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DIPLOMA THESIS

Analysis of Business Processes inside the IT -Project Portfolio Management Office Team and Proposal of Changes for Increasing Efficiency

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Study degree programme: Innovation Project Management

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MASTER'S THESIS ASSIGNMENT

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Guidelines:

Goal: Description of existing processes and proposal of changes to increase their efficiency.
Benefits: Analysis and description of existing processes in the Project Portfolio Management office team and suggestion of improvements of critical processes. It is also expected that communication and interaction across the Resource Management group will be increased.
Structure: Introduction; Theoretical part - general terminology, standards of process modelling, information system, methods of economic evaluation of investments; Practical part - company introduction, analysis of current processes and evaluation, proposal of changes, economic evaluation, Conclusion

Bibliography / sources:

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Abstract

Effective project portfolio management is essential for organisational success as it ensures alignment with strategic objectives, optimal resource allocation, and tracking performance. Despite its significance, many organisations rely on manual and time-consuming methods. The purpose of this thesis is to analyse and suggest improvements to the business processes of the Project Portfolio Management Office team (PMO team) within the European Organisation for Nuclear Research's Information Technology Department. The theoretical part of this thesis introduces common business process modelling methods, their importance, and their limitations. The practical part provides a deep analysis of the business processes of the IT-PMO Team and suggests a redesigned version implementing a common information system. Through the unique combination of theoretical evaluation and practical experience within the IT-PMO team, the proposed enhancements seek to increase productivity, nurture collaboration, and improve communication across the resource management group.

Key words

Business Process, Business Process Modelling, Business Process Model and Notation, Unified Modelling Language, Use Case Diagram, Entity Relationship Diagram, Methods of Economic Evaluation of Investment

Content

Introduction

Effective project portfolio management is an important pillar of any successful organization. Its goal is not just selecting the right projects and efficient allocation of resources but also making sure all the decisions and projects are in alignment with organisational objectives, thus bringing value to the whole organisation (European Commission, 2022). Despite the critical nature of project portfolio management, many places rely on manual and often tedious methods of managing their portfolios.

The purpose of this master's thesis is to map and analyse the business processes of the Project Portfolio Management Office (PMO) team at the European Organisation for Nuclear Research's Information Technology Department. The goal is to understand how the team handles all of its responsibilities by studying its current methods and processes. Building on the findings of this study, the goal is to propose improvements that would increase team productivity, improve communication, and foster stronger interactions among teams within the Resource Management group.

This thesis will provide a comprehensive analysis through theoretical exploration of standards of process modelling combined with practical insight gained from the day-to-day experiences within the IT-PMO team. This unique combination will provide a thorough understanding of project management's fundamental principles as well as real-world applications within the IT-PMO context.

THEORETICAL PART

1. Introduction to Business Process Modelling

In 1921, Fran and Lillian Gilbreth introduced process charts as a device for visualising processes as a means of improving them. Building on the idea that every detail of a process is more or less affected by every other detail, thus showing the need to visualise the process in its entirety to assess any proposed changes properly (Gilbreth & Gilbreth, 1921). Later on, in 1967, the term "business process modelling" was used by S. Williams in the context of systems engineering. However, it did not gain popularity until the 1990s, when this term finally established itself as a new productivity paradigm (von Rosing et al., 2015).

The definition of a business process can vary as widely as there are areas of business. A process can be a simple visit to the grocery store, where the final step is the customer walking away with their shopping; it can also be the process of innovation, the process of building a house, or the production of a product. The most universal way to look at them is as a summary of activities that transform inputs into outputs for the benefit of people or other processes while using tools or people to achieve so (Řepa, 2007).

The sheer number of processes and their complexity often make it difficult to manage without a structured approach. That is where the need for Business Process Modelling (BPM) comes into play. In the book Fundamentals of Business Process Modelling, the authors define BPM as “*a body of methods, techniques, and tools to discover, analyse, redesign, execute, and monitor business processes”* (Dumas, La Rosa, Mendling, & Reijers, 2013, p. 5). Another definition states that BPM provides a simple way for organisations to understand and optimise workflows by creating a data-driven visual representation of key business processes (IBM Cloud Education, 2021). In other words, it is a graphical representation of any workflow, its activities, participants, decision points, inputs, and outputs that helps to understand any given process (Myslín & Kaiser, 2022). BPM is focused on managing entire chains of events, activities, and decisions that ultimately add value to the organisation (Dumas et al., 2013).

The way processes are designed and performed affects both the service’s quality and its efficiency. Proper management of business processes and their execution can outshine similar organisations with poor business process management (Dumas et al., 2013).

1.1. Approaches of Business Process Modelling

The field of business process modelling distinguishes between three different approaches. Each one offers a unique definition of a process and what it consists of. These approaches are functional, behavioural, and structural (Myslín, 2012).

The functional approach focuses on the specific functions of the process, the inputs that it works with, and the outputs that the process generates. However, this approach treats the process itself as a "black-box," and the only way to alter the outcome is through inputs.

In contrast, the behavioural approach focuses on the specific sequence of activities and the conditions under which it operates. It presents the process as a series of precisely defined activities performed by designated roles.

Lastly, the structural approach concentrates on the structure of a process, emphasising the participants and their interrelationships. This approach is the least used in common practice (Myslín, 2012).

It is essential to note that these approaches are not mutually exclusive; rather, they represent complementary perspectives on a given process. Methodologies derived from these approaches are not strictly confined to a single one. For instance, the Business Process Model and Notation (BPMN), while primarily behavioural, also incorporates elements of the structural approach (Myslín & Kaiser, 2022).

1.2. Components of a Business Process

Generally, a business process consists of several events and activities. An event happens automatically and thus has no duration. The event can trigger the execution of a series of activities. An activity takes time; however, if it is simple and requires only one step, we call it a task. To give an example, imagine a process that begins with receiving an order. This event then triggers several different activities, such as preparing the products for delivery, packing the order, generating an invoice, or arranging a delivery service. Additionally, a business process involves so-called decision points. A decision point is a point in time when a decision is made that affects the way a process is executed as well as what happens later in the process. A business process can also involve several actors. Those can either be human actors, an organisation, or a software system acting on behalf of a human. A common actor involved in a business process is a customer, i.e., a person who consumes the outputs of the process. A business process often has more than one customer. The next component of a business process is a physical object, which can be equipment, materials, products, or tangible documents. Alongside physical objects, we find an immaterial object, which can be an intangible document or electronic record. And finally, all these components lead to an outcome. Ideally, we are hoping for a positive outcome, in which case all involved actors are satisfied. In the worst case, the process outcome is negative, meaning no value is gained for either of the involved actors (Dumas et al., 2013).

Figure 1 illustrates all of the above-mentioned components and their connections.

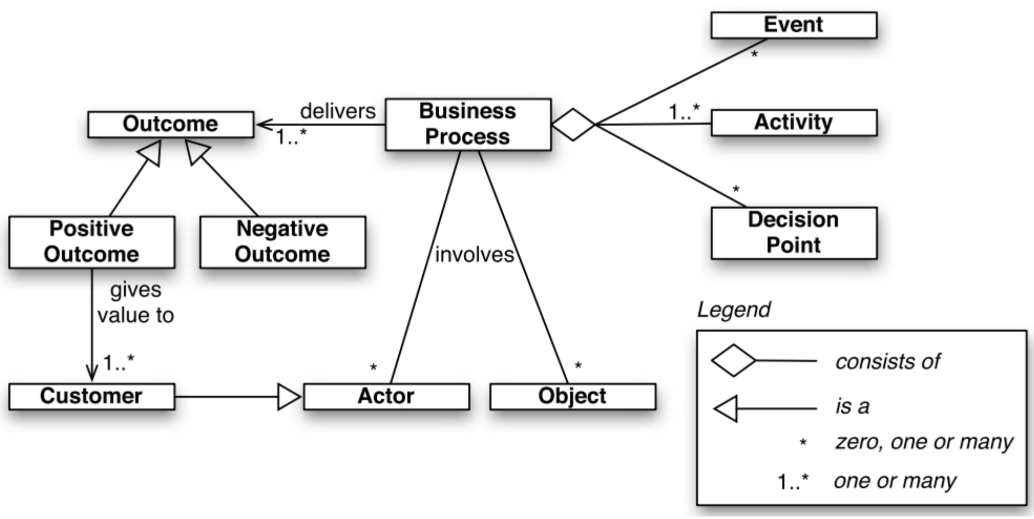


FIGURE 1: COMPONENTS OF A BUSINESS PROCESS (DUMAS ET AL., 2013)

1.3. Business Process Hierarchy

Business process hierarchy involves breaking down complex processes into smaller, more manageable components to provide a clear and ordered structure for understanding and optimising them. It adds significant value by offering granular detail on who is responsible for each process, ensuring consistency and coherence throughout the organisation. By organising processes in this hierarchical manner, businesses can better prioritise, improve, and optimise their core operations. The significance of a well-defined process hierarchy lies in its ability to trace every process within an organisation and highlight its contribution to strategic business goals.

Typically, three primary levels are defined within this hierarchy. The top-level captures the highest level of processes, which mostly cover business architecture and coordination between departments and units. Mid-level business processes can be further divided into processes and subprocesses that are directly related to the value chain of an organisation. The third, and last, level depicts individual tasks and activities that make up sub-processes and cannot be decomposed any further (Usman, 2024; Team Kissflow, 2024). Figure 2 provides a high-level view of the three described levels.

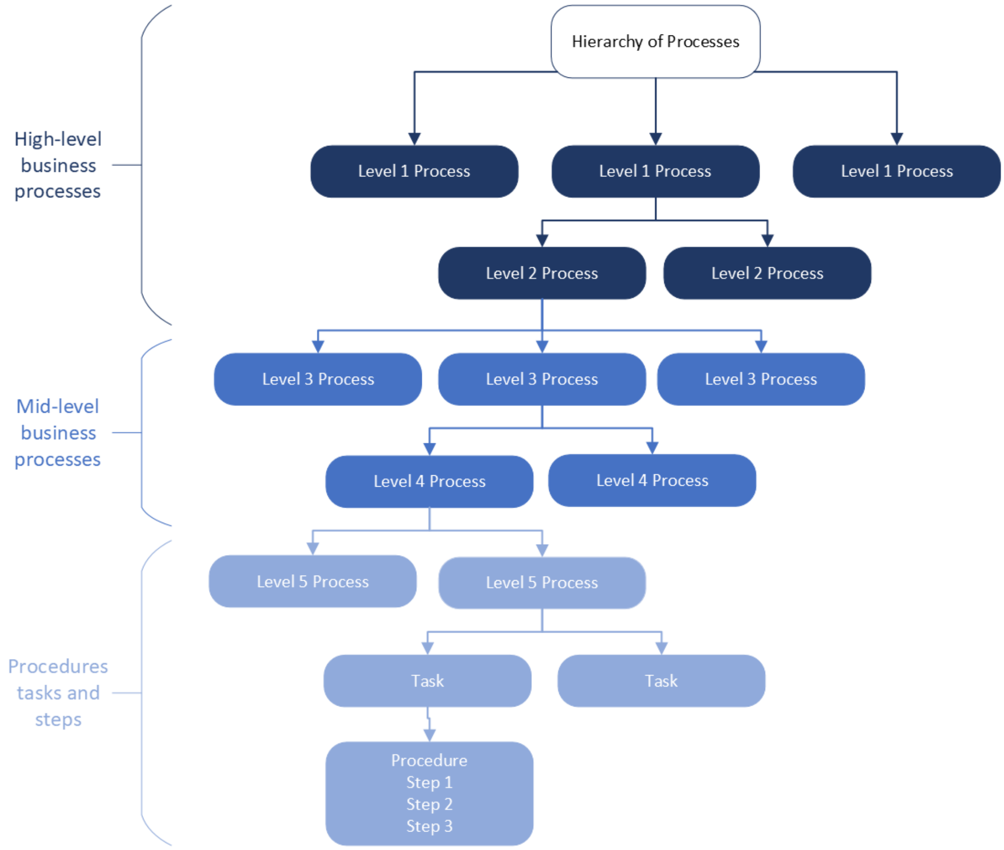


FIGURE 2: BUSINESS PROCESS HIERARCHY

1.4. Business Processes Improvement

In today's dynamic business world, pursuing excellence, agility, and efficiency is essential. Both the requirements and the technology are constantly evolving. Regardless of how well-modelled a process is, it will deteriorate if it is not constantly monitored and improved. The concept of business process improvement involves a systematic approach to enhancing organisational workflows, optimising resource utilisation, and fostering continuous growth (Amblard-Ladurantie, 2023).

This chapter introduces the cycle of business process improvement and describes each step in more detail.

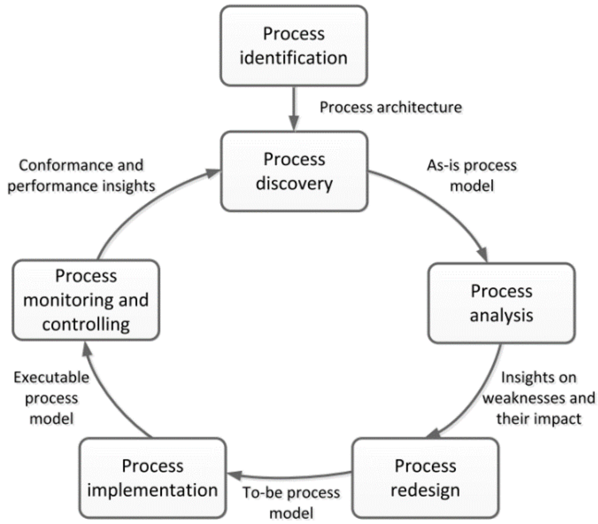


FIGURE 3: BUSINESS PROCESS IMPROVEMENT PROCESS (DUMAS ET AL., 2013)

Process identification phase

To begin the procedure of business process improvement, we start by identifying the processes that are relevant to the problem at hand, defining their scope, and identifying relations between them, i.e., one process is part of another process. In some cases, this phase also includes the identification of performance measures. However, more often than not, the performance measure identification is found in a later phase. The outcome of the process identification phase is either a new or updated process architecture that depicts the processes and relationships within an organisation (Dumas et al., 2013).

Process discovery phase

Following the decision on the relevant business process, it needs to be documented. A business process model in its current state represents what people know about how the work is carried out (Dumas et al., 2013).

Process analysis phase

In the process analysis phase, the previously identified processes are analysed in order to identify issues. As previously mentioned, this phase can also include the classification of performance measures that complete the full assessment of the shape of the process at hand. Depending on the organisation and the studied business process, the issue at hand can vary widely. The performance measures can, for example, be the error rate, the total costs, the time it takes to reach the desired outcome, or the amount of rework that needs to be done if things don't go smoothly. Time is a valuable entity, and no organisation wants to spend it unwisely. To perform a thorough analysis, the organisation should find out why the issue or negative outcome is happening. It can, for example, come from simple miscommunication, inaccurate data, bottlenecks, or an error by one of the actors. Only after identifying and understanding the main triggers can the most suitable way of addressing said issue be found. The phase provides a list of the identified issues (Dumas et al., 2013).

Process redesign phase

The next step is to come up with changes that would address the previously identified issues. Generally, multiple potential remedies are considered and evaluated based on the chosen performance measures. Changing a process that addresses one issue can potentially cause other issues in consequence. It is important to keep in mind that changing a process is not as easy as it might sound. People are used to working in a certain way and might not like the change. Furthermore, if the change implies modifying the information system, it can be quite costly. To this end, multiple options are analysed to make an informed decision. Once the analysis of issues and potential remedies is done, a new, redesigned version of the process can be proposed. This to-be process is the outcome of this phase (Dumas et al., 2013).

Process implementation phase

After one solution is chosen, the implementation phase comes in. The goal at this point is to prepare and perform the changes. Generally, we can say that process implementation covers two complementary aspects: organisational change management and process automation. Organisational change management is defined as *"a set of activities required to change the way of working of all participants involved in the process"* (Dumas et al., 2013, p. 20). Such activities can include, for example, communicating the change to the participants so they understand the benefits, putting in place a change management plan so that stakeholders know the time scope of the changes, and lastly, training users and adapting them to the new way of working. On the other hand, process automation refers to the development and implementation of IT systems that are to support the new process. A new system like this should assist the participants in carrying out tasks, allow assignments, help them with prioritisation, and provide them with information necessary for their tasks (Dumas et al., 2013).

Process monitoring and controlling phase

The process monitoring and controlling phase sets off when the redesigned process is up and running. It is crucial to continue collecting data and to continuously analyse how the process is performing. Any deviations from the intended outcomes need to be noted because, over time, more adjustments might be needed (Dumas et al., 2013).

It is necessary to actively monitor the processes, analyse their performance, and, if needed, implement new adjustments. Addressing a handful of issues does not mean a finished job. The process of reengineering is a cycle and requires continuous effort and proactive treatment. If not, even a well-designed process will eventually degenerate (Dumas et al., 2013).

2. Methods of Business Process Modelling

Business process modelling is an essential tool for managing complex sets of business processes, overseeing their efficiency, and enhancing communication among involved stakeholders. Consequently, it is desired to make them as easy to understand as possible. While a textual description of a business process is possible, it can be cumbersome to write and interpret, potentially leading to misinterpretation. To overcome this challenge, it is common practice to use diagrams instead, as they offer a more intuitive way of understanding the process and leave less room for misinterpretation. Nevertheless, it is important to note that diagrams modelled using a common notation can still be enhanced with a textual description to provide a more comprehensive view (Ottensooser et al., 2012).

Several business process modelling techniques were developed based on the three different approaches described earlier in this thesis. This chapter examines the various business process modelling languages, starting with simple flowcharts and working its way up to more detailed languages.

2.1. Flowcharts

Flowcharts are versatile visual tools that offer a structured and intuitive method for illustrating processes, systems, and algorithms, making them applicable across a wide range of disciplines. These diagrams provide a systematic graphical depiction of workflows, leading users through a series of steps and choices to achieve specific objectives. Flowcharts play a crucial role in visualising work processes, enhancing success rates by providing a roadmap for task completion, and helping to foster the alignment of the actors involved. They are essential for documenting and analysing processes, supporting process enhancement, and facilitating communication. Due to their versatility, they meet diverse requirements in both technical and non-technical fields. From software development, engineering, and manufacturing to project management, flowcharts help with efficient management and visualisation, helping to identify bottlenecks and fix issues, and by providing a universal language that simplifies complex concepts into diagrams that are easily communicated across departments (Gaskin, 2023).

It is perhaps the oldest modelling language for business processes. In their simplest form, we distinguish two types of nodes: activity nodes and control nodes. Activity nodes describe units of work that may be performed by humans, software applications, or their combination and are represented by rectangles. Control nodes, reflect decision points, and capture the flow of execution between activities. These are represented by a diamond shape. Some more detailed modelling languages are enhanced with event nodes. If so, event nodes tell us that something might happen within the business process that requires a reaction. For example, the arrival of an order request from a customer requires a reaction from the company's sales team (Dumas et al., 2013).

2.2. Unified Modelling Language

The Unified Modelling Language (UML) was developed and is being maintained by the Object Management Group. The latest version was released in 2017 and defines the objectives of the UML as providing tools for analysis, design, and implementation of software-based systems as well as for modelling business processes. To this end, UML is widely adopted in software engineering as a tool for describing, designing, and documenting, nonetheless; it contains diagrams that can find their application in almost any field (Object Management Group, 2017).

The wide range of diagrams that UML offers is divided into two groups: structure diagrams and behaviour diagrams. Structure diagrams show the static structure of the objects in a given system, whereas behaviour diagrams show their dynamic behaviour (Object Management Group, 2017).

One of the behaviour diagrams is the Activity Diagram. An Activity Diagram is initially a cross-organisational flowchart that allows us to capture the flow of activities, decisions, and parallel flows. But it also provides symbols for data objects and signals that make it a suitable choice for business process modelling (André et al., 2014). Another example of a behaviour diagram is the Use Case Diagram, which allows us to depict the user's possible interactions and requirements with any given system. It is an essential stage of software development since it captures the primary functions and requirements of the system, identifies its boundaries, and defines user-system interactions (Object Management Group, 2017).

The Unified Modelling Language helps to improve the quality, communication, and maintenance of the models. However, there is a learning curve to the notation and a need for consistent application, which might make its use problematic (Poest, 2020).

2.2.1. Components of Unified Modelling Language Diagrams

Activity diagrams commonly consist of Start and End nodes, Actions, and Decision points. Like flowcharts, actions describe a process or a transformation that occurs within the modelled system. Such an activity can include, for example, sending an order. A Decision indicates a point in a process where the flow can go one of two or more ways. In the case of multiple flows, a Fork and a Join can connect and split several different flows. We can imagine the actions before sending an order, where one flow would be preparing the items for shipment and the second flow would be the need to contact the delivery service. Once both of these flows were done, they would be merged using a Join, and the activity of sending an order would follow (Sparx Systems-a, n.d.).

A Use case diagram consists of an Actor who is the user of the modelled system and can either be a human, a machine, or another system. The Actor is connected via Associations to different Use Cases that are represented by an oval shape and specify how a user interacts with the system. Arrows can indicate connections to source elements that either include or extend the use of another element. The Include relationship indicates that an additional process is included as a part of the use case to which it is connected, whereas the Extend relationship indicates that the connected process is an optional extension (Sparx Systems-b, n.d.).

Figure 4 shows an example of a use case diagram that illustrates the order fulfilment process within a company, focusing on the activities performed by a warehouse attendant. The warehouse attendant is responsible for preparing orders, updating inventory, and sending orders to customers. The Prepare Order use case includes the step of updating inventory, ensuring that stock levels are accurately reflected after an order is prepared. Additionally, the Send Order use case may optionally include the Verify Payment use case as an additional step, thus indicating that payment verification can be performed, if necessary, prior to sending the order to the customer.

