Identifying Core Functions of Asset Management

Vladimir Frolov, Lin Ma, Yong Sun and Wasana Bandara

Abstract It is widely acknowledged that effective asset management requires an interdisciplinary approach, in which synergies should exist between traditional disciplines such as: accounting, engineering, finance, humanities, logistics, and information systems technologies. Asset management is also an important, yet complex business practice. Business process modelling is proposed as an approach to manage the complexity of asset management through the modelling of asset management processes. A sound foundation for the systematic application and analysis of business process modelling in asset management is, however, yet to be developed. Fundamentally, a business process consists of activities (termed *functions*), events/states, and control flow logic. As both events/states and control flow logic are somewhat dependent on the functions themselves, it is a logical step to

V. Frolov
Cooperative Research Centre for Integrated Engineering Asset Management,
School of Engineering Systems, Queensland University of Technology (QUT),
Brisbane Queensland 4001, Australia

L. Ma
Cooperative Research Centre for Integrated Engineering Asset Management,
School of Engineering Systems, Queensland University of Technology (QUT),
Brisbane Queensland 4001, Australia

Y. Sun
Cooperative Research Centre for Integrated Engineering Asset Management,
School of Engineering Systems, Queensland University of Technology (QUT),
Brisbane Queensland 4001, Australia

W. Bandara
Business Process Management Cluster, Faculty of Information Technology,
Queensland University of Technology (QUT),
Brisbane Queensland 4000, Australia

J.E. Amadi-Echendu, K. Brown, R. Willett, J. Mathew,
Definitions, Concepts and Scope of Engineering Asset Management, © Springer 2010

first identify the functions within a process. This research addresses the current gap in knowledge by developing a method to identify functions common to various industry types (termed *core* functions). This lays the foundation to extract such functions, so as to identify both commonalities and variation points in asset management processes. This method describes the use of a manual text mining and a taxonomy approach. An example is presented.

Keywords Asset management, Functions, Processes, Complexity, Business Process Modelling

1 Introduction

In many organisations, physical assets are the foundation for success and future growth. The effective management of these assets (hereon referred to as *asset management*) is essential to the overall success of such organisations [1]. Around the world, hundreds of billions of dollars are spent on managing assets. However, along with monetary significance, the rising importance of asset management is being fuelled by other factors, such as: the general ageing of assets; changing stakeholder and service level requirements; augmented emphasis on public health and safety; and increasingly stringent requirements set by regulating bodies [2, 3]. Organisations are acknowledging such factors as being significant to their operations and are thus looking to continually improve their asset management practices. In turn, this has led to an increase in research on asset management in both the academic and practitioner arenas, evident in the amounts of literature being published by both fields.

Asset management (in the context of physical assets, rather than financial assets) is a systematic, structured process covering the whole life of physical assets, whereby the underlying assumption is that assets exist to support the organisation's delivery strategies, and requires a certain level of management insight and expertise from diverse organisational disciplines [4]. In support of this definition, it has been acknowledged in the literature that effective and optimal management of physical assets requires an interdisciplinary approach [5, 6]. Thus, it is no longer sufficient to consider asset management as simply the maintenance of an asset [7], but rather as a holistic approach to the management of assets, incorporating elements such as strategy, risk measurement, safety, environment and human factors.

To aid in achieving optimum outcomes when managing physical assets, it is desirable to decompose asset management into a set of processes [8–16]. An asset

management process is a set of linked activities and the sequence of these activities that are necessary for collectively realising asset management goals, normally within the context of an organisational structure and resource constraints [17]. Business process modelling is proposed as an approach to manage the complexity of asset management through the modelling of asset management. In simple terms, business process modelling is an approach for visually describing how businesses conduct their work [18], and is used for a variety of purposes in domains other than asset management to: increase awareness and knowledge of business processes; deconstruct organisational complexity; identify process weaknesses; adapt best business practices; design and communicate new business blueprints to relevant stakeholders; and design and configure software and workflow systems [19–21].

