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# Building a Coordination Approach to Integrate Interdependent Projects into Program Management

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Words are often too weak to express profound gratitude; yet, I would like to take this opportunity to express my deep sense of appreciation and respect to all those who helped me throughout the duration of this thesis project. Not to mention the strength, courage, perseverance, and patience given to me to complete this thesis.

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<p>This thesis aims at building an overall coordination approach to integrate supplier's different interdependent projects into program management. Due to challenges in greenfield plant projects and its large number of different projects, coordination in such a large setting requires a standardized approach for the management of multi-project interdependencies.</p> <p>This study is based on triangulated data and was conducted by analyzing the current state of the case company's project management processes and coordination practices. Subsequently and ascended from particular challenges identified, relevant literature covering project and program management was scrutinized to construct a conceptual framework. This conceptual framework formed the basis for building the coordination approach. Thereupon, the coordination approach was built, improved, and validated with the key stakeholders.</p> <p>The outcome of this thesis is a coordination approach for the management of multi-project interdependencies through time and communication management. Time management processes produce project stages, activities, and their relationships. These outputs are employed for the management process of multi-project interdependencies where they further categorize, display, and improve multi-project interdependencies. The improvement actions to enhance multi-project interdependencies are then communicated through communication management processes.</p> <p>The coordination approach built for the case company constitutes project stages and activities control, enhances project communication management, and facilitates the identification of multi-project interdependencies in addition to overlaps and gaps resolution. What is more, this thesis showed that the coordination approach proposed can be made applicable in similar instances of large-scale and complex greenfield plant projects.</p>	
Keywords	Coordination, Project Management, Program Management

## Contents

Preface

Abstract

List of Figures

List of Tables

1	Introduction	1
1.1	Business Context	2
1.2	Business Challenge, Objective and Outcome	3
1.3	Thesis Outline	3
2	Method and Material	5
2.1	Research Approach	5
2.2	Research Design	5
2.3	Data Collection and Analysis	7
3	Current State Analysis of Coordination Practices of Projects	13
3.1	Overview of Current State Analysis Stage	13
3.2	Description and Analysis of the Current Project Management Processes	14
3.2.1	Project Initiating Process	17
3.2.2	Project Planning Process	18
3.2.3	Project Implementing Process	20
3.2.4	Project Controlling Process	21
3.2.5	Project Closing Process	22
3.3	Description and Analysis of the Current Multi-Project Coordination Practices	22
3.4	Strengths and Weaknesses of the Current Processes and Practices	25
3.5	Key Findings from the Current State Analysis	28
3.5.1	Key Findings outside the Focus Area	28
3.5.2	Key Findings inside the Focus Area	29
4	Existing Knowledge on Greenfield Plant Projects Coordination in Relevant Literature	30
4.1	Project Management: Time and Communication	30
4.1.1	Time Management	35
4.1.2	Communication Management	41
4.2	Program Management: Multi-Project Interdependencies	45
4.3	Conceptual Framework of This Thesis	53

5	Building a Coordination Approach for Program Management	55
5.1	Overview of the Coordination Approach Building Stage	55
5.2	The Coordination Approach Outline	56
5.3	Project Management Improvements: Time and Communication	58
5.3.1	Time Management	59
5.3.2	Communication Management	65
5.4	Program Management: Multi-Project Interdependencies	72
5.5	The Initial Proposal of the Coordination Approach	77
6	Validation and Feedback to the Coordination Approach	79
6.1	Overview of the Validation and Feedback Stage	79
6.2	Validation of Project Management: Time and Communication	81
6.3	Developments to Program Management: Multi-Project Interdependencies	82
6.4	The Final Proposal of the Coordination Approach	86
7	Discussion and Conclusions	90
7.1	Executive Summary	90
7.2	Managerial Implications and Practical Recommendations	92
7.3	Thesis Evaluation	93
7.3.1	Objective versus Outcome	93
7.3.2	Validity, Logic, Reliability and Relevance	94
7.4	Closing Words	95
	References	96
	Appendices	
	Appendix 1. The Pilot of the Management Process of Multi-Project Interdependencies	

## List of Figures

Figure 1. The project department organization structure of the case company .....	2
Figure 2. Research design of this thesis .....	6
Figure 3. Projects breakdown structure.....	14
Figure 4. Project management processes.....	16
Figure 5. Project initiating process .....	17
Figure 6. Project planning process.....	19
Figure 7. Project implementing process .....	20
Figure 8. Project controlling process .....	21
Figure 9. Project closing process .....	22
Figure 10. Coordination levels and responsibilities .....	24
Figure 11. Strengths and weaknesses of the current coordination practices.....	26
Figure 12. Grouping of key findings from the current state analysis .....	29
Figure 13. Project management process groups (PMI 2013: 50).....	31
Figure 14. PRINCE2 process model (Hinde 2012: 15).....	33
Figure 15. Develop a project management plan process: inputs, tools & techniques, and outputs (PMI 2013: 72).....	33
Figure 16. Define activities process: inputs, tools & techniques, and outputs (PMI 2013: 150) .....	36
Figure 17. Sequence activities process: inputs, tools & techniques, and outputs (PMI 2013: 153) .....	37
Figure 18. Project schedule network diagram (PMI 2013: 160) .....	39
Figure 19. Simplified PERT network diagram (Adopted from Kerzner 2013: 500).....	40
Figure 20. Plan communication process: inputs, tools & techniques, and outputs (PMI 2013: 289) .....	42
Figure 21. Manage communication process: inputs, tools & techniques, and outputs (PMI 2013: 297) .....	43
Figure 22. DSM model (Eppinger & Browning 2012: 4) .....	48
Figure 23. Activity relationships in process DSM (Eppinger & Browning 2012: 134) ...	49
Figure 24. DSM approach to modeling and analysis (Eppinger & Browning 2012: 10)	50
Figure 25. Conceptual framework of this thesis .....	53
Figure 26. The initial improvements to the project and program management processes .....	57
Figure 27. Define activities process: inputs, mechanisms, and outputs.....	61
Figure 28. Activity list and attributes template.....	62
Figure 29. Sequence activities process: inputs, mechanisms, and outputs.....	63

Figure 30. Time management proposal evaluation against key findings and contributing strengths.....	64
Figure 31. Plan communication process: inputs, mechanisms, and outputs.....	67
Figure 32. Communication matrix example.....	69
Figure 33. Manage communication process: inputs, mechanisms, and outputs.....	70
Figure 34. Communication management proposal evaluation against key findings and contributing strengths.....	71
Figure 35. The Initial proposal of the management process of multi-project interdependencies.....	74
Figure 36. Multi-project interdependencies management proposal evaluation against key findings and contributing strengths.....	76
Figure 37. The initial proposal of the coordination approach.....	78
Figure 38. The management process of multi-project interdependencies.....	84
Figure 39. The final improvements to the project and program management processes.....	87
Figure 40. The final proposal of the coordination approach.....	88

**List of Tables**

Table 1. Thesis data plan .....	7
Table 2. Data 1 collection information and techniques.....	8
Table 3. Management system documents.....	9
Table 4. Data 2 collection information and techniques.....	11
Table 5. Data 3 collection information and techniques.....	12
Table 6. Time management suggestions as of Data 2.....	60
Table 7. Communication management suggestions as of Data 2.....	66
Table 8. The management process of multi-project interdependencies suggestions as of Data 2.....	72
Table 9. Time and communication management suggestions as of Data 3.....	81
Table 10. The management process of multi-project interdependencies suggestions as of Data 3.....	83



## 1 Introduction

This thesis explores the project management of large megaprojects in the context of a power plant built onto a *greenfield* site. A greenfield plant project is a megaproject characterized by its large scale, and complex venture (Flyvbjerg, 2016). A greenfield plant project is not constrained by prior work and is constructed on unused land. Thus, it typically takes many years to build, and involves multiple public as well as private stakeholders. It may be grouped as well as a program due to its large number of projects. The distinct features and complex nature of the greenfield plant project impose unique demands on project and program management processes.

These project and program management processes aspire to effectively manage the plant project during its life cycle in order to directly or indirectly achieve specific objectives, and meet specific criteria within organization's strategy. However, complex interdependencies between projects hinder the overall efficiency of the management processes of the program; therefore, managing the projects' interdependencies in such a large setting requires standardized processes or approaches.

The management of the interdependencies of these projects generally refers to managing multiple tasks simultaneously. It therefore encloses the realization of all project objectives with complete visibility of the on-going activities for the achievement of a high-quality outcome.

What's more, the International Atomic Energy Agency (IAEA, 2012) highlights the importance of coordinating project activities and managing project interfaces inside and outside the organization in greenfield plant projects. This coordination and management of project activities and interfaces is essential so as to produce a high quality, reliable product within the constraints of schedule, budget, and requirements.

Correspondingly, recent researches acknowledge the fragmented, time pressured work nature of multiple projects and, to a major extent, constantly managing situations of crisis. (Gustavsson & Jerbrant 2012)

Concisely, success in the management of greenfield plant projects requires strong interdisciplinary coordination of projects. Thus, this thesis pursues a coordination approach for the management of the multi-project interdependencies as program management in order to enhance the management of the projects in terms of communication, scope, time, and resources.

## 1.1 Business Context

The case company is a power company established by a consortium of power and industrial companies. The case company's business objectives aims at building a new greenfield power plant, operating generation assets, and selling power for a competitive and reasonable stable price.

At the moment, the case company's operations focus on the supervision of the power plant project design, quality, and management, as well as the application of various permits and licenses.

The largest department in the case company's organization in this phase is the project department. The overall structure of the power plant project department is illustrated in Figure 1.

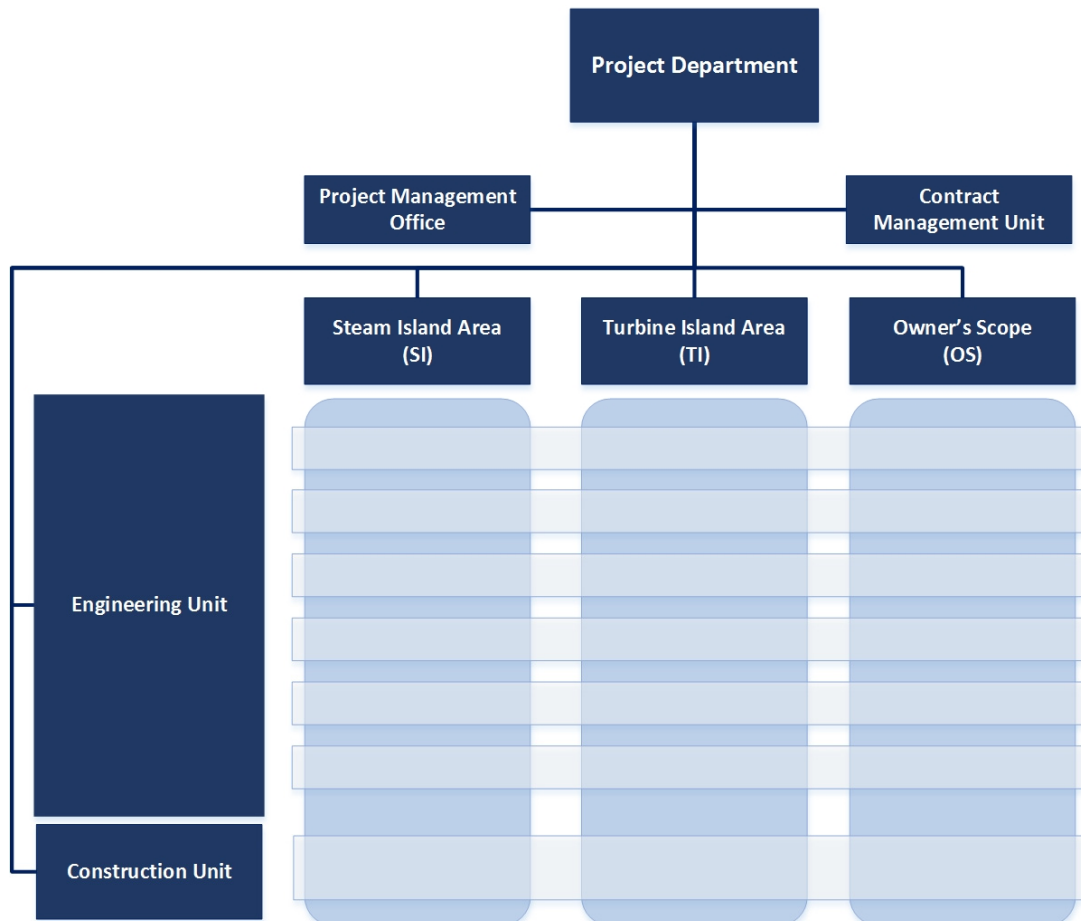


Figure 1. The project department organization structure of the case company

As perceived from Figure 1, the project department consists of several units. Those units are the project management office, contract management unit, engineering unit, and construction unit.

In addition, the project department comprises the project areas of the Steam Island (SI), Turbine Island (TI), and the case company's scope of works as an Owner's Scope (OS). The progress of the project is controlled and monitored within these areas through several projects and sub-projects. Those projects and sub-projects are managed from the project areas using engineering expertise from the engineering unit.

## 1.2 Business Challenge, Objective and Outcome

The power plant project has a complicated supply chain structure for the case company through a turnkey plant supplier, hereinafter referred to as "the supplier". The supplier is using a multitude of sub-suppliers. As of 2018, the total number of sub-suppliers is 524.

In fact, the responsibility of the design and construction relies on the supplier and its supply chain. However, the case company supports the supplier in the planning and coordination of project works in order to ensure a high quality, safe, and reliable plant. For that reason and in order to meet its business objectives, the case company is managing the power plant project through different projects and sub-projects.

Yet, operative project management structure is currently not sufficiently clear and interfaces between projects as well as sub-projects are not well-defined. This is likely to lead to overlapping responsibilities, scope gaps in the projects and time-schedule challenges.

Given these challenges, the objective of this thesis is to develop an overall coordination approach for the case company to integrate the supplier's different interdependent projects into program management. The outcome of this thesis is thus a coordination approach for the management of the multi-project interdependencies.

## 1.3 Thesis Outline

This thesis is organized into seven sections. The first section outlines the organization of the thesis in terms of business context, challenge, objective and outcome. Section 2 sets the framework of this thesis by demonstrating the research methods and materials. Furthermore, it established the research approach, and research design along with data collection and analysis methods.

Section 3 analyses the current state of the case company's multi-project coordination practices. It starts with the overview of this thesis stage, followed by a description of the case company's current project management processes and multi-project coordination practices along with strengths and weaknesses. The section ends with the key findings from the current state analysis both inside the focus area and outside the focus area.

Section 4 illuminates the existing knowledge on the greenfield plant project coordination in conjunction with the key findings of the current state analysis. This section starts with literature covering project management. After that, it scrutinizes literature on the management of the multi-project interdependencies as a vital function of program management. Finally, it concludes with the conceptual framework of this thesis.

Section 5 describes the building stages of the proposed coordination approach for the case company. That consists of improving the project management processes and building the management process of multi-project interdependencies as part of program management. The findings of data collection towards building the coordination approach as well as the proposal assessment against key findings are described as well. Finally, it ends with the initial proposal of the coordination approach.

Section 6 validates the initial proposal of the coordination approach in terms of the feedback received and corrections undertaken. It starts with the overview of the validation and feedback stage, and then the validation of the project management parts of the coordination approach are demonstrated. Consequently, developments to the management of multi-project interdependencies as part of program management are revealed. Lastly, it concludes with the final proposal of the coordination approach.

Finally, Section 7 summarizes the thesis in addition to managerial implications and practical recommendations in terms of the most important future next steps and development areas. This conclusive section evaluates this thesis against the objective in addition to validity, reliability, logic and relevance.

## 2 Method and Material

This section describes the research method and associated material used in this thesis. First, it focuses on the research approach in terms of strategy and methodologies. Second, it illustrates the research design stages as well as data utilized and activities involved. Finally, it defines the methods used for the data collection in addition to the planned data analysis methods.

### 2.1 Research Approach

Research projects begin with a discussion of a problem or a challenge; where a discourse often triggers the researcher's interest in a topic to be researched. Subsequently, the research is concerned with the emergence of theory through the development of ideas, the observation of evidences, and the evaluation of results. (Remenyi 2005)

Following this concept, and after setting out the business challenge, the next step is to select the research approach. The research approach explains the strategy as well as methodologies employed for this research.

Baxter and Jack (2008: 544) define the qualitative case study approach as "an approach to research that facilitates exploration of a phenomenon within its context using a variety of data sources. This ensures that the issue is not explored through one lens, but rather a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood."

Consistently, Baxter and Jack (2008: 556) expose that a case study enables the researcher to answer "how" and "why" type of questions, while taking into consideration how a phenomenon is influenced by the context within which it is situated.

Moreover, Yin (2011: 307) identifies that a case study may rely on quantitative or qualitative data (or both), but usually involves some field-based data.

Thus, in the context of this study, the qualitative case study approach is selected to tackle the business challenge where qualitative field-based data is utilized. Correspondingly, the research question is the coordination approach used to manage the interdependencies of the different projects.

### 2.2 Research Design

Certainly, qualitative researchers ought to produce a detailed research design to facilitate the coherent and rigorous development of the research project. (Mason 2002: 25)

In particular, the research design mosaics all the gathered data in a logical manner to the research questions and ultimately relate it to the outcomes. This study's research was designed into five stages. Figure 2 below illustrates these five stages where the collected and utilized data are embedded in each stage.

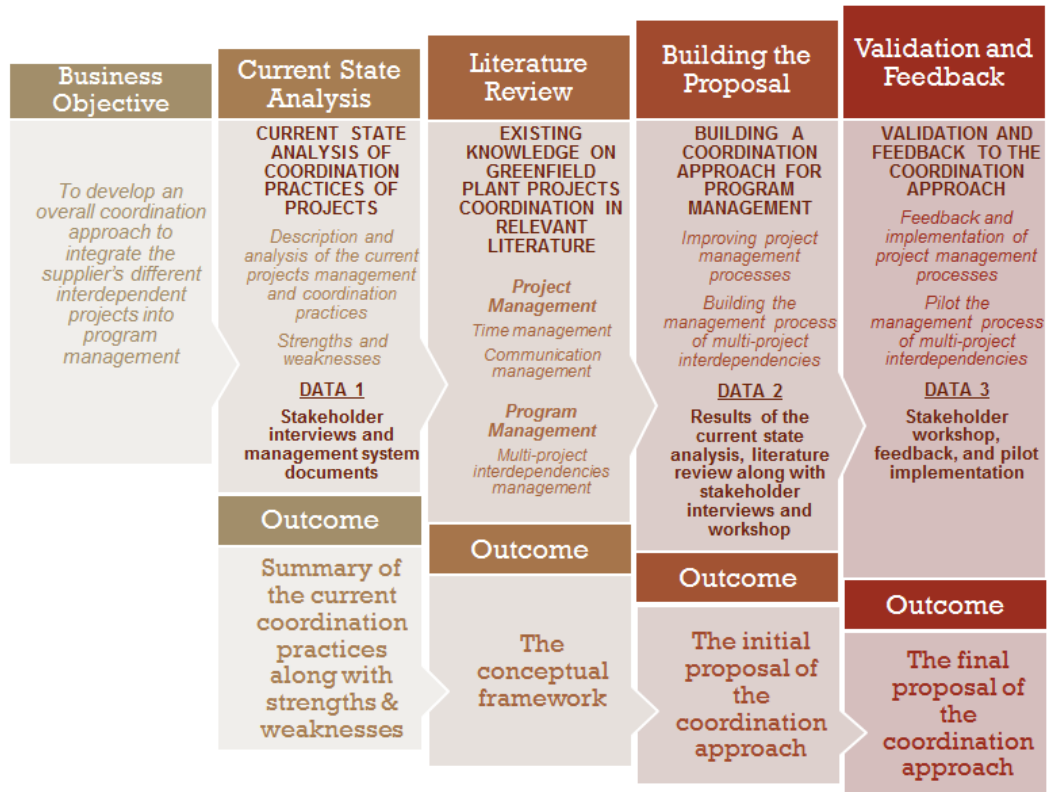


Figure 2. Research design of this thesis

As perceived from Figure 2, the research design originated from the business objective. Precisely, the business objective was perceived from the business challenge as part of the first research stage.

The second stage analyzed the current state of the projects management and coordination practices inside the case company. Thus, the outcome of this stage was the summary of the current project management processes and coordination practices along with strengths and weaknesses. The third stage identified the existing knowledge of the greenfield plant projects coordination in terms of project management and program management. Literature review in the existing knowledge covered time management as well as communication management as part of project management. Furthermore, multi-project interdependencies management as part of program management was scrutinized. As a result, the outcome of this stage was the conceptual framework.

The fourth stage concerned with the proposal building for the case company. This stage covered improving project management processes and building the management process of multi-project interdependencies. Accordingly, the outcome of this stage was the initial proposal for the coordination approach.

The fifth and last stage validated the initial proposal. This stage covered feedback and implementation of project management processes and pilots the management process of multi-project interdependencies. Therefore, the final outcome of the research is the final proposal of the coordination approach.

The research utilized three data sets throughout the research project. Thereupon, the definition of those three data sets collected and utilized in the research along with the collection and analysis methods are described in the next subsection.

### 2.3 Data Collection and Analysis

Data gathered for this study were drawn from a variety of data sources in three data collection rounds. Each round produced a set of data corresponding to the research stage objective. Detailed data collection information and techniques for the three data sets are presented in Table 1 below.

Table 1. Thesis data plan

	<b>Content</b>	<b>Source</b>	<b>Informant</b>	<b>Timing</b>	<b>Outcome</b>
<b><u>DATA 1</u></b> <b>CURRENT STATE ANALYSIS</b>	<ul style="list-style-type: none"> <li>• Description of the current projects management and coordination practices</li> <li>• Strength and weaknesses of the current processes and practices</li> </ul>	<ul style="list-style-type: none"> <li>• Stakeholder Interviews</li> <li>• Management system documents</li> </ul>	<ul style="list-style-type: none"> <li>• Project Management Office (PMO) project manager</li> <li>• Commissioning manager</li> <li>• Unit manager</li> <li>• Project manager</li> </ul>	January-Mid February	Description of the current projects management and coordination practices along with strengths & weaknesses
<b><u>DATA 2</u></b> <b>BUILDING THE PROPOSAL</b>	<ul style="list-style-type: none"> <li>• Improving project management processes</li> <li>• Building the management process of multi-project interdependencies</li> </ul>	<ul style="list-style-type: none"> <li>• Results of current state analysis and literature review</li> <li>• Stakeholder interviews</li> <li>• Stakeholder workshop</li> </ul>	<ul style="list-style-type: none"> <li>• Project management office (PMO) project manager</li> <li>• Commissioning manager</li> <li>• Unit manager</li> <li>• Project manager</li> </ul>	March-April	The initial proposal of the coordination approach
<b><u>DATA 3</u></b> <b>VALIDATION AND FEEDBACK</b>	<ul style="list-style-type: none"> <li>• Feedback and implementation of project management processes</li> <li>• Pilot the management process of multi-project interdependencies</li> </ul>	<ul style="list-style-type: none"> <li>• Stakeholder workshop</li> <li>• Proposal feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Engineering management</li> <li>• Data 1 and Data 2 participant</li> </ul>	April	The final proposal of the coordination approach

As realized from Table 1, data for this research was collected in three rounds. In the first round, the first set of data (Data 1) was gathered from key stakeholders and analyzed as part of the current state analysis stage. In the second round, Data 2 were gathered from stakeholder interviews and workshops as part of the building proposal stage.

In the third round, Data 3 were gathered from key stakeholders as part of the validation and feedback to initial proposal stage. It is worth mentioning that new stakeholders were added to Data 3 as part of the critique to the initial proposal in order to seek outsider's opinions and take full advantage of the validation and feedback stage.

As to Data 1, Table 2 presents the detailed techniques used in the data collection for Data 1 along with informant's information, interviews dates, duration, and topics.

Table 2. Data 1 collection information and techniques

Informant's position and affiliation		Data Collected	Topic	Date, Duration	Recorded
1	Project Management Office (PMO) project manager	Two Interviews, face-to-face	Projects management processes and governance processes, projects life cycle, and projects coordination practices	12 Jan 2018, 60 minutes	field notes
				23 Jan 2018, 120 minutes	
2	Commissioning manager	Interview, face-to-face	Project management processes, project life cycle, and commissioning coordination practices	29 Jan 2018, 90 minutes	field notes
3	Project manager	Interview, face-to-face	Project management processes, project life cycle, and project coordination practices	01 Feb 2018, 50 minutes	field notes
4	Unit manager	Interview, face-to-face	Projects management processes and governance processes, and projects coordination practices	08 Feb 2018, 60 minutes	field notes
5	Management system documents (plans, procedures, and manuals)	Records investigation	N/A	N/A	e-format

As seen in Table 2, different methods were used for the data collection and analysis via five interviews as well as studying and investigating management system documents.



To recognize different coordination practices in different levels, the interviews were conducted as semi-structured, face-to-face, held on the company premises, with questions created in advance. The interviews were logged and field notes taken.

The first and second interviews were conducted with Project Management Office (PMO) project manager responsible for program planning and control, project management processes development, and projects structure establishment both internally as well as with supplier.

Later on, the third, fourth, and fifth interviews were conducted with the commissioning manager, a plant engineering project manager, and a unit manager representing the operative project management level, where their responsibilities include project management processes operation in terms of planning, implementation, and control.

Data 1 included management system document study and investigation. Thus, Table 3 presents and describes the management system documents.

Table 3. Management system documents

	<b>Document Name</b>	<b>Document Description</b>
<b>A</b>	Organization manual	Organization structure, tasks, and responsibilities
<b>B</b>	Program reporting procedure	Streamline the program reporting by forming project progress and information channels.
<b>C</b>	Description of project areas	Project areas structure, tasks, and responsibilities
<b>D</b>	Sub-area plans	Sub-area projects, systems descriptions
<b>E</b>	Project management procedure	Project management processes description
<b>F</b>	Project manual	Principles, methods, and structure for project management
<b>G</b>	Project scope management procedure	Manages project scope by ensuring that the scope is assigned and the potential changes are analyzed
<b>H</b>	Project plan template	Outlines the elements that the project plan covers
<b>I</b>	Project management processes diagrams	Projects and sub-projects process description, and ownership
<b>J</b>	Commissioning manual	Commissioning activities scope, purpose, and guidance

As seen in Table 3, a number of internal management system documents were scrutinized as well as classified into two categories. The first category encompassed the organization manuals, plans and descriptions along with program management. Documents A through D belong to this category. The second category included project management procedure, project manual, and associated process diagrams. Documents E through G belong to this category.

These documents were analyzed for the current state analysis, Data 1, to acquire an overall understanding of the organizations involved in coordination responsibilities. Besides, gaining good insights about project management processes inside the case company was the second objective.

These interviews in addition to management system documents were analyzed using a thematic content analysis method by interpreting and evaluating textual materials, such as field notes, electronic format documents, and oral communication.

In detail, thematic content analysis assesses views from different groups by developing a theory of visualizing and experiencing a process. Moreover, the research decides in advance the information needed based on prior categories, or on categories emerging as the analysis proceeds. (Lancaster 2009: 162)

In fact, field notes data consist of specific items, such as events, objects, and opinions. Associated with those items contextualized details; therefore, the purpose of data coding is to move to a slightly higher conceptual level that can be further categorized. (Yin 2011: 187)

Thematic content analysis starts by coding and organizing the data and addressing the cases involved; then, categorizing the data and creating a short description of each case. Lastly, the fundamental topics revealed by the interviewee concerning the research issue are summarized. (Flick 2009: 318)

Thematic content analysis for Data 1 interviews was established on pre-defined categories. The categories covered topics and concepts recognized during the business challenge and objective stage. Those categories are project management processes, and coordination practices.

