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Recommendations to Improve the Product Lifecycle Management (PLM) Capability Fulfillment Process of the Case Company

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Preface

Finally, I am here writing this section with a sense of achievement and happiness after going through the splendid journey of writing this thesis in the Industrial Management program. Despite the global pandemic challenges and restrictions, studying in the Industrial Management programme has been rewarding and allowed me to learn the best practices from industrial management theories and apply them to real business challenges.

I would like to thank the case company for providing me with the opportunity to continue learning as well as for suggesting the meaningful topic for this thesis work. I want to thank all the stakeholders who participated in the interviews, workshops and survey as well as my colleagues who kept motivating me over various coffee sessions. My special thanks go to my supervisor for all the insightful discussion and guidance in supporting my study.

I would like to take this opportunity to thank my thesis advisor, Dr Thomas Rohweder for the guidance and Sonja Holappa for steering my professional language for this thesis work. Also, I would like to express my gratitude to Dr Juha Haimala and Dr James Collins for their insightful lectures and feedbacks during the thesis work.

Finally, I would like to express my most deep gratitude to my wife Shilpa and kids Chirag and Harsh for being my exceptional support during the rigorous journey and kept encouraging me to move forward at some of the most difficult times. I owe to their sacrifices in allowing me the time I needed in completing this study. As a final note, I am grateful to my parents for enabling me to reach this height.

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Abstract

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The objective of the study was to recommend improvements for the Product Lifecycle Management (PLM) Capability Fulfillment process of the case company. PLM Capability Fulfillment process has an increasing importance for the success of the case company in the evolving market environment.

This thesis followed the design research approach and included four stages. The first stage was a current state analysis utilizing various methods and sources to map the process as well as identify the key improvement areas to improve based on the strengths and weaknesses. In the second stage the existing literature was reviewed to find best practices to address the identified weaknesses and compiled into the conceptual framework. The third stage included co-creating initial recommendations with key stakeholders to improve the identified key improvement areas. The fourth stage included validation and prioritization of the initial recommendations based on the feedback received from the case company executive.

In the current state analysis, a variety of strengths and weaknesses were identified and categorized based on their characteristics and areas of occurrence. The selection of key areas for improvement emphasized the value that would be gained by improving the weaknesses associated with them. Additionally, the possibility of additional improvements to the process that were not included in the scope of this study was evaluated and considered outside of this thesis.

The outcome of this thesis is a validated set of recommendations to improve the identified weaknesses and a roadmap to implement the recommendations. By improving the process, the case company will benefit significantly by having a simple and standardized process for handling all PLM Capabilities and build a strong foundation for knowledge management across organization.

Keywords: Process Improvement, Product Lifecycle Management, Application Portfolio Management

Contents

List of Figures

List of Tables

List of Abbreviations

APM:	Application Portfolio Management
BPM:	Business Process Management
BPMN:	Business Process Model and Notation
CKT:	Capability and Know-How Transfer
COTS:	Commercial-off-the-Shelf application
CSA:	Current State Analysis
GDPR:	General Data Protection Regulation
IT:	Information Technology
ITDD:	Information Technology and Digital Development
PDA:	Process-Driven Architecture
PEMM:	Process and Enterprise Maturity Model
PLM:	Product Lifecycle Management
SAFe:	Scaled Agile Framework

1 Introduction

Over the years, Information Technology (IT) has moved from being considered a mere support function to be part of the corporate DNA now. With the advent of digitalization, IT functions have become strategically important for growth and progress of businesses and help elevate the position of the organization ahead of its competition.

The growth of any company is influenced mostly by the degree of willingness to grow, and the level of capability of a company. Generally, Capability is referred to a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end (Raphael et al. 1993). Furthermore, Capability is referred as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments (Teece et al. 1997). It is clear to say that capabilities form the primary basis for competition between firms (Corbett et al. 2002).

The capabilities that a company needs most to ensure growth, maintain leadership position and differentiate itself from its competitors are evolving every day but there have been challenges in fulfilling the needed capabilities in a timely manner. Currently, these challenges arise from fragmented or inefficient processes with limited digital connections that rely more on individuals to meet these needs. Hence capability which is defined as a) The ability of employees to fulfil their roles effectively in organizations and b) What an organization requires in order to deliver its mandates successfully, not only in the present but continually (Bhatta, 2005:78), organizations need to have streamlined, highly predictable and digitally enabled processes. To support business operations and assist in growth journey, IT plays a significant role with its diverse technical and domain talent pool.

Manufacturing companies across industries have adopted the Product Lifecycle Management (PLM) approach for the entire lifecycle of products to optimize the manufacturing processes and help keep the cost low. According to Michael

Grieves (2005) Product Lifecycle Management (PLM) is an integrated, information-driven approach comprised of people, processes/practices, and technology to all aspects of a product's life, from its design through manufacture, deployment and maintenance—culminating in the product's removal from service and final disposal. By trading product information for wasted time, energy, and material across the entire organization and into the supply chain, PLM drives the next generation of lean thinking. (Grieves, 2005).

In many manufacturing or engineering industries, fulfilling engineering Product Lifecycle Management (PLM) capability has been a major problem compared to other traditional industry's needs. A key issue in PLM capability fulfillment is that the IT team needs to understand business terminologies, understand complete product lifecycle management within the organization, as well as possess techno-functional skills. These issues are driving organizations to look for fresh and innovative solutions as new capabilities are linked to the organization's growth and to have the competitive advantage over competitors. One of the greatest opportunities of looking at the PLM capability fulfillment now is that capability building is considered as one of the high strategic priorities of organizations and also driven based on customer demand.

This thesis focuses on recommendations to improve the existing PLM capability fulfillment process in the case company leveraging various literature and best practices along with a current state analysis of the case company's PLM Capability fulfillment process. In the case company, PLM capability fulfillment is categorized in two different ways: First is the PLM capability that needs development in the existing systems and second is the PLM capability that needs a Commercial-Off-the-shelf (COTS) application.

1.1 Business Context

The case company in this thesis is a Finnish multinational company operating in the aggregates, mining, and metals businesses. The company has three major segments: Aggregates, Minerals, and Metals. Aggregate segment provides

crushing and screening equipment for the production of aggregates. The mining segment provides equipment and complete plant solutions for minerals processing, including comminution, separation, and pumps. The metals segment provides processing solutions and equipment for metal refining and chemical processes. The case company operates in 50+ countries and has 150 years of expertise in the mining and metals industry. The case company is ranked 8th on the 2021 Global 100 list of the world's most sustainable companies. The case company was created through the combination of two different companies operating in Aggregates, Minerals and Metals industries. The case company has a combined strength of 15000+ employees and has 5 different business areas – Aggregates, Minerals, Metals, Services and Consumables.

For the next phase of growth, the case company has identified the following key growth areas: Products with high aftermarket intensity, Sustainable offering and Automation and Digitalization. Also, in its strategy, the case company has specified to become a top-tier supplier of products, technologies and services in the aggregates and minerals industries. The management of the case company emphasizes to continuously grow on services and focus on product development and this aligns with the key growth areas mentioned earlier. In order to stay ahead of the competition, the case company must continue to develop its capabilities in the PLM application landscape and extend existing capabilities at a much faster pace and in a sustainable way with a predictable process to ensure that they do not end up in creating an ecosystem silo.

1.2 Business Challenge, Objective and Outcome

The case company has gone through a big integration in the past year post the combination of two different companies. This has resulted in challenges like different set of tools and systems, dissimilar ways of working, parallel processes and personnel with different domain and technical expertise. The key business challenge in the case company is that the current PLM capability fulfillment process is not functioning in the intended way. The case company recognizes

that the PLM capability fulfillment process is strategically important and realizes that it is vital for an engineering technology company.

To further challenge the current state is the limited availability of existing application portfolio mapped to the PLM capabilities within the organization. Different businesses approach key IT personnel directly to discuss on their PLM Capabilities and then move forward. These capability requests are not recorded in any system or tools making it difficult to track for future references and also lead to delays in timebound fulfillment. Additionally, supporting functions such as global solution architecture team are involved late in the process or not involved at all in many cases. The global solution architecture team plays a vital role by supporting business areas, market areas, group functions and IT teams to plan and initiate development projects with purpose-fit solution architecture design. The global solution architecture team guide the business domains towards case company level synergies and re-use of existing solutions and technologies with development roadmaps and target architecture definitions. The global solution architecture team is responsible for capability mapping across organizations and is a vital part of the PLM Capability fulfillment process. All these issues have negative consequences and impact on the company's key business deliveries and product development.

The objective of this study is to provide recommendations to improve the existing PLM Capability fulfillment process by drawing upon best practice in capability fulfillment process and leveraging expert knowledge and insights inside the case company.

Consequently, the outcome is recommendations to improve the existing PLM Capability fulfillment process, which is designed to help the case company in making evidence-based, predictable, sustainable and timebound decisions for their PLM Capabilities.

1.3 Scope and Outline

The scope of this thesis is limited to improving the existing capability fulfillment process for the PLM (Engineering application) domain. The existing PLM Capability fulfillment process is set as a standard process across all business areas by top management and does not have any tailored solutions for any business areas.

The scope of the study does not include the implementation or further development of the PLM Capability fulfillment process owing to a longer time being spent on analysing the current state and recommending improvements to the existing PLM capability fulfillment process. Additionally, the study does not include any recommendations on how the procurement process needs to be set for purchase of new COTS applications from the market nor recommend how to review and renew any existing COTS application contracts. Furthermore, the scope does not include any recommendations on the tools to be used for visualizing the existing application portfolio.

This study contains seven sections. The introduction describes the business context, challenge, objective of the study, expected outcome from the study and scope of the study. Section 2 introduces the project plan which illustrates the research design for the study and describes the methodology and tools for data collection and analysis. Section 3 describes the current state analysis in the context of the business challenge, covering the case company and provides a summary of strengths and weaknesses in the current process. Following section 3, Section 4 focuses on the findings from the literature research in the context of the weaknesses identified from the current state analysis and the outcome of this section is the conceptual framework. Section 5 is built on the outcomes of section 3 and 4 and describes the initial proposal of recommendations. The initial recommendations created in section 5 is validated in section 6 based on the feedback and concludes with the final recommendations. The final section of this thesis provides the conclusion with an executive summary of the study and details

recommendations for the future along with the evaluation of the relevance and rigour of the study.

2 Project Plan

The business challenge, objective and the outcome were explained in the previous section. This section outlines the selected research approach and design followed by the data collection and analysis methods used in this thesis.

2.1 Research Approach

To reach the objective of this thesis, it was important to choose the best research approach available. Generally, in research, there are two main types of research types: basic research and applied research (Saunders et al. 2012). According to Bajpai (2011), conducting research to solve any problem is a scientific, systematic, and interconnected process that requires experience and knowledge. Furthermore, the purpose of both basic and applied research is to contribute to or develop a body of knowledge.

Basic research is generally not related to a specific problem and its findings cannot be immediately applied whereas applied research directly addresses the problem at hand. In applied research, the researcher uses a systematic and scientific procedure to conduct the study. Using the presented findings, the decision maker makes a decision about how to handle the problem. Thus, the difference is the application of the findings. Basic research is an improvement or addition to the theory where the findings are used directly or immediately. On the other hand, applied research is conducted to address a specific problem, and its results are immediately implemented by decision makers if they are feasible and sustainable (Bajpai 2011).

Applied research can be performed in one of the following ways such as case study-based research or action research with prescribed and fixed procedures. The purpose of the case study-based research is to understand a specific case

at hand which answers specific research questions derived from multiple sources of evidence. Case study helps further to understand the context before applying any theories to create changes that works best (Gillham, 2000). In Action research, the process consists of a spiral of cycles of action and research with four major phases: planning, acting, observing and reflecting. (Zuber-Skerritt, 2019:5). The challenge with action research is that the cyclic process does not stop when the research is 'written up', rather it is continued until a decision is taken to intervene the process in order to publish its outcome to date (Somekh, 2005:6).

An alternative approach is formulated to address the limitations in the ways of performing applied research - Design research. According to Kananen (2013) design research produces functional and practical solutions to improve operations in organizations with the combination of development and research. Furthermore, Kananen (2013) explains that design research is a part of every organization's natural development work as they improve their operations, and in essence development work is considered science when it is properly documented, using appropriate scientific methods, and produces new knowledge. (Kananen, 2013: 20-22).

This thesis utilizes the design research as its research approach. As the study deals with a specific organizational issue and there is a need to work with people who are directly involved in the process to implement a change, design research is considered to be the suitable approach compared to other approaches.

The next sub-section describes the design research and the methodology of the study.

2.2 Research Design

The primary motive for this study is to recommend improvements to the existing PLM Capability fulfillment process and the required actions were organized into four distinct stages in order to achieve the objective.

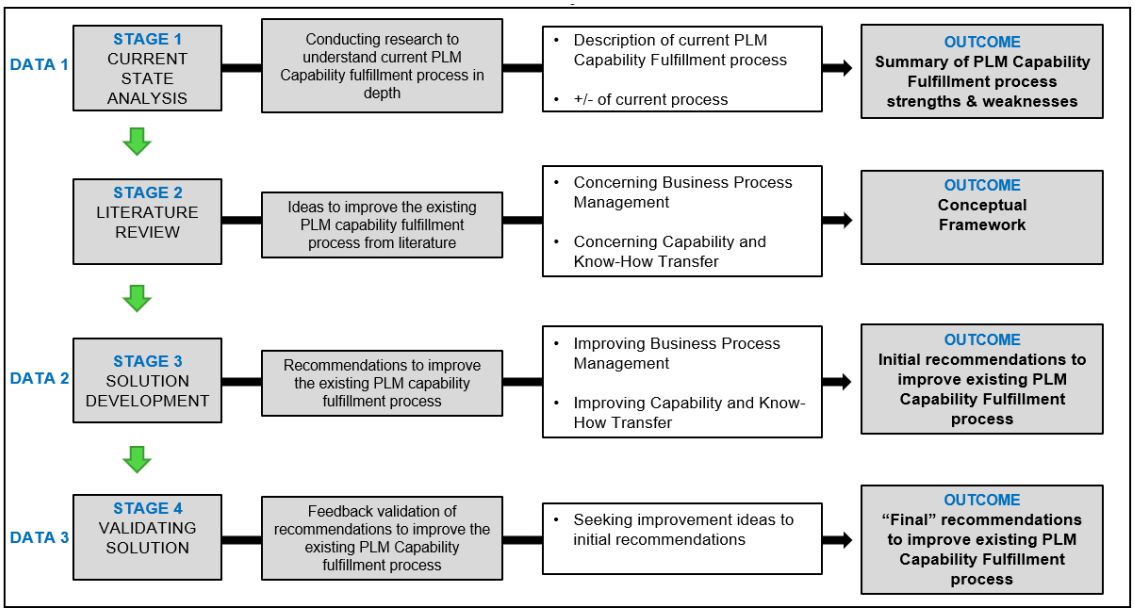

Figure 1. Research Design of this study

As shown in Figure 1, the first stage was the current state analysis of the PLM Capability fulfillment process. The current state analysis was performed to understand the as-is process and to gather the strengths and weaknesses of the current process. To better understand the current situation, the current state analysis was performed in three steps:

The first step of data collection relied on the existing documents related to capability fulfillment. The documents included various templates to assist business with requesting for new capabilities, "How-to" documents to get new development initiatives into IT & Digital development portfolio and a typical flow of new development initiative from start to completion. These documents provided a generic overview for all kinds of business capabilities and lacked Product Lifecycle Management (PLM) Capability fulfillment specific needs that needed an application instead of any development in the existing systems. The second step focused on eight targeted interviews which were performed in order to collect data and analyse the current way of requesting and processing of PLM Capabilities from business. The third and final step included surveying the same participants to identify the strengths and weaknesses of the current way of working. The questionnaire was themed around understanding further the current

ways of working and the interviewees were requested to list improvements and their expectations in the to-be PLM capability fulfillment process. Some of the key improvement suggestions and expectations highlighted by the interviewees revealed in even more detail some of the key weaknesses in the current process. Finally, all the findings from the above three steps were summarized and analysed.

The second stage shown in Figure 1 was the literature review. Following the understanding of the current state of the PLM Capability fulfillment process, professional academic literature and best practices across industries and organizations were researched to focus on recommendations to improve the existing PLM capability fulfillment process and emphasizing the identified key weaknesses from the current process. The outcome of the literature review was summarized into the conceptual framework of this study.

In the third stage with the information collected from the first and second stage, an initial recommendation was proposed based on the conceptual framework and countering the identified weaknesses. Furthermore, the initial recommendations emphasized the key weaknesses identified from the current state analysis. The recommendations were an outcome of the literature study and the suggestions received from various participants during the interview and workshops. The outcome of this stage was the co-creation of initial recommendations for the process improvement.

The fourth and final stage shown in Figure 1 was the validation of the initial recommendations. The validation was performed by presenting the initial recommendations to the key leadership team member who is responsible for the overall process development across the organization. Based on the feedback received, the initial recommendations were updated to deliver the final outcome of this study - the final recommendations to improve the PLM Capability fulfillment process.

2.3 Data Collection

This study draws data from multiple data sources such as existing process documentation, interviews, survey and workshops with various stakeholders from the case company. The data collection was conducted in three stages as shown in Figure 1. Data 1 was gathered during the current state analysis, Data 2 was gathered while building the initial recommendations to improve the PLM capability fulfillment process and Data 3 was during the feedback and validation of the initial recommendations. The summary of the data collection along with the outcome from each stage is presented in Figure 2.