Curtis *et al.* [22] outlines that business process modelling typically includes graphical depictions of *at least* the activities (*i.e.* functions), events or states, and control flow logic, the combination of which constitutes the necessary elements of a process. A review of the literature reveals that asset management processes are currently implied, or at best, represented in part in a myriad of definitions, frameworks and textual contexts, stemming from both highly authoritative and lesser significant studies. Despite this, a sound foundation for research on the systematic application of business process modelling in asset management does not exist. Varying forms of business process modelling are used by organisations practicing asset management; initiatives such as this, however, are generally carried out in an ad-hoc manner or non-systematic manner.

This research addresses the current gap in knowledge by developing a fundamental method that outlines a.) the extraction of *core* asset management functions, and b.) the pooling of identified functions into appropriate levels of abstraction. Core functions are identified as those being common to industry types practicing asset management. This method outlines the use of a manual text mining and taxonomy approach, due to the varied nature of representation of asset management literature in both practitioner and academic arenas.

The remainder of this paper is structured as follows: the overall method is presented in Section 2; examples of applying the method are presented in Section 3; conclusions and directions for future research are presented in Section 4.

2 Method

The method to extract core functions is presented in the form of a flowchart, followed by accompanying details.

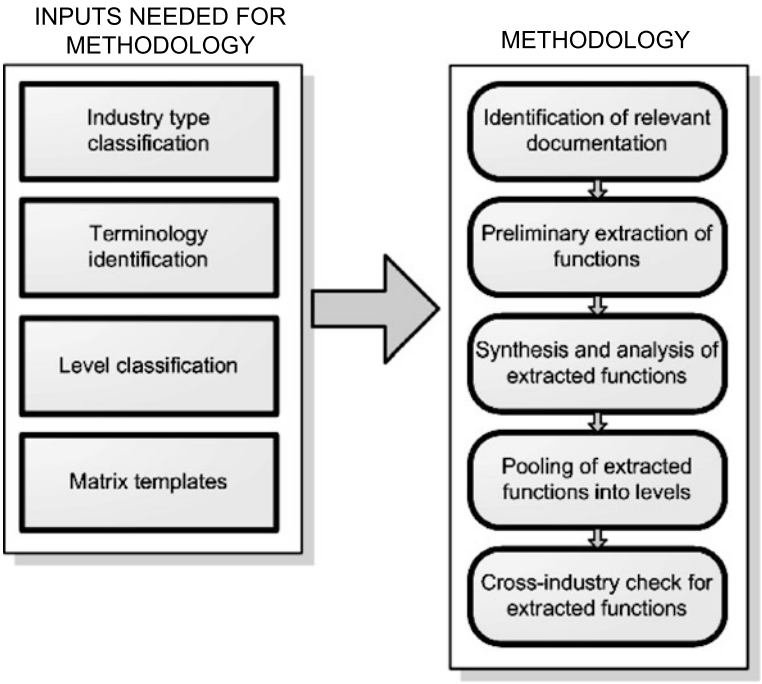

Figure 1 Overall Method

2.1 Industry Type Classification

The asset management literature is, more often than not, written in a particular industry context. As the aim of future research in this area is to identify common asset management processes (as well as the variation points within such processes in different industry types), it makes sense to first identify the industry *types*. Rather than developing a new classification of these different industry types, the classification developed by the Centre for Integrated Engineering Asset Management (CIEAM) is used [23]. This classification represents asset owners and management service providers of both infrastructure and industrial assets (*i.e.* physical assets) in the various public and private sectors. The main industry types practicing asset management, as classified by CIEAM are:

- State Treasuries and Agencies;
- Local Government Authorities;
- Transport Infrastructure including Main Roads;
- Water Facilities;
- Power Utilities;
- Manufacturing, Mining and Process Industries;

- Defence Organisations;
- Other Sectors: Education Facilities.

These industry types are utilised in the matrix templates, as per Section 2.4.

