The Value of Business Process Management to Understand Complex Asset Management Processes

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Abstract. Asset Management (AM) processes play a significant role in organisations' profitability. Clearly documented and managed AM processes improve the delivery potential of assets and minimise the costs and risks involved. Business Process Management (BPM) is a discipline that uses various methods, tools, and techniques to discover, model, analyse, measure, improve, optimise, and automate business processes. Despite the prevalence and proven effectiveness of BPM in a wide variety of domains, there has been little research investigating its potential for describing AM processes. This paper presents a case study that explores the application of BPM to power transmission assets. BPM principles were applied for decision modelling and to capture the lifecycle of power transmission assets. The case study demonstrates how BPM application to AM processes can result in greater clarity of processes, increased collaboration, a better understanding of data, external rules, and regulations, and serve as an internal point of audit.

1 Introduction

Organisations worldwide spend trillions of dollars managing their portfolio of assets [1], and improvements in the management of physical assets remain one of the largest business improvement opportunities of the 21st century [2]. An organisation often conducts a wide variety of interlinked Engineering Asset Management (EAM) activities (e.g., data collection, condition assessment, and refurbishment), resulting in complex processes that involve a diverse team of personnel from different business units. Consequently, it is often quite challenging to obtain a comprehensive view of the tasks, data, supporting standards, etc., involved in key asset decisions. However, a comprehensive view of EAM processes is essential to evaluate their quality, communicate EAM processes clearly across the business to enable a common understanding, and understand where process improvements will have the most significant impact [3]. Managing these complex EAM processes improves business performance [4] and integrating core EAM practices in business is evidenced to improve operational performance [5].

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Business Process Management (BPM) is a discipline that focuses on enhancing ways organisations identify, describe, analyse, support, and monitor their business processes in order to increase their operational performance [6]. Several industries, e.g., healthcare, finance, and retail, have used BPM to improve their business processes. However, its use in asset management remains relatively inconspicuous. Techniques such as process architecture and process modelling can be used for EAM processes by organisations to identify their capabilities and visualise, describe, and understand their business processes. Additionally, BPM can help develop data requirements, coordinate different EAM activities with the personnel, generate workflow to develop EAM information systems and assist in integrating the current EAM information system with other systems [3].

Given the apparent advantages of applying BPM to EAM processes, this paper presents the application of BPM techniques, particularly process and decision modelling, at Powerlink Queensland—a State Government Owned Corporation that owns, develops, operates, and maintains 15,339 circuit kilometres of high voltage electricity transmission lines and 147 substations transmission network. Powerlink's asset management system seeks to ensure that assets are managed in consistence with asset management policy and overall corporate objectives to deliver cost-effective and efficient services. Powerlink was interested in identifying, visualising, and describing key decision-making processes during the asset's lifecycle. BPM techniques were applied at Powerlink over six months to develop process models elucidating key decisions taken during reinvestment of transmission asset lifecycle.

The rest of the paper is structures as follows. Section 2 presents the methodology adopted in this study. Section 3 presents the findings, and a discussion in followed in Sect. 4. The paper concludes with an overview of contributions, limitations, and future work.

2 Methodology

This section provides an overview of the key steps undertaken and the BPM techniques applied to identify, visualise, and describe key decision-making processes at Powerlink during the reinvestment of Transmission Line Assets (TLA).

2.1 Interviews

Interviews were the primary mode of data collection in this study. Interviews are an important data collection method in qualitative research [7] and one of the most popular methods for qualitative organisational research [8]. They assist in obtaining the personal perspective of the interviewee and create an interactional situation in a face-to-face encounter between researchers and participants. In this method, the interviewer acts as an instrument and, with the help of carefully designed questions, attempts to elicit the other person's opinions, attitudes or knowledge about a given topic. Semi-structured interviews were used in this project. According to Mabry [9], semi-structured interviews allow for "*probative follow-up questions and exploration of topics unanticipated by the interviewer, facilitate development of subtle understanding of what happens and why*".

Since the intention was to gather insights from Powerlink's stakeholders regarding the processes and key decisions involved during the reinvestment of TLAs, semi-structured interviews were considered suitable. Interviews were conducted with subject matter experts (SMEs) of various teams involved in the reinvestment of TLAs. Nine SMEs were interviewed in total, which included two SMEs from bigger departments and one SME from smaller departments involved in reinvestment of TLAs. Table 1 provides a profile of respondents involved in this study.

