STRATEGIC INFRASTRUCTURE ASSET MANAGEMENT: THE WAY FORWARD

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Organisations owning and managing infrastructure asset are constantly striving to obtain the greatest lifetime value from their infrastructure assets. Many such organisations have adopted the concept of "asset management" with the aim of improving the performance of their infrastructure assets. This paper evaluates the adoption of asset management to improve performance in the context of organisations managing infrastructure assets. Relevant previous research studies on main barriers to the adoption of asset management are reviewed. Analysis of these findings, together with deductive reasoning, leads to the development of the proposed improvement strategies. Three issues were identified as barrier to the advancement of the concept of asset management. They are (1) lack of recognition, (2) fragmentation; and (3) growing complexity. To overcome these issues, this paper suggests that the organisations manage infrastructure assets must (1) adopt a more strategic approach in the management of infrastructure assets, (2) develop a framework of strategic infrastructure asset management processes, and (3) identify the core capabilities needed in the management of infrastructure assets. This paper presents the direction for further research to advance the concept of asset management in the management of infrastructure asset.

Keywords: Infrastructure; Asset Management; Strategic, Capabilities, Processes

1. Introduction

Building and operating infrastructures consumes a large amount of resources [1]. The provision and development of infrastructure assets typically requires long lead times; significant planning; and involves many stakeholders to ensure the community is appropriately consulted. Under these circumstances, asset managers are faced with a mounting challenge in terms of the management and sustainability of these assets.

In response to these challenges, an emerging theme that is being recognised in today's ever changing business environment is the need for infrastructure organisations to increase their efficiencies and effectiveness in order to improve their delivery of services to their customers. This recognition is driving organisations to adopt an integrated, or holistic, "asset management" approach to achieve their overall corporate objective by optimising all available resources at higher levels but manageable risk to improve shareholder value.

This paper aims to evaluate the current state of asset management and suggest the way forward so that asset management can be adopted successfully by organisations that manage infrastructure assets. It will begin by examining the growing importance of infrastructure asset management. This is followed by the discussion on the current development of asset management and the barriers to the adoption of such concept in infrastructure organisations. Finally, it will propose some measures to facilitate the successful adoption of asset management in order to improve infrastructure performance.

2. The Growing Importance of Infrastructure Asset Management

Accountability is a requirement for any organisational structure. Those in charge of economic resources must give account of their stewardship, irrespective of whether the transactions and resources in question are those of a government or a private

sector entity [2]. In the 21st century, the various stakeholders for infrastructure will continue to demand value for money for their investment in infrastructure. Depending on the issue different stakeholders interests may impact on success and failure of a particular infrastructure delivery. In such a situation, infrastructure asset provision become a matter of deciding who the stakeholders of the infrastructure asset in question are, what and how important their demands are, and how these demands can best be met. To satisfy the needs and conflicting demand of the various stakeholders, they have to explore ways to create value from their infrastructure assets. With so many stakeholders involved in the provision and management of infrastructure assets, there is a need to understand everything about infrastructure assets. This includes the need to meet the expectations for quality including safety characteristics, operational efficiency and durability and accountability as guardian of infrastructure assets.

This growing recognition by infrastructure organisations of the need to improve effectiveness and overall operating performance requires clear understanding of how to manage infrastructure assets in a way that allow their current performance to improve and be competitive, while ensuring they are planning and re-investing for the future. Consequently, organisations that manage infrastructure assets are driven to adopt a formal and holistic approach to the management of infrastructure assets in order to provide services in the most cost effective manner, and to demonstrate this to customers and stakeholders. The shift in perspective is in sync with the concept of asset management. Asset management aims at providing a customer focus for business to systematically invest, maintain, upgrade, and operate infrastructure assets [3]. The primary goal of asset management is to meet a required level of service, in the most cost effective manner, through the management of assets for present and future customers [4].