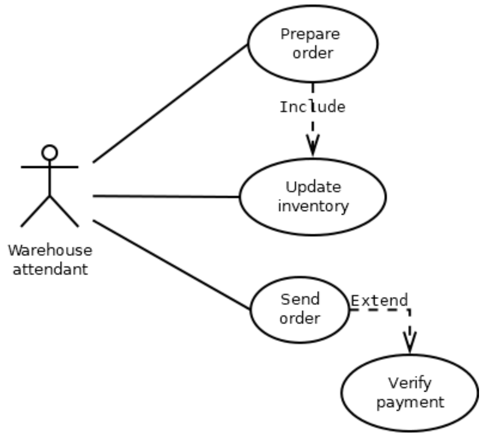


FIGURE 4: USE CASE DIAGRAM EXAMPLE

2.3. Business Process Model and Notation

The Business Process Model and Notation (BPMN) is a widely used standard for process modelling that was originally created by the Business Process Management Initiative (BPMI) and is now being maintained by the Object Management Group (OMG). It is standardised under ISO/IEC 19510:2013, and the latest version, BPMN 2.0, was released by OMG in 2011. This graphical notation enables businesses to depict their processes in a clear and consistent manner, allowing for the representation of a sequence of activities, events, gateways, and flows within a process. By providing a common standardised language for stakeholders across different departments and organisational levels, BPMN fosters collaboration, facilitates decision-making, and supports process improvement initiatives (Group Object Management, 2011; von Rosing et al., 2015).

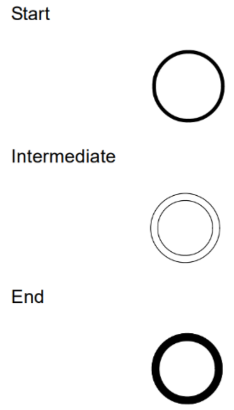
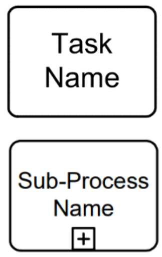
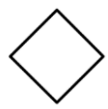
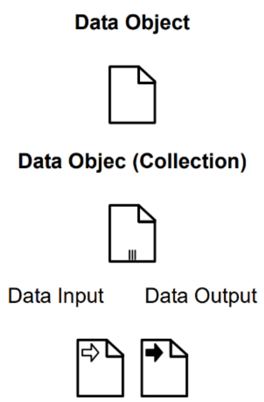
This chapter delves into the fundamental concepts of BPMN, explaining how it can be used to visualise, analyse, and communicate complex business processes.

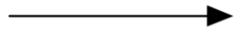
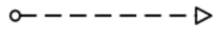
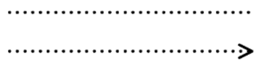
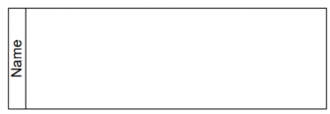
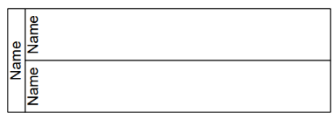
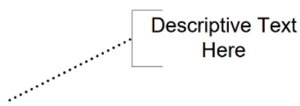
2.3.1. Components of Business Process Model and Notation

The notation recognises five core categories of elements within BPMN. The first Category is Flow Objects, under which we find Events, Activities, and Gateways. These three elements define the behaviour of a business process. The second category represents data within the business process. In this category, we find four elements, which are Data Objects, Data Inputs, Data Outputs, and lastly, Data Stores. The connections between the first two categories of elements are defined as Connecting Objects. Depending on the two elements at hand, we define Sequence Flow, Message Flow, Associations, and Data

Associations. The fourth category, Swimlanes, represents two ways of grouping the primary elements, either into Pools or Lanes. This way of visualising a process provides insight into the participants involved and the specific activities each one performs. The last category of main elements is the Artifacts, which are used to provide additional information about the Business Process. Under the current notation, we recognise two artifacts: a Group and a Text Annotation (Object Management Group, 2011).

The key elements of BPMN are further described in the table below, as well as their standardised visualisation, as defined by the Object Management Group.

Element Name	Description	Notation
Event	Happens during the course of a business process and affects the flow. It generally either has a trigger or a result. Based on when the Event affects the flow, three types are distinguished: Start, Intermediate, and End.	
Activity	Any work performed within a process. The notation defines two types: a Sub-process and a Task, represented by a rounded rectangle.	
Gateway	Used to control the divergence and convergence of Sequence Flow. It determines decisions as well as the forking, merging, and joining of paths. By adding different icons within the diamond shape, we indicate the type of flow control behaviour.	
Data Object	Can either provide information about what certain activities need to be performed and/or what information they produce. They can represent a single object or a collection. Data Input and Data Output provide the same information within a process.	

Data Stores	Provide a mechanism for Activities to retrieve or update stored information that will persist beyond the scope of the modelled process.	
Sequence Flow	Shows the order in which activities are to be performed.	
Message Flow	Is used to show the flow of a message between a participant who prepares it and a participant who receives it. Each participant is in one pool.	
Associations	Is used to link a piece of information and an artefact within a process. If needed, an arrowhead indicates the flow. In the case of Data Associations, the same notation is used.	
Pools	It is a graphical representation of a Participant in a process. It can either show a set of activities that are performed or be empty, i.e., a black-box, in cases where the actions are not known.	
Lanes	A Lane is a sub-part of a Pool and is used to organise and categorise activities.	
Group	This element does not affect the flow of the process. It serves as a visual for showing categories of objects.	
Text Annotation	Offers the modeller a chance to provide more information about the process for the intended reader.	

2.3.2. Path flow

For a high-level view, the initial notation elements suffice. They can provide a great summary for an external person when simple and understandable models are required or when the goal is to document how things work. However, if the intention is to carefully analyse the process and measure its performance, additional details might be needed. In such a case, the core elements can be enhanced with additional details. This is particularly relevant for the Gateway element (Dumas et al., 2013).

The basic Gateway type is the Exclusive gateway. It is illustrated either as an empty diamond shape or with an X in the middle. Depending on the condition, only one of the alternative paths is chosen. Another option is an Event-Based gateway, where the branching occurs based on a specific Event. For example, a message is received, and one of the alternative paths follows. An Inclusive gateway represents independent paths. All of the paths can be taken, only some or none at all. However, it is recommended to design the process in such a way that one path is set to default. The Parallel gateway is used in cases where multiple actions can be done simultaneously. For example, when an order is received, the flow separates into two paths: one for the packing of the order and the second for the invoice preparation. Only when both paths are done can the flow join back into one and the order can be sent. The last option is the Complex Gateway. In this case, the modeller defines its own decision mechanism, depending on the needs of the business process. The gateway can have multiple ingoing flows and multiple outgoing flows (Object Management Group, 2011).

FIGURE 5: GATEWAY TYPES

The term "Fork" refers to the act of dividing a path into two or more. Such action is used in cases where two paths can occur simultaneously. However, using a Gateway element, we can indicate that the flow of the path depends on a decision and thus can take one or more alternative paths. On the other hand, "Join" refers to the act of combining two or more paths back into one. Figure 6 shows an example of a parallel fork (left) and a parallel join (right) (Object Management Group, 2017).

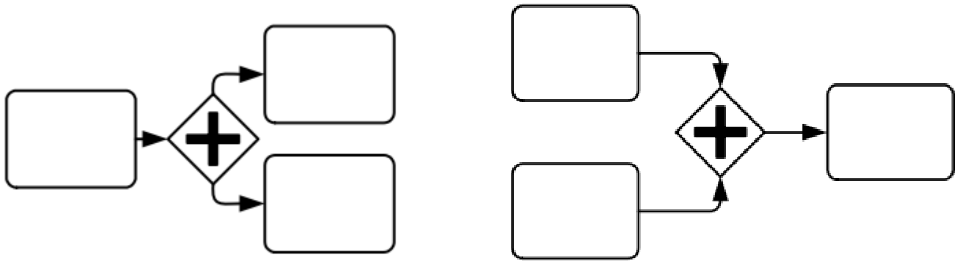


FIGURE 6: PARALLEL FORK AND JOIN

3. Information systems

In the field of information technology, the concepts of data, information, and knowledge play a crucial role in understanding how information is being processed, managed, and utilized. The term data refers to any recorded value or representation of facts, figures, or symbols. These essentially raw and unprocessed values can be simple notes on paper, a Microsoft Excel document, or a database set. For instance, in a database, data can be individual entries such as names, numbers, or dates. Information, on the other hand, is data that has been given context or meaning. It involves interpreting the data in a useful and relevant manner. For example, if we have data on sales figures, converting this data into a report that shows trends or patterns would be considered information. And lastly, knowledge goes a step further, it is the ability to draw conclusions or make decisions based on the information available. It requires understanding and applying the information in a meaningful way. For instance, using the sales trends information to make strategic business decisions would demonstrate knowledge (Bruckner et al., 2012).

"Where Data becomes Knowledge", CERN IT Department

An information system is a structured set of people, technologies, and processes designed to collect, store, process, and distribute data and information in order to support decision-making and other organisational activities (Molnár, 2009). They are the backbone of storing, managing, and utilising data and information effectively within an organisation and play a crucial part in striving for a competitive and innovative organisation (Zwass, 2024).

3.1. Database

A database is a collection of structured data designed to facilitate efficient storage, retrieval, and management. Acting as a central repository, it helps in maintaining data integrity, enforcing security measures, and supporting collaboration, even in scenarios with complex requirements. Databases play a crucial role in enhancing overall performance and increasing reliability (Oracle, n.d.).

3.1.1. Entity Relationship Diagram

The Entity Relationship Diagram (ER) is a fundamental element in database design, offering a visual representation of the database scheme and illustrating relationships between entities within the system. It plays a crucial role in developing well-structured databases by preventing data redundancy and defining cardinality. Additionally, ER diagrams help in visualising complex data structures, serve as a communication tool among stakeholders, and provide a shared understanding of the data model. ER diagrams can be used to identify dependencies, streamline workflows, and optimise resource allocation. They are commonly used for designing or debugging relational databases across various fields and expressing organisational data and relationships between entities (Visual Paradigm, n.d.).

ER diagrams are highly regarded for their simplicity and ease of understanding, even by non-specialists. They provide an intuitive way of representing a user's information requirements, describing the world in entities and attributes. However, one drawback of the Entity Relationship Diagram is its lack of standardisation, resulting in numerous variations. Furthermore, it is only suitable for structured data and can be difficult to integrate within an already existing database (Lucidchart, n.d.).

3.1.1.1 Components of Entity Relationship Diagram

As mentioned, the ER diagram consists of attributes, entities, and relationships. Entities represent real-world objects or concepts, such as people or profiles, whereas attributes describe the properties of entities. An entity can also be referred to as a table, with entity attributes as columns within that table. Lastly, the relationships depict connections between entities.

There are three types of relationships: one-to-one, one-to-many, and many-to-many. In the one-to-one relationship, each entity instance in an entity set is associated with exactly one entity instance in another entity set, and vice versa. In other words, only one record in the first entity set corresponds to only one record in the second entity set, and the same goes the other way around. A great example is that a citizen of one country can only have one ID number, and an ID number can belong to only one person. In the case of a one-to-many relationship, each record in the first entity set can be associated with zero or more records in the second entity, however, each record in the second entity can only correspond to one record in the first entity. The most common example is a customer being able to have multiple orders, but an order can only be associated with one customer. Lastly, the many-to-many relationship reflects a situation in which every record in the first entity can have multiple corresponding records in the second entity, and vice versa. For example, an order can contain multiple products, and a product can be in multiple orders.

The primary key (PK) is a specific number or code that is unique and can be used to identify records in a database table. A foreign key (FK) refers to the primary key of a foreign table. It helps to identify relationships between different entities (Visual Paradigm, n.d.).

Figure 7 shows an ER diagram illustrating the examples given for the one-to-many and the many-to-many relationships, as well as the use of primary and foreign keys.

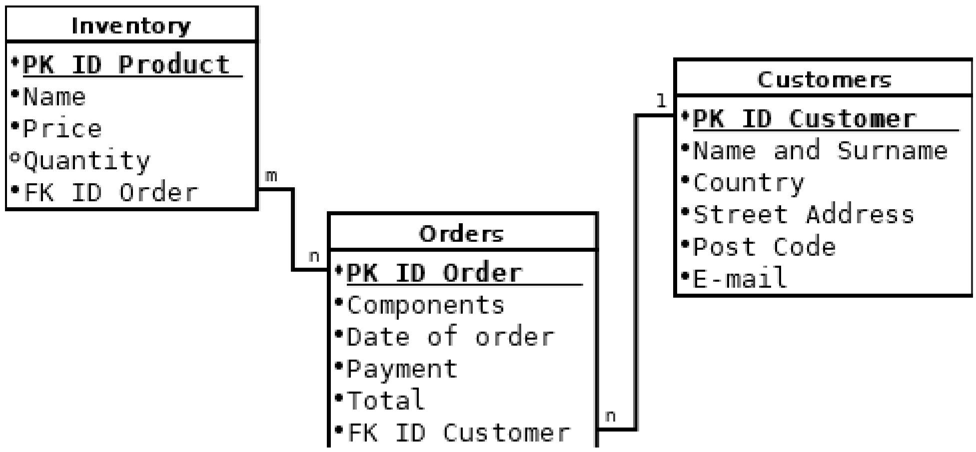


FIGURE 7: ER DIAGRAM EXAMPLE

3.1.1.2 Connection to UML and BPMM

UML, as a standardised notation for representing various aspects of software systems, complements ER diagrams by offering a broader perspective on system architecture and behaviour. While ER diagrams focus on data modelling and relationships between entities, UML models extend this view by incorporating structure, behaviour, and interactions within a system (Object Management Group, 2017; Lucidchart, n.d.).

As described in the chapter "Components of BPMN," the Data Object symbol represents data input into process activities or data output from process activities. This way, entities within ER diagrams can be aligned with data objects in business process diagrams. ER diagrams can complement business processes by representing the structure of data objects that are needed in the modelled process. They can also stand as the core element, and BPMN diagrams can complement them by showing how the data is to be utilised (Visual Paradigm, n.d.).

4. Methods of Economic Evaluation of Investments

Thoroughly evaluating the costs and benefits associated with a potential project or investment plays a key role in deciding whether to move forward, choose between different options, or dedicate resources elsewhere. Making well-informed choices in this regard is imperative to ensure the sustained growth and development of the organisation (Fotr & Souček, 2011).

This chapter explores various methods of economic evaluation of investments, which can help in assessing the risks and potential benefits of an investment and in making an informed decision.

Net Present Value

One of the most commonly used formulas for determining the economic value of an investment is Net Present Value (NPV). It provides an insight into the expected cash flows over specific time periods and takes into account liquidity, time, and risks. In other words, it is the sum of all capital costs and incomes at their present value. Because it offers a general approach that requires only the predicted cash flows and discount rate[1], it is extremely popular. Additionally, it is easily adaptable to any number of investments (Scholleová, 2009). However, it can be difficult to accurately estimate the cash flow projections, and the outcomes are sensitive to discount rate changes. Furthermore, it is not possible to compare the NPV values of projects that vary in duration (Tamplin, 2023).

The primary notion is that an investment generates more profit than its initial cost if the net present value (NPV) is greater than zero. In these situations, the organisation gains value and can use the profit for expansion and new initiatives. When the NPV value is equal to 0, the necessary capital returns are obtained, but no more profit is made. Conversely, if the value comes out negative, the investment will not benefit the company, and the intended profit will not be realized. The formula is as follows:

[1] Discount rate = the interest rate used to determine the present value of future cash flows (Majaski, 2022)

$$NPV = \sum_{t=o}^{T} \frac{CFt}{(1+r)^t} - IN$$

Where CF_t is the cash flow at time *t*, *r* is the discount rate, *T* is the number of periods, and lastly, *IN* is the initial investment cost (Scholleová, 2009).

Internal Rate of Return

The Internal Rate of Return (IRR) provides a relative view of the investment's profitability. It is a discount rate that makes the NPV of all cash flows equal to zero in a discounted cash flow analysis (Fernando, 2024). In other words, it shows the percentage value of the profit that the investment generates during its lifetime. It is particularly helpful when considering different investment opportunities, in which case the higher the IRR, the more profitable the option. The calculation finds the discount rate that equals the present value of cash flow to the initial investment, i.e., where NPV = 0 (Scholleová, 2009).

Unlike the Net Present Value, IRR is not additive, and thus the IRR values of two different investments cannot be added. On the other hand, the value of IRR is not related to the discount rate and provides a trustworthy relative view of profitability, which makes it an excellent choice in situations where assessing the available funds is the main objective (Scholleová, 2009).

The IRR can be calculated from the formula shown below, and the variables are the same as described above for the calculation of the NPV.

$$0 = \sum_{t=1}^{T} \frac{CF_t}{(1+IRR)^R} + (-IN)$$

Profitability index

Similarly, the profitability index (PI) also provides the relative profitability of an investment, but in this case by comparing the present value of cash flows with the initial investment. If the ratio is greater than 1, the investment is likely to be lucrative. This also means that if the PI value is > 1, the present value of future cash flows is higher than the initial investment, which directly corresponds to a positive NPV, i.e., the difference between these values. Generally speaking, it can be said that the greater the value is than 1, the better the profitability (Scholleová, 2009).

This strategy is excellent for evaluating several possible projects and complements the NPV method by offering a relative view of NPV's absolute. However, this technique, like IRR, is non-additive since the denominators change. And, like NPV, its reliance on the discount rate limits the accuracy of establishing its exact value. (Scholleová, 2009).

The formula for calculating PI is shown below, and the variables are the same as described above for the calculation of the NPV.

$$PI = \frac{\sum_{t=O}^{T} \frac{CFt}{(1+r)^t}}{IN}$$

Payback period

The payback period is a quick method that shows how long it takes to get back the initial cost of the investment. It is a simple division of the initial investment and the annual cash flow. Usually, management specifies the desired payback period for projects, typically aiming for a duration shorter than the project's lifecycle. A project that has a shorter payback period recovers its initial costs more quickly, freeing up assets for use in future ventures (Scholleová, 2009).

The biggest advantages of this method are its simplicity, ease of calculation, and ease of communication. Furthermore, it clearly reflects the liquidity and risk of the project. Despite these advantages, the simplicity of this method also has its drawbacks. The primary one is that it does not take into account the time value of money, ignoring the opportunity cost of capital, inflation, and interest rates. Additionally, this method does not consider the profitability or return of the investment beyond the breakeven point, which may favour initiatives with lower total cash flows over ones with longer payback periods and higher total cash flows (What are the advantages and disadvantages of using the payback period as a decision criterion?, 2024).

The formula for the calculation of the payback period is as follows:

$$Payback\ Period = \frac{Initial\ Investment}{Annual\ Cashflow}$$

While all of the above-mentioned methods assess the economic benefits of an investment, each provides a different point of view. It is important to consider the characteristics of each specific case and the organisation's goals when choosing which method to use. This can mean factors such as the absolute or relative profitability of the investment or the pressure to achieve a short payback period. Each method has its benefits and limitations, so a combination of a few is recommended to provide a comprehensive view of the investment's potential (Scholleová, 2009).

An organisation may, under special circumstances, be in a position to invest in something that is unquestionably valuable but for which a profit cannot be estimated. It can be an easy decision when it comes to organisational or regulatory changes. Nevertheless, it is necessary to carefully weigh the expected advantages against the needed resources, technology, and time (Scholleová, 2009).

PRACTICAL PART

An effective Project portfolio management is an important pillar of any successful organisation. Its goal is not just selecting the right projects and efficient allocation of resources but also making sure all the decisions and projects are in alignment with organisational objectives and thus bringing value to the whole organisation. Despite the critical nature of project portfolio management, many places rely on manual and often tedious methods of managing their portfolios (European Commission, 2022).

The practical part of this thesis leverages the knowledge gained in the theoretical part and applies it to the concrete processes of the Project Portfolio Management office team.

To provide a comprehensive understanding, the first chapter briefly outlines the organisation itself, followed by a deeper introduction to the IT Department and the nature of its duties and significance for the organisation. This is followed by a detailed view of the PMO team's characteristics, responsibilities, and project specifications. Building on this, a detailed analysis of the current state of processes is conducted, and a proposal for a changed model follows.

5. Company Introduction

The European Organisation for Nuclear Research, commonly known as CERN (Conseil Européen pour la Recherche Nucléaire), was founded in 1954 and is situated in Geneva, Switzerland. Since its beginning, it has set out to explore and understand the fundamental building blocks of the universe. It stands as a global hub for cutting-edge scientific exploration in the field of particle physics and brings together scientists, engineers, researchers, and students from around the world, fostering collaboration and innovation (CERN-a, n.d.).

The heart of CERN is the Large Hadron Collider (LHC), a powerful accelerator that enables scientists to recreate extreme conditions similar to those just moments after the Big Bang, thus allowing them to study different particles at unprecedented energy levels. Through those experiments, researchers aim to unravel mysteries related to dark matter and dark energy, contributing invaluable knowledge to the realm of theoretical physics.

CERN prides itself on its Open Science Policy and international cooperation. The Open Science Policy ensures that all the organisation's inventions and knowledge are freely available, supporting effective collaboration and knowledge transfer around the world (Dinmore, 2022). In 1989, a British scientist invented what is probably the most famous and widely used invention from the grounds of CERN, the World Wide Web (The birth of the Web, n.d.). The most recent groundbreaking discovery was the finding of the Higgs boson in 2012 (The Higgs boson, n.d.).

5.1. Information Technology Department

The Information Technology Department provides a wide range of services that ensure the smooth running of all activities inside CERN. The core one is providing effective support to all the members of the organisation and the experiments. Furthermore, the IT Department acts as a driving force for collaboration and innovation in the scientific community between the Member States and beyond.