The interview started with questions regarding the role and previous decisions made. Following this, the questions centred around the key activities undertaken in their teams, interaction with other teams, external documents, regulations used, and the role of IT systems. The interviews concluded by asking SMEs about room for improvement at Powerlink. Each interview lasted for around 60 min and was audio recorded with the permission of the respondent. The interviews were then transcribed, and the information was used to model the initial decision-making process. Once the entire process model was derived, follow-up interviews were held with the SMEs to verify and validate the process model. Follow-up interviews lasted under 30 min. The process model was explained to the SME, and they commented on the appropriateness of the process model. The process model was updated based on feedback from follow-up interviews. This process continued until all the SMEs were satisfied with the output.

Table 1. Overview of interview respondents.

Department	# of SMEs	Role
Line Strategies	2	Provide options to replace/refurbish based on corrosion data
Project Portfolio and Operations (PPO) and Network and Alternative Solutions	2	Decide to replace/refurbish TLA
Maintenance facilitator	1	Facilitate communication among maintenance planner, line strategies, and projects
Projects	2	Costing and planning resources for reinvestment options
Maintenance planner	1	Programming SAP for maintenance actions
Works Control Manager	1	Responsible for routine and corrective inspection management

2.2 Document Analysis

While interviews were the primary form of data collection in this project, document analysis was also conducted. Document analysis involves using both printed and electronic documents by the research team to give voice and meaning to the topic. Like other qualitative methods, document analysis requires that the data be interpreted to obtain meaning, gain understanding, and develop empirical observations [10]. Therefore, the research team collected and analysed documents such as internal policies, external and internal standards, and organisation's operating procedures before, during, and after interviews to augment the contextual information gained during interviews. The documents also assisted in filling in the gaps when building the initial process model, which were verified through follow-up interviews.

2.3 Process and Decision Modelling

Process modelling, a BPM technique, was used to identify, visualise, and describe the process during the reinvestment of TLAs. Organisations are increasingly structuring themselves around their business processes to improve responsiveness to business opportunities and threats, and also for adopting integrated software solutions that support the organisation's core business process needs [11, 12]. To support these aims, a better understanding of business processes is required. "*Process modelling is an approach for visually depicting how businesses conduct their operations; defining and depicting business processes, including entities, activities, enablers and the relationships between them*" [13]. Process models enable capturing systems, data, people, and control flow into a logical framework, which can thereafter be used for analysis and improvement purposes. Process modelling for EAM can assist in visualising EAM processes, demystifying interaction among various personnel, and generating workflow, which can help improve EAM processes. EAM processes have been widely used to guide EAM practices; however, these processes are usually modelled using a flowchart. Flowcharts lack comprehensiveness, which is essential to capture the complexity involved in EAM processes [3]. To capture the complexities of EAM processes in business process models, we used Business Process Model and Notation (BPMN), version 2.0. BPMN provides businesses with the capability to express their business processes using a graphical notation, which enables enterprises to communicate these processes in a standard manner. BPMN is maintained by Object Management Group (OMG) since 2005. Complete details related to BPMN2.0 notation are available at OMG [14]).

Additionally, we used decision modelling to model the key decisions undertaken by the stakeholders during the reinvestment of TLAs. In most process models, decisions are embedded within the models and scattered over constructs of process models, resulting in difficulty in maintainability [15]. Decision modelling assists in modelling decisions in a more precise and transparent manner, separately from the process [16]. According to recent research, decision modelling alongside processes enables better management of complexity and supports the flexibility of processes [17]. To model decisions, we used Decision Model and Notation (DMN), a recent standard of the OMG. It allows efficient detailing and modelling of repeatable decisions in an organisation [16]. DMN provides a notation that is readable by businesses as well as IT users. DMN has been designed to work with BPMN providing a separation of concerns between the decisions and the process [18].

3 Findings

Based on the interviews with SMEs, we built a comprehensive process model encapsulating TLA lifecycle decisions taken during reinvestment. One over-arching process model and seven linked DMN sub-models were developed. Figure 1 shows this process model, which was built using BPMN and DMN on Signavio[1].

