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Information Systems as Strategic Advisors and Strategic Translators – Proposing Information Centred Performance Management

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35. INFORMATION SYSTEMS AS STRATEGIC ADVISORS AND STRATEGIC TRANSLATORS – PROPOSING INFORMATION CENTRED PERFORMANCE MANAGEMENT

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Abstract

Information technologies, in general, and information systems, in particular, are fast becoming the prime enablers of success and survival in business organisations. These technologies, on one hand, enrich economic, social, and cultural environment of organisations, and on the other hand enhance their competitiveness. For asset managing engineering enterprise, information systems not only help in capturing, storing, and exchanging information, but also enable an integrated view of asset lifecycle management through integration and interoperability of lifecycle information. The variety of systems and the range of objectives associated with these systems demand that organisations need to take stock of their capabilities, resources, and aspirations to enable informed choices regarding Information systems investments. This paper tackles the issue of performance management of information systems utilised in asset lifecycle management, by providing a performance evaluation framework. The framework institutes a generative learning based continuous improvement regime for asset lifecycle management. It provides a cyclical approach to performance measurement such that it assesses and informs the role of Information systems in translating and informing the asset management strategy in a single cycle, thereby enhancing competitiveness of asset managing engineering enterprises.

Keywords
Information systems, information, performance, learning.

1. Introduction

Information systems (IS) utilised for engineering asset management constitute an important aspects of IT investments in engineering organisations. Engineering organisations traditionally take a deterministic view of technology while adopting IS (Haider 2007), and thus, their emphasis is more on the outputs rather than the cause and effects that shape and institutionalise technology in the organisation. Role of IS in asset management is quite diverse. IS with their process enabling characteristic act as strategic translates of asset management, and with their information analyses abilities advise asset strategy by enabling asset mangers to make informed decisions. The variety of systems and the range of objectives associated with these systems demand that organisations need to take stock of their capabilities, resources, and aspirations to enable informed choices regarding IS investments. An attempt to evaluate IT investment should be aimed at understanding the context within which the IS are deployed, as well as the processes that affect and are affected by their use. Performance evaluation, thus, is a subjective activity that cannot be detached from the human understanding, social context, and cultural environment, within which it takes place. Evaluation of IT investments, therefore, means assessments of hard quantifiable benefits that appear on an organisation's financial statements, as well as soft qualitative benefits that are reflected in organisational culture, behaviour, and intellectual capital. This paper focuses on the IS utilised for asset life cycle management and proposes an information centric performance evaluation framework. It starts with a discussion the IS utilised for asset management, which is followed by an analysis of issues involved in the evaluation of these systems. The paper then presents a comprehensive evaluation framework for asset management.

2. Asset Management

The term asset in engineering organisations 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. Oxford Advanced Learner's Dictionary describes an asset as valuable or useful quality, skill or person; or something of value that could be used or sold to pay of debts (OALD 2005). These two definitions imply that an asset could be described as an entity that has value, creates and maintains that value through its use, and has the ability to add value through its future use. This means that the value it provides is both tangible and intangible in nature. A physical asset should be taken as an economic entity that provides quantifiable economic benefits, and has a value profile (both tangible and intangible) depending upon the value statement that its stakeholders attach to it during each stage of its lifecycle (Amadi-Echendu 2004). Management of assets, therefore, entails preserving the value function of the asset during its lifecycle along with economic benefits. Consequently, asset management processes are geared at gaining and sustaining value from design, procurement and installation through operation, maintenance and retirement of an asset, i.e. through its lifecycle. Asset management is a strategic and integrated set of processes to gain greatest lifetime effectiveness, utilisation and return from physical assets (Mitchell and Carison 2001). According to Hastings (2000), asset management is derived from business objectives and represents set of activities associated with asset need identification, acquisition, support and maintenance, and disposal or renewal, in order to meet the desired objectives effectively and efficiently. Fundamental aim of asset management is the continuous availability of value that it enables to its stakeholders through its service, production, or manufacturing provision. Consequently, asset management processes interact with a variety of other business processes within the business as well as with business partners, in order to allow for activities such as demand management, procurement, logistics, maintenance and repairs, and customer relationship management. Therefore, asset management is a set of disciplines, methods, procedures and tools derived from business objectives aimed at optimising 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 organisation's assets (Woodhouse 2001).

