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Information systems implementation in production environments

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Education and research trends

ABSTRACT

Purpose: This paper discusses the issue of information systems for managing plant and equipment assets utilised in production and service provision environments. It takes a holistic systems view of the business environment and proposes a generative learning centric framework that provides valuable learnings on the value that information systems provide and the maturity of the processes that they enable.

Design/methodology/approach: It starts with establishing the definitions and descriptions of asset and its management and the role of information systems in production and manufacturing environments as well as in asset lifecycle management. This is followed by a detailed discussion of information system implementation for asset lifecycle management, by accounting for their alignment with the business objectives and their fit with the organization's cultural, social, and technical settings. The paper then presents a generative learning centric framework that provides valuable learnings on the value that information systems provide and the maturity of the processes that they enable.

Findings: Theoretically, information collected throughout the asset lifecycle provides the basis for analysis aimed at generating valuable learnings that could be used to enable generative learning.

Practical implications: Generative learning not only serves as the basis for evaluation of asset lifecycle management processes performance, but in so doing also highlights the gaps between the existing and desired levels of performance; thereby informing the asset management strategy and plan.

Originality/value: The information systems frameworks provide for a continually improving asset management regime and its enabling infrastructure by extending the resource based view of asset management to a knowledge based view, thereby building competencies that contribute to competitiveness and responsiveness of the organisation.

Keywords: Learning; Asset management; Information systems; Organisational culture; Information systems implementation; Organisational alignment; Functional integration

1. Introduction

Information Technologies are fast becoming the prime enabler 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. This trend is also evident in the information systems utilised to support the lifecycle of critical asset plant and equipment employed by manufacturing and production businesses. Information systems utilised for asset lifecycle management not only have to provide for the acquisition, exchange, processing, and storage of information relating to asset lifecycle, but also have to provide for the control of information and knowledge guiding lifecycle processes and decision support for lifecycle planning and execution. Information systems for asset management, therefore, are required to provide an integrated view of lifecycle information so as to ensure smooth flow of asset lifecycle and to ensure that informed choices about asset lifecycle

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planning and execution could be made. The realisation of this integrated view, however, requires appropriate hardware and software applications; quality, standardised, and interoperable information; appropriate skill set of employees to process information; the strategic fit between the asset management processes and the information systems; and a conducive organisational environment.

A critical aspect of Information technology adoption in general and information systems in particular, is to find the strategic fit between the way an organisation executes its businesses and the technologies selected to aid in its execution. Information systems deployment should not be viewed as technical constructs or information deposits; in fact they are systems involving people and are embedded in human organizations. Organisations' expectations associated with adoption of information systems are quite diverse, such as operational efficiency, reduction in operating expenses, or enhanced competitiveness. However, there are divergent views held about the value creation of information systems investment. Although, recent studies have concluded that information systems investments provide positive economic returns; nevertheless the impact of information systems investments varies within organisations. Evidence found in literature, both industry and academic, sustains the argument of success (see for example, [1]) and failure (see for example, [2]). The reason for this polarisation is the propensity to neglect the active interaction and shared shaping between technology and people [3].

This paper discusses the issue of information systems implementation for the lifecycle support of plant asset equipment used to produce products and services. It starts with establishing the definitions and descriptions of asset and its management and the role of information systems in production and manufacturing environments as well as in asset lifecycle management. This is followed by a detailed discussion of information system implementation for asset lifecycle management, by accounting for their alignment with the business objectives and their fit with the organization's cultural, social, and technical settings. The paper then presents a generative learning centric framework that provides valuable learnings on the value that information systems provide and the maturity of the processes that they enable. This framework thus aids asset and technology managers in matching information systems with asset lifecycle processes requirements and in so doing ensures the fit between technology, business processes, and business objective.

2. Production assets management

The term asset in manufacturing or production environments 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 [4], 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 [5]. 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, thus, 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. 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 [6].