Each lane refers to a team at Powerlink. The rectangular boxes with rounded ends indicate an activity conducted by a resource in a team. A rounded rectangular box with a table at the top left shows a decision taken, and when the table is clicked, the DMN sub-model is displayed, which provides more detail on the decision-making process. A document attached to an activity shows an external or internal regulation used for the activity. Similarly, an IT system attached to an activity displays the IT system used by the activity. A diamond symbol refers to a gateway. A diamond with an 'X sign' is an XOR gateway, which communicates the process instance's optional paths from the previous activity. A diamond with a '+ sign' in an AND gateway indicates parallelism, i.e., both paths are undertaken in any order from the previous activity to proceed to the next activity.

3.1 Description of Process Model

The Works Control Manager (WCM) prioritises routine and corrective maintenance tasks. Figure 2 shows the data, which is used as input by the WCM.

In DMN notation, the rectangular box (with a table icon at the top left) shows the decision that is to be taken. The rectangle with a rounded left and right side displays the input required to make the decision. The document-shaped box displays the special knowledge necessary to execute the decision.

Prioritisation of maintenance activities is a decision taken by the WCM as they are responsible for the dissemination of routine and corrective maintenance work orders. To prioritise these activities, the key input used are budget, KPIs, and data from SAP. Additionally, expert advice from the lines maintenance facilitator is also used. A priority risk system is the IT system, which is used to prioritise the tasks.

Once the tasks are prioritised, the WCM assesses the restrictions in discussion with network planning/operations. The planned outages document is used as an input here. Based on these details, the corrective and routine maintenance tasks are planned with the assistance of MS project. This data is fed into the works manager system. Then, work orders are assigned to Maintenance Service Providers (MSPs). On receiving the work order from the WCM, the MSPs conduct inspection using works manager or Line Asset Measuring Points (LAMP). The data to be collected is documented in detail in Appendix E of the maintenance specification document of Powerlink. The data is directly updated from the works manager in SAP, which finishes the work order. The data collected using LAMP is checked for quality by the maintenance planner. The maintenance planner then performs basic consistency and quality checks on inspection data, which is then

[1] https://www.signavio.com/.