	CONTENT	SOURCE	INFORMANT	TIMING	OUTCOME
DATA 1 ANALYSIS OF CURRENT PLM CAPABILITY FULFILLMENT PROCESS	- Description of current PLM Capability Fulfillment process - +/- of current process	- Existing process documents	- Value Stream Lead	NOVEMBER - DECEMBER - JANUARY	- Summary of Current PLM Capability Fulfillment process along with a summary of **strengths & weaknesses**
		- Key user survey - Interview with various key users from business	- IT Engineering Manager - Value stream lead - 6 different Business Key users		
		- Interview	- Global solution architect		
DATA 2 RECOMMENDATIONS TO IMPROVE EXISTING PLM CAPABILITY FULFILLMENT PROCESS	- Recommendations to improve existing PLM capability fulfillment process for identified weaknesses	- One-to-one meeting over Microsoft (MS) Teams	- IT Engineering Manager - 2 Global solution architect - Value stream lead - Portfolio Manager	MARCH	**Initial recommendations** to improve existing PLM Capability Fulfillment process
		- MS Teams Workshop 1	- IT Engineering Manager - 2 Process architect		
		- MS Teams Workshop 2	- Value stream lead - Head of Portfolio Management		
DATA 3 FEEDBACK VALIDATION OF RECOMMENDATIONS TO IMPROVE THE EXISTING PLM CAPABILITY FULFILLMENT PROCESS	- Improvement ideas to initial recommendations	- MS Teams Workshop	- Company Decision Maker	MARCH	**Final recommendations** to improve existing PLM Capability Fulfillment process

Figure 2. Summary of data collection

An overview of all data collection rounds is presented in the following two tables. Table 1 shows the details of interviews, survey, workshops and discussion and their methodology for the documentation during the various data collection stage.

Table 1. Details of interviews, survey, workshops, and discussions in Data 1-3

#	Participants / Role	Data Type	Topic, Description	Date, Length	Documented as
	Data 1, for the current state analysis (Section 3)				
1	Respondent 1a: IT Engineering Manager	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Nov 2021, 1h	Field Notes and recording
2	Respondent 2a: Value stream lead	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Nov 2021, 1h	Field Notes and recording
3	Respondent 3a: Key user, Business area 1	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Nov 2021, 1h	Field Notes and recording
4	Respondent 4a: Key user, Business area 2	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Nov 2021, 1h	Field Notes and recording
5	Respondent 5a: Key user, Business area 3	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Nov 2021, 1h	Field Notes and recording
6	Respondent 6a: Key user, Business area 4	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Nov 2021, 1h	Field Notes and recording
7	Respondent 7a: Key user, Business area 5	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Dec 2021, 1h	Field Notes and recording
8	Respondent 8a: Key user, Business area 6	Microsoft Teams meeting (Online)	Current PLM Capability fulfillment process	Dec 2021, 1h	Field Notes and recording

9	Respondent 9a: Global solution architect	Microsoft Teams meeting (Online)	Current PLM capability mapping process and challenges from architecture point of view	Jan 2022, 0.5h	Field Notes and recording
10	Respondents 1a to 8a	Survey (Microsoft Forms)	Identify strengths and weaknesses of current PLM Capability fulfillment process. Requirements for future state process	Nov - Dec 2021	Field Notes and survey results
	Data 2, for initial recommendations building (Section 5)				
11	Participants: 2 Global solution architects, 1 Value stream lead, Portfolio Manager and IT Engineering Manager	One to One Meetings	Present summary of CSA and CF	March 2022, 30 mins each	Field Notes
12	Participants: Respondent 1b: Portfolio Manager Respondent 2b: Value Stream Lead	Workshop over Microsoft Teams meeting (Online)	Initial Recommendations for Business Process Management	March 2022, 2h	Field Notes and Recording
13	Participants: Respondent 3b: IT Engineering Manager Respondent 4b: Global Solution Architect Respondent 5b: Global Solution Architect	Workshop over Microsoft Teams meeting (Online)	Initial Recommendations for Capability and Know-How Transfer	March 2022, 2h	Field Notes and Recording
	Data 3, from Validation (Section 6)				

14	Participants: Respondent 1c: Company Decision Maker	Microsoft Teams meeting (Online)	Validation of initial recommendations	March 2022, 2h	Field Notes and Recording

As seen in Table 1, data was collected in three rounds. Data 1 collection helped to understand and map the current PLM Capability fulfillment process. Data 1 collection relied on the analysis of the existing process documents from the case company followed by conducting interviews and a survey with various participants. The interviews were conducted over Microsoft Teams (online) due to covid-19 restrictions. All meetings were recorded for future reference as well as field notes were prepared. The topics focused on how the PLM Capability fulfillment is currently handled in the case company. Each interview was followed by a survey which captured the strengths and weaknesses of the current process along with the suggestions to improve the PLM Capability fulfillment process. As part of the data collection activity in Data 1, several internal documentations were analysed as shown in the below Table 2.

Table 2. Internal documents used in current state analysis

Item #	Name of the document	Description
1	Onboarding self-study on the IT and Digital Development (ITDD) model	A self-study material on the case company IT & Digital development aka value stream development based on role
2	How to get new development initiatives to IT & Digital development portfolio?	Process description explaining how to move the new development needs from business to development portfolio.
3	Story of a capability - a typical flow	Instructions on various stages of the capability fulfillment process in ITDD based value stream team.
4	Handover from development to service operations	Documentation explaining the handover from development to service operations team.

As seen in Table 2, the current state analysis focused on the internal process documents to understand the current capability fulfillment process across the whole organization. All the internal documents were available on the intranet site of the case company.

Data 2 collection focused on co-creating a set of initial recommendations to improve the PLM Capability fulfillment process. Data 2 was also gathered by conducting workshops with key participants. The result from the workshops was confirmed by the workshop participants and reviewed with the IT Engineering manager before being presented to the management team member who was also the final approver of the initial recommendations.

Data 3 collection, the final validation round, was reserved for the company decision maker insights in order to be able to validate the outcome and gain the approval. The recommendations, which was built earlier during Data 2 collection round, was presented to the company decision maker. Upon validation of the recommendations, the decision maker suggested modifications and additions. The initial recommendations were updated to deliver the final outcome of this study - the final recommendations to improve the PLM Capability fulfillment process.

The next section of this study presents the results of Data 1 collection as the findings of the current state analysis of the case company's PLM Capability fulfillment process.

3 Current State Analysis of the PLM Capability Fulfillment Process

This section describes the current state analysis (CSA) of the Product Lifecycle Management (PLM) Capability fulfillment process of the case company and covers the findings from the study into strengths and weaknesses of the current state.

In this section, an overview of the current state analysis is provided along with a visual representation of the process using the Business Process Model and Notation (BPMN 2.0) specification. The detailed process is divided into four different sub-sections: PLM Capability Inception, Validating PLM Capabilities from business, PLM Capability fulfillment through development of existing systems and PLM Capability fulfillment by using a Commercial off-the-shelf (COTS) application.

In the case company, IT & Digital development portfolio (ITDD) team is responsible to fulfil the PLM Capabilities from business and is structured around the customer in the way that six value streams have been identified in the business, each reflecting the steps that are taken to produce value to its external customers, or to a company-internal customer or end user.

At the end of each value stream, there is a customer who understands what should be developed to improve the business in a particular value stream and the IT & digital development team (ITDD) works with business to tell them how the same can be achieved.

In this development model, agile teams are organized into these value streams, with the functional value streams supporting the business capability-oriented ones. Each value stream will have a product owner, and steering group consisting of business stakeholders who guide the prioritization of work in each area.

3.1 Overview of the Current State Analysis

The current way of PLM Capability fulfillment process is well documented in parts and there is ambiguity for majority of the process. Different business areas follow an ad hoc way of initiating their PLM Capabilities and the general observation has been that very few business areas approach the IT & Digital Development (ITDD) team. To better understand the current situation, the current state analysis was performed in three steps:

The first step of data collection relied on the existing documents related to capability fulfillment within IT & Digital development portfolio team. The documents included various templates to assist business with requesting for new capabilities, “How-to” documents to get new development initiatives into IT & Digital development portfolio and a typical flow of new development initiative from start to completion. These documents provided a generic overview for all kinds of business capability needs and lacked Product Lifecycle Management (PLM) Capability fulfillment specific needs.

The second step focused on eight targeted interviews which were performed in order to collect data and analyse the current way of requesting and processing of PLM Capabilities from business. Additionally, an interview was conducted with global solution architect team member to understand the current PLM capability mapping process with existing applications and the ongoing challenges from architecture point of view.

The third and final step included identifying the strengths and weaknesses of the current process by conducting a survey with the eight participants as shown in Table 1 by using Microsoft Forms application. The questionnaire was themed around understanding further the current ways of working and the interviewees were requested to list improvements and their expectations with the to-be process for PLM Capability fulfillment. The survey questionnaire was sent after the interview with all the stakeholders identified for data 1collection.

Finally, all the findings from the above three steps were summarized and analysed and presented in the next sub-section.

3.2 Description and Analysis of the existing process

The existing PLM Capability fulfillment process was not explained thoroughly in any existing documentation and hence there was no up-to-date process visualization. With various data collection methods explained in the previous

section, the PLM Capability fulfillment process was mapped and presented in a visually useful format using the BPMN 2.0 specification.

The visualization of the main process is presented in the below Figure 3. Detailed descriptions and visualizations of the process are explained in the following sub-sections.

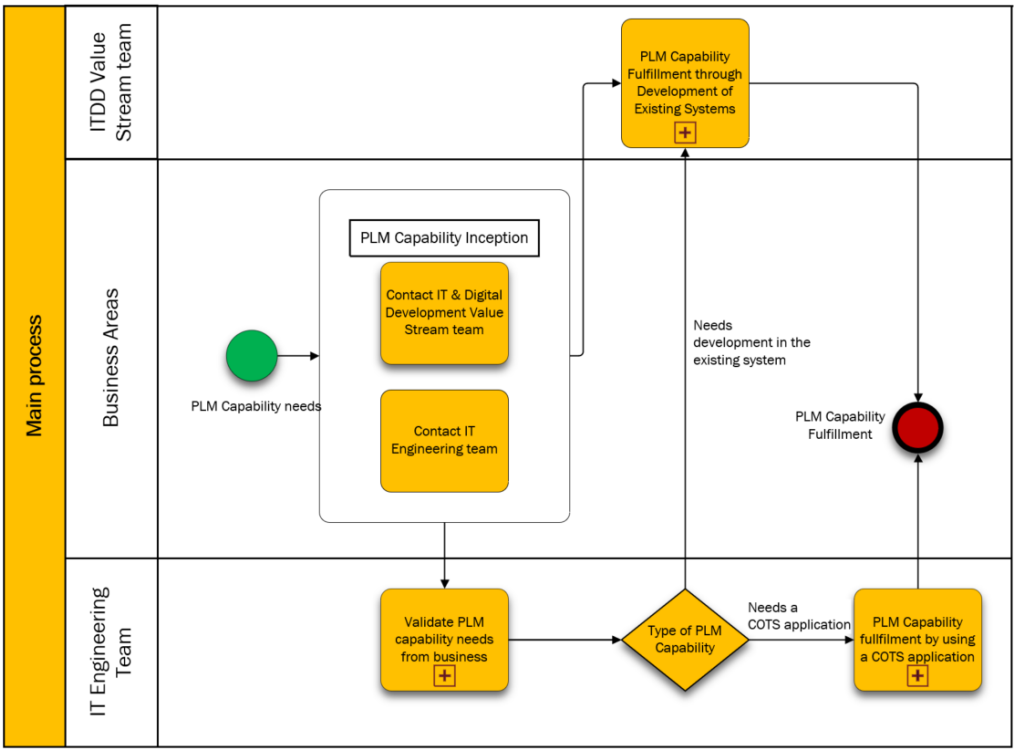

Figure 3. Main process of Current PLM Capability Fulfillment Process

In the Figure 3, the main process is divided into four sub-processes: PLM Capability Inception, Validate PLM Capabilities from business, PLM Capability fulfillment through development of existing systems and PLM Capability fulfillment by using a COTS application. The following sub-sections describe the current state of the PLM Capability Fulfillment process in detail.

3.2.1 The Main Process

Several stakeholders from the interviews highlighted that PLM capability fulfillment is a critical component for the case company's growth as well as for every business area within the case company.

Several stakeholders in the CSA interviews and surveys informed that there is no clear process description available on how, when and whom to contact for new PLM Capabilities that need a COTS application. The interviewees informed that as part of the current process, the IT engineering team or the ITDD defined value stream leads are contacted for support. Very few of the interviewees reported that they contact ITDD based Value stream team for PLM capability that needs a COTS application whereas the majority of them contacted the IT Engineering team directly based on their professional relationship.

Several stakeholders of the CSA interviews and surveys identified that they preferred contacting the IT Engineering team directly and have acknowledged that it has worked well for them even though the process is person dependent. The majority of the interviewees from various business areas confirmed that typically they can find the required information for decision making in co-operation with IT. One of the interviewees summed the situation up as follows:

> Good communication with known contacts and persons. Usually gets straight answers.

One of the fundamental weaknesses reported was the lack of visibility of existing PLM capabilities. The interviewees stated that they generally rely on the knowledge of the IT Engineering team on the existing PLM Capabilities and there was no single system that could provide the complete information. One of the interviewees summed the situation up as follows:

> Need clear visibility of what PLM capabilities exist and who is the "knowledge base" for each application so we can understand how/what is required to fulfil the business needs then a committee of Business and IT heads to review and prioritize investments, development and consolidation of PLM capabilities.

The next set of sub-sections present the sub-processes involved in fulfilling the PLM capabilities and explains the current state in detail.

3.2.2 PLM Capability Inception

PLM Capability inception process is visualized as a sub-process in Figure 4 below. This sub-section starts with the PLM capabilities identified in each of the business area and ends up with contacting the ITDD defined value stream team or the IT Engineering team.

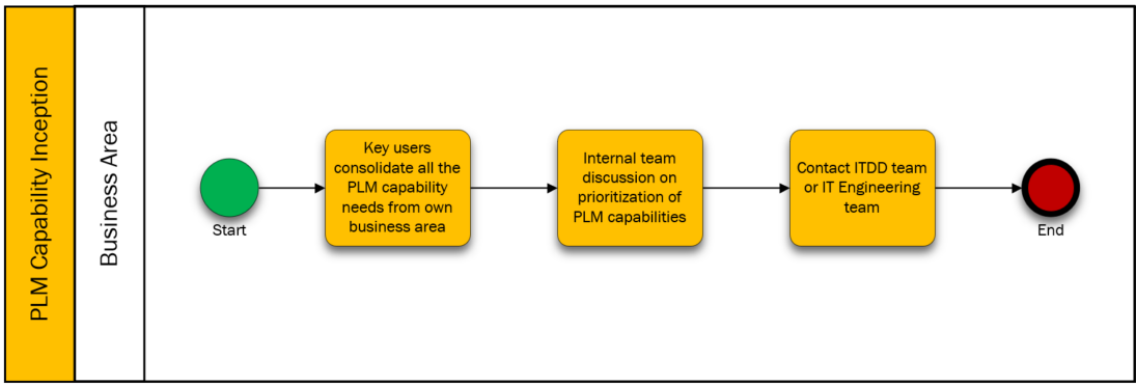

Figure 4. PLM Capability Inception

As shown in Figure 4, the inputs to the process are the PLM Capabilities identified from each business areas. The need for new PLM Capabilities originates from various organization strategy initiatives, team members, different business lines, application vendors, suppliers, system admins and application owners. Some of the criteria fulfilled by these PLM capabilities are: Improve efficiency of the team on a daily basis, Business transformation initiatives linked to organizational strategy or continuous process improvement and new ways of working.

Key users from business areas collect various PLM capabilities from various sources on a periodic basis. The PLM capabilities are reviewed, possible use cases defined, business impact is evaluated and then a decision is made to pursue for further discussion. One of the interviewees commented that the PLM capabilities are taken forward to the concerned teams only if more than ~70% of the team was benefitted by the new PLM Capability.

During the interviews, all key users acknowledged that they categorized PLM capability into two different types based on the fulfillment: The first is the PLM capability that needs development in the existing systems and the second is the PLM capability that needs an application that is available for purchase – Commercial off-the-shelf (COTS) application.

Existing process documentation as well as the stakeholders from the interview confirmed that there is no clear process definition for requesting PLM capabilities that need a COTS application. Furthermore, the stakeholders informed during the interview that the current process of requesting PLM capability fulfillment is unclear and different stakeholders follow different processes. A few stakeholders informed that they contact the ITDD defined values stream team for all types of PLM Capabilities whereas the majority of the stakeholders informed that they contact the IT Engineering team for all of their PLM Capabilities. One of the interviewees summed up the situation as follows:

> I contact the team/person directly who handles Engineering application.

Overall, the current process of PLM capability fulfillment is unoptimized and most often the strategic goals are misinterpreted differently by different business areas as seen in Figure 5 below.

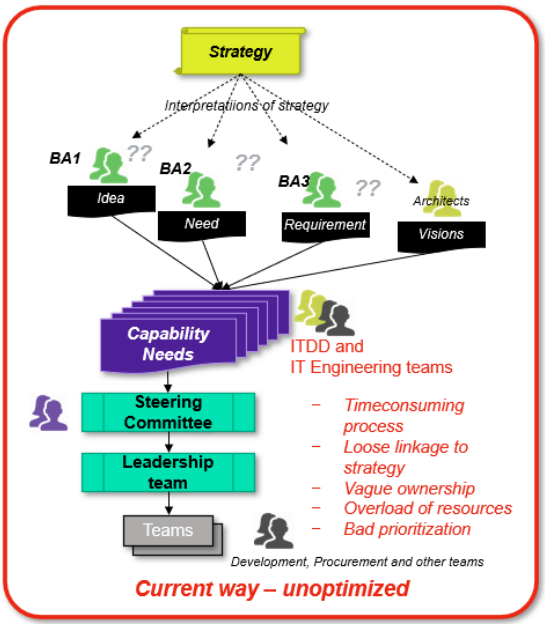

Figure 5. Current Capability Process - Unoptimized from top to bottom

The key challenge from this sub-process was the lack of standard input process to route all types of PLM Capabilities. Furthermore, there was no valid and formal process to initiate PLM Capability requests with the IT Engineering team. This was further visible in the interviews and survey when various stakeholders had different understanding and expectations from the current PLM Capability fulfillment process.

3.2.3 Validate PLM Capabilities from Business

The validation of PLM Capabilities by the IT Engineering team is captured in Figure 6 below. The sub-process continues from the PLM Capability inception process where business areas directly contact the IT Engineering team, and this sub-process ends with the decision on the fulfillment needs and are moved to respective sub-processes.

