transfer the business-requirements and challenges to technical designs and development

packages to the actual developers. The co-creation that should already happen during the implementation project to develop and implement the missing concepts also applies here, even with greater weight.

Understanding that it takes time to develop the lean maturity within organization, especially after such disruption within the whole enterprise. Either way, this is the only way to move towards the ERP enabled enterprise. Especially since the currently implemented modern software platform allows also the use of robotics and process automation – but not before the processes have stabilized and unnecessary steps removed, since the automating the wasteful operation and steps creates nothing automated waste in the system.

7 SUMMARY AND CONCLUSIONS

Moving towards lean processes and organizations is never easy, and it takes time for the results to mature to a level where the operational excellence and performance benefits can be reached, especially when talking about intangible things like data or information. Even though the benefits of the streamlined and more effective utilization of information would bring to the table are clear, it is not always clear what should be done and where. Optimizing information processes requires also the understanding and inclusion of organization and the technical solution, as not to create any partly optimized solutions and automating the waste creation. As found in this thesis, development of the solution and data management tools, missing processes and also the organization are required to move towards a leaner information management processes.

7.1 Results and their implications

In this thesis, the aim was to research the use of ERP systems in a lean enterprise through a case study of a company going through an ERP implementation and business transformation program. To go through the results based around the three research questions defined in the beginning of this thesis, we can conclude the study.

RQ1: What is the role of the ERP in a lean enterprise?

ERP systems act as a centralized database for all information and control and record the resources and their utilization in the company. The role may vary from being the backbone of the organization that is used to control all processes and actions, to an application that is used to store only the basic data but is not used for controlling of processes and operations per se. Based around transactions, the ERP system prevent or negatively affect the flow of both information and materials, and acting as a source of lean waste. Especially in the early stages, when the users are not that familiar with the system, and the

focus is on the master data management side, and not on the level of actually controlling processes throughout the system.

Like found during the interviews and this research, in an operational business where the volumes and amounts of transactions are high, the ERP system is the engine that keeps the whole business moving and without it stops almost completely. Combining multiple surrounding systems and solutions, people and organizations, the systems impact to the overall performance and flow of goods and materials is significant. Improving the system enables improved process control, enabling empowerment of information workers and improving the value flow through removal of unnecessary operations that result in not only just as information but also physical wastes in the forms of excess inventories, late deliveries, and

> *RQ2: How has the implementation of a new global ERP system affected the process performance in the case unit?*

In the case company, issues were found especially in the purchasing, and warehousing processes, where the materials and information flow were not without additional waste after the implementation of the system. Some processes were working well, but the end-to-end process flow throughout the enterprise was clearly disrupted by the implementation of the new system. Based on literature review, this was bound to happen with the implementation of the new system and should be expected before the new ERP system is taken fully into use and the users are also familiar with it. Issues like excess inventories, missing materials and/or item data and places to store necessary information causing the users to rely on emails and other information sources and to spend excess time on going through them for necessary information all have a negative effect on the overall flow enabled by the system.

The most critical parts were the missing system concepts and processes that were forcing some parts of the organization to use the old ERP system alongside the newly implemented one for an interim period of time. These are also related to the last research question we defined in the beginning:

RQ3: What actions should be done to improve the information flow of the new business processes in the case business unit??

The implementation of new ERP systems always causes disruptions in the enterprise: both on the process level but also on the organizational level, and there is always a need to reorganize the organizations and ways of working so that they are aligned with the new system and its functionalities. (van de Lans, 2013, pp. 104-110) Since the current processes are still volatile, and unstable due to the missing system concepts, it is not beneficial to do traditional lean development before they have stabilized (Browning & Sanders, 2012) and the overlapping legacy systems removed. The focus should be on starting the system developments that can help in data handling and management and help the movement towards a more tactical enterprise process integration.

Currently as the main bottleneck on the end-to-end process was recognized to be the item enrichment and data maintenance step in the beginning. Especially with the volumes and amount of transactions in the business unit, the time spent currently enriching and maintaining the items can be reduced through system customizations that enable a more centralized maintenance of underlying master data that is the foundation on which the information generated by the processes can be built on. Improving the different roles and authorizations in the system also enables support for better master data management and can help align the new processes with the organization and share the responsibilities between people.