"The IT Department's vision is to reinforce its position as a trusted and efficient IT service provider and technology partner for the CERN community and to be recognised as a reference catalyst driving collaboration and innovation in the scientific computing environment in the member states and beyond."
(CERN IT Department, 2022)

The IT Department at CERN works towards achieving its vision through the implementation of four main strategic objectives. These are defined as IT as a Provider, IT as an Optimizer, IT as a Pioneer, and finally IT as a Connector.

Within the first objective, the IT Department functions as the primary information technology provider for the whole organisation. This means delivering a wide range of services tailored to both the scientific programmes of CERN and the whole user community. Striving for efficiency, the department seeks a balanced approach between standardised, common services and specialised tools to fulfil the ongoing requirements of the organisation and its partners. In the role of optimizer, the IT Department supports the success of CERN's core scientific mission by delivering state-of-the-art services and providing dedicated technical support for the organisation's mission-critical activities and programmes. Within the third objective, the IT Department actively prepares for the ever-changing and evolving scientific programmes and the organisation's activities. Through fundamental research and close collaboration with communities, the department works on developing future computing models, software, and services that address issues with scalability and rising requirements for storage and data management. The department also focuses on exploring and advancing new technologies, such as Artificial Intelligence and Quantum Computing. And lastly, the Connector role focuses on consolidating and advancing a portfolio of IT solutions in the spirit of Open Science. Through the CERN Openlab initiative, the department continues to support collaboration with CERN's member states, High Energy Physics (HEP) researchers and partners, and other research communities, academia, and industry, as well as continue to nurture an ecosystem of tools and services. Aligning with the European vision for Open Science, the department aims to reinforce the sustainability of software, services, and communities and create a positive impact on society (CERN IT Department, 2022).

5.1.1. Departmental Reorganisation

To keep up with CERN's growing research agenda and ambition to strengthen its dedication to Open Science, the IT Department undertook an extensive reorganisation at the beginning of the year 2022. The initiative was drafted by the head of the IT Department in collaboration with a significant number of IT staff.

The resulting strategy, which covers the years 2022–2025, demonstrates a dedication to ongoing development and establishes the IT Department as a reliable service provider for all CERN experiments and other departments. Understanding how important it is to stay up-to-date with technology, the department strives to be a centre of innovation, constantly pushing the boundaries of the field. In addition, this proactive strategy goes further beyond hoping to nurture and support upcoming generations of scientists. A crucial part of forming this strategy was incorporating the feedback collected from multiple other CERN departments as well as experiments and addressing the key pain points that have been identified.

5.1.2. Organisational Structure

The IT Department is divided into four domains. Computer Security, Strategy & Executive Governance, Technical Delivery and Resource Management. The computer security domain is responsible for the definition and implementation of computer security policies, establishing best practices, and assisting in the event of incidents. The strategy and executive governance domain is in charge of defining and driving the execution of IT strategy, ensuring alignment with CERN's mission and objectives. Additionally, it is responsible for monitoring and managing overall departmental performance, establishing governance frameworks, and defining the risk management strategy as well as business continuity and disaster recovery plans. The technical delivery domain maintains the technical side of the department's objectives. Within its responsibilities, we find tasks such as ensuring implementation and operational responsibility of the service management tool, delivering software and services nurturing collaboration and communication, delivering and evolving databases and data stores, and procuring and managing IT equipment necessary for the experiments and user community across the whole organisation. Lastly, the Resource Management (RM) group is responsible for the areas of administration, resource management, facility management, talent management, procurement and training, and project portfolio management (CERN-b, n.d.).

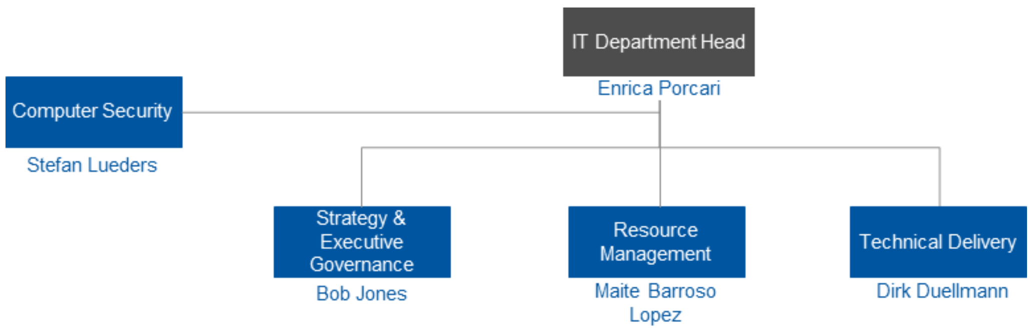


FIGURE 8: GOVERNANCE SCHEMATIC

5.1.3. Project Governance

The IT Department handles a wide variety of projects. These projects take place either within the department, across the organisation, or in collaboration with other facilities as part of the European Commission-funded projects. According to the nature of the project, the IT Department recognises three initiation pathways: Innovation, Business Engagement and Technical Delivery. The projects are further categorised by the type of funding they receive. Figure 9 depicts all the possible pairings of initiation pathways and funding.

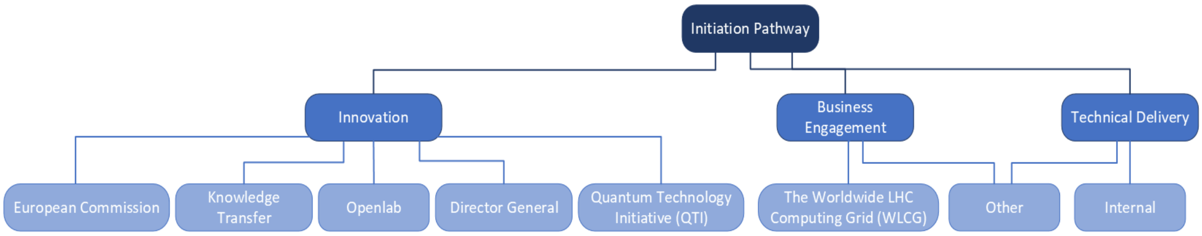


FIGURE 9: INITIATION PATHWAYS AND FUNDING

5.2. Project Portfolio Management Office Team

The Project Portfolio Management Office (PMO) Team is a part of the Resource Management Group. It was established as a result of the reorganisation of the IT Department. The team was established with a vision to provide a consistent overview of the portfolio of projects within the IT Department, to provide support for project managers to run projects efficiently, and to support relevant review boards in decision-making.

5.2.1. PMO Team Responsibilities

The responsibilities of the PMO Team can be found within three groups of the departmental-set objectives. For the "Optimizer" objective, the PMO team is responsible for measuring the volume of resources allocated towards projects and helping the management understand how the resources are prioritised. Within the "Pioneer" objective, the PMO team works on measuring the number of innovative projects and their progress through set milestones. Lastly, for the "Connector" objective, the PMO team measures the number of active cross-departmental projects (CERN IT Department, 2022).

To achieve the set objectives, the PMO Team completes a wide range of activities. One of which is maintaining three separate project catalogues up to date. The catalogue of projects pending approval, the catalogue of ongoing projects, and the catalogue of closed projects. In doing so, the PMO team can provide a dashboard with a consistent view of all the projects and important metrics that help review boards make informed decisions. The portfolio consists of around 80 ongoing projects, up to 20 projects pending approval, and close to 50 closed projects. The team also maintains the project management methodology, lifecycle workflows and templates specific to each lifecycle phase, and individual SharePoint sites and repositories for each project.

Figure 10 illustrates the business processes of the IT-PMO team. The highest level displays the team's task of managing the project portfolio, the project portfolio statistics, and the alignment with strategic objectives. The project portfolio management contains most of the day-to-day tasks the team performs. The portfolio statistics first and foremost reflect the monthly task of preparing statistics for each project phase that are communicated to management. The strategic objectives reflect the contribution of each project towards every strategic objective.

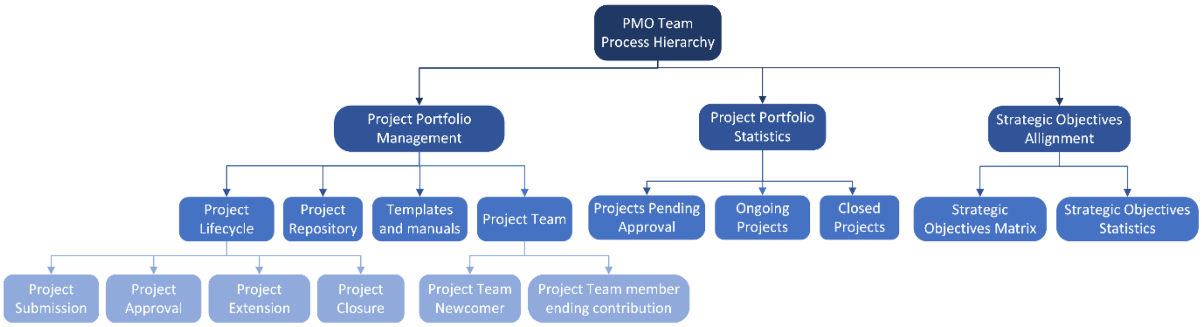


FIGURE 10: PMO TEAM - BUSINESS PROCESS HIERARCHY DIAGRAM

The team was implemented shortly after the reorganisation, leading to the gradual development and refinement of processes, templates, and methods based on the gathered experience and feedback. This iterative approach involved trial and error, resulting in continual improvement and adaptation. However, the current methods are not necessarily the most productive or sustainable for maintaining such a large number of projects.

5.2.2. Input and Output Channels

The PMO team uses a wide range of platforms and software, both for internal purposes and for communication with project managers and management. Figure 9 illustrates the communication channels of the PMO team, and a detailed description can be found below.

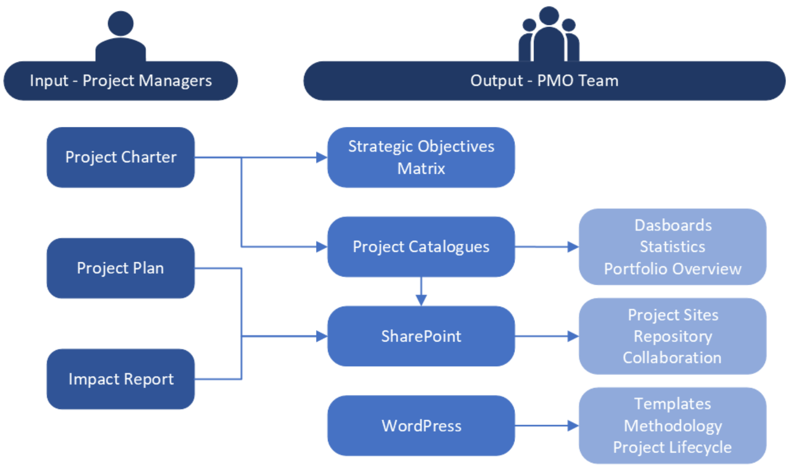


FIGURE 11: COMMUNICATION CHANNELS

Input Channels

The main input channel for the project portfolio overview is the Project Charter. Each project manager must submit a project charter for the project to be considered for approval. This document provides details about the scope of the project, the needed resources (personnel and technical), the duration, the alignment of strategic objectives, and the benefits. The Demand Management Review Board makes decisions about project approval and/or project extensions and notifies the PMO leader. All projects that are predefined by initiation pathway leaders as “high impact” also submit a lightweight Project Plan with milestones and deliverables. Towards the end of the project, all projects except those funded by the EU are asked to submit an Impact Report stating the outcomes, lessons learned, and future opportunities.

Output Channels

As already mentioned, the team maintains three separate Project Catalogues using Microsoft Excel. The catalogues of projects pending approval and ongoing projects contain information both about the project and the project team. The catalogue of closed projects does not track personnel information anymore. All three catalogues also include dashboards with important statistics that are reported to the management every month. Current and past catalogues are stored on CERNBox.

Another Microsoft Excel document contains the strategic objective matrix along with a list of all pending, ongoing, and closed projects and their alignment with each objective. This document also contains a dashboard with statistics that are reported to the management.

The team maintains a SharePoint website with important information both for the project managers and for management. A copy of the updated catalogues is uploaded monthly and available to the whole department. Furthermore, this SharePoint website is complemented with subgroups for each initiation pathway, which are further divided into each funding category. Under these sites, all the project information is stored, based on the lifecycle of the project. For projects pending approval, only a folder with the project charter is created. Once a project is approved by the Demand Management Review Board, the PMO team creates a full SharePoint site that serves as a repository throughout the project's lifetime. Rejected project charters are moved into a rejected subgroup, and project sites of closed projects are moved to an archived subgroup. Figure 12 shows an example of the structure of a SharePoint site for the Technical Delivery pathway.

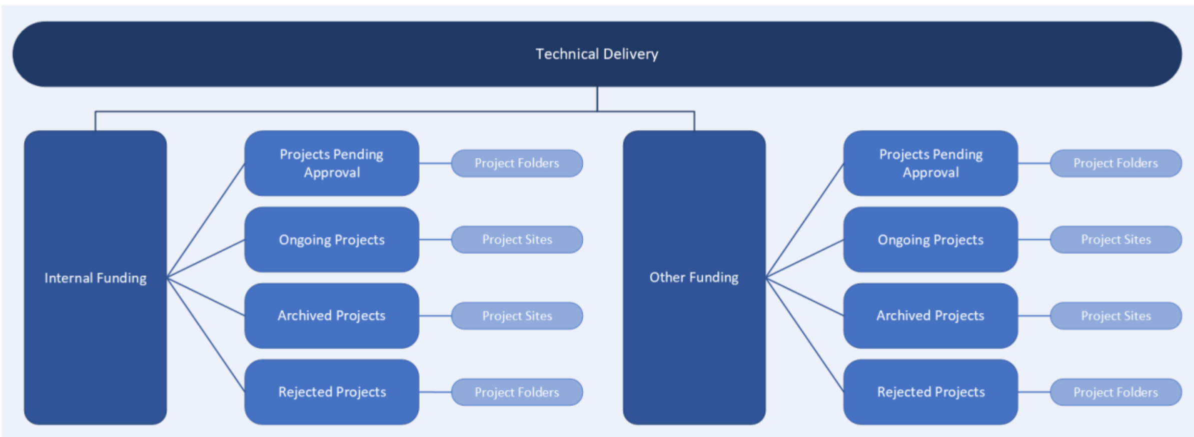


FIGURE 12: SHAREPOINT SITE STRUCTURE

A WordPress site of the Project Portfolio Management Office team contains the main methodology overview, a lifecycle chart illustrating the approval process and use of each document, and most importantly, the project charter, project plan, and impact report templates.

5.3. Analysis of the Current State of Processes

The description of the current state of processes is based on personal experience working in the PMO team, gathered from July 2022 to August 2023. For the purpose of this thesis, I have selected processes that occur frequently, duplicate work, and would benefit the most from any level of automation. Specifically, it is the process of submitting a new project proposal, the process of obtaining project approval, and the process of project closure. Following the approval of a project, a project repository needs to be created, and in case a project is not progressing as expected, an extension procedure is initiated. Lastly, the two final diagrams illustrate the registration of a newcomer joining a project and a project team member ending their contribution.

The processes are described using a Business Process Model and Notation and enriched with a textual description for full clarity. Full-scale diagrams are also available in the thesis appendix as well as electronic attachments under the same names.

Project Submission Process	Appendix A
Project Approval Process	Appendix B
Project Repository Process	Appendix C
Project Closure Process	Appendix D
Project Extension Process	Appendix E
Project Team Newcomer Registration Process	Appendix F
Project Team Member Leaving Process	Appendix G

5.3.1. Project Submission Process

A project manager submits a project proposal using a project charter template prepared by the PMO team. The filled-in document is submitted via email addressed to the PMO team, where an appointed member first makes sure the project proposal was endorsed by an initiation pathway leader (IPL) [1], and if so, continues by checking if all of the necessary information is filled in [2]. In case the project proposal does not get approval from IPL, the project charter is rejected. Similarly, if the project charter does not contain all of the necessary information needed by the PMO team and management, it is sent back for adjustment. The corrected project charter can be resubmitted later on. If the document is found adequate, the PMO team member continues by extracting the needed details about the project and the project team from the catalogue of projects pending approval [3]. In doing so, the project is assigned an ID, which is used for its identification throughout its lifetime. Once the project is added to the projects pending approval catalogue, two independent tasks follow. One flow indicates the PMO member's task of creating a folder on the relevant SharePoint site [4] and uploading the project charter there [5]. Once the folder is created, a URL link is added to the catalogue [6]. The second flow shows the need to extract the project's strategic objectives alignment [7] into the strategic objective matrix document. Once both of these flows are done, the process is considered closed, and a project is successfully submitted.

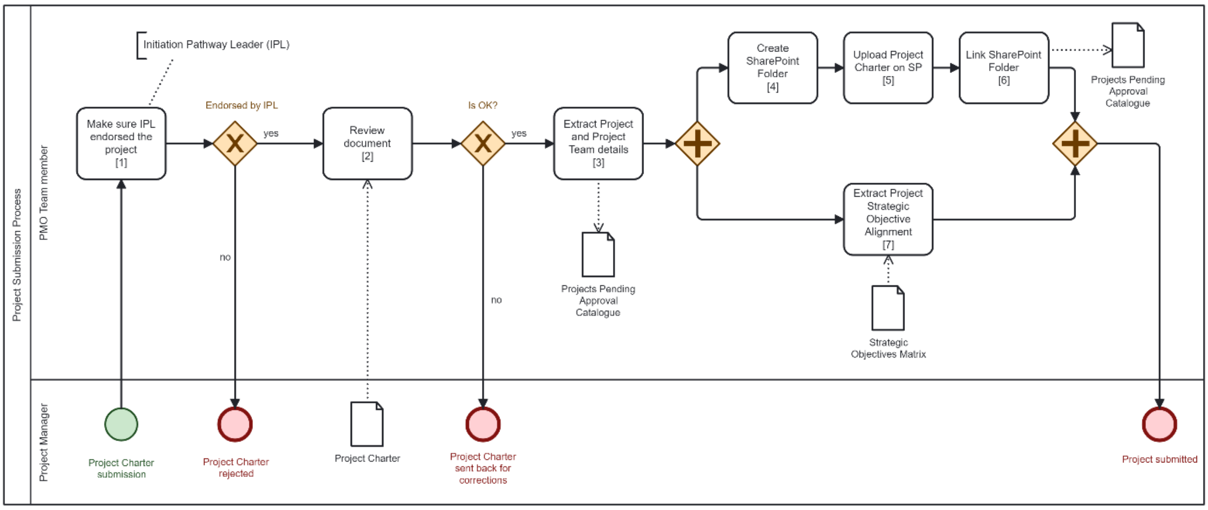


FIGURE 13: PROJECT SUBMISSION PROCESS

5.3.2. Project Approval Process

When a Demand Management Review Board (DMRB) meeting is approaching, the board requests information about all newly submitted projects for their agenda. The PMO leader extracts the information from the project pending approval catalogue [1]. If no projects have been submitted, the process ends. If there are projects pending approval, the PMO leader also adds the URL links to their SharePoint folders [2] to provide a clear path to the project charters for the review board. Once this is complete, this information is sent to members of the DMRB [3], and they include it in the next meeting's agenda [4]. In case the meeting does not take place and is postponed, the process ends here. Once the meeting takes place, a DMRB representative informs the PMO leader about the decisions made regarding the projects [5]. After extracting details from the decisions [6], one of three outcomes happens. One option is for the project to be deferred, thus ending this process. The second option is for the project to be rejected. In such a case, the PMO leader removes the project and project team information from the catalogue of projects pending approval [11] and re-enters only the project details into the closed projects catalogue [12]. Following the rejection of a project, the strategic objective (SOM) status needs to be updated [13], and on SharePoint, the project folder needs to be relocated to the rejected section and the link updated [14]. The desired outcome is for the project to be accepted, and in that case, the PMO team removes the project and personnel information from the pending approval catalogue [7] and re-enters this information into the ongoing projects catalogue [8]. After that, two tasks follow: updating the SOM status [9] and creating the project SharePoint site [10]. After both of these tasks are done, the project is considered approved, and the process ends.

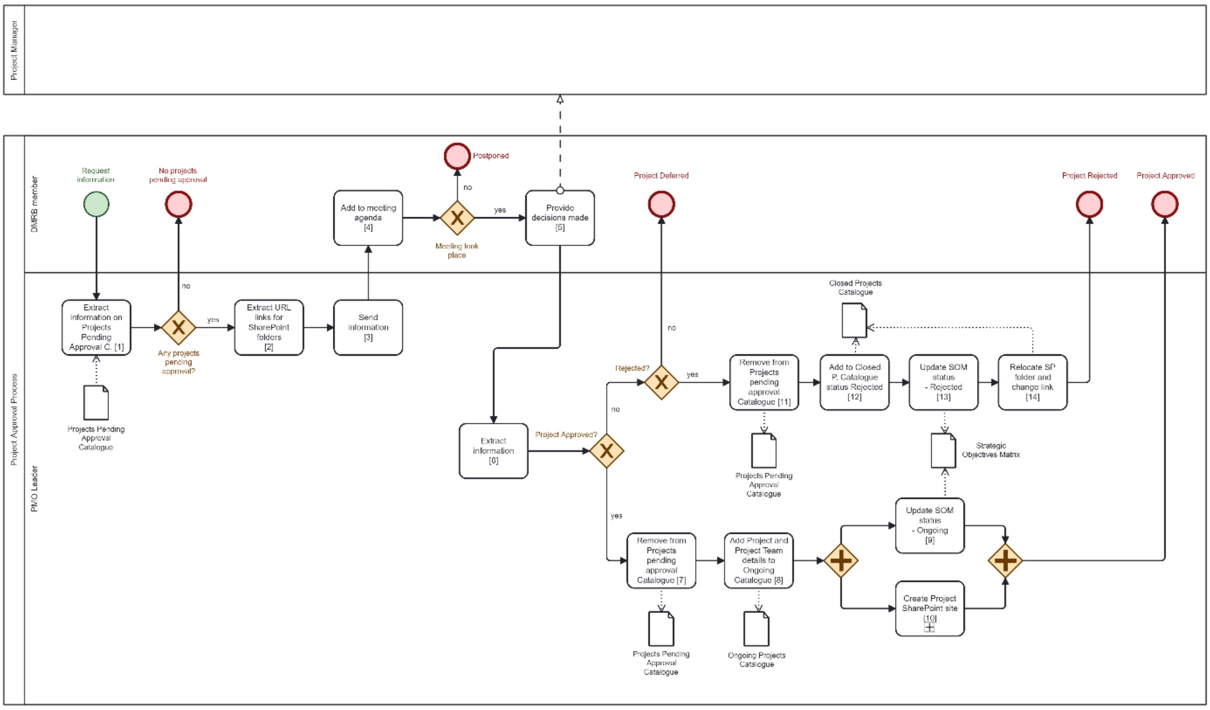


FIGURE 14: PROJECT APPROVAL PROCESS

5.3.2.1 Project Repository Process

In this process, the task of creating a project SharePoint site/project repository is a subprocess. The steps of this subprocess are illustrated below. A project is approved, and the PMO team needs to create a SharePoint site placed in the ongoing section [a], upload project documents [b], grant access to the project manager and the management [c], and link this site to the ongoing project catalogue [d]. Lastly, the previous project folder needs to be deleted [e]. Once all these activities are done, the sub-process is done.