In the next round, the second set of data (Data 2) was collected as part of the building the proposal stage. This data gathered the results of the current state analysis and literature review along with a stakeholder interview and workshop.

Regarding Data 2, Table 4 presents the detailed techniques used in the data collection for Data 2 along with informant's details, dates, duration, and topics.

Table 4. Data 2 collection information and techniques

Informant's position and affiliation		Data Collected	Topic	Date, Duration	Recorded
1	Project Management Office (PMO) project manager	Three interviews, face-to-face	Time management as part of project management	23 Mar 2018, 60 minutes	field notes
			Communication management as part of project management	29 Mar 2018, 90 minutes	
			Management of multi-project interdependencies as part of program management	12 Apr 2018, 60 minutes	
2	Project Management Office (PMO) project manager Commissioning manager Unit manager Project manager	Workshop, face-to-face	The initial proposal of the coordination approach	17 Apr 2018, 60 minutes	field notes

As shown in Table 4, different methods were used for the data collection via three interviews and workshop in the form of suggestions. So as to build the initial proposal of the coordination approach. The interviews were conducted as semi-structured, face-to-face, held on the company premises, with the initial proposal of the coordination approach created in advance based on literature and best practices identified in literature review stage. The interviews and workshop were logged and the field notes taken.

The three interviews enclosed the key findings groups discovered in current state analysis stage. The workshop covered the initial proposal of the coordination approach co-creation with key stakeholders. Data 2 detailed findings are presented as part of the initial proposal of the coordination approach in Section 5.

In the next round, the third set of data (Data 3) was collected during the validation and feedback stage. This data included stakeholder workshop and proposal feedback. The stakeholder for this round included engineering management as part of the critique to maximize the return from the validation and feedback stage. The final data was collected when receiving feedback for the proposal from key stakeholders inside the case company.

As to Data 3, Table 5 presents the detailed techniques used in the data collection for Data 3 along with informant's details, dates, duration, and topics.

Table 5. Data 3 collection information and techniques

Informant's position and affiliation		Data Collected	Topic	Date, Duration	Recorded
1	Engineering manager Quality management expert	Workshop, face-to-face	Feedback to the initial proposal of the coordination approach	20 Apr 2018, 60 minutes	field notes
2	Project Management Office (PMO) project manager Commissioning manager Unit manager Project manager	Initial proposal feedback	Feedback to the initial proposal of the coordination approach	N/A	e-format

As described in Table 5, different methods were used for the data collection via workshop and proposal feedback in the form of improvement suggestions. With the aim of building the final proposal of the coordination approach, the workshop were conducted as semi-structured, face-to-face, held on the company premises, with the initial proposal of the coordination approach created in advance resulting from the initial proposal of the coordination approach building stage. The workshop and proposal feedback were noted as improvement suggestions to the initial proposal. These improvement suggestions are later implemented to form the final proposal of the coordination approach. Data 3 detailed findings are presented as part of the final proposal of the coordination approach in Section 6.

The majority of data analysis was conducted during the current stage analysis stage; henceforth, the analysis footsteps, and findings of the current state analysis stage are presented in the next section.

### 3 Current State Analysis of Coordination Practices of Projects

This section presents the current state analysis of the project management processes as well as coordination practices in the case company under study. First, it overviews the footsteps of the current state analysis conducted, the rationale behind the choices made, and the objectives sought after.

After that, it illustrates the description and analysis of the current project management processes. Furthermore, the description and analysis of the current coordination practices are presented. Subsequently, strengths and weaknesses of the current coordination practices are identified. Finally, this section ends with key findings discovered from the current state analysis both outside the focus area and inside the focus area.

#### 3.1 Overview of Current State Analysis Stage

The current state analysis was conducted through one-to-one interviews with selected key stakeholders covering the entire project management spectrum in the case company. In addition, existing management system documents were studied and analyzed.

The case company does not possess a documented approach or a process for coordination between projects as well as sub-projects. Hence, as such, coordination does not represent a standardized process. Therefore, to map how coordination practices have been conducted in the case company, interviewees from different project management levels were selected.

The current state analysis was constructed as follows. Firstly, the Project Management Office (PMO) project manager representing the program management level in the case company was interviewed in order to gain insights of the current projects management, and projects governance processes in practice.

Secondly, the project management processes identified from the first and second interview formed a basis for the third, fourth, and fifth round of interviews. Those interviews were conducted with the commissioning manager, a project manager, and a unit manager representing the operative project management level in the case company. Those interviews were conducted so as to clearly identify challenges in the project management processes and coordination activities.

Alongside the interviews conducted, existing management system documents were studied to check for consistency or gaps with case company's practices as well as to acquaint projects' life cycle description along with roles and responsibilities.

The objective of the current state analysis was to clarify how the coordination practices are currently performed at the case company. The following subsections describe the current project management processes as well as coordination practices in more detail.

### 3.2 Description and Analysis of the Current Project Management Processes

This section presents the results found, and the analysis made during the interviews conducted within the case company concerning the current project management processes.

For an effective start of the current state analysis stage, the first and second interviews with the Project Management Office (PMO) project manager were analyzed. Additionally, the project management manual, procedure, and processes were scrutinized. That resulted in realizing the overall projects breakdown structure of the power plant program as illustrated in Figure 3.

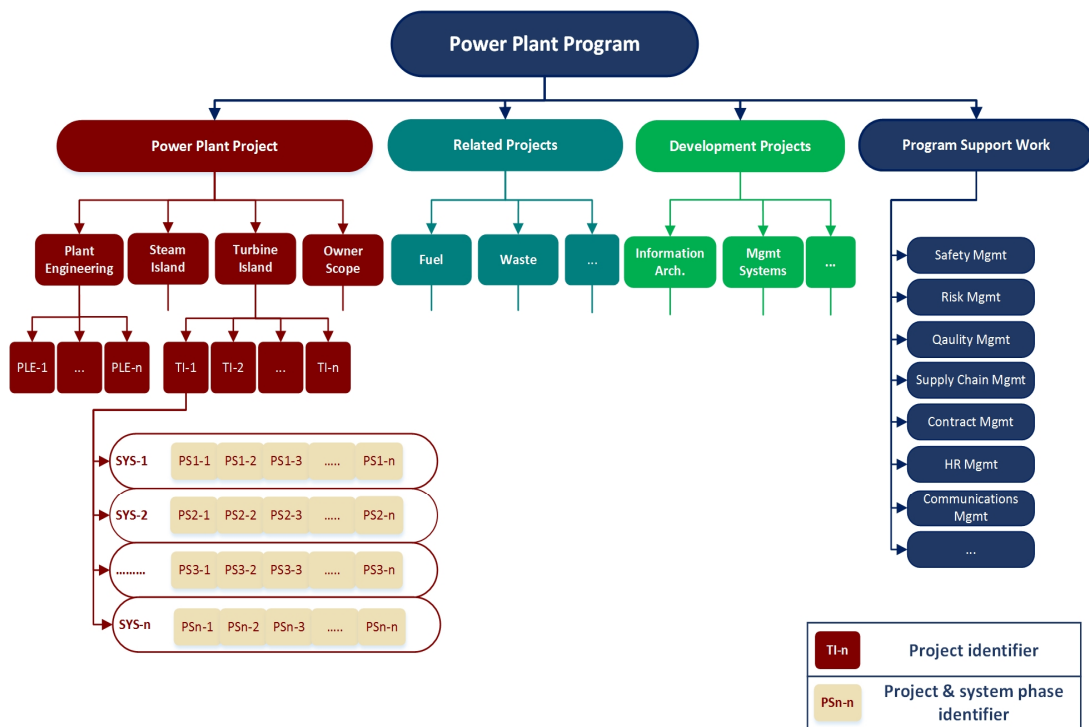


Figure 3. Projects breakdown structure

As demonstrated in Figure 3, the power plant program is separated into three types of projects. The first type is the power plant project. The second type is the related projects to the power plant project, such as fuel project and waste project. The third type is the projects related to the organization development.

Following the organization structure presented in Figure 1, the main areas classified under the power plant project are plant engineering, Steam Island (SI), Turbine Island (TI), and Owner Scope (OS). Each area is managed by director, unit managers, and project managers. Moreover, each area is further broken down to several projects and sub-projects.

Therefore, the case company has several levels of project and sub-projects that require strong planning and managing interdependent tasks simultaneously. This research is focused on those projects and sub-projects under the power plant project, since the rest of the projects are relatively independent from the power plant project.

The interviews and management system documents were further analyzed to identify the project management processes as well as liaison to the organization's strategy as shown in Figure 4.

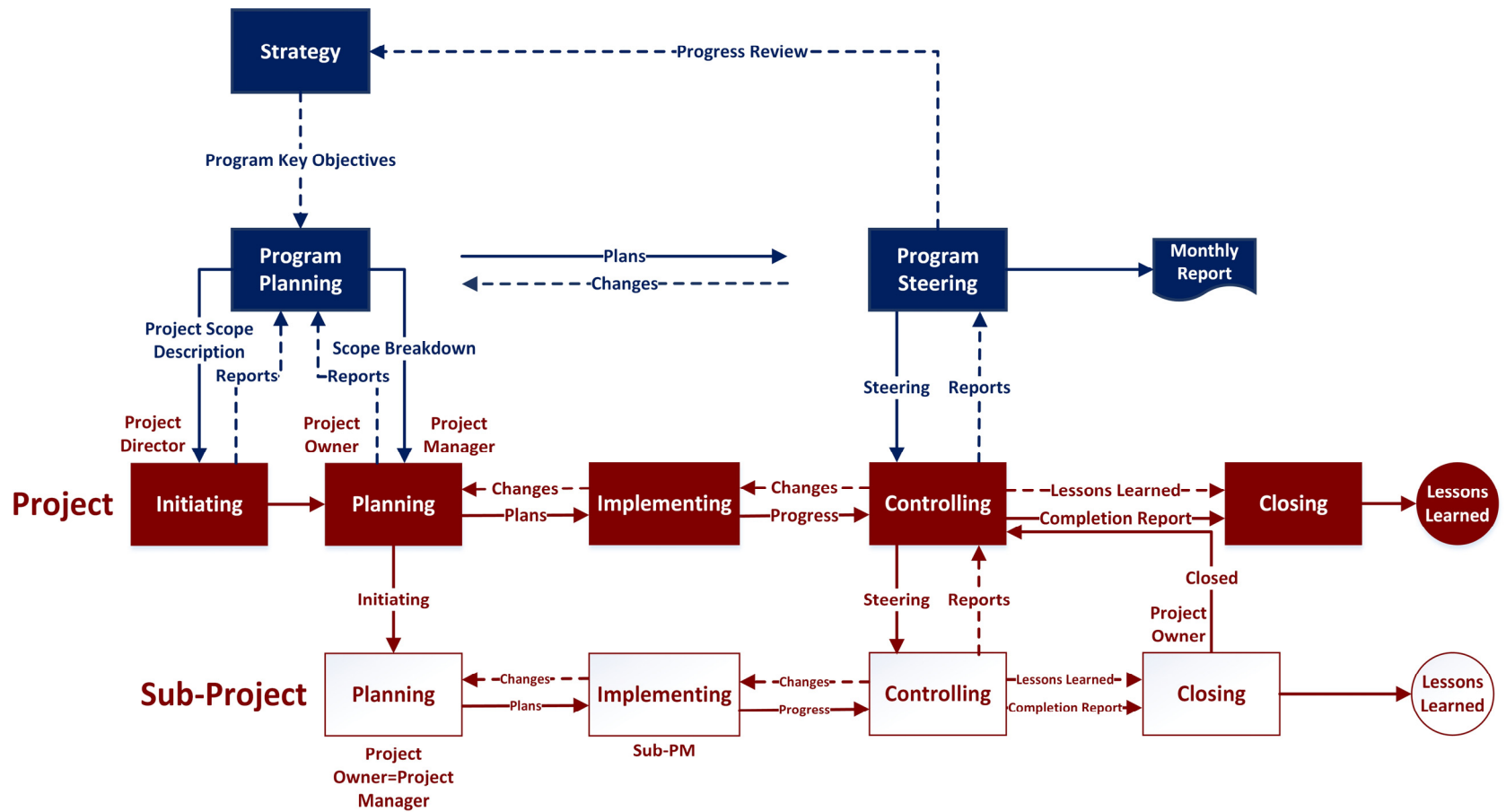


Figure 4. Project management processes



As demonstrated in Figure 4, the case company has project management processes defining the project life cycle based on ISO 21500 standard - guidance on project management (ISO 2012).

The project management processes start by program planning from strategy to the program management, where it further initiates the project and follow up with the project planning. For instance, project planning could initiate a sub-project, if necessary and based on scope. The project phases flow from initiating to planning then to implementing and further to controlling. During the controlling phase, steering and progress reporting connects the project to the strategy via program steering. Finally, the project phases end with closing.

It is worth mentioning that the project owner is responsible for the project initiation, budget, and monitoring, where the project owner can be an area director or an engineering director as identified in Figure 3. However, the project manager is responsible for the project planning, implementation, and control. Identically, the project manager can act as a project owner for the sub-project as well. For more details, each phase of the project is further explained and its process is mapped in the subsequent subsections.

### 3.2.1 Project Initiating Process

The project initiating process is used to start a project, to define project objectives and to authorize the project manager to proceed with the project work. Figure 5 maps the project initiating process starting from program management until the project planning phase.

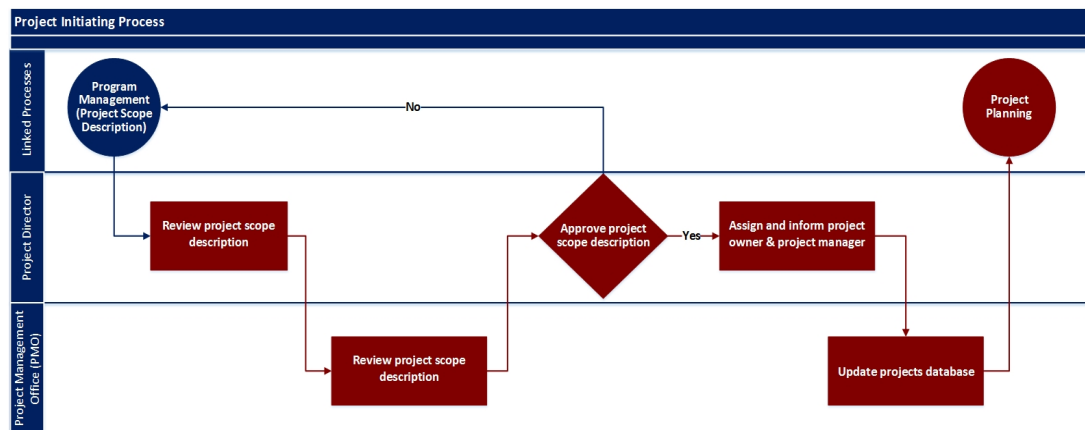


Figure 5. Project initiating process

As mapped in Figure 5, the project initiation phase starts by issuing a project from the program management via a project scope description. Then, the project director as well as Project Management Office (PMO) review the project scope description. If approved, a project owner and project manager are appointed, assigned, and informed. Lastly, the projects database are updated accordingly and project planning process starts.

### 3.2.2 Project Planning Process

The project planning process is used to develop project planning in detail. This is done in order to establish bases against which project implementation could be managed and project performance could be measured and controlled. Figure 6 maps the project planning process starting from project authorities defined in the project initiating phase until the project implementing phase.

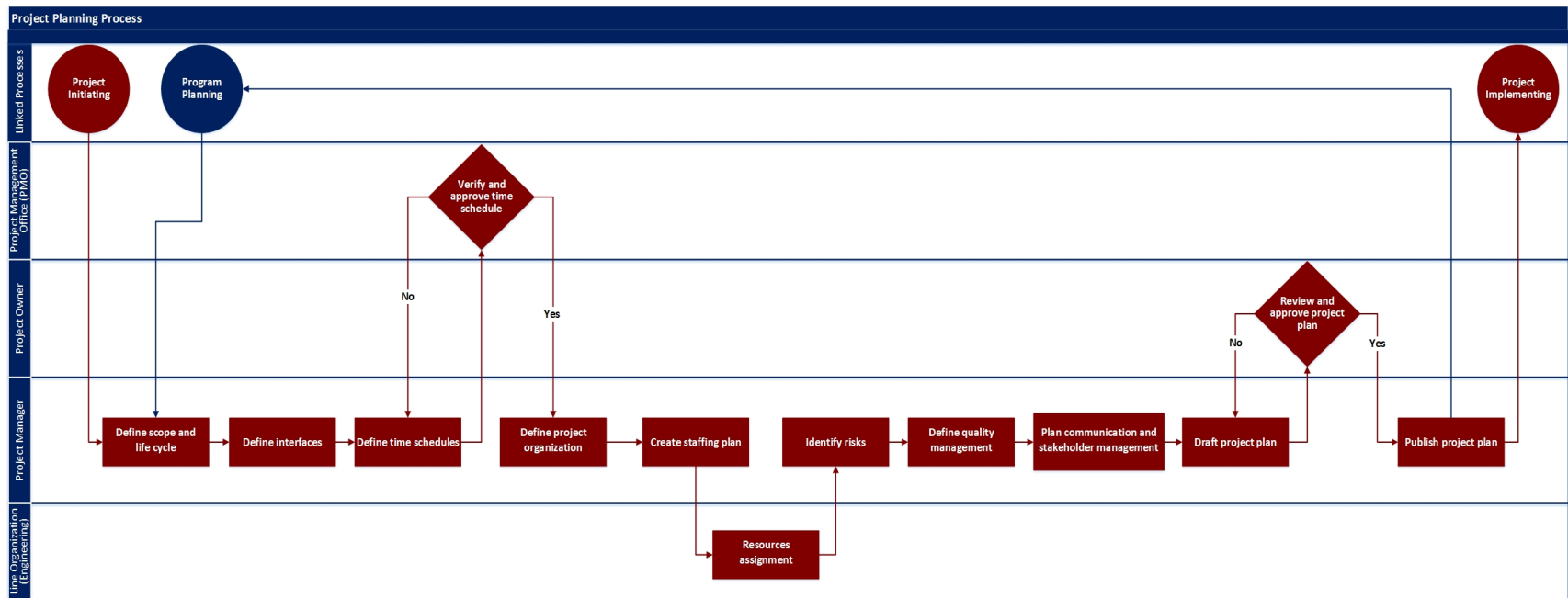


Figure 6. Project planning process

As mapped in Figure 6, project planning is the responsibility of the project manager. To elaborate, the project planning phase consists of defining scope and life cycle. It is followed by approving the time schedule with project management office (PMO). Later on, the project organization is defined, and a staff plan is created. This staff plan is communicated with the line organization to assign resources from the engineering unit. Additionally, the project manager identifies risks, defines quality management, and plans for communication. The project planning phase ends with drafting a project plan and approving it with the project owner, then publishing it. That is where the project implementing phase starts.

### 3.2.3 Project Implementing Process

The project implementing process is used to perform the project activities in accordance with the project plans. Figure 7 maps the project implementing process starting from project plan defined in the project planning phase.

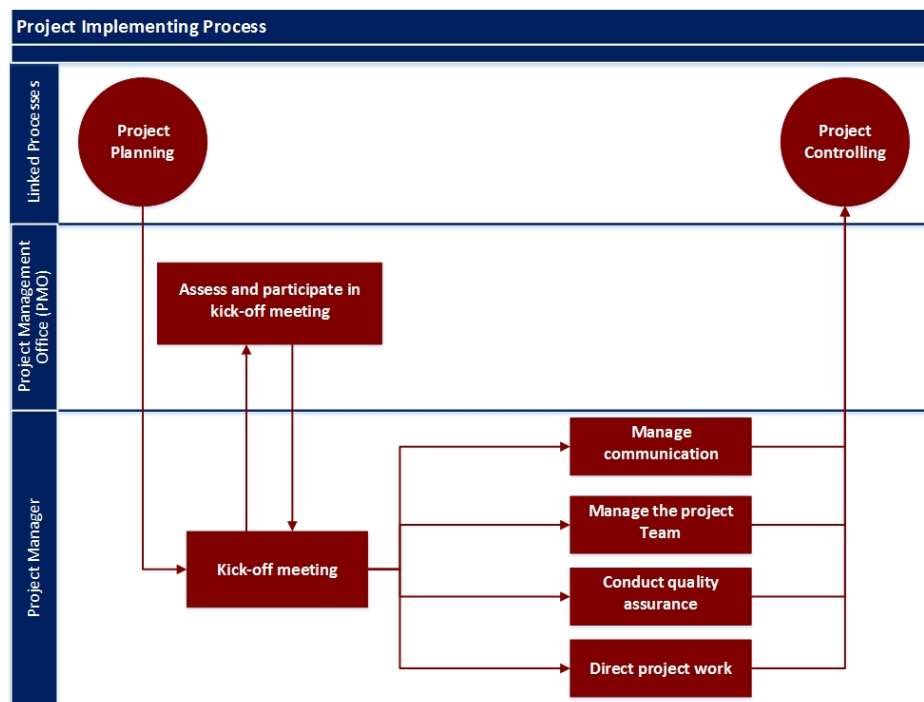


Figure 7. Project implementing process

As mapped in Figure 7, project manager's activities commence with initiating a kick-off meeting where the Project Management Office (PMO) assesses and participates. In par-

allel and during project team implementation, the project manager manages communication as well as the project team; moreover, the project manager conducts quality assurance and directs project work. That is where the project controlling process is linked.

### 3.2.4 Project Controlling Process

The project controlling process is used to monitor, measure and control project performance against the project plan. Figure 8 maps the project controlling process starting from project work defined in the project implementing phase till the project closing phase.

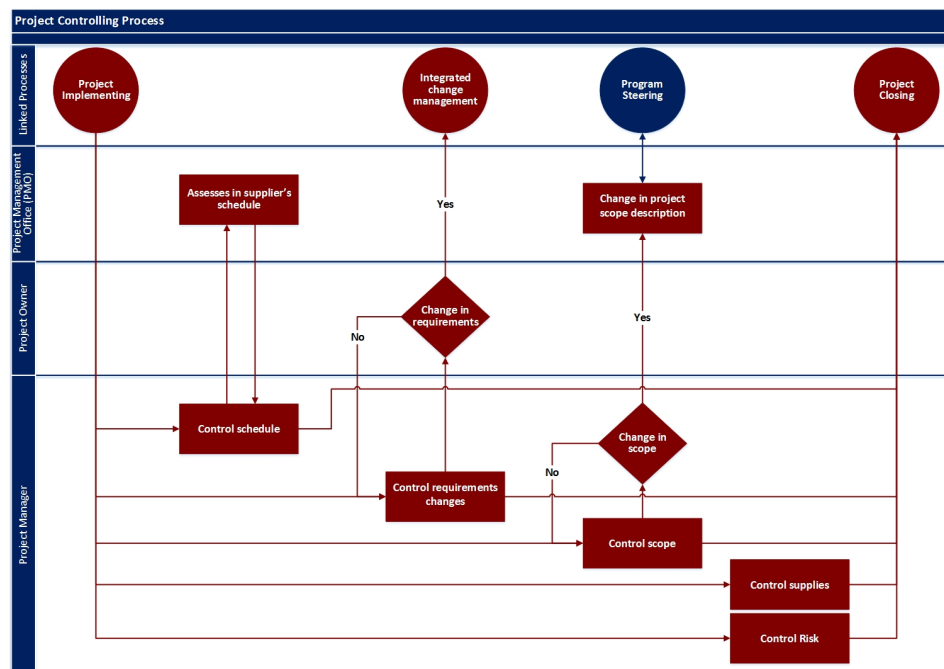


Figure 8. Project controlling process

As mapped in Figure 8, the project manager controls the schedule with the help of the Project Management Office (PMO). Also, the project manager controls requirement changes and gets an approval from the project owner. In addition, the project manager controls scope changes with the Project Management Office (PMO) in order to be escalated to the program steering. At all times, the project manager controls project supplies as well as project risk. At this point, if the project deliverables are met according to the project plan, the project moves to the closing process.

### 3.2.5 Project Closing Process

The project closing process is used to formally terminate the project, and to provide lessons learned. Figure 9 maps the project closing process starting from controlling project performance defined in the project controlling phase till the 'project closed' status.

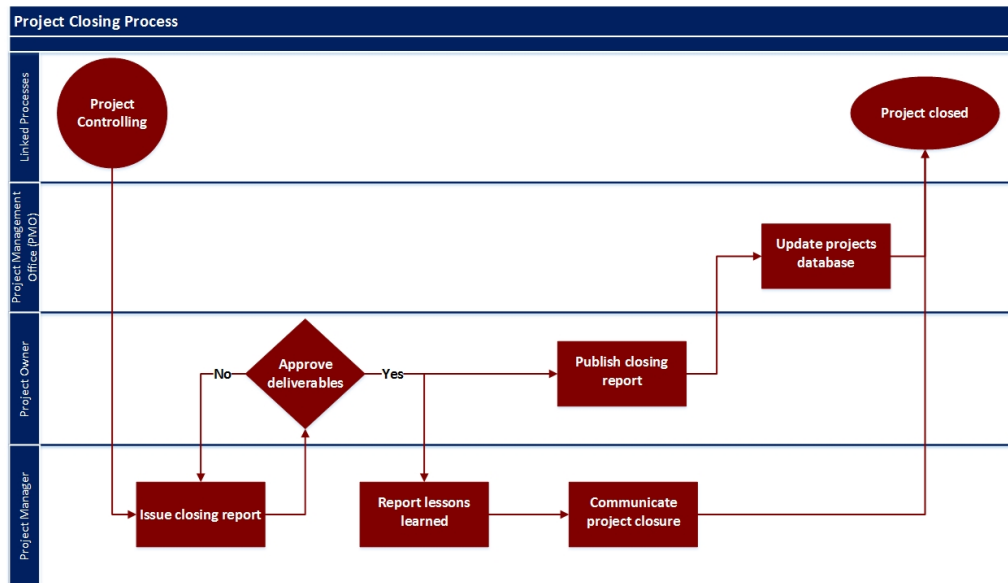


Figure 9. Project closing process

As mapped in Figure 9, the project manager issues the closing report to the project owner. In effect, the project owner approves deliverables and publishes the closing report. At the same time, the project manager reports lessons learned and communicate project closure. Correspondingly, the Project Management Office (PMO) updates the projects' database. That is where the project is officially declared as closed.

### 3.3 Description and Analysis of the Current Multi-Project Coordination Practices

This section presents the results found, and the analysis made during the interviews conducted within the case company concerning the current multi-project coordination practices.

After merging Figure 3 of the projects breakdown structure and Figure 4 of the project management processes, the gap in the multi-project coordination became evident. In particular, *Project Management Procedure* expected prospective significant amount of interface and coordination management of the projects during the project planning phase by stating that

*“Projects have a significant amount of interfaces. Project managers define needs for inputs, to whom they produce deliverables, and with whom they coordinate required common practices and applications.”*

*Project Management Procedure, Project Planning Phase*

What is more, during the project controlling phase, only scope changes are reported to the program steering group, whereas the project manager’s responsibility is to manage these coordination activities without a standardized process for the management of the interdependencies among projects as well as sub-projects as indicated below:

*“Responsibility of the Project Manager is to keep the scope up-to-date and in line with other projects.”*

*Project Management Procedure, Project Planning Phase*

Evidently, the interdependencies of the projects are not well defined and planned during the project planning phase. In addition, the project scope in terms of activities expand throughout the implementation phase. Furthermore, in the greenfield power plant project under study here, the number of projects and sub-projects is enormous. It consists of numerous coordination activities on project owners and project managers.

Those coordination activities are based on communication means, such as personal conversations, workshops, workgroups, meetings, and e-mails; therefore, coordination practices distinguished from one unit to another and even from team to team.

For instance, unit managers may appoint specific coordinators and/or interface engineers to assist in coordination activities; specifically, in meetings which is the most common coordination means with the supplier, and personal conversations as the most common coordination means within the case company.

