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IT Enabled Engineering Asset Management: A Governance Perspective

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Abstract

Engineering asset lifecycle management requires a variety of information as well as operational technologies to keep their

asset base in running condition In theory these technologies are used in collection, storage, and analysis of information spanning asset lifecycle processes; providing decision support capabilities through analytic conclusions arrived at from analysis of data; and in providing an integrated view of asset management through processing and communication of information that also allows for the basis of asset management functional integration. In doing so, these technologies not only provide for the control of asset lifecycle tasks, but also contribute to the overall advise on effective asset management though the critical role that they have in decision making.

However, even though operational technologies depend a lot on information technologies for their smooth functioning, yet due to their specialized nature these operational technologies are not considered as part of the overall organizational information technology infrastructure. Consequently, when it comes to governance of information technologies, operational technologies are not accounted for. This paper provides a framework for governance of information technologies utilized for asset lifecycle management. It concludes that information technologies should not be taken as technical constructs, these are at the core of strategic alignment, value delivery, resource management, and risk management. Governance of information technology, therefore, calls for understanding and accounting for the whole information technology base and enabling infrastructure of the organization.

Keywords: Asset management, IT governance, Asset lifecycle

Introduction

Information Technologies (IT) for asset management are required to translate strategic objectives into action; align organizational infrastructure and resources with IT; provide integration of lifecycle processes; and inform asset and business strategy through value added decision support. However, the fundamental element in achieving these objectives is the quality of alignment of technological capabilities of IT with the organizational infrastructure, as well as their fit with the operational technologies (OT) used in lifecycle management of assets. IT and OT are becoming inextricably intertwined, where OT facilitate running of the assets and is used to ensure system integrity and to meet the technical constraints of the system. OT includes control as well as management or supervisory systems, such as SCADA, EMS, or AGC. These systems not only provide the control of asset lifecycle tasks, but also contribute to the overall advice on effective asset management though the critical role that they have in decision making. However, even though OT owes a lot to IT for their smooth functioning, yet due to their specialized nature these technologies are not considered as IT infrastructure. This paper, therefore, attempts to uncover the relationship between industry specific OT used for asset management and organizational use of mainstream IT applications for asset lifecycle management. It starts with an analysis of the IT utilized for asset management, which is flowed by a discussion on their relationship with OT in asset lifecycle management. The paper, thus, presents a framework for IT-OT nexus.

Asset Management

The scope of asset management activities extends from establishment of an asset management policy and identification of service level targets according to the expectation of stakeholder and regulatory/legal requirements, to the daily operation of assets aimed at meeting the defined levels of service. Asset managing organizations, therefore, are required to cope with the wide range of changes in the business environment; continuously reconfigure manufacturing resources so as to perform at accepted levels of service; and be able to adjust themselves to change with modest consequences on time, effort, cost, and performance.

Asset management can be classified into three levels, i.e. strategic, tactical, and operational (Figure 1).

Strategic level is concerned with understanding the needs of stakeholders and market trends, and linking of the requirements thus generated to the optimum tactical and operational activities.

Operational and tactical levels are underpinned by planning, decision support, monitoring, and review of each lifecycle stage to ensure availability, quality, and longevity of asset's service provision. The identification, assessment, and control of risk is a key focus at all levels of planning, with the results from this process providing inputs into the asset management strategy, policies, objectives, processes, plans, controls, and resource management.

IT and Asset Management

In theory IT in asset management have three major roles; firstly, IT are utilized in collection, storage, and analysis of information spanning asset lifecycle processes; secondly, IT provide 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 allow for the basis of asset management functional integration. According to Haider (2007), minimum requirements for asset management at the operational and tactical levels are to provide functionality that facilitates, knowing what and where are the assets that the organization owns and what is their condition; establishing suitable maintenance, operational and renewal regimes to suit the assets and the level of service required of them by present and future customers; implementing job/resources management, and improving risk management techniques; and identifying the true cost of operations and maintenance; and optimizing operational procedures.