Management of assets has been approached in various ways in industry and academic research. Economic benefits have traditionally been an implicit or explicit value expected from an asset, the concept of terotechnology was therefore introduced in Britain around 1970 [7]. Having its origin in resources management, it terms asset management as combination of management, financial, engineering, and other practices applied to physical assets in pursuit of economic life-cycle costs. Its practice is concerned with specification and design for reliability and maintainability of plant machinery, equipment, buildings, and is structured by their installation, commissioning, maintenance, modification, replacement, and feedback of information on design, performance, and costs [8].Concept of terotechnology stresses minimising cost of owning an asset over its lifecycle. To achieve this aim, this concept states that it is necessary to lower the traditional boundaries between the design, operation, maintenance, production, finance, and other functions. Terotechnology embraces both the aim of lifecycle cost optimisation and the multifunctional approach to achieving it. Modern asset management owes its genesis to terotechnology, which although extensive, still is predominantly maintenance oriented and cost focused.

Asset management is, however, a strategic and integrated set of processes to gain greatest lifetime effectiveness, utilisation and return from physical assets. 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 [9]. This definition suggests that the scope of asset management processes is geared at three levels, i.e. operational, tactical, and strategic. Operational level represents the set of activities necessary to keep the asset up and running to meet the stakeholders' needs; tactical level represents operational asset management i.e. including asset lifecycle support management; and the strategic level represents a long term focus on asset management from a total cost of ownership perspective. In crux, asset management is policy driven, information intensive, value adding, and is aimed at achieving cost effective peak asset performance. The core objective of asset management processes is to preserve the operating condition of an asset to near original condition. In theory, Information systems have an integral role in asset management. At the operational level, these systems business processes at each stage of asset lifecycle, at the tactical level these systems allow for decision support on how best these processes could be executed, and at the strategic level these systems allow for integration of business value chin aimed at creating value for the entire business through the effective management of these assets [9].

3. Social nature of technology implementation

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 [9]. Owing to this deterministic view of technology, managerial expectations from investments in information systems are those of increased quality and quantity of output, as well as substitution of human effort through automation [10]. Haider [9] further asserts that engineering enterprises adopt a traditional technology-centred approach to asset management, where technical aspects command most resources and are considered first in the planning and design stage. Skills, process maturity, and other organisational factors are only considered relatively late in the process, and sometimes only after the systems are operational. However, human, organisational, and social factors have a direct relationship with information systems, which underscores the social nature of information systems.

Information systems implementation is a contextualised activity that cannot be detached from the human understanding, social context, and cultural environment, within which these systems are deployed. Information systems implementation, therefore, is influenced by the actors who carry out this exercise; and the principles and assumptions that they employ to implement the technology. Central to these assumptions are the information requirements of the processes that these systems enable. Considering the fact that the information requirements and their human interpretation shapes and reshapes over a period of time, the nature of suitability of technology also changes from time to time. Information systems implementation, thus, is aimed at the existing aspirations and interests that individuals or communities associate with the use of technology within the socio technical environment of an organisation. The focal point of socio technical perspective is the interactive association between people, Information systems, and the social context of the organisation [11]. However, action is an important element of this interaction. This notion of action is contained in the structuration theory [12], which describes that it is facilitated and influenced by the social structure. People's interaction is, therefore, fashioned by the social structure and their actions persistently shape or transform social structure [13]. There is, thus, a dynamic relationship between technology, and the context within which it is employed and humans who interact with technology and construct it both socially and physically.

When technology is physically adopted and socially composed, there is generally a consensus or accepted reality about what the technology is supposed to accomplish and how it is to be utilized. This temporary interpretation of technology is institutionalised and becomes associated with the actors that constructed technology and gave it its current significance, until it is questioned again for reinterpretation. This requirement of reinterpretation may grow owing to changes in the context, or the learning that may render the current interpretation obsolete. Technology, therefore, is not an objective entity, such that it could either be implemented without considering its interaction with social and human factors, or it could be viewed in basic and one-dimensional economic terms.