As a long-term development, the case business unit should secure the organizational support for lean development. Improving the delivery model to support a lean approach by reducing the required bureaucracy and focusing in reducing the current solution lead times that in their shortest are around 8 months and in worst cases can even extend to over a year. Understanding this long-term support needed after the implementation project with a fixed time period, aim and cost is crucial for developing the processes after they have stabilized.

The managerial implications of this thesis' results can be interpreted both from the perspective of ERP systems and the impact they have on the organization, and from lean management and continuous improvement perspective. Due to the disruptive nature of the ERP system implementations, the operations take time to stabilize and before starting any further development of them, they should be fully aligned with the underlying organizations and ways of working. In the beginning, enabling the master data management capabilities and reducing flow barriers from that side through system development and improvements on those areas. Ensuring that all the users are also up-to-date with their skills and understanding of the system changes and requirements is also essential, so enabling already during the implementation project a fluid flow of information towards the end-users about the changes needed and done both on the system and in ways of working.

From lean perspective, the time it takes to reach the required level of stableness on the processes and operations should be taken to use in building and organization that can support in the future the strides towards continuously improvement of information processing and sharing within the ERP system. Recognizing, training and assigning the correct people to the role of co-creators that can drive the development in the future together with the end-users and system specialists and developers are in key position for successful delivery of both operational and system improvements.

After all, enterprises and organizations should always seek to improve their operations and strive towards continuous improvement, as has been the focus of lean for decade.

7.2 Reliability and validity of the study of the study

Evaluation of reliability is important for scientific research, ensuring that the results are consistent in their nature and also replicable in a similar setting and with similar study methodology. Reliability can be considered to be the key characteristic about the research quality, and ensuring the reliability is not

always easy due to the possible errors on participant and researcher sides which might have a negative impact on the reliability of the research. These false responses and interpretations can be mitigated with methodological approach to the research process and making sure there are no false assumptions or logic leaps within the process. (Saunders, et. al., 2016, pp.202-207)

Assessing and evaluating the reliability of lean related case studies can be challenging, since like Modig & Åhlstrom (2016, pp.139-145) argue the lean related developments and studies are always dependent on the organizational context and should be adjusted to match the challenges and goals of the specific organization instead of just implementing the generally touted lean tools. Also the environment in which the research for this project has been done, as part of still ongoing ERP implementation project mean that the cross-sectional snapshot of certain time is not necessarily repeatable and cannot be repeated due to the development still ongoing and continuously done both in the system itself but also on organizational level.

Participant bias is also one dimension to be considered as a threat to reliability of the study. Part of the people interviewed were involved already since the beginning of the implementation project itself. The decisions and actions made during the design and testing phase of the system itself and the how the project was handled was had clear effect on answers based on the interviews – one interviewed manager that was participating in the implementation project even mentioned that their feedback and critique is more related to the implementation project itself and not the system itself and how it functions. To mitigate this risk, also people whom had not participated to the implementation project planning were included as end-users to gather feedback also from people whom were not affected by the politics that are bound to affect the implementation project.

Besides reliability of the research, also the validity of the research should be evaluated. Saunders et. al. (2016, pp. 202-207) describe the validity of the research under three main principles: have the appropriate measurements been used, can the results or findings be generalized and what is the accuracy of the

performed analysis performed. Internal and external validity can be used to describe the validity of the research. Evaluation of internal validity is common especially in quantitative research where the research is expected to demonstrate the causal relationships between variables, while the external validity is concerned about the question if the results can be generalized to other settings or groups.

Even though the challenges that the ERP system poise and which were listed earlier are in general applicable to most of the cases, single case study on this area is not necessarily applicable for generalization. Project related schedules, operational scope and the implementation model itself are all variables that fluctuate between organizations, as well as the previously mentioned context and case dependent role of lean developments required. Especially for cross-sectionally done single case studies, the external validity of the results could be challenged, given that the motives and reasons for these always differ between business do not stay constant over time. In general, the research and its results are valid only in a similar environment and organization with similar solution architecture.

The drawn conclusions and findings from this case study could be generalized to similar environments to a degree. The challenges with the change management and missing system concepts will prevent the operations from stabilizing in any environment, system from being fully utilized as designed. Building the internal understanding and capabilities to do process level development and not only focusing on individual operations and tasks is crucial for successful ERP system and lean development in system level.

