Information Technologies for Engineering Asset Management – Cultural and Technical Barriers

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Abstract
Engineering enterprises utilize a variety of technologies to manage the lifecycle of their critical assets. These technologies consist of operational as well as information technologies that aim to provide control of individual asset management processes as well as to create overall information enabled integrated view of the asset lifecycle management regime. However, implementation and adoption of these technologies is not a linear progression and raises many issues at both the macro and micro levels in the organization. It is for the same reason that utilization of same technologies produces variance in efficiency, results, and outputs among different organizations. In many instances, the consideration of organizational and cultural issues is more important than technological issues in determining a successful outcome for information technologies deployment. In fact, it has been stated that the primary cause for information technology’s failure to yield positive results has been organizational behavior problems. This paper reports the findings from a study conducted in Australian asset managing organizations, which highlights how these organizations have used information technologies for asset management. This paper highlights that value maximization from information technologies utilization has strong contextual and social underpinnings. Their optimal utilization, therefore, calls for understanding the context within which they are deployed, as well as the processes that influence and are influenced by their use.

Keywords
Information systems, asset management, culture.

1. Introduction
The term ‘asset’ in engineering organizations is defined as the physical component of a manufacturing, production or service facility, which has value, enables services to be provided, and has an economic life greater than twelve months (IIMM 2006), such as manufacturing plants, roads, bridges, railway carriages, aircrafts, water pumps, and oil and gas rigs. Asset management is a set of disciplines, methods, procedures and tools derived from business objectives aimed at optimizing the whole life business impact of costs, performance and risk exposures associated with the availability, efficiency, quality, longevity and regulatory/safety/environmental compliance of an organization’s assets (Haider 2007). In engineering enterprises asset management strategy is often built around two principles, i.e., competitive concerns and decision concerns. Competitive concerns set manufacturing/production
goals, whereas decision concerns deal with the way these goals are to be met. Information technology (IT) provides for the these concerns through value added asset management support, in terms of enabling business processes, and enabling decision support for choices such as, selection of assets, their demand management, support infrastructure to ensure smooth asset service provision, and lifecycle decision support. 

Most engineering enterprises mature technologically along the continuum of standalone technologies to integrated systems, and in so doing aim to achieve the maturity of processes enabled by these technologies, and the skills associated with their operation (Haider 2007). The purpose of this paper is to explore issues and challenges posed to asset managing organizations in wake of maximizing value from IT adoption. This paper presents findings from a study undertaken in Australian asset managing organizations and uncovers how these organizations utilize information technologies for the management of their assets’ lifecycle. This paper contributes to the literature by describing the issues associated with IT adoption to support asset lifecycle management. The impediments to effective utilization of IT for asset lifecycle management in this case highlight the need for understanding of the social nature of IT adoption and the ways in which engineering enterprises can maximize value from the utilization of these technologies. This starts with a discussion on the scope of IT in asset management, followed by a discussion on the experience of Australian asset managing with utilization of IT for asset management. Drawing on the learnings thus gained the paper develops a framework for technology implementation for asset lifecycle management.

2. Scope of IT in Asset Management

IT in asset management not only act as strategy translators but also act as strategy enablers, which means that real value of IT relies upon how effectively IT are mapped to the asset lifecycle management processes, and how effectively they are synchronized with other technologies in the organization. In theory IT in asset management have three major roles; firstly, IT is utilized in collection, storage, and analysis of information spanning asset lifecycle processes; secondly, IT provides decision support capabilities through the analytic conclusions arrived at from analysis of data; and thirdly, IT provide an integrated view of asset management through processing and communication of information and thereby allowing for the basis of asset lifecycle management functional integration. However, information requirements in asset lifecycle management are prone to change, due mainly to the changes in the internal as well as business environment. The ability of an organization to understand these changes not only contributes to its responsiveness, but also improves its capacity to enhance reliability of asset operations, to deliver optimized level of asset lifecycle management. However, this ability is directly influenced by the way an organization implements IT, which acquire, process, and present information to enable asset managing organizations to understand these changes. The following sections provide insights into a study conducted to ascertain how engineering enterprises utilize technology that they employ to support asset lifecycle management.