Indeed, the below responses of three interviewees show the lack of a standardized process or formal approach; in addition to the difficulty of the communication based approach for managing the multi-project interdependencies.

*“Project managers, unit managers, and area managers communication is the coordination approach used presently. Currently it is not working perfectly but it is the method.”*

*Interviewee 1, PMO Project Manager*

*“Challenge is to keep people in the loop, even to keep myself in the loop, every now and then, they discuss issues without my participation.”*

*Interviewee 3, Project Manager*

*“We are having lot of meetings and several cases I have noticed that the same issues are handled in several meetings (and not always with the right persons participating).”*

*Interviewee 4, Unit Manager*

As a first attempt for resolution, the project areas (NI, TI, and OS), identified in Figure 1 and Figure 3, reorganized to include unit managers between area director (project owner) and project managers. Unit managers' responsibilities include technical coordination between project managers, as well as between other units.

In addition, several technical coordination groups are established, chaired by the project director and its members including area directors, engineering director, unit managers, and other responsible persons depending on the handled issues. To demonstrate, Figure 10 shows these different coordination levels along with the responsibilities.

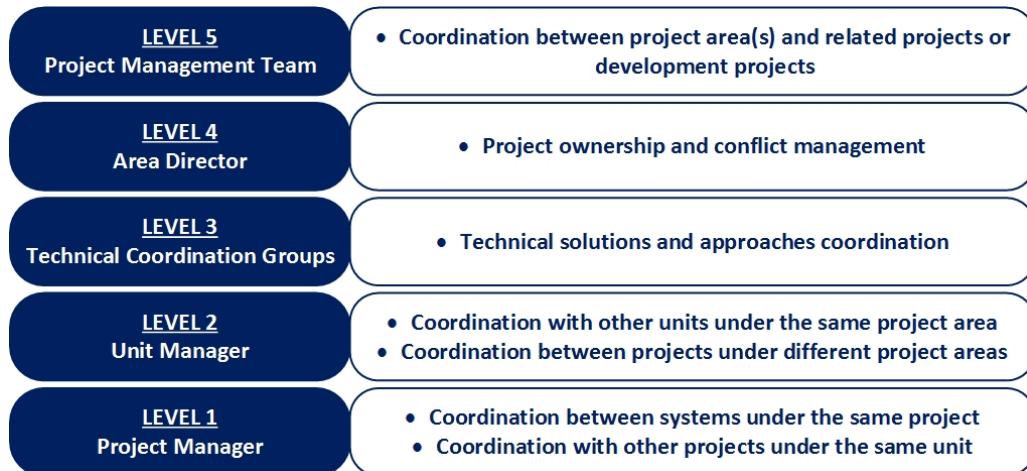


Figure 10. Coordination levels and responsibilities

As described in Figure 10, the first level is the project manager's coordination between systems under the same project or with other project under the same unit. The second level is the unit manager's coordination with other units under the same project area or between projects under different project areas. The focus of this thesis is on these two levels of coordination.



The third level is for the technical solutions and approaches coordination by technical coordination teams. The fourth level is for project ownership and conflict management by area director. It is worth mentioning that special core tasks can be also initiated for distinct purposes in case of multidisciplinary and time limited tasks. And as a result of a core task, a new project can be initiated by area director.

The fifth and last level is for the project management team to coordinate between the power plant project and related projects as well as development projects as shown in Figure 3.

Despite of all the changes mentioned, the coordination practices still constitute a problem for the case company. Besides, newly created levels of organizational hierarchy and groups led to overlapping responsibilities and/or scope gaps as well as hindering the overall program progress.

#### 3.4 Strengths and Weaknesses of the Current Processes and Practices

In conjunction with the current project management processes as well as the current multi-project coordination practices, several strengths and weaknesses were discovered as presented in Figure 11.



Figure 11. Strengths and weaknesses of the current coordination practices

As illustrated in Figure 11, the strengths and weaknesses are distributed over the project management processes and multi-project coordination practices. Four strengths and five weaknesses were revealed under the category of the project management processes.

Strengths include the availability of links between projects planning and organization strategy; moreover, the projects' scope of works is allocated to smaller sub-projects for better coordination. Additionally, the availability of project plans as well as collection of lessons learned are identified as strengths.

The weaknesses include the lack of supplier control in the projects governance process. Likewise, the supplier's project management processes are not yet lucid and project management processes are highly dependent on the supplier's processes; therefore, project management processes are relatively loose.

Accordingly, the vagueness of project breakdown structure as well as project activities augmentation as the project proceeds are identified as weaknesses. Correspondingly, project activities concerning project interfaces are not well-planned.

Meanwhile, three strengths and five weaknesses were discovered under the coordination practices category. The first strength is the simplicity of project initiation in case of interdependent projects works. The second strength is the availability of various technical coordination groups for interdisciplinary works. The third strength is the recognition of coordination activities in responsibilities.

On the other hand, weaknesses include the uncontrolled communication based coordination activities in spite of the availability of manage communication and stakeholders' management task in the project planning process. As a consequence, a conflict in coordination with supplier between different projects as well as units was recognized. These two weaknesses propagated to the coordination practices as a result of weaknesses in the project management processes.

Similarly, multi-project interdependencies are identified based on intuition and technical knowledge in addition to the impreciseness in priority setting were acknowledged as weaknesses in the coordination practices. That constituted several project delays because of delayed recognition of interdependencies.

Last of all, and as identified in the coordination levels shown in Figure 10, several levels of organizational hierarchy, such as unit managers, interface engineers were supplemented to the organization to cover the management of multi-project interdependencies.

### 3.5 Key Findings from the Current State Analysis

This section provides an overview of the key findings regarding strengths and weaknesses identified in the current state analysis stage. In particular, the main strengths of the current multi-project coordination practices should be reinforced and weaknesses should be improved. Furthermore, some of the current strengths contributed to the proposed coordination approach.

Some of those key findings are outside the focus area of this thesis; however, improvements on those key findings would certainly contribute to the coordination approach efficiency and effectiveness. Those key findings are presented in the next subsection. The rest of the key findings inside the thesis focus area are presented in Section 3.5.2

#### 3.5.1 Key Findings outside the Focus Area

This section offers a set of key findings outside this thesis focus area. Three out of ten key findings are characterized to be outside the focus area. Those key findings could be considered in further research projects.

Developing supplier control processes as part of the project governance processes constitute a problem for the case company. Specifically, in the case of a turnkey project where the supplier has the full responsibility of engineering, procurement, construction, and management.

Additionally, the reliance of project management processes on the supplier's project management processes needs to be investigated. That is particularly in the case of a turnkey project where the contractual obligation with the supplier includes project management responsibility.

As an example, supply chain management in projects is the sole responsibility of the supplier; therefore, different sub-suppliers under the project or sub-project are identified and managed through the supplier.

Lastly, the projects' breakdown structure along with work breakdown structure is not obvious at the moment; however, both the case company and the supplier are working on that subject. Precisely, instituting a clear product breakdown structure for a greenfield power plant becomes an essential demand in order to contribute to the effectiveness of the project management processes.

### 3.5.2 Key Findings inside the Focus Area

The rest of the weaknesses, of which there are seven in all, are covered under this thesis focus area. Those key findings revealed weaknesses in both the project management processes and the multi-project coordination practices. Furthermore, weaknesses are further classified into three groups. These three groups are driven from the challenges of the current project management processes and multi-project coordination practices inside the case company. Besides, these groups compromise the general subjects for further examination in the literature. As presented in Figure 12, the groups are time management, management of the multi-project interdependencies, as well as communication management.

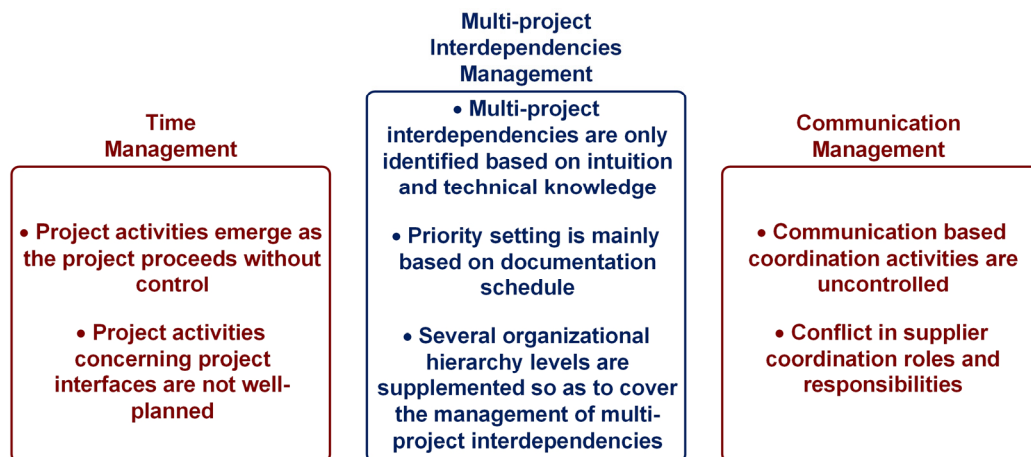


Figure 12. Grouping of key findings from the current state analysis

As Figure 12 illustrates, the key findings are distributed over the three groups. Deliberately, the management of the multi-project interdependencies is prioritized over the other two. Nevertheless, sorting out time management, as well as communication management, as part of project management processes, contributes to finding a solution for the management of the multi-project interdependencies.

Those three groups of key findings form the basis for the existing knowledge exploration and the conceptual framework construction research stage. This research stage is comprehensively explained in the next section.

## 4 Existing Knowledge on Greenfield Plant Projects Coordination in Relevant Literature

This section captures the existing knowledge and best practices in the coordination of the greenfield plant projects. Following the key findings identified in the previous section, this section starts with literature covering project management in terms of time management as well as communication management.

Afterwards, it scrutinizes literature on the management of the multi-project interdependencies as a vital function of program management. Finally, it concludes with the conceptual framework of this thesis.

### 4.1 Project Management: Time and Communication

This section explores the existing knowledge in project management via project management standards, methodologies, and best practices.

Following the project management framework in the case company, the International Organization for Standardization (ISO) standard on guidance for project management (ISO 21500) is examined. Besides, Project Management Institute (PMI) standard for project management is explored as well in order to provide an alternative standpoint.

While standards provide a foundation and guidelines for project management, different methodologies and tools can be used too and in harmony with the standards. One of those methodologies is Projects IN Controlled Environments (PRINCE2) that is examined as well. Therefore, the structure of this section contains the standards view point as well as the methodology and ends with the best practices for each topic. This structure applies as well for time management and communication management as part of the project management.

PMI (2013: 5) defines project management as the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Project management is accomplished through the application and integration of the project management processes. Those processes provides a set of activities required to manage the project.

ISO (2012: 25) categorizes project management processes into three types. The first type is the processes, which are specific to project management and determine how the activities selected for the project are managed. The second type is the delivery processes, which are not unique to project management, which result in the specification and provision of a particular product, or service. The third type is support processes,

which are not unique to project management and which provide relevant and valuable support to product and project management processes.

Alternatively, PMI (2013: 50) maps project management processes into five groups so as to ensure the effective flow of the project as shown in Figure 13

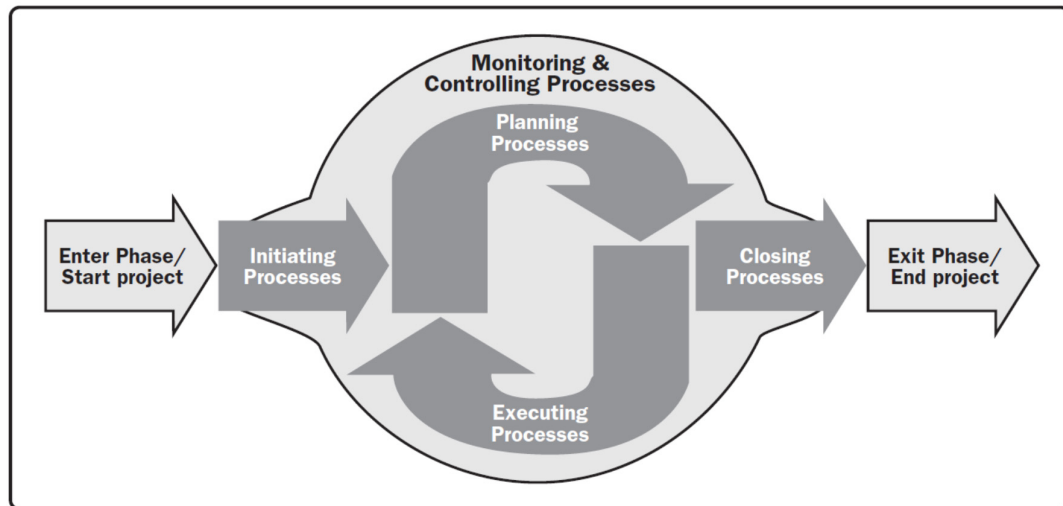


Figure 13. Project management process groups (PMI 2013: 50)

As mapped in Figure 13, project management process groups are initiating, planning, executing, monitoring and controlling, as well as closing. Notably, the project management processes and its process groups are presented as discrete processes with well-defined interfaces. Yet, those processes in practice overlap.

The initiating process group consists of those processes performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase. The planning process group consists of those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to attain those objectives. The executing process group consists of those processes performed to complete the work defined in the project management plan to satisfy the project specifications. (PMI 2013: 55)

The monitoring and controlling process group consists of those processes required to track, review, and orchestrate the progress and performance of the project; identify any areas in which changes to the plan are required; and initiate the corresponding changes. The closing process group consists of those processes performed to conclude all activities across all project management process groups to formally complete the project, phase. (PMI 2013: 57)

Typically, the project is identified by a project life cycle. A project life cycle is the series of phases that a project passes through from its initiation to its closure. The phases are generally sequential, and their names and numbers are determined by the management and control needs of the organizations involved in the project, the nature of the project itself, and its area of application. The phases can be broken down by functional or partial objectives, intermediate results or deliverables, specific milestones within the overall scope of work or financial availability. Phases are generally time bounded with a start and ending or control point. The project life cycle can be determined or shaped by the unique aspects of the organization, industry, or technology employed. The life cycle provides the basic framework for managing the project. (PMI 2013: 38)

When the project is divided into phases, the process groups interact within each phase; since the process groups are not project life cycle phases. In fact, it is possible that all process groups could be conducted within a phase. As projects are separated into distinct phases, such as concept development, design, build, or test. All of the process groups would normally be repeated for each phase until the criteria for phase completion have been satisfied. (PMI 2013: 52)

Similarly, APM (2012: 26) defines the project life cycle as the inter-related phases of a project to govern the progression of work. In addition, a project life cycle can take various forms to suit the context.

Typically, large and complex projects are frequently executed in an iterative fashion to reduce risk by allowing the team to incorporate feedback and lessons learned between iterations. Iteration here means repeating project activities as the project team's understanding of the product increases. (PMI 2013: 45)

When it comes to methodology, PRINCE2 classifies project management areas into plan, delegate, monitor, and control. Those project management areas are adjacent to project management process groups in PMI standard. In particular, PRINCE2 integrates project management processes along with seven principles, themes, and project environment. The principles are the core concepts used in the methodology. The themes are the recommendations on how to perform project management processes. Whereas, the project environment shows how to tailor the methodology to each specific project. PRINCE2 process model is depicted in Figure 14.



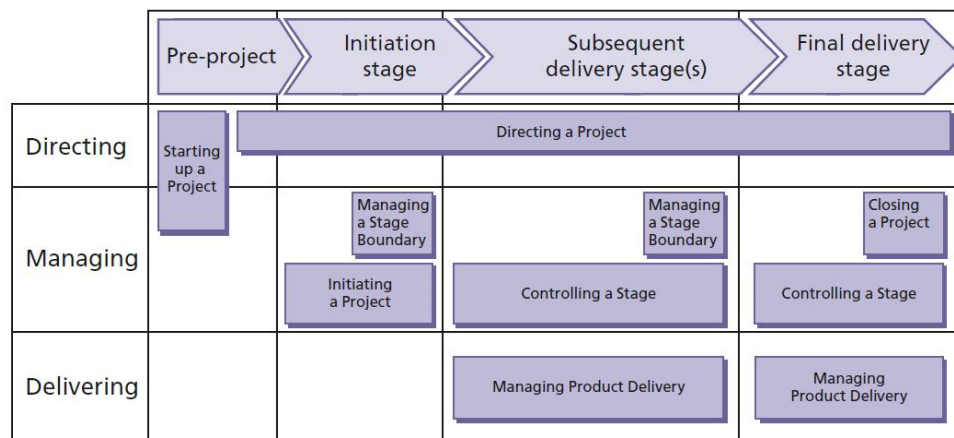


Figure 14. PRINCE2 process model (Hinde 2012: 15)

As illustrated in Figure 14, there are three horizontal rows that correspond to the project management structure. Those levels are project board representing direction, project manager representing management, and team manager representing delivery. Correspondingly, the seven project management processes used in this approach consist of starting up a project, directing a project, initiating a project, controlling a stage, managing product delivery, managing a stage boundaries, and closing a project. (Hinde 2012: 28)

On the other hand, in order to identify the project management processes along with the methodology for a specific project, PMI (2013: 63) identifies project integration management processes as the means to coordinate the various processes and project management activities. As part of the integration management processes, project management plan development is the process of defining, preparing, and coordinating all subsidiary plans and integrating them into a comprehensive project management plan. Figure 15 demonstrates the data flow diagram of project management plan development.



Figure 15. Develop a project management plan process: inputs, tools & techniques, and outputs (PMI 2013: 72)

As demonstrated in Figure 15, inputs to project management plan comprise project charter that defines the high level boundaries of the project as well as output from all other

planning processes. Additionally, the enterprise environmental factors and the organizational process assets are used as well. Enterprise environmental factors contain industry standards, information systems, and organizational structure. Organizational process assets contain standardized guidelines, work instructions, project management plan template, change control procedures, and lessons learned.

Expert judgement and facilitation techniques are utilized as tools and techniques to develop the project management plan. Expert judgement is utilized to tailor the process to meet the project needs, develop technical and management details, and determine resources and skill levels needed to perform project work. Facilitation techniques are the tools used to guide the development of the project management plan, such as brainstorming, conflict resolution, problem solving, and meeting management.

The final project management plan includes the project's scope, schedule, and cost. It may also include a life cycle selected for the project and the processes that will be applied to each phase; furthermore, it includes a description of how the selected processes will be used to manage the specific project, including the dependencies and interactions among those processes and the essential inputs and outputs.

Subsidiary plans can also be included to this development, such as scope management plan, schedule management plan, communication management plan, and stakeholder management plan.

In fact, due to the potential for change in projects, the development of the project management plan is an iterative activity and is progressively elaborated throughout the project's life cycle. Progressive elaboration involves continuously improving and detailing a plan as more detailed and specific information and more accurate estimates become available. For projects that exist in the context of a program, project management plan is developed in consistent with the program management plan. (PMI 2013: 74)

While the project management plans are primary documents used to manage the project, other project documents are also used. Those project documents may include activity list, activity attributes, activity duration estimates, and milestone list (PMI 2013: 78)

Updates arising from approved changes during the project may significantly impact parts of the project management plan and the project documents. Those update are documented to the project management plan or to various project documents.

In terms of best practices in complex projects, Dinsmore & Cabanis-Brewin (2014: 47) provide typical elements to be included in the project management plan. Those elements include mission and objectives, work scope, planning basis, work breakdown structure,

resource plan, logic and schedules, risk analysis and contingency plan, quality and productivity plan, in addition to documentation and configuration management plan.

After exploring the project management literature and its processes in this section and following the key findings from the current state analysis stage, time management as well as communication management are studied in more detail in the next two subsections.

#### 4.1.1 Time Management

Time management includes the processes required to manage the completion of the project on time. Precisely, In order to manage the project efficiently during the project life cycle, a set of activities should be performed in each phase, thus a project phase is a collection of logically related project activities. Project phases usually completed sequentially, but it can overlap too. Project phases are collectively known as the project life cycle. This structure allows the project to be easily and efficiently managed, planned, and controlled through logical subsets. (PMI 2013: 41)

In particular, PMI standard and PRINCE2 methodology share two key features. Firstly, projects are delivered in stages, and secondly, certain common project management processes run across these stages.

In detail, according to (Hinde 2012: 24), one of the PRINCE2 principles is managed by stages principle. This principle ensures that projects are divided into number of time periods called stages. The project is planned, managed, and controlled in a stage-by-stage basis. At the end of each stage, the project board assesses the performance of the last stage, and plans for the next stage, then decides whether to proceed with the next stage or not. Stages have a high-level project plan for the whole project and a very detailed plan for the current stage, also, they make sure that the plans for future stages can also learn from previous stages.

As established, the decomposition of the project to stages requires defining and sequencing activities as parts of the time management. Therefore, each of those processes is described below in details.

Defining activities is the process of identifying and documenting the specific actions to be performed to produce the project deliverables. Figure 16 demonstrates the data flow diagram of that process.

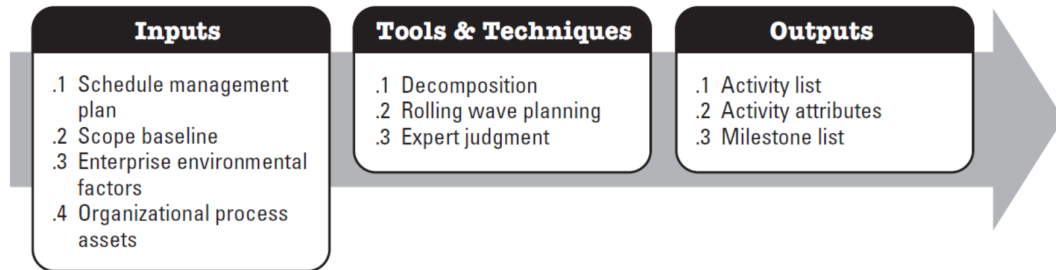


Figure 16. Define activities process: inputs, tools & techniques, and outputs (PMI 2013: 150)

As demonstrated in Figure 16, inputs to define activities include schedule management plan and scope baseline. Those plans prescribe the level of detail necessary to manage the work as well as the project work breakdown structure (WBS), project deliverables, constraints, and assumptions. Besides, enterprise environment factors and organizational process asset are used as well as described in project management plan development process.

Tools and techniques used to define activities contain decomposition, rolling wave planning, and expert judgement. In detail, decomposition is a technique utilized for dividing the project scope and project deliverables into smaller manageable parts where the final outputs of this process is defined as activities rather than deliverables.

Rolling wave planning is an iterative planning technique in which the work to be accomplished in the near term is planned in detail, while the work in the future is planned at a higher level. Expert judgement is utilized from the project team members or other experts who are experienced and skilled in developing detailed project scope and activities allocation.

The define activities process outputs comprise the activity list along with activity attributes, and the milestone list. Comprehensively, the activity list is a comprehensive list that includes all schedule activities required on the project. The activity list also includes the activity identifier and a scope of work description for each activity in an adequate detail understandable to the project team members. Each activity has a unique title that describes its place in the schedule. (PMI 2013: 152)

Activities have durations, during which the work of that activity is performed, and may have resources and costs associated with that work. Activity attributes extend the description of the activity by identifying the multiple components associated with each activity. The components for each activity evolve over time. During the initial stages of the project, they include the activity identifier, and activity label or name, and when completed, may include activity codes, activity description, predecessor activities, successor

activities, logical relationships, leads and lags, resource requirements, imposed dates, constraints, and assumptions. As a final output, a milestone list is a list identifying all project a significant points or events in a project and indicates whether the milestone is mandatory or not. (PMI 2013: 153)

Activities identification best practice suggests to understand the issues that currently exist and exactly what the project is expected to deliver. These steps are forerunners to define activities process. These steps will support in identifying the interdependencies among activities. Thus, start from the beginning, not the end, and resist the temptation to focus only on dates; although later it will be necessary to come back and look at how the “realistic” plan fits into the project. At this point, it is not imperative to have the entire team available, as the focus is not on creating dependencies. The lead of each project area can provide enough input to develop and define those activities. (Dinsmore & Cabanis-Brewin 2014: 87)

Besides, Gustavsson & Jerbrant (2012) highlight the importance of a task list as an alternative form of activity list in multi-project work. A task list is an aid to stage-gate-models in order to avoid frequent interruptions and adjustments between projects. Similarly, a task list guides decision-making, planning, control, reporting, and prioritizing. Furthermore, a task list solves action challenge in multi-project work by supporting control through short-term and long-term actions. However, there are risks involved with task list implementation, for instance the tendency to prioritize by exclusion and focusing on fewer tasks.

Since the task list and milestone list have the inability to show the interdependencies between activities, sequence activities process as part of the time management processes is studied. Sequence activities is the process of identifying and documenting relationships among the project activities. Figure 17 demonstrates the data flow diagram of that process.

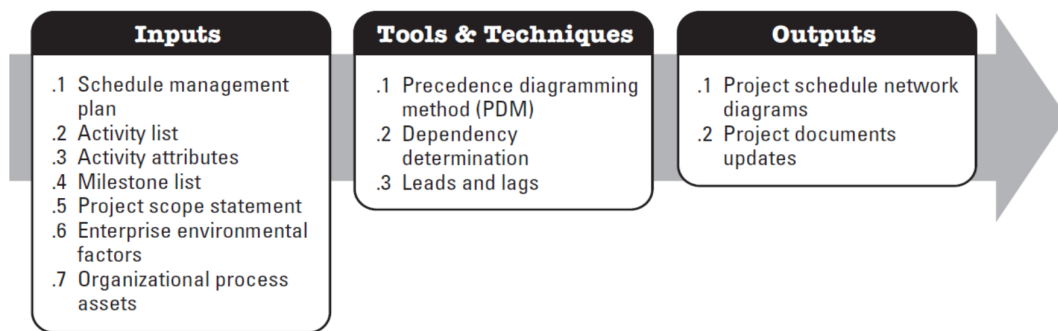


Figure 17. Sequence activities process: inputs, tools & techniques, and outputs (PMI 2013: 153)

As demonstrated in Figure 17, inputs to sequence activities process include the same inputs used for define activities process. Those inputs are schedule management plan, enterprise environmental factors, and organizational process assets. Additionally, define activities process outputs are used as inputs as well. Those are activity list, activity attributes, milestone list. Project scope statement is utilized as well as an input to sequence activities. Project scope statement contains the description of the product(s) delivered as part of the project. (PMI 2013: 154)

Tools and techniques used to sequence activities include a precedence diagramming method, dependency determination, in addition to leads and lags. Each of these techniques is described below in detail.

The precedence diagramming method (PDM) is a technique used to construct a schedule model in which activities are represented by nodes and are graphically linked by one or more logical relationships to show the activities sequence. In general, a predecessor activity is an activity that logically comes before a dependent activity in a schedule. Whereas, a successor activity is a dependent activity that logically comes after another activity in a schedule. (PMI 2013: 156)

PDM includes four types of dependencies or logical relationships. These relationships are Finish-to-Start (FS), Finish-to-Finish (FF), Start-to-Start (SS), and Start-to-Finish (SF). Finish-to-start is a logical relationship in which a successor activity cannot start until a predecessor activity has finished. Finish-to-finish is a logical relationship in which a successor activity cannot finish until a predecessor activity has finished. Start-to-start is a logical relationship in which a successor activity cannot start until a predecessor activity has started. Start-to-finish is a logical relationship in which a successor activity cannot finish until a predecessor activity has started. (PMI 2013: 157)

A second technique utilized in sequence activities process is dependency determination. Dependency is the reliance between activities where an activity uses an outcome of another activity. In detail, dependencies is characterized as mandatory or discretionary, internal or external. In mandatory dependencies, dependencies are legally or contractually required or inherent in the nature of the work. Discretionary dependencies are established based on knowledge of best practices within a particular application area where a specific sequence is desirable, even though there are other suitable sequences. External dependencies involve a relationship between project activities and non-project activities, such as components procurement. Internal dependencies encompass a precedence relationship between project activities. (PMI 2013: 158)

A third technique utilized in the sequence activities process is leads and lags. A lead is the amount of time whereby a successor activity can be advanced with respect to a predecessor activity. Lead is often represented as a negative value. A lag is the amount of time whereby a successor activity will be delayed with respect to a predecessor activity. (PMI 2013: 158)

Outputs of the sequence activities process are project schedule network diagram, as well as updates to originally established project documents, such as activity list, activity attributes, milestone list, and risk register. To enumerate, the project schedule network diagram is a graphical representation of the logical relationships and dependencies, among the project schedule activities. Figure 18 illustrates a sample of a project schedule network diagram.