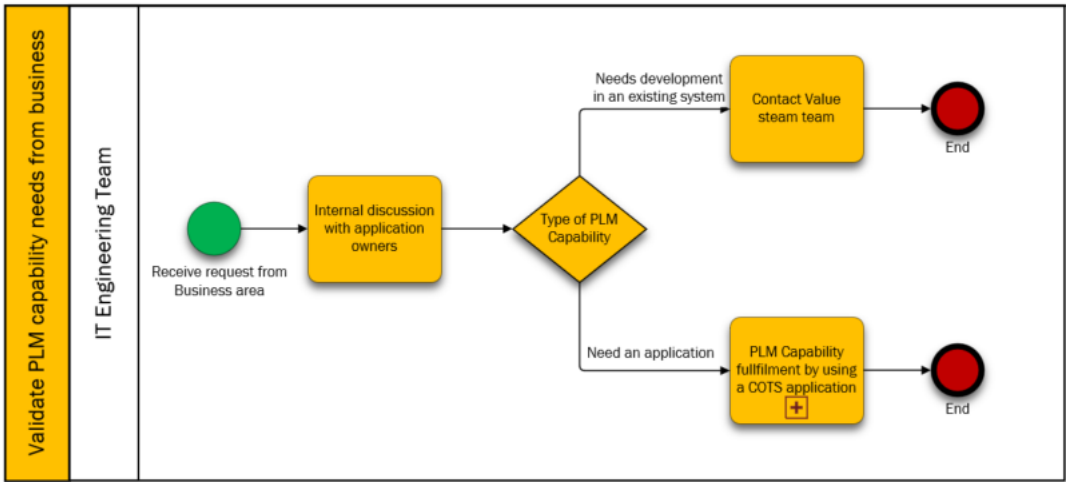

Figure 6. Validate PLM Capabilities from business

Most of the stakeholders in the interviews and survey informed that contacting the IT Engineering team is the preferred choice due to lack of process description to handle different PLM Capabilities. This form of communication is generally informal happening over a Microsoft Teams call, Microsoft teams chat or over emails. One of the biggest challenges with this approach is that the PLM Capability requests are not recorded anywhere and there is no traceability from request to fulfillment. Furthermore, the IT Engineering resource effort is not logged anywhere and makes it difficult to provide right capacity planning for other planned activities.

The interviewees reported in the interviews as well as in the surveys that they trust the professional connection with the IT Engineering team members to discuss their PLM Capabilities and have even acknowledged that the current process is working well and does not need any changes. Furthermore, the interviewees understood that there are person dependencies with this approach, yet they acknowledged that the business areas are ready to wait in case the IT Engineering team members were unavailable for a certain period of time. One of the interviewees summed up the situation as follows:

> Good communication with known contacts and persons. Usually gets straight answers.

All the PLM Capability discussions with the IT Engineering team revealed a need for technical skills and expertise in the engineering domain. The interviewees acknowledged during the interviews as well as in the survey that having key people in the IT Engineering team with good technical skills and understanding of the PLM landscape has helped them to receive a quicker response and assistance in quick decision making to see potential value from the COTS application.

The last major challenge with this sub-process is the availability of the IT Engineering team members and how much of time can be spared to validate each and every PLM Capability request coming from different business areas. The lack of structured communication leads to minimal details specified initially during validation. Hence more than often, further discussions are needed at a later stage to specify all the details to move forward.

3.2.4 PLM Capability Fulfillment through Development of Existing Systems

The PLM Capability fulfillment process through development of existing system is captured as a sub-process in Figure 7 below. The input for this sub-process is either the PLM Capability inception sub-process or the validation of PLM Capabilities by the IT engineering team and the output of this sub-process is the fulfillment of the PLM Capability.

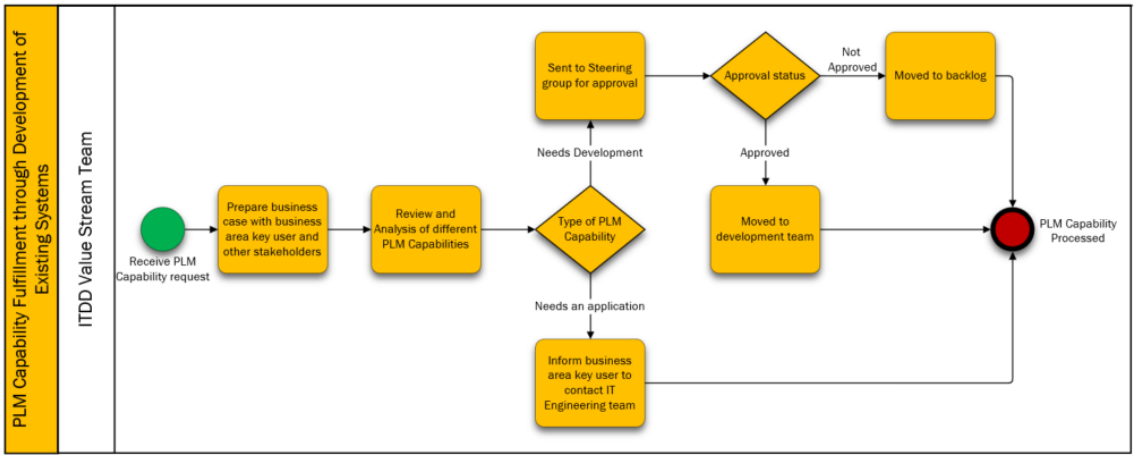

Figure 7. PLM Capability Fulfillment through Development of Existing Systems

As shown in Figure 7, Key users from business areas directly contact the ITDD defined value stream team to discuss about the PLM Capabilities. Also, PLM capability requirements flow from the IT Engineering team post the validation phase. Traditionally, PLM Capabilities that need development in existing systems follow this sub-process. There is a standardized process defined in the ITDD documentation explaining the steps for requesting a PLM capability to the development cycle and is captured in the Figure 8 below.

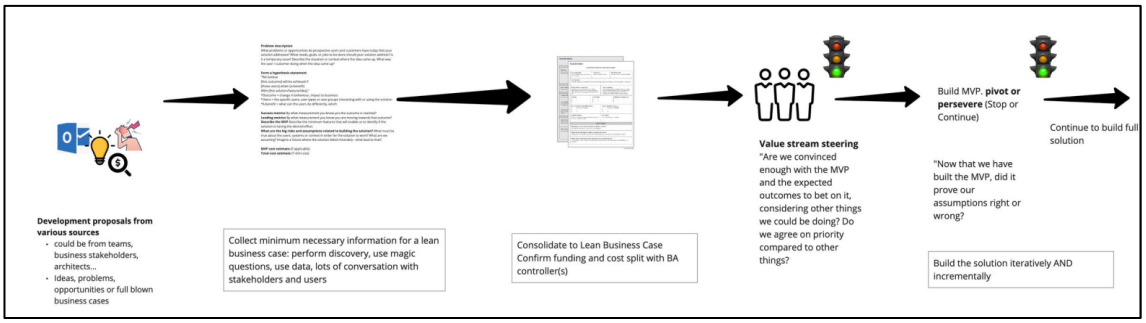

Figure 8. Value Stream development process

Various business capabilities including PLM capabilities are collected, discussed, prioritized and approved by steering committee. The current state of PLM capability fulfillment as per ITDD documentation is defined in three stages: Initiation, Review and Analysis phase and Development and closing. In the initiation stage, all new PLM capability initiatives are sent to value stream leads for further discussion. An initial set of information is collected about the PLM Capability initiative and the activity takes somewhere between 15-30 minutes. The responses to the initial set of questionnaires are used as a potential lean business case text. The completed business case document is processed further for steering group for approval. A lean business case is a document describing a minimum first version to see if an idea might actually work and get measurements and feedback on the result. Then another decision can be made whether to stop or continue iteratively toward the full solution.

In the second stage, the lean business case is reviewed and analysed to understand if the assumed solution is understood well enough. In many a case, a review by the global solution architecture team is performed to ensure the

solution fitment in the overall architecture. Finally, the lean business case is sent for value stream steering group for approval.

In the third and final stage, based on the capacity of the development team, the approved PLM Capability initiatives are pulled from the backlog and moved into development queue. Typically, this activity is performed at the beginning of a new development cycle which is planned four times across a year. Once the development is complete, the value stream steering group is given a presentation about the results achieved.

One of the key observations from the interviews and surveys was that the preparatory work for the planning phase is time consuming and laborious at times for smaller development activities. Another key challenge highlighted by the interviewees was that there is a high volume of PLM Capabilities from different business areas, but the development team have limited capacity. This has led to a huge backlog of PLM Capabilities and a delay in fulfilling business needs. One of the interviewees summed up the situation from their own business area point of view as follows:

> If I write my business case well, lobby the correct people and demand loudly enough in the planning I can get my development need ahead sooner or later.

During the interviews, it was realized that the biggest challenge in this sub-process was that there was no clear process for PLM Capabilities that needed a COTS application. In some cases, the PLM Capabilities were taken as a development activity and in many other cases, it was transferred to the IT Engineering Manager or team members and not tracked further. This has been ascertained from the IT and Digital Development documentation as well and is clearly a pain area for the case company.

3.2.5 PLM Capability fulfillment by using a Commercial off-the-shelf (COTS) application

PLM Capability fulfillment by using a COTS application as a process is shown in the Figure 9. Typically, PLM capability initiatives start from business and the informal process to fulfil PLM capabilities needing an application follows this sub-process. The primary source of input for this sub-process is a direct, informal requests from business areas and validated by IT Engineering team. The other lesser source is the PLM Capabilities that are transferred from value stream teams to IT Engineering team.

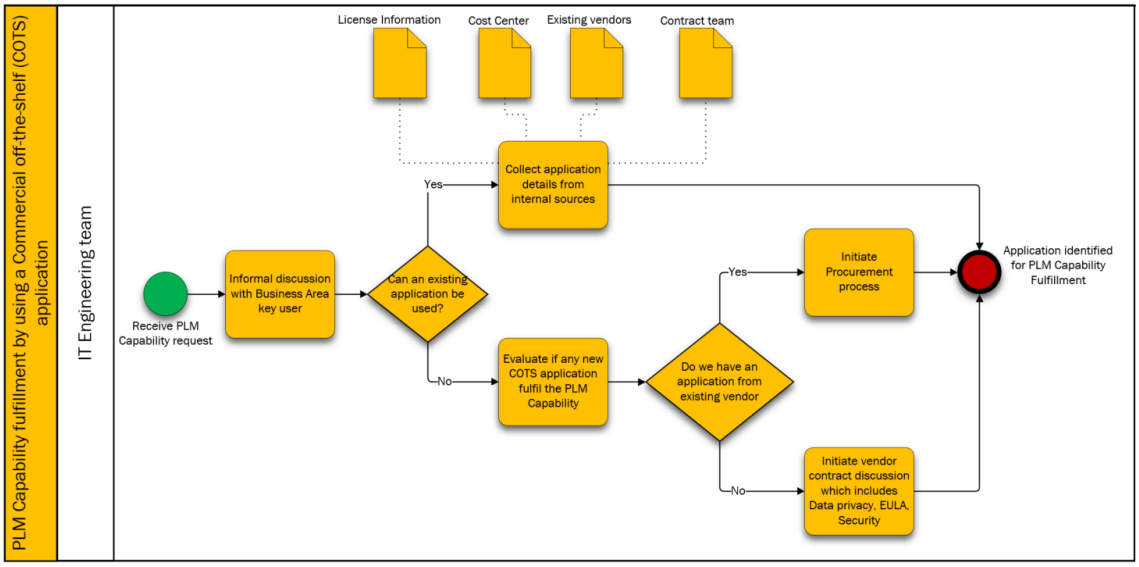

Figure 9. PLM Capability fulfillment by using a Commercial off-the-shelf (COTS) application

The current state of the PLM Capability fulfillment process which needs an application has not been documented in the ITDD documentation. Furthermore, the interviewees have further ascertained during the interviews as well in the surveys that the activity with IT Engineering team is informal, undocumented, difficult to track, yet interviewees were happy with this process of fulfillment. One of the interviewees who is a key user from a business area stated as follows:

> I got good advice, good support and we are quite happy to know that we have this IT engineering team to solve our issue. We do not need more.

During the CSA, it was also understood that the global solution architecture team was not involved in the PLM Capability fulfilment process performed by IT Engineering team. Global solution architecture team guides the business domains towards case company level synergies and re-use of existing solutions and technologies with development roadmaps and target architecture definitions. Global solution architecture team is responsible for capability mapping across organizations and are vital part of the PLM capability fulfillment process. One of the interviewees from the IT Engineering team stated as follows:

> The architecture team is bypassed. They are building the capability model and are mapping the big picture and they should be involved in the process and give the guidance and also to educate themselves about what we have from Engineering.

The next big challenge identified during the CSA of the sub-process was the undocumented effort of resources which included business area key users as well as the IT Engineering team resources. This unaccounted effort spent for PLM Capability fulfillment affected the resource capacity planning for other development activities. Likewise, IT engineering team resources had less capacity to focus and support on the ad-hoc PLM Capability fulfillment request and hence not all requests ended up with proper application decision.

During the stakeholder interviews and through various documentation, it was realized that there was a lack of existing engineering application portfolio which shall typically include critical application information like application name, versions, PLM capability supported, key users of the application, cost of the application, contractual obligations of using the application across location, country or regions and many more. This meant that in principle, the IT Engineering team had a very limited key application information either available locally in excel or emails or then purely known from experience and day-to-day interactions. The outcome was that the IT Engineering resource had to contact various internal team members for full information on various applications fulfilling certain PLM capability. Service manager was contacted for license and support related information whereas vendor and contract management team were contacted for contractual clarification. Similarly, various other IT internal teams

were contacted to collect all vital information for an application. This further resulted in delay in addressing a PLM Capability request and the unaccounted effort increased further.

The output of this sub-process was to identify if an existing application within the PLM landscape can fulfil the PLM Capabilities from business or else identify a potential COTS application from market. For an existing application to be used, IT engineering team had to review the existing contractual obligations and limitations and also work with vendor and internal procurement teams for additional licenses. Additionally, necessary training had to be arranged for the new team members as part of PLM capability fulfillment using an existing COTS application.

The biggest challenge in this sub-process was the tacit knowledge about various engineering applications and the PLM Capability that the application fulfilled lied with the IT engineering team members. IT engineering manager also acknowledged during the interview that his team did have existing application information gained through experience, yet the knowledge was not available explicitly in a tool or a system that is accessible to all users anytime without any need for support. Additionally, capability mapping with the existing application landscape was work in progress and the global solution architecture team has started with the basic PLM Capability mapping but was missing application information like key users, license information, contractual information, cost information and many other important information.

3.3 Summary of the Findings

This subsection presents the strengths and weaknesses identified in the current PLM capability fulfillment process of the case company. In addition, this subsection explains the logic used to organize the strengths and weaknesses into themes to determine the key improvement areas to be discussed in the subsequent sub-section.

The analysis of the existing documentation, interview recordings and the field notes, survey responses, and observations made during the data collection of the current state analysis found that there were similarities among the data collected from different sources. Moreover, the findings from the current state analysis revealed overlapping strengths and weaknesses that could be mapped into specific themes for further analysis. However, these overlapping strengths and weaknesses identified in the current process revealed specific challenges in some of the key areas of the existing process caused either by improper business process management or cross-functionality within the process. From the discussions with the stakeholders and observation, it was evident that addressing the key weaknesses could improve the existing process significantly.

The identified strengths and weaknesses were first collected to an Excel spreadsheet from the field notes and survey responses and were mapped to the various stages of the existing process. Once the data was analysed, the listed strengths and weaknesses were organized based on certain themes to enable further analysis.

Table 3 presents the strengths of the existing PLM Capability fulfillment process of the case company identified from the data collection of the current state analysis.

Table 3. Strengths of the PLM Capability Fulfillment Process

#	Theme	Strengths
1	Organizational Characteristics	PLM capability fulfillment process is recognised to be an important core process for the case company.
2	Organizational Characteristics	A clearly defined and documented process is available for PLM capability fulfillment process which needs development
3	Organizational Characteristics	New application investment is easily done through Regional IT or through application owners.
4	Teams and Coordination	Global solution architecture team are involved for PLM capabilities that are handled by Value Stream teams
5	Teams and Coordination	There is a capability inception structure established in every business area
6	Teams and Coordination	Business area key users informed unanimously during interviews that the current process of contacting IT Engineering team directly is working very well.

As can be seen in Table 3, the first theme that was found to represent several identified strengths was Organizational Characteristics. The case company has established value stream development (ITDD based Value stream teams) which follows the principles of Scaled Agile Framework (SAFe®), a widely recognized development model adopted by many large corporations. The IT & digital development (ITDD) model facilitates the collaboration between IT and the business and provides a systematic way to follow-up on value delivery and for a joint mitigation of issues. The model brings transparency to IT & digital costs and investments and provides a framework for structuring the development initiatives for the size of the case company.

The second theme characterizing the remaining strengths was Teams and Coordination. These strengths were mainly enabled by the strong foundation process set in the case company and the highly experienced IT Engineering

team with a long work history at the case company. Furthermore, the majority of the PLM Capabilities are handled by the IT Engineering team informally due to the professional connections between business and the IT engineering team. One of the interviewees summed the situation up as follows:

> Good communication with known contacts and persons. Usually gets straight answers.

Table 4 presents the weaknesses identified in the existing process based on the data collected. Several weaknesses were identified from the current state analysis and were mapped to the sub processes in which they were identified and then mapped to different themes.

Table 4. Weaknesses of the PLM Capability Fulfillment Process

Weakness #	Process	Theme	Weaknesses
1	Main Process	Business Process Management	Lack of standard and simple way to request for all types of PLM Capabilities.
2		Business Process Management	No clear process description available for all users across organization.
3	Capability Initiation	Business Process Management	No centralized PLM capability requirement management system for all types of business needs.
4		Business Process Management	No valid and formal process to initiate PLM capability requests with IT Engineering team.
5	Validation by IT Engineering team	Business Process Management	Challenges to receive timely support and handling of request when contacting outside value stream team.
6		Business Process Management	Various stakeholders have different understanding and expectations from PLM Capability fulfillment process
7		Business Process Management	Lack of visibility of the entire process from PLM Capability initiation to completion by IT Engineering team.
8	PLM Capability fulfillment by ITDD Value Stream	Prioritization and process optimization	Significant preparatory hours needed to prepare the business case for PLM Capability requests with value stream team.
9		Prioritization and process optimization	Prioritization of PLM capability requests is a big challenge in the current value stream team.
10		Prioritization and process optimization	Huge backlog of PLM Capability requests due to limited capacity of resources.
11		Capability and Know-How Transfer challenges	Unclear process to transfer PLM Capabilities requests from value stream team to IT engineering team.