4. Perspectives on information systems implementation

In computer science implementation is considered as an activity that is concerned with installation of the hardware system and software applications, and is centred entirely on the technical aspects of the systems development process. On the other hand, in information systems paradigm, implementation is a process that deals with how to make use of hardware, software and information to fulfil specific organizational needs [14]. This perspective of information systems 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 s result of information systems 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 [15]. As a consequence, information systems 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 use of 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.* [16] 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.

Table 1.
Perceptions on Technology Implementation [16]

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

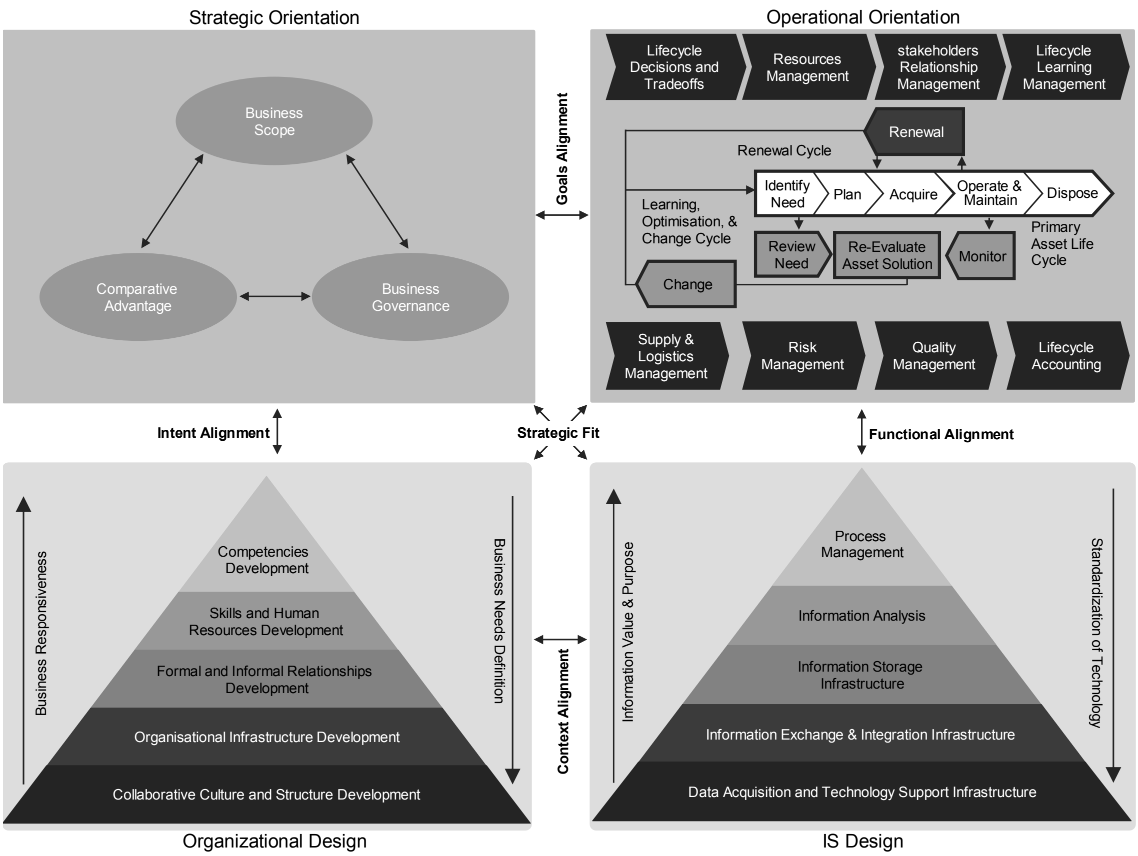

Fig. 1. Information systems implementation for asset management [9]

5. Information systems for asset lifecycle management

It has been argued before that information systems implementation and its alignment with organisational environment, infrastructure, and strategy do not follow a mechanistic pattern, and require time to take shape and deliver the expected results. It is a process that is socially and technically embedded in an organisation and therefore requires maturity of interacting actors and infrastructure to provide an appropriate level of fit.