3. Research Methodology

This exploratory research employs an interpretive epistemology with a qualitative perspective. It is obvious that the issues relating to IT investments in asset lifecycle management are multifaceted and require a broad and flexible perspective for comprehensive examination. It
include investigation of technical as well as an assortment of other dimensions such as organisational, social, and cultural. The aim of this research is to explore the issues and impediments to maximising IT value for asset management from technical, social, and cultural perspective. The research question framed for this research is: What factors impede maximising value of IT adoption? In order to address this question, 23 middle managers representing various roles associated with asset lifecycle management were interviewed in asset managing organisations that manage below track rail assets, water pumping station assets, electricity assets, and infrastructure assets. These interviews were conducted over a one - one and half hours period and included the following job descriptions, asset designers, maintenance engineers, network access manager, business development manager, Operations and Maintenance manager, manager projects, manager assets management, project officer assets, finance manager, and IT manager. Interviewees were chosen based on their responsibilities as they are between senior mangers (who make decisions) and operational employees (who act on the decisions made by senior mangers). They are the actual implementers of IT and, therefore, are well placed to provide insights into policy setting and decision making of the senior management and the issues and challenges posed to these policies and decisions at the operational level. The interview questions were open-ended and interviewees had freedom to describe their experiences and problems beyond the scope of the questions. In addition, researchers were provided access to all documentation concerning asset lifecycle management, as well as access to sites of asset operation. The interviews were transcribed and data from all sources were analysed using case study techniques of themes, descriptions and assertions as detailed in Creswell (1998). The interviews were transcribed and data from all sources were analysed using NVivo software using its features of themes, descriptions and assertions. The interviews were followed up by email and telephone for further clarifications, where it was deemed necessary. The conclusions drawn in the following case, thus, represent interpretations of the evidence as understood by the authors.

4. IT Maturity in Case Organizations
Owing to the legislations, changes in technology, and demands of aging asset infrastructure, in 1990 asset managing organizations took initial steps towards introducing IT for asset management. As a result an asset register and management system (ARMS) system was implemented in many asset managing organizations. However, this system allowed nothing more than simple record keeping of asset inventory. Apart from limited functionality the system was not integrated with any other organizational information system, hence there was no way of finding out costs incurred during asset lifecycle. In addition, there were issues with data quality, duplication of data, and lack of data standardization, therefore maintenance history lacked creditability. Mid 1990s saw expansion of ARMS to include extra functionality such as, accrual accounting, asset identification, asset valuation, bill of quantities, and calculation of direct and indirect costs. The trend continued and at the beginning of 2000s ERP systems became quite popular among asset managing organizations and automation of asset lifecycle management processes gained momentum. However, the initial focus was on implementing the plant maintenance module to provide improved data quality, work management and costing, and management decision support. In asset managing organizations, implementation of ERP and in particular SAP was undertaken due to the pressures from regulatory authorities rather than in response to the process needs of asset management. Consequently, implementation of ERP has been far from satisfactory. At the same time, it has to be acknowledged that ARMS was not a
completely functional system and both ARMS and ERP conform to different information models, therefore migration of data from ARMS to ERP has been extremely difficult. It is for the same reason that a fully operational and integrated IT enabled asset management regime could not be found in any of the organizations investigated for this research. Other major technologies implemented in asset managing organizations relate to areas such as condition monitoring, i.e. SCADA systems; lifecycle costing, i.e. asset accounting, billing system; health management, i.e. CMMS; and customer relationship management.

4.1 IT for Operational Support
The major concern of IT implementation at operational level is how it should be implemented to meet operational requirements of assets. These technologies aid in ensuring asset design, operation, condition monitoring, failure notifications, maintenance execution and resource allocation, and enabling other activities required for smooth asset operation. Most of the assets investigated for this study were designed and developed before 1950s; therefore almost all information regarding their design, except for some relating to their refurbishment is available in a non digital format. Consequently, these organizations are unable to exchange design information with other asset lifecycle management functions. The lack of digital information poses a number of issues; with the foremost among them being the inability to develop an information culture. As a result, at the operational level the organizations lack functional integration. Each function of these organizations works in isolation from the other function. For example, design manger of the utility asset management organization noted, ‘we have particular needs in design and most of our information is driven from top down. To be honest with you our experience with technology has not been that good. Software implementation is usually very difficult to achieve and in fact we’ve seen quite a few of them come and go without providing benefit to us. The intricacies of integration with other applications just ended up proving to be too difficult. SAP has been with us for a long time, but we are not seeing the benefits though I am sure what SAP is capable of providing us’.