12	PLM Capability fulfillment by a COTS application	Capability and Know-How Transfer challenges	Tacit knowledge exists with the IT Engineering team members about existing applications and PLM capabilities fulfilled. Existing PLM application portfolio should be available explicitly or codified in a recorded form.
13		Business Process Management	Global solution architecture team is not involved in PLM capability fulfillment process handled by IT Engineering team.
14		Capability and Know-How Transfer challenges	Mapping PLM capabilities to current application environment is work in progress.
15		Capability and Know-How Transfer challenges	Non-availability of request management process makes it difficult to track effort spent by IT Engineering team
16		Business Process Management	Multiple ways of requesting for a PLM capability request makes it difficult to use existing KPIs from the existing PLM capability fulfillment process.
17		Miscellaneous	Process to add a new COTS application to existing application environment is unclear.
18		Miscellaneous	Downstream activities for extending an existing application are complex and time consuming.

As shown in Table 4, three distinctive themes were defined that describe the identified weaknesses in the current PLM Capability fulfillment process of the case company. Additionally, two weaknesses that did not fit into any of the themes were classified as miscellaneous issues as they were not in the scope of this study yet valuable to be addressed outside this study.

The first theme identified was Business Process Management. Nine weaknesses identified from different stages of the main process were included in the theme

which covered issues such as lack of process description for all PLM Capabilities, different stakeholder involvement, foundation process not fulfilling all business needs as well as the risk related to the timely fulfillment of the PLM Capabilities.

The second key theme identified was Capability and Know-How Transfer challenges with four key weaknesses mapped to the theme. As explained in section 3.2.5, the data collected from the current state analysis suggest that improving the interoperability within the process along with the availability of the existing application portfolio mapped to capability has the potential to improve the existing PLM Capability fulfillment process.

The third key theme defined to map identified weaknesses was Prioritization and process optimization. This theme covered issues related to prioritization and process optimization challenges identified in the foundational process. These weaknesses were identified close to the business process management theme and provided a potential to further improve the existing PLM Capability fulfillment process managed with the value stream teams.

To summarize the overall PLM Capability fulfillment process of the case company, it can be described as having a strong foundation, business case driven process with experienced stakeholders performing the required actions with the available capacity.

In the current state, the process has all the necessary elements in place like strong foundation process driven by top management, tools and systems, capacity planning and a certain degree of prioritization. There was no need identified during the current state analysis to introduce a completely new PLM Capability fulfillment process. Similarly, there was no need for changing the nature of the overall process as the benefits of the process were clearly defined and well communicated across the organization. By improving some key elements in different stages of the process, capturing know-how knowledge and addressing the PLM Capabilities that need a COTS application, the existing process would be more effective and deliver value to the business.

The different data sources from the current state analysis highlighted similar shortcomings in the existing process. For example, neither the documentation provided any information, nor the interviewees had any knowledge on how to handle PLM Capability request that need a COTS application, other than contacting the IT Engineering team. Furthermore, the transfer of the PLM capability requests between different team within the process was not working. The case company had challenges with the cross-functionality which is one of the main characteristics of a core organization process. The findings also applied to the lack of explicit application knowledge mapped to the PLM Capability available within the case company which were underlined in the interviews as well as from the survey response.

The fact that some of the weaknesses were widely recognised among various data sources indicated that these themes and the weaknesses should be considered when defining the key improvement areas of this study. The next sub-section presents the identified key improvement areas to be discussed in the following stages of this study and further explains the reasoning behind the selections.

3.4 Key Findings to Elaborate

The following subsection focuses on the key improvement areas identified through the current state analysis utilizing the themes identified while categorizing the weaknesses of the PLM Capability fulfillment process of the case company. The key improvement areas to be studied further were summarized in the below Table 5.

Table 5. Key Improvement Areas to Focus

Weakness #	Theme	Weaknesses	Key Improvement Area
1	Business Process Management	Lack of standard and simple way to request for all types of PLM Capabilities.	Business Process Management
2		No clear process description available for all users across organization.	
4		No valid and formal process to initiate PLM capability requests with IT Engineering team.	
11	Capability and Know-How Transfer challenges	Unclear process to transfer PLM Capability requests from value stream team to IT engineering team.	Capability and Know-How Transfer
12		Tacit knowledge exists with the IT Engineering team members about existing applications and PLM capabilities fulfilled. Existing PLM application portfolio should be available explicitly or codified in a recorded form.	
14		Mapping PLM capabilities to current application environment is work in progress.	

As shown in Table 5, two key improvement areas were defined for this study. The first area to focus was Business Process Management. During the current state analysis, several weaknesses were identified to be related to the management of the existing business process. The key findings from the identified weaknesses

included issues such as lack of process description, lack of process standardization and unclear process to handle all types of PLM Capabilities. Additionally, non-availability of a process owner to design, review and improve the process was one of the key findings. Furthermore, improving the existing fulfillment process which is part of the core operational process within the case company, numerous weaknesses linked to this key improvement area were addressed automatically. By utilizing the existing core process to handle all PLM Capabilities from business in the future, the case company could trace all business requests till fulfillment, extend the tools and systems to manage requirements, include the capacity planning of all resources including the IT Engineering team and improve the overall cross-functionality within the existing PLM capability fulfillment process.

The second key improvement area is Capability and Know-How Transfer. The key findings identified from the weaknesses were lack of application portfolio management, significant tacit knowledge with experienced team members as well as challenges in Business-IT alignment during process design and improvement. Furthermore, it was noted that the Solution Architecture team were mapping PLM capabilities to existing applications in the case company from the business-fit perspective. This activity did not include general characteristics (such as software versions, key users, license type) and certain key attributes (such as cost, dependencies) of applications used in the organization. IT Engineering team members contact various team members internally for many of the general characteristics needed for business discussions. Furthermore, there is a clear lack of process to transfer work between different teams and making it difficult to transfer different types of PLM Capabilities.

The following section covers the literature review of this study based on the identified key improvement areas.

4 Improvement Ideas from Relevant Literature

This section discusses the key improvement areas identified in the previous Section 3 while analysing the current state of the PLM Capability fulfillment process of the case company and formulates it into the conceptual framework for the study. Through a literature review and utilizing existing knowledge, related improvement ideas are gathered for section 5 of the report, which looks at the improvements for addressing the key improvement areas utilizing the conceptual framework. The following subsections 4.1 and 4.2 present the findings of the literature review for each key improvement area as well as the justification of choosing the findings to be consumed in the scope of this study. Subsection 4.3 presents the conceptual framework demonstrating the findings of the literature review for each key improvement area.

4.1 Overview of the Build Core Operational Process

Business Process Management (BPM) is an approach to managing and controlling business transactions between organizations both within and outside of corporations by viewing the processes as transaction flows. This can be achieved by breaking down traditional walls between organizations, sharing information, and combining and connecting their processes. Business Process Management (BPM) should be used to manage the organization's response to drastic environmental changes, which will require (i) changing the traditional vertical communication system usually found in organizations to a horizontal communication system, and (ii) establishing a system which can rapidly and flexibly respond to such changes (Lee et al., 2009).

4.1.1 Process Standardization and Ownership

Hammer and Stanton (1999, 108-118) have observed that process reengineering has enabled companies to operate faster and more efficiently and to use IT more effectively to deliver value to customers. According to them, although many companies have developed their operations to a process-oriented direction, they

have not been able to fully capitalize the possibilities of process management. One of the key challenges of many businesses according to Hammer and Stanton (1999) is that horizontal processes pull people in one direction whereas traditional vertical management systems pull them in another direction. An essential part of process management is to assign a process owner responsible for driving the improvement efforts as well as measuring the performance of the process. Moreover, the process owner should remain active in order to ensure continuous development to meet the requirements of the changing business environment and customer needs. Businesses need to accept that vertical units continue to play essential roles and both horizontal and vertical management structures have to coexist and should work in tandem. (Hammer and Stanton, 1999).

Another finding by Hammer and Stanton (1999) with companies shifting to a process enterprise mindset is whether all units of a business do things the same way, or should they be allowed to tailor their process to their own needs. Process standardization offers many benefits such as:

- Lower overhead costs as the process requires only one owner with one staff, only one set of documentation and training materials, and only one information system.
- Companies with standardized processes presents one face to its suppliers and customers, reducing transaction costs.
- Process standardization can increase organizational flexibility when all business units are performing a process the same way in turn helping companies to easily reassign people from one unit to another to respond to shifts in demand.

Hammer and Stanton (1999) claim that a process enterprise is the organizational form for a world in constant change. In addition, companies should standardize their processes as much as possible without compromising their ability to meet diverse customer needs.

In the analysis stage of this thesis, the lack of process standardization was identified as one of the key weaknesses of the PLM Capability fulfillment process of the case company. Moreover, from the current state analysis, it was evident that there was a need for a dedicated process owner to continuously review the process, identify improvement areas, measure the process and reengineer the process as needed. Therefore, Process standardization to fulfil all PLM Capabilities will offer many benefits of the case company and improve turnaround time and bring transparency.

4.1.2 Process and Enterprise Maturity Model

Many businesses have embraced process management to transform business. According to Hammer (2007), through focusing on, measuring, and redesigning their customer-facing and internal processes, every industry and company of all sizes have achieved significant improvement in cost, quality, speed, profitability, and many other key areas. Hammer (2007) acknowledges that organizing work into processes that run end to end across the enterprise leads to radical improvements in performance, but it is challenging to manage.

According to Hammer (2007), a framework known as the Process and Enterprise Maturity Model (PEMM) was developed after a five-year study in collaboration with a consortium – a group of renowned organizations. The framework is designed to aid decision makers in assessing and to implement changes to processes in the organizations. An important advantage of this model is that it can be applied to any industry and process and can be viewed as a roadmap for process development as the framework does not specify how a particular process should be structured.

To ensure that the business processes are performing well and that the performance is sustainable, Hammer (2007) identified two key group of characteristics that are needed for every business: Process Enablers and Enterprise Capabilities. Process enablers are applicable to individual processes and determine the effectiveness of the process to deliver results over time. On

the other hand, enterprise capabilities are a decisive factor that explains the adaptability within a company to put the enablers in place and support processes. The combination of enablers and capabilities provide an effective way for companies to plan and evaluate process-based transformations. (Hammer, 2007: 112).

The PEMM framework developed by Hammer (2007: 113) includes five process enablers and four enterprise capabilities. By combining these criteria, Hammer (2007) has developed a table with statements that assist companies in assessing both the maturity of their processes (based on the five process enablers) and the maturity of their enterprise (based on the four organizational capabilities). All the enablers and capabilities are divided in 2-4 finely defined components. Process and Enterprise maturity are then evaluated on a scale of 1-4 (P1-P4 for processes, E1-E4 for enterprises) with 1 being the weakest and 4 being the strongest value. The strength of organizational capabilities sets the stage for stronger enablers, and the strength of the enablers determines how mature a process is for the delivery of higher performance over the long run.

Considering the objective of this thesis, the PEMM model would be a very good choice for assessing the current process from the point of view of the five process enablers. Furthermore, evaluating the enterprise maturity based on the four capabilities is significant before reengineering the current process. Overall, the ease of using the PEMM framework and simplicity would provide organizations an imperative to conduct maturity analysis of the existing PLM Capability fulfillment process in the case company.

The detailed PEMM framework by Hammer (2007) is shown in Appendix 3.

4.1.3 Process Owner Roles and Responsibilities

Kohlbacher and Gruenwald (2011) recommend organizations to implement both concepts, process performance measurement and process ownership, in order to reap the benefits of process management. Process design determines the

performance limits of a process, so no process can operate at a higher level than its design permits. Hence, there must be a process owner who has the competence and authority to redesign the process. After conducting a systematic literature review of 100 academic papers and 10 books on BPM, Kjersti (2019) recognised that the objective of process governance is to manage and improve process performance by establishing accountability through structures, metrics, and roles and responsibilities. A critical part of process governance is to appoint process owners who are responsible and accountable for the process. Furthermore, Hammer and Stanton (1999: 111) highlights that a process enterprise differs significantly from a traditional organization because it has process owners. As senior managers with end-to-end responsibility for individual processes, process owners embody a company's commitment to processes.

Process owners typically hold overall responsibility for a process and its results. Some organizations assign them a strategic role or give them considerable authority. Kjersti (2019) summarizes the findings from the PEMM framework developed by Hammer (2007) that process owners are one of five process enablers in the Process and Enterprise Maturity Model framework. Furthermore, Hammer (2007) suggests that the role of process owners can change over time, and its development is connected to the organization's BPM maturity. In the below Figure 10, Kjersti (2019) describes how the role of the process owner advances over four levels of process management maturity across an organization as per the PEMM framework.

Maturity level	The role and responsibilities of process owners
P-1	*Process owners are not formally appointed* At the lowest maturity level, there are no process owners with formal authority. However, an individual or a group may be informally in charge of process improvement (small-scale improvement projects), process documentation, and communication with process employees
P-2	*Process owners are appointed* Process owners are responsible for developing objectives and vision for the process, undertaking process improvement and redesign, and leading a process team. The process owner has some budget control (typically of technology resources)
P-3	*Process work is a priority for process owners* At this maturity level, there is collaboration between process owners. Individual process owners exert some control over personnel assignments, and a higher degree of budget control than at lower maturity levels. Process owners also have control of IT-systems that support process work or process change
P-4	*Process owners are part of the senior management team* At this maturity level, process owners participate in strategy formation for the process and for the organization as a whole, and in not only local, but also interorganizational process improvement. The process owner has full budget control for the process and exerts strong influence over personnel assignments

Notes: Hammer (2007, pp. 116-117)

Figure 10. The advancement of the process owner's role and responsibilities in PEMM (Hammer, 2007) and (Kjersti, 2019)

Figure 10 explains that the role of process owners changes based on the process maturity of the organization. Organizations that follow the PEMM framework as defined in section 4.1.2 can identify the process owner as one of five process enablers and identify the role of process owner based on the process maturity. The lowest level (P-1) states that the process owner is an individual or a group of persons who are informally responsible for process improvement activities. P-2 and P-3 levels are intermediatory level by having an appointed process owner with limited or a higher degree of budget control. In the highest level (P-4), the process owner is part of the senior decision-making body and thus plays a significant role in strategic planning, budgeting, and personnel assignments within the organization.

A process owner might have responsibilities organized across the organization or restricted to a group or region, depending on the organization's size. From various systematic literature study, Kjersti (2019) divided the responsibilities of Process Owner into five different categories: planning and organizing, process performance management, process improvement and innovation, team leadership and stakeholder management and advocacy. Table 6 indicates the responsibilities of the Process Owner (Kjersti, 2019: 1387-1388).

Table 6. Process Owners' Responsibilities

#	Category	Process Owner Key Responsibilities
1	Planning and Organizing	Design the process Define subprocesses and process boundaries using process map Ensure standardization and documentation Advocate compliance with the process Coordinate Activities
2	Process Performance Management	Define performance indicators Monitor and manage process performance
3	Process Improvement and Innovation	Follow the competitive environment, technological progress and changing business needs Process Improvement and Innovation
4	Team Leadership	Lead process team
5	Stakeholder Management and Advocacy	Create process awareness Communicate with stakeholders Collaborate with other process owners and functional managers

One of the key findings of the current state analysis was the non-availability of a dedicated process owner to oversee the existing process and be responsible for assessing the maturity of the existing process, identify process improvements, design and implement the process improvements and coordinate various activities and communicate with all stakeholders. As shown in Table 6, all five process owner responsibilities (Kjersti, 2019: 1387-1388) were found relevant for addressing the key weaknesses of having a process owner with clear role and well-defined responsibility in the case company.

4.2 Capability and Know-How Transfer

The PLM Capability fulfillment process was identified in the CSA to contain weaknesses related to Capability and Know-How Transfer. The first weakness that needs improvement was to define way to transfer requests from value stream team to IT engineering team and to ensure that there was a proper Business-IT alignment framework leveraged to address the weakness. The second area requiring improvement was to capture tacit knowledge and make it available explicitly and build common principles for sharing knowledge across organization. The last weakness requiring improvement was the process to map the existing PLM capabilities to current application environment leveraging an Application Portfolio Management framework.

4.2.1 Application Portfolio Management

Today, many organizations struggle with a heterogeneous and multifaceted application landscape, a result of mergers and acquisitions, rapid growth and a lack of transparency. The complexity of application landscape has led companies to struggle with insufficient support to business processes and increasing application cost. With companies realizing the need to overcome these challenges, the concept of Application Portfolio Management (APM) has gained significance in the last few years. A number of researchers have stressed the importance and necessity of APM and the enormous impacts on business value. (see e.g. Kersten and Verhoef 2003; Caruso 2007 and Bahadur et al. 2006).

Simon et al. (2010) defined Application Portfolio Management as an ongoing and a continuous process to build a view to capture different applications used across organization. The portfolio wide view should include different application information from business and technical perspective including cost, lifecycle, key users, business processes linked to the application and much more. Furthermore, the significance of APM has been tied closely to the concept of Enterprise Architecture process and organizations should approach APM from a holistic viewpoint.

Simon et al. (2010) acknowledged the importance of a strong Application Portfolio to support the business processes across organization and presented an APM framework specifying the following aspects:

- drivers, objectives, and risks of Application Portfolio Management
- the Application Portfolio Management process
- Application Portfolio Management maturity.

From the aspect of key drivers for APM, Simon et al. (2010: 39) explains that organizations that face high portfolio complexity may suffer significant constraints with regard to seeking opportunities to innovate. That is because resources may be heavily allocated to light-on activities, leaving only a small amount of resources available for investing in future capabilities. APM aims at reducing application portfolio complexity through simplification and harmonisation.

The core part of the APM framework is the Application Portfolio Management Process. The APM process developed by Simon et al. (2010) has four phases : Data Collection, Analysis, Decision-Making and Optimization. In the Data Collection phase, all the relevant information about the current state of the application is captured and ensured to be centrally available for access. Simon et al. (2010: 40) explains further that the application inventory should include general characteristics of the application which includes but not limited to, application name, release version, application owner, key capabilities, number of users, vendor and enabled business processes. In addition to the general characteristics, there are few key attributes such as cost, business process support, regulatory compliance relations and dependencies that need to be considered in the application inventory. (Simon et al., 2010: 40-41). In summary, the Data Collection phase includes three levels of understanding of the application portfolio as shown in Figure 11 below.