The results also generate further questions and research areas for the future. Based on the findings from this there are two main approaches for future research through either widening it to cover other enterprises or deepen it to gain more knowledge and findings from the case company itself. Since the results here can be generalized to an extent, expanding the research area and defining best-practices for post-implementation development of ERP related

processes from lean perspective from also other enterprises is a natural extension to the topic.

Also researching the change management needs and requirements from within the case company around the area would give a great environment to conduct a longitudinal study of the changes and needed, especially after the system solution has been stabilized and could be further developed from process perspective. Especially since more emphasis should be put to the post-implementation phases and success factors for ERP systems. Improving the flow and use of information throughout the organization could bring new business opportunities and enhance the value creation when utilized more efficiently.

REFERENCES

Abdi, F. (2006). “Glean lean: how to use lean approach in service industries?” Journal of Services Research, Vol. 6, pp. 191-206.

Abreu-Ledón, R. (2018). “A meta-analytic study of the impact of Lean Production on business performance”. International Journal of Production Economics, 200, pp. 83-102.

Acar, M. F., Tarim, M., Zaim, H., Zaim, S. & Delen, D. (2017). “Knowledge management and ERP: Complementary or contradictory?” International Journal of Information Management, Vol. 37, No. 6, pp. 703-712.

Ağaoğlu, M., Yurtkoru, E.S. & Ekmekçi, A.K. (2015), "The Effect of ERP Implementation CSFs on Business Performance: An Empirical Study on Users’ Perception", Procedia - Social and Behavioral Sciences, Vol. 210, No. C, pp. 35-42.

Agostinho, O.L., Seraphim, E.C., da Silva, I.B., Lima Junior, O.F. & Batalha, G.F. 2015, "Lean office in health organization in the Brazilian Army", Lean Six Sigma Journal, vol. 6, no. 1, pp. 2-16.

Albliwi, S., Antony, J., Abdul Halim Lim, S. & van Der Wiele, T. (2014). “Critical failure factors of Lean Six Sigma: A systematic literature review”. The International Journal of Quality & Reliability Management, Vol. 31, No. 9, pp. 1012-1030.

Bartholomew, D. (1999). “Lean vs ERP”. Industry Week, Vol. 248, No. 14, pp. 24-30.

Baskarada, S., Koronios,A. (2013), "Data, Information, Knowledge, Wisdom (DIKW): A Semiotic Theoretical and Empirical Exploration of the Hierarchy and its Quality Dimension", Australasian Journal of Information Systems, vol. 18, no. 1.

Bell, S. (2006). Lean enterprise systems: Using IT for continuous improvement. 1st ed. Hoboken, N.J.: Wiley-Interscience, pp. 417.

Blijleven, V., Koelemeijer, K. & Jaspers, M. (2017). “Identifying and eliminating inefficiencies in information system usage: A lean perspective”. International Journal of Medical Informatics, Vol. 107, pp. 40-47.

Bortolotti, T. (2012). “‘Lean first, then automate’: A framework for process improvement in pure service companies”. A case study. Production Planning & Control, lo-Vol. 23, No. 7, pp. 513-522.

Boudreau, M., & Robey, D. (2005). “Enacting Integrated Information Technology: A Human Agency Perspective”. Organization Science, Vol. 16, No. 1, pp. 3-18.

Browning, T. R. & Sanders, N. R., (2012). “Can Innovation Be Lean?”, California Management Review, vol. 54, No. 4, pp. 5-19.

Buonanno, G., Faverio, P., Pigni, F., Ravarini, A., Sciuto, D. & Tagliavini, M. (2005). ”Factors affecting ERP system adoption”. Journal of Enterprise Information Management, Vol. 18, No. 4, pp. 384-426.

Chaabouni, A. & Yahia, I. (2014). “Contribution of ERP to the decision-making process through knowledge management”. Journal of Decision Systems, Vol. 23, No. 3, pp. 303-317.

Choo, C., Furness, C., Paquette, S., van Den Berg, H., Detlor, B., Bergeron, P. & Heaton, L. (2006). “Working with information: Information management and culture in a professional services organization”. Journal of Information Science, Vol. 32, No. 6, pp. 491-510.

Costello, T. (2011).” Lean: More than a Shop-Floor Fad.” IT Professional, Vol. 13. No. 3, pp. 64-63.