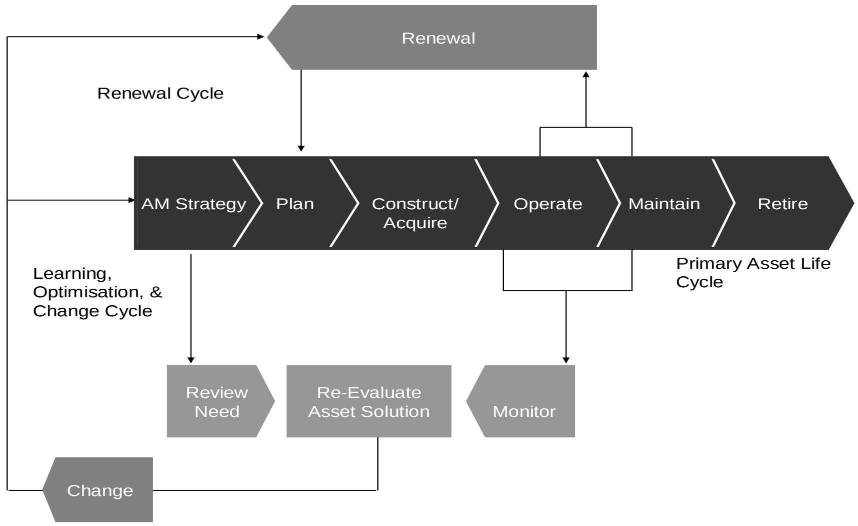

Figure 1: Core Asset Management Lifecycle (Haider 2007)

Core asset management processes are derived from the asset management strategy and are arranged through operating plans and procedures. These processes represent the primary asset lifecycle through stages such as, asset design, acquisition, construction, and commissioning; operation; maintenance; refurbishment; decommissioning; and replacement. An asset lifecycle management process, thus, consists of three cycles, i.e. primary asset management cycle, learning and change cycle, and renewal cycle (figure 1).

The learning, optimisation, and change cycle is aimed at changing of an asset solution in the existing asset solution to meet stakeholders' needs. Therefore the essential aims of this exercise are, firstly, to identify enhancements in asset solution design, and secondly, if the first response to factors such as asset need redefinition, technology refresh, environmental and regulatory concerns, and maintenance and other economic trade offs. However, the crucial factor in this cycle is the ability of the organisation to have complete information on asset lifecycle so as to evaluate and compare its outputs with the business objectives. The gap analysis provides learnings on effectiveness of is not possible, to provide alternatives for asset renewal. Subsequently, the learning, optimisation, and change cycle has a much greater impact calls for redefinition of asset strategy, whereas the renewal cycle does not go as far and necessitates adjustment to asset management plan. The core objective of asset management processes is to preserve the operating condition of an asset to near original condition. IS are an integral part of an asset lifecycle management and perform various tasks at each stage of the lifecycle through data acquisition, processing and manipulation operations. However, the scope of IS in asset management extends well beyond the usual data processing and reaches out to business value chain integration, enhancing competitiveness, and transformation of patterns of business relationships (Haider and Koronios 2006).

3. Theoretical Foundations of IS Implementation

IS implementation is an organizational effort to diffuse and appropriate technology in a user community (Haider 2007). This user community has some aspirations attached to the use of technology, which characterise the values and interests of various social, political and organizational agents (Ihde 2002). Walsham (1993) notes that IS implementation needs to cover all the human and social aspects and impacts of implementation in organizations. Effectiveness of IS implementation, therefore, becomes a subjective term. Implementation of IS thus becomes a process that deals with how to make use of hardware, software and information to fulfil specific organizational needs. This perspective of IS implementation is generally governed by two quite opposing views. In a technology driven view, humans are considered as passive entities, whose behaviour is determined by technology. It is argued that technology development follows a casual logic between humans and technology, and therefore is independent of its designers and users. This mechanistic view assumes that human behaviour can be predicted, and therefore technology can be developed and produced perfectly with an intended purpose. This view may hold true for objective machine such as, microcontrollers which have a determined behaviour; whereas for information systems this view has inherent limitations due to its disregard of human and contextual elements. A corollary of this objective view is the managerial assumption that information systems implementation increases productivity and profitability. This view basically works on the assumption that social and organisational transformation is measurable and therefore can be predicted. Consequently, management decisions are governed by the expectations from technology rather than the means that enable technology to deliver the expectations. Although, it is clear that these approaches have inherent limitation, yet these views dictate majority of contemporary research and practice.