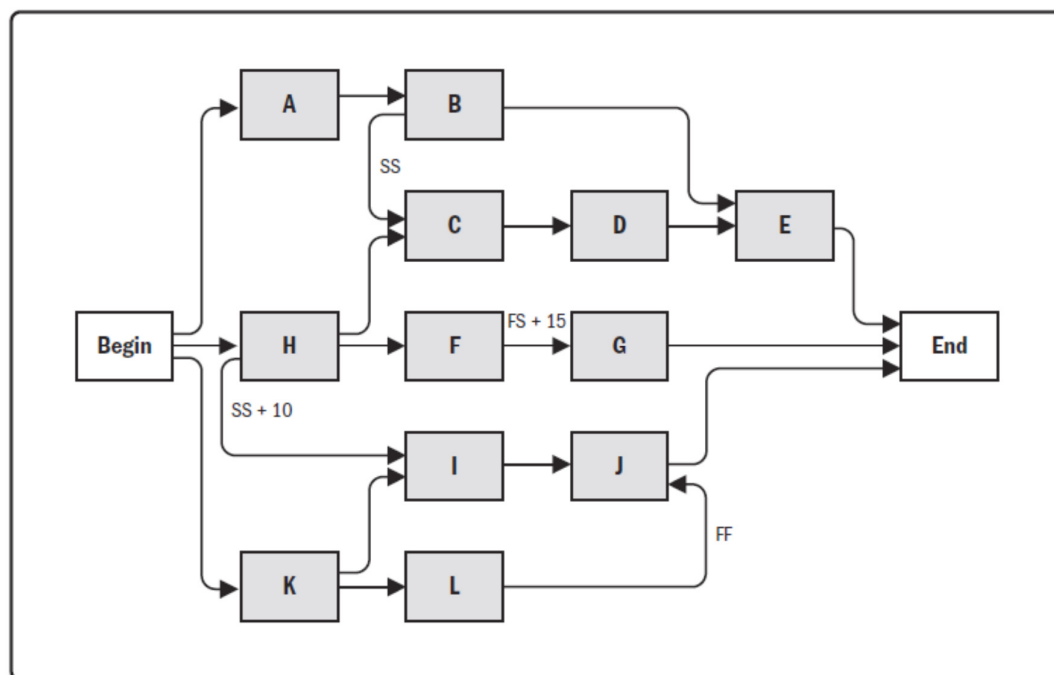


Figure 18. Project schedule network diagram (PMI 2013: 160)

As shown in Figure 18, the project schedule network diagram includes activities with precedence, dependency, as well as lag and lead relationships. Also, it can include full project details in terms of activities as elements of processes. In fact, various types of network scheduling techniques are used to coordinate the flow of information in processes, such as Program Evaluation and Review Technique (PERT), and the Critical Path Method (CPM).

PERT chart is constructed to determine how much time is needed to complete the project, therefore, it uses time as a common denominator to analyze those elements that directly influence the success of the project. Later on, a similar technique was initiated that is known as the critical path method (CPM). (Kerzner 2013: 498)

PERT technique advantages comprise the disclosure of activities independencies in addition to the impact of later start or early start through extensive planning. In addition, PERT has the ability to evaluate the effect of project changes on another project. Figure 19 illustrates a simplified PERT network diagram

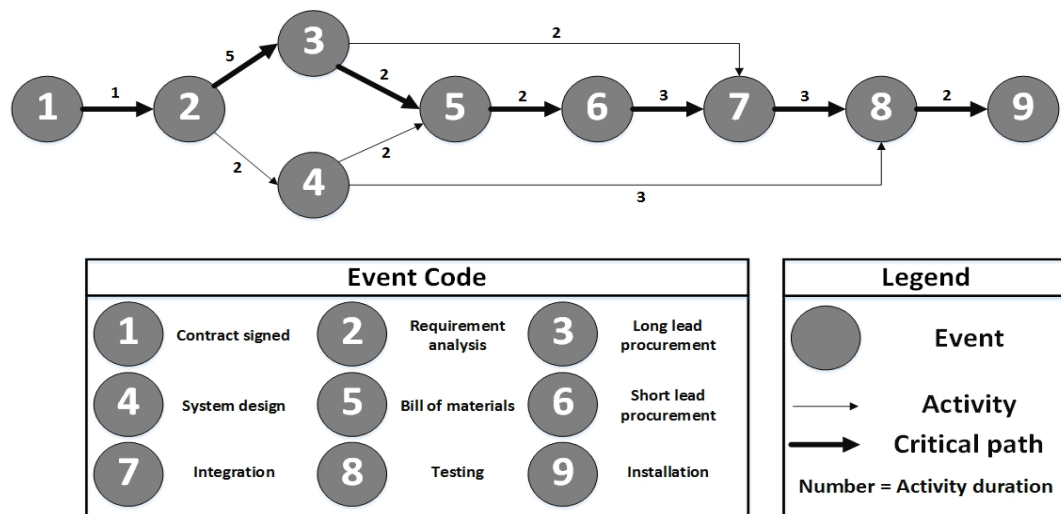


Figure 19. Simplified PERT network diagram (Adopted from Kerzner 2013: 500)

As shown in Figure 19, PERT technique distinguish between event and activity. Event is equivalent to a milestone indicating when an activity starts or finishes. Whereas, activity is the element of work that must be accomplished. Where, the duration is the total time required to complete the activity. Furthermore, the bold line represents the critical path which is the longest path or time span through the network. It is also the shortest amount of time necessary to accomplish the project. (Kerzner 2013: 496)

The principles discussed so far apply to PERT and CPM techniques. However, PERT technique uses three time estimates (optimistic, most likely, and pessimistic) to derive an expected time, whereas CPM uses one time estimate that represents the normal time. (Kerzner 2013: 499)

Since the critical path represents the longest path in the network, the other paths must be either equal in length to or shorter than that path. Therefore, there must exist events and activities that can be completed before the time when they are actually needed. The time differential between the scheduled completion date and the required date to meet



critical path is referred to as the slack time. PERT network diagram can be further enhanced by appending earliest and latest time for each event. (Kerzner 2013: 502)

Furthermore, PERT network diagram encompasses four values cover the earliest and latest times for each activity. Those are the earliest time when an activity start (ES), the earliest time when an activity can finish (EF), the latest time when an activity can start (LS), and the latest time when an activity can finish (LF). (Kerzner 2013: 504)

Activities sequencing best practice recommends to focus first on those tasks within a particular team of the project and push for a discussion on what is needed for each of those activities to get started. Be aware of the risk of documenting too much detail; for that reason, one helpful guideline is to base the amount of detail on the complexity and length of the project. During this discussion, ask if tasks can start sooner, as opposed to a “Finish-to-Start” relationship. Also, performing tasks in parallel could result in over allocation of resources and/or rework if a problem occurs with the first task. Beware of overlapping dependencies, such as tasks that have a Start-to-Start or Finish-to-Finish dependency. These tasks can prove to be a block point in the timeline. (Dinsmore & Cabanis-Brewin 2014: 88)

To determine the sequence of activities, bring in a few experts/leads from each team and sub-team to discuss the dependencies. Start linking activities that come out of these discussions. Use “What happens next?” and “What do you need to get started?” questions. If there is a disagreement among the teams, document those disagreements. If the majority of the team can agree that should be sufficient. (Dinsmore & Cabanis-Brewin 2014: 89)

As deliberated, identifying and sequencing activities and later on, communicating and distributing improvements require an effective communication management process in place. Therefore, the next section discusses project communication management as part of project management.

#### 4.1.2 Communication Management

Communication is a vital element for all the parties involved in the project and communication ranks high among the factors leading to the success of a project. ISO (2012: 32) underlines the importance of communication management in projects since the communication management process focuses on increasing the understanding and cooperation among the various stakeholders through good communications. Moreover, providing timely, accurate and unbiased information and resolving communication issues to minimize the risk that the project is negatively affected by unknown or unresolved stakeholder

issues or misunderstandings. Comprehensively, the communication management plan should be developed during project planning and eventually, communication management plan should be regularly reviewed and revised as needed in later project stages.

Correspondingly, PMI (2013: 287) identifies that the communication management comprises the processes required to ensure timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and the ultimate disposition of project information. The communication management comprises plan communication process and manage communication process. Therefore, each of those processes is described below in details.

Plan communication is the process of developing an appropriate approach and plan for project communications based on stakeholder's requirements, as well as available organizational assets. Figure 20 demonstrates the data flow diagram of that process.

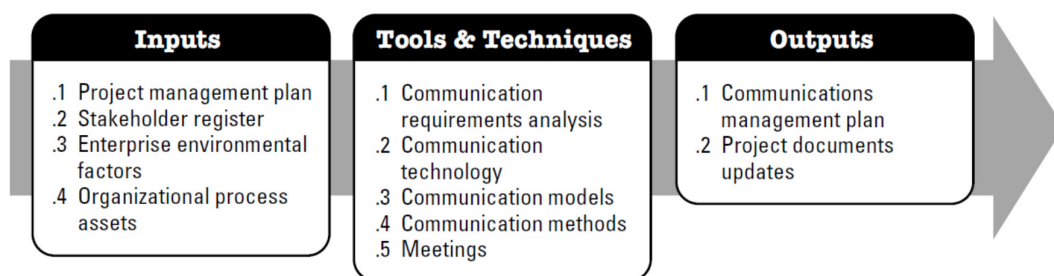


Figure 20. Plan communication process: inputs, tools & techniques, and outputs (PMI 2013: 289)

As demonstrated in Figure 20, inputs to the plan communication process include project management plan as an output for plan project management process, and stakeholder register that provides the information needed to plan the communication with project stakeholders. Besides, enterprise environment factors and organizational process asset are used as well as described in project management plan development process.

Tools and techniques used to plan communication include communication requirement analysis, communication technology, communication models, and communication methods, and meetings. To demonstrate, communication requirements analysis determines the information needs of the project stakeholders in addition to the methods used to transfer information among project stakeholders along with the choices made. Also, meetings are used as one communication technique for work requiring discussion and dialogue. Consequently, the communication management plan is developed as an output of the communication planning process, besides any relevant project documents are updated.

Actually, the communication management plan is a component of the project management plan that describes how project communications are planned, structured, monitored, and controlled. It contains information, such as stakeholder communication requirements, person responsible for communicating the information, Methods or technologies used for communication, and escalation process. (PMI 2013: 296)

Similarly, APM (2012: 53) obligates the development of project communication management plan that conform to policies set out in the communication management plans of the program.

Alternatively, PRINCE2 recommends a communication management strategy that describes how the project management team will communicate with each other. It contains the communication procedure, tools and techniques, records, reporting, timing of communication activities, roles and responsibilities, stakeholder analysis, information needed for each interested party. The communication management strategy is created at the beginning of the project and reviewed at the end of each stage. (Hinde 2012: 93)

In practice, the communication management plan is based upon five fundamental questions. Those questions are who will make decisions on issues, who will develop an action list of tasks and who will be responsible for the tasks, when will these tasks be completed and reported, how will other pertinent information be distributed, and to whom will the information be delivered. (Dinsmore & Cabanis-Brewin 2014: 174)

After developing the communication management plan, communication throughout the project life cycle is managed according to communication management plan; therefore, manage communication the process of creating, collecting, distributing, storing, retrieving, and the ultimate disposition of project information in accordance to the communications management plan. Figure 21 demonstrates the data flow diagram of that process.

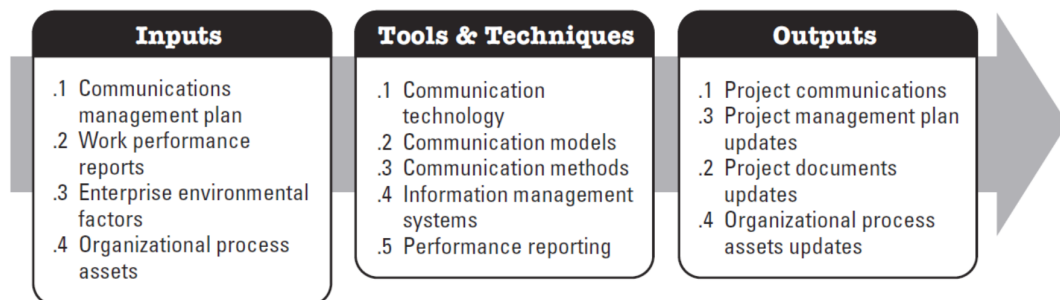


Figure 21. Manage communication process: inputs, tools & techniques, and outputs (PMI 2013: 297)

As demonstrated in Figure 21, inputs to manage communication process include the same inputs used for plan communication process. Additionally, plan communication process outputs are used as inputs as well. Besides, work performance reports are used to manage communication. Work performance reports are the measurements identified during activities performance to accomplish the project work such as activities reports.

Tools and techniques used to plan communication include the same tools and techniques used for plan communication process. Additionally, Information management system, and performance reporting are utilized. Information management system is the various tools used for communication. Performance reporting is the collection and distribution of performance information, including status reports, and progress measurements.

Consequently, project communications as an output from manage communication process is the activities required for the information to be created, and distributed, such as performance reports, and project status. Updates to project management plan, project documents, and organization process assets, such as reports and stakeholders notifications. (PMI 2013: 301)

In practice, to achieve project success through stakeholder management, the project manager must understand who determines success, what their motivations are, and what costs are involved. Hence, the project team is built to address all stakeholder requirements by categorizing project stakeholder. (Dinsmore & Cabanis-Brewin 2014: 182)

Furthermore, projects are usually considered successful if the objectives are well defined, work is accomplished as scheduled, and resources are used efficiently. However, projects rarely function as perfectly as planned. One reason is that project objectives have different meanings for different people, therefore, the project manager needs to establish success goals, identify the success process, develop a project success scenario, and finally, define the project team's modus operandi. (Dinsmore & Cabanis-Brewin 2014: 183)

Up to the present time, project management literature and best practices were studied in order to improve time management and communication management for each individual project. Nevertheless, to comprehend the interdependencies between projects, program management literature and best practices were scrutinized in the next subsection aimed at the management of multi-project interdependencies.

#### 4.2 Program Management: Multi-Project Interdependencies

A program is defined as a group of related projects or subprograms. Program activities are managed in a coordinated way to obtain benefits not obtainable from managing them individually. Program management focuses on interdependencies between projects and helps to determine the optimal approach for managing and realizing the desired benefits. Program management functions comprise resolving resources conflicts, aligning organizational/strategic direction with projects and program goals and objectives, and resolving shared program governance structure issues. (PMI 2013: 9)

Similarly, APM (2012: 14) defines program as the coordinated management of projects where projects coordination is managing interdependencies between projects and its relation to business activities.

Correspondingly, MSP (2011) as a program management methodology provides a structured framework with principles, practices, and processes that can help organizations deliver successful programs. Furthermore, it necessitates the availability of monitoring and control strategy to manage interdependencies between projects. This monitoring and control strategy defines how the program will apply internal controls to itself.

In harmony with project management, PRINCE2 methodology identifies the program management entity as the top level of management in a project. To elaborate, the program management function is to initiate the project by creating the project mandate that describes the project. The project mandate might be detailed; particularly when the project is part of a program with a coherent aim. (Hinde 2012: 83)

Notably, the program is typically coupled with the organizational strategy framework. This framework utilizes projects, and program management along with organization practices to deliver organization strategy. In detail, projects and program management activities should be aligned with this top-level organizational strategy and business direction, and if there is a change, then the projects as well as the program objectives need to be realigned. For instance, a mix of related projects could be collected, organized, and managed as one program to align projects objectives. (PMI 2013: 14)

Program management best practices recognizes that the process of handling multiple projects is fundamentally the same as handling single projects; however, the integrated planning of each single project in case of a program should not only look at the internal task interdependencies but external interdependencies with other projects as well. Those external interdependencies include the influence of functional organizations, and sub-

contractor activities. Respectively, research studies exposed that improvement in coordination of interdependent activities is a distinct feature of the organization that has demonstrated competence in managing projects. (Dinsmore & Cabanis-Brewin 2014: 350)

Furthermore, interdependencies between projects should be considered in the course of projects initiation. As by increasing interdependencies between projects; the project organization in addition to the project work become less predictable. (Gustavsson & Jerbrant 2012)

In particular, managing projects in a large setting programs requires an implementation of a Project Management Office (PMO). A PMO is a management structure that standardizes the project related governance processes and facilitates the sharing of resources, methodologies, tools, and techniques. PMO responsibilities range from providing project management support functions to being responsible for the direct projects management. Besides, the PMO evaluates how higher level strategic objectives are being fulfilled and integrates data from strategic projects. (PMI 2013: 10)

There are several types of PMO structures, such as supportive, controlling, and directive. Each of those structures varies in the degree of control and influence on projects within the organization. A primary function of the PMO is to support project managers in identifying and developing project management methodology, best practices, and standards. Therefore, PMO develops project policies, procedures, and templates and afterwards, PMO is coaching, training, and monitoring compliance to it. On top of that, PMO is coordinating communication across projects. (PMI 2013: 11)

In practice, Darling & Whitty (2016) suggest that the PMO should be a liaison between complex relationships of strategy and projects. Furthermore, PMO should conduct project reviews and supervises lessons learned from project to project. Additionally, KPMG (2017: 8) in its project management survey highlights that 56 per cent of organizations use PMO to coordinate between interdependent projects.

Therefore, standardization as a common function of PMO found in different literature. Many practitioners believed that PMOs perform particular roles or functions which attempt to standardize project management methodology, and 75 per cent of those surveyed organizations utilize the standardized practice regularly. Moreover, when implementing PMO functions, different standards and practices should be reviewed and examined, since PMO functions are changed over time. Moreover, what is claimed to be best practices in one case might not be the best for other cases. (Darling & Whitty 2016)

Coordination and managing interdependencies between projects as one of PMO functions can take several forms. One form is time and communication management that is studied in the previous section. Another form is the standardization of the management process of multi-project interdependencies. In general, multi-project interdependencies refer to mutual dependences between projects as perceived for the current state analysis stage. This mutual dependence is recognized between projects' stages as well as between projects' activities.

In particular, PERT and CPM as schedule network diagramming techniques presented in Subsection 4.1.1 don't capture coupled iterations in activities relationships; moreover, they prohibit those iterations due to the cyclic inaccuracies resulting in the inability to calculate the critical path. (Eppinger & Browning 2012: 134)

Yet, those iterations are a distinct phenomenon of Greenfield plant projects due to its enormous number of projects and sub-projects accompanied by stages and activities carried out concurrently. Thus, a different technique is scrutinized. That is Dependency Structure Matrix (DSM) technique. Design structure matrix term refers also for the same technique.

The DSM is a network modeling tool used to represent the elements comprising a system or process and their interactions by highlighting the system or process architecture. DSM is been applied in the applications of complex systems development, engineering management and project management. The DSM is represented as a square  $N \times N$  matrix, mapping the interactions among the set of  $N$  process elements. Compared with other network modeling methods, the primary benefit of DSM is the graphical nature of the matrix display format. The matrix provides a concise and intuitively readable representation of a process architecture especially when the processes are complex and iterative. (Eppinger & Browning 2012: 9)

This process architecture describes its activities as elements and their relationships as interactions. Those activities and relationships form the structure of the process architecture that is initially designed and continuously evolves over time. (Eppinger & Browning 2012: 7)

The type of DSM used for process modeling is the process architecture DSM, also called activity-based DSM. Typically, the term process refers to an entire DSM model and the term activity refers to one of the elements within it where the interactions are the flows of information between activities. The full names of the activities are often listed to the left of the rows. (Eppinger & Browning 2012: 131)

The cells along the diagonal of the matrix represent activities corresponding to the nodes in the project network diagram. Each diagonal cell is potentially having inputs entering from its left and right sides and outputs leaving from above and below. The sources and destinations of these input and output interactions are identified by marks in the off-diagonal cells equivalent to the directional arcs in the project network diagram. Figure 22 shows a simple DSM model of a process along with its equivalent graph representation of project network diagram.

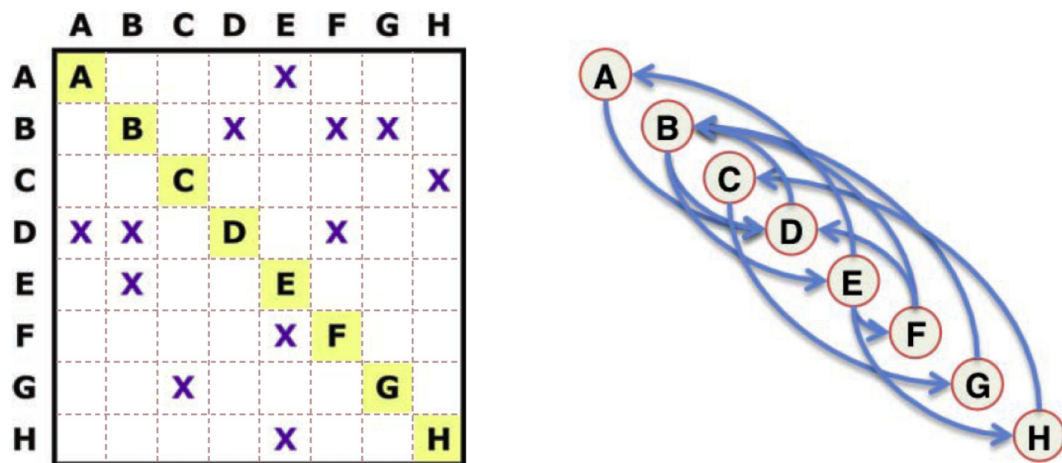


Figure 22. DSM model (Eppinger & Browning 2012: 4)

As shown in Figure 22, DSM has eight activities labeled from A to H where activity's inputs are shown in its rows and its outputs shown in its columns. Accordingly, marks in any row in the matrix reveals all of the inputs to the activity in that row. Similarly, marks in any column of the matrix shows all of the outputs from the activity in that column. For example, element D has inputs from elements A, B, and F, represented by the X marks in row D, columns A, B, and F. Reading down column F, we see that element F has outputs going to elements B and D.

As demonstrated, this simple DSM is called a binary DSM because the off-diagonal marks indicate the presence or absence of an interaction. However, the binary DSM can be extended to include further attributes of the interactions, such as the number of interactions or the impact. Those attributes can be represented by numerical values. Additionally, DSM can be used to capture several interdependencies using Multi Domain Dependency Matrix (DDM). (Eppinger & Browning 2012: 5)

In the area of project management that is concerned with the management of process flow, the main advantage of DSM is the emphasis on interactions between activities. DSM indicates the flow of information that establishes activities dependencies with the



representation of the full set of inputs and outputs for each activity. Moreover, DSM is improving the order of activities. (Eppinger & Browning 2012: 133)

In detail, process architecture consists of three types of mappings. The first one is the hierarchical decomposition of the process into activities. This type of mapping encompasses project breakdown structure, activity list, and attributes as deliberated in Subsection 4.1.1. The second one is input/output relationships between activities. DSM is applied for this type of mapping. The third one is various mappings of meta-relationships between activities such as multiple instances of similar activities; however, such relationships assumed to be nonexistent in project management processes. (Eppinger & Browning 2012: 132)

Figure 23 illustrates how the process DSM is used to represent interactions among activities using different types of activities relationships.

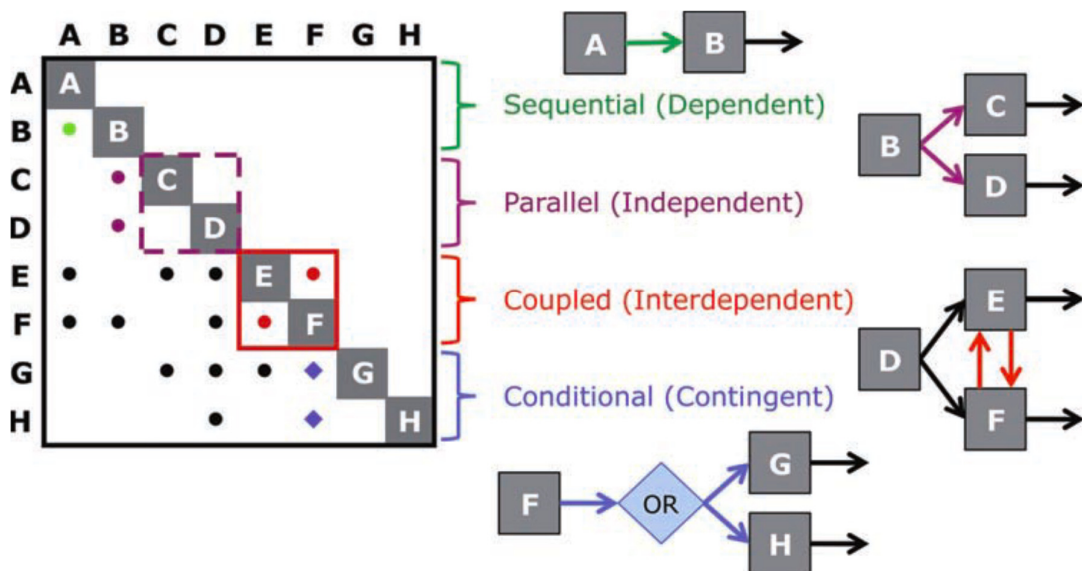


Figure 23. Activity relationships in process DSM (Eppinger & Browning 2012: 134)

Four fundamental types of activities relationships along with its representation in DSM are elucidated in Figure 23. Those types are sequential, parallel, coupled, and conditional. Sequential activities are activities executed sequentially where the output of the upstream activity enables execution of the downstream activity. Sequential activities may be partially overlapped where starting of the downstream activity is allowed before the upstream activity is completed; however, overlapping requires careful analysis of each finish-to-start dependency.

Parallel activities are activities without input/output interaction between them; therefore, they are executed simultaneously. Coupled activities are activities where each activity

needs input from one or more of the other activities. Thus, these activities iterate until a mutually satisfactory solution is reached. Coupled activities are common in project management, particularly where uncertainties are addressed. Conditional activities are activities where the execution of the downstream activity is dependent on decisions made in the upstream activity. As a feature of coupled activities, iterations involve the repetition of activities. Iterations are represented by feedback loops or cycles in the process. Sources of iterations include inherent coupling, poor activity sequencing, incomplete activities, poor communication, input change, or mistakes. Some of these sources can be avoidable through careful process analysis; whereas, other types of iteration are more fundamental to the process and need to be planned and managed differently. (Eppinger & Browning 2012: 135)

To model the activities relationships in the process, the process architecture DSM principally follows a five-step approach as illustrate in Figure 24.