Haider [9] thus proposes an approach to information systems implementation for asset management and their alignment with the organisational subsystems as well as the overall organisation. The author proposes an information systems based alignment framework as illustrated in Figure 1. It treats alignment as a process that is technically and socially embedded in the organisation; and highlights the role of information in shaping alignment. The framework treats information as the key enabler and emphasises that information systems implementation is not a managerial process or activity. In actual fact it is a social process that is continuously aimed at aligning information systems with business objectives and requirements.

Proponents of contingency theory suggest that performance of an entity, (for example information systems or an organisation) is contingent upon various internal and external constraints. These theorists further highlight three important points, i.e. there is no one best way to manage an organisation; subsystems of an organisation need to be aligned with each other as well as the overall organisation; successful organisations are able to extend this fit to the organisational environment; and organisational design and management must satisfy the nature of the task and the work groups. The framework applies systems theory [17] and instead of considering the organisation's or its constituent domains' properties alone, it builds upon the relationships and understanding of the domains that collectively provide for the information systems alignment within and with the organisation. Haider [9] argues that contingency theory stresses multivariate nature of organisations, and along with systems theory it assists in understanding the interrelationships within and among subsystems of an organisation. This framework embodies these relationships and applies the theory of dynamic capabilities to address the changing nature of the asset management business environment, by stressing integration, building, and reconfiguration of competencies to address the changing business environment [18].

The framework takes a resource based view and proposes four domains, i.e. strategic orientation, operational orientation, information systems design, and Organisational design. Analogous to Henderson and Venkatraman's [19] model, it argues that strategic orientation of the asset managing organisation is defined through the interaction of business scope, unique competencies, and business governance choices. Operational orientation of an asset management organisation is derived from this strategic orientation. The framework seeks to develop alignment of asset lifecycle management processes' goals with the organisation's objectives and gaols. The asset lifecycle management domain is strategically aligned with the organisational design domain in the sense that not only the asset lifecycle objectives are met, but they also contribute to the responsiveness of the organisation, and in so doing help asset lifecycle management processes to adapt to changes in the internal as well as external business environment.

Requirements of asset lifecycle processes derive the information systems design required to support the execution of lifecycle processes. The alignment sought between these two domains is aimed at functional integration of asset lifecycle. information systems design domain, therefore, develops a two way approach, i.e. top down and bottom up. It argues that the fundamental element of information systems design is to provide standardised information to enables processes, and as the information and information systems enable the business processes its value and purpose increases. To ensure information integration and quality the information systems design domain takes a bottom up approach and stresses standardised data acquisition and technology support infrastructure, which facilitates information integration and communication, and consequently allows for information storage in a way that it is accessible and available throughout the organisation. The analysis layer refers to both, the analysis to evaluate if the existing standard of information and information systems are meeting the process and organisational objectives (hence the strategic alignment between the information systems design domain and strategic orientation); and the decision support that is required to enable various stages of an asset lifecycle. Since quality of the processes strongly depends upon quality of information, the analysis layer also measures the alignment between and within the information systems and the processes. However, technology use and its institutionalisation are not mechanistic processes and rely on the culture, structure, and actors of an organisation. Therefore the framework proposes contextual alignment between information systems design and organisation design domain.