The importance of asset management can be seen with the growing number of reports and guidelines published by various organisations managing infrastructure assets. In addition, grouping of professionals, councils and other professional institutions are being formed to advance the concept of asset management (e.g. the Institute of Asset Management in UK, Asset Management Council in Australia). Conferences, discussion meetings, symposia, courses have also sprung up prolifically, as have the inevitable battery of consultants seeking to persuade business of the huge rewards. Asset management has become more important than ever before because asset management has emerged as a tool that provide a holistic management of infrastructure assets to support important decisions such as need analysis, condition assessment, performance prediction, prioritisation, optimisation etc. The benefits of an improved asset management envisaged by IPWEA [4] are enhanced service and customer satisfaction, improved governance and accountability, improved risk management, improved financial efficiency and enable more sustainable decisions.

3. The Development of Asset Management

The concept of asset management is not a new but an evolving idea that has been attracting attention of many organisations operating and/or owning some kind of infrastructure assets. The term asset management have been used widely with fundamental differences in interpretation and usage. Woodhouse [5] suggested that there is at least 6 distinct current uses of the term as follows:

- The **financial services** sector has long used the phrase to describe the management of a stock or investment portfolio – trying to find the best mix of capital security/growth and interest rates/yield.
- Main board (usually **financial) directors** and some city analysts use the term in relation to mergers and acquisitions– buying and selling companies, re-organising them, divesting low value elements and trying to raise capital value and/or yields.
- **Equipment maintainers** have also adopted the name in an attempt to gain greater credibility and respect for their activities. As ‘maintenance’ has for so long been treated as a necessary evil and low on the budgeting priority list, perhaps calling it ‘Asset Management’ instead will raise awareness on the corporate agenda. ‘Asset Management’ becomes, therefore, a more sellable way of saying ‘better and more business-focussed maintenance’.
- In line with the maintainers seeking greater corporate clout, the large number of **software vendors** selling ‘computerised maintenance management systems’ (i.e. asset registers, work management, history gathering, materials & cost databases) have relabelled their products as “Enterprise Asset Management Systems”.
- In the **information systems** world, “Asset Management” is interpreted as just the bar-code labelling of computers and peripherals, and the tracking of their location/status.

- An increasing number of critical **infrastructure** or **plant owners and operators** have adopted 'Asset Management' to describe their core business – the combination of investing in, exploiting and caring for appropriate physical plant and infrastructure over its entire life.

In the current usage, infrastructure asset management has been adopted as the label for the integrated, whole life, risk based management of industrial infrastructure, as evolved principally in the North Sea oil and gas industry during the late 1980's and early 1990's [6]. Deregulation and privatisation of infrastructure such as utilities, transport and public services in the late 1980's and early 1990's have resulted in many organisations need to transform their infrastructure assets from cost centres charged with carrying out budget projects into profit centres charged with contributing to earnings growth. This has indirectly encouraged organisations to adopt a more holistic approach to manage their infrastructure assets and hence the adoption of asset management.

In comparison to other disciplines such as construction, facilities, maintenance, project management, economics, finance, to name a few, infrastructure asset management is a relatively new discipline and is clearly a contemporary topic. The primary contributors to the literature in asset management are largely government organisations and industry practitioners. These contributions take the form of guidelines and reports on the best practice of asset management. More recently, some of these best practices have been made to become a standard such as PAS 55 [7] in UK. Hence, the literature tends to lack well-grounded theories.

To-date, while receiving relatively more interest and attention from empirical researchers, the advancement of this field, particularly in terms of the volume of academic and theoretical development is at best moderate. A plausible reason for the lack of advancement is that many researchers and practitioners are still unaware of, or unimpressed by, the contribution that asset management can provide to the overall improvement to the performance of asset. The development and advancement of theories require, firstly, enthusiasm and dedication on the part of empirical researchers to carry out extensive research and disseminate the findings of such studies, and secondly, the participation of industry practitioners in such research. The following sub-sections discuss some of the barriers that prevent the advancement and development of asset management in the context of infrastructure organisations.

3.1 Lack of Recognition

The first barrier to the adoption and advancement of asset management is found in the 'step child' status that is often bestowed upon infrastructure asset management and maintenance groups within organisations. Recognition and prestige are always accorded to finance and investment activities of new construction and development. On the other hand, asset management is frequently associated with only maintenance, asset inventory, and its related services and therefore considered to be of less strategic importance.