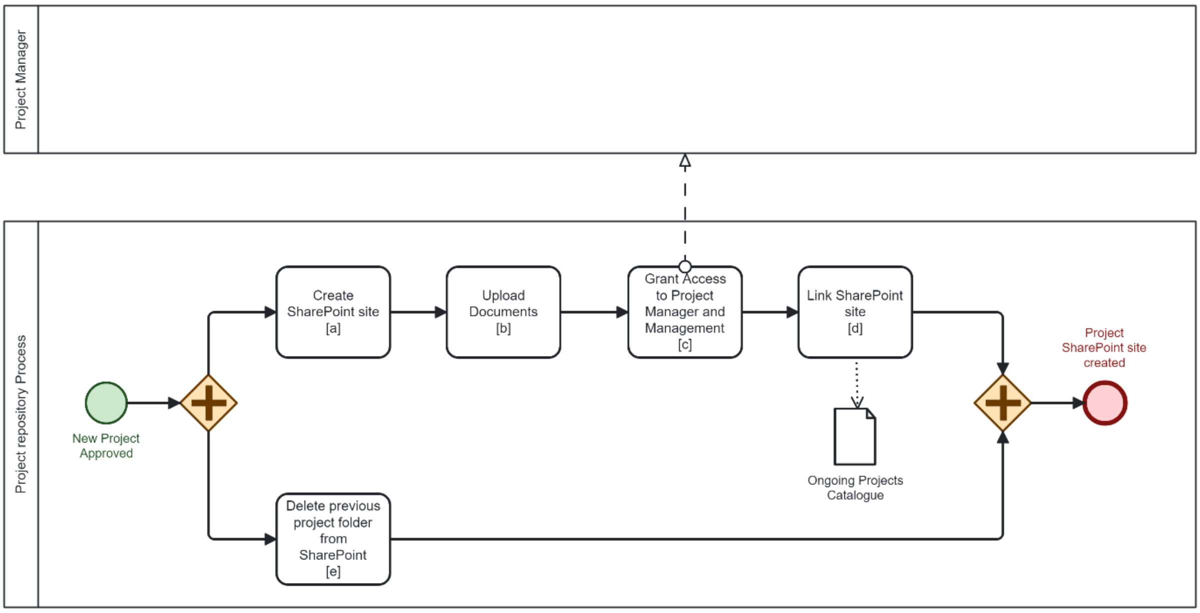


FIGURE 15: PROJECT REPOSITORY PROCESS

5.3.3. Project Closure Process

Three months before the end date of the project, the PMO leader asks for the status of projects with an end date set to the relevant month. A PMO member follows up on this request by extracting this information from the catalogue of ongoing projects [1]. In cases where no projects are supposed to be ending, the process ends. However, if a project is set to be finished by the end of the said month, the PMO member must confirm the status with the project manager [2]. Following this activity, one of two options can happen: either the project is on time or it requires an extension [3]. If the project is going according to plan, the following steps depend on whether it is funded by the European Commission or not. The reason for this is the fact that projects funded by the European Commission (EC) are very well reported throughout the whole lifetime of the project and are asked to prepare a final EC report once finished. This report substitutes the impact report requested by IT management. Subsequently, EC-funded projects follow straight to the tasks of updating the project catalogues [8–11]. For projects under other types of funding, the flow is separated into two parallel flows. Firstly, the project managers are asked to prepare the impact report [4]. Then the process waits for the impact report to be submitted to continue; in case the project manager does not submit the report on time, the PMO member asks again [4]. Once the project manager submits the impact report, a revision of the document is needed [5]. If the document is found to be insufficient, the project manager is asked to make corrections [6], and the review is carried out again [5]. An impact report that is found to be complete is then uploaded to the project SharePoint site [7]. The second of the two parallel flows illustrates the need to delete the project information from the ongoing projects catalogue [8] and enter it into the closed projects catalogue [9]. After this task is done, the project status in the strategic objective matrix document needs to be updated [10]. The last task of this process flow is to place the project SharePoint site in the archived section [11]. Then the flow, depending on the nature of the project, either waits for the merging of two parallel flows back into one and ends the process, or, in the case of an EC-funded project, once the steps [8-11] are carried out, the process ends.

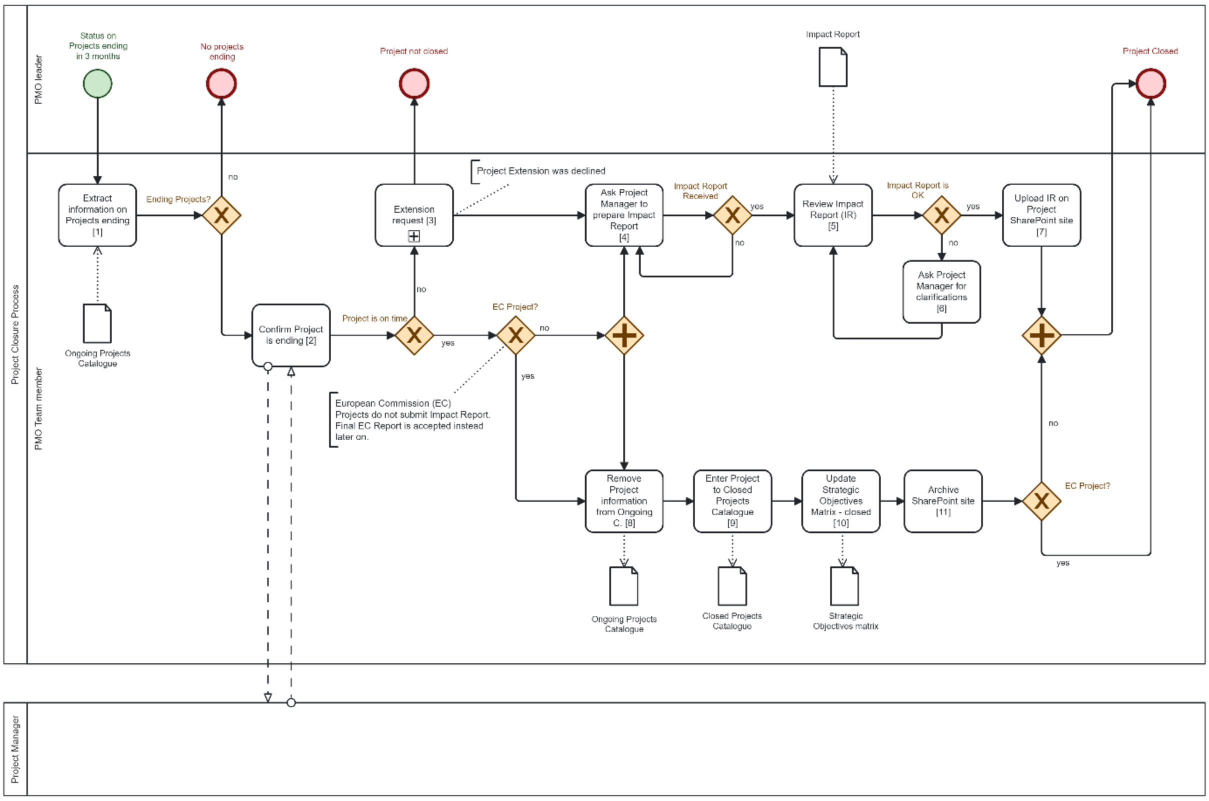


FIGURE 16: PROJECT CLOSURE PROCESS

5.3.3.1 Project Extension Process

Going back to the task of confirming if the project is indeed ending [2], the second option is for the project to need an extension. The extension request [3] is in this model a subprocess. This subprocess starts when the project manager informs the PMO team that the project is not going as planned. A PMO member retrieves information about the project [a], and depending on the nature of the project, one of two options follows. Extensions of projects that are under European Commission (EC) funding are managed and approved by the EC. The PMO member in this case only asks for details of the extension [b], such as the new end date and approved resources. The project manager provides this information, and the PMO member updates the catalogue of the ongoing project [c]. This option ends the process here. Any other project goes through the second route. The PMO member asks for additional information [d], such as the time scope and requested resources, to fill in the extension request. The project manager provides the additional information, and the PMO member notes down the extension request [e]. Once this is done, the Demand Management Review Board needs to be informed [f], so the request is added to the agenda of the next meeting [g]. In case the meeting does not take place, the issue at hand is added to the agenda of the next meeting. Once the DMRB meeting takes place, a DMRB representative informs the PMO team about the decisions made [h]. In case the extension is not approved, the subprocess ends here; however, the process continues back in the parent process flow with the task [4]. An approved extension is noted in the catalogue of ongoing projects with a new end date and extended project team contribution end dates [i], and the process ends.

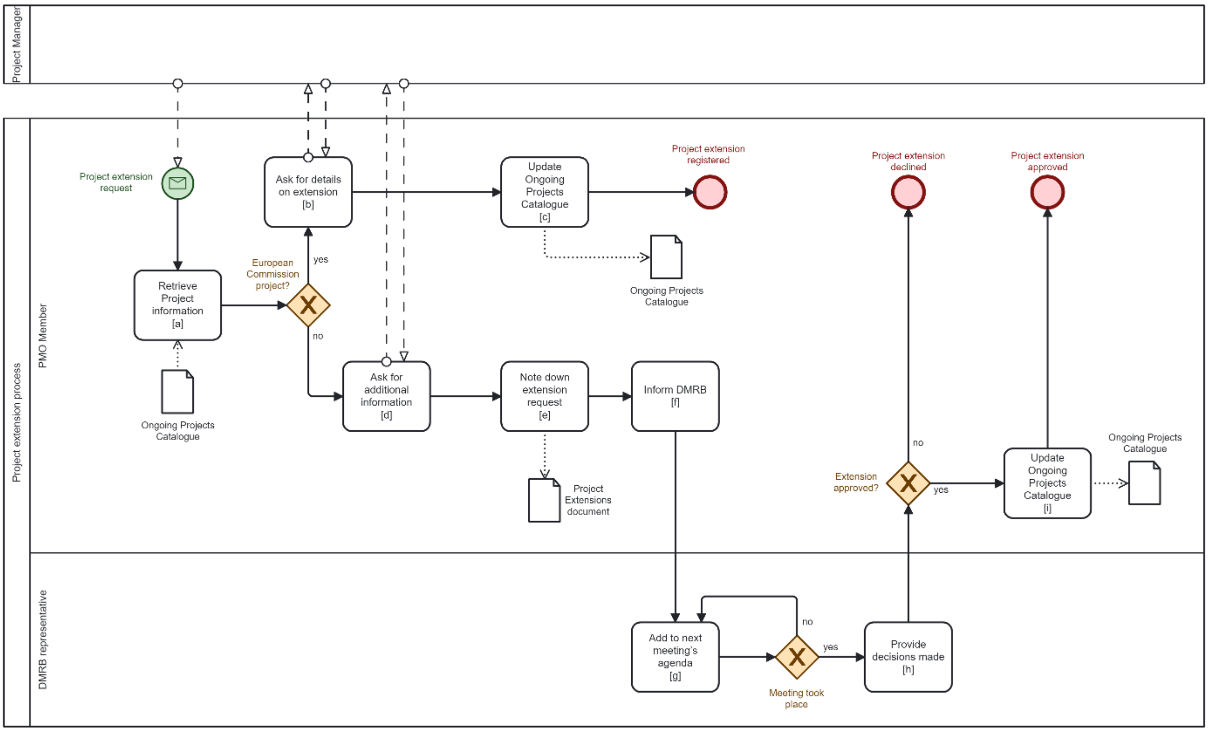


FIGURE 17: PROJECT EXTENSION PROCESS

5.3.4. Project Team Newcomer Registration Process

At the beginning of each month, the IT secretariat notifies the whole department about the newcomers to the IT Department. A PMO team member reviews this information [1] in order to update the ongoing project catalogue. The easiest solution is when the information provided by the IT secretariat clearly states a person's involvement in a project. In this case, the PMO member extracts this information [2] and updates the ongoing catalogue accordingly [5], finishing the process. However, often, the information provided in the notification does not specify a person's involvement in a project. In those cases, the PMO member needs to confirm with the supervisor of the relevant newcomer [3]. If the supervisor confirms that the new member of personnel is involved in a project, the PMO member confirms additional details [4], such as the end date and effort, and updates the ongoing catalogue accordingly [5]. This way, the registration of a new project team member is completed. In other cases, the supervisor informs the PMO member that the newcomer is involved in a service and not a project, and the process ends.

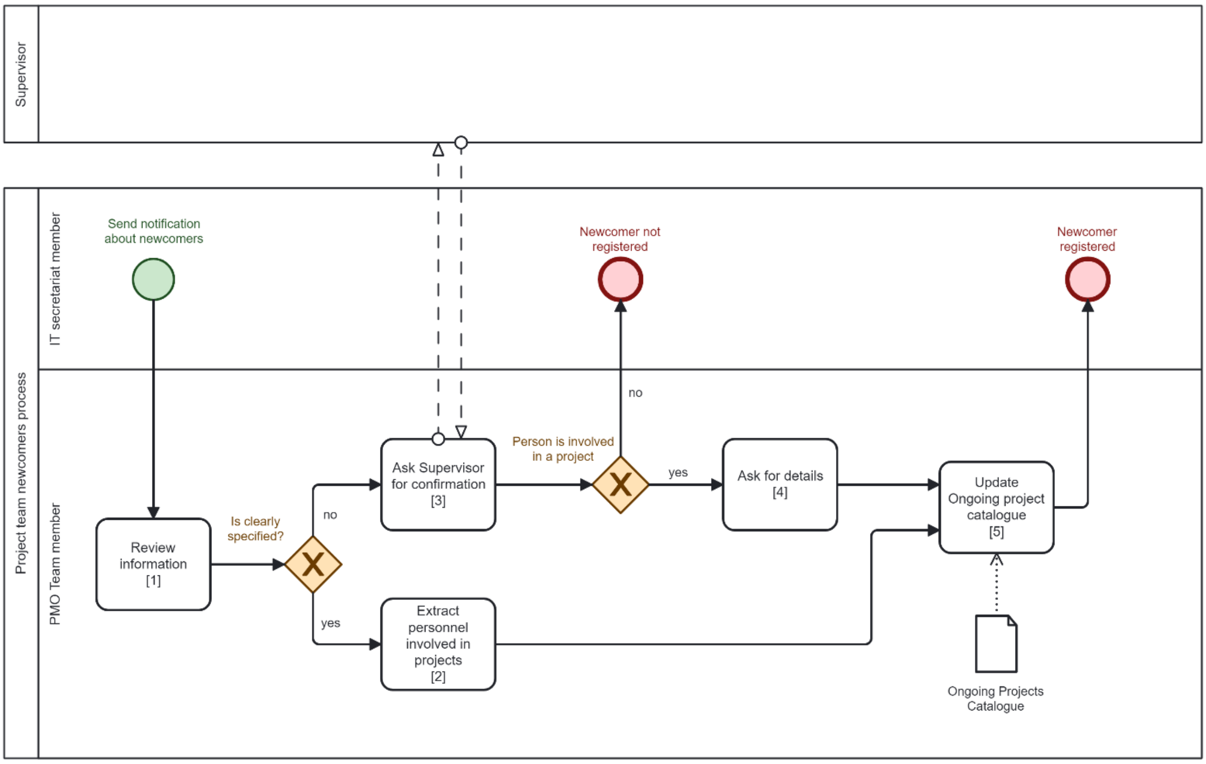


FIGURE 18: PROJECT TEAM NEWCOMER REGISTRATION PROCESS

5.3.5. Project Team Personnel Leaving Process

To provide a comprehensive view of the portfolio of the projects, the maintenance includes monthly revisions of the project team members' contributions ending that month. The PMO leader requests that one of the team members provide this information. The PMO member follows this request by checking the ongoing project catalogue [1]. If no project team members end their contribution at that time, the process ends. If a person is set to end their contribution to a project, the status needs to be confirmed with the project manager [2]. When the project manager confirms this situation, the person is removed from the project team list in the catalogue of the ongoing projects, and the process ends. However, if the project manager informs the PMO team that the person is extending their contribution, follow-up details are needed [4]. The PMO member confirms whether the extension was approved by management, and if so, updates the ongoing project's catalogue accordingly and ends the process. In case the extension is not approved, the person is removed from the catalogue of ongoing projects [3], and the process ends.

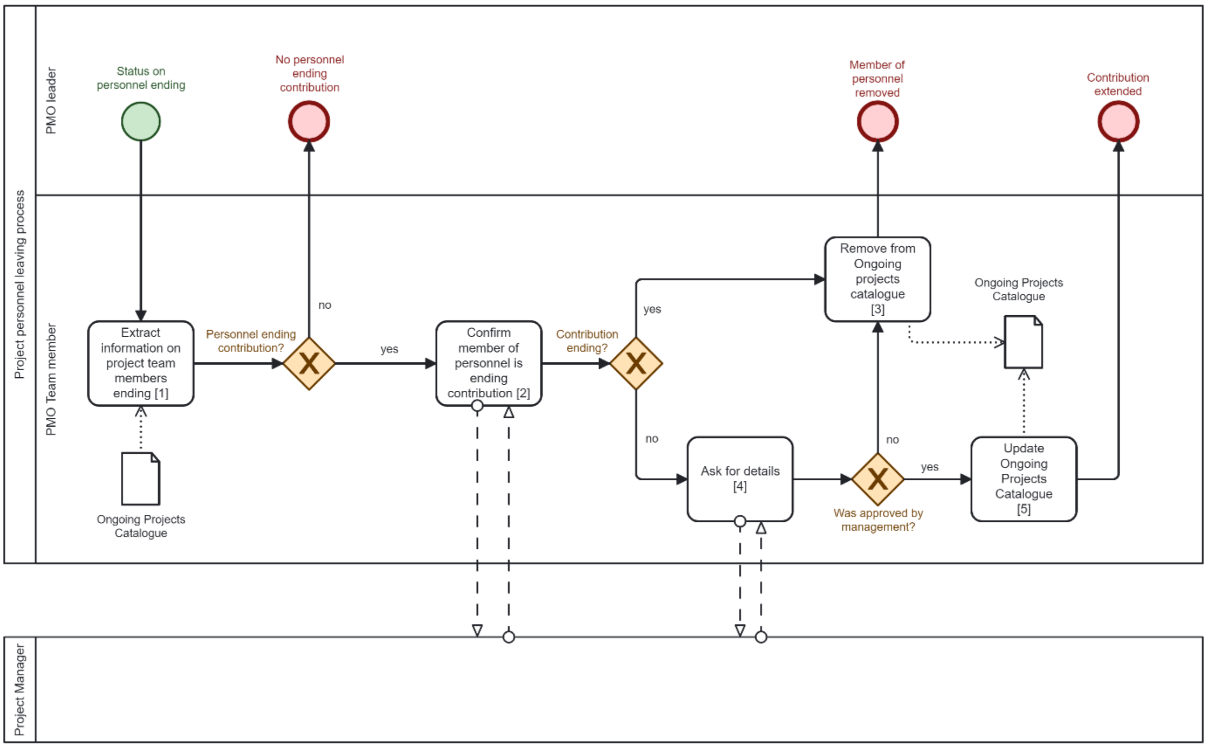


Figure 19: Project Team Member Leaving Process

6. Proposed Changes to Business Processes

While the current state of things accomplishes what is needed, the processes are repetitive, tedious, and prone to human error. An information system and a centralised database where data on projects and project personnel would be stored would bring much-needed automation and accessibility. Establishing a new business information system would eliminate duplication of work and information streams, improve accuracy, make maintenance easier, and lower human error possibilities.

This chapter introduces a high-level view of the proposed information system and a detailed view of the previously described processes in their new and improved structure. Full-scale diagrams can be found in the thesis appendix as well as electronic attachments under the same name.

Remodelled Project Submission Process	Appendix H
Remodelled Project Approval Process and Project Repository Process	Appendix I
Remodelled Project Closure Process	Appendix J
Remodelled Project Extension Process	Appendix K
Remodelled Project Team Newcomer Registration Process	Appendix L
Remodelled Project Team Member Leaving Process	Appendix M

For better clarity, the remodelled business processes are colour-coded, illustrating which activities and data objects remain the same, which remain but are executed differently, and which are new. Activities and data objects that are white remain the same as in the previously described process. Those that are highlighted in blue remain the same but are executed in a different manner (e.g., using a newly implemented system). Lastly, those that are highlighted in purple are completely new. For example, the catalogue update is not done manually but automatically via the information system (blue), or the system notifies the PMO member about any changes (purple).