In terms of asset design, water asset managing organization presented an interesting scenario. In the formal process of asset design/redesign chief engineers visit different regions and talk to designers and operations to discuss the design and operational requirements. Deign/redesign process of an upgrade or refurbishment is carried out through consultation with designers and is fully reviewed by the technical service engineers in that region. The company thus ensures that they have consensus from all the parties involved. In so doing, there is heavy reliance on the tacit knowledge held by staff, whereas there is no system for preserving the same or making it available to other functions within the organization. In the words of the design manger, ‘we use AutoCAD but that just gives us an electronic version of a drawing. Ideally we would like to have access to information to analyze how good our design is. The information available to us has been input by the people who really don’t have sufficient technical background to understand the key things that need to be there. We’ve got long way to go I think before our systems are going to be sufficiently up to date and have sufficient useful information that our guys could pretty quickly get a hand on. Once we cannot get our hands on this information we have no choice but to rely on the knowledge held with our filed staff’.
4.2 IT for Planning and Management Support
It was found that there are a plethora of information systems and technologies used to plan and manage asset lifecycle. At this stage the major IT concern is how it must be implemented to meet the planning and control of asset lifecycle management? Whereas, the aim of implementation of these technologies is to fulfill asset lifecycle planning and control requirements aimed at continuous asset availability, through performance analysis based on analysis of various dimensions of asset information such as, design, operation, maintenance, financial, and risk assessment and management. However, the situation on ground is far from being perfect. For example, in case of water infrastructure asset management, the organization’s assets base consists of a variety of asset types and is spread anywhere between 30 km to 100 km or even longer. Asset condition monitoring involves a number of different operational and administrative technologies that make the process costly and time consuming. Although, the company makes use of GIS (geographical information system) and SCADA system to monitor asset operation, yet asset operation and condition assessment is largely manual. The information captured through SCADA systems is only used for alarms generation and failure reporting, it is not used or aggregated with other information for analysis such as failure root cause. The operations manager of the company suggests that, ‘condition assessment is manual exercise at the moment, since we are struggling to integrate different systems with our major asset management system (SAP). When we are required to do condition assessment, our guys will go and do that and in the process if they identify something that in their opinion presents an undesirable outcome they will flag that’.

The organizations investigated for this research have different ownership of maintenance function and overall ownership of the asset, i.e. maintenance is carried out by maintenance crew, whereas asset ownership is the mandate of another function. Consequently, there are multiple versions of the same information within the organization. Furthermore, these versions have their own bias and standard of quality. Although the organizations are aware of the potential of quality information, yet there is little attention given to recording and capturing correct and complete information. For example, a maintenance engineer of the rail asset managing organization summarized the situation as, ‘maintenance crew is not technically qualified or capable to operate an IT system. They consider it as an add-on to maintenance work, something that just has to be recorded. At the end of the day they will not be judged on what information they entered. Their performance is evaluated on the quality of their maintenance work’.

Maintenance information, however, is crucial for asset lifecycle management, as it provides the basis for lifecycle cost benefit analysis, remnant lifecycle calculations, as well as for asset refurbishment, upgrade, and overhauls. However, maintenance information is not exchanged with other lifecycle functions. In addition, the main focus is on capturing maintenance execution information with little provision for integrating this information with financial information to profile the cost benefit of asset operation. Consequently, there is no way of calculating the cost of asset failure or planned shutdown, as well as real costs incurred on maintaining the asset.

All the organizations investigated for this research are semi government organizations and characterize most of the advantages and disadvantages associated with a hierarchical structure. There is little cross functional and cross departmental collaboration with each function working within well defined boundaries. Consequently, the general approach is ‘if it ain’t broke don’t fix it’. The business development manager of one of the organization’s provided some insights into the organizational culture by stating that his office is at the same floor as many of the electrical engineers, but they have never spoken to each other. This function centered approach has
translated into the way IT are utilized in these organizations, i.e. with a range of different systems and each aiming to accomplish individual tasks. In the words of the Asset Manager of the electricity asset managing organization, ‘there is huge range of standalone information collection devices, which primarily collect historical information. So it’s range of historic information that’s available to us. What we want to do is to actually get all of it to be available at one spot, get all of the systems talking to each other, reduce the duplication of data so that when we go in and ask for any query we know it’s the same. Then there is standardization of data across the organization. We want to move beyond the individual data management to predictive issue based management’.