There are many asset management systems that have been used for years and these systems have inherent investment analysis capabilities. These asset management systems focus on databases, asset inventories, technical models and other analytical tools. Most of these systems are used to monitor conditions and then plan and program their projects on a 'worst off' basis. As such, these systems typically function at the operations level and focus on one particular asset. This approach to asset management in general, and resource allocation and investment analysis in particular, is tactical rather than strategic. This view is supported by the findings and conclusions from the Australian National Audit Office Report No.27 [8] in their audit of asset management practices common to 24 organisations. One of the main weaknesses identified related primarily to the lack of a strategic approach to asset management. Similarly, Woodhouse [9] argued that emphasis has been disproportionately aimed at getting the jobs or functions done more efficiently resulting in "doing the wrong work 10% quicker and cheaper" and does not lead to a better total performance.

Consequently, the concept of asset management as applied to infrastructure organisation is viewed in research more from an operational (engineering and maintenance) and asset management functional perspective rather than from the strategic and holistic management perspective. In view of the amount of emphasis in the analytical tools and technical models, there is a risk of leaping to the conclusion that the implementation of asset management should start through the development of more advanced technical modelling and other analytical tools that can talk to one another.

This approach to asset management also ignores a systematic focus that involves bringing a variety of assets under one single entity [10]. This view is also echoed by Stapelberg [11] who noted that most asset management frameworks fail to have

a system wide focus The focus is more on individual assets rather than the long-term asset management needs of an organisation. Hence, a compelling argument against the progression of the concept of asset management is the general lack of interest from an organisation due to its operational perspective and therefore it is not able to contribute value to their stakeholders.

3.2 A Fragmented Approach

The second barrier is the contentious state of what constitutes asset management. Over the years many definitions of asset management have been provided. Some of these definitions are shown in Table 1.

Table 1: Definition of Asset Management

A systematic process of operating, maintaining and upgrading transportation assets cost effectively. It combines engineering and mathematical analyses with sound business practice and economic theory. The total asset management concept expands the scope of conventional infrastructure management systems by addressing the human element and other support assets as well as the physical plant [12]	New York State Department of Transportation (US)
The set of disciplines, methods, procedures and tools to optimise the whole life business impact of cost, performance and risk exposures (associated with the availability, efficiency, quality, longevity and regulatory / safety / environmental compliance) of the company's physical assets [13]	Institute of Asset Management (UK)
The systematic and coordinated activities and procedures through which an organisation optimally manages its physical assets and their associated performance, risks and expenditures over their lifecycles for the purpose of achieving its organisational strategic plan [7]	British Standard, PAS 55 (UK)
The combination of management, financial, economic, engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost effective manner for present and future customers [4]	International Infrastructure Management Manual 2006 Edition (Australia, NZ and UK)
A comprehensive and structured approach to the long term management of assets as tools for the efficient and effective delivery of community benefits [14]	AUSTROADS (Australia)
Provides a flexible service delivery approach, driven by present and future needs, and using both asset and non-asset solutions [15]	The National Public Works Council (Australia)
Lifecycle management of physical assets to achieve the stated outputs of the enterprise [16]	Asset Management Council (Australia)
Provides a structured and systematic resource allocation approach to infrastructure and physical asset management so that resources are aligned with the service objectives of agencies [17]	NSW Total Asset Management (Australia)
The process of guiding the acquisition, use and disposal of assets to make the most of their service delivery potential ad manage the related risks and cost over their entire life [18]	Victorian Government Asset Management Series (Australia)
Aims to provide an approach to the management of assets, encompassing the principles of integrated planning, asset planning, asset accountability, asset disposal and the internal control structure [8]	Australian National Audit Office, 1995 Auditor General's Report No. 27
The process of organising, planning and controlling, the acquisition, use, care, refurbishment, and/or disposal of an organisation's physical assets to optimise their service delivery potential and to minimise the related risks and costs over their entire life [19]	CRC for Integrated Engineering Asset Management (Australia)

From the various definitions given, it can be noted that different perspectives have been taken by agencies and organisations to align their corporate objectives with their own asset management practices. The definition of asset management that is used by an organisation is an important one as this understanding plays a major role in how the organisation ultimately implements the associated asset management processes and models within their organisation. These different frameworks were developed and used to suit each different organisation's business and corporate objectives and hence each has its own focus. Consequently, these diverse frameworks and guides, issued by different organisations being used

in practice cover different aspects and principles of asset management in accordance with what asset management means to them.