In engineering enterprises asset management strategy is often built around two principles, i.e., competitive concerns and decision concerns (Rudberg, 2002). Competitive concerns set manufacturing/production goals, whereas decision concerns deal with the way these goals are to be met. IT provide for the these concerns through support for value added asset management, in terms of the choices such as, selection of assets, their demand management, support infrastructure to ensure smooth asset service provision, and process efficiency. Furthermore, these choices also are concerned with in-house or outsourcing preferences, so as to draw upon expertise of third parties. IT not only aids in decision support for outsourcing of lifecycle processes to third parties, but also provide for the integration of extra-organizational processes with the intraorganizational processes. Nevertheless, the primary expectation from IT at the strategic level is that of an integrated view of asset lifecycle, such that informed choices could be made in terms of economic tradeoffs and/or alternatives for asset lifecycle in line with asset management goals, objectives, and long term profitability outlook of the organization. However, according to IIMM (2006), the minimum requirements for asset management at the strategic level are to aid senior management in,

a. predicting the future capital investments required to minimize failures by determining replacement costs;

b. assessing the financial viability of the organization to meet costs through estimated revenue;

c. predicting the future capital investments required to prevent asset failure;

d. predicting the decay, model of failure or reduction in the level of service of assets or their components, and the necessary rehabilitation/ replacement programmers to maintain an acceptable level of service.

e. assessing the ability of the organization to meet costs (renewal, maintenance, operations, administration and profits) through predicted revenue;

f. modelling what if scenarios such as, technology change/obsolesce; changing failure rates and risks they pose to the organization, and alterations to renewal programs and the likely effect on levels of service,

g. alteration to maintenance programs

and the likely effect on renewal costs; and

h. impacts of environmental (both physical and business) changes.

IT for asset management seeks to enhance the outputs of asset management processes through a bottom up approach. This approach gathers and processes operational data for individual assets at the base level, and on a higher level provides a consolidated view of entire asset base (figure 1).

Figure 1: Scope of IT for Asset Management (Haider 2009)

Please see Figure 1 in full PDF version.

At the operational and tactical levels, IT systems are required to provide necessary support for planning and execution of core asset lifecycle processes. For example, at the design stage, designers need to capture and process information such as, asset configuration; asset and/or site layout design and schematic diagrams/drawings; asset bill of materials; analysis of maintainability and reliability design requirements; and failure modes, effects and criticality identification for each asset. Planning choices at this stage drives future asset behavior, therefore the minimum requirement laid on IT at this stage are to provide right and timely information, such that informed choices could be made to ensure availability, reliability and quality of asset operation. An important aspect of asset design stage is the supportability design that governs most of the later asset lifecycle stages. The crucial factor in carrying out these analyses is the availability and integration of information, such that analysis of supportability of all facets of asset design and development, operation, maintenance, and retirement are fully recognized and defined. Nevertheless, effective asset management requires the lifecycle decision makers to identify the financial and non financial risks posed to asset operation, their impact, and ways to mitigate those risks.

OT and Asset Management

OT set of technologies are primarily used for process control; however, they also include technologies such as sensors, gauges, and meters, which are used in many control systems and automated data acquisition systems that perform a variety of tasks within the asset lifecycle. Technically, OT is a form of IT as it necessarily deals with information and is controlled by (in most cases) a software. For example, the Supervisory Control and Data Acquisition (SCADA) systems used for real time monitoring and control of processes consist of software and hardware and produces intelligible information that is used for a variety of follow up actions and decision support.

From the discussion on IT and OT for asset management, it is clear that these technologies not only have to provide for standardized quality information but also have to provide for the control of asset lifecycle processes. For example, design of an asset has a direct impact on its asset operation. Operation, itself, is concerned with minimizing the disturbances relating to production or service provision of an asset. At this level, it is important that IT systems are capable of providing feedback to maintenance and design functions regarding factors such as asset performance; detection of manufacturing or production process defects; design defects; asset condition; asset failure notifications. There are numerous IT systems employed at this stage that capture data from sensors and other field devices to diagnostic/prognostic systems; such as SCADA systems, Computerized Maintenance Management Systems (CMMS), and Enterprise Asset Management systems.