The opposing stance to traditional technical view is much more liberating and takes a critical scrutiny of the deterministic technological and managerial views of the relationship of technology with human, organisational, and social aspects. This view illustrates that technology has an active relationship with humans, in the sense that humans are considered as constructors and shapers of technology as well as reality. In this stance, technology users are active rather than passive, and their social behaviour, interaction, and learning evolves continuously towards improving the overall context of the organisation. This organisational change, as a result of IS implementation, is not a linear process and represents intertwined multifaceted relations between people in a variety of opposing forces, which makes the human and organisational behaviour highly unpredictable. This unpredictability is attracting attention of researchers to uncover the relationship between humans and technology, and development of emancipatory human centred technology (Walsham 1995). As a consequence, IS implementation is increasingly being considered as strategic translation through accomplishment of social action, and technological maturity in an organisation is viewed as an outcome of strategic choices and social action.

These two views provide divergent perspectives on technology implementation and use, with one considering it as structure and the other as process. Considering it as structure, demonstrates that technology determines the business processes; whereas the process view argues that technology alone cannot determine the outcomes of business processes and in fact it is open to an intentional propose. Schienstock *et al.* (1999) summarises various perceptions on implementation of technology using different descriptions (see Table 1). When these descriptions are viewed in the light of the two views described here, the first three metaphors, i.e. tool, automation and control instrument conform to the technical view. The process metaphor matches the emancipatory view; whereas the organisation technology and medium metaphors are debateable and can conform to either view.

Metaphor	Function	Aim
Tool	Support business process	Increase quality, speed up work process, cope with increased complexity
Automation technology	Elimination of human labour	Cost cutting
Control instrument	Monitoring and steering business process	Adjustment to changes, avoiding defects
Organisation technology	Co-ordination of business processes	Transparency, organizational flexibility
Medium	Setting up of technical connections for communication	Quick and intensive exchange of information and knowledge
Process	Improve information system	Continuous learning

Table 1: Perceptions on Technology Implementation
(Schienstock *et al.* 1999)

In crux, review of literature on IS adoption and implementation reveals that researchers have attempted to address these issues from many different perspectives. At the same time, it also reveals that the value profile that organisations attach to IS implementation spans from simple process automation to strategic competitiveness. These theories have originated from diversified fields of knowledge, such as business management, organisational behaviour, computer science, mathematics, engineering, sociology, and cognitive sciences. Therefore, value profile of IS varies with their area of implementation and the organisational level where it is implemented. IS users are not isolated individuals but operate within the cultural norms or values which influence the use of IS in an organization. At the macro level, the corporate image and strategic orientation of the organization may influence the adoption of IS. At the micro level, there exist different attitudes arising from different sub-cultures within the organization which influence IS use. For example, the IS department may be enthusiastic about adoption of a certain IS, however, the finance department, which is where the system is to be deployed, may be reluctant to the change. IS projects in large organisations are more successful if the organisational culture is such that the employees identify more with the organisation, where work activities emphasize groups, and where there is a strong unit integration, high risk tolerance, performance-based rewards, high conflict tolerance, an open-systems focus and a balanced focus on people, control and means-orientation (Schawlbe 2006). However, a practical work environment which ticks all these boxes is very rare and as a result, problems arise and evolve which affect the whole process of IS system implementation. The following sections provide theoretical overview of the IS utilized for asset management, and then illustrate the value profile of IS achieved by asset managing organisations.

4. IS as Strategic Advisors and Strategic Translators of Asset Management

In theory IS utilised in asset management has three major roles; firstly, they systems capture, store, and exchange information spanning asset lifecycle processes; secondly, they provide decision support capabilities through the analytic conclusions arrived at from analysis of data; and thirdly, they enables an integrated view of asset management through integration and interoperability of asset lifecycle information IS thus help in translating asset management strategy into action by enabling asset lifecycle processes, and also inform the asset management strategy through their ability to analyse lifecycle information that asset mangers use in lifecycle planning and decisions. IS for asset management, thus, 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 2).