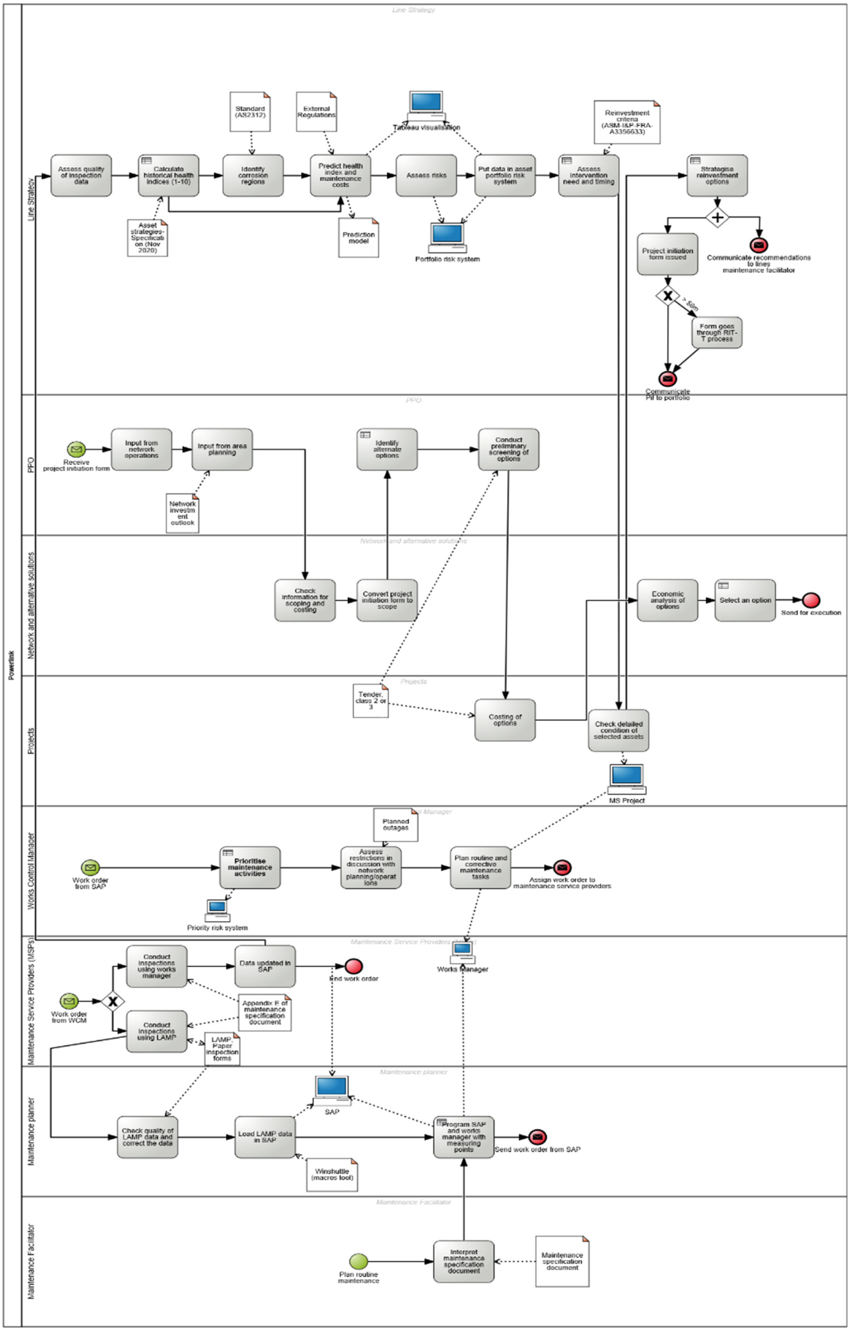

Fig. 1. A Process model capturing key decisions made during the refurbishment and end-of-life phase of TLA.

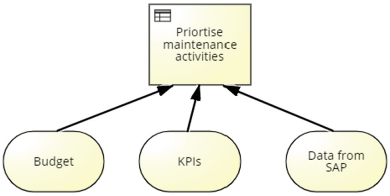

Fig. 2. A DMN model to prioritise maintenance activities.

loaded into SAP. The winshuttle macros tool is used to load the data. Additionally, the maintenance planner programs SAP and works manager with measuring points used by MSPs to enter inspection data. Figure 3 displays the input data that is used to program SAP. This programming is done in consultation with the maintenance facilitator, who interprets the maintenance specification document and provides expert input.

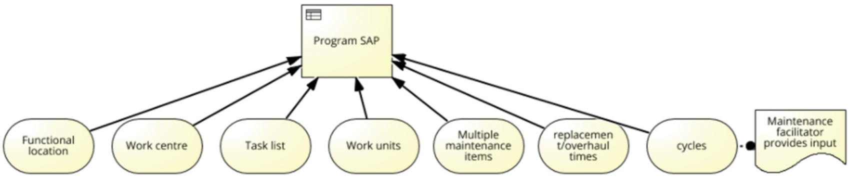

Fig. 3. A DMN model depicting data required to program SAP.

The Line Strategies team uses the data updated in SAP regarding the inspection of TLA. They first assess the quality of data. When the data is ascertained to be of adequate quality, the health index of built sections of TLAs is calculated. The input required for the calculation of the health index is captured in Fig. 4.

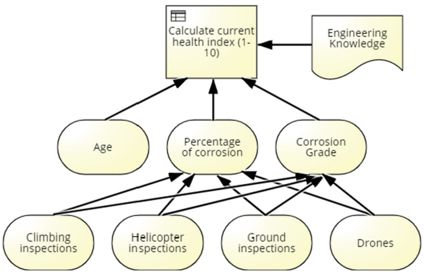

Fig. 4. A DMN model to calculate the current health index.

The age of the asset, percentage of corrosion, and corrosion grade are the three main inputs that determine the health index. Percentage of corrosion and corrosion grade is calculated using the data recorded in SAP during climbing, helicopter, ground, and drone inspections. Input from SAP and engineering knowledge that comes from experience helps in deriving the health index of the built section of TLAs. The ‘asset strategies specification (Nov 2020)' document provides details regarding the calculation of the health index. Then the corrosion regions are identified using the standard AS2312. Next, the health index and maintenance costs are predicted. External regulations, such as the Regulatory Investment Test for Transmission (RIT-T), play an important role. Predictions are made using a prediction model, visualised on Tableau. Following this, the risks are assessed using the portfolio risk system, which is also visualised on Tableau. Based on all the data calculated so far, the timing for intervention is assessed. This decision is captured in Fig. 5.