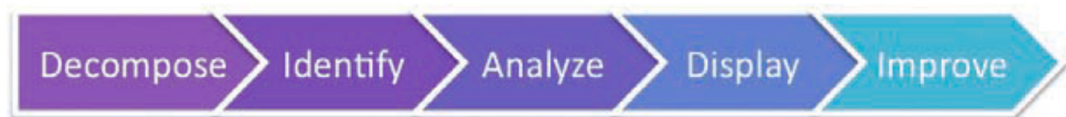


Figure 24. DSM approach to modeling and analysis (Eppinger & Browning 2012: 10)

As depicted in Figure 24, the steps of process architecture modeling are decompose, identify, analyze, display, and improve. Decompose as a first step comprises decomposing the overall process down into its activities via intermediate sub-processes and stages if needed. Besides, lay out the DSM with activities and label the rows and columns. Identify as a second step contains identifying the known interactions that is input/output relationships between the activities and represent these using marks or values in the DSM cells. (Eppinger & Browning 2012: 138)

Analyze, as a third step, involves analyzing the activities and rearranging the activities and relationships to understand structural patterns and their implications for process behavior. Sequencing is the most common method for analyzing DSM models. Sequencing is a DSM partitioning analysis that involves reordering the rows and columns of the DSM to minimize iterations. (Eppinger & Browning 2012: 141)

The main aim of sequencing is to find the order of activities that minimizes the amount of feedback in the process. What is more, if feedbacks are unavoidable, then short feedbacks are preferable to long ones. A typical example that a mark in the upper right corner of the DSM indicates a potential return from the end of the process all the way back to the beginning. (Eppinger & Browning 2012: 142)

To demonstrate, activities usually begin and end at different times. It is usually preferable to perform the activity when all of its inputs are ready and available; however, because inputs come from other activities, the input/output relationships among the activities provide the initial basis of their appropriate sequence. When an activity begins without all of its inputs, it uses assumptions as an alternative solution for those missing inputs; though, that is a double-edged sword in a project process. Using assumptions adds a rework risk as well as the risk that the assumptions will be partially or even completely invalidated when the actual input becomes available. (Eppinger & Browning 2012: 141)

Display, as a fourth step, embraces displaying and creating a useful representation of the DSM model, as well as highlighting features of particular importance or of special interest in the DSM model. Improve as a fifth and final step includes improving the process through actions taken as a result of the DSM analysis and interpretation of its display. (Eppinger & Browning 2012: 10)

In terms of DSM model operations, sequencing a DSM as an analysis method might not much change the original sequence of activities and the overall process; for that reason, several operations are identified to resolve coupled activities. Those are decomposition, aggregation, adding new activities, and tearing. Decomposition is to see whether the coupled block of activities may be decomposed into smaller activities and then re-sequenced to disclose a less coupled sub-process. (Eppinger & Browning 2012: 146)

Aggregation is representing the model at a higher level of abstraction by reducing coupled activities to appear as a single activity. Likewise, adding new activities is an operation that benefits the process by creating more information. This allows other activities to use real information instead of making assumptions that may cause rework. (Eppinger & Browning 2012: 146)

Respectively, tearing is a systematic method of suggesting an effective way to execute a block of coupled activities with minimal iteration. Tearing is performed by breaking the longest feedback then re-sequencing the activities. Then, this broken feedback is replaced by an assumption, and lastly, document this assumption in order to rework this activity when information is available. (Eppinger & Browning 2012: 147)

Several best practices are suggested for DSM with reference to model visualization, granularity, boundaries, and validation. On the subject of model visualization, appropriate graphics can be used to help explain the process, such as colors, shading, symbols, and labels. On the subject of model granularity, the model can be represented in different levels to cover main processes and sub-processes. On the subject of model boundaries,

DSM can refer to only a part of a process for better process understanding. On the subject of model validation, it is important for process owners and process managers to involve process users in the model validation and their insights for improvements. (Eppinger & Browning 2012: 138)

As elaborated, DSM is beneficial in projects planning and developing a realistic schedule based on a more detailed process model. In addition, it identifies the need for cross-functional, and cross-team interactions. Yet, visual representation is an additional instrument for an effective information demonstration. Visual representations can provide an effective format for displaying and communicating information to support strategic decision making. The advent of computers and software-based tools has greatly enhanced the ease of creating visual representations.

Visual information enhances analysis when combined with human cognitive capabilities, since it has the ability to preserve interrelationships between multiple elements. One of those visual representation is the network mapping that has the ability to display relationships between nodes in a network at multiple levels. Killen & Kjaer (2012) developed a visual project mapping (VPM) technique. VPM technique considers each project as a node in the network. Furthermore, VPM captures and displays information on the relationships or interdependencies between nodes using arrows where the size and color of the circle are related to projects characteristics.

Killen & Kjaer (2012) developed the method to employ the use of VPM in mapping multi-project interdependencies. These interdependencies between projects are collected from project managers and further categorized by type of interdependency and interdependency strength. These strengths can be classified into minor, important, and critical.

Minor interdependency strength is characterized by the ability of the project to be completed without major adjustments even if the other project is delayed, cancelled, or significantly altered. Important interdependency strength is characterized by the damaging effects, such as delay, or reduction in scope or quality, if the other project is delayed, cancelled, or significantly altered. Critical interdependency strength is characterized by the complete inability to complete the project or will experience very significant detrimental effects if the other project is delayed, cancelled, or significantly altered. Different types of Interdependencies can be recognized for different VPMs as well. After all, mapping the interdependencies between projects by VPM enables an easy grasp of these interdependencies. Besides, VPM can be supplemented by several VPM snapshots in addition to different filtering options so as to represent different levels of the process.

In conclusion, this subsection along with the previous subsections illustrated different methods that can be utilized to represent projects' activities in addition to multi-project interdependencies, such as a tabular representation, dependency structure matrix, and network mapping techniques. Those methods provide detail for projects as well as activities interdependencies, cross-project visibility and ultimately, support for management decisions in complex projects settings.

#### 4.3 Conceptual Framework of This Thesis

In this section, project and program management standards and different methodologies in addition to best practices are summarized into the conceptual framework for this thesis as depicted in Figure 25.

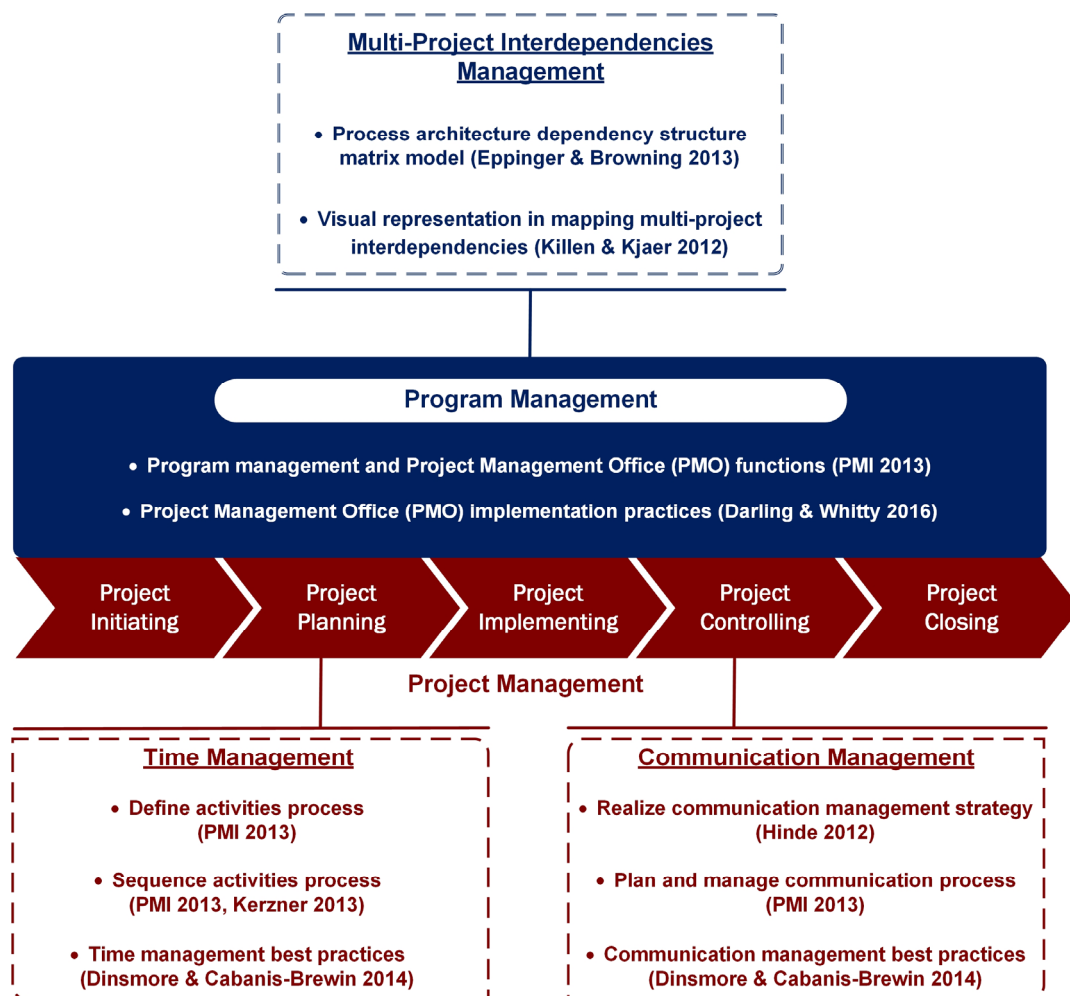


Figure 25. Conceptual framework of this thesis

As shown in Figure 25, the conceptual framework comprises the groups of the key findings identified in the previous section, which include time management, communication management, and management of multi-project interdependencies.

The first two groups comprise time management as well as communication management. These two groups were studied in relevant literature and best practice of project management. Relevant literature covered project management standards, along with methodologies and concludes with best practices in the field.

Time management literature framework comprises defining activities process and consequently, sequencing activities process, and concludes with time management best practices.

Communication management literature framework encompasses realizing communication management strategy, and subsequently, planning communication process, and concludes with communication management best practices.

The third group is the management of multi-project interdependencies. Since this is a primary function of the program management and in order to recognize the environment in which the management of multi-project interdependencies is implemented, relevant literature and best practices of a program management were examined. Those literature and best practices included program management and project management office (PMO) functions, in addition to project management office (PMO) implementation practices.

The literature framework for the management of the multi-project interdependencies embraces the dependency structure matrix technique that is utilized in process architecture. By the same token, visual representation in mapping technique is employed for the visualization of the multi-project interdependencies.

These three groups of the conceptual framework form the basis for the coordination approach development for program management in the case company; therefore, in the next section, this conceptual framework is applied for the development of the coordination approach.

## 5 Building a Coordination Approach for Program Management

This section merges the results of the current state analysis and the conceptual framework towards building the coordination approach for the case company. First, this section overviews the coordination approach building stage. Afterwards, it outlines the coordination approach.

Subsequently, the initial proposal of the coordination approach are demonstrated. That consists of the project management processes improvements and the management process of multi-project interdependencies development as part of program management. Findings of Data 2 collection towards building the coordination approach as well as the proposal assessment against key findings are described as well. Finally, this section ends with the initial coordination approach proposal.

### 5.1 Overview of the Coordination Approach Building Stage

The research originated from the business objective perceived from the business challenge. To achieve the objective, the current state of the management and coordination practices of the projects was analyzed inside the case company. This current stage analysis revealed challenges in time management, communication management as well as the management of multi-project interdependencies. To tackle these challenges, existing knowledge on project management as well as program management were scrutinized for the selected key challenges.

At this instant, this stage is concerned with building the initial proposal for the coordination approach. This stage is encompassed into three steps. Firstly, an initial proposal of the coordination approach is drawn based on literature and best practices identified in literature review stage; and so, the coordination approach outline is introduced in Section 5.2.

Secondly, the outline is worked on together with the key stakeholders to co-create the initial proposal of the coordination approach. Findings of Data 2 collection enlightenments are found in Sections 5.3, and 5.4. Those sections are portraying the coordination approach parts.

Thirdly, the initial proposal of the coordination approach is evaluated against the key findings from the current state analysis stage. In the same fashion, this evaluation is found in Sections 5.3, and 5.4. This evaluation is conducted by comparing the results from the current state analysis stage with the initial proposal. The comparison is conducted to ensure that weaknesses are mitigated, as well as to ensure that the strengths

contribute to the initial proposal. After all, the initial coordination approach proposal is concluded and presented in Section 5.5.

Three interviews and one workshop were held with all the key stakeholders who participated in the current state analysis stage. The participants of the interviews and workshop are the process owners from the project management office (PMO). Besides, more participants were selected from among the users of the coordination approach such as unit manager, project manager, and commissioning manager.

During those interviews and workshop, the key findings from the current state analysis were presented and followed by a presentation of the conceptual framework. Then, the initial proposal of the coordination approach and assessment against key findings was presented to the key stakeholders.

After reviewing these aspects, the initial proposal of the coordination approach was further co-created with the key stakeholders where suggestions from stakeholders were utilized to modify the initial proposal.

The results of the discussions and suggestions on the initial proposal formed the Data 2 of this thesis. According to the stakeholders' suggestions, the initial proposal of the coordination approach was formed for further validation and feedback. This initial proposal of the coordination approach is outlined in the next section.

## 5.2 The Coordination Approach Outline

The proposed coordination approach consists of the identification and chronology of projects stage and activities; and subsequently, the management of multi-project interdependencies concerning these stages and activities; and equally importantly, communicating the improvement actions to the stakeholders of different projects.

Thus, the initial proposal of the coordination approach is composed of three parts. Those parts are allocated as improvements to the project management as well as program management processes. Two parts are associated with project management processes, i.e. time management and communication management. The third part is the management of multi-project interdependencies as part of program management.

In fact, project management processes as well as liaison to the organization's strategy were identified in the current state analysis stage as discussed in Section 3.2 and drawn in Figure 4; accordingly, the coordination approach parts are drawn as improvements to the project and program management processes as shown in Figure 26.



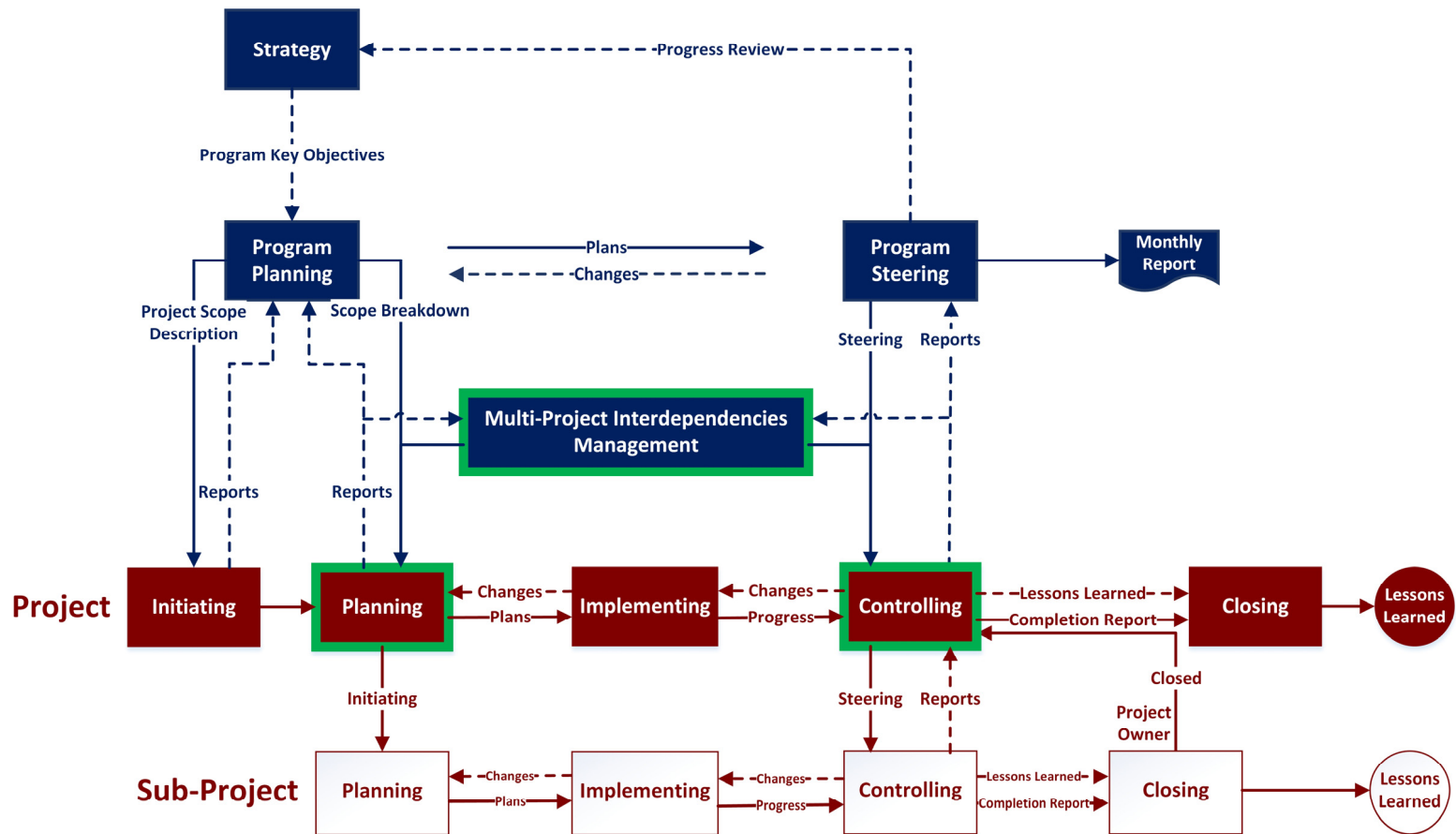


Figure 26. The initial improvements to the project and program management processes

As shown in Figure 26, the management process of multi-project interdependencies is appended to the program management in order to manage and coordinate the interdependencies among projects, and among stages and activities within projects.

Moreover, time management in addition to communication management are supplemented to the project management processes. Those parts are complemented in the project planning and controlling processes in order to facilitate the implementation of the management process of multi-project interdependencies.

The management process of multi-project interdependencies utilized the liaison from project management to the program planning and steering processes. That was premeditated so as to reduce the disturbance to the previously established project and program management processes. Additionally, the newly added process gains the maximum benefit when unified with the reporting and steering mechanism as part of program management.

Time and communication management as project management parts of the coordination approach are described in detail in the next subsection. The management of multi-project interdependencies as program management part of the coordination approach is described in the subsequent subsection.

### 5.3 Project Management Improvements: Time and Communication

Multi-project interdependencies are managed with information extracted from projects through project management processes. Therefore, project planning and controlling processes are employed to provide information on the projects' stages and activities to the management process of multi-project interdependencies. Subsequently, communicating and reporting improvement actions collected from the management process of multi-project interdependencies to the stakeholders of different projects.

For that reason, time management as well as communication management processes are improved as part of project management processes. Those processes are proposed for implementation in the project plans. Henceforth, time management as well as communication management parts of the coordination approach are exposed below.

### 5.3.1 Time Management

The time management part of the initial proposal includes the processes required to manage the implementation of the project on time. In detail, a set of activities are performed in each stage, thus a project stage is a collection of logically related project activities. Those stages are structured to form the project life cycle.

Hence, the decomposition of the project to stages requires defining and sequencing activities as parts of the time management. For that reason, these processes are proposed for the case company in order to overcome the key findings identified during the current state analysis stage.

Besides, different quality criteria are introduced for the time management processes. Those quality criteria are observed during the project execution in order to monitor and control a successful execution of the project's time management.

Comprehensively, five quality criterion are identified. Firstly, the project life cycle reflects the complete scope of the project. Secondly, the decomposition of the project life cycle stages reflects the project breakdown and activities.

Thirdly, the project life cycle defines how the project products will be accepted. Fourthly, the level as well as the frequency of activities reporting and update are right for the stage and/or project. Fifthly, any interface activities with other projects are described, together with their impact.

Henceforth and in terms of Data 2 collection findings, the results regarding the initial proposal from interviews and the workshop with key stakeholders formed the basis of Data 2.

Stakeholder inputs are identified in the form of suggestions to the time management elements of the coordination approach. Key stakeholder suggestions for proposal building in relation to time management elements are demonstrated in Table 6.

Table 6. Time management suggestions as of Data 2

Reference	Suggestions from Key Stakeholders	Description of the Suggestion	
1	<b>Define activities process</b>	Include project life cycle description as a first output to define project stages sequence.	The PMO project manager suggested that project life cycle description to be added as the first output of the define project stages sequence so as to assist in creating activity list and attributes through the identification of project stages.
2	<b>Define activities process</b>	Add a triggering mechanism to update define activities process outputs.	The PMO project manager suggested that activity list and attributes can be updated at the end of each life cycle stage or when project deliverables in terms of design is 80 per cent ready.
3	<b>Define activities process</b>	Add an option to import or export activity list and attributes from project management software.	When discussing with stakeholders, commissioning manager pointed out that activity list as well as attributes can be import to or export from project and program management software.
4	<b>Activity list and attributes template</b>	Add responsible organization to the activity list and attributes template	When discussing with stakeholders, a responsible organization is recommended for each activity to be added to the activity list and attributes template to facilitate the follow up process.
5	<b>Sequence activities process</b>	Include a high level project network diagram in the project plan	The PMO project manager suggested that a high level project network diagram can be included in the project plan to aid the management of multi-project interdependencies in program management.

As demonstrated in Table 6, three suggestions are endorsed to define the activities process. Firstly, enclosure of project life cycle description to the define activities process so as to assist in creating activity list. Secondly, adding a triggering mechanism to the define activities in order to simplify continuous updates. Thirdly, an option can be added to import or export activity list from project management software used in the case company.

One suggestion is endorsed for the activity list and attributes template to add a so-called 'responsible organization' to facilitate the execution of the activity as well as the interfaces and interdependencies. Another suggestion is endorsed for the sequence activities process to include a high level project network diagram in the project plan to aid the management of multi-project interdependencies in program management.

Now, based on the case company's business context, the define activities and sequence activities processes are introduced to the project management procedure as part of management system documents. This project management procedure describes the project management processes as revealed in Table 3 as part of Section 2.3.

Define activities is the process of identifying the actions to be performed in the project. Figure 27 demonstrates the data flow of the define activities process developed for the case company.



Figure 27. Define activities process: inputs, mechanisms, and outputs

As demonstrated in Figure 27, the define activities process inputs include project scope description, project plan, and applicable supplier's plans related to the project scope. Those plans describe the level of detail necessary to manage the work as well as the project work breakdown structure (WBS), deliverables, constraints, and assumptions.

Mechanisms used to define activities contain requirement analysis, decomposition, rolling wave planning, and expert judgement. In detail, requirement analysis is utilized in the case company by analyzing the plant contract as well as sub-suppliers' contracts requirements to assess in structuring project's scope. Decomposition is utilized for dividing project's scope into smaller stages and activities from project lifecycle.

Rolling wave planning is an iterative planning technique in which the work to be accomplished in the near term stages of the project is planned in detail, while the work in the future stages of the project is planned at a higher level. Expert judgement is utilized from the project team members both internally and externally who are experienced and skilled in developing detailed project scope and activities allocation.

The define activities process outputs comprise project life cycle description, the activity list, and activity attributes. The project life cycle is the series of stages that a project passes through from its initiation to its closure. The activity list is a comprehensive list that includes all activities required on the project. Activity attributes extend the description of the activity by identifying the multiple components associated with each activity.

In addition to the define activities process, a template for an activity list and attributes is introduced to the project plan template as revealed in Table 3 as part of Section 2.3. This activity list and attributes template can be also imported to or exported from project and program management software tools. Figure 28 shows activity list and attributes template along with project information.

<b>Project Name</b>		<b>Date</b>	
<b>Project Number</b>		<b>Project Plan Number</b>	
<b>Project Manager</b>		<b>Project Owner</b>	

<b>Activity Number</b>	<b>Activity Name</b>	<b>Activity Description</b>	<b>Responsible Organization</b>	<b>Predecessors</b>	<b>Successors</b>	<b>Interface Milestone</b>	<b>Status / Comments</b>

Figure 28. Activity list and attributes template

As seen in Figure 28, the activity list template comprises project information and activities information. The project information contains project name, project number, project manager, project plan number, and project owner. The activities information includes number, name, description, responsibility, precedence and interface milestone to other projects as well as activities within the same project. In general, a predecessor activity is an activity that logically comes before a dependent activity. Whereas, a successor activity is a dependent activity that logically comes after another activity.

Since activities concerning projects interfaces are obscure, sequence activities process is introduced as a second process for time management. Sequence activities is the process of identifying relationships among project activities. Figure 29 demonstrates the data flow of sequence activities process developed for the case company.

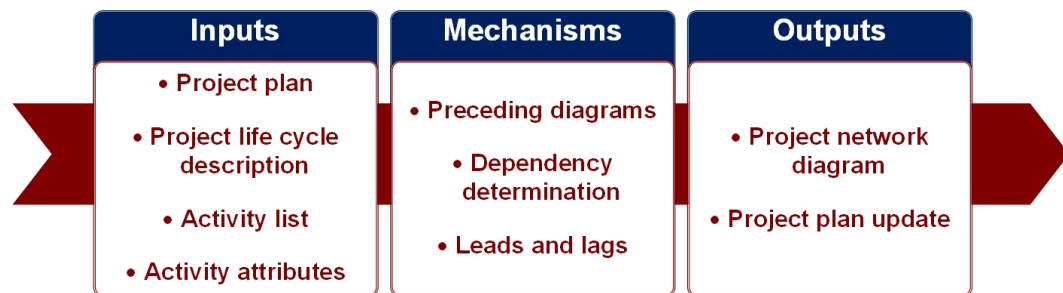


Figure 29. Sequence activities process: inputs, mechanisms, and outputs

As demonstrated in Figure 29, inputs to the sequence activities process include project plan; additionally, define activities process outputs are used as input as well. Those are project life cycle description, activity list, and activity attributes. Mechanisms used to sequence activities include precedence diagramming method, dependency determination, and leads and lags. The precedence diagramming method (PDM) is used to construct a model in which activities are represented by nodes and are graphically linked by one or more logical relationships to show the activities sequence.

A second mechanism utilized in the sequence activities process is dependency determination. The project team usually supports the project manager in dependency determination through the identification of activities relationships, and further categorizing as well as attributing those dependencies, such as mandatory or discretionary, internal or external dependencies.

A third mechanism utilized in the sequence activities process is leads and lags. Leads and lags are identified by the project team both internally and externally with the supplier and sub-suppliers. Leads and lags can be also identified from the overall project time

schedule and later, necessary modification to the overall project time schedule can be modified based on the project team inputs.

Outputs of the sequence activities process are the project network diagram and project plans updates. The project network diagram is a graphical representation of the logical relationships and dependencies among project activities. In addition, originally established project documents are updated, such as activity lists, activity attributes, milestone list, and project plan.

In particular, the define activities and sequence activities processes and their detailed outputs are not issued as part of the project plan template since project detailed activities are more volatile. However, those outputs are required to further support the implementation of the management process of multi-project interdependencies as identified in the stakeholders' suggestions in Table 6. For that reason, a high level activity list and its associated attributes along with project network diagram inclusion in the project plan is desirable.

At this point and after building the time management part of the coordination approach, the initial proposal is evaluated on how it tackles the time management key findings from the current state analysis (CSA) stage. Besides, the contribution from CSA's strengths to the proposal is appended as shown in Figure 30.

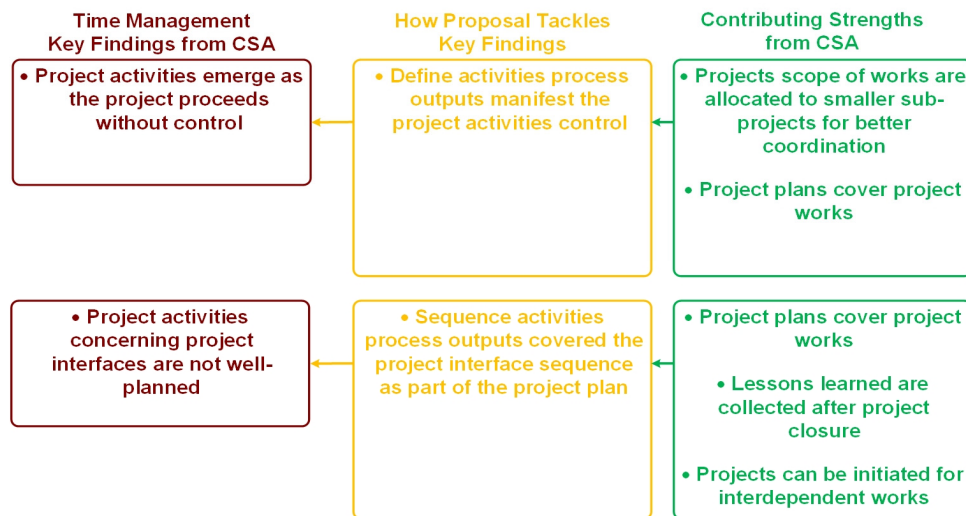


Figure 30. Time management proposal evaluation against key findings and contributing strengths

As exposed in Figure 30, and in terms of unrestrained project activities emergent as a first key finding, the control of project activities is taken into consideration in the define activities process. Particularly, the define activities process outputs manifest the project



activities control by formal identification of project stages, and activities as well as attributing those activities.