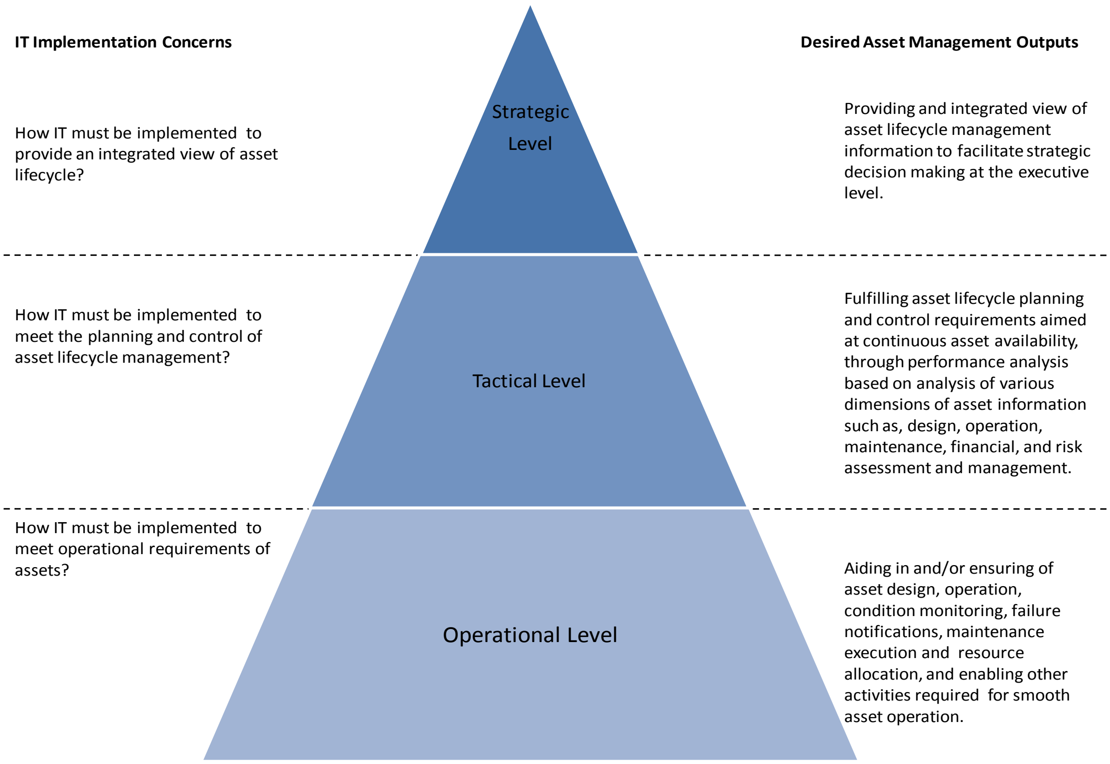

Figure 2: Scope of IS for Asset Management

At the operational and tactical levels, IS 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 drive future asset behaviour, therefore the minimum requirement laid on IT at this stage is 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 recognised 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.

IS for asset management not only has to provide for standardised 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 minimising the disturbances relating to production or service provision of an asset. At this level, it is important that IS 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 IS employed at this stage that capture data from sensors and other field devices to diagnostic/prognostic systems; such as Supervisory Control and Data Acquisition (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. IS, 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 IS, therefore, is the level of integration that they provide in bringing together different functions of asset lifecycle management, as well as stakeholders, such as business partners, customers, and regulatory agencies like environmental and government organisations.