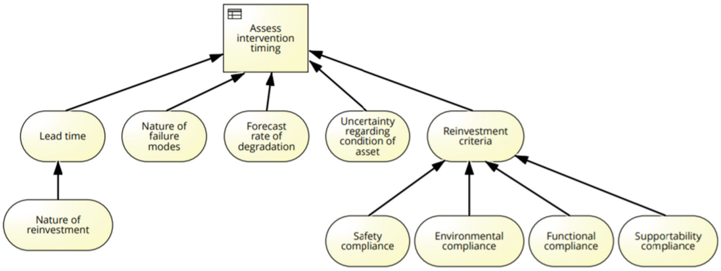

Fig. 5. A model to decide intervention timing.

Figure 5 displays the key input required to make the decision. Nature of failure modes, rate of degradation forecasted using health index and visualised on Tableau, and uncertainty regarding the condition of an asset directly impact assessment of when should intervention be made. Further, the lead time, which is dependent on the nature of the investment, is another input to this decision. Finally, the reinvestment criteria, which is an internal document at Powerlink, also influence intervention timing. The reinvestment criteria outline four areas that need to be considered when deciding on intervention – safety, environmental, functional, and supportability compliance. To further strategise reinvestment options and their timing, the Line Strategies team sends the identified need and options to projects. The Projects team does a detailed assessment of the asset's condition and sends that information back to the Line Strategies team. This data is then used to strategise reinvestment options. The details related to this decision are captured in Fig. 6.

Strategising reinvestment options is dependent on multiple decisions, as shown in Fig. 6, e.g., insulator replacement, damper retrofitting and replacement, etc. For each of these and the main decision, the primary input required is the condition data from SAP, details of risk exposure, and the associated refurbishment costs they receive from the projects team. The strategised options are communicated to the lines maintenance facilitator. At the same time, a project initiation form is issued. If the amount is above $6m, the form goes through the RIT-T process. Then the form is sent to the Project Portfolio and Operations (PPO) team.

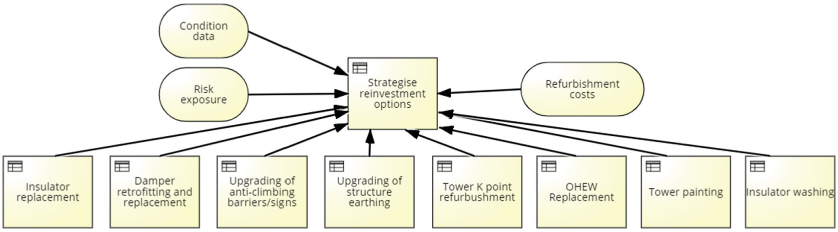

Fig. 6. A DMN model to strategise reinvestment options.

The project initiation form is received by the PPO team of the network portfolio. The team seeks input from network operations and then area planning. The network investment outlook (an internal document) is a crucial input here. Next, the project initiation form options are sent to the Network and Alternative Solutions (NAS) team of the network portfolio, who check the information for scoping and costing. The project initiation form is then converted to scope, which is sent back to the PPO team. The team reviews the scope and identifies alternate options. The input data required to identify alternate options is presented in Fig. 7. There are two high-level options, network configuration or non-network options, to consider. If network configuration needs to be done, the options considered are targeted refurbishment, extensive refurbishment, rebuilding of transmission line, or decommissioning a line. For non-network configuration, options considered include the use of batteries, generation support, and demand management investment, among others.

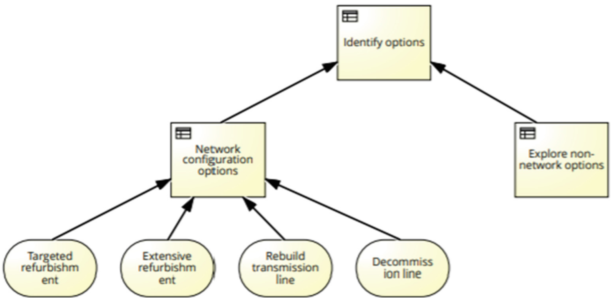

Fig. 7. A DMN model to identify alternative options for reinvestment.

Following this, a preliminary screening of options is done. For this screening, the options are sent to the Projects team, which calculates the costing of options using tender, class 2, or class 3. The costing information is sent to the NAS team, which conducts an economic analysis of options. Finally, an option is selected (Fig. 8), and the decided option is sent for execution. The costing and scoping of the project and the capital expenditure budget are the three main inputs required to decide an option for reinvestment.