2.2 Identification of Terminology

Several terms, which have different meanings when used in different contexts, are used in this paper. To maintain consistency and set the context of the terms as used in *this* paper, a small glossary section is presented below. The terms that were selected for further clarification are: process, function(s), core function(s) and level(s).

Process:
In a generic sense, a process is an activity one performs, usually transforming an object from one state to another. For this paper, a comprehensive definition by Green and Rosemann [24] is used:

> *"A process is a self-contained, temporal and logical order (parallel or serial) of those activities that are executed for the transformation of a business object with the goal of accomplishing a given task."*

Thus, a process has a specific order of *activities* across time and place, with a beginning and an end and clearly identified inputs and outputs with a structure of action [25].

Function:
A function generally refers to what something does or is used for. In this paper, a function refers to the *activities* in the *above* definition of a process. That is, a function *is* an activity that uses inputs, and manipulates an object to produce an output.

Core Function:
A core function, as used in the context of this paper, is a function that is common to several industry types. A core function is also an essential *activity/function* within a core process, which if removed, would deem a process non-effective or unable to be continued. Core processes reflect the core competencies and value-adding activities of an organisation [26].

Level:
To successfully identify the core processes of an organisation, two methods can be used: top down and bottom up. Based on the corporate strategy of a business, the top-down method generates core processes from the strategic business fields [26]. These processes are then decomposed further in the course of modelling through

hierarchical refinement (*i.e.* using hierarchical levels in the process models). That is, models are shown in a high level of abstraction first, then decomposed into more detailed models as one moves down the levels.

2.3 Level Classification

Levels, as mentioned in the previous section, describe the level of abstraction of an overall process model or map. For example, a high-level manager is interested in the top-level processes, and thus, the top-level functions (*i.e.* coarse granularity). A lower-level manager is interested in more detailed processes/functions (*i.e.* fine granularity). Thus, when extracting the functions from literature, it is beneficial to follow the common practice of pooling functions into various levels. This is done by considering the relationship and significance of each function, in relation to other functions. In this method, functions are classified into generic layers. An example is shown in Figure 2.

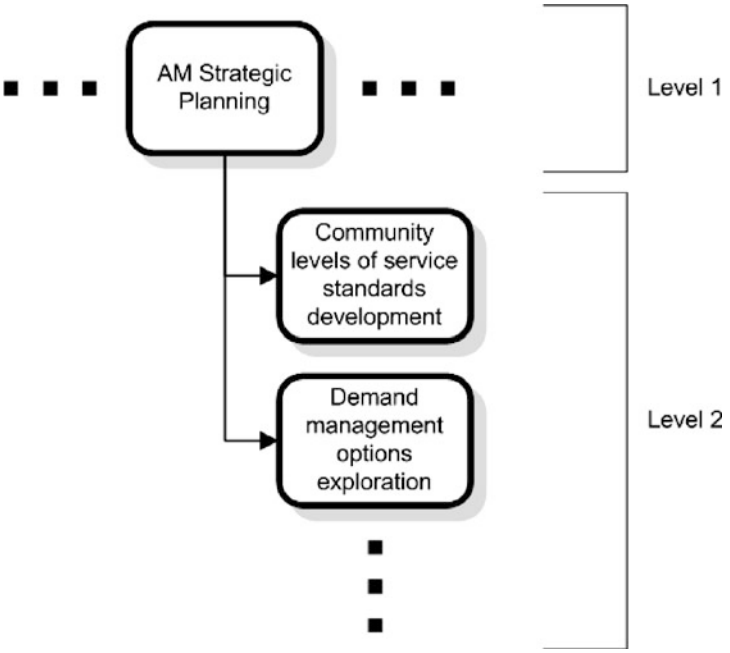

Figure 2 Example of Level Classification

2.4 Development of Matrix Templates

To summarise the information extracted from literature, two matrix templates are developed (shown in Tables 1 and 2). The first matrix template shows how relevant information from asset management can be extracted and represented in a common way. Relevant information from *individual* literature is mapped onto this matrix first. This matrix is used to capture:

- Document name;
- Industry type (context);
- Macro functions (*i.e.* high-level functions);
- Sub-functions (*i.e.* lower-level functions);
- Inputs and outputs of each sub-function (based on $IDEF_0$ notation).