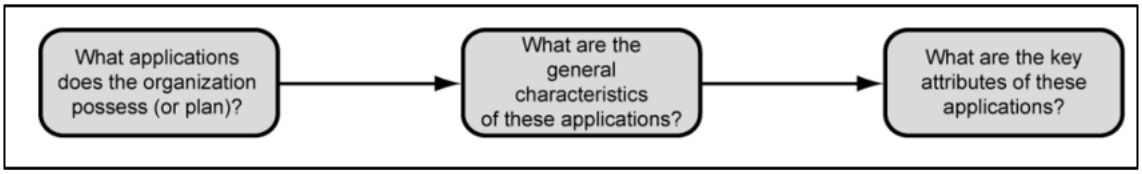

Figure 11. Levels of Application Portfolio Understanding (Simon et al., 2010)

The main deliverable of the Data Collection phase is an accurate application inventory centrally managed that is structured to meet the specific needs of the organization. The rest of the phases are important for the APM process within the framework, but they are out of scope of this study.

The last aspect of the APM framework is the Application Portfolio Management Maturity model. Simon et al. (2010: 44) describes APM maturity model as a measure of how much an organization has institutionalized APM process and define six different levels of maturity along with the validation whether the APM activities are performed once or adopted as a continuous process within the organization.

Considering the objective of this thesis, Application Portfolio Management fits very well for the purpose of building the existing application portfolio with general characteristics and technical attributes. Additionally, the APM framework can be utilized for creating the basic building block of application inventory for the case company and leverage the APM maturity model at a later stage. Having an APM will help the case company in spending less effort on finding the existing application information every time and improve the overall turnaround time for PLM Capabilities that need a COTS application.

4.2.2 Aligning Business and IT

A process redesign or improvement often involves the use of technology to achieve significant performance improvements. The use of information technology (IT) has enabled innovative and efficient processes by removing

limitations of time, place, people, or organizational structure and provides a significant basis for differentiation. Processes and technology can be aligned to achieve these results, but this requires effective collaboration between teams and alignment to the organization goals.

Strnadl (2006) describes a model of a four-layer Process-Driven Architecture (PDA) that can be used as a framework for addressing the alignment of business and IT. The four layers link the IT systems and the various stakeholders and fulfills the goals and objectives of organizational strategy. The four-layer Process-Driven Architecture Model is shown in the below Figure 12.

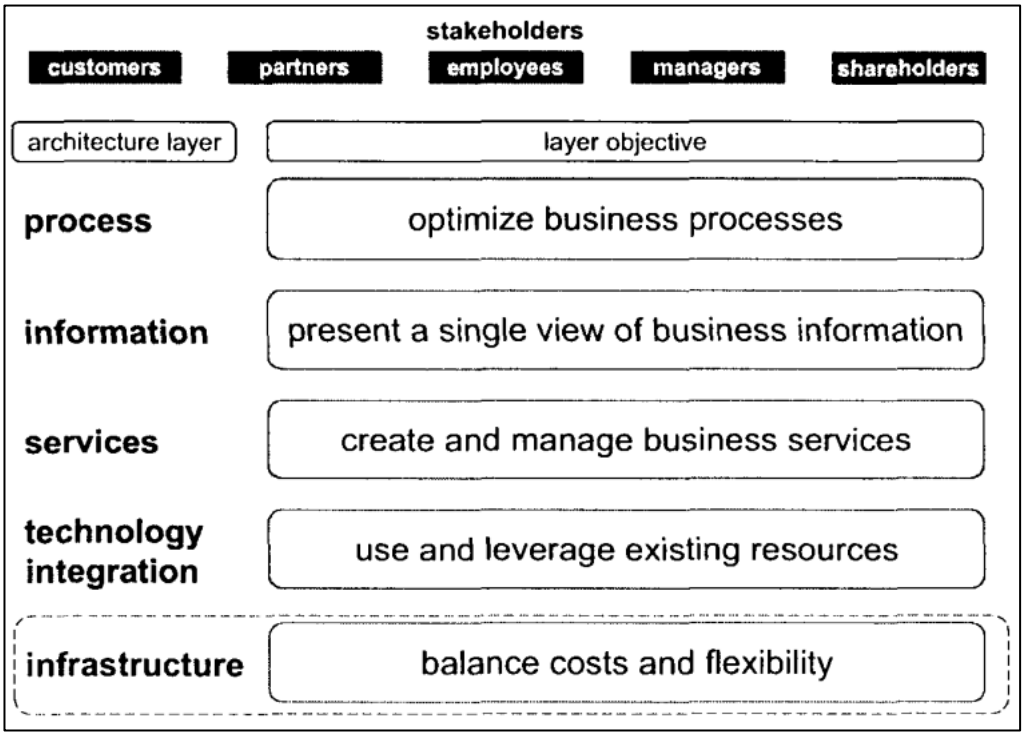

Figure 12. Four Layer Concept of the Process-Driven Architecture Model (Strnadl, 2006)

According to Strnadl (2006), the PDA model can be used to map the current IT and business alignment issues to the four layers as shown in Figure 12. The outcome of the study will help in validating the current state of Business-IT alignment for a process. However, the PDA model can also be used for planning a future mode of operations which either incorporates a new process or re-design an existing one.

As illustrated in Figure 12, the first layer is the Process layer which provides a means for Process Design and modelling, Process Improvements and overall Process Management. The Information layer provides a single view for the information needs from business by collecting information from various applications within the landscape and present the information in a readable form. This layer eliminates the challenges with inconsistent meaning and different semantics of corporate data. The Services layer provides a means to decouple process and activity logic from the actual technical implementations. Generally, Services are well-defined, self-contained functions supplied by an application or module on behalf of another application to fulfil a particular business need. The last layer is the Technology Integration layer where the logic and functions of legacy systems and applications are implemented. Technology Integration layer provides a means to migrate to a service-oriented architecture and process driven architecture for organizations that cannot afford in time, costs, or complexity of undertaking to completely exchange their existing information systems landscape with purely service-oriented applications. (Strnadl , 2006: 67-77).

Strnadl (2006) proposes the four-layer PDA model as a conceptual tool to bridge the divide between business and IT from the perspective of enterprise architecture. By leveraging the Process-Driven Architecture model, the case company can plan to improve the current process while redesigning the process to address one of the identified weaknesses of transferring PLM Capability requests from value stream team to IT engineering team by using existing IT applications.

4.2.3 Lean Knowledge Management

Establishing common principles for sharing knowledge across organization is a key task for a process-oriented organization. Knowledge is described in contemporary business literature as a critical resource for firms seeking to remain competitive in the marketplace. Yet, many organizations struggle to apply lean

approach to knowledge work compared to leaner operations. Staats and Upton (2011) define “Lean” as a combination of many approaches that have been developed to improve operations, all based on the principles of uncompromising attention to detail, data-driven experimentation, and charging workers with the continual task of improving efficiency and eliminating waste from their jobs. According to Staats and Upton (2011), It is possible to articulate and capture in writing a substantial amount of knowledge that is assumed to be tacit if the organization makes the effort to take it out of people's heads. Another benefit of all knowledge work is that many tasks are not related to applying judgement, and they can be streamlined by training employees to find and eliminate waste. Nevertheless, lean principles from operations can be applied in some form to almost all types of knowledge work within an organization and generate significant benefits like faster response times, higher quality, and creativity, lower costs, reduced frustration and drudgery, and greater job satisfaction. (Staats and Upton, 2011: 102).

Staats and Upton (2011) summarizes six key principles for efficient knowledge work by following the lean principles:

- Continually root out all waste - Eliminate waste.
- Strive to make tacit knowledge explicit – Specifying the work clearly.
- Specify how workers should communicate – Structured communications.
- Use the scientific method to solve problems quickly - Address problem quickly and directly.
- Recognize that a lean system is a work in progress - Plan for an incremental journey.
- Have leaders blaze the trail - Engage managers and management.

An overview of the six key principles and the steps to follow the principle is presented in the following Table 7. The contents of Table 7 is a summary of the Lean Knowledge Work Principles as explained by Staats and Upton (2011: 100-110).

Table 7. Lean Knowledge Work Principles (Staats and Upton, 2011: 100-110)

#	Principle	Steps to follow the principle
1	Eliminate waste	• Educate everyone to ask “the five whys” • Encourage all to look for small forms of waste as well • Regular review of job structure and content
2	Specifying the work clearly	• Look for repeatable parts of the process and codify them • Don’t try to specify everything initially, build gradually • Use data to get buy-in from management • Keep studying the work that has been designated as tacit.
3	Structured communications	• Define who should be communicating, how often and what and to whom • Create a shared understanding • Resolve disagreements with facts, not opinions
4	Address problem quickly and directly	• Person who created the problem should fix it • Problem should be solved where they occur • Solve problems as soon as possible after they emerge
5	Plan for an incremental journey	• Codify the lessons learned • Keep looking for new ways to work • Remember that the lean approach is not useful everywhere like experimental projects
6	Engage manager and management	• Project managers and other midlevel leaders must train and motivate their teams • Senior leaders must be long-term champions promoting the knowledge work

In the current state analysis described in section 3, the lack of knowledge transfer was identified as one of the key weaknesses of the PLM Capability Fulfillment

process. Moreover, from the current state analysis, it was evident that there was a need for engagement from senior management to promote knowledge management across teams using the process. Furthermore, a conscious effort was needed to identify opportunities in the existing PLM Capability Fulfillment process to capture tacit knowledge and make it available explicitly. Overall, the case company was missing a structured communication across teams that could provide a clear direction of the future state of knowledge work across the organization as a whole. Hence, the six principles shown in Table 7 by Staats and Upton (2011) was a very good fit for the purpose of identifying areas of knowledge work within the PLM Capability fulfillment process and establish efficient knowledge management in the case company.

4.3 Conceptual Framework

The following subsection presents the conceptual framework of the thesis derived from various literatures. The conceptual framework is derived based on the improvement ideas from existing literature that are relevant to the context of this study to address the business challenge and the identified weaknesses through the current state analysis. Figure 13 illustrates the conceptual framework of this thesis.

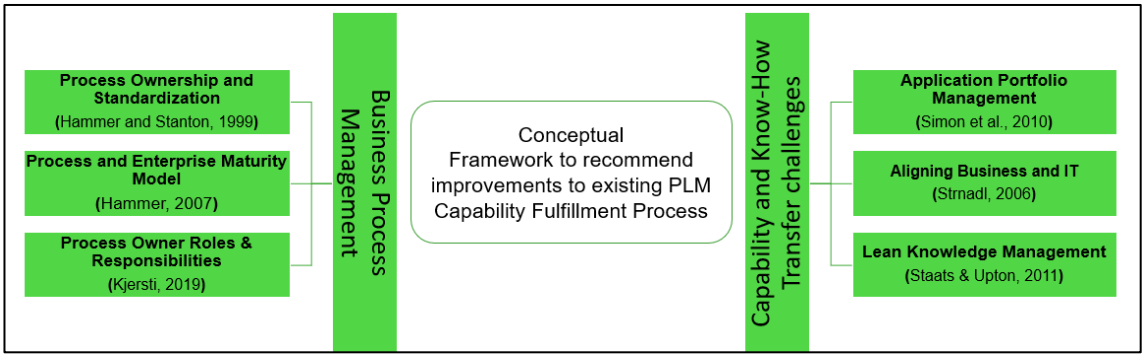

Figure 13. Conceptual Framework of this Thesis

Figure 13 presents the conceptual framework developed for the two key improvement areas identified from current state analysis. Three solutions or ideas from existing literature are presented to handle the identified weaknesses for

each key improvement areas. The business process management element of the conceptual framework consists of the general idea of process ownership and standardization by Hammer and Stanton (1999), the Process and Enterprise Maturity Model (PEMM) by Hammer (2007) to assess the maturity of process and enterprise and the role and responsibilities of a process owner by Kjersti (2019).

For capability and know-how transfer element, the conceptual framework suggests introducing the Application Portfolio Management by Simon et al., (2010) and perform data collection of existing applications. Moreover, Business and IT alignment (Strnadl, 2006) framework known as Process-Driven Architecture is considered in the conceptual framework. Finally, the framework emphasizes on the importance of knowledge management that should be taken into consideration to make tacit knowledge available explicitly based on the principles of Lean Knowledge Management by Staats and Upton (2011).

The following section covers the initial recommendations co-created with key stakeholders based on the conceptual framework to eliminate the weaknesses identified in the current state analysis .

5 Initial Recommendations for Improving Process

This section presents the results of the current state analysis and the conceptual framework of this thesis. The results of the study are combined to form initial recommendations for the studied process that will be validated in the following section. This section begins with an overview of the co-creational proposal building stage and then summarizes the initial recommendations, followed by the recommendation building workshop findings for each key improvement area.

5.1 Overview of the recommendation building stage

Based on the current state analysis, two key improvement areas were identified and selected in the scope of this study. The purpose of the literature review was to identify existing knowledge related to the weaknesses of the key improvement

areas in the process. Therefore, relevant literature findings were used to create the conceptual framework for this thesis. This stage applies the tools and best practices available in existing knowledge to identify and address the issues found in the two previous stages of the thesis. The purpose of the recommendation creation stage was to ensure that all relevant stakeholders were involved in creating the recommendation for improving the PLM Capability fulfillment process.

The initial recommendations were co-created with five stakeholders out of which three of them were part of the Data 1 collection for current state analysis. The key stakeholders providing Data 2 were selected from within the IT team related to the core process based on the discussion with the immediate supervisor of the researcher from the case company. Two workshops were planned to cover two key improvement areas identified from the current state analysis. The first workshop covered the key improvement area – “Business Process Management” and the second workshop covered the key improvement area – “Capability and Know-How Transfer”.

The recommendation building was performed in ten steps. The first step in preparing the first recommendation building workshop was to prepare a set of preliminary ideas on how to approach each key improvement area based on the conceptual framework. In the second step, one-to-one meetings were arranged with all the participants of the first and second workshop to provide an overview of the conceptual framework and a summary of the current state analysis. In the third step, first workshop was scheduled and included the introduction of the preliminary ideas to the participants of the first workshop. In the fourth step, participants were asked to share their comments and feedback and the creation of initial recommendations was done through open discussion and brainstorming between participants. The fifth step was to save the audio recording and transcripts from the Microsoft Team meetings along with the field notes after receiving the needed approvals from all participants ensuring GDPR compliance. In the sixth step, the findings of the first workshop were used to compile the first stage recommendations. In the seventh step, participants in the second

recommendation building workshop were given a similar briefing as in the first workshop which included an introduction of the preliminary ideas and the outcomes of the first workshop were also presented to them in the second workshop. In the eighth step, participants from second workshop were asked to share their comments and feedback and the creation of initial recommendations was done similar to the first workshop. The ninth step was to save the audio recording and transcripts from the Microsoft Team meetings along with the field notes from the second workshop after receiving the needed approvals from all participants ensuring GDPR compliance. The tenth and the last step introduced the first stage recommendations based the findings of the second workshop.

The next subsections summarize and describe the initial recommendations for each key improvement area, which were created during the recommendation building workshop. The findings of the workshops are also presented in the subsequent subsections.

5.2 Initial Recommendations for Business Process Management

The following subsection presents the initial recommendation for Business Process Management. The illustration is followed by a brief description of each recommendation. A more detailed description of the logic and concrete measures for recommendations is provided in the next subsection, as well as the workshop findings. Figure 14 visualizes the initial recommendations for Business Process Management.

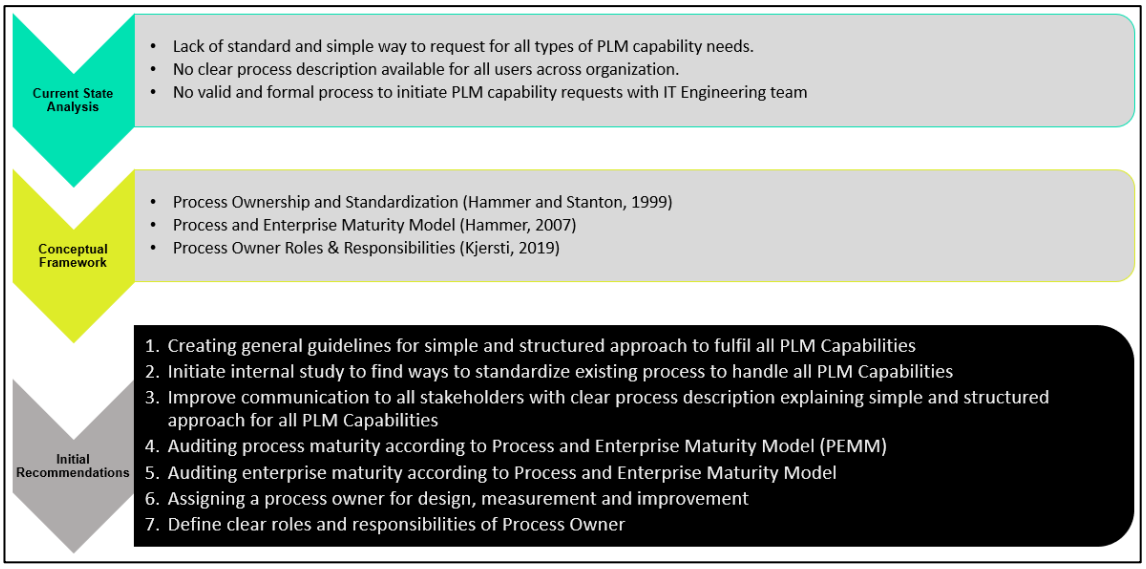

Figure 14. Summary of Initial Recommendations for Business Process Management

As shown in Figure 14, seven initial recommendations for Business Process Management were co-created during the building workshop with the value stream lead and the portfolio manager in the case company. Each recommendation is ranked based on its priority based on the discussion from the workshop. Recommendations 1-3 cover the weaknesses related to the lack of the standard process to request for all PLM Capabilities and non-availability of any process description explaining the process to all business stakeholders. The first recommendation advises to create general guidelines for all business stakeholders to use the existing ITDD based Value Stream process for all PLM Capabilities. This will ensure that the business area key users have one standard process for all PLM Capabilities and do not spend time in classifying each PLM Capabilities and decide where and whom to approach for different PLM Capabilities. The second recommendation advises on a need for an internal study to find ways to redesign existing PLM Capability Fulfillment process to handle all PLM Capabilities and not to address only on the PLM Capabilities that needed development in existing systems. This recommendation had a correlation with one of the initial recommendations from the second key improvement area – “Business-IT alignment” for improved integration between business processes and technology. The third recommendation emphasizes on the need for improved and continuous communication with all stakeholders explaining the change in the

process and how the improved process will help the business. By establishing a standard process for all PLM Capabilities, substantial efficiency gains can be achieved with relatively little effort and by leveraging tools, systems, and training materials that are already available within the core process.