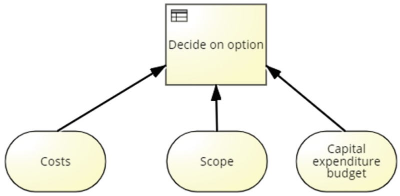

Fig. 8. A DMN model depicting the input required to decide on an option.

4 Discussion

The comprehensive process model developed in this study explains the critical asset management activities and decisions undertaken by the key stakeholders when managing the reinvestment of TLAs. In particular, the process model: (a) allows an *understanding of data/activities/systems/resources* that are not documented but are used in the process, (b) enables people to *understand the key roles and responsibilities* of the teams in an organisation, and (c) assist the *identification of high impact processes* that would benefit from centralisation or IT infrastructure. For example, we found that the health index is a crucial indicator for many decisions made in the organisation, which was not explicit in the documentation. Similarly, we evidenced that Tableau visualisation used by Line Strategies is central to the reinvestment decisions and developing a mature and widely accessible system could aid in communication and assessment across multiple teams. The process model also brought forth the *significance of data quality checks* as it is that data used to make crucial decisions involving a significant financial impact later. The DMN models embedded in the process model were also found *beneficial to capture the key requirements* for decision-making while ensuring that the overall process model is manageable.

Numerous other advantages of the comprehensive process model were noted. The process model can help in *knowledge transfer* and assist a new person entering the organisation to visualise and understand the process. It can also be used as a tool to explain internal processes to auditors/regulators. The model assists in greater *transparency* around the execution of processes as well as their upstream and downstream impact on the organisation. Moreover, the process model acts as a *tactical blueprint*, enabling cross-process comparison (e.g., comparing TLA asset management processes with substations) and identifying areas of high impact.

Additionally, a process model like the one developed in this project can *complement existing documentation* and *check alignment* with ISO55000 or other standards/practices. For example, ISO55000 outlines the significance of having a clearly defined method and criteria for decision-making. While elements of this were present in tactical documents of Powerlink, the detailed process model made the underlying process explicit. As was seen in the case of TLAs, many of the lower-level processes in ISO55000 will likely not be documented at the strategic level or even in more tactical documents—they often lie in the tacit knowledge of the teams and individuals working together. The process model can help make this knowledge explicit. For instance, a requirement by ISO55000 is the clear identification of roles and responsibilities. We found that some roles have not been elucidated in the tactical documents of Powerlink, but the teams have well-defined roles and responsibilities, most being tacit knowledge. Moreover, ISO55000 indicates the significance of taking actions to address risks when managing assets. While Powerlink provided the document, Overview of Asset Risk Methodology, it did not contain some elements that the process modelling exercise revealed were important for risk assessment, e.g., health index calculation. The process model provides more detail on the assessment of risks via health indices, who is involved in it (line strategies, projects, and network portfolio), and what data supports it.

Finally, a clear, detailed process model can be used for further enhancement activities in the organisation. For example, it can be used to automate mature processes and divert attention to more resource-intensive processes. It can also be used as input for automated process improvement techniques such as process mining.

5 Conclusion

This paper presents the application of Business Process Management, in particular process and decision modelling, to model complex EAM processes for TLAs at Powerlink. The project lasted for a period of six months. Semi-structured interviews were conducted with SMEs, documents were analysed, and BPMN2.0 and DMN standards were used to model the EAM processes. The overall process model representing the key activities, decisions, personnel involved, and the system as well as data used was presented. The process model captures the complexities involved in making reinvestment decisions for TLAs and provides a detailed understanding of the underlying process. Overall, the process model was considered beneficial by Powerlink providing the stakeholders a detailed understanding of – the process itself, the interaction among various teams, the key data used for making decisions, the key decisions made by stakeholders, and identify areas of possible improvement. The project clearly demonstrates the significance of application of process and decision modelling, for asset management processes. We acknowledge the limitation of applying process modelling to only reinvestment decisions of TLAs and only one organisation. However, Powerlink is a big organisation with a diverse set of stakeholders, and all stakeholders well received the process models. For future research, process modelling can be applied to other assets and through other phases of an asset lifecycle. Additionally, other BPM techniques such as process automation and process mining can also be applied to improve EAM processes further.

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