Correspondingly, two strengths certainly contributed to the proposal for this key finding. Those are the ability to allocate project scope works to smaller sub-projects, and the availability of project plans covering the definition of project works. Those strengths supported the ability to identify and attribute activities as the project scope can be further decomposed to sub-projects. Moreover, the inclusion of high level project works in project plans facilitates the identification of the project life cycle, stages, and activities.

In terms of unplanned project interfaces as a second key finding, project activities regarding interfaces are addressed in the sequence activities process. Principally, the sequence activities process outputs include a project network diagram that supports the project interfaces definitions. In addition, this project network diagram is incorporated as part of the project plan.

Similarly, three strengths contributed to the proposal for this key finding. Firstly, the project plans' inclusion of project works aid in the identification and sequencing of activities. Secondly, the collection of lessons learned contributes to sequencing the activities based on practices from previous projects. Thirdly, the projects' initiation for interdependent works supports the project's network diagram moderation.

The time management part of the coordination approach is now complete. The second part related to communication management is described in the next subsection to conclude the improvements on the two project management processes for the coordination approach.

### 5.3.2 Communication Management

The communication management part of the initial proposal includes the processes required to appropriately plan and manage project information. Specifically, it describes information flow regarding regular project meetings, workgroups, workshops, authority communications, internal communication and coordination of other remarkable activities.

Hence, effective communication management requires planning and management. Therefore, these processes are proposed for the case company in order to overcome the key weaknesses identified in the current state analysis stage. Besides, different quality criteria are introduced for the communication management processes. Those quality criteria are observed during the project execution in order to monitor and control successful stakeholder communication.

Five quality criterion are identified. Firstly, all stakeholders have been identified and their communication requirements have been analyzed. Secondly, all stakeholders agreed about the content, frequency and method of communication. Thirdly, the project plan allocated the time, effort, and resources required to carry out the identified communications. Fourthly, the frequency of communication was reasonable for the project's importance and complexity. Fifthly, the lines of communication and the reporting structure between the project and program were made clear.

In terms of Data 2 collection findings, the results regarding the initial proposal from interviews and workshop with key stakeholders formed the basis of Data 2. Stakeholder inputs are identified in the form of suggestions to the communication management elements of the coordination approach. Key stakeholder suggestions for proposal building regarding communication management elements are revealed in Table 7.

Table 7. Communication management suggestions as of Data 2

Reference	Suggestions from Key Stakeholders	Description of the Suggestion
1 <b>Plan communication process</b>	Use applicable management system manuals.	The PMO project manager suggested that the case company's management system manuals identifying communication management requirements can be used for the plan communication process.
2 <b>Plan communication process</b>	Requirement analysis technique is required.	The PMO project manager suggested that the requirement analysis technique is needed to analyze the plant contract and the sub-suppliers contracts.
3 <b>Communication matrix example</b>	Distinguish between internal and external project team meetings.	The PMO project manager suggested that project team meetings needs to be disintegrated to internal team meeting and external team meetings; since Internal and external team meetings are different in terms of objectives, frequency as well as audience.
4 <b>Communication matrix example</b>	Internal project team meeting deliverable is the action log.	Stakeholders suggest that in practice, deliverable in internal project team meetings is the action log.
5 <b>Communication matrix example</b>	Design meetings to be changed to engineering meetings.	Stakeholders suggest to change design meetings to be engineering meetings; since the project involve several meetings for engineering outside design such as reviews and verifications.
6 <b>Communication matrix example</b>	Communication owner to decide the audience of the communication.	When discussing with stakeholders, stakeholders identified that the communication owner decides the communication audience; since the participation depends on the project as well as tasks on hand.
7 <b>Communication matrix example</b>	Meetings frequency to be decided by communication owner.	When discussing with stakeholders, stakeholders identified that the communication owner should identify the communication frequency in the project plan based on project scope and tasks nature.

As demonstrated in Table 7, two suggestions are endorsed for the plan communication process. Those are the use of applicable management system documents to identify the communication management requirements and requirement analysis technique is required in order to analyze different contracts' requirements.

A number of suggestions are endorsed for the communication matrix as well. Those are the distinction between internal and external team meetings. Moreover, an action log is the main deliverable in internal team meetings. In addition, a communication matrix to include engineering meetings is suggested in lieu of design meetings. In addition, having a communication owner to identify the audience as well as the frequency of meetings is proposed.

Now, based on the views of the case company's stakeholders, the plan communication and manage communication processes are introduced to the project management procedure as well as the project plan template as part of management system documents. Those describe the project management processes as well as the project plan elements as revealed in Table 3 as part of Section 2.3.

Plan communication is the process of developing a plan for project communications based on stakeholder's information needs and requirements. Figure 31 demonstrates the data flow of the plan communication process developed for the case company.

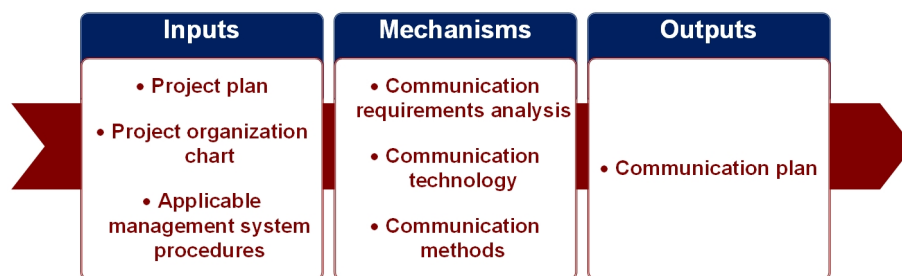


Figure 31. Plan communication process: inputs, mechanisms, and outputs

As demonstrated in Figure 31, inputs to the plan communication process include project plan, project organization chart, and applicable management system procedures. Mechanisms used to plan communication include communication requirement analysis from the applicable parts of the plant contract as well as sub-suppliers' contracts.

In addition, different communication technologies, such as conference calls over Skype are used. As well as different communication methods, such as meetings, workgroups, workshops, conference call, and reports are utilized. The plan communication process

comprises a communication plan that is included as part of the project plan in the case company's projects.

In particular, effective communication means providing information in the right format, at the right time, and with the right impact. Thus, a communication matrix can be utilized as an element in the communication plan to plan the communication management process.

A communication matrix as an element of the communication plan allows deliberation on how to communicate efficiently and effectively to the various project stakeholders. The communication matrix for the project can be constructed through a four-step process.

The first step is to determine project stakeholders. In a typical project, there can be many types of users, vendors, managers, and stakeholders; therefore, the idea behind this step is to determine people or groups of people to include in the communication matrix.

The second step is to determine the communication needs of each stakeholder. For each of these stakeholders identified in first step, determine their communications needs. For instance, certain managers have a need for ongoing status information. Program steering committee need ongoing status reporting.

The third step is to determine how to fulfill the communication needs of each stakeholder. In fact, project communication can take many shapes and forms; therefore, in this step, brainstorming is needed on how to fulfill the communication needs for each stakeholder. When possible, the types of communication that can cover more than one stakeholder's needs should be explored. Those types of communication could be project status reports, status meetings, engineering meetings, regular conference calls, and videoconferences with remote stakeholders.

The fourth step is to prioritize the communication options. Definitely, some communication activities provide more value than others; thus, now, the items are prioritized to determine which communication items provide the most value for stakeholders.

Figure 32 shows a communication matrix example along with an illustration of meetings and status reports.

Communication Type	Objective of Communication	Medium	Recommended Frequency	Audience (Owner to decide)	Communication Owner	Deliverable
• <b>Kickoff Meeting</b>	<ul style="list-style-type: none"> <li>• Introduction of the project team to the project.</li> <li>• Review project objectives and management approach.</li> </ul>	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>	<ul style="list-style-type: none"> <li>• Once</li> </ul>	<ul style="list-style-type: none"> <li>• Project sponsor</li> <li>• Project team</li> <li>• Major stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>• Project manager</li> </ul>	<ul style="list-style-type: none"> <li>• Agenda</li> <li>• Meeting minutes</li> </ul>
• <b>Project Team Meetings (Internal)</b>	<ul style="list-style-type: none"> <li>• Review project status with project team.</li> </ul>	<ul style="list-style-type: none"> <li>• Face-to-face</li> <li>• Conference Call</li> </ul>	<ul style="list-style-type: none"> <li>• Weekly</li> </ul>	<ul style="list-style-type: none"> <li>• Project team</li> </ul>	<ul style="list-style-type: none"> <li>• Project manager</li> </ul>	<ul style="list-style-type: none"> <li>• Action log</li> </ul>
• <b>Project Team Meetings (External)</b>	<ul style="list-style-type: none"> <li>• Review project status with the project team.</li> </ul>	<ul style="list-style-type: none"> <li>• Face-to-face</li> <li>• Conference Call</li> </ul>	<ul style="list-style-type: none"> <li>• Monthly</li> </ul>	<ul style="list-style-type: none"> <li>• Project team</li> </ul>	<ul style="list-style-type: none"> <li>• Project manager</li> </ul>	<ul style="list-style-type: none"> <li>• Agenda</li> <li>• Meeting minutes</li> </ul>
• <b>Engineering Meetings</b>	<ul style="list-style-type: none"> <li>• Discuss design solutions for the project.</li> </ul>	<ul style="list-style-type: none"> <li>• Face-to-face</li> </ul>	<ul style="list-style-type: none"> <li>• As Needed</li> </ul>	<ul style="list-style-type: none"> <li>• Project technical engineers</li> <li>• Interface projects</li> </ul>	<ul style="list-style-type: none"> <li>• Project technical engineers</li> </ul>	<ul style="list-style-type: none"> <li>• Agenda</li> <li>• Meeting minutes</li> </ul>
• <b>Project Status Meetings</b>	<ul style="list-style-type: none"> <li>• Report the status of the project to management.</li> </ul>	<ul style="list-style-type: none"> <li>• Face-to-face</li> <li>• Conference Call</li> </ul>	<ul style="list-style-type: none"> <li>• Monthly</li> </ul>	<ul style="list-style-type: none"> <li>• Project owner</li> <li>• Unit manager</li> <li>• Interface projects</li> </ul>	<ul style="list-style-type: none"> <li>• Project manager</li> </ul>	<ul style="list-style-type: none"> <li>• Project status report</li> </ul>
• <b>Project Status Reports</b>	<ul style="list-style-type: none"> <li>• Report the status of the project including activities, progress, accomplishments, and issues.</li> </ul>	<ul style="list-style-type: none"> <li>• Email</li> </ul>	<ul style="list-style-type: none"> <li>• Monthly</li> </ul>	<ul style="list-style-type: none"> <li>• Project owner</li> <li>• Project team</li> <li>• Major stakeholders</li> <li>• PMO</li> </ul>	<ul style="list-style-type: none"> <li>• Project manager</li> </ul>	<ul style="list-style-type: none"> <li>• Project status report</li> </ul>

Figure 32. Communication matrix example

As shown in Figure 32, the communication matrix example comprises communication type, objective, medium, recommended frequency, audience, owner, and deliverable. The communication types include meetings and status reports with different objectives, frequency owner for each. Those communication types are utilized to manage the communication throughout the project life cycle and should be managed according to the communication plan. Beside the plan and manage communication processes, an example of a communication matrix is introduced to the project plan template as revealed in Table 3 as part of Section 2.3.

Therefore, the manage communication process identified as the process of collecting, distributing, storing, retrieving, and disposing project information in accordance with the communication plan. Figure 33 demonstrates the data flow of manage communication process developed for the case company.

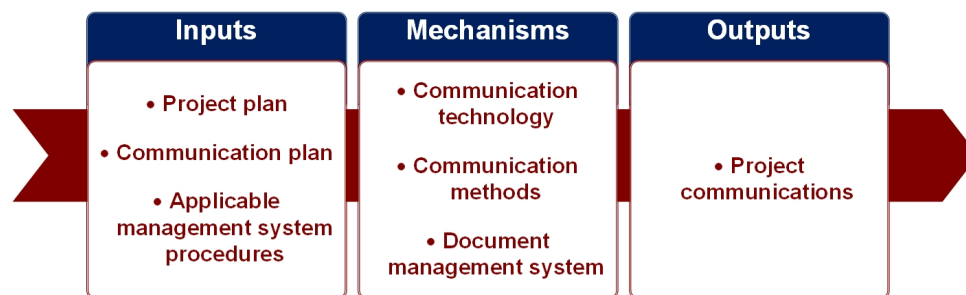


Figure 33. Manage communication process: inputs, mechanisms, and outputs

As demonstrated in Figure 33, inputs to the manage communication process include project plan, communication plan, and applicable management system procedures. Mechanisms used to plan communication include communication technology such as conference calls through Skype, and different communication methods such as meetings, conference calls. In addition, document management system actions logs, project status reports, and meeting minutes are utilized as part of the mechanisms. Consequently, project communications as an output from manage communication process is the activities required for the information to be created, and distributed, such as project team meetings both internal and external, project status meetings, and project status reports.

For the whole communication management proposal, the initial proposal is evaluated on how it tackles the communication management key findings from the current state analysis (CSA) stage. Besides, the contribution from the CSA's strengths to the proposal is appended as shown in Figure 34.

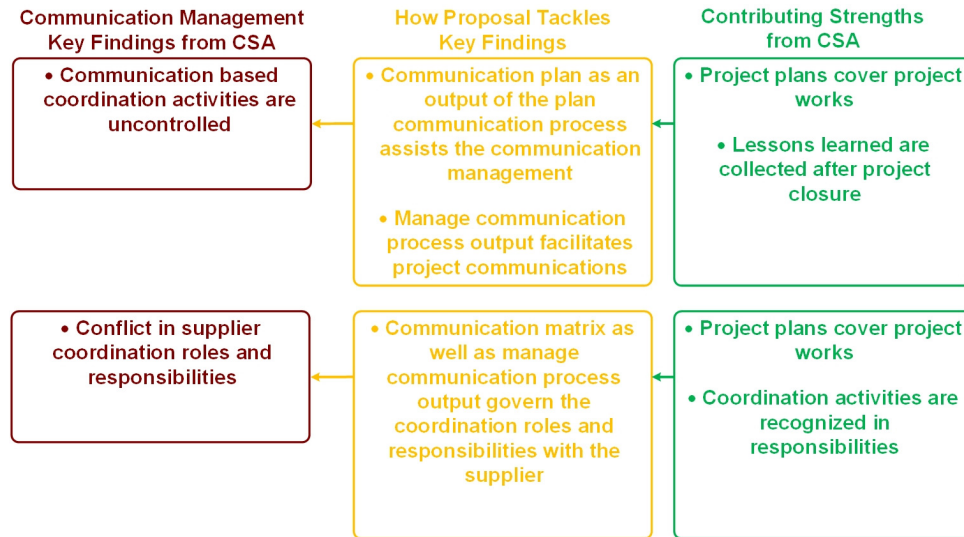


Figure 34. Communication management proposal evaluation against key findings and contributing strengths

As exposed in Figure 34, and in terms of uncontrolled coordination communication as a first key finding, communication plan as an output of plan communication process assist the communication management throughout the project. Moreover, manage communication process output facilitates project communications.

Correspondingly, two strengths certainly contributed to the proposal for this key finding. Those are the availability of project plan covers project works and the collection of lessons learned after each project. Those strengths enabled the identification of stakeholders involved in the project as well as their needs in order to manage and control communication.

In terms of the conflicts in supplier coordination as a second key finding, communication matrix as well as management communication process outputs govern the coordination roles and responsibilities for an effective resolution of the coordination conflicts.

Similarly, the availability of a project plan covers project works and the collection of lessons learned after each project contributed to the proposal. Specifically, project plans offered an operative media for a communication matrix and lessons learned facilitate updates to processes as well as the communication matrix.

The two project management parts intended for the coordination approach are now established in terms of time management and communication management. The program management part related to the management of multi-project interdependencies is described in the next subsection towards concluding the coordination approach.

#### 5.4 Program Management: Multi-Project Interdependencies

The case company's framework for program management utilizes projects management as well as organization practices to deliver organizational strategy. This framework is implemented through Project Management Office (PMO).

Since standardization and coordination is a common function of PMO where PMO standardize project management methodology as well as coordination between projects. The process of managing multi-project interdependencies is proposed for implementation as a dedicated projects' coordination procedure as part of the program management.

The current liaison from project management processes to program management, as shown in Figure 26, are utilized for the newly added management process of multi-project interdependencies. This utilization is employed in order to avoid disturbing the current processes and use the currently implemented reporting and steering mechanism.

Henceforth and in terms of Data 2 collection findings, results regarding the initial proposal from interviews and workshop with key stakeholders formed the basis of Data 2. Stakeholder inputs are identified in the form of suggestions to the multi-project interdependencies management part of the coordination approach. Key stakeholder suggestions for proposal building in relation to multi-project interdependencies management elements is demonstrated in Table 8.

Table 8. The management process of multi-project interdependencies suggestions as of Data 2

	<b>Reference</b>	<b>Suggestions from Key Stakeholders</b>	<b>Description of the Suggestion</b>
<b>1</b>	<b>Identification</b>	Categorization of projects' interdependencies information.	Stakeholders suggested to categorize projects' interdependencies information to be related the importance for each interdependency.
<b>2</b>	<b>Display</b>	Several visual maps to be built.	Visual maps could be implemented in different level, such as projects, stages, and activities so as to facilitate clear identification of enormous number of interdependencies.
<b>3</b>	<b>Improvement</b>	Limit improvement solutions to the dependency structure matrix model	Projects' practices propose that decomposition and tearing by assumptions are the best and essential improvement solutions to the dependency structure matrix of multi-project interdependencies.



As demonstrated in Table 8, categorization of multi-project interdependencies information is suggested for identification. This categorization needs to be realized in relation to the interdependency importance. In addition, several visual maps to be built for different levels in the display element of the process, such as projects, stages, and activities so as to facilitate clear identification of enormous number of interdependencies.

Also for the improvement element of the process, projects' practices propose to limit improvement solution to decomposition and tearing by assumptions. Those elements of the multi-project interdependencies management along with the process are exposed below.

Definitely, the purpose of the management process of multi-project interdependencies is to collect, identify, analyze, display, and improve projects' activities as well as stages; thus, these elements are explained below in details.

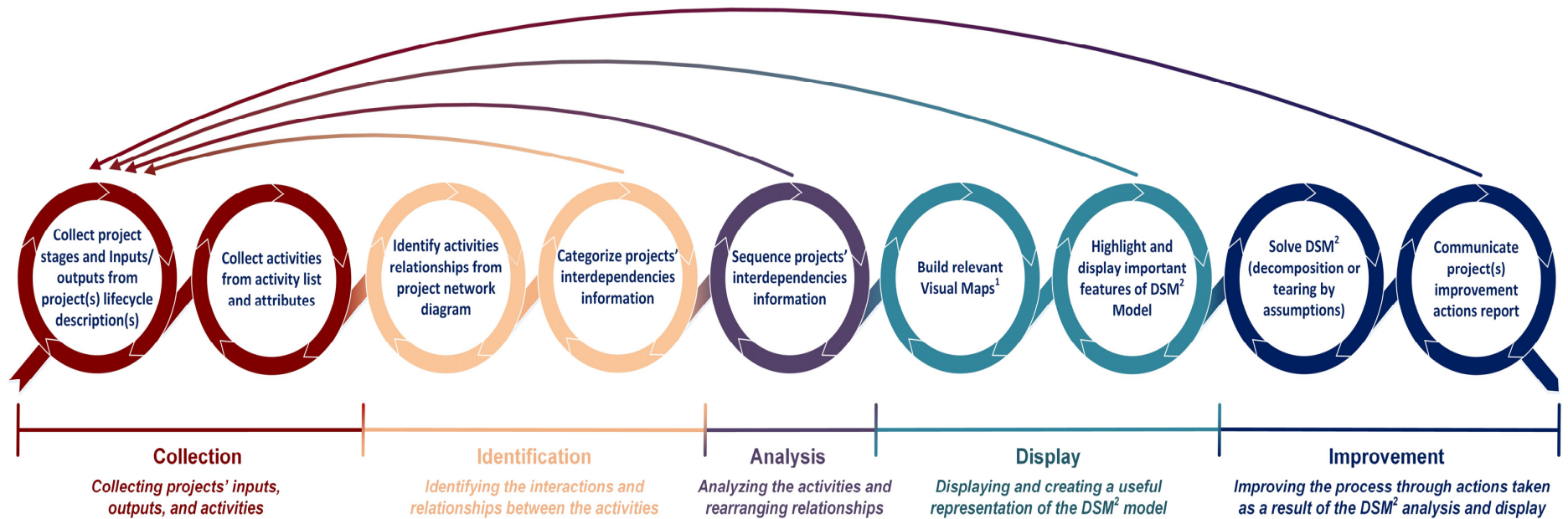
Collection is the course of collecting projects' stages, inputs, outputs, and activities. Identification is the course of identifying the interactions and relationships between projects. Analysis is the course of analyzing the activities and rearranging the relationships between activities.

Display is the course of displaying and creating a useful representation of the multi-project interdependencies. Improvement is the course of improving the process through actions taken as a result of multi-project interdependencies analysis and display.

These multi-project interdependencies management elements utilize visual maps as well as Dependency Structure Matrix (DSM) to model multi-project interdependencies information.

Within the case company's business context, visual maps is a network mapping that has the ability to display relationships between projects as nodes in a network at multiple levels. These levels could be projects, activities, and stages. By the same token, Dependency Structure Matrix (DSM) is a network modeling tool used to represent projects' activities architecture and their interactions.

The overall management process of multi-project interdependencies comprising these elements is shown in Figure 35.



<sup>1</sup> Visual Maps: Network mapping to display relationships between projects in a network at multiple levels (program, project, stages, and activities).

<sup>2</sup> DSM: Dependency Structure Matrix is a network modeling tool represents projects, activities, and their interactions by highlighting the architecture of the projects' interdependencies.

Figure 35. The Initial proposal of the management process of multi-project interdependencies

As shown in Figure 35, collection encompasses two steps. The first step utilizes project plans to collect project stages, inputs, and outputs. The second step uses outputs from activities identification in the time management processes (i.e. project life cycle description, activity list, and activity attributes) to collect projects' activities and attributes.

Identification comprises two steps. The first step employs the project network diagram from sequence activities in the time management processes to identify activities relationships. The second step is categorizing the information of these projects' interdependencies based on importance and priorities.

Analysis comprises one step that contains sequencing the information of the projects' interdependencies as part of the DSM model to recognize the best sequence of activities. Dependency Structure Matrix represents projects, activities, and their interactions by highlighting the architecture of the projects' interdependencies.

Display involves two steps. The first step is building the relevant visual maps. Visual Maps refers to network mapping to display relationships between projects in a network at multiple levels; thus, relevant visual maps are implemented for different levels, such as program, project, stages, and activities.

The second step is emphasizing and displaying the important features of projects activities in the DSM model. Those important features could be decided on project by project basis. General important features could be extensive activities iterations, deadlock activities patterns, or different supplier's relationship.

Lastly, improvement involves two steps. The first step is solving the DSM by decomposition or tearing by assumptions. The second step exploits the communication matrix and communication management processes outputs in a form of communication improvement actions to relevant projects' stakeholders. These stakeholders include internal project team, supplier, and sub-suppliers.

It is worth noting that feedback to the initial step is recognized in the course of the process in case of modification to projects' stages, inputs, outputs, or activities. This modification might require a change to the project plan, project lifecycle, stages, or ultimately, activities.

For that reason, feedback is recognized from identification, analysis, display, and improvement at the end of their respective steps in case of rigorous modification to the projects' interdependencies.

For the management process of multi-project interdependencies, the initial proposal is evaluated on how it tackles the key findings from the current state analysis (CSA) stage. Besides, the contribution from the CSA's strengths to the proposal is appended as shown in Figure 36.

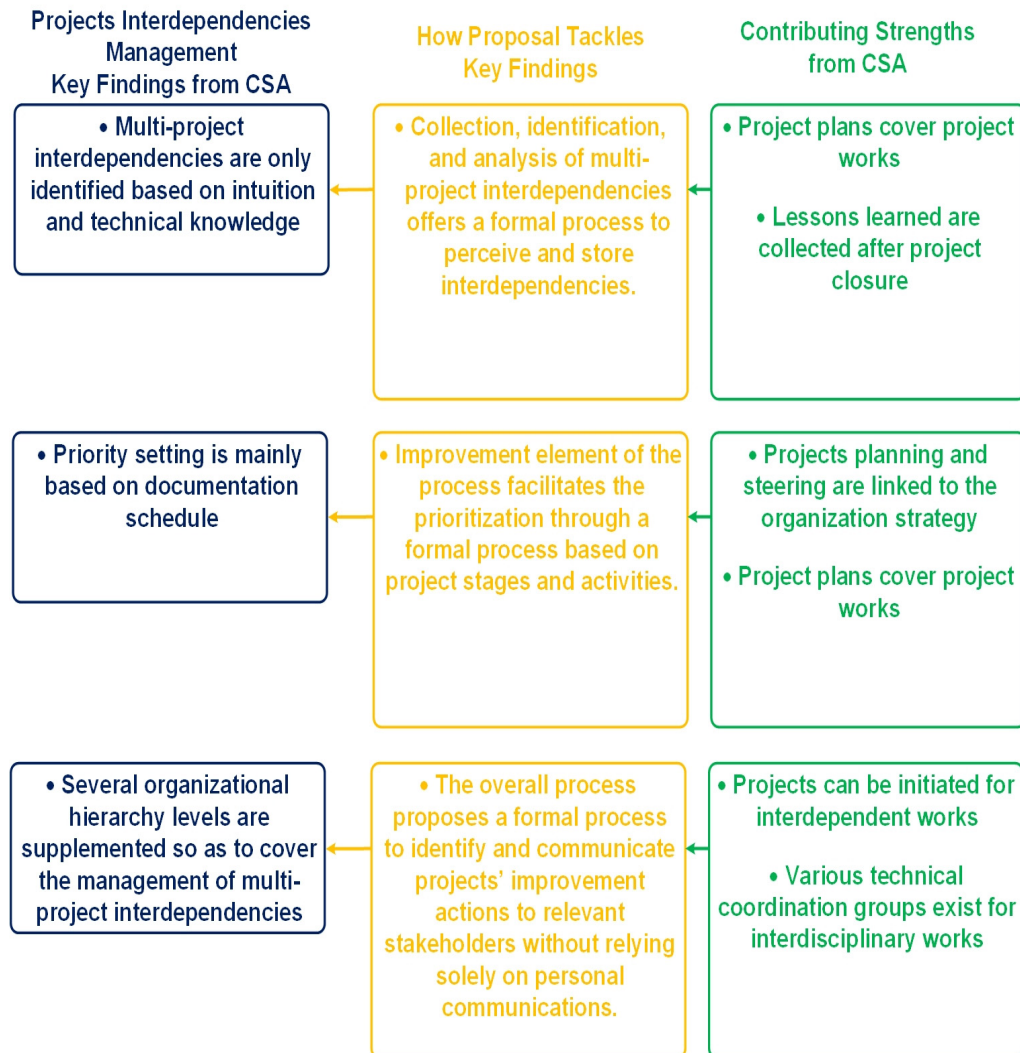


Figure 36. Multi-project interdependencies management proposal evaluation against key findings and contributing strengths

As exposed in Figure 36, first key finding is the identification of multi-project interdependencies by only intuition and technical knowledge. For this key finding, collection, identification, and analysis elements of the management process of multi-project interdependencies are established. Those elements offers a formal process to perceive and store multi-project interdependencies efficiently.