5. Evaluation of IS for Asset Management - A Wicked Problem

IS evaluation is often difficult and a wicked problem, due mainly to its varying roles in different organisations. Evaluation by nature is a subjective term and is defined in the Oxford Advanced Learner's Dictionary as, the process of judging or forming an idea of the amount, value, or worth of an entity (OALD 2005). Neely *et al.* (1995) suggest that performance is the measure of efficiency and effectiveness of action; and performance evaluation is the process of measuring accomplishments, where measurement deals with quantification of action and accomplishment illustrates performance. Tangen (2004) takes the argument further and contends that performance evaluation represents the set of metrics used to quantify the efficiency and effectiveness of organisational actions taken towards achieving its objectives. The efficiency and effectiveness constitute the value profile that the organisational stakeholders attach to action in an organisation. In light of this discussion IS evaluation could be defined as an assessment of value profile of IS to asset lifecycle using appropriate measures, at a specific stage of IS lifecycle within each stage of an asset lifecycle, towards continuous improvement aimed at achieving the overall organisational objectives. However, role of IS investments in asset management is no more considered as inwardly looking systems aimed at operational efficiency through process automation; in fact, it extends beyond the organisational boundaries and also addresses areas such as business relationships with external stakeholders, to deliver business outcomes. This complicates the process of decision making for IT investments, since this decision needs to take care of the impact of the investment on business processes and resources, as well as integration of these technologies with other systems. However, IS evaluation, generally has a narrow focus and involves people who cannot evaluate IT on anything other than technological dimensions. Consequently, simplistic measures are adopted to measure the effectiveness of IS, while these efficacy criteria are aimed at process efficiency rather than its prospectus of organisational transformation. The measurement attributes involved in such IT investments, require both aspects of IT benefit to be taken care of i.e. soft benefits, such as stakeholder satisfaction, and customer relationship management; and hard benefits, such as cost, IS throughput. However, evaluation methods wanting in completeness render the accuracy and credibility of evaluation mechanisms questionable, in terms of their role as instruments of decision support. In IS evaluation the generally applied generic performance measures are financial measures, such as costs of implementation; technical measures, such as response time; system usefulness attributes, such as user satisfaction; and quality of the information (DeLone and McLean 1992). IS, however, are social systems embedded within the organisational context and choosing criteria that encompasses evaluation of all the IS benefits is a difficult task. Teubner (2005) points out these difficulties are due to a range of factors, such as,

a. *Technical Embedding.* Individual IS components are often embedded in the overall technological infrastructure, which makes it difficult to assess the performance of these individual components. For example, while evaluating the effectiveness of a condition monitoring system, it is difficult to quantify the contribution of individual sensors.
b. *Organisational Embedding.* IS infrastructure is an integral part of an organisation, and influences and is influenced by a number of organisational factors, such as culture and structure of the organisation. Consequently it has progressively become difficult to take the impact of IS apart from these organisational aspects. IS utilised in engineering 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. For example, a critical aspect of effective asset lifecycle management is the learning or knowledge gained at each stage, which provides for the feedback to other processes. Asset operation profiling has significance for asset redesign as well as asset maintenance, asset operation cost benefit analysis, and lifecycle decision support. Furthermore, the utility of an IS is not just restricted to the business process or process that it enables, but is also reflected in the ambiance of the organisation, such as through job satisfaction, culture, and social environment.

c. *Social Construction.* The social impact of IS is well documented, which makes it much more than just a technical solution. Impact of changes that IS implementation brings affect work practices as well as the intellect and working habits of employees. However, impact of IS on staff, social life of the organisation, and collective sense making, is intangible and is difficult to measure.

d. *Social Adoption.* IS adoption is a social process, since their use evolves over time and depends heavily upon skills of employees and culture of the organisation. It also means that IS may not start delivering desired results straight after their implementation. Evaluation criteria, therefore, needs to account for the time frame of IS lifecycle within which evaluation is to be carried out.

In light of above discussion, evaluation of IS for asset lifecycle management need to be comprehensive, which evaluates various hard and soft dimensions of IS and their impact on the organisation and strategic orientation of asset management; fit of IS with the information requirements of the asset lifecycle management processes; and contribution of IS in creating a unified view of asset lifecycle. This evaluation, thus, needs to provide insights into the effectiveness of asset lifecycle management through IS utilisation, and enable feedback on the relevance and fit of existing asset management strategies so as to enable continuous improvement.

6. Constructing an Evaluation Framework

IS for asset management evaluation depends upon three dimensions, i.e. the asset lifecycle processes that the IS enable; the elements of an IS, such as software, hardware, information, and skills; and the value profile attached to IS at each stage of asset lifecycle, such as efficiency, effectiveness, availability, compliance, and reliability of an asset solution. Figure 3 illustrates a three dimensional integrated view of IS based asset management.