The second matrix template is used to aid in summarising the extracted functions from the first matrix (Table 1) in order to demonstrate more meaningful information. The various industry types are shown in the top, horizontal row, whereas the extracted functions are shown as the left-most column. This matrix can assist to identify the common core functions across different industry types.

Table 1 Matrix Template for Individual Asset Management Documents

Reference	**Industry Type**	Main Functions **(Bold)** - Sub-Functions *(Italics)* - Inputs / Outputs		
[Name]	[Type]	**Function 1 - [title]**	---	**Function X - [title]**
		First Sub Function Inputs List of inputs Outputs List of outputs *Second Sub Function* Inputs List of inputs Outputs List of outputs *X Sub Function* Inputs List of inputs Outputs List of outputs		*First Sub Function* Inputs List of inputs Outputs List of outputs *Second Sub Function* Inputs List of inputs Outputs List of outputs *X Sub Function* Inputs List of inputs Outputs List of outputs

Table 2 Matrix Template for Synthesised Core Functions

Core Functions	INDUSTRY TYPE		
	Industry Type 1	…	Industry Type X
Core Function 1	✓ | ×	✓ | ×	✓ | ×
…	✓ | ×	✓ | ×	✓ | ×
Core Function X	✓ | ×	✓ | ×	✓ | ×

2.5 Preliminary Extraction of Functions

Text mining is the discovery, by computer, of new, previously unknown information, by automatically extracting information from different written resources [27]. In text mining, patterns are extracted from natural language text. A review of the asset management literature reveals a very diverse range of publications. Within these publications, an eclectic mix of text, diagrams and inconsistent formatting exists, which leads to the text mining procedure having to be conducted manually, rather than through the use of a computer. Conducting the process manually also allows for contextual information to be captured, which is generally not the case when done by automation. Manual text mining involves the scanning of text and identifying the three open word classes: nouns, verbs and adjectives. These three classes of words make up the majority of extracted text elements. Other word classes are used for contextual purposes and support the main word classes. Primary publications on asset management are used to extract *all* described functions within each publication (as per Table 1). These functions are then inputted into an *intermediate* second matrix, whereby *all* extracted functions are listed on the left hand side. This forms the necessary foundation for synthesis and analysis.

2.6 Synthesis and Analysis of Extracted Functions

Upon conducting an in-depth analysis of relevant literature, both inconsistency *and* similarity are encountered in the naming of functions, and the definitions and meanings of such functions. To manage this phenomenon, a taxonomy approach is utilised. A taxonomy of categories of terms and meanings is developed to capture all the possible combinations of naming and descriptions in the text of the publications. Functions are found to fit in one of the categories shown below.

a) **Same** function term or name | **same** function meaning;
b) **Same** function term or name | **different** function meaning;
c) **Different** function term or name | **same** function meaning;
d) **Different** function term or name | **different** function meaning.

When analysing the relevant literature, if a source is found to be describing a function using similar wording and implying a similar meaning, the described function is deemed to fit into category **a)**. This is the easiest combination to deal with. Category **b)** is arguably the most difficult to handle *i.e.* text found to be describing two similar meanings, yet using the same name. In these instances, the PAS 55 [2, 28] document is consulted to identify the most appropriate name for each meaning (PAS 55 being a quasi-standard in best practice asset management). Category **c)** is dealt with in a similar manner. When two pieces of text are found to be describing a similar activity, however, using different terminology, PAS 55 is used to identify the appropriate terminology for both function meanings. In category **d)** if the described functions are found to be not common in either name or meaning, then they are treated separately, as individual name-checked functions.