6.1. Remodelled Project Submission Process

A project manager submits a project proposal directly through the project charter form within the information system (IS). The IS validates the completeness of the project charter based on predefined criteria [1]. If some of the criteria are not met, the system generates an error message notifying the project manager about the incompleteness of the project charter, ending the process. If the system finds the project charter to be complete, it notifies the relevant initiation pathway leader (IPL) [2], asking for the project to be endorsed. The IPL receives this message [3], views project details [4], and inputs the decisions directly into the system [5]. A rejected endorsement from IPL means the end of the process. An endorsed project proposal is automatically catalogued with a unique ID in the project catalogue [6]. The project catalogue and project personnel catalogue contain all the necessary details, the same as in the old project pending approval catalogue. The system assigns the project a pending approval phase [7] and automatically notifies the PMO team [8] about the newly submitted project. Once the PMO member receives the notification [9], he views the project details in the catalogue [10] and creates a folder on SharePoint in the relevant initiation pathway section [11]. The PMO member downloads a copy of the submitted project charter [12] and uploads it to the SharePoint folder [13]. The last task to do is to update the SharePoint folder link in the project catalogue [14]. Fulfilling all these tasks ends this process with a successful project submission.

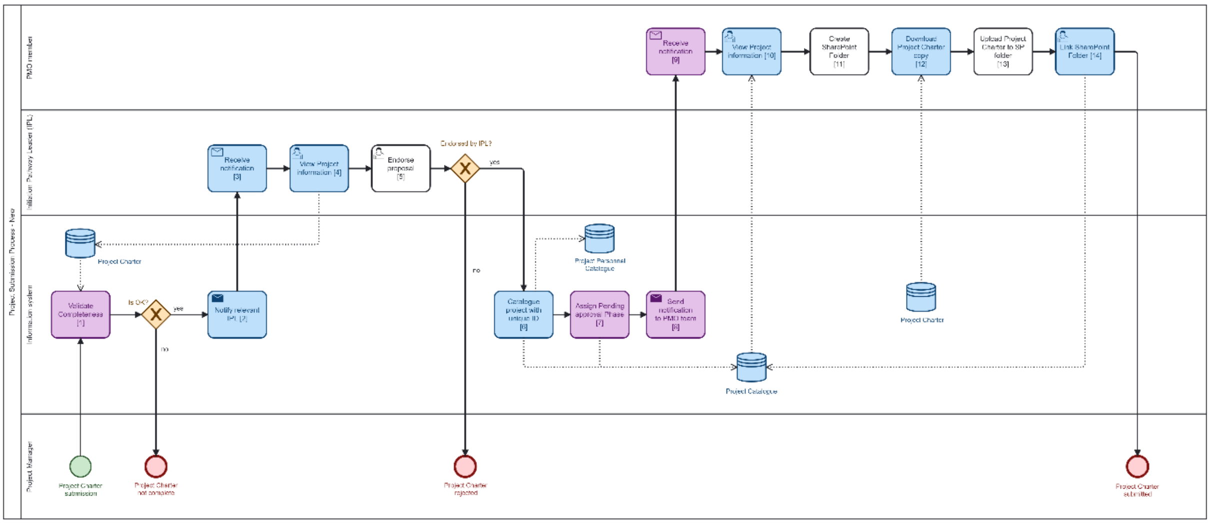


FIGURE 20: REMODELLED PROJECT SUBMISSION PROCESS

Comparison of processes

The biggest changes in this proposed model include the integration of direct submission and validation. The project manager submits the project charter directly through the information system instead of using an email. Furthermore, the IS validates the completeness of the proposal based on predefined criteria, whereas before this task was upon the PMO member. Secondly, the implementation of the automated endorsement process allows for a seamless transition between the submission of a project charter and notifying the relevant initiation pathway leader. The IPL's decision is updated directly into the system, eliminating manual communication and making the endorsement process smoother. Cataloguing a project after its endorsement and assigning a unique ID is also a task of the PMO member in the current process. The remodelled version reduces the manual task of the PMO member by automatically cataloguing an endorsed project in the project catalogue. However, the same situation remains for the creation of a SharePoint folder and the storage of the project charter. This approach ensures consistent document management while leveraging the already established PMO SharePoint site accessible to personnel of the IT Department.

6.2. Remodelled Project Approval and Project Repository Process

When a DMRB meeting is approaching, a DMRB representative needs to gather information on projects pending approval. This information can be extracted directly from the information system [1]. If no projects are in the pending approval phase, the process ends here. Projects that are pending approval are added to the upcoming meeting agenda [3]. In case the meeting does not take place, the projects are shifted to the next upcoming meeting. The outcome of the meeting can be updated directly in the information system [4]. The IS registers this [5] and, depending on the decision input, executes the following tasks. A project that is not approved but also not rejected is deferred, and the process ends. For a rejected project, the IS updates the project phase to "closed" with the status rejected [8]. After this, the IS sends a notification to the PMO member [9], who, once the notification is received [10], goes on to relocate the project folder on SharePoint to the rejected section [11] and update the project catalogue with the new link [12]. For a rejected project, the process ends there. However, if the project is approved during the DMRB meeting, the IS updates the phase to ongoing [6] and notifies the PMO team about this outcome [7].

Project Repository Process

The PMO member receives the notification about a newly approved project, and a subprocess of creating the project repository starts. The PMO member creates the SharePoint project site [a], uploads the necessary documents [b], grants access to the project manager and management [c], and finally updates the project catalogue with the new SharePoint link [4]. In parallel, the previous project folder needs to be deleted [e]. Once both of the parallel flows are done, the subprocess ends, returning to the parent process and ending as a successfully approved project.

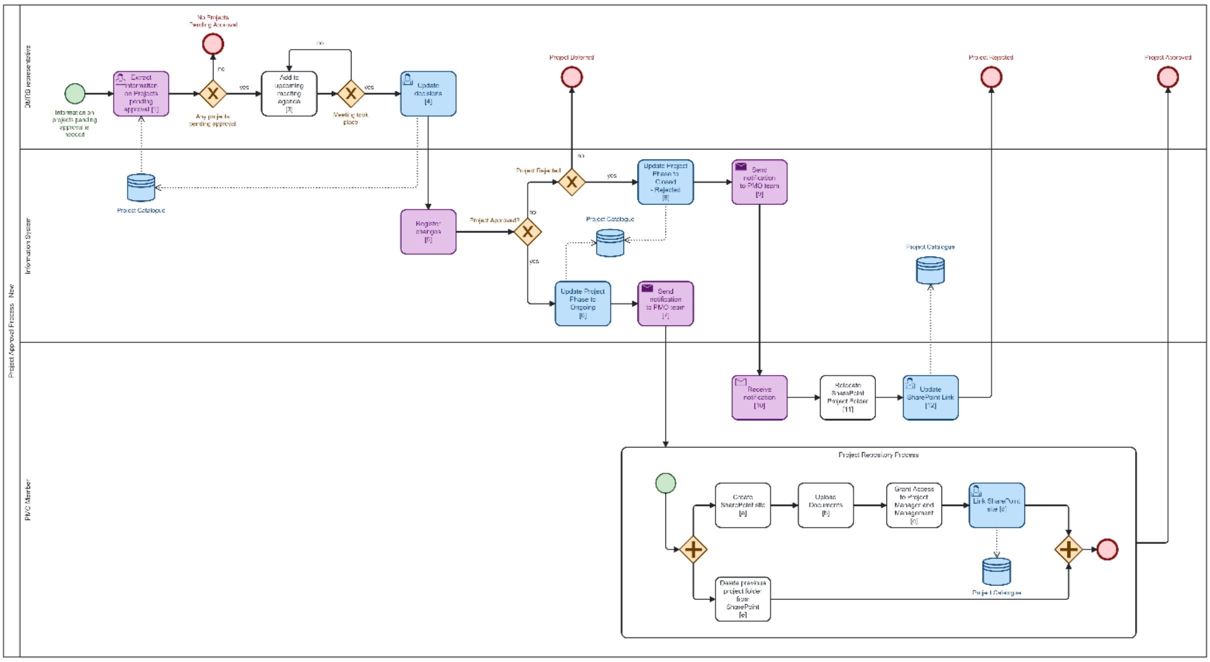


FIGURE 21: REMODELLED PROJECT APPROVAL AND REPOSITORY PROCESS

It is important to note that the tasks of creating folders on SharePoint for project proposals and the creation of project SharePoint sites for approved projects (the project repositories) remain the same. While the maintenance of the PMO SharePoint site can seem tedious, it acts as a valuable knowledge base for the personnel of the IT Department as well as for the management. Furthermore, the individual SharePoint sites serve as project repositories not only for the documents requested by the PMO but also for the individual project managers, who utilise them for project management needs.

Comparison of processes

As opposed to the current process, where the PMO leader extracts the information on projects pending approval and provides this information to the DMRB representative, the new model offers the DMRB representative a seamless extraction of this information. Furthermore, the DMRB representative updates the decision taken during the meeting directly into the system, and the system automatically executes the corresponding tasks. Automatic project status updates minimise the risk of errors and discrepancies in project information in comparison to the current state, where the PMO member manually removes and enters data between different project catalogues. And lastly, as mentioned above, the process of creating a SharePoint site (the project repository) remains the same as in the current version. The existing SharePoint site offers a well-structured representation of the project portfolio, with each section accessible to the relevant users.

6.3. Remodelled Project Closure Process

The system monitors the end dates, and when it registers an approaching end date [1], it automatically triggers notifications to the project manager [2] to confirm the project status. The project manager provides the status update directly through the information system [3]. The information system (IS) registers this input [4] and, based on the given status, initiates one of two flows. In case the project is not on time the IS notifies a PMO member [5], who, once the message is received [6], initiates the project extension subprocess [7]. The extension process is described in detail further below in subchapter 6.3.1. The activities following when the project is on time depend on whether the project is under European Commission (EC) funding or not. A project funded by the EC does not have to submit an impact report, and once the end date approaches, the system updates the project phase to closed [15] and removes the project team members from the project personnel catalogue [16]. Following this, the system notifies the PMO member [17], who, once the notification is received [18], moves the project SharePoint site to the archived section [19], thus ending the project closure process. In the case of a project under any other type of funding, the process separates into two parallel flows. The first flow begins with the system asking the project manager to prepare an impact report (IR) [8]. The project manager receives this message and prepares and submits the impact report [9]. The PMO member reviews the document [11] and, if some additional information is needed, requests corrections from the project manager [12]. The project manager modifies the document [13] and submits it again [10]. An impact report that the PMO member finds to be complete is uploaded to the project SharePoint site [14], and this flow ends. The second flow follows the same activities as described for the EC-funded projects. In case the project manager's input [3] states that the project is on time, the system waits for the end date to come to update the project catalogue with the phase closed [15] and to remove the project team members [16]. This activity triggers the system, and it notifies the

PMO member [17], who, once the notification is received [18], moves the project SharePoint site to the archived section [19], thus ending the project closure process.

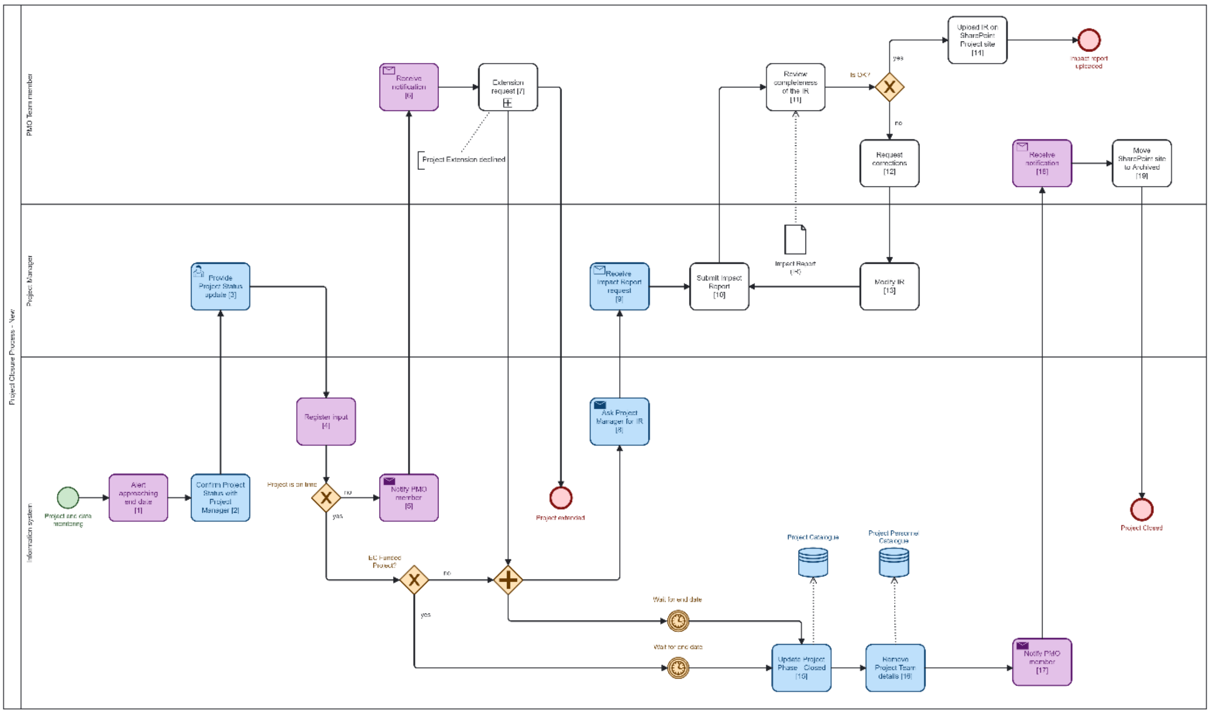


FIGURE 22: REMODELLED PROJECT CLOSURE PROCESS

Comparison of processes

One of the biggest advantages of the new process is the automated monitoring. The system automatically monitors the project catalogue end dates and triggers notifications to project managers, thus eliminating the need for manual tracking and follow-ups by the PMO members. Similar to previous modifications, the project managers provide status updates directly through the information system, triggering the subsequent activities. Lastly, the IS proceeds with project phase updates automatically based on the end date, reducing manual effort on the PMO member's side.

6.3.1. Remodelled Project Extension Process

When the project is not on time, the system informs the PMO member. The PMO member looks up the project information [1], and depending on the project funding, one of two options follows. For a project that is funded by the European Commission, it is only necessary to ask the project manager for details [2]. The project manager provides this information, and the PMO member updates the project catalogue and the affected project personnel manually in the information system [3]. In this case, the process ends with a successfully registered extension of the project. In the case of a project under any other type of funding, the PMO member asks the project manager for details [4] and notes down the extension request [5]. The IS registers the request [6] and sends a notification to the DMRB representative [7], who registers this notification [8] and adds the request to the agenda of the next meeting [9]. In case the meeting does not take place, the request is added to the agenda of the next meeting. Following the meeting, the decision can be updated directly in the system [10], which registers this information [11]. Depending on the management's decision, the extension is either rejected and the process ends, or it is approved and the IS updates the project catalogue and the project personnel catalogue accordingly [12]. Lastly, the IS notifies the PMO member [13], and the process ends.

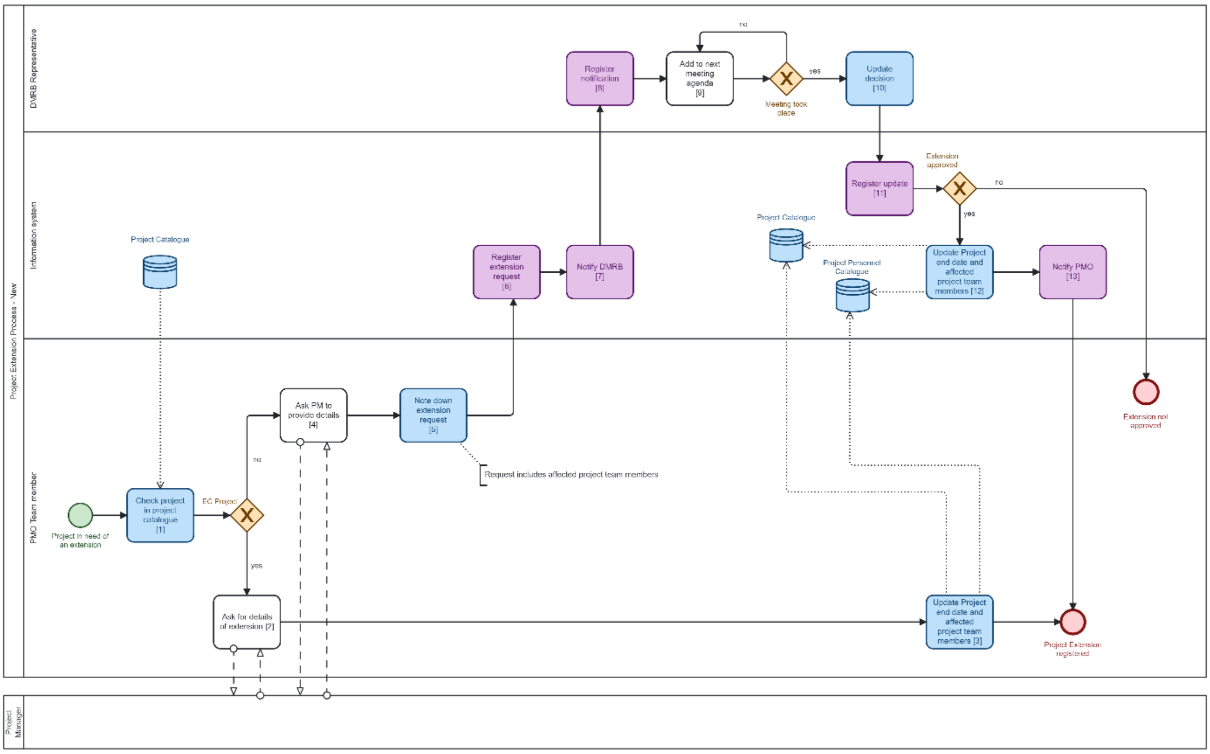


FIGURE 23: REMODELLED PROJECT EXTENSION PROCESS

Comparison of processes

The new model integrates an automatic notification for the PMO member. The PMO member personally communicates with the project manager regarding the extension request details. The reason for this manual effort is the unique nature of each extension request.

Direct communication in this case ensures that the PMO member gathers all necessary details and can clarify uncertainties while considering the project manager's specific circumstances. This approach ensures personalised interaction and informed decision-making. The system automatically notifies the DMRB representative when a new extension request is registered. Later, the DMRB representative updates the decision directly into the system, and subsequent activities follow automatically. For projects funded by the European Commission, the process remains less automated. In this case, following the notification from the system, the PMO member communicates manually with the project manager and updates the catalogue accordingly, taking into consideration the specific circumstances.

6.4. Remodelled Project Team Newcomer Process

The process of registering a project team newcomer remains without any significant changes. Integration with the existing HR database might seem like a logical step; however, it is essential to recognise that this task would be very complex and the decision could not be taken lightly. The HR database functions across the whole organisation, and such integration would require careful planning and consideration of various factors, including data security and privacy regulations. For this reason, the steps of the process are as follows:

The IT secretariat sends a notification about the newcomers to the IT Department. A PMO member reviews this information [1], and depending on the provided details, one of two paths can be taken. In cases where the information provided by the secretariat specifically states the involvement of the newcomer in a specific project, the PMO member extracts this information [2] and inserts this data into the information system [5]. However, if the information provided by the IT secretariat is not clear enough, the PMO member follows up with the supervisor [3]. Depending on the supervisor's feedback, the newcomer can either not work on a project at all or contribute to a project. In that case, the PMO member confirms additional details [4] about the contribution, such as the end date and effort. The PMO member updates the project personnel catalogue [5] and ends the process.

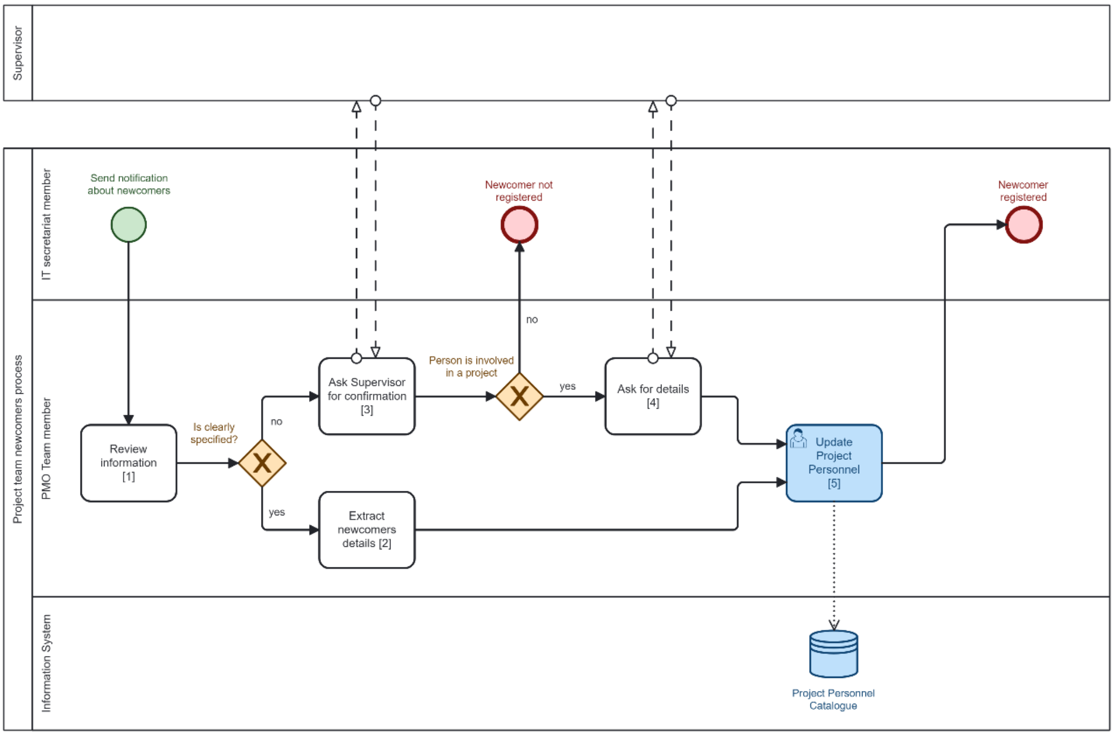


FIGURE 24: REMODELLED PROJECT TEAM NEWCOMER PROCESS

6.5. Remodelled Project Personnel Leaving Process

The information system continually monitors the end dates of the project team members, and when a project team member's end date is approaching, the IS is alerted [1] and triggers a notification to the relevant project manager [2] to confirm the status. The project manager receives this message [3] and provides the details directly to the information system [4]. The system continues with the process based on the project manager's input. If the person's contribution to the project is ending, the IS waits for the end day to come to remove this person from the project personnel catalogue [5] and to notify the PMO member [6]. This way, the process ends. In such a case, the project manager states that the project team member is not ending his contribution towards the project, and the system asks for details [7], such as confirmation on whether the extension was approved by the management and the new end date. The project manager receives this information from the system [8] and provides the details [9]. The process continues depending on whether the extension was approved by management or not. If so, the system updates these changes in the project personnel catalogue [10], notifies the PMO member [11], and the process ends. In case the manager does not confirm the approval of management, the IS waits for the end date to come, and the steps follow the same as stated before. The system removes this person from the project personnel catalogue [5] and notifies the PMO member [6], ending the process.