The diverse and fragmented adoption of asset management by different organisations does not help in the development and advancement of asset management but rather, creates more confusion to practitioners. Consequently, organisations are struggling to come to terms with the constitution of asset management and how this can improve the performance of their infrastructure asset and this can have an enormous impact across the entire organisation.

3.3 Increasing Complexity

Globalisation is intensifying economic and other linkages among countries making it increasingly necessary to plan, develop and finance infrastructure across national borders. There is an increased emphasis on a more performance-focused, customer-oriented, and proactive asset management strategy. In this context, the main goals of asset management are to achieve maximum return on assets, optimise total cost of ownership and fulfil safety and environmental requirements.

Thus, infrastructure asset must generate revenue and ensure that business needs are met without compromising the competitiveness of the business in future. This suggests that scope of infrastructure asset management is broadening. For example, FHWA [3] proposed that infrastructure asset management should be an interdisciplinary and comprehensive business strategy integrating finance, planning, engineering, construction, personnel, economics and information management.

This broadening of scope for infrastructure asset management suggests that asset management responsibilities are numerous and complex but it have the capacity to radically transform the structure and business processes of infrastructure organisations. In such enlarged scope, infrastructure asset management business is dependent on the support of a large range of service providers to deliver the required services to meet the corporate objectives for the business.

In addition, infrastructures usually last a very long time, often generations, and also take a long time to build, so that bringing about change in their systems requires long range thinking and vision [20]. Moreover, the key players too change over time, as the roles and responsibilities of the public and private sectors shift and evolve. This complexity is still evolving and needs refinement before it can transform the business of infrastructure organisation. A survey conducted by Bartlett [21] confirmed that asset management is still an evolving concept and that the roles and organisational arrangements varied widely requiring further development and ongoing refinement.

4. The Way Forward

The development of asset management discussed in the previous section suggests that infrastructure organisations need to pay attention to three key issues in order to improve their performance. Firstly, asset management needs to be viewed from a strategic approach in order to create value to the organisation. Secondly, there is a need for a clear understanding of what asset management is. Thirdly, there is a need to break down the complexity of asset management due to the involvement of many parties over a considerable period of time. All these three issues are interrelated and will be discussed below.

4.1 A strategic approach to infrastructure asset management

As owners, operators and maintainers of infrastructure assets, infrastructure organisations assume a significant responsibility in ensuring the successful performance of the assets to meet the service needs of their customers and expectation of stakeholders. Hence any infrastructure organisation should be striving to improve its operations, whether from the point of view of customer satisfaction, increased productivity, better asset quality, better environmental performance or any host of other performance indicators.

For asset management to become a true value-adding pursuit within a corporate framework, it must be primarily concerned with filling a strategic role, i.e. an asset manager must be proactive not reactive in their approach. They must be able to forecast the needs of their organisations and make forward plans that will support the aims of the organisation in the future. This strategic view is important as it takes a long-term view of infrastructure performance and cost. Having a strategic

perspective is about "the determination of the long run goals and objectives of an organisation, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals" [22]. Accordingly, strategic infrastructure asset management must aim at achieving organisational long term goals and effectiveness through dynamic alignment of the required infrastructure assets to meet changing customer needs. It is thus critical to predict future asset needs and develop strategies that will enable a timely response.

Strategic approach brings with it issues of value identification, cost-benefit analysis, risk assessment and stakeholder negotiation. A strategic approach can also provide a better understanding of how to align the asset portfolio so that it best meets the service delivery needs of customers, both now and in the future [23]. The need for a strategic and integrated approach has slowly gained attention. For example, Too et al. [24] reviewed some of the current asset management practice by government agencies in Australia revealed that despite the different frameworks adopted in the practice, they are all advocating a strategic approach.