Following this, common functions are then pooled together based on the same taxonomy approach mentioned earlier, so as to eliminate similarly named functions, and produce only one account of that function (*i.e.* in Table 2). Whilst doing this, it is also cross-checked to see whether the different industry types currently acknowledge or practice the function, as extracted from available publications.

3 Examples

The first level of functions, extracted from relevant literature is shown in Table 3. These examples of method application were achieved by applying the steps in Section 2.

Preliminary findings show that high level functions are common to all industry types. That is, all industry types implement such functions in their asset management practice(s). However, at a lower level of abstraction, differences in functions begin to emerge (as per available literature). This is an important starting point in identifying the variation points in asset management functions and processes.

Table 3 Core Functions in Highest Level of Abstraction

Core Functions	INDUSTRY TYPE							
	State Treasuries and Agencies	Local Government Authorities	Transport Infrastructure inc. Main Roads	Water Facilities	Power Utilities	Manufacturing, Mining and Process Industries	Defence Organisations	Other Sectors: Educational Facilities
Existing Asset Knowledge Identification	✓	✓	✓	✓	✓	✓	✓	✓
AM Strategic Planning	✓	✓	✓	✓	✓	✓	✓	✓
AM Planning	✓	✓	✓	✓	✓	✓	✓	✓
Asset Performance Evaluation	✓	✓	✓	✓	✓	✓	✓	✓

Table 4 Examples of Core Functions in Second Highest Level of Abstraction for *AM Strategic Planning*

Core Functions	INDUSTRY TYPE							
	State Treasuries and Agencies	Local Government Authorities	Transport Infrastructure inc. Main Roads	Water Facilities	Power Utilities	Manufacturing, Mining and Process Industries	Defence Organisations	Other Sectors: Educational Facilities
…	…	…	…	…	…	…	…	…
Community Levels of Service Standards Development	✓	✓	✓	✓	✓	×	✓	✓
Demand Management Options Exploration	×	×	✓	✓	✓	✓	✓	×
…	…	…	…	…	…	…	…	…

4 Conclusions

This paper develops a method for the extraction of core asset management functions and the classification of such functions into appropriate levels. The method describes the use of a manual text mining approach. Examples show that functions at the highest level are common to all industry types considered. This research builds a sound foundation for further research in both asset management process modelling (AMPM), as well as the development of asset management process patterns through the identification of both common asset management processes and the variation points within such processes. Future work will see extensive effort in the development of asset management process patterns, based on the outcomes of an analysis on the comprehensive and complete matrix. The method described in this paper can be used for future work by both academics and practitioners. For a practitioner, the template can be used to map an organisation's asset management practice in a consistent manner, whilst identifying unknowns or 'gaps' in any identified function. A practitioner can also use the matrix as a benchmark tool to identify potential gaps in their overall asset management practice as compared to best practice asset management publications (such as PAS 55). This holds significance in building a foundation for the development of asset management process patterns, which encapsulate asset management processes common to several industry types. It lays the foundation for further research in the systematic, researched application of business process modelling in the asset management domain. Asset management is an immensely complex field; by decomposing this complexity, using an approach such as business process modelling allows organisations to optimise their asset management processes, in turn producing increased levels of efficiency in areas of their asset management.

Acknowledgments This research is sponsored by the Cooperative Research Centre for Integrated Engineering Asset Management (CIEAM), as well as QR Limited. The authors are grateful for both the financial support and the opportunity of working with these organisations.

References

[1] Woodward D.G. (1997) Life cycle costing – theory, information acquisition and application. *International Journal of Project Management*, 15(6), 335–344.

[2] The Institute of Asset Management. (2004) *PAS 55-1 (Publicly Available Specification – Part 1: specification for the optimized management of physical infrastructure assets).*

[3] Lutchman R. (2006) Sustainable asset management: linking assets, people, and processes for results: DEStech Publications, Inc.

[4] Cooperative Research Centre for Integrated Engineering Asset Management. (2008) What CIEAM do. Retrieved 25 June, 2008, from http://www.cieam.com/aboutus.html#what_is_eam.