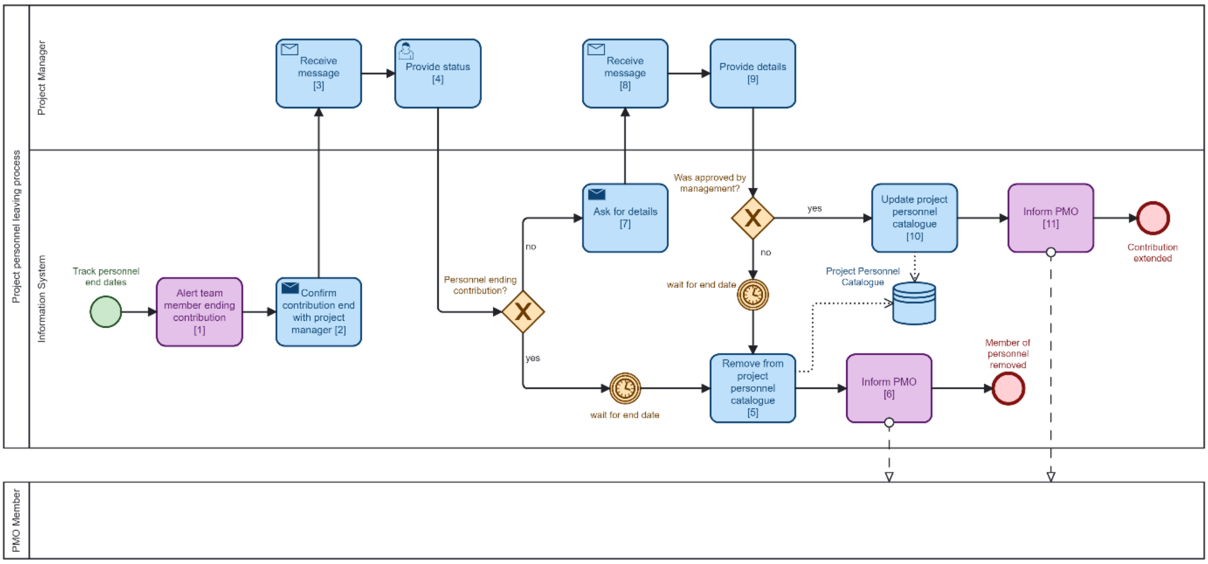


FIGURE 25: REMODELLED PROJECT PERSONNEL LEAVING PROCESS

Comparison of processes

Similar to previous processes, the process of a project team member ending their contribution also offers continual monitoring and automatic notification, eliminating the need for manual tracking by the PMO team. Furthermore, the system automatically alerts the project manager to confirm the status of the relevant team member, enabling effortless updates and reducing manual communication. The process continues with activities based on the project manager’s input, fully eliminating effort on the PMO member's side. This seamless integration not only enhances efficiency but also ensures timely updates and an accurate overview of project team members' contributions.

7. Information System Specifications

The structure of the redesigned business processes reflects a couple of key requirements. The IS can be designed to be accessible to multiple different roles, while each individual would only be able to modify data relevant to their role. Full access and permissions would be available across the PMO team, allowing them to efficiently manage the portfolio of projects and the project team personnel. The management (in this case, the DMRB representatives) would be able to make edits following a request generated by the information system. The same situation would apply to the project managers. Eliminating any unofficial alterations, this structure would ensure data consistency and security.

The system would help to streamline communication between PMO members, project managers, and management by providing a centralised platform for sharing project-related information, reducing manual follow-ups, and increasing efficiency.

Leveraging the integrity of the data, the system can provide real-time dashboards on the portfolio of projects and strategic alignment. Furthermore, customisable reports can be generated following a request from review boards, enhancing decision-making capabilities.

By reducing the manual effort of managing project data and communication, the PMO team members can allocate their time and resources more efficiently towards other tasks and responsibilities.

7.1. Use Case Diagrams

This subchapter provides a set of use case diagrams illustrating a high-level view of the actor's interactions with the proposed information system. A separate diagram for each user (actor) is modelled to provide a clearer view, illustrating their specific interactions with the system. This representation can help define the system's functional requirements by highlighting the specific use cases and interactions relevant to each actor and building on the unique roles and permissions. For the previously described business process, four main actors can be distinguished.

The project manager is responsible for initiating the process by submitting a new project proposal. Furthermore, he is responsible for providing updates on project progress and project team members' collaboration.

The initiation pathway leader (IPL) can view the project proposal details and update their endorsement decision.

A member of the demand management review board can view the projects to oversee the project approval or rejection as well as approve project extension requests.

Lastly, the PMO member represents the centre of all the processes, being able to view the projects and update both the project catalogue and the project personnel catalogue. Based on the inputs provided by other actors, the PMO member can add new team members and remove projects or personnel, ensuring data accuracy.

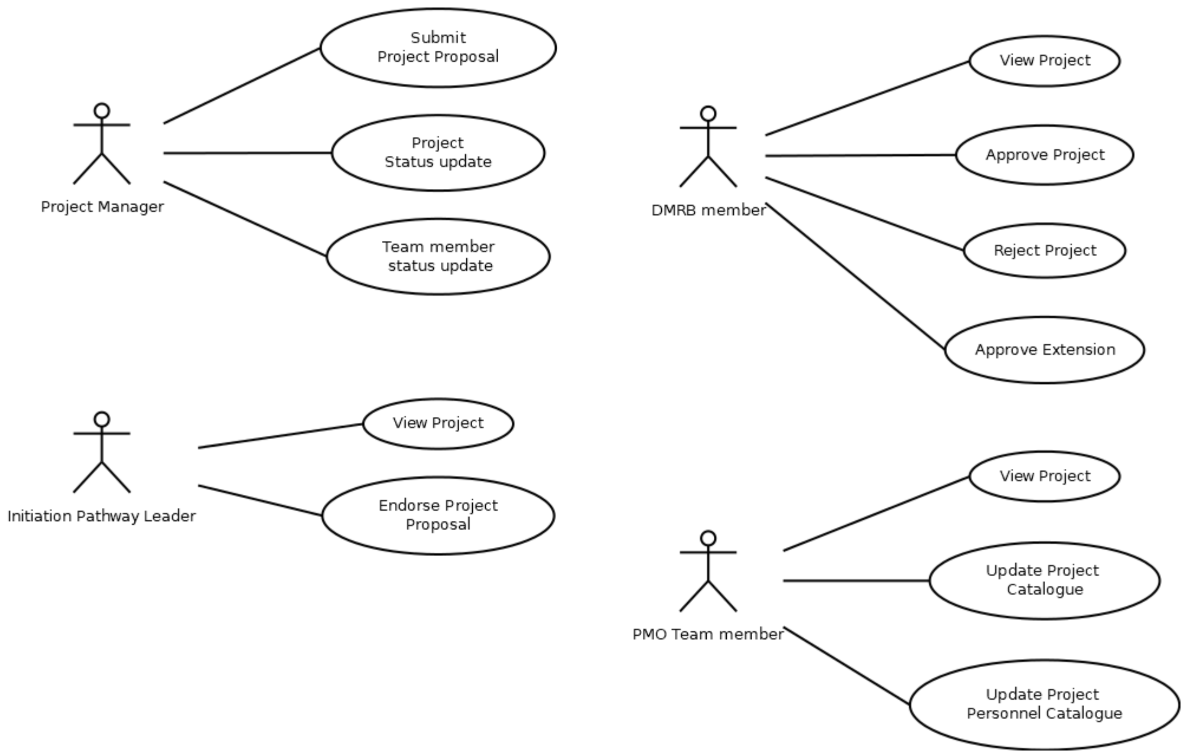


FIGURE 26: USE CASE DIAGRAM FOR THE NEW MODEL

Figure 27 illustrates in detail how each actor interacts with the system in a specific business process and activity modelled in Chapter 6.

Actor	**Use Case**	**Business Process**	**Activity**
Project Manager	Submit Project Proposal	Project Submission Process (Chapter 6.1.)	Start event
	Project Status Update	Project Closure Process (Chapter 6.3.)	Activity [3]

	Team Member Status Update	Project Personnel Leaving Proces (Chapter 6.5.)	Activity [4]
IPL	View Project	Project Submission Process (Chapter 6.1.)	Activity [4]
	Endorse Project Proposal	Project Submission Process (Chapter 6.1)	Activity [5]
DMRB Member	View Project	Project Approval Process (Chapter 6.2.)	Activity [1]
	Approve Project	Project Approval Process (Chapter 6.2.)	Activity [4]
	Reject Project	Project Approval Process (Chapter 6.2.)	Activity [4]
	Approve Extension	Project Extension Process (Chapter 6.3.1.)	Activity [10]
PMO Team Member	View Project	Project Submission Process (Chapter 6.1) Project Extension Process (Chapter 6.3.1.)	Activity [10] Activity [1]
	Update Project Catalogue	Project Approval Process (Chapter 6.2.) Project Repository Process (Chapter 6.2.)	Activity [12] Activity [d]
	Update Project Personnel Catalogue	Project Newcomer Process (Chapter 6.4.)	Activity [5]

FIGURE 27: USE CASE CONNECTION TO BPMN DIAGRAMS

7.2. Entity Relationship Diagram

An entity relationship diagram illustrating the common database of the proposed system is shown below. Figure 28 shows three entities: the project catalogue, the project personnel catalogue and the strategic objectives matrix. The attributes are modelled based on the current state of the corresponding documents. However, to simplify the three separate catalogues, a new attribute was added to the "project" entity. The "Phase" now specifies whether the project is pending approval, ongoing, or closed.

The relationships between entities reflect the interconnected nature of project management. Each project can have multiple people working on it, and one person can simultaneously contribute to multiple projects. Each project is linked to the strategic objectives, showing that one project can align with and contribute to multiple strategic objectives.

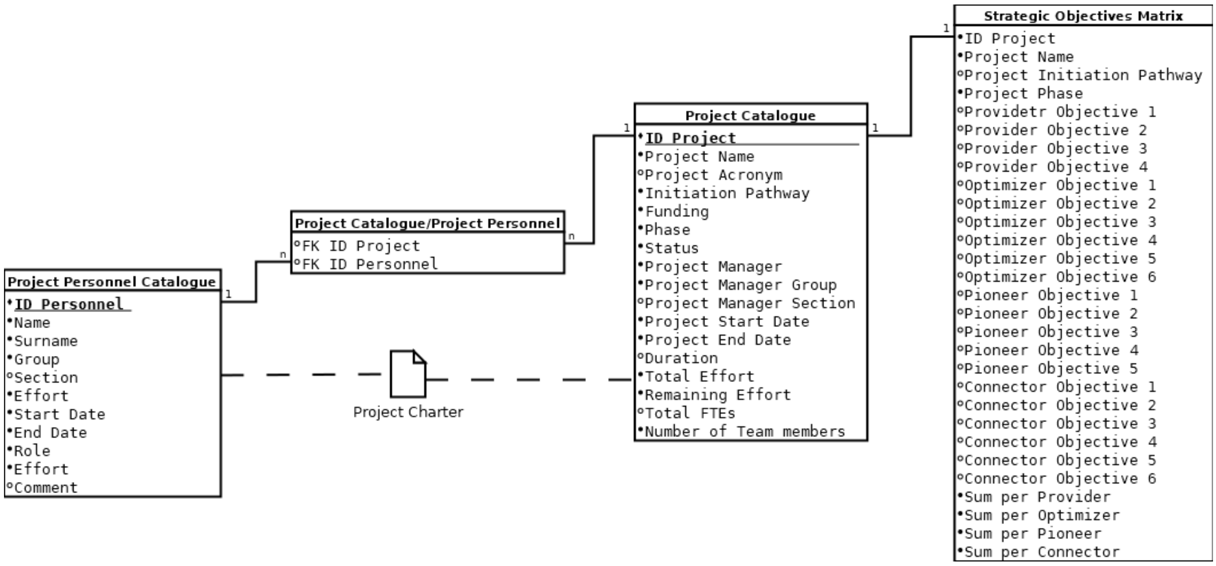


FIGURE 28: ER DIAGRAM FOR THE NEW MODEL

7.3. Possible solutions

The process of choosing the right solution for implementation and remodelling business processes is challenging. The ideal solution should be able to achieve maximised efficiency, enhance collaboration, and support decision-making while being economically advantageous and easy to maintain. Consideration of factors such as budget restraints, requirements, scalability, long-term sustainability, and integration procedures is a critical part of this process. For the proposed model, several plausible options come into view.

The first option is for the team to acquire a custom-made solution from one of the many suppliers on the market. This solution would offer several advantages. The existing system can be tailored to the unique requirements of the business processes of the project portfolio management office. Furthermore, an established company offering project portfolio management software incorporates cutting-edge features and functionalities that cater to the complexity of the processes at hand and enhance productivity and effectiveness. Integration with already existing software and platforms such as Jira, Microsoft Outlook, Project, and Excel. Procuring a custom-made solution would also mean access to professional support services and regular maintenance and updates, which would ensure smooth operation and easier resolution of any issues. Lastly, procurement would leverage an existing external framework and expertise, and the development timeline would be considerably shorter in comparison with the second option. However, this solution also brings higher costs as well as dependence on the external entity for any updates or modifications. Furthermore, there are a vast number of systems on the market, and choosing one solution would require a thorough evaluation of their compatibility and costs.

The second option is for the department to customise one of the existing open-source solutions. This option would target the disadvantages of the first one, bringing full control and ownership of the system. Having full control of the development process allows for flexible customisations made to meet evolving needs. Another advantage of this option is lower costs, as it eliminates fees associated with commercial software solutions. A high level of customisation would enable seamless integration within the existing workflows and business processes. Furthermore, leveraging the expertise of the IT personnel fosters knowledge transfer and skill development within the department. On the other hand, in-house customisation requires a significant time frame, resources, and expertise.

A somewhat in-between solution would be the customisation of Microsoft Power Apps. This approach would leverage existing partnerships with Microsoft and the knowledge base already within the IT Department. This choice would also allow for further automation with already existing processes and offer integration with project managers who are using Microsoft Project.

8. Economic evaluation of the investment

Due to the nature of the work carried out by the PMO team and the organisation itself, no revenue is generated, making it challenging to apply economic evaluation methods of investment as described in Chapter 4.

The proposed changes would without doubt add value to the team itself by making their workload more manageable and automated. By implementing an information system, automating activities, and reducing manual effort, the proposed model would help decrease labour costs. Furthermore, by reducing human error and thus the recovery period, more labour cost savings would be generated.

Taking into consideration that a PMO member is typically a part-time role, thus the person who takes it on has to divide their effort in multiple places, an automatization would free up their time and allow them to dedicate effort elsewhere. Furthermore, the information system would help streamline communication between all involved members and provide a less tedious way of collaborating. On the other hand, such a change would require the creation of a new infrastructure, its implementation, and maintenance, as well as the need for technical support throughout the whole lifecycle.

For the second possible solution outlined in Chapter 7, a technical student or fellow could be hired for the development and implementation. In that case, the cost of a technical student or fellow would be the total initial cost of this investment. A one-year technical student contract would allow for the development and possibly implementation of the proposed model. The task of monitoring the performance of the system and its maintenance could then be a part-time role of another member of the personnel. In the case of a fellow, a two to three-year contract would allow for fulfilling all the necessary tasks. Furthermore, considering the workload towards the second and/or third year of the contract wouldn't be as excessive, the remaining effort could be dedicated elsewhere.

When it comes to the first option, purchasing a custom-made solution, apart from the cost of the acquired system, additional expenses would include the cost of a member of personnel overseeing the implementation process. In this case, an administrative student with a technical background would be an appropriate choice. However, the full effort of said student would not be required, allowing for the allocation of effort elsewhere, thus reducing the labour costs by some percentage.

Subsequently, both options would require investment in time and financial resources for training the personnel involved.

It is essential to consider the potential benefits and drawbacks of each solution. While the first option allows for earlier implementation, reliance on an external provider might pose challenges. On the other hand, the second possible solution would require substantial technical expertise from within the organisation.

Ultimately, while there are costs and challenges associated with implementing these proposed changes, the potential benefits in terms of streamlining processes, reducing manual effort, and enhancing overall team effectiveness make them worthy considerations for the PMO team and the organisation as a whole. It's essential to carefully weigh the pros and cons of each option and choose the one that best aligns with the organisation's goals and resources.

Conclusion

This thesis has undertaken a thorough study of the internal processes of the Project Portfolio Management Office team at the European Organisation for Nuclear Research's Information Technology Department. The study has underlined the importance of effective project portfolio management in achieving organisational strategic objectives and maximising its value. By combining theoretical research with practical insight gained from the daily activities of the IT-PMO team, this thesis offers a comprehensive understanding of the problems and challenges. The proposed improvements address not only the current challenges faced by the IT-PMO team but also lay the groundwork for establishing a more efficient project portfolio management system by enhancing team productivity, nurturing communication, and promoting better collaboration among the Resource Management group.

The theoretical part covers the fundamentals of business processes, methods of business process modelling, and the phases of business process improvement. The second section provides an outline of the Unified Modelling Language and Business Process Model and Notation and illustrates modelling principles. The following section of the theoretical part introduces the essentials of information systems and database modelling. The last chapter introduced several methods of economic evaluation of investment.

The practical part begins by introducing the European Organisation for Nuclear Research and its Information Technology Department. Delving further into the responsibilities of the IT Department, a detailed study of the Project Portfolio Management Office team and its wide range of activities is conducted. Following the introduction of the IT-PMO team, a detailed description of a set of its business processes is given. Building on these findings, a proposal for remodelling the business processes is presented, highlighting specific changes and providing a descriptive comparison. The subsequent section provides a further specification of the new model, describing the specific actors and use cases as well as illustrating the proposed data model. Furthermore, several different solutions are proposed, evaluating each of their advantages and disadvantages. And lastly, an overview of the economic evaluation of each proposed solution is provided.

In conclusion, this thesis serves as a roadmap for enhancing project portfolio management practices within CERN’s IT department. By implementing the proposed improvements, the department can position itself for greater success in achieving its strategic objectives and delivering value to stakeholders and the whole organisation.

By sharing this insight and best practices, I believe this thesis can serve as an example for other departments at CERN and similar research and innovation facilities.

Additionally, conducting a thorough internal analysis of the proposed solutions and undertaking a detailed economic evaluation to depict the costs associated with each member of personnel could enhance the findings of this thesis. Furthermore, upon selecting a preferred solution and preparing a detailed implementation plan, a study focusing on monitoring and collecting feedback can be conducted, serving as input for further improvements.