These systems further provide inputs to maintenance planning and execution. However, effective maintenance not only requires effective planning but also requires availability of spares, maintenance expertise, work order generation, and other financial and non financial supports. This requires integration of technical, administrative, and operational information of asset lifecycle, such that timely, informed, and cost effective choices could be made about maintenance of an asset. For example, a typical water pump station in Australia is located away from major infrastructure and has considerable length of pipe line assets that brings water from the source to the destination.

The demand for water supply is continuous for twenty four hours a day, seven days a week. Although, the station may have an early warning system installed, maintenance labour at the water stations and along the pipeline is limited and spares inventory is generally not held at each station. Therefore, it is important to continuously monitor asset operation (which in this case constitutes equipment on the water station as well as the pipeline) in order to sense asset failures as soon as possible and preferably in their development stage. However, early fault detection is not of much use if it is not backed up with the ready availability of spares and maintenance expertise. The expectations placed on water station by its stakeholders are not just of continuous availability of operational assets, but also of the efficiency and reliability of support processes. IT and OT systems, therefore, need to enable maintenance workflow execution as well as decision support by enabling information manipulation on factors such as, asset failure and wear pattern; maintenance work plan generation; maintenance scheduling and follow up actions; asset shutdown scheduling; maintenance simulation; spares acquisition; testing after servicing/repair treatment; identification of asset design weaknesses; and asset operation cost benefit analysis. An important measure of effectiveness of IT and OT, therefore, is to treat operational technologies as information technologies are governing them with the same guidelines as the overall IT infrastructure is managed. An integrated governance framework of IT and OT will allow for setting up a regime that will provide standardisation of quality and interoperable information through development and procurement of appropriate hardware and software applications; establishing appropriate skill set of employees to process information; and the strategic fit between the asset lifecycle management processes and technology.

Governance of IT Based Asset Management

IT resources represent the combination of IT infrastructure, human IT resources, and the soft assets involved in the use of IT (Gunasekaran et al., 2006), such as the shared performance and prospect development potential of an organisation (Lin, 2007). Implementation of these technologies should, therefore, properly match the process requirements. Implementation considerations need to account for internal development of the organisation as well as addressing the external forces impacting the organisation. Organisations improve externally and internally by making decisions which may affect the learning, acquiring and operation of IT resources (Stoel and Muhanna, 2009). The closeness between the CEO and CIO can improve the organisation by bringing new technology and supporting organisational changes, which are vital for achieving internal efficiencies as well for competitiveness of the organisation (Ranganathan and Kannabiran, 2004; Booth and Philip, 2005). It is therefore, important to have appropriate governance structures in place that treat IT infrastructure and related resources as strategic assets and guide the organization on achieving internal as well as external efficiencies through the use of IT.

There are many definitions of IT governance in the extant literature. Some researchers argue that IT governance is the organisational capability operated by the board, executive management and IT management to organize the creation and implementation of IT strategy to certify the combination of business and IT (Grembergen, 2004).

However, IT Governance Institute (2005) describes it as the accountability of the leadership and posits that it is a fundamental component of Corporate Governance which involves the management and organisational structures and processes to certify that the organisation's IT maintain and broaden the organisation's strategies and objectives. Luftman

(1996) in Grembergen (2004) contends that IT governance is the extent to the rights for IT decision-making which is determined and shared between management and the processes of leadership in both IT and business enterprises that consists of IT priorities and IT resources distribution. These definitions show that the issues of IT governance has been approached and investigated by researchers from a variety of angles. However, this research accepts that IT governance is the decision rights and accountability framework for encouraging desirable outcomes and behaviours in the use of IT (Weil and Ross, 2004). In crux, IT governance addresses the organizational resources which control IT infrastructure, execute IT strategy, and ensure business IT assets fit with the business strategy (Brown, 2006). It embodies strategic information system planning and management, ensuring system reliability through internal controls, and managing-system related business risks (O'Donnell, 2004). IT governance involves the relationship between IT and business management by combining business systems thinking, which concerns business knowledge and understanding of IT to support the relationships and skills of employees in both business and IT areas (Liu, Lu and Hu, 2008). The five core areas of IT governance include value delivery, risk management, performance management, resources management, and strategic alignment. IT governance, thus, allows an organization to achieve three important objectives, which are decision-making, functional superiority, and risk management optimization. There are a variety of potential frameworks which may be suitable to apply or implement in organisations and different industries. IT governance is strongly influenced by factors such as company size, expansion forecasts, business processes, IT operations, industry, financial health of the organisation, and IT support infrastructure (Dehning, Richardson and Stratopoulos, 2005). However, the success of a governance framework depends upon aligning business goals and IT operational processes to deliver value, IT strategy, and build internal efficiencies; through effective audit, control and management of IT and related resources in diverse business aspects such as operation, compliance, finance and IT risk (Tuttle and Vandervelde, 2007).