In short, for asset management to create value to infrastructure organisations, the focus should be on strategic management of assets, with asset managers devoting their attention to a very broad range of concerns that combines engineering principles with sound business practices, information management and economic theory as well as the more traditional operational concerns related to maintenance of assets. It is thus pertinent to adopt a strategic approach to asset management that can support the broader and more strategic business goals.

4.2 Development of infrastructure asset management process

Asset management is more than a new management buzz word. There are still many questions about what asset management really means. Asset managers want and need a better understanding of its meaning, impact, and value to their organisations. The definitions given in Table 1 reveal that asset management is in some ways no different than what infrastructure organisations have always done. Decisions must be made about operating and maintaining infrastructure assets. New investments need to be planned. Resources need to be allocated, and budgets need to be specified. Knowledge about the condition of the equipment and structures has always been, and continues to be, valuable.

A closer examination of the definitions reveals key unifying themes that form the heart of asset management and are described below:

1) Alignment of assets and operations with corporate objectives: The key goal of asset management is the creation of value to the organisation stakeholders from infrastructure asset [25-26]. It is about understanding and managing the trade-offs between financial performance, delivered operational and service performance and risk exposure [25]. Hence, asset management provides a structure for driving and integrating customer expectations, legislative requirements, operating requirements, and financial objectives throughout an organization.

2) It links decision-making and action with information: Asset management is about obtaining the knowledge needed to optimise trade-offs among financial performance, operational performance and risk exposure [e.g. 25, 27]. It is about decision making, rather than the blind pursuit of technical performance [26]. Decisions are driven by the actual condition and performance of assets individually and collectively as well as by the risks to corporate objectives from asset failure. Analytical methods and information integration are central.

3) Life-cycle costing is a key concept: Costs are minimized, starting with the initial investment, continuing through operation and maintenance, and ending with disposal [e.g. 14, 17, 28-29]. The connections between the choice of assets and the implications for the cost stream from maintaining those assets are critical.

4) It is a process: To understand asset management, we need to identify and define the activities involved. Asset management is about designing and implementing a new business process that can deliver higher returns to corporate stakeholders [16]. One of the precepts of the discipline is that all business units should make decisions based on the same criteria. A sound asset-management process ensures that business units do not sub optimize by emphasizing parochial criteria at the expense of overarching corporate objectives [26].

Synthesising the above discussions and themes, strategic infrastructure asset management can be defined as follows:

> Infrastructure Asset Management is a strategic and systematic process of optimising decision-making in resources allocation with the goal of achieving planned alignment of an infrastructure asset with corporate goals throughout its lifecycle.

This definition can provide guidance on the development of core infrastructure asset management processes. Peterson & Holbus [30] take a more structured approach for asset management founded on the philosophy of quality systems. Their interpretation is known as Strategic Asset Management (SAM) business processes. The SAM is an integrated business process that allows continuous process improvements to be achieved to provide operational excellence. This stronger focus on the integrated processes will then be able to deliver higher levels of customer service and reliability while balancing off the financial objectives for the business. Craig & Parrish [31], Brown [32] and Sklar [27] all support a holistic view of asset management as an integrated business process designed to optimise the use of a utility's assets while balancing the varying needs of key stakeholders. Similarly, Tao et al. [33] proposed that from a business perspective, it requires an asset management framework that comprised of dynamic business processes to link all asset types together under a single business context. To enable organisation to develop infrastructure, it need a strategic framework to identify the specific infrastructure service needs, facilitate the selection and implementation of infrastructure projects, and to monitor the performance of infrastructure assets and services. Establishing a strategic infrastructure asset management process is therefore fundamental to improving efficiency and effectiveness of infrastructure delivery.

4.3 Develop capabilities for infrastructure asset management

At the heart of asset management is the concept of continuous improvement. Byrne [34] for example explains that asset management should be implemented based on the principles of continuous improvement, in successive and manageable steps, to allow the complexities and dynamics of the process to be fully understood progressively. In the light of the complex nature of asset management, Humphrey [26] and Woodhouse [6] advocated the dividing of responsibility among three key entities: the asset owner, the asset manager, and the service provider. This approach provides a clear separation between making the decision and carrying out the action, and allows each entity to specialise and thereby focus on specific capabilities and responsibilities [26]. This relationship is shown in Figure 1 below.