Davenport, T.H. (1998). ”Putting the enterprise into the enterprise system”, Harvard Business Review, Vol. 76, No.4, pp. 121-131

Dehe, B., Forrester, P., Bamford, D. & Leese, R.G. (2015). "Partial and iterative Lean implementation: two case studies", International Journal of Operations & Production Management, Vol. 35, No. 5, pp. 702-727.

DeLone, W.H. & McLean, E.R. (2003), "The DeLone and McLean Model of Information Systems Success: A Ten-Year Update", Journal of Management Information Systems, Vol. 19, No. 4, pp. 9-30.

Detlor, B. (2010). “Information management”. International Journal of Information Management, Vol. 30, No. 2, pp. 103-108.

Devece, C., Palacios, D. & Martinez-Simarro, D. (2017), "Effect of information management capability on organizational performance", Service Business, vol. 11, no. 3, pp. 563-580

Douglas, J., Antony, J. & Douglas, A. (2015). “Waste identification and elimination in HEIs: The role of Lean thinking”. International Journal of Quality & Reliability Management, Vol. 32, No. 9, pp. 970-981.

Elbanna, A. (2007). “Implementing an integrated system in a socially dis-integrated enterprise: A critical view of ERP enabled integration”. Information Technology & People, Vol. 20, No. 2, pp. 121-139.

Frank, L. (2004). “Architecture for integration of distributed ERP systems and e-commerce systems”. Industrial Management & Data Systems, Vol. 104, No. 5, pp. 418-429.

Ganesh, K., Mohapatra, S., Anbuudayasankar, S. and Sivakumar, P. (2014). “Enterprise Resource Planning: Fundamentals of Design and Implementation”. 1st ed. Switzerland: Springer International Publishing. pp. 170

Gibson, W. & Brown, A. (2009). Working with qualitative data. 1st ed. London: SAGE, pp.219.

Gilardi, S., Guglielmetti, C. & Pravettoni, G. (2014). ”Interprofessional team dynamics and information flow management in emergency departments”. Journal of Advanced Nursing, Vol. 70, No. 6, pp. 1299-1309.

Gillham, B. (2000). Case study research methods. London: Continuum. pp. 106

Halgeri, P., McHaney, R. & Pei, Z.J., (2011). “ERP systems supporting lean manufacturing in SMEs”. In Enterprise Information Systems: Concepts, Methodologies, Tools and Applications. IGI Global. pp. 1121-1140

Hallam, C. (2005). “Lean Enterprise Transformation: Measuring and Accelerating the Transition to Lean”. Available online: https://www.researchgate.net/publication/37598003_Lean_Enterprise_Transformation_Measuring_and_Accelerating_the_Transition_to_Lean [Cited 19.5.2019]

Hansen, M.T., Nohria, N. & Tierney, T. (1999). "What's Your Strategy for Managing Knowledge?", Harvard business review, vol. 77, no. 2, pp. 106-116.

Haque, B. & James-Moore, M. (2004). “Applying lean thinking to new product introduction”. Journal of Engineering Design, Vol. 15, No. 1, pp. 1-31.

Hendricks, K.B., Singhal, V.R. and Stratman, J.K. (2007), “The impact of enterprise systems on corporate performance: a study of ERP, SCM, and CRM system implementations”, Journal of Operations Management, Vol. 25, No. 1, pp. 65-82.

Herrala, M., Leviäkangas, P. & Haapasalo, H., (2009). “Information value attributes and assessment methods–a construct from a traffic and traveller information perspective”, Value World, vol. 32, no. 1, pp. 34-45

Hicks, B.J. (2007), "Lean information management: Understanding and eliminating waste", International Journal of Information Management, vol. 27, no. 4, pp. 233-249.

Hines, P., Holwe, M. & Rich, N. (2004). “Learning to evolve - A review of contemporary lean thinking”. International Journal of Operations & Production Management, Vol. 24, No. 9-10, pp. 994-1011.

Hofer, C., Eroglu, C. & Rossiter Hofer, A. (2012). "The effect of lean production on financial performance: The mediating role of inventory

leanness", International Journal of Production Economics, Vol. 138, No. 2, pp. 242-253.

Hossain, L., Rashid, M., and Patrick, J., (2002) “The Evolution of ERP Systems: A Historical Perspective” In: Hossain, L., Rashid., M. and Patrick, J., Enterprise Resource Planning: Global Opportunities and Challenges. 1st ed. Hershey, PA: Idea Group Pub., pp. 300.