Organisational design takes time to develop and its alignment with information systems is also subjected to the same constraints. Therefore, the organisation design domain argues the 'development' of collaborative culture and structure as the fundamental element of organisational design. This foundation provides the building block for developing the organisational infrastructure, which shapes the formal and informal relationships, and drives human resources management and skills development. The base thus achieved provides for the development of core competencies that aid in developing the comparative advantage of the organisation through alignment of intent. In so doing, the organisational design domain improves the responsiveness of the organisation, which enables the organisation to respond to the changes in the business environment. At the same time the organisational design domain is strategically aligned to the operational orientation domain, therefore, it accounts for the objectives of the overall business as well as the asset lifecycle demands and goals. It thus provides the context within which the information systems are employed, shaped, and institutionalised. It is clear that the context of the organisation is subjected to internal as well as external change; therefore the framework suggests context based dynamic alignment between information systems design and organisational design domains.

Having set the high level priorities for information systems implementation for asset lifecycle management, the following section discusses in detail the information systems based asset management. The emphasis of this section is on the top right hand quadrant in Figure 1 and illustrates how information systems deployed at different asset lifecycle stages contribute towards the immediate aim of enabling asset lifecycle requirements and towards achieving the overall goals of organisational and functional integration by accounting for the technical, social, ad cultural requirements of the organisation.

6. Information systems based asset management framework

In order to institutionalise a competitive information systems based asset management regime, it is essential to focus on continuous improvement of asset lifecycle management processes rather than just fixing faults and errors. Therefore, information systems should enable constructive action oriented feedback, which enables continuous improvement in asset lifecycle management processes and the information systems 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 [20]. Having a generative learning focused performance evaluation methodology not only provides for the assessment of the tangible and intangible contributions of information systems to asset lifecycle management, but also provides assessment of the maturity of information systems infrastructure. Figure 2 illustrates an information systems based asset management framework. It is a learning centric framework and accounts for the core information systems based asset management processes as well as the allied areas where information systems also make contributions. In so doing, it accounts for the soft as well as the hard benefits gained from information systems utilisation in an asset lifecycle.

This framework divides the asset lifecycle into 7 perspectives, where each perspective consists of processes that contribute to overall asset lifecycle management. The framework begins with assessing the usefulness and maturity of information systems in mapping the organisation's competitive priorities into asset design and reliability support infrastructure. The framework thus assesses the contribution and maturity of information systems through four further perspectives before informing the strategic priorities of the asset managing organisation. In so doing, the framework