4.3 IT for Operational Efficiency

IT resources represent the combination of IT infrastructure, human IT resources, and soft assets, such as the shared performance and prospect development potential of a corporation. Organizations improve externally and internally by making informed choices which may affect the learning, acquiring and operation of IT resources. The closeness between the Chief Executive Officer, Chief Information Officer, and Chief Technology Officer can improve the organization by bringing technology and supporting organizational changes together, which are vital for successful performance as well as effective management of related resources. The visions of business and asset managers must address the role which IT presents in their organizations; managers must also address directions to employ resources to gain more benefits for their business. The important point here is that IT infrastructure needs to be designed to provide a holistic view of the asset lifecycle. In such a setting, it is imperative to preserve lifecycle learnings and the organization should use the same to evolve, grow, and mature. This study revealed that, generally asset managing organizations are using IT for information recording or what could be best described as recording what the organization has done. This information is seldom used for more high profile purposes, such as organizational integration, planning, and executive decision support. The prevailing silo approach has thus affected departmental efficiency as well as functional integration. User training has traditionally been a weak area, as little training is provided and even whatever is provided is aimed at training managers and supervisors rather than the staff who use the system on daily basis. The idea is that the supervisory staff (with the help of IT department) train functional staff. In these circumstances it is obvious that staff does not feel comfortable with using major platforms such as SAP, and business units A are more inclined towards using internally developed spreadsheets and databases. Since there is little information exchange internally as well as with business partners, there is substantial information and knowledge drain. Senior management is not technology savvy and therefore does not rely on IT for asset lifecycle decision support. Even otherwise information lacks quality and there is no way of managing the important asset lifecycle learning. For example, the water asset managing organization depends a lot on the tacit knowledge (particularly for maintenance) and at present more than 65% of the staff at the company is within 10 years of retirement age, which means substantial amount of intellectual capital loss. A senior manager from the company attributes this to the culture of the company and summarizes that, ‘it has a lot to do with culture. Our culture is wrestling with fundamental issues. Some would argue that we are in an asset based industry and not an intellectual property based industry or anything like that. Certainly true to say that there is a difference of opinion in the organization as to how asset portfolio should be managed through IT. Perhaps people are not trained or skilled for the
organization to change. IT implementation needs to be addressed a little more strategically. As an organization we have to try to convert people from break down heroes into more strategic thinkers’.

5. Discussion

Technical infrastructure of the case organizations consists of various off the shelf proprietary, legacy, customized systems and a number of ad hoc solutions in the forms of spreadsheets and databases. Legacy systems have evolved with the organizations; however, are generally weak in technological terms. These systems have been developed using old technologies and are not compatible with new technologies. On the other hand, off the shelf systems are developed on customized guidelines and supports proprietary data formats. Similarly, ad hoc solutions do not conform to any quality and technical standard. This has resulted in isolated pools of data that may serve the needs of individuals or individual departments, but this information is of little use to other departments or functions. As a result, there is lack of information integration, which contributes to lack of functional integration. In crux, the existing technical infrastructure does not conform to an information model or the organizational operating model. This means that the technical infrastructure is not aligned with the strategic asset management considerations. This further gives rise to issues relating to lacking process maturity, varying degree of data quality, inadequate decision support and overall organizational efficiency.

The first and foremost learning from this study is the fact that asset managing organizations adopt a technologically deterministic approach to technology implementation, where technology is considered first and human and organizational factors are not considered until after the actual implementation of technology. It is clear from the study that these organizations are aiming to mature technologically along the continuum of standalone technologies to integrated systems, and in so doing are aiming to achieve the maturity of processes enabled by these technologies and the skills associated with their operation. This may be attributed to the propensity of engineering organizations to exhibit mechanistic attitude towards technology, which focuses on automation of processes rather than viewing IT as strategy enablers. This also explains the heavy leaning towards maintenance activities in the overall asset lifecycle management strategies. Consequently, the existing backdrop of IT implementation in asset management represents a fragmented approach aimed at enabling individual processes in functional silos, and has therefore failed to enable integration of asset lifecycle management activities and processes.

Extemporized and unplanned nature of technology adoption is prevalent in the culture of the organizations in this research. Top management is not technology savvy and the functional staff considers technology use as an unnecessary addition to their routine jobs. It is all summarized in the knockout quote from the group manager who stated that “some would argue that we are in an asset based industry and not an intellectual property based industry or anything like that”. In such circumstances top management is not aware of the capabilities of technology that would allow them to create a vision or a technology roadmap by mapping organizational needs with capabilities of technology to fulfill the demands of asset management.