Figure 2: Five Core Areas of IT Governance (IT Governance Institute 2005, p. 7)

Please see Figure 2 in full PDF version.

Figure 2 illustrates an IT based engineering asset governance framework. It is a learning centric framework and accounts for the core asset management processes as well as the allied areas where IT make contributions. It therefore accounts for the soft as well as the hard benefits gained from IT utilisation in an asset lifecycle.

This framework divides the asset lifecycle into 7 perspectives, where each perspective consists of processes that contribute to asset lifecycle management. The framework begins with assessing the usefulness and maturity of IT in mapping the organisation's competitive priorities into asset design and reliability support infrastructure. The framework thus assesses the contribution and maturity of IT through four further perspectives before informing the competitive priorities of the asset managing organisation. In so doing, the framework translates asset management strategy into action through the use of IT. At the same time, this framework could be used as an evaluation framework to examine the role of IT as strategic translators as well as strategic enablers of asset lifecycle management and enables generative learning. It means that instead of just providing a gap analysis of the desired versus actual state of IT maturity and contribution, it also assesses the information requirements at each perspective and thus enables continuous improvement through

action oriented evaluation
learning.

Capacity and Demand Management

In a usual asset lifecycle, asset demand and capacity specify the nature of assets, as well as the types of supportability infrastructure required to ensure asset reliability through its lifecycle. The success of IT at this stage depends upon the availability, speed, depth, and quality of information regarding competitive environment of the organisation. This information allows asset managers to measure the demands of asset customers, which specifies the types of assets or the improvements required in existing asset configuration to address the customers' demands. At this stage, asset managers require the

IT to provide them with decision support capabilities by accounting for economic and environmental constraints, optimised levels of asset utilisation, and costs of asset reliability to ensure sustainable service delivery. The nature of this information is multifaceted and therefore, requires scanning of the external business environment as well as taking into consideration the learnings gained over the years from managing assets employed by the organisation.

The value profile that asset managers attach to IT at this point, is of business intelligence management, so as to aid the design of the asset as well as the support infrastructure.

Within design perspective itself, there is a variety of information demands that the IT are required to fulfil. In a nutshell, the value profile of IT demanded by the asset designers specifies how the IT aid in asset design/re-design, installation, and commissioning. Nevertheless, each of these processes further consist of a series of activities that require an assortment of information to enable evaluations and alternative solutions, such that the organisation is able to choose the best possible solution to asset design/redesign. These alternatives are arrived at after having considered a series of analysis that encompass the capability potential and associated costs for ensuring reliability of the asset operation. The success factor of IT in ensuring asset supportability and design reliability is the depth and coverage of supportability analysis, which provide a roadmap for the later stages of the asset lifecycle. These analyses not only specify the costs associated with supporting the asset lifecycle, but also identify other critical aspects such as the throughput of the asset, spares requirements, and training requirements. Therefore, at this stage it is important to assess how IT meet the demands of asset design and design for supportability of asset reliability, as well as their integration with other IT in the organisation and the capacity of IT to preserve learnings and make them available throughout the organisation.

Disturbance Management

Asset workload is defined according to its ‘as designed' capabilities and capacity. However, during its operational life, every asset generates some maintenance demands. During the asset operation stage, the critical feature of

IT is to aid asset managers in managing disturbances. This requires availability of design as well as supportability information, as well as current information on the condition of an asset. Different organisations deploy different condition or health monitoring systems, such as sensors, manual inspections, and paper based systems.