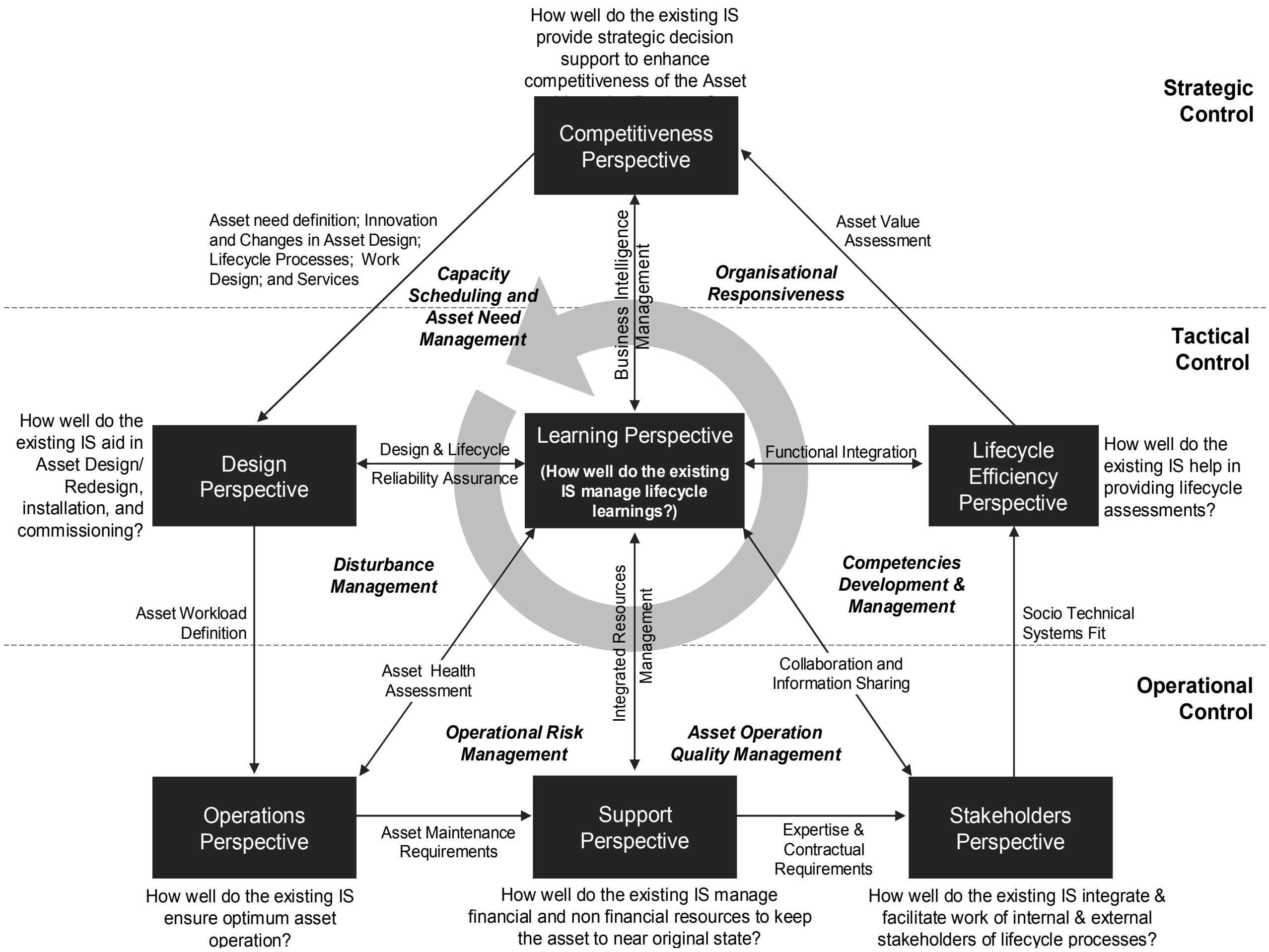

Fig. 2. Information systems based asset management framework

evaluates the role of information systems 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 information systems maturity and contribution, it also assesses the information requirements at each perspective. These requirements form the basis for evaluating whether the existing technologies are capable of addressing these needs or what changes might be required to meet these needs, and thus enables continuous improvement through action oriented evaluation learnings. The following sections elaborate on these points and uncover the details of the framework.

6.1. Capacity and demand management

In a usual asset lifecycle asset demand and capacity specifies the nature of assets to be used to produce the required products and services, as well as the types of supportability infrastructure required to ensure asset reliability throughout its lifecycle. The success of information systems 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, which specifies the types of assets or the improvements required in existing asset configuration to address the demands. At this stage asset managers require information systems 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 requires scanning of the external business environment as well as the learnings gained over the years from managing assets employed by the organisation.

The value profile that asset managers attach to information systems 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 information systems are required to fulfil. The value profile of information systems demanded by the asset designers specifies how information systems aid in asset design/re-design, installation, and commissioning. 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 for 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 information systems 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 information systems meet the demands of asset design and design for supportability of asset reliability, as well as their integration with other information systems in the organisation and the capacity of information systems to preserve learnings and making them available throughout the organisation for later stags of asset lifecycle.

6.2. 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 information systems 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 rely on different condition or health monitoring systems, such as SCADA systems, sensors, manual inspections, and paper based systems. Nevertheless, information systems 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 information to maintenance function. Many of the design errors surface during asset operation, and therefore, it is important to assess if the existing information systems report back these errors to the asset design function so as to ensure asset design reliability. At the same time, the learnings gained at this stage help mitigate risks posed to smooth asset operation as well as for asset health and operation profiling.