Correspondingly, strengths such as the availability of project plans, and lessons learned contribute to the collection, identification, and analysis elements. Moreover, the time management processes shown in the previous subsection aid the collection and identification of project stages and activities.

In terms of priority setting as a second key finding, improvement element of the process and its output in the form of improvement action reports facilitate the priority setting based on projects' stages and activities other than documentation schedule.

Similarly, the liaison between the project management processes to the organization strategy through program management contributes to an effective communication of the improvement actions. In addition, project plans offer an effective media to those improvement actions.

In terms of the continuously augmented organizational hierarchy to cover coordination as the third key finding, the overall process proposes a formal process to identify and communicate projects improvement actions to relevant stakeholders. Also, the overall process alleviate personal communication needs.

Likewise, the initiation of projects for interdependent works and the availability of various technical coordination groups as strengths contribute to the overall process. These strengths contribute by swift identification of projects' interdependencies as well as fast response to the improvement actions.

As shown above, the management process of multi-project interdependencies is presented. Furthermore, in the previous subsection, the project management parts in terms of time management and communication management were established.

The coordination approach parts for the initial proposal are now complete. Consequently, in the next section, the complete initial proposal of the coordination approach is established.

### 5.5 The Initial Proposal of the Coordination Approach

The initial proposal for building the coordination approach for projects includes the time management processes, the management process of multi-project interdependencies, and the communication management processes. A simplified diagram of this process is displayed in Figure 37 below.

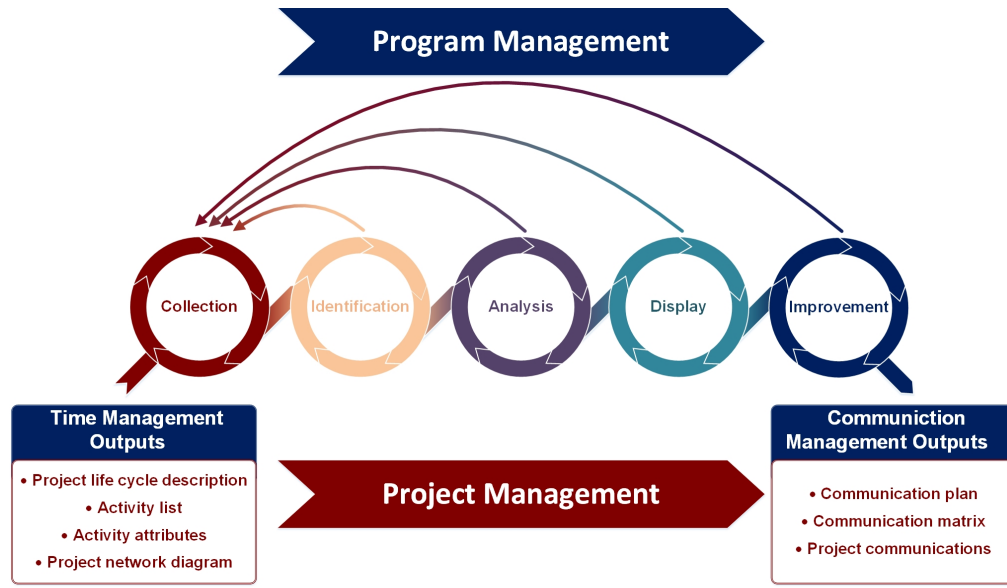


Figure 37. The initial proposal of the coordination approach

As displayed in Figure 37, time management comprises the identification and sequencing activities processes. Accordingly, outputs from the time management processes are project life cycle description, activity list, activity attributes, and project network diagram. Consequently, the management process of multi-project interdependencies collects those activities and its relationships.

Accordingly, the management process of multi-project interdependencies further identifies, analyzes, displays, and improves the information on the projects' interdependencies. Subsequently, the communication management processes communicate those improvement actions both internally and externally to the supplier and sub-suppliers. This communication is planned and managed in advance to facilitate those improvement actions. The communication management processes outputs are employed for those improvement actions. Those outputs are communication plan, communication matrix, and project communications.

The initial proposal of the coordination approach was portrayed in this section; therefore, the initial proposal is validated and feedback is undertaken in the next section.

## 6 Validation and Feedback to the Coordination Approach

This section reports on the results of the validation and feedback stage in the form of developments to the initial proposal of the coordination approach.

First, this section overviews the validation and feedback stage. Subsequently, the validation of the project management parts of the coordination approach are demonstrated. Those parts are time management and communication management.

Consequently, developments to the management process of multi-project interdependencies as part of program management are revealed. Lastly, this section concludes with the final proposal of the coordination approach.

### 6.1 Overview of the Validation and Feedback Stage

The initial proposal for the coordination approach was portrayed in Section 5. The coordination approach was built around time management, communication management, and the management process of multi-project interdependencies.

The initial proposal is now addressed in order to validate that the initial proposal solves the business challenge, fulfills the business objective, and satisfies its intended purpose within the business context.

This validation was conducted through a workshop with key stakeholders as well as comments to the initial proposal in an electronic format. The validation of the coordination approach was first conducted to the project management parts and program management part. The validation of those coordination approach parts are different in substance.

For time management and communication management as project management parts, the initial proposal was validated through implementation to the project management procedure and the project plan template.

Those parts are implemented in parallel for the two project management parts. Therefore, in Section 6.2, the validation steps through implementation and planned release are described for time management and communication management.

Regarding the management process of multi-project interdependencies as a program management part, the initial proposal was validated through feedback in the form of comments. Those comments were delivered both during a workshop and in an electronic format. Those comments were implemented as developments to the management process of multi-project interdependencies.

In fact, the validation steps for the management process of multi-project interdependencies were planned in that arrangement since the process expects the project management process parts to be executed primarily in projects to identify and sequence activities, as well as plan and manage communication.

However, a pilot implementation of the process was accomplished for projects in one sub-unit under the engineering unit in the case company. This pilot was implemented in order to test the process and to ensure that further enhancements are realized.

Therefore, in Section 6.3, the initial proposal is modified according to the feedback received from the key stakeholders as well as the pilot implementation. This consequently shaped the final proposal for the management process of multi-project interdependencies. When combined with time management and communication management, it forms the final proposal of the coordination approach.

All in all, in Section 6.4, the final proposal of the coordination approach is drawn for the case company based on validation undertaken and feedback received to the initial proposal of the coordination approach.

During the validation and feedback stage, one workshop was conducted as well as feedback in the form of comments was undertaken from key stakeholders. The participants of the workshops were selected among the probable users of the final process.

In addition, new stakeholders from engineering management were augmented in the validation and feedback stage as part of the criticism to the initial proposal and to seek outsider's opinion.

The results of the discussions and comments on the initial proposal form Data 3 of this thesis. Accordingly, the initial proposal is modified based on the stakeholders' comments to form the final proposal of the coordination approach.

In the next two sections, the validation to the project management parts and feedback to the program management part is discussed.



## 6.2 Validation of Project Management: Time and Communication

For the project management parts of the coordination approach, feedback was received from the key stakeholders through workshop as well as off-line comments in an electronic format. Consequently, corrections were undertaken so as to be ready for implementation in the next release of the project management procedure and the project plan template.

Hereafter and in terms of Data 3 collection, a number of improvement suggestions are identified for the initial proposal prior to implementation to the project management procedure and the project plan template. Those improvement suggestions from key stakeholders formed the basis of Data 3.

Stakeholder suggestions in relation to time management and communication management elements are shown in Table 9.

Table 9. Time and communication management suggestions as of Data 3

	Reference	Suggestions from Key Stakeholders	Description of the Suggestion
1	Time Management	Level of detail for activities identification and sequence to be identified	Level of detail for activities identification and sequence to be identified in order to facilitate the implementation in the project plan.
2	Time Management	Processes summary to be added to project management procedure and more detailed information and communication matrix to be added to the project plan template.	Targeting implementation, the processes needs to be summarized and added to the project management procedure. On the other hand, more detailed description of the process along with the activity list and attributes template to be added to the project plan template.
3	Communication Management	Processes summary to be added to project management procedure and more detailed information and communication matrix to be added to the project plan template.	Targeting implementation, the processes needs to be summarized and added to the project management procedure. On the other hand, more detailed description of the process along with the communication matrix example to be added to the project plan template.

As seen in Table 9, stakeholders suggested to identify the level of detail needed for the identification and sequence of activities in order to facilitate the implementation in the project plan. At the same time, more data can be identified in a rolling wave principle.

Also, and targeting the implementation, the key stakeholders suggested that a summary of time management processes to be implemented in the project management procedure. Alternatively, more details along with the activity list and attributes template were suggested to be added to the project plan template.

Likewise, the key stakeholders suggested that a summary of communication management processes be implemented in the project management procedure. Alternatively, more details of those processes along with the communication matrix example were suggested to be added to the project plan template.

Those suggestions targeted the implementation of time and communication management in the management system documentation; therefore, as such, the processes presented in Section 5 did not face a substantial change.

As a matter of fact, those processes are planned for release in the next revision of the project management procedure as well as the project plan template.

### 6.3 Developments to Program Management: Multi-Project Interdependencies

For the part related to the management of multi-project interdependencies in the coordination approach, feedback was received from the stakeholders through a workshop as well as off-line comments in an electronic format. Consequently, corrections were undertaken for the corresponding process steps.

Yet, a pilot was implemented for three interdependent projects in conjunction with projects' stages, interfaces, and interdependencies. This pilot was implemented for the process prior to further implementation in a dedicated projects' coordination procedure. This pilot implementation steps along with a summary of results and improvement actions are provided in Appendix 1.

Henceforth and in terms of Data 3 collection, feedback to the initial proposal from the workshop with the key stakeholders, the initial proposal feedback, and the pilot implementation formed the basis of Data 3.

The stakeholders' suggestions regarding the management process elements of multi-project interdependencies are shown in Table 10.

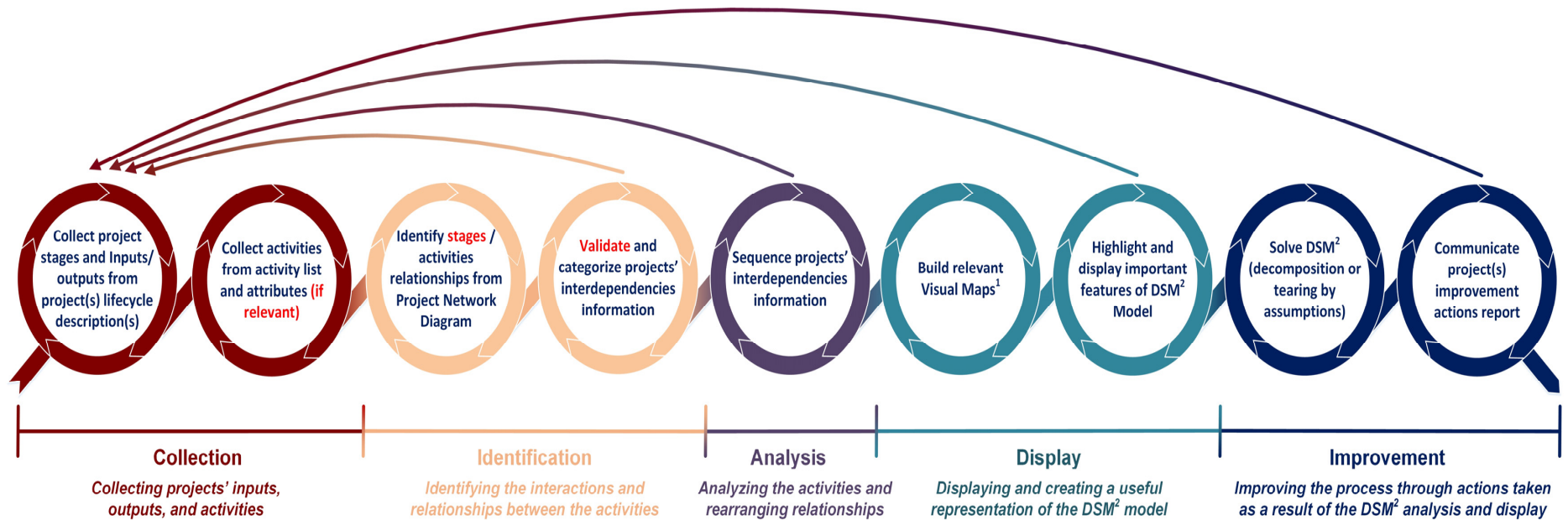
Table 10. The management process of multi-project interdependencies suggestions as of Data 3

Reference	Suggestions from Key Stakeholders	Description of the Suggestion
1	<p><b>Collection</b></p> <p>Activities collection can be skipped if only project stages relations are mapped.</p>	<p>Pilot outcome exhibited that activities collection sub-step can be skipped if only projects stages relationships are mapped.</p> <p>This applies to relationships within program, projects, and stages. This step is needed when activities relationships are mapped.</p>
2	<p><b>Identification</b></p> <p>Project scope validation could be added as part of projects' interdependencies information categorization.</p>	<p>Stakeholders suggested that the categorization of project interdependencies information could include validation.</p> <p>This validation is needed to validate the projects scope as well as the product(s) offered by each project.</p>
3	<p><b>The overall management process of multi-project interdependencies</b></p> <p>The process could be applied in different levels of the whole program.</p>	<p>Stakeholders suggested that the overall process can be made generic so it can be implemented in different levels inside the program.</p>

As seen in Table 10, for the collection element of the process, the pilot implementation exposed that the activities collection step can be skipped if only relationships of projects' stages are mapped. This applies to relationships within program, projects, and stages. However, this step is needed when activities relationships are mapped.

For the identification element of the process, validating the project scope is needed as well as the product offered by the project. This validation is added to the categorization step in the management process of multi-project interdependencies.

Yet, based on the feedback from stakeholders, a generic process will be used in different levels of the whole program. First, the generic process will be used in the program level within the program and second, in the unit level among projects and thirdly, in the project level between systems, activities and stages. Based on stakeholders' feedback, the overall management process of multi-project interdependencies was modified as shown in Figure 38.



<sup>1</sup> Visual Maps: Network mapping to display relationships between projects in a network at multiple levels (program, project, stages, and activities).

<sup>2</sup> DSM: Dependency Structure Matrix is a network modeling tool represents projects, activities, and their interactions by highlighting the architecture of the project' interdependencies.

Figure 38. The management process of multi-project interdependencies

As shown in Figure 38, the modifications to the process are marked in red. Corresponding to these modifications, second step of collection is marked as optional. Also, stage relationships are added to activities relationships as part of an identification element. Similarly, validation of the project scope and the product delivered is supplemented to the categorization of the information step of projects' interdependencies. The rest of the process remains the same as in the initial proposal.

Still, the management process of multi-project interdependencies requires one significant change in project management processes. This change embraces a genuine implementation of the time management and communication management processes. This implementation in the project management processes is a prerequisite to the management of multi-project interdependencies in order to collect the outputs of time management in terms of activities identification and sequence.

Chronologically, the management process of multi-project interdependencies will be implemented first and improvement actions acknowledged. Those improvement actions could be project scope change, activity prioritization, or assumptions recognition. Then, the process offers these improvement actions to the communication management processes. Finally, the communication management processes communicate these improvement actions both internally and externally to the supplier and sub-suppliers by means of meetings, and status reporting.

What is more, a pilot of the process was implemented for projects in one sub-unit under the engineering unit. This pilot was implemented for the first level of projects' interdependencies between projects' stages covering inputs and outputs. This pilot was applied to three projects (A, B, and C). The steps followed in this pilot implementation covered collection, identification, analysis, display, and improvement. As a concluding output from the management process of multi-project interdependencies, two important features were perceived. Those are long iterations and deadlock stages patterns.

Hence, the projects' important features along with improvement actions were offered in an improvement action report. The improvement actions included the decomposition of stages or stage tearing by assumptions. The process pilot implementation along with a summary of the results and improvement actions can be found in Appendix 1.

After the final proposal is completed, it is given to the case company's project management office (PMO) in order to be planned for implementation. This management process of multi-project interdependencies will be implemented in a projects' coordination procedure in order to be implemented in the case company's management system.

#### 6.4 The Final Proposal of the Coordination Approach

The initial proposal for building the coordination approach among projects was built around the time management processes, the management process of multi-project interdependencies, and the communication management processes.

The proposed modification to the project management processes as well as program management for the case company's is shown in Figure 39.

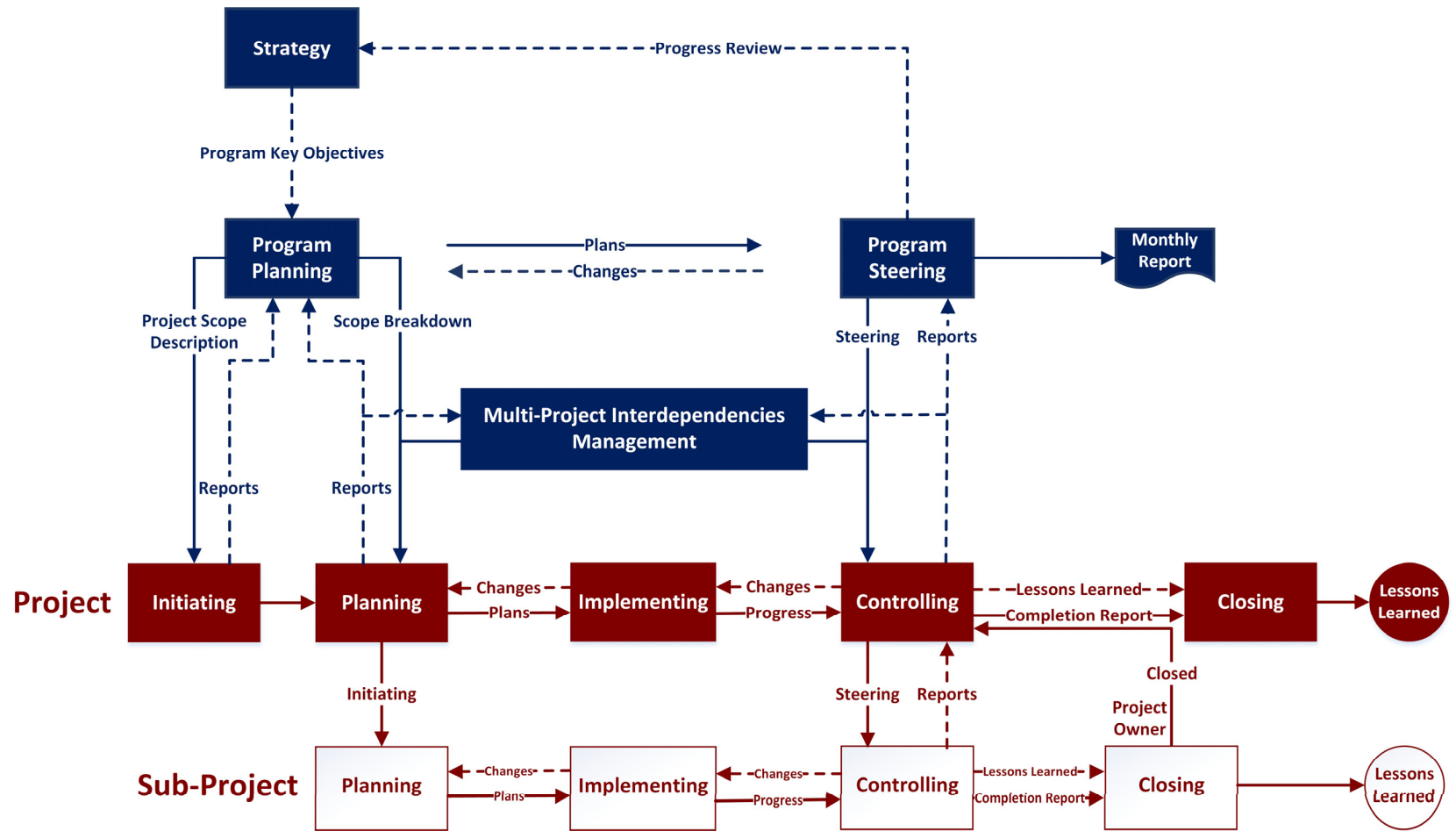


Figure 39. The final improvements to the project and program management processes

As seen from Figure 39, the management process of multi-project interdependencies is appended to the program management in order to manage and coordinate the interdependencies among projects, as well as among stages and activities within projects. The current liaisons from project management processes to program management are deployed for the management process of multi-project interdependencies. This deployment is engaged in order to avoid disturbing the current processes and to utilize the current reporting and steering mechanism.

Furthermore, time management processes are included in the project's planning and controlling processes. Time management processes incorporated define and sequence activities processes. Also, communication management processes are appended to the project's planning and controlling processes. Communication management processes encompassed plan and manage communication processes.

Accordingly, a simplified diagram of the final proposal of the coordination approach comprise time management, management of multi-project interdependencies, and communication management is displayed in Figure 40 below.

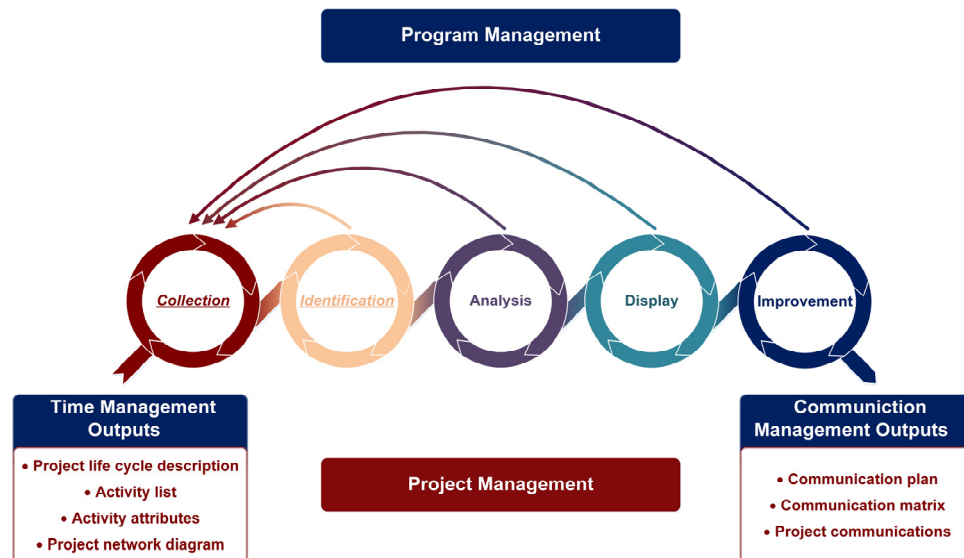


Figure 40. The final proposal of the coordination approach

As displayed in Figure 40, the overall coordination approach starts with time management processes that produce outputs employed for the management process of multi-project interdependencies. Those outputs are project life cycle description, activity list, activity attributes, and project network diagram.



Consequently, the management process of multi-project interdependencies collects project stages, activities, and relationships from those outputs. Henceforth, the management process of multi-project interdependencies further categorizes, analyzes, displays, and improves multi-project interdependencies information in terms of stages and activities. It is worth noting that collection and identification are changed from the initial proposal by making the process generic in terms of collection and identification in addition to supplementing validation as part of identification.

Subsequently, the communication management processes communicate those improvement actions both internally and externally to the supplier and sub-suppliers. This communication is enabled through communication management outputs. Those outputs are communication plan, communication matrix, and project communications.

This concludes the coordination approach proposed for implementation to integrate interdependent projects into program management.

## 7 Discussion and Conclusions

This section presents the executive summary of the thesis in addition to managerial implications and practical recommendations. This section evaluates as well the outcome of this thesis. This evaluation focuses on the thesis outcome versus the objective as well as validity, reliability, logic and relevance.

### 7.1 Executive Summary

The objective of this thesis was to build an overall coordination approach for the case company to integrate the supplier's different interdependent projects into program management. In particular, the case company's business objectives aim at building a new greenfield power plant.

A greenfield power plant project is a large scale, complex venture that typically implicates a vast number of stakeholders. This complex nature and the large number of projects in a greenfield plant project require effective and efficient project management and coordination. Without such scrutiny of project management and coordination, complex interdependencies and concurrence between projects hinder the overall project management processes efficiency; therefore, the management of multi-project interdependencies in such a large setting requires standardized process or approach. Too little coordination paralyzes the project and so does too much coordination; therefore, this thesis offered a coordination approach to standardize a process to integrate interdependent projects into program management. This coordination is a lever to reduce unnecessary non-added value iterations and associated rework.

Data gathered for this thesis were drawn from a variety of data sources in three data collection rounds. Each round produced a set of data corresponding to the research stage objective. Different methods were used for the data collection and analysis via interviews, workshops, electronic format feedback as well as management system documents study and investigation.

The research originated from the business objective perceived from the business challenge. The current state of the projects management processes and coordination practices was analyzed inside the case company. This current state analysis revealed challenges in time management, communication management in addition to the management of multi-project interdependencies. Accordingly and ascended from particular challenges, relevant literature on project management as well as program management was scrutinized.

As a result, the coordination approach proposal was built and further evaluated against the key findings from the current state analysis stage. This coordination approach parts covered time management and communication management as part of project management as well as management of multi-project interdependencies as part of program management.

The overall coordination approach starts with the time management processes that produce outputs employed for the management process of multi-project interdependencies. Those outputs are project life cycle description, activity list, activity attributes, and project network diagram.

Consequently, the management process of multi-project interdependencies collects project stages, activities, and relationships from those outputs. Henceforth, the management process of multi-project interdependencies further categorizes, analyzes, displays, and improves projects' interdependencies information in terms of stages and activities.

Subsequently, the communication management processes communicate those improvement actions both internally and externally to the supplier and sub-suppliers. This communication is enabled through communication management processes outputs, such as communication plan, communication matrix, and project communications. On the other hand, the rest of the coordination activities within the project team could be left over to communication based coordination using different means of communications such as personal conversations, workshops, workgroups, meetings, and e-mails. However, for this communication based coordination, this thesis offered communication planning and management processes in addition to the communication matrix in order to facilitate and manage this communication based coordination.

The proposed coordination approach was validated in order to ensure that the proposal solves the business challenge, satisfies the business objective, and satisfies its intended purpose within the business context.

For the project management parts of the coordination approach, validation was conducted through implementation to the case company's management system. What is more, it is planned for release in the next revision of the project management procedure and the project plan template.

For the multi-project interdependencies management part of the coordination approach, validation is conducted through stakeholder feedback and pilot implementation prior to further implementation in a dedicated projects' coordination procedure.

Thus, this thesis proposes a coordination approach that structure project stages accomplishment, manifests project activities control, assists project communication management, and alleviates personal communication needs. In the same fashion, this coordination approach governs coordination activities, supports the identification of projects' interfaces, authenticates multi-project interdependencies, and aids the priority setting of the projects.

In relation to business impact, this coordination approach would contribute to solving issues identified in the business challenge such as overlapping responsibilities, projects scope gaps and time-schedule challenges.

## 7.2 Managerial Implications and Practical Recommendations

The outcome of thesis is a coordination approach for multi-project interdependencies in program management. This coordination approach encompassed time management, communication management, and multi-project interdependencies management. Within the scope of this thesis, time management and communication management are planned for release into the next revision of the case company's project management procedure in addition to the project plan template.

However, the management process of multi-project interdependencies was built and validated through feedback in the form of comments as well as a pilot implementation of the process for projects in one sub-unit under the engineering unit in the case company. Therefore, this management process of multi-project interdependencies is not yet implemented in practice.