Recommendations 4-7 provides the approach to address the weakness of how to initiate PLM Capabilities with IT Engineering team due to lack of valid and formal process in place. The key findings from the current state analysis were lack of process owner and limited understanding of the maturity of the current PLM Capability Fulfillment process. Recommendations 4 and 5 are related to the Process and Enterprise Maturity Model by Hammer (2007). PEMM framework provides an effective framework for the process owner to determine both the current state of the process as well as the conditions and limitations for the process set forth by the case company. In addition, the PEMM model can be used to determine current and future development goals for the process under study.

In recommendations 6 and 7, it is suggested that a dedicated process owner be assigned to design, measure, and to improve the current PLM Capability Fulfillment process. It is essential to designate a process owner who works closely with different teams to implement the improvements presented in this thesis, as well as to develop the process in the future and address the identified weaknesses which are left outside of this thesis. Furthermore, it is important to clearly define the roles and responsibilities of the process owner to ensure autonomy and ownership to drive process changes.

The following subsection provides further explanations for the recommendations and describes the co-creation during the recommendation building workshop.

5.2.1 Workshop Findings for Business Process Management

During the recommendations building workshop, there was a common understanding regarding the need to bring informal process of contacting IT Engineering team and all relevant activities performed by IT Engineering team

within the ITDD defined value stream process and to avoid any distinctions between different PLM Capabilities. Respondent 1b pointed out the following:

> At value stream level, We should distinguish things into three different baskets – First basket should be big developments topics that needs contractual things and architectural thinking and reviews, second basket should be continuous improvement activities of existing systems such as good new feature, integrations that could be done by existing development team and the third basket could be PLM Capabilities that need COTS applications and should be handled with a simpler business case. This way we can handle all PLM Capabilities within the same ITDD Defined Value Stream process.

During the discussion, both Respondent 1b and 2b agreed that the business should only need to know where to initiate a PLM Capability and the ITDD defined Value Stream process should handle the rest. Furthermore, Respondent 1b mentioned that once a PLM Capability is initiated through the Value Stream process, all relevant information about the PLM Capability should be made available to business. In addition to providing a link to access the PLM Capability from the central requirement management tool, business users should be able to see the progress, delivery schedule, possible delays and any other dependencies. Respondent 2b underlined the importance of identifying all the stakeholders from different business before sending out the communication. Both Respondent 1b and 2b agreed that the stakeholders for communication should not be tied to a person rather it should be tied to the role of the person. This would help in ensuring continuous communication even when the person changes role or leaves organization.

Implementing Initial Improvement Proposals 4 and 5 is a concrete step that will be carried out by the process owner identified within the organization to put the findings of this thesis into practice. Respondent 1b and 2b concurred that auditing the maturity of the process adds depth to findings and will strengthen the existing process further. In the preliminary discussion, auditing the maturity of enterprise was debated in detail and respondent 2b suggested to focus on the process maturity rather than on the enterprise itself owing to size of the case company. However, at the end of the discussion it was mutually agreed by all participants

to include the maturity audit of the enterprise against the existing PLM Capability Fulfillment process. Hence, measuring the current maturity of both process and enterprise as defined in the PEMM framework was accepted to review the current maturity level as well as define the future target for the case company. Respondent 1b had the following opinion on the PEMM model and the need for maturity study:

> I am a big fan of maturity models and really appreciate what maturity models brings to the organization. From PEMM framework, we need to understand the scale where we could be and then discuss with the organization that what is the right level where we want to be and then do a gap analysis. So, we see are we there where we want to be and what do we need to do in order to get there. This is a very relevant tool.

The need for a process owner was understood to be necessary during the proposal building workshops, and all participants agreed that assigning one would have benefits for managing the process development and sharing best practices across teams. Respondent 1b pointed out the following:

> It is a good role and makes lot of sense to have someone as a process owner to own the entire process.

Both the respondents highlighted the importance of process owner to work closely with various stakeholders and lead the process improvement activities. It was considered extremely unlikely that the identified weaknesses could be improved without a dedicated resource and assigned responsibility for the design, measurement and development of the process. Furthermore, Respondent 2b underlined the importance of having a dedicated process owner who can start with one team within ITDD Defined Value Stream process, build the solution and scale to other value stream teams. Both the respondents agreed that assigning a process owner for the entire process with clear responsibilities must be included in the initial recommendations for Business Process Management.

Overall, both the participants agreed that current process needs to be documented well as it adds value and brings clarity across the organization. Furthermore, with the initial recommendations, the participants were confident

that the implementation of the recommendations will make it easier for business to approach Value Stream teams for all PLM Capabilities ensuring transparency and the value stream teams handle the “How” part of the process internally.

5.3 Initial Recommendations for Capability and Know-How Transfer

The following subsection presents the initial recommendations for Capability and Know-How Transfer. A more detailed description of the logic and concrete measures for recommendations is provided in the next subsection, as well as the workshop findings. Figure 15 visualizes the initial recommendations for Capability and Know-How Transfer.

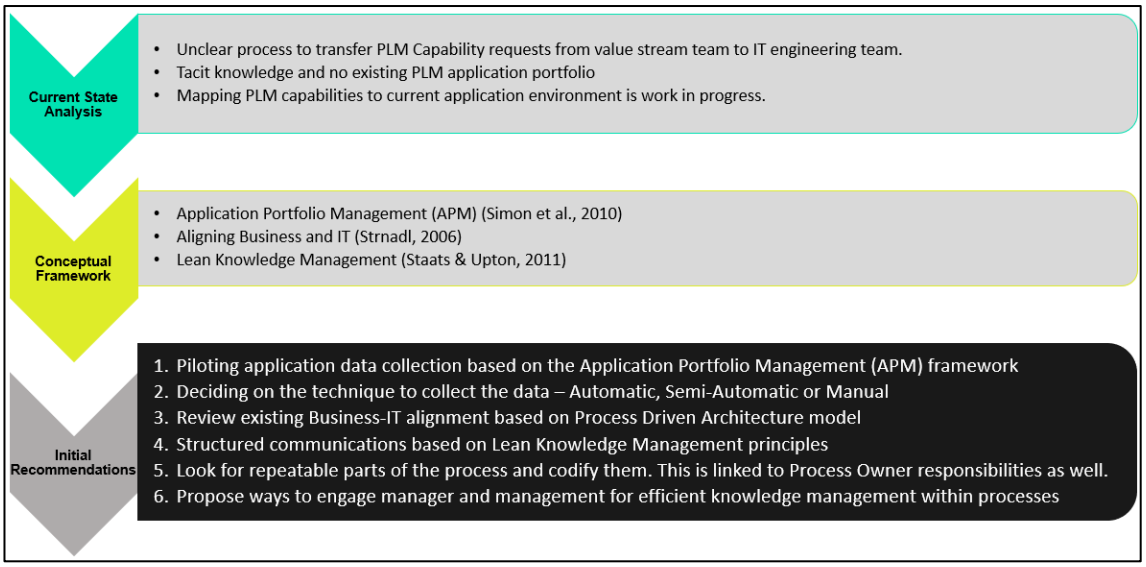

Figure 15. Summary of Initial Recommendations for Capability and Know-How Transfer

As shown in Figure 15, six initial recommendations for Capability and Know-How Transfer were co-created during the building workshop with two global solution architect and IT Engineering manager in the case company. Recommendations 1 and 2 address the lack of application portfolio which maps the existing application portfolio with the PLM Capabilities. It was recommended that the piloting of application data collection needs to be initiated based on the Application Portfolio Management Framework developed by Simon et al. (2010). Moreover, Recommendation 2 advises that a decision is needed on the method

to collect the existing application information which could be either fully automatic, semi-automatic or completely a manual exercise. Significant efficiency can be achieved with the availability of application portfolio with relatively little effort spent on analysing existing applications every time a PLM Capability from business needs analysis of existing application portfolio.

Recommendation 3 advises on leveraging the Process Driven Architecture model proposed by Strnadl (2006). This recommendation is tightly linked to the Recommendation 2 from Section 5.2 emphasizing the need for alignment between business processes and IT architecture. Recommendation 3 addresses the challenge of handling all PLM Capabilities in the existing process and the need for integrations between various IT systems based on the proposed process improvements. It was unanimously agreed that the recommendation 3 will help in breaking down the silo between business process changes and technology layer and will provide a holistic view of the underlying technology architecture available in the organization before implementing any process changes.

Recommendations 4-6 address the weakness of significant tacit knowledge available within processes and non-availability of strong knowledge management principles across the organization. Recommendation 4 and 6 advise the need for engagement of senior management to identify scope of knowledge management within existing process and to provide guidelines to teams to ensure that the knowledge is available explicitly with right tools and systems. In addition, recommendation 5 emphasizes on the need to identify knowledge areas within existing PLM Capability Fulfillment process that could be captured and made available explicitly for larger audience. This recommendation needs significant effort from process owner while measuring the existing process and recommended process changes. Furthermore, it was proposed that the key purpose of effective knowledge management is to eliminate barriers to information flow in order to foster knowledge sharing within organizations. Organizations with successful content-sharing cultures prioritize eliminating barriers to employee knowledge sharing and adjust well to changing business dynamics.

The following subsection provides further explanations for the recommendations and describes the co-creation during the recommendation building workshop for Capability and Know-How Transfer.

5.3.1 Workshop Findings for Capability and Know-How Transfer

The current state analysis highlighted the significant tacit knowledge related to existing applications available within the IT Engineering team. Moreover, the lack of application portfolio was highlighted as a key weakness in the subprocess where IT Engineering team handles application-based PLM Capabilities in the existing PLM Capability Fulfillment process. This challenge characterizes particularly the effort that IT Engineering team spends for every request coming in an informal way and repeating the same PLM Capability assessment against the existing applications due to non-availability of an Application portfolio. Hence the second recommendation workshop turned out to be very productive when discussing the corresponding issues with the key stakeholders responsible for these types of application portfolio management and solution architecture across organization.

During the second workshop, all the participants had a common understanding that all PLM Capabilities should be handled within the ITDD defined value stream process and Value Stream lead plays a significantly larger role to handle all types of requests from business. Furthermore, Respondent 3b suggested that every PLM Capability should be handled through Value Stream process which will enable better visibility of resource capacity and a centralized view for all PLM Capabilities.

Initial recommendations 1 and 2 are concrete tasks in enabling the IT Engineering team to assist businesses in evaluating and making decision on the right COTS application for the requested PLM Capability. Respondent 3b who is representing the IT Engineering team acknowledged that the current way of evaluating existing applications is fragmented and majority of the information is tacit in nature.

Furthermore, Respondent 3b added that a considerable effort is spent in trying to find out application specific information as basic application information is not available in one place for consumption. Respondent 4b and 5b acknowledged that the case company have couple of existing applications to build application portfolio, but it has been a struggle to build the information with those applications. All the participants agreed for a need to build an Application Portfolio with general characteristics of the application such as application name, feature it supports, key users, application owner and brief description about the application that will help business to understand the application better.

Respondent 4b underlined the importance of keeping the cost of the application outside of the Application Portfolio as the cost needs to be looked from a service cost perspective that may include hardware cost, support cost, etc. on top of license cost. The cost topic needs further internal discussion and hence it was agreed by all participants to keep cost outside of the data collection exercise for Application Portfolio Management. Respondent 4b pointed out the following:

> As per the top management guidelines, we need to look at the total cost of ownership and not on a single license cost.

Respondent 5b informed that the data collection for the Application Portfolio needs to be done manually even though the case company has different discovery tools in place to collect various application data. In the existing discovery tools, there is a need for proper configuration to capture the needed information and it needs further deliberation within various teams. All the participants agreed to start the data collection manually for all the PLM applications available in the case company based on the APM Framework developed by Simon et al. (2010).

Recommendation 3 underlined the need for a framework to integrate technology layer to the requirement before implementing any process improvements. All participants agreed that there were no guidelines nor any framework in the case company which integrates business processes and technology right from the requirement stage. Respondent 3b pointed out the following:

> We are not yet a process-driven company. The challenge comes from the two legacy companies bringing in their own challenges.

All the participants acknowledged that the process changes are decided separately and then the implementation with tools and systems are considered later during the actual implementation. Respondent 4b provided a very good example analysis on the maturity of organizations based on the Business-IT alignment. We can take a standard process based on literature and it becomes level zero and with some improvements we can reach somewhere between level 1 and level 2. Organizations that look to develop tools, data and integrations for any process change is above level three. Respondent 4b concluded that the case company is somewhere between level 1 and 2 and hence need a strong framework like Process driven Architecture model developed by Strnadl (2006) to bring alignment between business process and IT.

Initial recommendations 4-6 emphasizes the importance of knowledge management within the process as well as across organization. All the participants were presented with the six principles of lean knowledge management by Staats & Upton (2011), and it was agreed to include three key principles as part of the initial recommendations for the improvement of existing PLM Capability Fulfilment process. One of the key areas in the existing process that was identified as a repeatable part in the process and could be codified was the business case preparation and significant preparatory hours spent by business to prepare the business case was identified as one of the weaknesses during the current state analysis. The participants suggested moving away from traditional presentations to a pre-filled business case form which needs limited inputs from business area key users and available in an online version for easy submission. Respondent 5b summed up with the following statement:

> It sounds reasonable to focus on the 3 key principles and enable knowledge management within existing process with structured communication and engagement from senior management.

The initial recommendations from the two workshops were summarized and presented to the relevant case company decision maker for their feedback. The

findings and outcome of the validation of the recommendations are presented in the next section.

6 Validation of the Initial Recommendations

This section presents the results and adjustments made to the initial recommendations based on feedback received from the company decision maker of the case company during the proposal validation workshop. A summary of the recommendation validation stage is followed by the description of the final recommendations for each of the key improvement areas defined in the current state analysis. Moreover, the feedback is summarized to explain the reasoning behind the final recommendations. The final recommendations are followed by the description of the validation feedback. This section concludes by discussing the adjustments to the initial recommendations.

6.1 Overview of the Recommendations Validation

The validation of the initial recommendations was performed by presenting the initial recommendations to the company decision maker who happened to be the owner of the entire ITDD defined Value Stream process in the case company. The workshop was conducted as a Microsoft Teams meeting and the aim was to evaluate the implementation potential and effectiveness of the initial recommendations. The executive feedback was then taken into consideration to propose the final recommendations to reach the objective of this thesis -To recommend improvements to the existing PLM Capability Fulfillment process.

First, the recommendation validation workshop participant was presented with an overview of the study starting from the business challenge, objective and outcome of this thesis followed by a brief overview of the research design and data plan. The outcome of the current state analysis along with the identified strengths and weaknesses as well as the key improvement areas were covered in detail. Next, the company executive was shown the conceptual framework created from literature review followed by explaining the approach of co-creating

the initial recommendations for each key improvement area. The initial recommendations for both key improvement areas were explained in detail and allowing the executive to provide feedback on each recommendation. The feedback was captured in the field notes and the recording was stored. Based on the recording and field notes, the initial recommendations were adjusted to prepare the final recommendations for the PLM Capability Fulfillment process of the case company. The next subsection presents the final recommendations to improve the existing PLM Capability Fulfillment process of the case company.

6.2 Summary of the Final Recommendations

The final recommendations for the process improvements based on the two key improvement area defined during the current state analysis are presented in Table 8.

Table 8. Summary of the final recommendations

Key Improvement Area	#	Final Recommendations
Business Process Management (BPM)	1_{BPM}	Identify the key contacts from all business areas for efficient communication
	2_{BPM}	Creating general guidelines for simple and structured approach to fulfil all PLM Capabilities, including all the contacts from the core process
	$2a_{BPM}$	Improve communication to all stakeholders with clear process description explaining simple and structured approach for all PLM Capabilities
	3_{BPM}	Assigning a process owner for design, measurement and improvement
	4_{BPM}	Define clear roles and responsibilities of Process Owner
	5_{BPM}	Auditing process maturity according to Process and Enterprise Maturity Model
	6_{BPM}	Auditing enterprise maturity according to Process and Enterprise Maturity Model
Capability and Know-How Transfer (CKT)	1_{CKT}	Piloting application data collection (in excel) based on the Application Portfolio Management Framework.
	2_{CKT}	Deciding on the technique to collect the data – Automatic, Semi-Automatic or Manual
	3_{CKT}	Review existing Business-IT alignment based on Process Driven Architecture model
	4_{CKT}	Structured communications based on Lean Knowledge Management principles
	5_{CKT}	Look for repeatable parts of the process and codify them. This is key for changing business dynamics like resource movements, application landscape changes, development and many others
	6_{CKT}	Propose ways to engage manager and management for efficient knowledge management with a future state communication

As shown in Table 8, the recommendations were adjusted only in seven items along with changes related to the prioritization when comparing the initial recommendations found in section 5 and the final recommendations. The changes included removing one recommendation, adding a new recommendation, modifying four recommendations and moving an existing recommendation as a sub recommendation. All the changes excluding prioritization are shown in Table 9.