[5] Amadi-Echendu J.E., Willett R., Brown K., Lee J., Mathew J., Vyas N. & Yang B.S. (2007) What is engineering asset management? *The 2nd World Congress on Engineering Asset Management (EAM) and The 4th International Conference on Condition Monitoring*, Harrogate, UK. pp. 116–129.
[6] Wittwer E., Bittner J. & Switzer A. (2002) The fourth national transportation asset management workshop. *International Journal of Transport Management,* 1(2), 87–99.
[7] Amadi-Echendu J.E. (2004) Managing physical assets is a paradigm shift from maintenance. *2004 IEEE International Engineering Management Conference*. pp. 1156–1160.
[8] Moorhouse I. (1999) Asset management of irrigation infrastructure – the approach of Goulburn-Murray Water, Australia. *Irrigation and Drainage Systems,* 13(2), 165–187.
[9] Spires C. (1996) Asset and maintenance management – becoming a boardroom issue. *Managing Service Quality,* 6(3), 13–15.
[10] Hodkiewicz M. (2007) Education in engineering asset management (Paper 064). *ICOMS Asset Management Conference*, Melbourne, Australia.
[11] Brown R.E. & Humphrey B.G. (2005) Asset management for transmission and distribution. *IEEE Power and Energy Magazine,* 3(3), 39–45.
[12] Mohseni M. (2003) What does asset management mean to you? *2003 IEEE PES Transmission and Distribution Conference and Exposition*. pp. 962–964.
[13] Palombo C. (2005) Eight steps to optimize your strategic assets. *IEEE Power and Energy Magazine,* 3(3), 46–54.
[14] Holland C.P., Shaw D.R. & Kawalek P. (2005) BP's multi-enterprise asset management system. *Information and Software Technology,* 47(15), 999–1007.
[15] Mansour Y., Haffner L., Vankayala V. & Vaahedi E. (2005) One asset, one view – integrated asset management at British Columbia Transmission Corporation. *IEEE Power and Energy Magazine,* 3(3), 55–61.
[16] Sun Y., Ma L. & Mathew J. (2007) Asset management processes: modelling, evaluation and integration. *Second World Congress on Engineering Asset Management*, Harrogate, UK.
[17] Ma L., Sun Y. & Mathew J. (2007) Asset management processes and their representation. *2nd World Congress on Engineering Asset Management*, Harrogate, UK.
[18] Davenport T.H. (2005) The coming commoditization of processes. *Harvard Business Review,* 83(6), 100–108.
[19] Bandara W., Gable G.G. & Rosemann M. (2005) Factors and measures of business process modelling: model building through a multiple case study. *European Journal of Information Systems,* 14(4), 347–360.
[20] Barrett J.L. (1994) Process visualization – getting the vision right is key. *Information Systems Management,* 11(2), 14–23.
[21] Ungan M.C. (2006) Standardization through process documentation. *Business Process Management Journal,* 12(2), 135–148.
[22] Curtis B., Kellner M.I. & Over J. (1992) Process modeling. *Communications of the ACM,* 35(9), 75–90.
[23] Stapelberg R.F. (2006) *Australian infrastructure and industry assets management survey (preliminary literature review and survey analysis report)*. Brisbane, Australia: CIEAM.
[24] Green P. & Rosemann M. (2000) Integrated process modeling: an ontological evaluation. *Information Systems,* 25(2), 73–87.
[25] Davenport T.H. (1993) Process innovation: reengineering work through information technology. Boston: Harvard Business School Press.
[26] Becker J., Kugeler M. & Rosemann M. (2003) Process management – a guide for the design of business processes: Springer.
[27] Hearst M. (2003) What is text mining? Retrieved June 20, 2008, from http://people.ischool.berkeley.edu/~hearst/text-mining.html.
[28] The Institute of Asset Management. (2004) *PAS 55-2 (Publicly Available Specification – Part 2: guidelines for the application of PAS 55-1).*