Huniche, M. & Rahbek, G.P. (2011), "Determinants of lean success and failure in the Danish public sector: A negotiated order perspective", Intl Journal Public Sec Management, Vol. 24, No. 5, pp. 403-420.

Häkkinen, L., & Hilmola, O-P., (2008), "Life after ERP implementation: Long-term development of user perceptions of system success in an after-sales environment", Journal of Enterprise Information Management, Vol. 21, No. 3, pp. 285-310.

Jifa, G. & Lingling, Z. (2014), “Data, DIKW, Big Data and Data Science”. Propedia Computer Science, vol. 31, pp. 814-821.

Klaus, H., Rosemann, M., & Gable, G., (2000). ”What is ERP?” Information Systems Frontiers, Vol. 2, No. 2, pp. 141-162.

Kwak, Y. H., Park, J., Chung, B. Y. & Ghosh, S. (2012). “Understanding End-Users' Acceptance of Enterprise Resource Planning (ERP) System in Project-Based Sectors”. IEEE Transactions on Engineering Management, Vol. 59, No. 2, pp. 266-277.

Losonci, D., Demeter, K. & Jenei, I. (2011), "Factors influencing employee perceptions in lean transformations", International Journal of Production Economics; Innsbruck 2008, Vol. 131, No. 1, pp. 30-43.

Lyons, A., Vidamour, K., Jain, R. & Sutherland, M. (2013). “Developing an understanding of lean thinking in process industries”. Production Planning & Control, Vol. 24, No. 6, pp. 475-494.

Madenas, N., Tiwari, A., Turner, C. & Peachey, S. (2015), "An analysis of supply chain issues relating to information flow during the automotive product development", Journal of Manufacturing Technology Management, Vol. 26, No. 8, pp. 1158-1176.

Manela, A. (2014). “The value of diffusing information”. Journal of Financial Economics, Vol. 111, No. 1, pp. 181-199.

Marcotte, F., (2013). “How to Take into Account the Intuitive Behaviour of the Organisations in the ERP?” In: Grabot, B., Mayère, A., & Bazet, I., ed. ERP Systems and Organisational Change: A Socio-technical Insight. Springer, London. pp. 119 – 137.

Mayere, I. & Bazet, I. (2008). “ERP Implementation: The Question of Global Control Versus Local Efficiency”. In: Grabot, B., Mayère A & Bazet I., ERP Systems and Organisational Change: A Socio-Technical Insight, 1st ed. London: Springer London, pp.214.

Mayere, I., Grabot, B., & Bazet, I. (2008). “The Mutual Influence of the Tool and the Organisation”. In: Grabot, B., Mayère A & Bazet I., ERP Systems and Organisational Change: A Socio-Technical Insight, 1st ed. London: Springer London, pp.214.

Millet, P., A., & Botta-Genoulaz, V., (2008) “Process Alignment Maturity in Changing Organisations”. In: Grabot, B., Mayère, A., & Bazet, I., ed. ERP Systems and Organisational Change: A Socio-technical Insight. Springer, London. pp. 214.

Mithas, S., Ramasubbu, N. & Sambamurthy, V. (2011). "How Information Management Capability Influences Firm Performance", MIS Quarterly, vol. 35, no. 1, pp. 237-256.

Modig, N. & Åhlström, P. (2016). This is lean. 1st ed. Stockholm, SWE: Rheologica Publishing, pp.168.

Munir Ahmad, M. & Pinedo Cuenca, R., (2013). “Critical success factors for ERP implementation in SMEs”, Robotics and Computer-Integrated Manufacturing, Vol. 29, No. 3, pp. 104-111

Nauhria, Y., Wadhwa, S., & Pandey, S. (2009). “ERP enabled lean six sigma: A holistic approach for competitive manufacturing”. Global Journal of Flexible Systems Management, Vol. 10, No. 3, pp. 35-43

Netland, T.H. & Ferdows, K. (2016). "The S-Curve Effect of Lean Implementation", Production & Operations Management, Vol. 25, No. 6, pp. 1106-1120.

Netland, T.H. (2016). "Critical success factors for implementing lean production: the effect of contingencies", International Journal of Production Research, Vol. 54, No. 8, pp. 2433-2448.