Glossary

Acronym	Full Name
BPMN	Business Process Model and Notation
DMRB	Demand Management Review Board
EC Project	European Commission Project
ER (ERD)	Entity Relationship Diagram
IPL	Initiation Pathway Leader
IS	Information System
PM	Project Manager
PMO Team	Project Portfolio Management Office Team
RM	Resource Management
SOM	Strategic Objectives Matrix
UML	Unified Modelling Language

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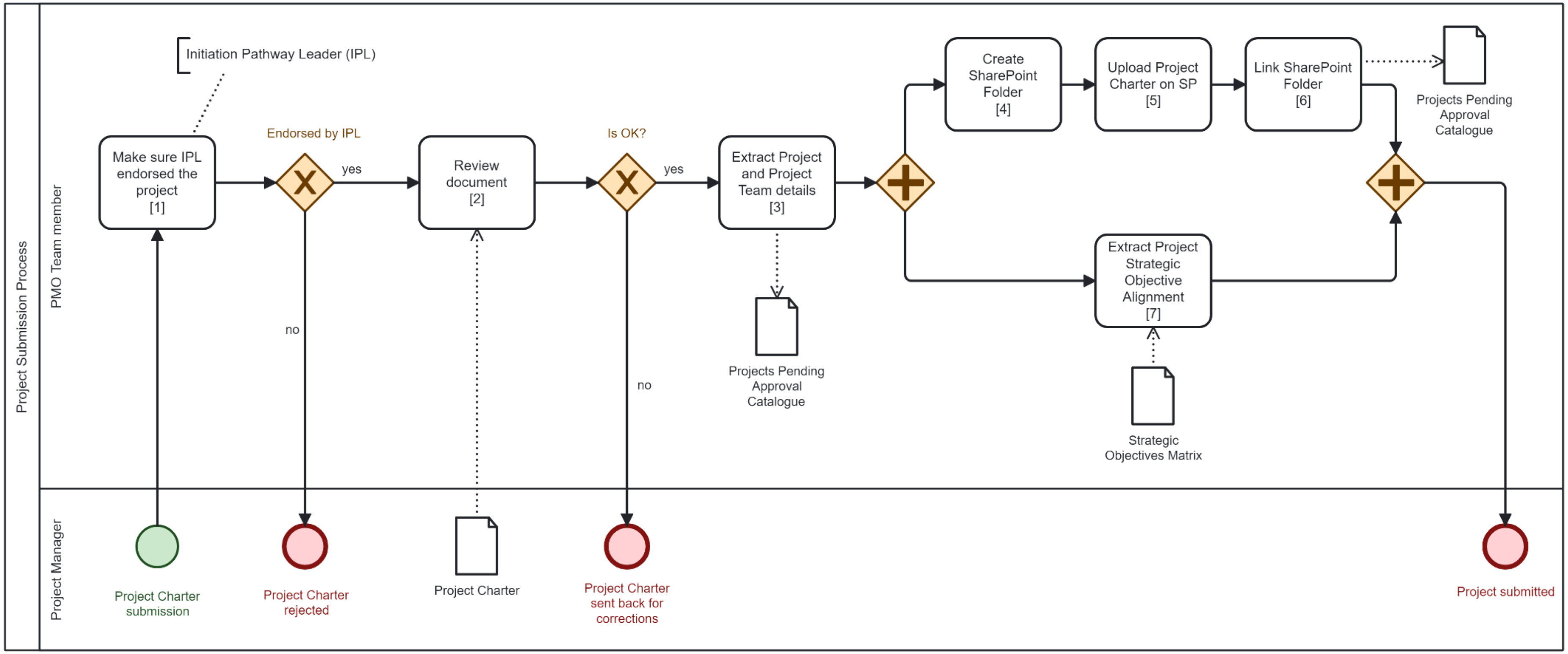
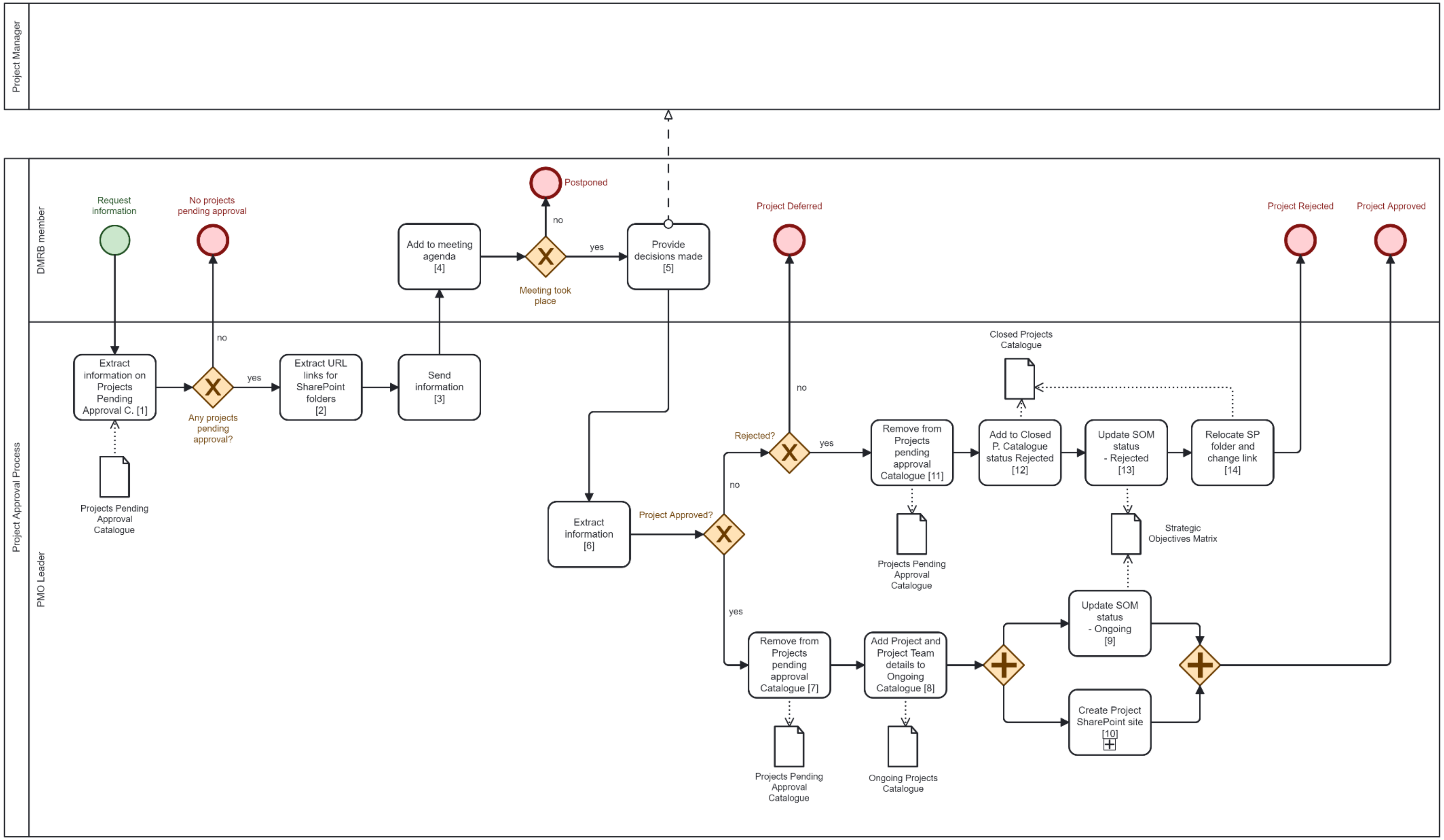
Table of Figures