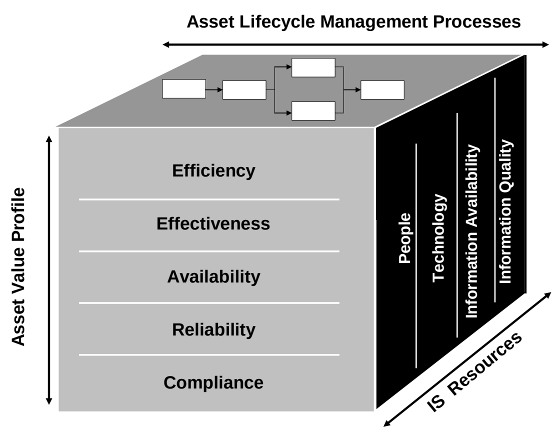

Figure 3: Dimensions of an Integrated IS based asset management evaluation

In order to have a complete measurement of the effectiveness of IS, different dimensions of IS must be assessed in terms of translating asset lifecycle management strategy into action, as well as advising strategy through decision support. However, in order to institutionalise a competitive IS based asset management regime, it is essential to focus on continuous improvement of asset lifecycle management processes rather than just fixing faults and errors. IS should enable constructive action oriented feedback, which enables continuous improvement in asset lifecycle management processes and the IS infrastructure that supports these processes. Such learning necessitates systemic thinking, shared vision, personal mastery, collective learning, and creative tension between the existing situation and vision. Having a generative learning focused performance evaluation methodology not only provides for the assessment of the tangible and intangible contributions of IS to asset lifecycle management, but also provides assessment of the maturity of IS infrastructure.