Table 9. Changes made to the initial recommendations

Key Improvement Area	Initial Recommendation	Final Recommendation	Change Type
Business Process Management		Identify the key contacts from all business areas for efficient communication (1BPM)	New
	Creating general guidelines for simple and structured approach to fulfil all PLM Capabilities	Creating general guidelines for simple and structured approach to fulfil all PLM Capabilities, including all the contacts from the core process (2BPM)	Modified
	Improve communication to all stakeholders with clear process description explaining simple and structured approach for all PLM Capabilities	Improve communication to all stakeholders with clear process description explaining simple and structured approach for all PLM Capabilities (2aBPM)	Moved as sub recommendation
	Initiate internal study to find ways to standardize existing process to handle all PLM Capabilities	~~Initiate internal study to find ways to standardize existing process to handle all PLM Capabilities~~	Removed
Capability and Know-How Transfer	Piloting application data collection based on the Application Portfolio Management (APM) framework	Piloting application data collection (in excel) based on the Application Portfolio Management Framework. (1CKT)	Modified
	Look for repeatable parts of the process and codify them. This is linked to Process Owner responsibilities as well.	Look for repeatable parts of the process and codify them. This is key for changing business dynamics like resource movements, application landscape changes, development and many others (5CKT)	Modified

	Propose ways to engage manager and management for efficient knowledge management within processes	Propose ways to engage manager and management for efficient knowledge management with a future state communication (6CKT)	Modified

As shown in Table 9

Table 9, the first change is related to adding a new recommendation to Identify the key contacts from all business areas for efficient communication (1_{BPM}). The recommendation was added to acknowledge the need to collect all the stakeholder information as a key foundation activity before implementing any other recommendation. The second recommendation in Table 9 is also from the Business Process Management category. The recommendation included addition of contact details of personnel involved in the existing PLM Capability Fulfillment process to the general guidelines to allow business area key users to contact the right personnel and to remove any ambiguity during the project initiation stage.

The third adjustment to the initial recommendations was to move the recommendation as a sub-recommendation to previous recommendation. The reasoning behind this change was to emphasize that the communication to all stakeholders can be improved only when the first two recommendations (1_{BPM} and 2_{BPM}) are implemented successfully. The fourth and the last change in Business Process Management category was the deletion of recommendation related to initiating internal study since this recommendation will be an outcome of existing process audit to measure maturity by an appointed process owner.

The fifth adjustment to the initial recommendation was made in the Capability and Know-How Transfer category related to piloting application data collection. The recommendation was changed to pilot the application data collection process in excel before making a decision to use one of the existing tools available within case company. The sixth adjustment to the initial recommendation was to

emphasize the need for identifying repeatable parts in a process to help the case company during the changing business dynamics such as resource movement, application landscape changes, development activities. The seventh and the final recommendation adjustment was done to add a future state of knowledge management in the communication where the senior management engages with teams to promote knowledge management across teams and processes.

The next subsection summarizes the feedback received in the recommendation validation workshop with the company decision maker and describes the logic behind finalizing the improvement recommendations based on it.

6.3 Feedback Received from the Initial Recommendations

The overall feedback received during the validation of initial recommendations was highly positive. A number of compliments were received on the introduction to the study and on the work till date. Moreover, the recommendation coverage of the whole process was considered a benefit, as was the importance of the study. The company decision maker pointed out the following:

> This study has been useful and thanks for doing the work. The study has brought in suggestions that will help you as well as others to work together to improve the overall process.

The structure of having a general guideline for all business users across organization was discussed in detail. Preparation of a general guideline to inform users of a unified, simple, and standard process to handle all PLM Capabilities was highlighted as a key factor for success of the process improvement. The company decision maker emphasized the need of general guideline before performing any communication with business and pointed out the following:

> Doing guideline and communicating is two different things. Without guidelines, there is no room for proper communication with business. Communication is the next activity once the guideline is available.

Furthermore, a recommendation to identify all key users from different business area (1_{BPM}) was discussed. The company decision maker emphasized that a key

pre-requisite for effective communication is to prepare the list of key users across all business areas and department. Therefore, the recommendation was added with the highest priority in the final recommendations. Similarly, the discussion to have the list of contacts from the ITDD defined value stream process was discussed multiple times during the workshop. The company decision maker suggested that the existing recommendation to prepare guidelines should be modified to include the contact details of stakeholders within the existing process to eliminate any challenges to business users to find the right contacts.

During the recommendation validation workshop, the recommendation of process ownership was covered in detail. Initial recommendation to assign a process owner for the studied process was presented to the company decision maker, who acknowledged the benefits but emphasized to change the order of priority. The discussion around process owner was characterized by the need to have a role within the organization who can lead the process improvements along with the communication and process maturity assessment.

The proposal to assess the process and enterprise maturity based on Process and Enterprise Maturity Model (PEMM) by Hammer (2007) was received positively and was regarded as a potential tool to measure the current maturity of the process and provide the case company with a direction for future maturity level to achieve. The company decision maker pointed out the following:

> The audit of the maturity of the current process will help us to identify how we can get to the next level of maturity.

The company decision maker suggested that the recommendation to initiate an internal study to standardize the current process can be removed as the outcome of the process maturity assessment would be the initiation of internal study to standardize the existing process for possible gaps and will be owned by an appointed process owner.

The recommendation to pilot the application data collection was discussed briefly as the company decision maker acknowledged the availability of two different

tools (tool XX and tool YY) within the organization and the challenges in utilizing them for building future application portfolio. The tool XX will provide application portfolio view from an IT perspective whereas tool YY will provide an overview from business perspective. Therefore, company decision maker suggested to pilot the data collection in a Microsoft excel file and then transfer the data to one of the existing tools identified within the organization at a later stage.

A recommendation concerning the review of existing Business-IT alignment based on Process Driven Architecture model initiated a brief discussion. The company decision maker acknowledged the current challenge of process and IT frameworks working in silo and the lack of any alignment model to bridge the gap between Business Process and IT. The company decision maker suggested to discuss the recommendation of utilizing process driven architecture defined by Strnadl (2006) with the head of architecture team. On the Business-IT alignment, the company decision maker pointed out the following:

> For this recommendation, I do not have any further opinion. This needs to be discussed with the head of architecture team and should seek their opinion to leverage the process driven architecture.

The final set of recommendations on lean knowledge management were discussed in great detail. During the discussion, the fundamentals of the knowledge management was discussed in depth and the six principles of lean knowledge management by Staats & Upton (2011) were discussed to understand the principles that will help the case company. The case company decision maker commented the following during the discussion:

> I was looking at the list of recommendations and they are all very valid points.

The company decision maker suggested that the six principles as a theory is good but there is a need to define future state within the case company so that senior management can get involved and motivate the teams for knowledge management. The company decision maker summed up the following on motivation:

> We start from unclear process and end with transfer into a PLM Capability Fulfillment process and that is our motivation. Building application portfolio is part of knowledge management and the motivation is already there to define a simple and standard process for all PLM Capabilities.

When evaluating the recommendation to identify repeatable parts within existing process to capture process, the company executive suggested to identify the most used processes and then optimize those with the lean knowledge management principles to derive maximum benefit. The executive summed up with the following:

> Let us assume that as per pareto analysis, it takes 20% of different parts of existing process to create 80% of the work and we identify those most used processes and then target them. There is no organization where you can standardize everything, then it becomes very rigid.

During the validation meeting, the fundamentals of the existing PLM Capability Fulfillment process were carefully discussed, and it was acknowledged that the current set of tools, systems, user guides and training materials should be extended with any process improvements. The company decision maker emphasized the need to start with preparing the general guidelines for business on priority as it emphasizes a simple and standard process for all PLM Capabilities. The company decision maker summarized where to begin improving the process:

> In my mind, whatever we do, the thing that counts is how business sees you and whether we are able to serve them better or worse. They are sort of the final advocates to decide whether we succeed or not. It is important thing that business knows how they should interact and whom should they contact and that is more important than anything else.

The next section of the study summarizes the work, recommends the next steps towards the implementation of the improvements and provides a self-evaluation of the study.

7 Conclusions

This final section of the study presents an executive summary of the results of this thesis, recommendations for the practical next steps in a form of an implementation plan, followed by a self-evaluation of this thesis and finally the closing words.

7.1 Executive Summary

The objective of this thesis was to recommend improvements for the PLM Capability Fulfillment process of the case company. PLM Capability Fulfillment process is identified as an important core process to address the rapidly changing business environment within and outside the case company. The case company has gone through a significant transition post the merger between two different companies and the business has increased the focus on PLM Capability Fulfillment with a simple and standard process. Moreover, it was assumed that the existing PLM Capability Fulfillment process had room for improvement to handle all PLM Capabilities which must be investigated further. The outcome of the study is the recommendations to improve the process and propose ways to resolve the issues identified during the current state analysis of the existing process.

This thesis included four stages. First, the current state of the process was analysed by utilizing various data collection methods such as interviews, survey and reviewing existing documentation. The outcome of this exercise was a process map including the identification of strengths and weaknesses of the process. Second, a literature review was done based on the findings from first stage and a conceptual framework was compiled from the relevant existing knowledge. Third, two workshops were organized with key stakeholders to co-create the initial recommendations to improve the existing PLM Capability Fulfillment process. In the fourth and the final stage, a validation workshop of the initial recommendations was done with the company decision maker to produce

the outcome of this thesis which are the final recommendations to improve the PLM Capability Fulfillment process.

The current state analysis uncovered a comprehensive set of strengths and weaknesses of the PLM Capability Fulfillment process. Based on characteristics and areas of occurrence, findings were categorized into themes. When choosing the key improvement areas to be elaborated in the context of this thesis, the identified weaknesses were evaluated based on the urgency and impact, as well as their potential for developing the process and the possibility to address other dependent weaknesses. Business Process Management and Capability and Know-How Transfer were the two key improvement areas identified for improvement in the scope of this thesis. Furthermore, a process mapping was done based on BPMN 2.0 specification to capture the current state analysis findings. The literature review was focused on these two key improvement areas.

A preliminary set of improvement ideas were prepared by combining the findings of the current state analysis and the conceptual framework based on the literature review. Two workshops were held during which the initial recommendations were co-created along with five key stakeholders. The outcome of the initial recommendations building workshops included seven recommendations to improve the business process management key improvement area and six recommendations to improve the capability and know-how transfer key improvement area.

The initial recommendations were presented to the case company decision maker in order to receive feedback and to make necessary adjustments to the initial recommendations. The purpose of the evaluation was to validate the recommendations and evaluate their potential for implementation. Valuable insights and comments were received that included one additional recommendation, removal of one recommendation and some minor additions to five existing recommendations. It was decided to focus with top priority on the creation of general guidelines for all business areas which was expected to bring significant tangible benefits before moving forward with other changes within the

existing process. The outcome of the validation workshop of the recommendations is the set of final recommendations presented in the section 6.2 of this thesis.

The final recommendations provide a comprehensive set of recommendations to improve the important PLM Capability Fulfillment process of the case company. By improving the process which impacts all business areas and support functions, all businesses are allowed to utilize one simple and standard process for all their PLM Capabilities without spending time on deciding the right process or the right contacts within the case company. Improvement of the PLM Capability Fulfillment process benefits all the support functions, business units and eventually the customers related to the case company through faster, efficient and transparent PLM Capability Fulfillment process.

The next subsection provides the recommendations for an implementation plan and allows the continuous improvement of the process.

7.2 Recommendations for an implementation plan

This subsection describes the actions that need to be carried out at the case company to implement the recommendations outside of this thesis. The scope of this study is limited to identify key elements of the process to improve, and to recommend improvements to address them. Therefore, it is important to also provide recommendations as to how to move forward. The recommendations come from the final recommendations presented in section 6.2 and the planned schedule presented in Figure 16. The planned timetable for the proposed actions to implement the recommendations is shown in Figure 16.

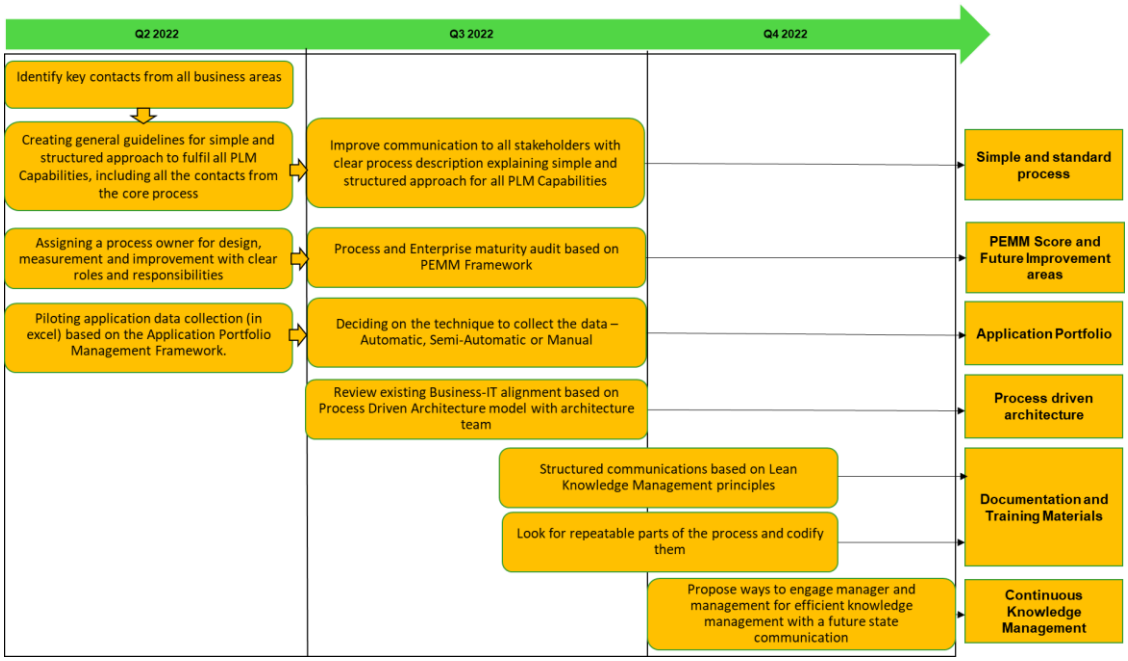

Figure 16. Planned schedule for recommended actions

The first quarter includes high impact recommendation implementation that includes creating general guidelines for all business areas, appoint a dedicated process owner with clear role and responsibilities and pilot application data collection for setting up the foundation for application portfolio management in the case company. The Process and Enterprise maturity assessment based on PEMM Framework as well as knowledge management initiatives within the organization can be initiated only after the assignment of a process owner who can take ownership of the activities. Additionally, the findings of the current state analysis as well as the workshops for building and validating recommendations were taken into consideration when developing the recommended next steps. The outcome of each recommendation is presented in the Figure 16. The following list summarizes the four recommended next steps sequentially by taking into consideration the general recommendations outlined during the validation stage and is followed by textual explanations.

- Implementing the final recommendations according to the roadmap.
- Ensuring the continuity of developing the key improvement areas further by
    - Piloting with one value stream team in the core process and then extend to other value stream teams.

    - Expand to other application areas (Non-PLM) as these are common challenges.
    - Documentation – Important but should not be too much effort spent activity and need to be careful as excessive documentation leads to difficulties to organize and utilize documentations.
- Assessment of existing tools (tool XX and tool YY) for application portfolio management to be done for full implementation of application portfolio management across the organization.
- Initiate discussion with global solution architecture team to study and implement the process driven architecture by Strnadl (2006).

The first recommended step is to implement the outcome of this thesis - the final recommendations based on two key improvement areas in a span of three-quarter timeframe provided in the Figure 16. The general recommendation from the recommendation validation stage was to limit the piloting to one value stream within the process and track the progress for further improvement before expanding the improvements to all value stream teams. Hence, step two discusses the importance of monitoring the progress of the process and taking appropriate actions in order to improve the key weaknesses of the PLM Capability Fulfillment process in the case company. Step three emphasizes the need for a separate assessment to evaluate existing tools for full implementation of Application Portfolio across the organization and ensuring that the application portfolio is available as a menu to access for all users across the organization. As a fourth and last step, a separate discussion is to be initiated between the portfolio management team and the architecture team to study and implement the process driven architecture model within the case company.

Table 10 includes a plan for responsibilities and deliverables to be created as an outcome of the proposed activities. Majority of the final recommendations need a dedicated process owner to lead the activity.

Table 10. Resources needed for the proposed actions and deliverables to be created

#	Final Recommendations	Resources Needed	Deliverables
1BPM	Identify the key contacts from all business areas for efficient communication	Portfolio Management team	Centrally maintained contact list
2BPM	Creating general guidelines for simple and structured approach to fulfil all PLM Capabilities, including all the contacts from the core process	Portfolio Management team	Updated and approved guideline
2aBPM	Improve communication to all stakeholders with clear process description explaining simple and structured approach for all PLM Capabilities	Portfolio Management team	Updated and approved guideline
3BPM	Assigning a process owner for design, measurement and improvement	Portfolio Management team	Appointment of a Process owner
4BPM	Define clear roles and responsibilities of Process Owner	Portfolio Management team	Approved and publish role and responsibilities matrix
5BPM	Auditing process maturity according to Process and Enterprise Maturity Model	Process Owner	Assessment result
6BPM	Auditing enterprise maturity according to Process and Enterprise Maturity Model	Process Owner	Assessment result
1CKT	Piloting application data collection (in excel) based on the Application Portfolio Management Framework.	IT Engineering Manager	Publish the data collection report
2CKT	Deciding on the technique to collect the data – Automatic, Semi-Automatic or Manual	Global Solution Architecture team	Decision on the one stop tool
3CKT	Review existing Business-IT alignment based on Process Driven Architecture model	Head of Architecture and Architecture team	Framework for Business – IT alignment

4CKT	Structured communications based on Lean Knowledge Management principles	Process Owner	Approved communication template
5CKT	Look for repeatable parts of the process and codify them. This is key for changing business dynamics like resource movements, application landscape changes, development and many others	Process Owner	Updated and approved guideline
6CKT	Propose ways to engage manager and management for efficient knowledge management with a future state communication	Process Owner	Guideline of future state of knowledge management

The next subsection presents the results in comparison with the objective of the thesis as well as the validity, reliability, relevance and logic of the thesis.

7.3 Self-evaluation of the study

The objective of this thesis was to propose evidence-based improvements to the PLM Capability Fulfillment process of the case company. The initial business challenge was an unclear process to handle different PLM Capabilities which was an increasingly important process in the case company. The outcome of this thesis is a set of recommendations to improve the process and address the weaknesses identified during the current state analysis. The recommendations were co-created with key stakeholders and were validated by the case company decision maker responsible for the overall process. Hence the outcome of this thesis meets the initial objective set for this thesis.

This study specifically addresses the identified process weaknesses. The question may arise as to whether all the weaknesses were identified or whether the findings taken forward were chosen correctly. The current state analysis of the study covered all the different business areas and represented individuals from all business areas and support functions, nevertheless there is no guarantee to identify all of the possible strengths and weaknesses. However, the objective of this study was still achieved since a wide range of strengths and weaknesses

were identified by a wide group of participants, with a repetition of the same results. An extensive number of weaknesses were addressed with specific and validated improvement recommendations that match the goals of the study.