Nevertheless, IT at this stage need to be able to provide consolidated health advisories by capturing and integrating this information, analysing asset workload information, health information, and design information to enable speedy malfunction alarms and communication of failure condition information to maintenance function. Many of the design errors surface during asset operation, therefore, it is also important to assess if the existing IT systems report back these errors to the asset design function so as to ensure asset design reliability. At the same time, it is important to assess the contribution of IT in enabling asset lifecycle processes under this perspective, along with the level of IT integration, and the contribution that they make in preserving lifecycle learnings.

Operational Risk Management

The notion of risk signifies the ‘vulnerabilities’ that asset operation is exposed to, due to operating in a particular physical setting or specific work conditions. Nevertheless, the success of risk management is dependent upon factors such as availability of expertise to carry out maintenance treatments, availability of spares, maintenance expertise, maintenance project management as well as complete information on the health status and pervious maintenance history of the asset. The role of IT therefore needs to be assessed for their ability to provide control of decentralised tasks and to ensure the availability of resources to keep the assets in near original state. However, as with the previous sections, the significant factor is to preserve the learnings from maintenance execution and making the same available to other functions of asset lifecycle so as to enable holistic decision support regarding asset maintenance, renewal, and retirement.

Asset Operation Quality Management

The aim of asset managing processes is to keep the asset to or near its original or as designed state throughout its operational life. Therefore, once a disturbance has been identified, it becomes crucial to curtail its impact to minimum and to take appropriate follow up actions. These follow up actions not only involve the direct actions taken on the asset such as maintenance execution, but also involve sourcing of maintenance, rehabilitation, and renewal materials and expertise as well as the contractual agreements. At the same time with the growing attention being given to the environment, it is equally important to ensure that the asset operation conforms to the governmental and industrial regulations, and to control the impact of disturbance on the environment. IT at this stage have a versatile role, and aid in maintenance and rehabilitation execution, enabling collaboration and communication, managing resources, as well as facilitating business relationships with external stakeholders and business partners. It is therefore important to measure these value provisions of IT at this stage.

Competencies Development and Management

During the course of performing asset lifecycle management activities, engineering organisations generate enormous amount of explicit as well as tacit knowledge. The knowledge thus generated, provides an organisation with competencies in managing its assets. IT not only has the ability to capture and process this knowledge, but can also facilitate knowledge sharing among organisational stakeholders. However, in order for this to happen, it is important to find the fit between the social and technical systems in the organisation, since competencies development depends upon the functional/technical knowledge, as well as cultural, social, and personal values.

Organisational Responsiveness

Functional integration and a consolidated view of the asset lifecycle facilitate the asset managing organisation in responding to the internal as well as external changes. IT play an important role in materialising such responsiveness, due mainly to their ability to provide asset lifecycle profiling from financial and non financial perspectives. These value assessments aid the organisation in making decisions, such as asset redesign, retirement, renewal, as well as cost benefits of service provision and asset operation, and assessments of market demands. Nevertheless, the fundamental requirements in producing these value assessments are the availability integrated and quality information that allow for an integrated view of asset lifecycle though maintaining the asset lifecycle learnings. This framework enables action oriented learning, as it highlights the gaps between the existing and desired levels of performance, thereby necessitating the need for corrective action through (re)investment in right technology and skills, and acceptance of the change in the organisation. The evaluation thus provides triggers for continuous improvement regarding IT employed for asset design, operation, maintenance, risk management, quality management, and competencies development for asset lifecycle management.

Conclusion

IT utilised in asset management not only have to provide for the decentralized control of asset management tasks but also have to act as instruments for decision support. However, information requirements for control and decision support in asset lifecycle management are prone to change, due mainly to the changes in the business, operational, and environmental environment. The ability of an organisation to understand these changes not only contributes to its responsiveness, but also improves its capacity to enhance reliability of asset operations, to deliver optimised level of asset lifecycle management. However, this ability is directly influenced by the way an organisation governs its IT infrastructure, which consequently acquires, processes, and presents information to enable asset managing organisations to understand these changes. This paper has presented a governance framework for IT utilised in engineering asset lifecycle management. This framework translates strategic objectives into action; aligns

organisational
infrastructure and
resources with information
technology and related
resources; providing
integration of lifecycle
processes; and ensures

informing asset and business strategy through value added decision support.

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