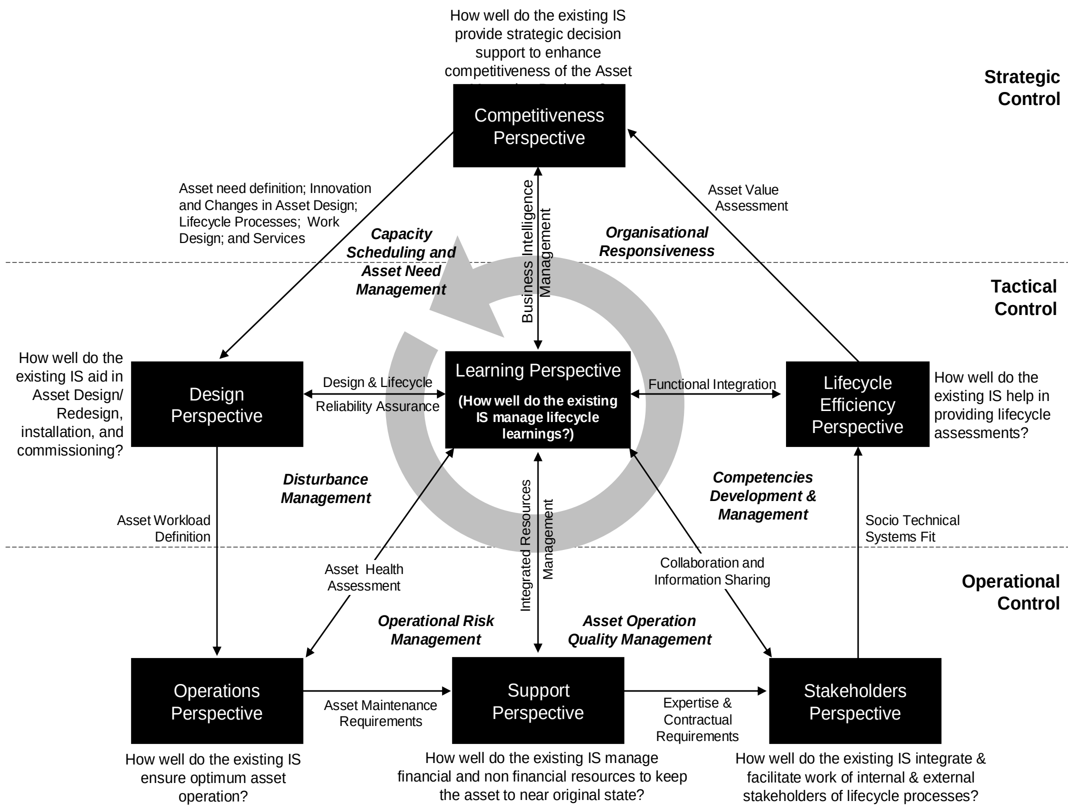

Figure 4: IS Based Asset Management Performance Evaluation Framework

Figure 4 illustrates an IS based asset management performance evaluation framework. It is a learning centric framework and accounts for the core IS based asset management processes as well as the allied areas where IS also make contributions. It therefore accounts for the soft as well as the hard benefits gained from IS 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 IS in mapping the organisation's competitive priorities into asset design and reliability support infrastructure. The framework thus assesses the contribution and maturity of IS through four further perspectives before informing the competitive priorities of the asset managing organisation. In so doing, the framework evaluates the role of IS 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 IS maturity and contribution, it also assesses the information requirements at each perspective and thus enables continuous improvement through action oriented evaluation learnings.

Capacity and demand management is a direct by product of the asset lifecycle strategy. In a usual asset lifecycle asset demand and capacity specifies the nature of assets, as well as the types of supportability infrastructure required to ensure asset reliability through its lifecycle. The success of IS 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 IS 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 IS 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 are a variety of information demands that the IS are required to fulfil. In a nutshell, the value profile of IS demanded by the asset designers specifies how the IS 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 chooses 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 IS 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 analysis 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 IS meet the demands of asset design and design for supportability of asset reliability, as well as their integration with other IS in the organisation and the capacity of IS to preserve learnings and make them available throughout the organisation.

Disturbance management deals with minimisation of asset shut down and any issues that hamper the asset to accomplish its workload. 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 IS 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, IS 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. As noted with the discussion of reliability paradigms in section 2.2.3, many of the design errors surface during asset operation. It is, therefore, also important to assess if the existing IS report back these errors to the asset design function so as to ensure asset design reliability. At the same time, it is important to asses the contribution of IS in enabling asset lifecycle processes under this perspective, along with the level of IS integration, and the contribution that they make in preserving lifecycle learnings.

Operational risk management deals with reducing the vulnerabilities of the asset lifecycle management processes. 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 IS therefore need 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 ensures smooth functioning of the asset, the processes that help it to function, and the support processes. 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. IS 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 IS at this stage.

Effective asset management calls for development of competencies operating and maintaining assets. This requires cross functional communication and sharing of knowledge. 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. IS not only have 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.

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, and thus improve organisational responsiveness. IS 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 allows 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 IS employed for asset design, operation, maintenance, risk management, quality management, and competencies development for asset lifecycle management. However, in order for that to happen, it is important that this framework be applied to the four dimensions of IS in a systematic way, where perception of IS suitability and fitness of purpose that different stakeholders attach to it is assessed first. This feeds into an objective evaluation to assess the fit between the processes and technology in terms of the systems matching the information requirements. This provides input to contextual evaluation, where the emphasis is on measuring the four dimensions according to the prevailing operational, cultural, and social environment. After having done that, evaluations into maturity of technical architecture as well as businesses processes could be made. Evaluation in this way becomes a longitudinal study, however it ensures that it covers soft as well as hard aspects of IS, i.e., role of IS from simple data acquisition to enabling an organisation environment conducive to learning.

7. Conclusion

Performance management of IS for asset management is an important aspect of IT investment and management in engineering organisations. Realisation of an effective performance management methodology, however, is extremely difficult due to a variety of organisational, technical, operational, and conceptual issues involved. An attempt to evaluate IT investment should be aimed at understanding the context within which the IS are deployed, as well as the processes that affect and are affected by their use. This paper has demonstrated that evaluation of IS for asset management calls for ascertaining both hard as well as soft benefits to the organisation by using quantitative as well as qualitative means and their connection to organizational development. The framework developed in the paper provides an actionable learning in terms of alternatives and choices, which acts as a strategic advisory mechanism that supports planning, decision making, and management processes. Evaluations from this framework provide feedback that facilitates learning, which indicates the fundamental reasons, factors, and causes for abnormal performance of IS. In doing so, it creates a roadmap that guides continuous improvement in the technical infrastructure that supports asset lifecycle.

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