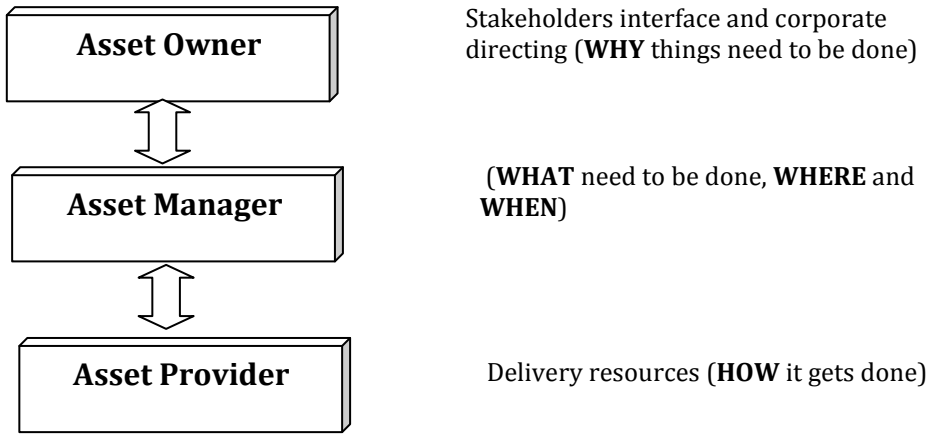

Figure 1: Demarcation of roles and scope of asset management (Adapted from IPWEA [4])

Accordingly, a truly optimised asset management outcome for an infrastructure business could only be achieved with alignment and recognition of this inter-dependence between these three key groups. The alignment and optimisation can be achieved by an asset owner formulating a corporate strategy, translated into asset requirements by an asset manager and executed by a service provider. The separation of roles placing asset management as the link between corporate strategy and service provision is a new concept [35]. This concept is a major paradigm shift in thinking for infrastructure organisations, as their assets have historically been driven by a build mentality based on the supply and demand principles that existed in the marketplace at the time.

This recognition of a clear asset management role brings with it some barriers to it being adopted as this would impact on the traditional divisional boundaries within an organisation, which would impact on the way these organisations currently operate. This would put pressure on the need for structural change to the organisation, to allow integration of asset management components into the way the business operates to ensure clear accountability resides with the appropriately responsible group [36].

To achieve this in practice means that the organisation also has to develop new capabilities to meet the challenges of aligning the inevitably complex processes that cross numerous accountability lines [25]. Asset management should not be

considered a big, quantitative "black box" that converts asset data into asset decisions. Besides having a framework and processes to guide their decisions, they have to ensure that they have the right capabilities to execute these processes in order to create value to their organisation. This is supported by Jones [25] who argues that the notion of value creation through asset management is based around a key set of capabilities. An organisation can only gain advantage and achieve superior performance when it has the right capabilities [37]. Such organisations need to build their strengths that they already have. They also need to develop capabilities that they currently do not have. Only with the right capabilities can infrastructure organisations capitalise and exploit the best from asset management. However, the literature is not clear on what capabilities are needed in infrastructure asset management. Thus more research on the core capabilities for the management of infrastructure asset need to be carried out to advance the concept of infrastructure asset management.

5. Conclusions

Organisations that manage infrastructure assets are confronted with the challenge of delivering value to their business. Asset management decisions need to be based on a proper evaluation of options, which take into account all costs, and benefits over the life of asset, and incorporate an explicit analysis and determination of an acceptable level of risk. Hence, there is a need to adopt a holistic and integrated approach in the management of their infrastructure assets. This paper has argued that for infrastructure organisations to fully embrace the concept of asset management to improve the performance of their infrastructure assets, three interrelated issues need to be addressed. Firstly, there is a need to adopt a strategic approach in the management of infrastructure assets. Secondly, there is a need to develop a strategic infrastructure asset management processes framework to guide their decision-making. Thirdly, core capabilities needed to competently execute the core strategic infrastructure asset management processes need to be identified and developed.

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