Appendix

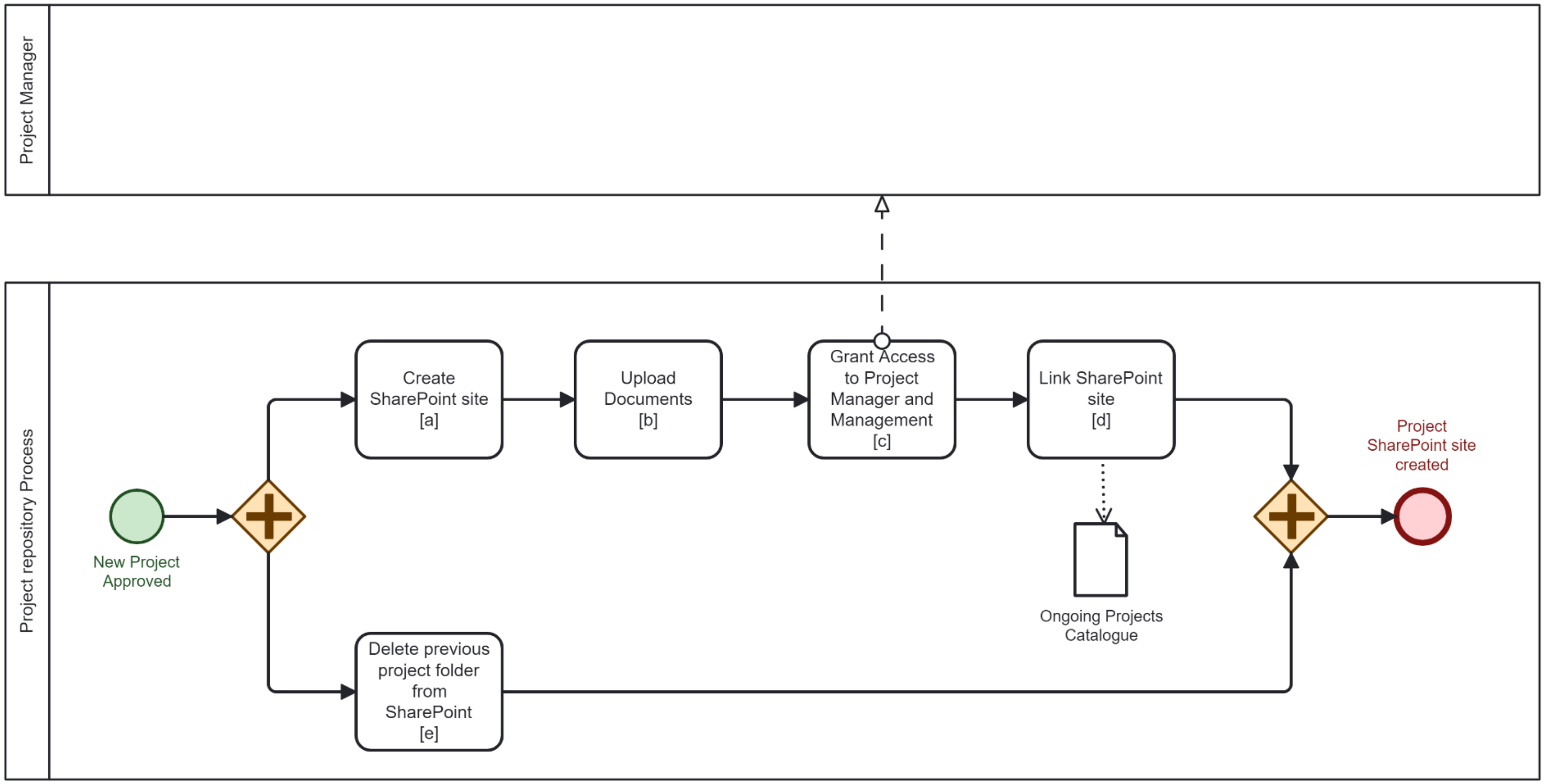
Appendix A – Project Submission Process



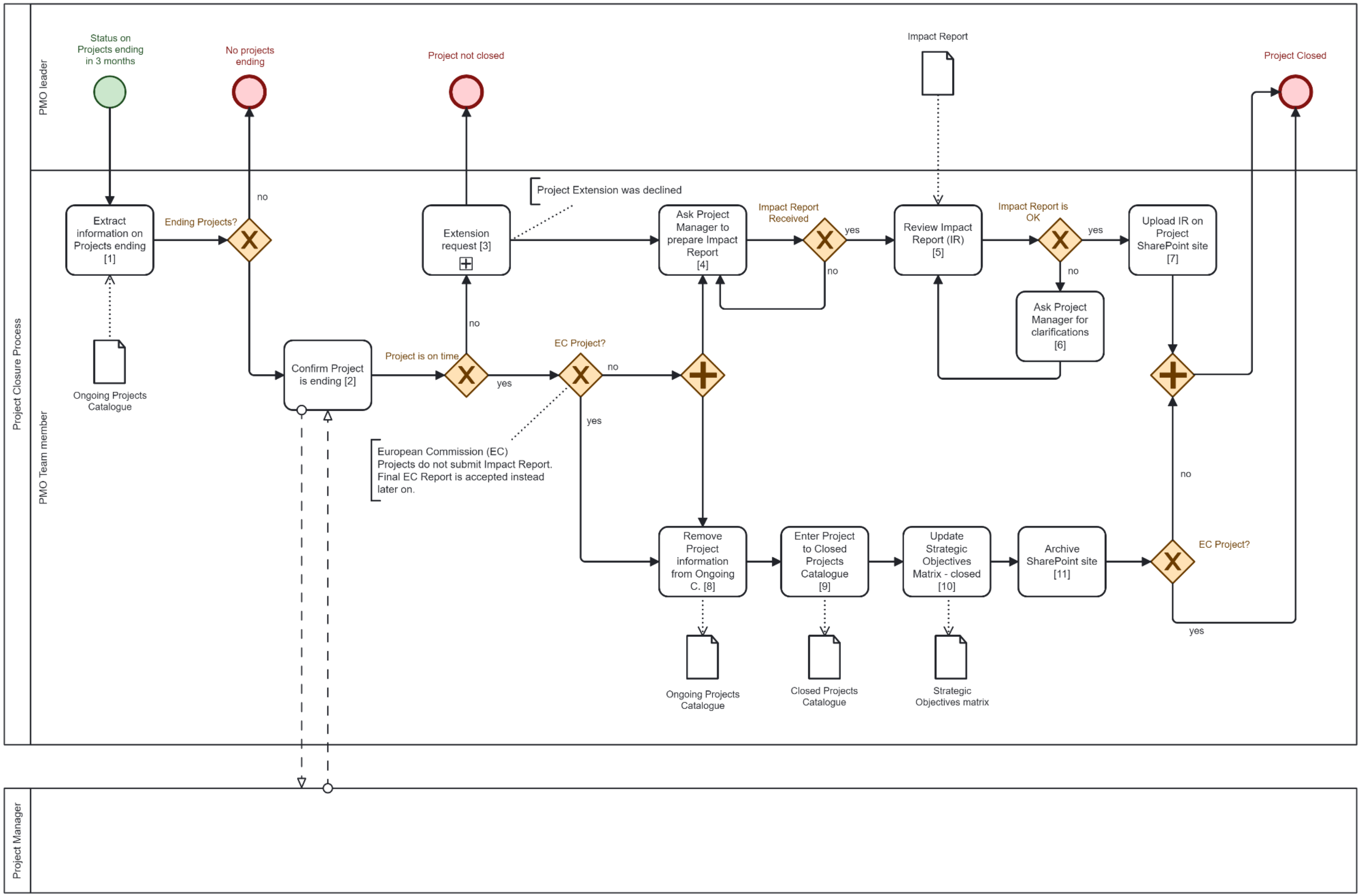
Appendix B – Project Approval Process



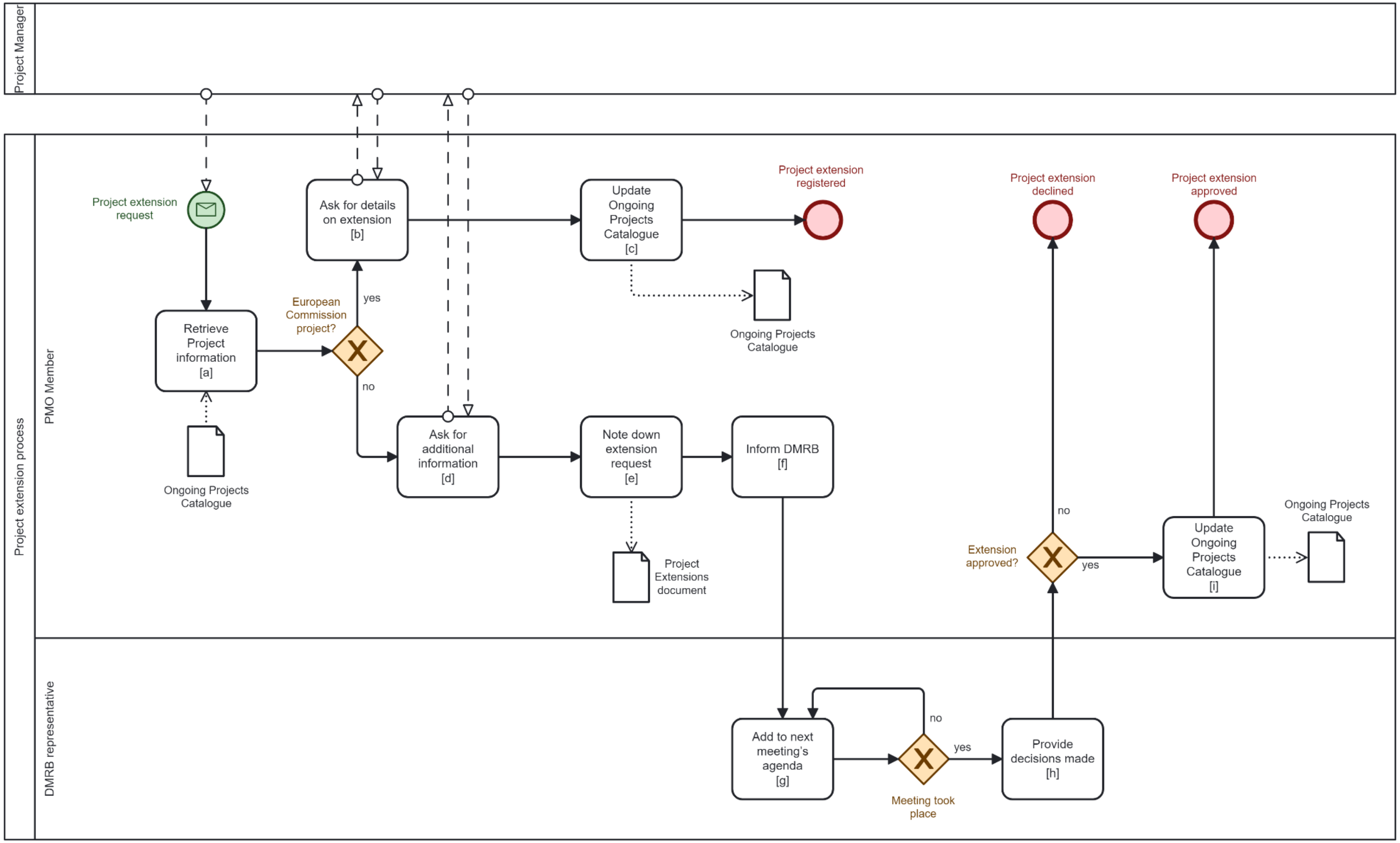
Appendix C – Project Repository Process



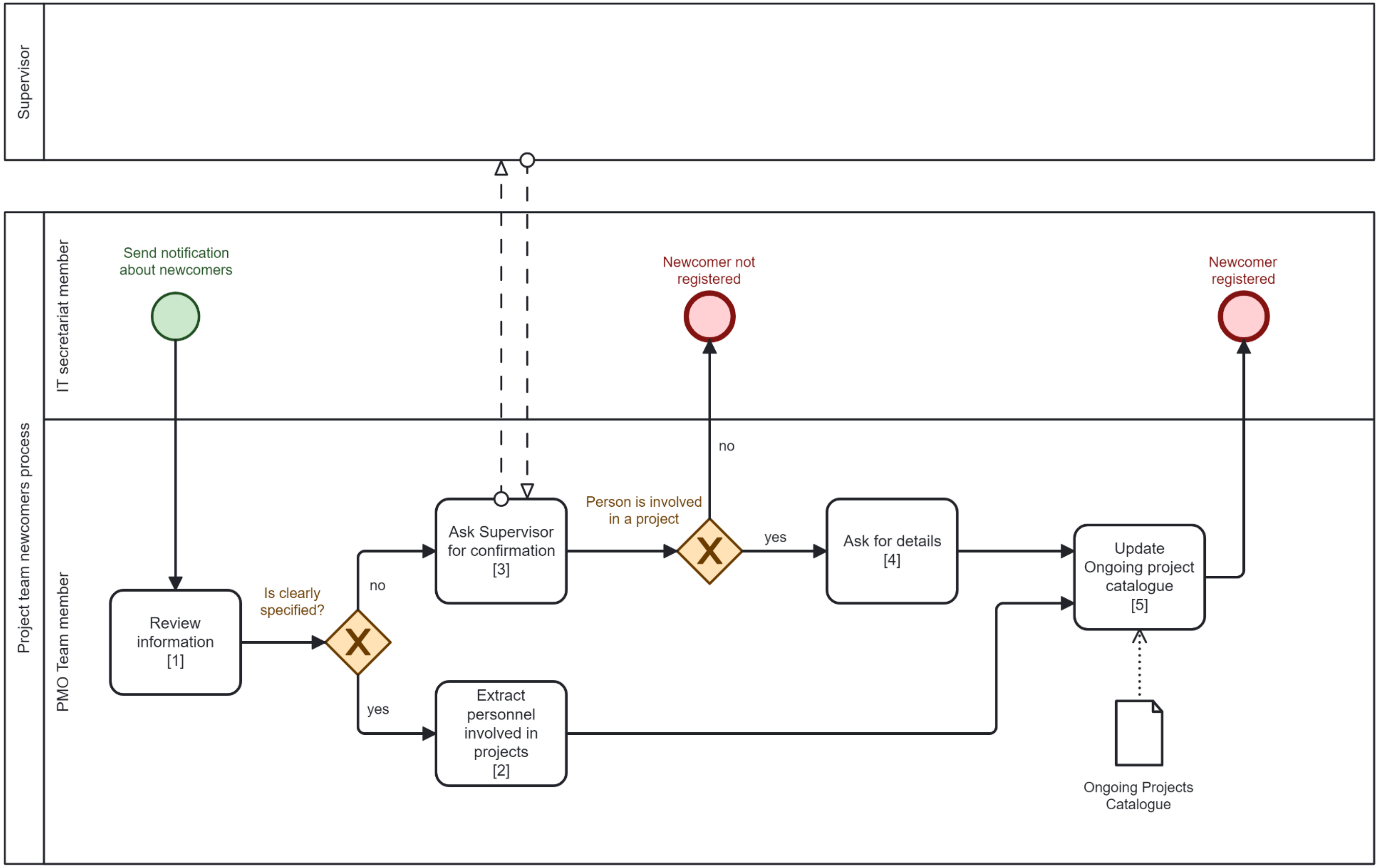
Appendix D – Project Closure Process



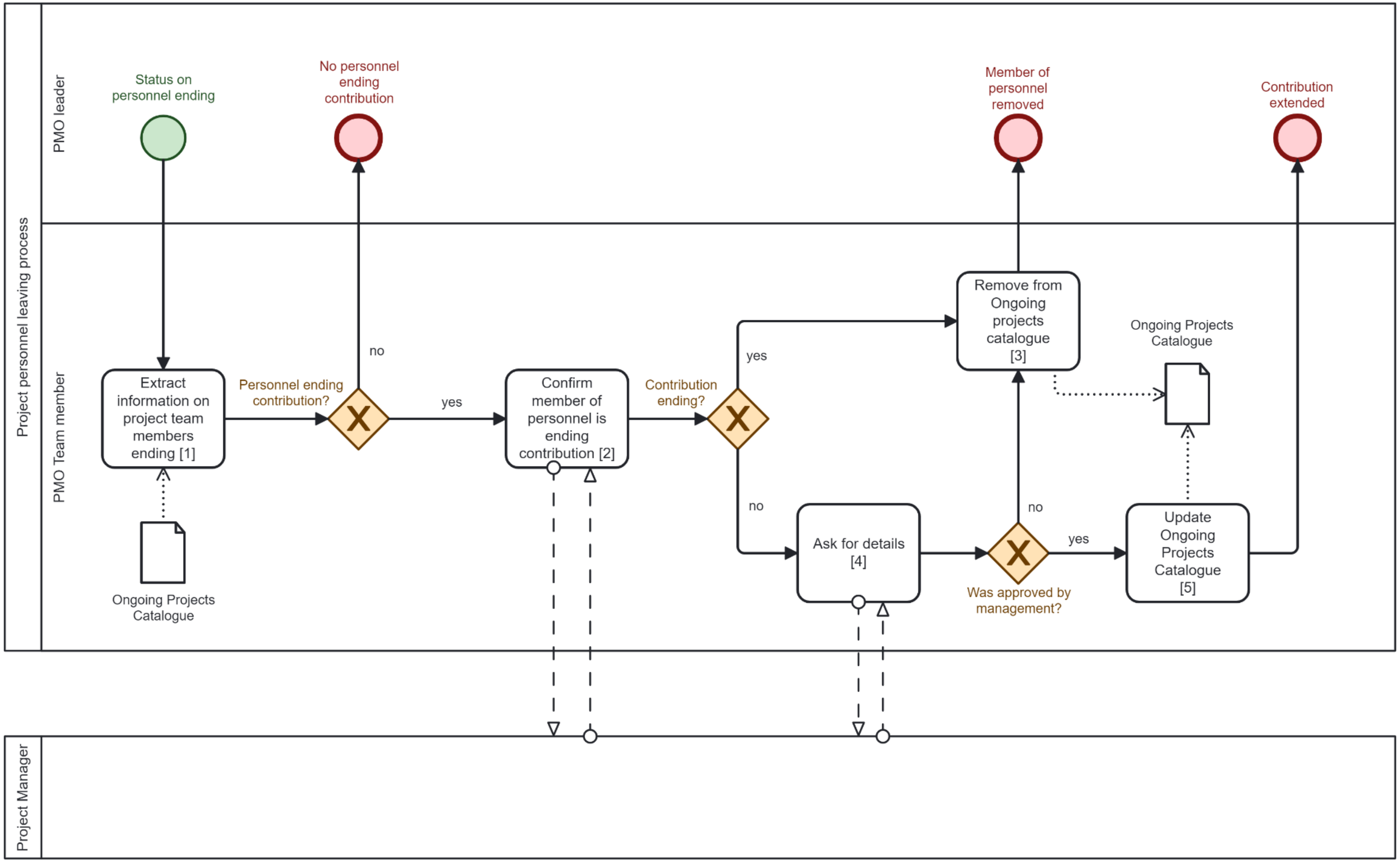
Appendix E – Project Extension Process



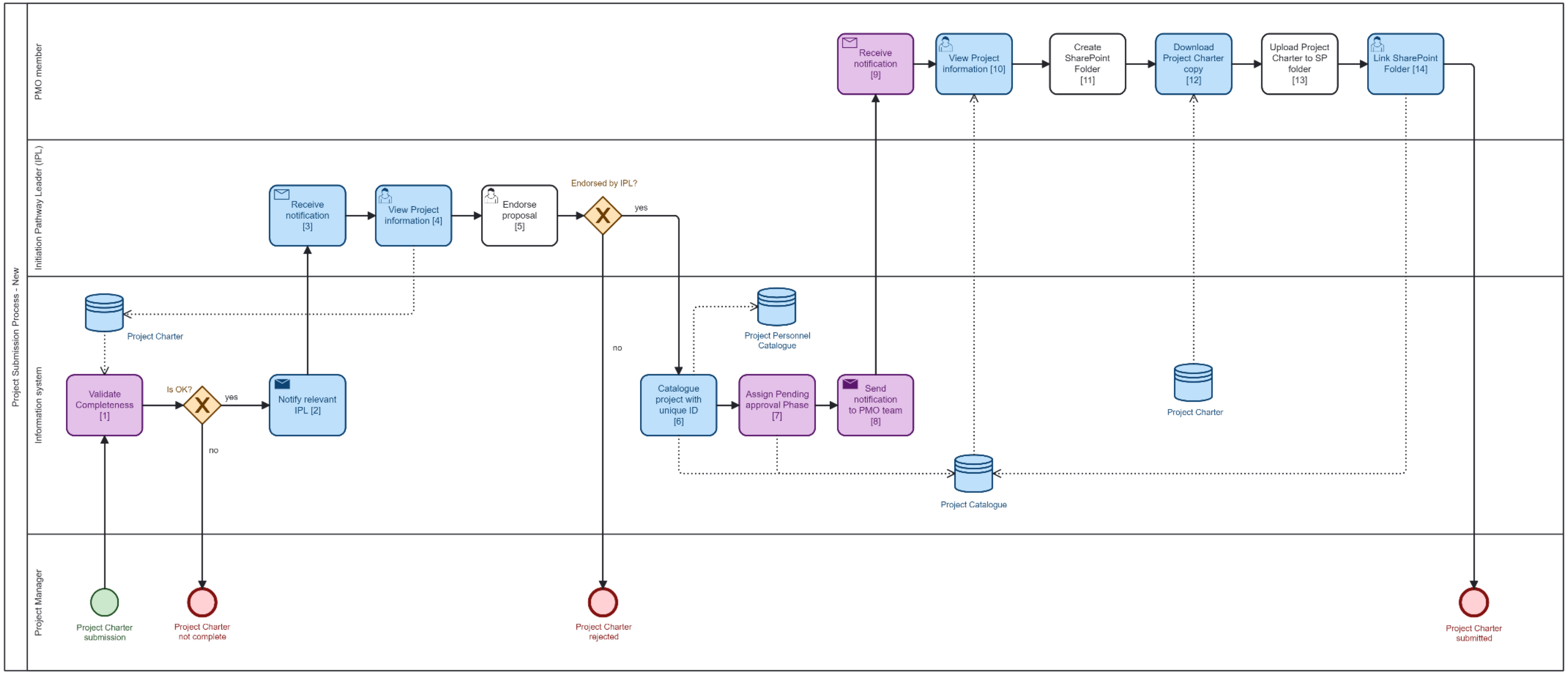
Appendix F – Project Team Newcomers Process



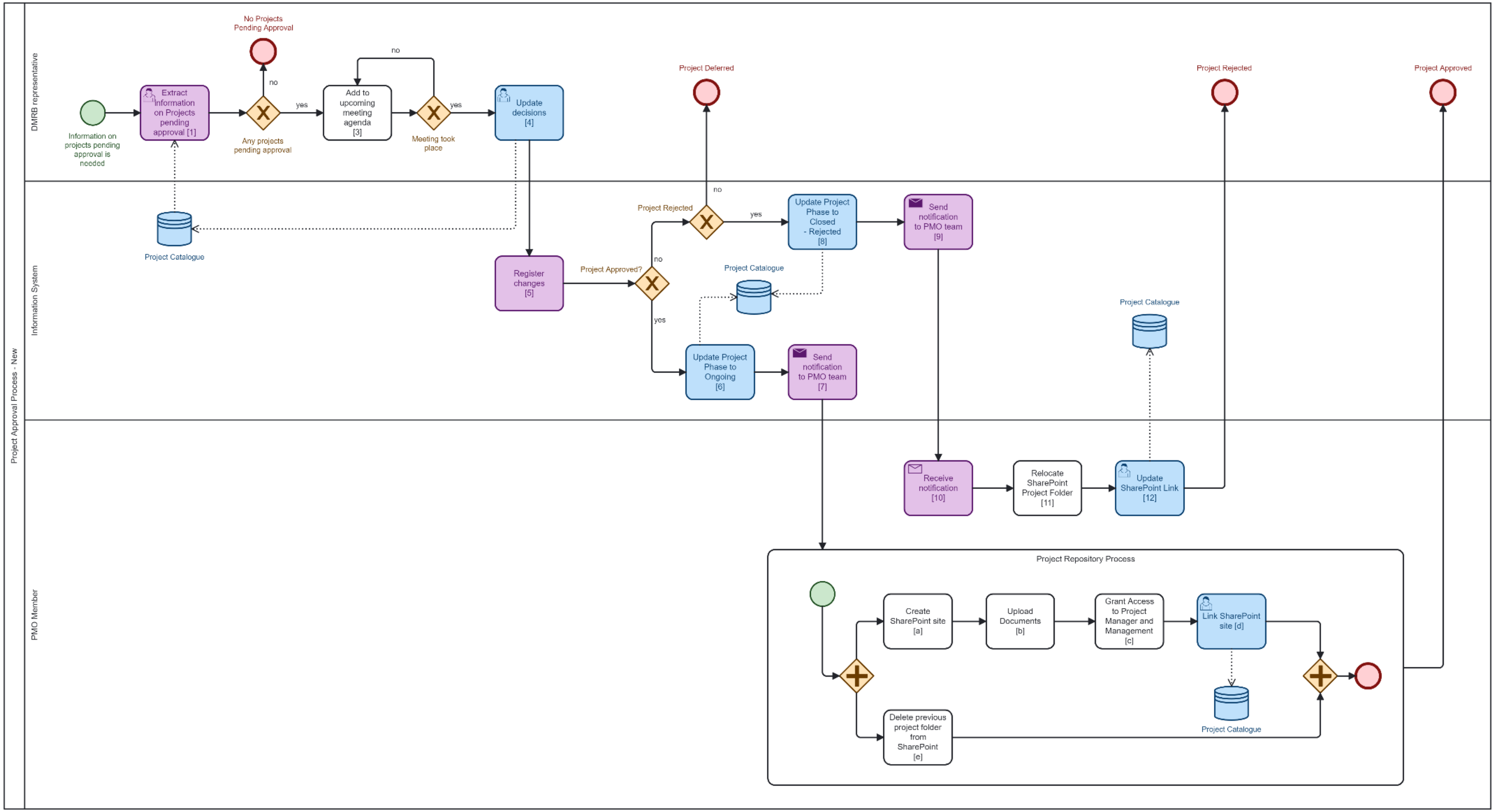
Appendix G – Project Personnel Leaving Process



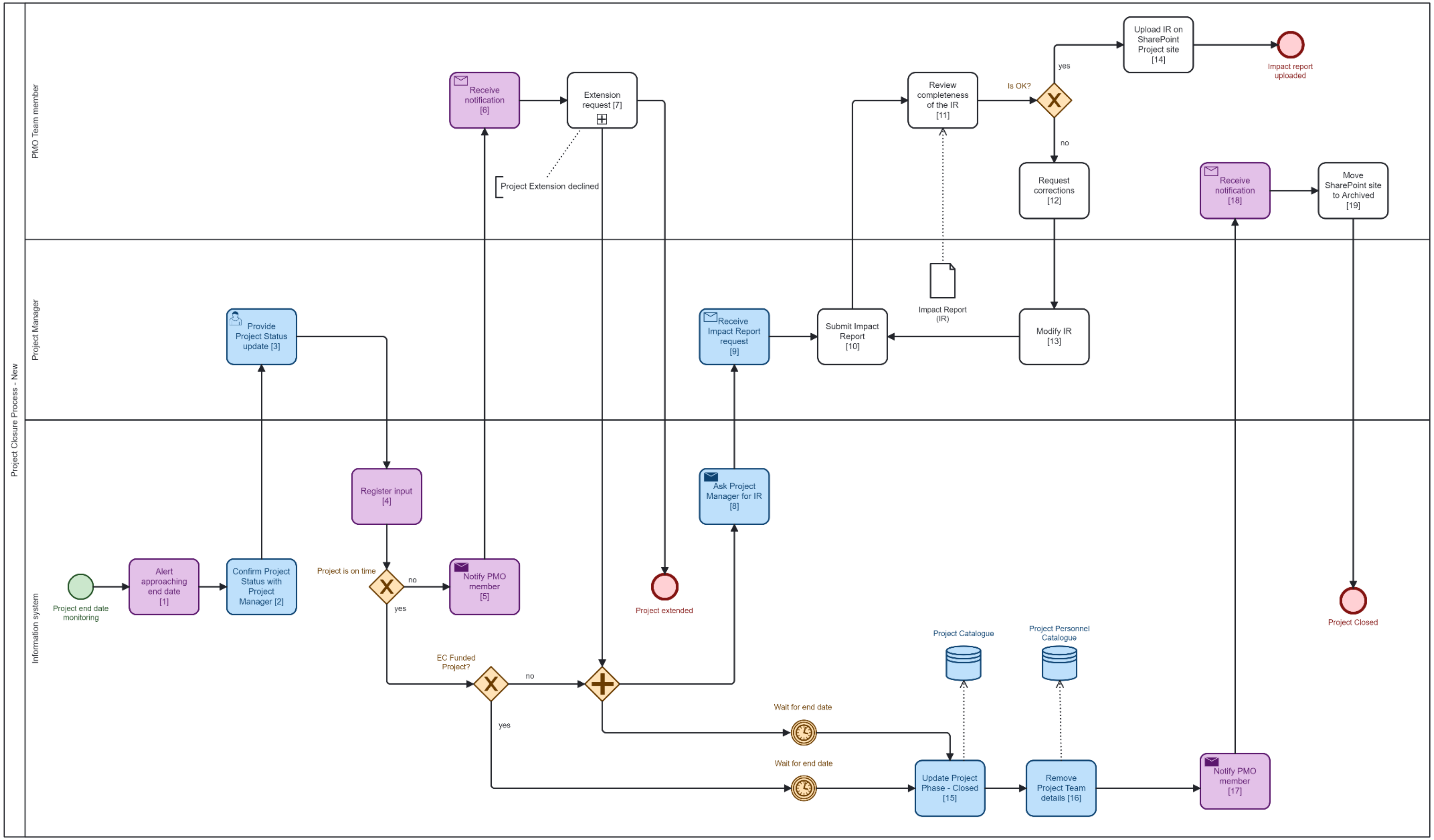
Appendix H – Remodelled Project Submission Process



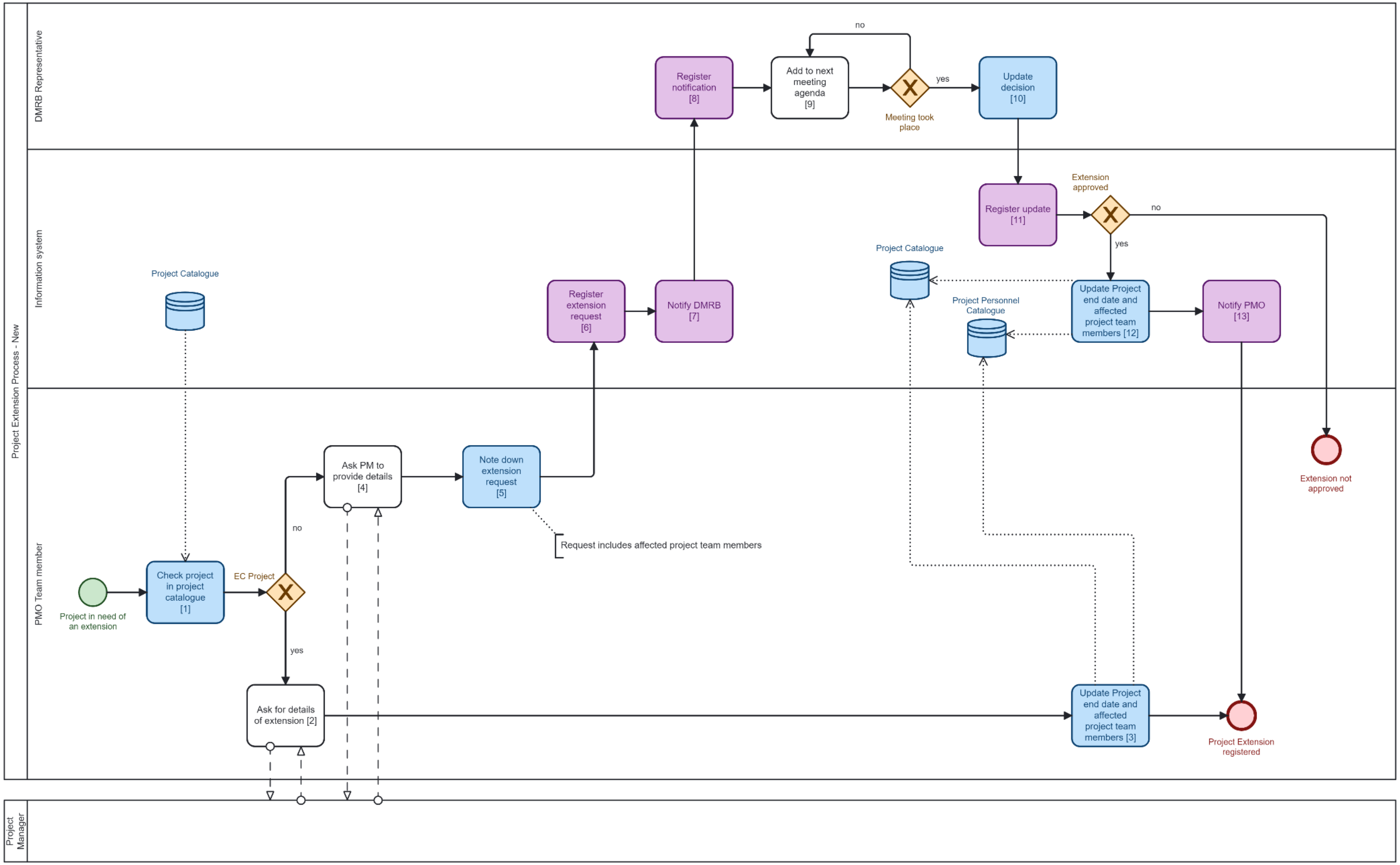
Appendix I – Remodelled Project Approval Process and Project Repository Process



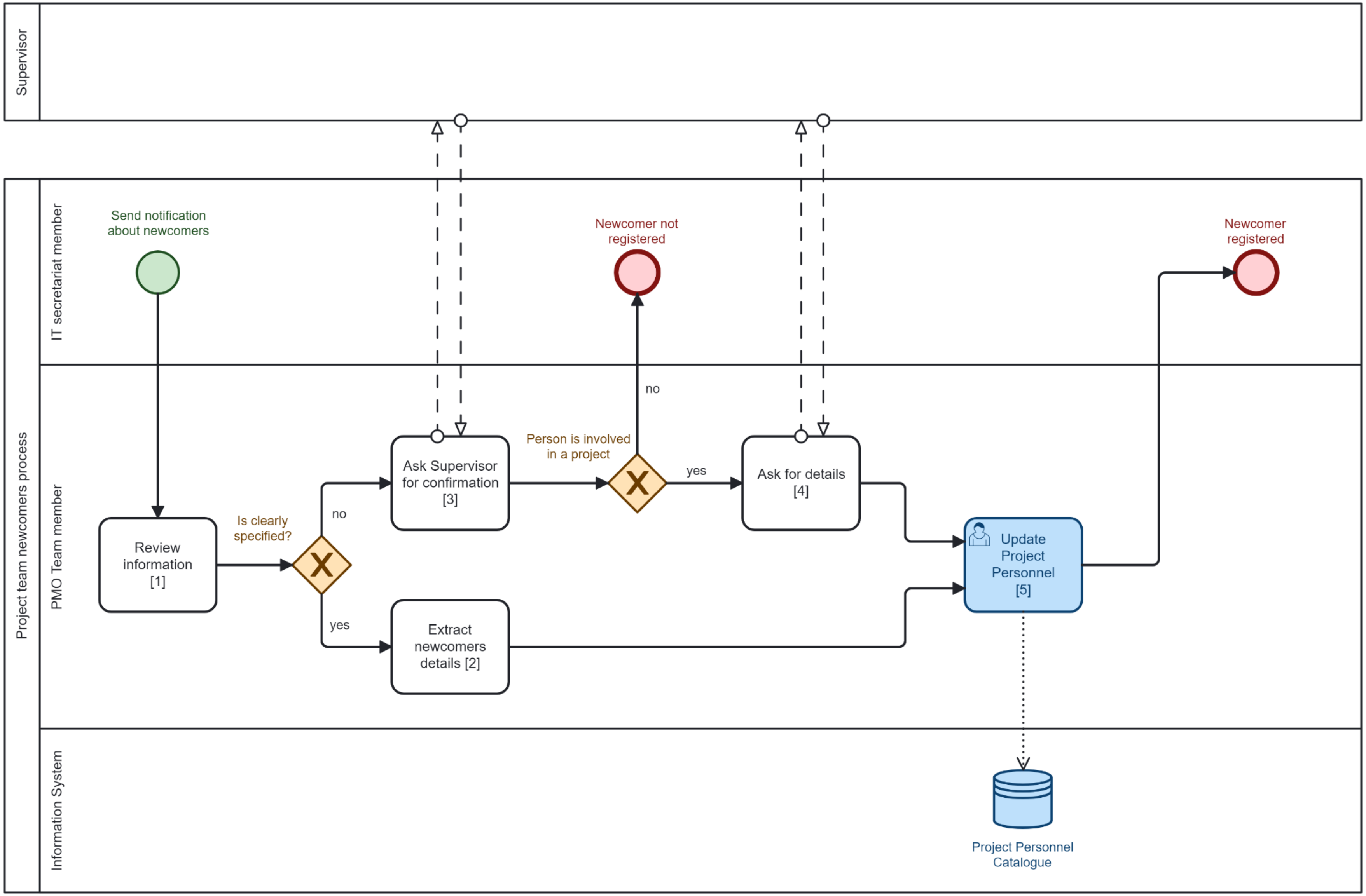
Appendix J – Remodelled Project Closure Process



Appendix K – Remodelled Project Extension Process



Appendix L – Remodelled Project Team Newcomer Process



Appendix M – Remodelled Project Personnel Leaving Process