The current state analysis involved a wide range of stakeholders from different business areas, support function teams and members from the current process. In the Data 1 collection, the key stakeholders were asked to respond to a survey as well as participate in one-to-one interviews to capture the understanding of the existing process and highlight the strengths and weaknesses of the current process. The Data 1 collection provided extensive amount of data from various sources and a wide-ranging set of strengths and weaknesses were identified. In the current state analysis results, it is difficult to determine whether all the prevailing strengths and weaknesses were captured. Nevertheless, a carefully planned series of interview topics and survey questionnaire with different stakeholders allowed a good number of different opinions to be expressed and captured for analysis.

The author of this thesis is a member of the IT Engineering team who are actively involved in handling all PLM Capabilities in the case company. Being part of the core process was a major advantage for the author to drive the interviews and workshops and allowed for a detailed discussion on the process with different stakeholders. The experience of the author was useful in assessing whether a particular weakness highlighted by one participant was a key concern for the overall process, or whether it was a challenge that the individual had been struggling with and not by other participants. As a result, the outcome of the current state analysis laid a solid foundation for the subsequent stages of the study, which included the development of the conceptual framework and the co-creation of the initial recommendations. Following the data collection process, the data was analysed and processed with the interpretation from the author.

Defining the key weaknesses to address to achieve the objective of this thesis was challenging, and the selection of targets can be questioned. There was a risk of targeting multiple key improvement areas at once for this thesis and after due

consideration, the scope of this thesis was narrowed to a feasible size of weaknesses and key improvement areas. The targeted key weaknesses of the process were identified during the current state analysis and determined to be the most urgent and impactful issues requiring attention in order to enhance effectiveness and output of the current process as well as to assist with the future development of the other weaknesses identified in the study but not included in the scope. Furthermore, the responses from different participants on common weaknesses helped in defining the key improvement area as well.

The initial recommendations building workshops with the selected stakeholders was smooth and ideas were brainstormed between different participants effectively over Microsoft Teams. The general observation was that the workshops could have delivered better results if the workshops were conducted in person but due to COVID-19 pandemic, restrictions were in place for using company premises and restrictions to travel to different offices. However, the initial recommendation building workshops resulted in the intended outcome of co-creating the initial recommendations to improve the process.

The workshop for validating the initial recommendations was also conducted online due to the COVID-19 restrictions. The discussion in the validation workshop covered the current PLM Capability Fulfillment process in depth and the company decision maker acknowledged the challenges in the current process. The company decision maker agreed on the initial recommendations that were presented and suggested to take those recommendations for further implementation with minor changes. In the end, the recommendation validation workshop provided the desired outcome of final recommendations adjusted based on the Data 3.

The next sub-sections evaluate the study by its validity, reliability, relevance and logic by discussing how these terms have been defined in the research literature.

7.3.1 Validity

The validity of the research analysis is defined as the degree to which the result of the study reflects the original objective of the study. Validity also refers to the approach to the analysis of the collected data and observations that reflect the purpose of an investigation. According to Quinton & Smallbone (2006: 126), a really crucial aspect of validity is to make sure that the reader is clear that the rigour of the researcher approach and the thinking about it from the data collection are transparent. There are two broad measures of validity - Internal and External validity. According to Roberts et al. (2006: 43), the internal validity of a study addresses why results are as they are and helps to eliminate other, often unanticipated, factors that may have led to these results. External validity pertains to the ability of the results to be applied to other people and other situations, as well as ensuring that the conditions under which the study is conducted are indicative of the conditions and time frame to which the results are intended to be applied.

In this thesis, validity was ensured by choosing the appropriate research design approach described in sections 2.1 and 2.2. The appropriate approach for this study was discussed with the thesis instructor in order to choose the most appropriate approach. Appropriate data collection methods with different stakeholders were conducted and the data was logged and documented as shown in Tables 1-2 in Section 2.3. In this thesis, an audit trail of all data collection activities provides external individuals with assurance of validity.

7.3.2 Reliability

Reliability can be defined as the likelihood of finding the same results if the study is repeated or conducted again (Quinton & Smallbone, 2006: 129). Below are some of the guidelines provided by Quinton & Smallbone (2006: 130) to improve or strengthen the reliability of the research work:

- using different data sources
- using different data collection tools

- using different researchers at different points of the research.

Quinton & Smallbone (2006: 131) highlights the importance of triangulation in research by using different data collection tools to answer the same interview questions which helps in providing a stronger body of evidence for the reader of this thesis.

In this study, reliability was planned and executed by the following steps: Participants used for the three data collection activities were from different business areas that were impacted by the PLM Capability fulfillment, support functions and process team within the case company. The collected data were grouped, categorized and finalized by discussions with relevant stakeholders in the case company at every step. Lastly, the final output of the study was developed with the responsible owner within the company to guarantee the credibility of the study.

7.3.3 Relevance

Toffel (2016) reports that research is relevant if it can improve the decision-making process of researchers. The relevance of research is determined by the research question, the hypothesis, and the implications. Research must also provide solutions to questions that are meaningful to researchers working within that field. The researcher must specify who will benefit from the outcome of the study. Toffel (2016: 1496) suggests that researchers should describe how their relevant research will encourage practitioners to take action. Researchers should therefore specify how their results are intended to affect decisions of the practitioner, providing examples when possible and defining their conclusions.

In this study, relevance was ensured from the start when the topic was chosen together with the supervisor representing the case company. The research question addresses a real business challenge requiring improvement to an existing process and the outcome of this study will have the biggest relevance to the case company team responsible for the PLM Capability Fulfilment process.

Based on the various stakeholders and executive feedback, the goal of the study was achieved extremely well and addressed a relevant business challenge within the case company.

7.3.4 Logic

Greenfield & Greener (2016) suggest that identifying the problem and its significance is the first step in the research process. It is important to have an explicit logic to the research process which provides the readers to believe the work and the researcher should provide grounds for that belief and explain the method or process by which the researcher has reached the conclusion.

In this study, the research design explained in Section 2.2 describes the logical steps and the interconnection between the steps to arrive at the desired outcome of the study. The logic of this study was ensured further by creating the conceptual framework which addressed the identified weaknesses from current state analysis based on the reviewed literature. As a next step, the initial recommendations were co-created with key stakeholders based on the conceptual framework and key improvement areas based on identified weaknesses. This study was structured so that different stages of the study were explained in chronological order so that it would be logical for a reader to follow. This thesis is concluded with the closing words below.

7.4 Closing Words

Continuous development of processes and services is necessary so that organizations can remain competitive and cost-effective in the ever-changing business environment. Organizations must analyse processes to identify and analyse collected data, plan and implement improvements and continuously assess the impact of those improvements. PLM Capability Fulfillment process is an important and a core process for the case company. This study has a specific and concrete objective and outcome and this study produced a practical solution to the case company that should help the company to improve the PLM Capability

Fulfillment process and also lays the ground for the future development of the process by focusing on the identified weaknesses left outside the scope of this study. By following the implementation plan to implement the recommendations, the case company can improve the current process significantly and also lay a strong foundation for future improvement of the process.

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CSA Interview Questions / Topics of Discussion

1. How will you define PLM capability?
2. How would you describe our current way of working?
3. Is the current process clear on " How to request for a new PLM capability?"
4. How do you address a new PLM capability needs in your business area?
5. What are the pain areas in the current process?
6. How important is cost a factor?
7. What do you want to see in the new process?
8. What is the frequency of new PLM capability planning?
9. What is the source for new PLM capability?

CSA Survey Questions

1. How efficient is the current process of fulfilling a PLM capability request from business? (*Rating based question*)
2. How do you request for a new PLM capability or a feature today? (*List of options*)
3. Do you know what engineering applications do we have in our engineering application portfolio and which apps are available for a certain capability? (“*Yes”, “No”, “Few of them” options*)
4. What is your recommendation when your team / team members ask for a new PLM capability? (Free text)
5. What is working in the current process? (Free text)
6. What is not working in the current process? (Free text)
7. What has been your business justification for requesting a new PLM capability? (List of options with free text option)
8. What is your suggestion on how the new process of PLM Capability fulfillment should be? (Free text)
9. From your point of view, What should be the key KPI for the new process? (List of options with free text option)
10. How important are the below factors when requesting for a new PLM capability? (Ratings)

The Process and Enterprise Maturity Model (Hammer, 2007)

To be used in conjunction with "The Process Audit" by Michael Hammer (HBR April 2007, Reprint R0704H).

How Mature Are Your PROCESSES?

You can evaluate the maturity of a business process and determine how to improve its performance by using this table. Decide how the statements defining the strength levels, from P-1 to P-4, for each enabler apply to the process that you are assessing. If a statement is largely true (at least 80% correct), color the cell green; if it is somewhat true (between 20% and 80% correct), shade the cell yellow; and if it is largely untrue (less than 20% correct), mark the cell red.

GREEN: largely true | YELLOW: somewhat true | RED: largely untrue

		P-1	P-2	P-3	P-4
Design	Purpose	The process has not been designed on an end-to-end basis. Functional managers use the legacy design primarily as a context for functional performance improvement.	The process has been redesigned from end to end in order to optimize its performance.	The process has been designed to fit with other enterprise processes and with the enterprise's IT systems in order to optimize the enterprise's performance.	The process has been designed to fit with customer and supplier processes in order to optimize interenterprise performance.
	Context	The process's inputs, outputs, suppliers, and customers have been identified.	The needs of the process's customers are known and agreed upon.	The process owner and the owners of the other processes with which the process interfaces have established mutual performance expectations.	The process owner and the owners of customer and supplier processes with which the process interfaces have established mutual performance expectations.
	Documentation	The documentation of the process is primarily functional, but it identifies the interconnections among the organizations involved in executing the process.	There is end-to-end documentation of the process design.	The process documentation describes the process's interfaces with, and expectations of, other processes and links the process to the enterprise's system and data architecture.	An electronic representation of the process design supports its performance and management and allows analysis of environmental changes and process reconfigurations.
Performers	Knowledge	Performers can name the process they execute and identify the key metrics of its performance.	Performers can describe the process's overall flow; how their work affects customers, other employees in the process, and the process's performance; and the required and actual performance levels.	Performers are familiar both with fundamental business concepts and with the drivers of enterprise performance and can describe how their work affects other processes and the enterprise's performance.	Performers are familiar with the enterprise's industry and its trends and can describe how their work affects interenterprise performance.
	Skills	Performers are skilled in problem solving and process improvement techniques.	Performers are skilled in teamwork and self-management.	Performers are skilled at business decision making.	Performers are skilled at change management and change implementation.
	Behavior	Performers have some allegiance to the process, but owe primary allegiance to their function.	Performers try to follow the process design, perform it correctly, and work in ways that will enable other people who execute the process to do their work effectively.	Performers strive to ensure that the process delivers the results needed to achieve the enterprise's goals.	Performers look for signs that the process should change, and they propose improvements to the process.
Owner	Identity	The process owner is an individual or a group informally charged with improving the process's performance.	Enterprise leadership has created an official process owner role and has filled the position with a senior manager who has clout and credibility.	The process comes first for the owner in terms of time allocation, mind share, and personal goals.	The process owner is a member of the enterprise's seniormost decision-making body.
	Activities	The process owner identifies and documents the process, communicates it to all the performers, and sponsors small-scale change projects.	The process owner articulates the process's performance goals and a vision of its future; sponsors redesign and improvement efforts; plans their implementation; and ensures compliance with the process design.	The process owner works with other process owners to integrate processes to achieve the enterprise's goals.	The process owner develops a rolling strategic plan for the process, participates in enterprise-level strategic planning, and collaborates with his or her counterparts working for customers and suppliers to sponsor interenterprise process-redesign initiatives.
	Authority	The process owner lobbies for the process but can only encourage functional managers to make changes.	The process owner can convene a process redesign team and implement the new design and has some control over the technology budget for the process.	The process owner controls the IT systems that support the process and any projects that change the process and has some influence over personnel assignments and evaluations as well as the process's budget.	The process owner controls the process's budget and exerts strong influence over personnel assignments and evaluations.
Infrastructure	Information Systems	Fragmented legacy IT systems support the process.	An IT system constructed from functional components supports the process.	An integrated IT system, designed with the process in mind and adhering to enterprise standards, supports the process.	An IT system with a modular architecture that adheres to industry standards for interenterprise communication supports the process.
	Human Resource Systems	Functional managers reward the attainment of functional excellence and the resolution of functional problems in a process context.	The process's design drives role definitions, job descriptions, and competency profiles. Job training is based on process documentation.	Hiring, development, reward, and recognition systems emphasize the process's needs and results and balance them against the enterprise's needs.	Hiring, development, reward, and recognition systems reinforce the importance of intra- and interenterprise collaboration, personal learning, and organizational change.
Metrics	Definition	The process has some basic cost and quality metrics.	The process has end-to-end process metrics derived from customer requirements.	The process's metrics as well as cross-process metrics have been derived from the enterprise's strategic goals.	The process's metrics have been derived from interenterprise goals.
	Uses	Managers use the process's metrics to track its performance, identify root causes of faulty performance, and drive functional improvements.	Managers use the process's metrics to compare its performance to benchmarks, best-in-class performance, and customer needs and to set performance targets.	Managers present the metrics to process performers for awareness and motivation. They use dashboards based on the metrics for day-to-day management of the process.	Managers regularly review and refresh the process's metrics and targets and use them in strategic planning.

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How Mature Is Your ENTERPRISE?

To determine if your organization is ready to support a process-based transformation, evaluate the statements in this table. They show the strength levels, from E-1 to E-4, of the capabilities that enterprises need in order to develop their business processes. If a statement is at least 80% correct, color the cell green; if it is between 20% and 80% correct, shade it yellow; and if it is less than 20% correct, make it red.

GREEN: largely true | YELLOW: somewhat true | RED: largely untrue

		E-1	E-2	E-3	E-4
Leadership	Awareness	The enterprise's senior executive team recognizes the need to improve operational performance but has only a limited understanding of the power of business processes.	At least one senior executive deeply understands the business process concept, how the enterprise can use it to improve performance, and what is involved in implementing it.	The senior executive team views the enterprise in process terms and has developed a vision of the enterprise and its processes.	The senior executive team sees its own work in process terms and perceives process management not as a project but as a way of managing the business.
	Alignment	The leadership of the process program lies in the middle management ranks.	A senior executive has taken leadership of, and responsibility for, the process program.	There is strong alignment in the senior executive team regarding the process program. There is also a network of people throughout the enterprise helping to promote process efforts.	People throughout the enterprise exhibit enthusiasm for process management and play leadership roles in process efforts.
	Behavior	A senior executive endorses and invests in operational improvement.	A senior executive has publicly set stretch performance goals in customer terms and is prepared to commit resources, make deep changes, and remove roadblocks in order to achieve those goals.	Senior executives operate as a team, manage the enterprise through its processes, and are actively engaged in the process program.	The members of the senior executive team perform their own work as processes, center strategic planning on processes, and develop new business opportunities based on high-performance processes.
	Style	The senior executive team has started shifting from a top-down, hierarchical style to an open, collaborative style.	The senior executive team leading the process program is passionate about the need to change and about process as the key tool for change.	The senior executive team has delegated control and authority to process owners and process performers.	The senior executive team exercises leadership through vision and influence rather than command and control.
Culture	Teamwork	Teamwork is project focused, occasional, and atypical.	The enterprise commonly uses cross-functional project teams for improvement efforts.	Teamwork is the norm among process performers and is commonplace among managers.	Teamwork with customers and suppliers is commonplace.
	Customer Focus	There is a widespread belief that customer focus is important, but there is limited appreciation of what that means. There is also uncertainty and conflict about how to meet customers' needs.	Employees realize that the purpose of their work is to deliver extraordinary customer value.	Employees understand that customers demand uniform excellence and a seamless experience.	Employees focus on collaborating with trading partners to meet the needs of final customers.
	Responsibility	Accountability for results rests with managers.	Frontline personnel begin to take ownership of results.	Employees feel accountable for enterprise results.	Employees feel a sense of mission in serving customers and achieving ever-better performance.
	Attitude Toward Change	There is growing acceptance in the enterprise about the need to make modest change.	Employees are prepared for significant change in how work is performed.	Employees are ready for major multidimensional change.	Employees recognize change as inevitable and embrace it as a regular phenomenon.
Expertise	People	A small group of people has a deep appreciation for the power of processes.	A cadre of experts has skills in process redesign and implementation, project management, communications, and change management.	A cadre of experts has skills in large-scale change management and enterprise transformation.	Substantial numbers of people with skills in process redesign and implementation, project management, program management, and change management are present across the enterprise. A formal process for developing and maintaining that skill base is also in place.
	Methodology	The enterprise uses one or more methodologies for solving execution problems and making incremental process improvements.	Process redesign teams have access to a basic methodology for process redesign.	The enterprise has developed and standardized a formal process for process redesign and has integrated it with a standard process for process improvement.	Process management and redesign have become core competencies and are embedded in a formal system that includes environment scanning, change planning, implementation, and process-centered innovation.
Governance	Process Model	The enterprise has identified some business processes.	The enterprise has developed a complete enterprise process model, and the senior executive team has accepted it.	The enterprise process model has been communicated throughout the enterprise, is used to drive project prioritization, and is linked to enterprise-level technologies and data architectures.	The enterprise has extended its process model to connect with those of customers and suppliers. It also uses the model in strategy development.
	Accountability	Functional managers are responsible for performance, project managers for improvement projects.	Process owners have accountability for individual processes, and a steering committee is responsible for the enterprise's overall progress with processes.	Process owners share accountability for the enterprise's performance.	A process council operates as the seniormost management body; performers share accountability for enterprise performance; and the enterprise has established steering committees with customers and suppliers to drive interenterprise process change.
	Integration	One or more groups advocate and support possibly distinct operational improvement techniques.	An informal coordinating body provides needed program management while a steering committee allocates resources for process redesign projects.	A formal program management office, headed by a chief process officer, coordinates and integrates all process projects, and a process council manages interprocess integration issues. The enterprise manages and deploys all process improvement techniques and tools in an integrated manner.	Process owners work with their counterparts in customer and supplier enterprises to drive interenterprise process integration.

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