Nicolaou, A. I. & Bhattacharya, S. (2006). “Organizational performance effects of ERP systems usage: The impact of post-implementation changes”. International Journal of Accounting Information Systems, Vol. 7, No. 1, pp. 18-35

Panayiotou, N. A., Gayialis, S. P., Evangelopoulos, N. P. & Katimertzoglou, P. K. (2015). ”A business process modeling-enabled requirements engineering framework for ERP implementation”. Business Process Management Journal, Vol. 21, No. 3, pp. 628-664.

Piszczalski, M. (2000). “Lean vs. information systems”. Automotive Manufacturing & Production, Vol. 112, No. 8, pp. 26-28.

Powell, D. (2013), "ERP systems in lean production: new insights from a review of lean and ERP literature", International Journal of Operations & Production Management, vol. 33, no. 11, pp. 1490-1510.

Powell, D., Alfnes, E., Strandhagen, J. O. & Dreyer, H., (2013). “The concurrent application of lean production and ERP: Towards an ERP-based lean implementation process”, Computers in Industry, Vol. 64, No.3, pp. 324-335.

Ripamonti, S. C. & Galuppo, L. (2016). “Work transformation following the implementation of an ERP system”. Journal of Workplace Learning, Vol. 28, No. 4, pp. 206-223

Saunders, M., Lewis, P. and Thornhill, A. (2016), Research methods for business students, 7th ed., Pearson Education Ltd, England, pp.730

Scherrer-Rathje, M., Boyle, T.A. & Deflorin, P. (2009). "Lean, take two! Reflections from the second attempt at lean implementation", Business Horizons, Vol. 52, No. 1, pp. 79-88.

Septer, J., (2013). The Importance of an Enterprise Information Management Strategy. In: Baan, P., ed. Enterprise Information Management: When Information Becomes Inspiration. 1st ed. Springer, New York, pp. 43-78.

Sreedharan V, R., V, G., Nair, S., Chakraborty, A. & Antony, J. (2018), "Assessment of critical failure factors (CFFs) of Lean Six Sigma in real life scenario", Benchmarking: An International Journal, Vol. 25, No. 8, pp. 3320-3336.

Staats, B. R., Brunner, D. J. & Upton, D. M. (2011). “Lean principles, learning, and knowledge work: Evidence from a software services provider”. Journal of Operations Management, Vol. 29, No. 5, pp. 376-390.

Tallon, P. (2007).”A Process-Oriented Perspective on the Alignment of Information Technology and Business Strategy”. Journal of Management Information Systems, Vol. 24, No. 3, pp. 227-268.

Tallon, P. (2012). “Value Chain Linkages and the Spillover Effects of Strategic Information Technology Alignment: A Process-Level View”. Journal of Management Information Systems, Vol. 28, No. 3, p. 9-44

Taylor, R. S. (1982). “Value-Added Processes in the Information Life Cycle”. Journal of the American Society for Information Science, Vol. 33, No. 5, pp. 341-46.

Tyagi, S., Choudhary, A., Cai, X. & Yang, K. (2015), "Value stream mapping to reduce the lead-time of a product development process", International Journal of Production Economics, vol. 160, no. C, pp. 202-212.

van Der Lans, A., (2013). “Business Process Management (BPM): The Information Loop”. In: Baan, P., ed. Enterprise Information Management: When Information Becomes Inspiration. 1st ed. Springer, New York, pp. 101-123

Velcu, O. (2010). “Strategic alignment of ERP implementation stages: An empirical investigation”. Information & Management, Vol. 47, No. 3, pp. 158-166.

Ward, P. & Zhou, H. (2006), "Impact of Information Technology Integration and Lean/Just-In-Time Practices on Lead-Time Performance", Decision Sciences, Vol. 37, No. 2, pp. 177-203.

Wempe, W.F. & Fullerton, R.R. (2009). "Lean manufacturing, non-financial performance measures, and financial performance", International Journal of Operations & Production Management, Vol. 29, No. 3, pp. 214-240.

Womack, J. and Jones, D. (2003). Lean thinking: banish waste and create wealth in your corporation. 2nd ed. New York: Free Press. pp. 352

Yusuf, Y., Gunasekaran, A. & Abthorpe, M. S. (2004). “Enterprise information systems project implementation: : A case study of ERP in Rolls-Royce”. International Journal of Production Economics, Vol. 87, No. 3, pp. 251-266.

Appendix 1.

Basic spare part delivery process from system perspective