All the organizations exhibited strong tendencies towards keeping legacies and resisted change. It may be attributed to the character of semi government organizations, since stability, as opposed to change, is their survival. These organizations, however, lack effective change managers. Organizational members can only judge the magnitude of a change and not its consequences. It is the job of the change managers to take leadership and facilitate change
Users in the organizations investigated for this research appear to resist use of IT due to the complexity of the systems. As with resistance to change, some staff may fall into a routine of stability and comfort, and may be unwilling to learn new things or utilize new technology for fear of the unknown. In the case organizations, new technologies do not appear to be enough of a step forward from the existing technologies and users, generally, feel that the new implementation is useless. Knowing the why, the where, and the how enables staff to feel more involved and informed of management decisions, and therefore more keen and willing to adopt new technology. There are three domains, which must be understood by management to develop effective change management strategies (Orlikowski and Gash 1994). Firstly, technology in use, i.e. users’ understanding of how the technology will be used on a day-to-day basis; secondly, nature of technology, i.e. users’ images of technology and their understanding of its capabilities and functionality; and thirdly, technology strategy, i.e. user’s understanding of why the organization acquired and implemented the technology.

Resistance to change is usually perceived as negative behavior by management, and can involve attempting to stop, hinder or alter change. However, resistance to change can actually be harnessed to predict any foreseeable consequences of proposed change, and how staff may react to these. It is also necessary to ensure employees do not fall into routines of stability, which may allow them to become complacent and unmotivated. Using resistance to change to identify consequences and employee reactions allows management to identify causes for concern staff may have, and this allows them to plan a line of approach that will reassure any doubts staff may have. As it is argued that organizational culture influences organizational change, Rashid et al. (2004) expect that particular types of organizational culture may assist the change process more readily than other types. Determining the specific types of organizational culture that can assist in organizational change is therefore necessary.

This discussion emphasizes the intertwined nature of type of technology, organizational infrastructure/architecture, and the human resources available in the organization (figure 1). Use of technology is shaped by the interaction of these three factors. Organizational culture towards technology is shaped by the interaction of organizational policies, structure, and value system, and the skills level of employees, their motivation, and their job design (Goffee and Jones 1998). However, the fundamental issue while implementing technology is to map business process requirements with capabilities of technology. The efficiency of business processes and that of the overall business depends upon the way an organization is designed to accept technology or the way the available technology architecture/infrastructure meets the needs of organizational design. At the same time, the existing human resource management policies have an impact on the way technology is developed and maintained to support organizational design. The interaction of these domains is further subjected to certain constraints, objectives, and aspirations.

The effectiveness of these three domains further defines how the organization contributes to functional alignment, resources management, operational quality, functional and overall risk management, development of core competencies, and the responsiveness of the organization to respond to competitive pressures and opportunities. Overall the organization works in the broader social, technical, economic, and legal/legislative environment of its geographical jurisdiction. Therefore, asset managing organizations cannot adopt a deterministic approach (as evidenced in this study) to technology implementation and technical infrastructure development. While implementing new technology it is imperative that a holistic view of technology is taken by accounting for the factors that shape or reshape the use of technology. The term holistic view
is not a mere academic or literal term, as the author acknowledges that a robust, completely functional, technically able environment cannot be established. However, with a holistic view of technology and the forces interacting with it that contributes to the overall efficiency of the organization provides a set of options and the opportunities to select the best trade-off available, and the best change management strategies that can overcome the technical, social, and cultural barriers posed to maximizing value from implementation of technology.

6. Conclusion
This study reveals that the range of technical, social, and cultural issues posed to organizations after introduction of new technologies are broad and encompasses many facets of organizational theory. Human resource management, resistance to change, organizational culture, and organizational change management strategies all play a part in the success of technological implementation or changes within an organization. Human resource management in itself encompasses a great deal of factors relating to the management of work and people. In regard to organizational automation, human resource management can be used to pre-empt staff opinions and actions when implementing new technologies and working procedures. Providing adequate training allows staff to feel more comfortable with new systems and programs, especially for older generation employees who may not feel as comfortable using technology as their younger
workmates. In the same vein, staff should be notified why and when new technologies are being introduced, as this enables them to feel informed about company decisions, and therefore more valued team members.

Change management is a method of predicting user reactions to proposed change. For change to be successful, support must be provided by senior management. However, literature suggests that while there is plenty of change management theory available, there is little evidence of it being put into practice successfully. And finally, organizational culture deals with the beliefs and values of members of an organization, and is closely linked with change management and organizational transformation. Understanding the particular culture of one’s organization allows for better decision making during the planning and implementation phases of organizational transformation. Effective planning, initiation and management of each of these issues may include adopting the best approach, or a combination of approaches to ensure the success of the transformation attempt. In essence, it is the combination of planning, communication, training and effective management that creates the ideal environment for successful organizational transformation to occur. Without many, or all, of these factors present, the technical, cultural and social issues discussed here will impede on the transformation process, decreasing results.

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