6.3. Operational risk management

The notion of risk signifies the ‘vulnerabilities’ that asset operation is exposed to. These vulnerabilities may arise due to operating in a particular physical setting or specific work conditions. Nevertheless, the success of risk management strategies 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 information systems at this stage therefore is to allow for speedy arrangement of maintenance resources and its execution, which in actual effect is how quickly these systems communicate information to relevant departments and stakeholders. The learnings gained at this stage allow for the calculation of remnant life, degradation patterns, environmental impact of plant asset malfunction, asset operation cost benefit analyses, asset renewal and retirement, and for various other financial and procedural decisions.

6.4. Asset operation quality management

The aim of asset management 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 execution of 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. information systems at this stage have a versatile role, and aid in maintenance and rehabilitation execution, enabling collaboration and communication between various stakeholders, managing resources, as well as facilitating business relationships with external stakeholders and business partners.

6.5. Competence development and management

During the course of 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. Information systems 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. This fit is aimed at developing competencies to handle three important areas of the business, i.e., resources; capabilities that allow the organisation to organize and develop these resources; and competencies that enable the organisation to put into practice corporate strategies. Information systems at this stage, therefore, provide the measure of the strategic directions that shape the asset management strategy to meet its objectives, by taking into account the strategic priorities, organisational competencies, and how these competencies could mitigate the financial and non financial risks posed to the organisation. This includes developing staff profiles, providing learning and innovative environment, and other staffing issues such as training, awareness and competence; and communication and to/from stakeholders, to ensure functional integration.

6.6. Organisational responsiveness

Functional integration and a consolidated view of the asset lifecycle facilitate asset managing organisation in responding to the internal as well as external changes. Information systems 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 of integrated and quality information that allows for an integrated view of asset lifecycle though maintaining the asset lifecycle learnings. At this stage, information systems need to be able to provide an integrated view of asset lifecycle through integration of operational and administrative information spanning various aspects of lifecycle and through their ability to analyse and mine such information for decision support.

The major contribution of this framework to information systems implementation is its ability to enable action oriented learning. 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. Being learning centric, this framework provides triggers for continuous improvement of information systems utilised for asset design, operation, maintenance, risk management, quality management, and competencies development for asset lifecycle management.

7. Conclusions

Scope of asset management spans engineering as well as business activities. In addition, most of these activities are cross functional and even cross enterprise. For example, maintenance processes influence many areas of activity, such as quality of operations; safe workplace and environment; plant availability. The outputs from maintenance are further used to predict asset remnant lifecycle considerations, asset redesign/rehabilitation, and planning for the support resources management. Asset managing organisations are increasingly implementing information systems to automate and bond these activities together. However, result of their implementation has been a mixed one, and most organisations struggle to make effective use of the data that they collect, as they hardly collect the right data. Collection of right data requires proper mapping of information systems with the processes, which not only enables asset management functional integration, but also provides for quality inputs into related processes.

Theoretically, information collected throughout the asset lifecycle provides the basis for analysis aimed at generating valuable learnings that could be used to enable generative learning. This generative learning not only serves as the basis for evaluation of asset lifecycle management processes performance, but in so doing also highlights the gaps between the existing and desired levels of performance; thereby informing the asset management strategy and plan. Lifecycle learnings, thus, provide the focal point that is accessible to every function within the asset lifecycle, so as to ensure congruity of goal and execution in all of the asset management processes and activities and their enabling infrastructure. Asset operation influences and is influenced by a variety of processes and the information thus collected. The close collaboration and openness of information exchange on asset management processes holds the key to effective asset lifecycle management. This, nevertheless, requires a cohesive learning environment that supports tacit and explicit exchange of information and rewards such exchanges. The information systems frameworks presented in this paper provide for a continually improving asset management regime and its enabling infrastructure by extending the resource based view of asset management to a knowledge based view, thereby building competencies that contribute to competitiveness and responsiveness of the organisation.

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