For that reason, the first practical recommendation for next steps concerning the coordination approach is the implementation of the management process of multi-project interdependencies into a dedicated projects' coordination procedure. What is more, a dedicated reporting mechanism could be implemented for this process so as to facilitate the fast improvement actions to projects and on-line implementation of the process. To elaborate, the management process of multi-project interdependencies within the scope of this thesis utilized the current program planning and steering mechanism in order to capture project information without disturbing the current processes.

Given these implications and looking back to the current state analysis stage where several key findings were recognized and addressed in this thesis; however, other findings were outside the focus area of this thesis. Taking into account these findings outside the focus area, the first key finding was the lack of supplier control processes as part of the

program governance. Specifically, in the case of a turnkey project where the supplier has the full responsibility of engineering, procurement, construction, and management.

Additionally, a second key finding was the project management processes' reliance on the supplier's project management processes needs to be investigated. That is particularly the case in a turnkey project where the contractual agreement with the supplier includes project management responsibility.

Lastly, a third key finding was the obscure projects' breakdown structure along with work breakdown structure for the program. Precisely speaking, instituting a clear product breakdown structure for a greenfield plant becomes an essential demand in order to contribute to the effectiveness of the project management processes.

To sum up, future steps include the implementation of the management process of multi-project interdependencies in a dedicated procedure in addition to founding a dedicated reporting mechanism for the projects. Equally important, key findings outside the focus area could be considered in further research projects. That is why future researches could investigate turnkey supplier controls processes, project management processes within turnkey plant supply, and greenfield plant projects' breakdown structure.

### 7.3 Thesis Evaluation

This section evaluates the outcome of this thesis against the objective. In addition, it evaluates this thesis in terms of validity, reliability, logic and relevance.

#### 7.3.1 Objective versus Outcome

The objective of this thesis was to build an overall coordination approach for the case company to integrate supplier's different interdependent projects into program management. Correspondingly, the outcome is a coordination approach comprise time and communication management as part of project management in addition to multi-project interdependencies management as part of program management.

Originally, the case company did not possess a standardized process or approach for multi-project coordination; therefore, the coordination approach was co-created with key stakeholders and further validated against the business objective and for its intended purpose within the business context.

In comparison to thesis objective, the coordination approach supports the case company's business needs by supporting projects' interdependencies identification, authentication, and management. This would aid the case company in moderating overlapping responsibilities, reducing projects scope gaps, and resolving time-schedule challenges. However, this management process of multi-project interdependencies is not yet implemented in practice; since it requires a meticulous implementation of time and communication management processes into project management.

### 7.3.2 Validity, Logic, Reliability and Relevance

Since the research project is representing a coherent logical set of development and statements, the quality of the research is judged according to logical set of tests. The four logical tests relevant to case studies are validity, reliability, logic, and relevance. (Yin 2009: 40)

*Validity* of the research can be covered by three tests covering construct validity, internal validity, and external validity. Construct validity refers to the operational set of measures that subjectively judgements are used to collect the data. Internal validity is the concern of explanation where the researcher properly defined relationships between events. External validity deals with the idea if the current study's findings are generalized beyond the current case study. (Yin 2009: 41-44)

During this study, construct validity is ensured by using multiple data sources in three data collection rounds. These data sources are drawn from different program and project management levels inside the case company. Besides, an evidence chain is established in the data collection in terms of field notes, electronic format feedback, and management system documents.

*Internal validity* (in other terms: *logic*) is ensured via reliable data analysis method i.e. thematic content analysis and building explanation logic. Correspondingly, the research employed grounded conclusions as well as counter arguments. The logic of those conclusions is validated with key stakeholders and therefore were not solely reliant on the author of this thesis.

*External validity* is ensured by the research relevance outside the current settings. In particular, the current study of multi-project interdependencies management and coordination is appropriate in large-scale and complex mega projects settings.

*Reliability* is the assessment of whether the same findings would be obtained if the research was repeated. (Quinton & Smallbone 2006: 129)

During this study, different data sources are used with diverse data collection methods, such as interviews, workshops, electronic format feedback, as well as management system documents study and investigation. Furthermore, data is collected in three different stages throughout the research; while selected literature follows the business objective and the current state analysis stage key findings. In addition, selected literature comprises project management standards view point as well as methodologies and best practices.

*Relevance* addresses the question of how well the outcome of this thesis satisfies the business challenge of the case company. During this thesis, relevance is assured by co-creating the coordination approach with key stakeholders in the proposal building stage. In addition, the coordination approach is validated with key stakeholders during the validation and feedback stage using different methods. Relevance is further augmented by adding new stakeholders in the validation and feedback stage as part of the criticism to the initial proposal and seek outsider's opinion.

#### 7.4 Closing Words

A greenfield plant project as a large scale, and complex venture requires efficient coordination of project activities and management project interfaces with all stakeholders. Thereupon, this thesis addressed this business challenge of the case company and built a coordination approach to overcome time pressured work characterized by multiple projects and constantly managing situations of crisis.

Besides, this thesis offered several future research topics such as greenfield plant projects' breakdown structure, turnkey supplier controls, and project management processes within turnkey plant supply.

Overall, the coordination approach is offered for the case company to integrate, coordinate, and manage its supplier's interdependent projects into program management; yet, it is can be made applicable in similar instances of large-scale and complex greenfield plant projects.

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## **Appendix 1. The Pilot of the Management Process of Multi-Project Interdependencies**

This appendix describes the pilot conducted for the management process of multi-project interdependencies in the case company in order to validate the initial proposal of the process and gain insights into the process steps prior to further implementation in a dedicated projects' coordination procedure.

This appendix is organized as follows. First, it introduces the pilot description as well as the projects information used. Subsequently, it illustrates the management process of multi-project interdependencies implementation steps through collection, identification, analysis, display, and improvement. Finally, it ends with the pilot implementation conclusions.

### **Introduction**

The management process of multi-project interdependencies developed in Section 5.4 is generic; therefore, it will be implemented in different levels inside the program (i.e. projects, stages, activities). This pilot is implemented for the first level of projects' interdependencies. That is between projects' stages covering inputs, and outputs. Activities interdependencies are excluded from this pilot's scope; since project plans in the current stage include only information about project stages, inputs, and outputs.

This pilot is applied for three projects (A, B, and C) within one sub-unit under the engineering unit in the case company as demonstrated in Section 1.2. Each of those projects comprise several stages and sub-suppliers. Information is recognized based on those projects individual project plan. This pilot is implemented using Cambridge Advanced Modeller (Wynn et. al, 2010). Cambridge Advanced Modeller is a software tool for modelling and analyzing the interdependencies and flows in complex processes.

### **Collection Steps**

The first step in collection utilized outputs from project plans for those three projects and further collected project stages, inputs, and outputs. Figure 1-1 shows the life cycle of Project A.

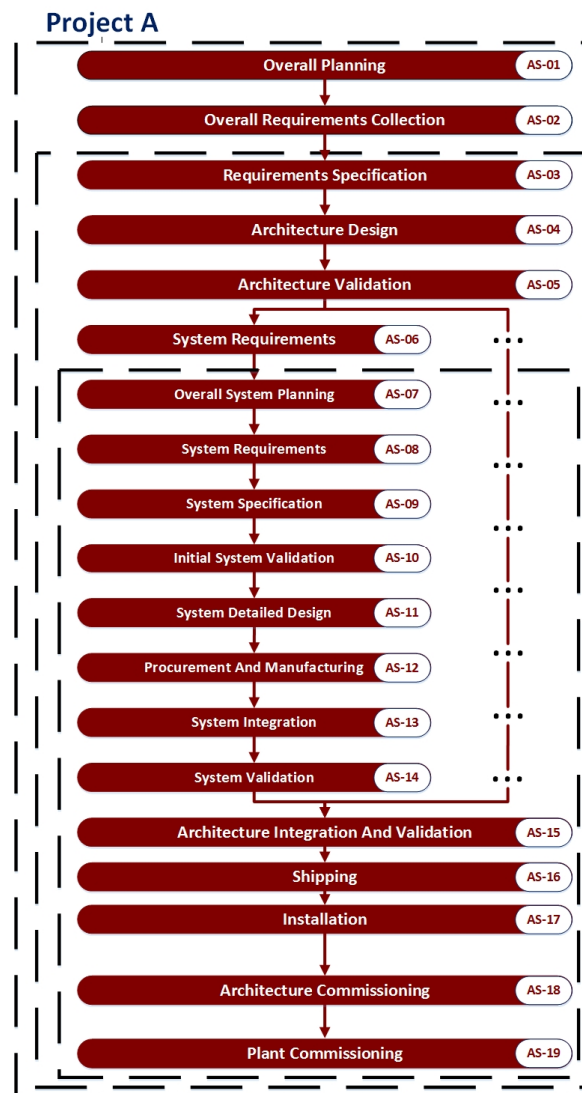


Figure 1-1. Project “A” life cycle

As demonstrated in Figure 1-1, the life cycle of project “A” is divided into stages. Each stage has a unique identifier. In each stage, several inputs and outputs are identified. Worth mentioning that each stage involve one or more sub-suppliers. Moreover, stages from AS-01 till AS-06 represent planning and architectural design life cycle; whereas stages from AS-07 till AS-14 represent system planning, design, and validation life cycle; therefore, in those stages, life cycle stages would be duplicated for the number of systems involved in the project. Likewise, further stages from AS-15 till AS-19 represent plant integration.

Second project information is acquired as well from its project plan. Figure 1-2 shows the life cycle of Project B.

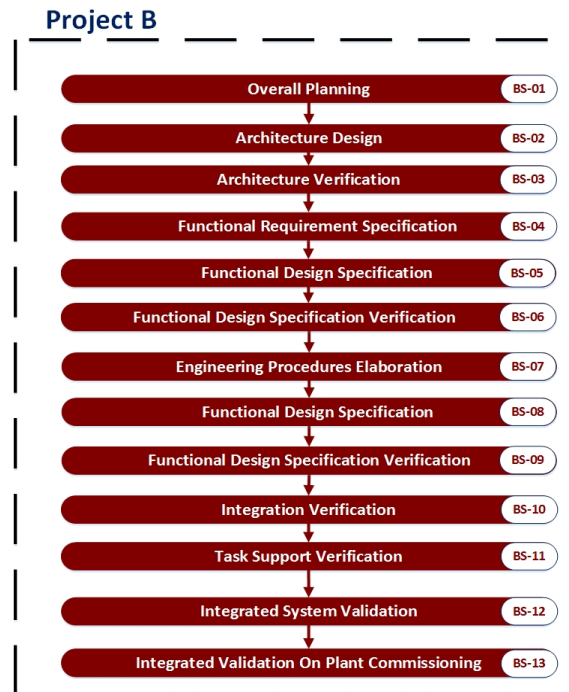


Figure 1-2. Project “B” life cycle

As demonstrated in Figure 1-2, the life cycle of project “B” is divided into thirteen stages with unique identifiers. In each stage, several inputs and outputs are identified.

Third project information is acquired as well from its project plan. Figure 1-3 shows the life cycle of Project C.

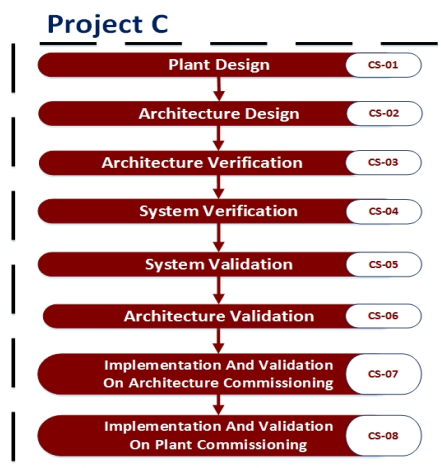


Figure 1-3. Project “C” life cycle

As demonstrated in Figure 1-3, the life cycle of project “C” is divided into eight stages with unique identifiers. In each stage, several inputs and outputs are identified. The second step of collection is skipped in this pilot since this pilot’s scope covers only first level of the program that is stages, inputs, and outputs.

**Identification Steps**

Identification comprise two steps. In the first step, the project network diagram is employed to identify stages relationships. Those stages relationships are identified from its respective sections from project plans of projects A, B, and C. The second step categorized these projects’ interdependencies information based on importance and priorities. Categories comprise critical, major, and minor interdependencies.

Critical interdependencies are characterized by prevention and inability of progress in other projects in case of significant changes. Major interdependencies are characterized by the damaging effect and major rework to other projects in case of significant changes. Minor interdependencies are characterized by the ability of the other projects to progress without major adjustments in case of significant changes. Figure 1-4 shows the initial Dependency Structure Matrix (DSM) model built for projects A, B, and C stages as well as interdependencies between stages.

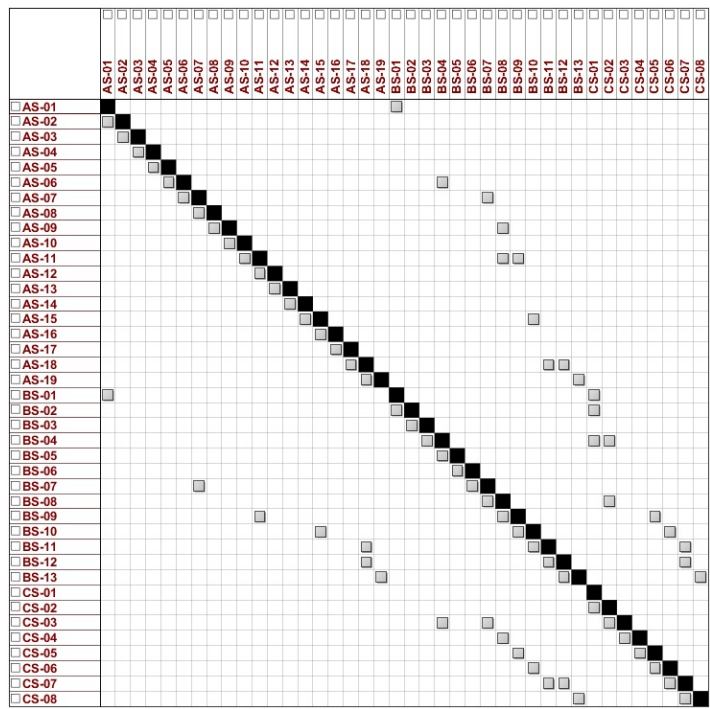


Figure 1-4. Initial projects’ Dependency Structure Matrix (DSM)

As exposed in Figure 1-4, The DSM is built for projects A, B, and C stages. These stages identifiers collected from project plans are used for the DSM model to identify stages. Interdependencies between stages are recognized by marks in the off-diagonal cells representing sources and destinations of these input and output interactions.

### Analysis Step

Analysis is a one-step contains sequencing projects' interdependencies information to recognize the best sequence of stages. Figure 1-5 shows the Dependency Structure Matrix (DSM) model for projects A, B, and C stages after sequencing the stages based on its interdependencies.

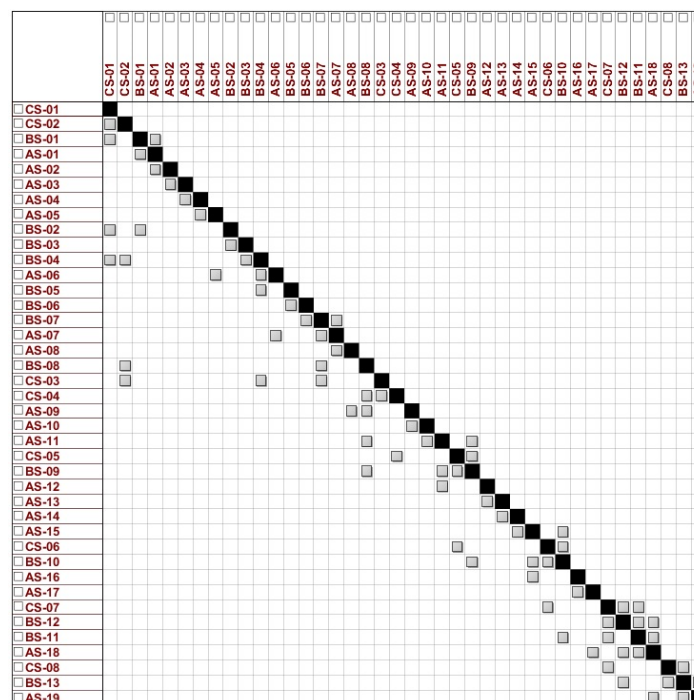


Figure 1-5. Sequenced projects' Dependency Structure Matrix (DSM)

As exposed in Figure 1-5, stages are sequences in order to find the order of stages that minimizes the amount of iteration represented by cycles and feedbacks in the projects. Stages in the DSM are rearranged by reordering the rows and columns.

### Display Steps

Display involve two steps. In the first step, relevant visual maps are built. Relevant visual maps implemented for these three project, and stages is shown in Figure 1-6

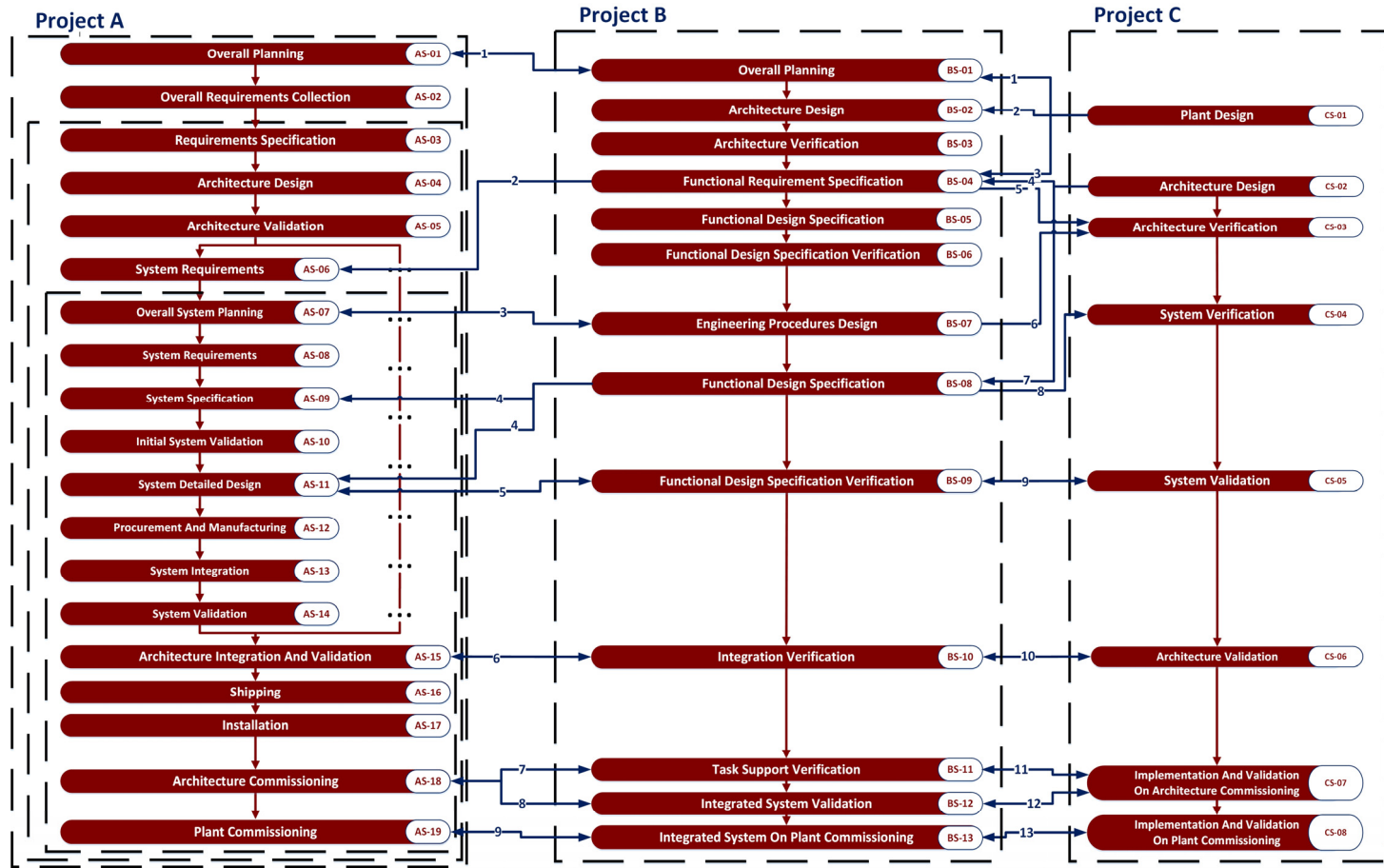


Figure 1-6. Multi-project visual map

As demonstrated in Figure 1-6, projects A, B, and C are interconnected based on their stages' interdependencies. In addition, each interdependency is uniquely identified in order to facilitate easier input/output connection between stages.

The second step of display comprise displaying the important features of projects activities in the DSM model. Those important features could be decided on a project by project basis. General important features could be extensive activities iterations, deadlock activities patterns, or different supplier's relationship. Figure 1-7 shows the DSM model of these projects after highlighting the important features.

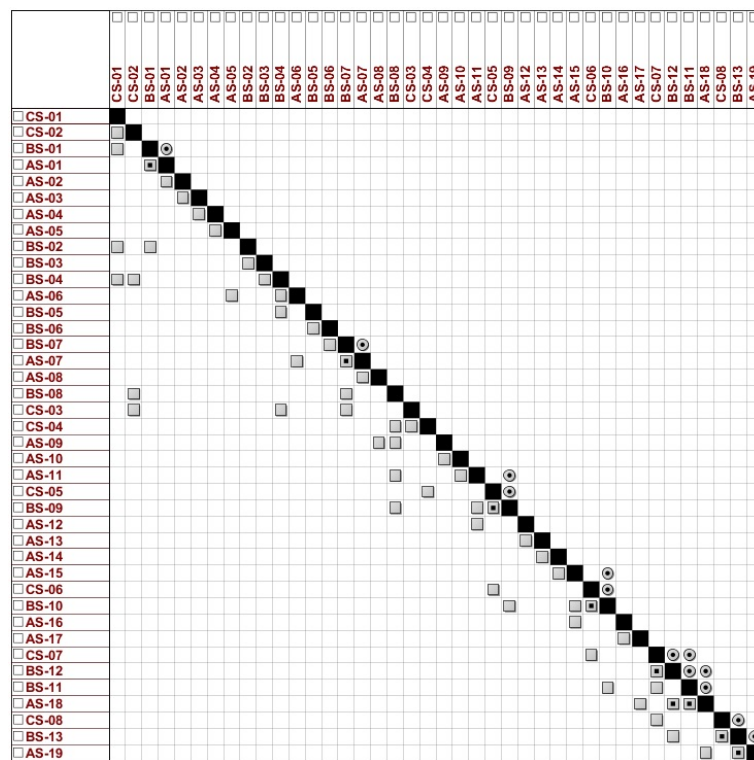


Figure 1-7. Highlighted projects' Dependency Structure Matrix (DSM)

As exposed in Figure 1-7, the important features highlighted are iterations represented by feedback loops or cycles in the process. Those iterations are displayed as a dotted circle in the DSM model.

Another highlighted important feature is the deadlock stages' patterns where two stages from two different projects are dependent on each other in terms of inputs and outputs. This important feature is highlighted as a dotted square. The rest of the DSM model is the same as the sequenced DSM model built during the analysis steps.



### Improvement Steps

Improvement involves two steps. In the first step, the important features of the DSM identified in the previous step are solved by decomposition or tearing by assumptions. Hence, for long iterations, decomposition of stages into sub-stages is introduced as a solution. For deadlock pattern in stages inputs and outputs, tearing by assumptions is introduced in one those coupled stages in the first round; thus in the next round, those assumptions could be replaced by actual information from the first round.

The second step of improvement exploits communication matrix and communication management processes outputs to communication improvement actions to relevant projects' stakeholders. Those stakeholder include internal project team, supplier's project team, and sub-suppliers.

Consequently, as recognized in analysis steps, first acknowledged improvement actions is to sequence projects stages as identified in Table 1-1.

Table 1-1. Best projects' stages sequence

Project		Stage ID	Important Feature	Proposed Improvement Action
1	Project C	CS-01 and CS-02	Sequence	Stages CS-01, and CS-02 to be firstly concluded in the three projects
2	Projects A, B, and C	AS-01, BS-01, CS-01, and CS-02	Sequence	Stage AS-01 and BS-01 to follow stages CS-01 and CS-02
3	Projects A and B	BS-07, AS-07, and CS-03	Sequence	Stage BS-07 to be concluded at latest before closing stages AS-07 and CS-03
4	Projects A, B, and C	AS-11, BS-09, and CS-05	Sequence	Stage AS-11 to be concluded at latest before closing stages BS-09 and CS-05
5	Projects A, B, and C	AS-15, BS-10, and CS-06	Sequence	Stage AS-15 to be concluded at latest before closing stages BS-10 and CS-06

As recognized in Table 1-1, the best sequence of stages is identified as concluding stages CS-01 and CS-02 before starting projects A, and B. Then stages AS-01 and BS-01 to follow. Moreover, stages BS-07 of project B, AS-11 of project A, and AS-15 of project A to be concluded before closing its respective interdependent stages in projects A, B, and C.

What is more, different important features of projects and stages are identified along with proposed improvement actions. These important features are identified as part of the first step of the improvement steps as demonstrated in Table 1-2.

Table 1-2. Projects' important features along with improvement actions

Project		Stage ID	Important Feature	Proposed Improvement Action
1	Projects A and B	AS-01 and BS-01	Deadlock stages pattern	Tearing those two stages by introducing assumptions for the first iteration then proceed with actual data in the next iteration.
2	Projects A and B	AS-07, and BS-07	Deadlock stages pattern	Tearing those two stages by introducing assumptions for the first iteration then proceed with actual data in the next iteration.
3	Projects A, B, and C	BS-09, AS-11, and CS-05	Long iterations	Stage BS-09 to be decomposed to sub-stages in order to introduce new inputs and outputs to facilitate progress in other projects stages.
4	Projects B and C	BS-10, AS-15, and CS-06	Long iterations	Stage BS-10 to be decomposed to sub-stages in order to introduce new inputs and outputs to facilitate progress in other projects stages.
5	Projects A, B, and C	BS-11, BS-12, AS-18, and CS-07	Long iterations	Stages BS-11 and BS-12 to be decomposed to sub-stages in order to introduce new inputs and outputs to facilitate progress in other projects.
6	Projects B, and C	CS-07, and BS-12	Deadlock stages pattern	Tearing those two stages by introducing assumptions for the first iteration then proceed with actual data in the next iteration.
7	Projects A, B, and C	BS-13, AS-19, and CS-08	Long iterations	Stages BS-13, AS-19, and CS-08 to be decomposed to sub-stages in order to introduce new inputs and outputs to facilitate progress in other projects.

As recognized in Table 1-2, three deadlock stages patterns are perceived. The proposed improvement actions included tearing those two stages by introducing assumptions for the first iteration then proceed with actual data in the next iteration.

Furthermore, three long iterations are perceived. The proposed improvement actions for those long iterations included decomposition of stages to sub-stages in order to introduce new inputs and outputs to facilitate progress in other projects.

## **Conclusions**

This pilot is implemented for the first level of projects' interdependencies between projects' stages covering inputs, and outputs. This pilot is applied for three projects (A, B, and C) within one sub-unit under the engineering unit in the case company.

Steps followed in this pilot implementation covered collection, identification, analysis, display, and improvement. In collection, projects stages, inputs, and outputs are collected from project plans. In identification, stages relationships are identified based on interdependencies information from project plans. In analysis, the DSM model is sequences in order to recognize the best sequence of stages. In display, important features of projects' interdependencies are highlighted. In improvement, the DSM model is improvement in relation to the important features identified in projects' interdependencies in terms of stages iterations and deadlock stages patterns.

As a concluding output from the pilot of the management process of multi-project interdependencies, important features along with improvement actions are offered as part of an improvement actions report. Long iterations and deadlock stages patterns are identified as two important features of the projects scrutinized. Improvement actions for these two important features included stages decomposition and tearing by assumptions for long iterations and deadlock stages patterns respectively.