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Institutionalising Information Technology for Engineering Asset Management-Impeding Issues

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Abstract: Information technologies implementation in asset managing organisations does not follow a linear path. It is primarily driven by cost concerns, rather than an approach that takes into account the existing technological infrastructure, business requirements, available skill base, social and cultural environment, and operational and strategic value of technology investment. This paper presents a case of information technologies implementation in asset managing organisations. It concludes that technology for asset management needs to be physically adopted, and socially and organisationally institutionalised, to create consensus on what the technology is supposed to accomplish and how it is to be utilized in the organisation.

Keywords: Information Technologies, Asset Management, Institutionalization

1. Introduction

Traditionally, asset managers focus on developing the technical foundation for asset lifecycle management around operational technologies and leave the selection, adoption, and maintenance of information technologies (IT) to IT managers. This may be attributed to the propensity of asset managers to view information systems utilisation in general as a secondary or support activity to execute business processes. Their emphasis is more on the substitution of labour through technology utilisation rather than business automation and functional integration aimed at internal efficiency and overall strategic advantage. Since the level of input from asset managers regarding choice of information systems has a narrow focus, these systems do not contribute to the organisation's responsiveness to internal and external challenges. As a result, role of IT in managing engineering assets has not fully institutionalised. Institutionalisation of IT for asset management, however, is strongly underpinned in the technical and cultural context of the organisations, which bring together individuals and groups with particular interests and interpretations and help them in creating and sustaining information systems as socio-technical systems. This research presents a study of infrastructure asset managing organisations and focuses on how they should implement IT to manage the lifecycle of their assets.

2. Scope of IT Based 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. In theory IT in asset management have three major roles; firstly, it is utilized in collection, storage, and analysis of information spanning asset lifecycle processes; secondly, IT provides decision support capabilities through the analytic conclusions arrived at from analysis of data; and thirdly, IT facilitates an integrated view of asset management through functional integration.

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Generally, engineering enterprises mature technologically along the continuum of standalone technologies to integrated systems, and in so doing aim to achieve the maturity of processes enabled by these technologies and the skills associated with their operation (Haider 2009). Asset managing engineering enterprises have twofold interest in information and related technologies, first that they should provide a broad base of consistent logically organised information concerning asset management processes; and, second the availability of real time updated asset related information available to asset lifecycle stakeholders. In theory information systems in asset management have three major roles; firstly, information systems are utilised in collection, storage, and analysis of information spanning asset lifecycle processes; secondly, information systems provide decision support capabilities through the analytic conclusions arrived at from analysis of data; and thirdly, information systems provide an integrated view of asset management through processing and communication of information and thereby allow for the basis of asset management functional integration. Information systems for asset management, thus, seek 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).

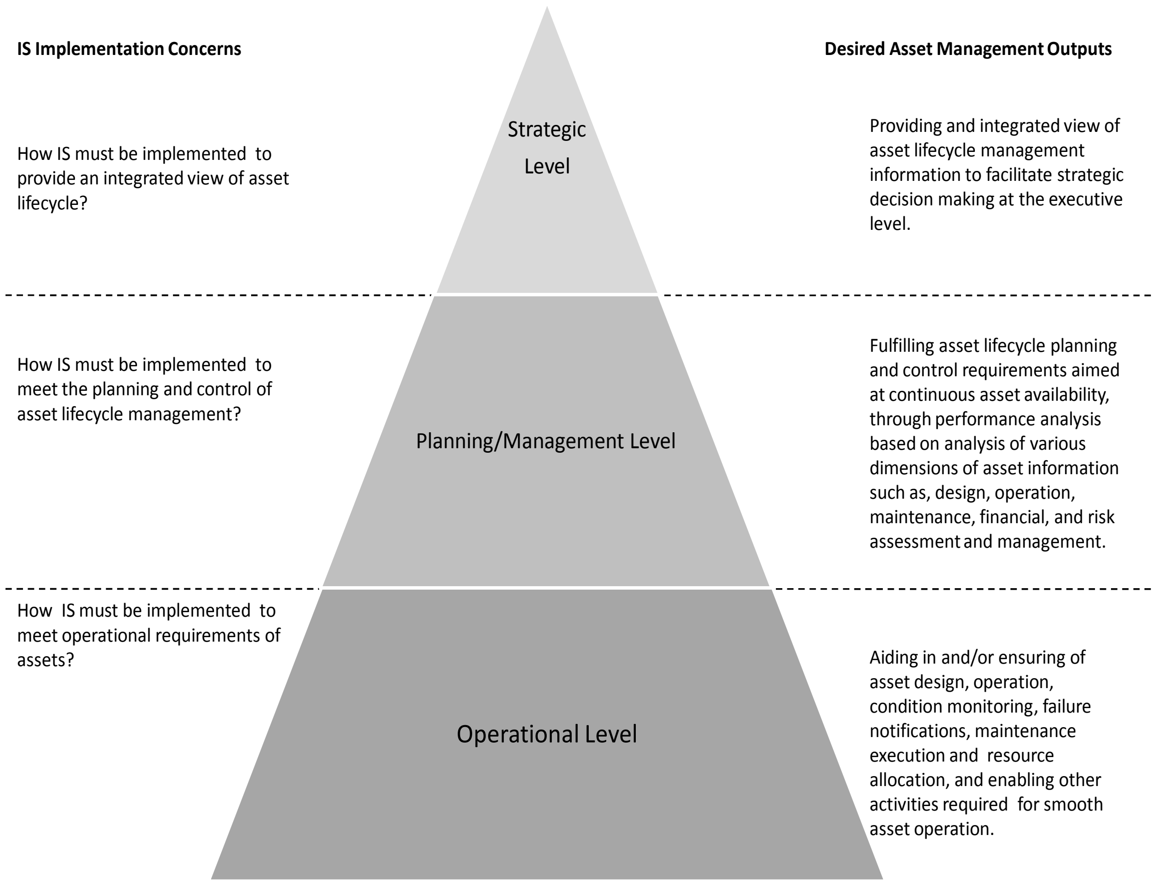

Figure 1: Scope of Information Systems for asset management Source (Haider 2007)

Theoretically speaking, information systems translate strategic asset management decisions through the planning and management consideration into operational actions, through a process of alignment of information systems with asset management strategy. At the operational level information systems are implemented to enable and support execution of core asset lifecycle processes. These processes are designed at the planning and management level and are translated from the strategic asset management considerations at the strategic level. Thus, in top down direction the information systems 'translate' strategic asset management considerations into action. On the other hand, from bottom up these information systems provide information analysis and decision support. This decision support allows for assessment of the effectiveness and maturity of existing asset lifecycle processes, enabling technical infrastructure, and management controls. Top management utilises these assessments, at the strategic level, to bridge up gaps in performance or to re-engineer or re-adjust strategic asset management considerations. Therefore, in bottom up direction the information systems act as 'strategic enablers'. In crux, information systems for asset management must allow for horizontal integration of business processes and vertical integration of functional areas associated with managing lifecycle of assets. Nevertheless, minimum requirements for asset management at the operational and planning/management levels are to provide functionality that facilitates the following (IIMM 2006),

a. knowing what and where are the assets that the organization own and is responsible for;
b. knowing the condition of the assets;
c. establishing suitable maintenance, operational and renewal regimes to suit the assets and the level of service required of them by present and future customers;
d. reviewing maintenance practices;
e. implementing job/resources management;
f. improving risk management techniques;
g. identifying the true cost of operations and maintenance; and
h. optimizing operational procedures.

In engineering enterprises asset management strategy is often built around two principles, i.e., competitive concerns and decision concerns. Competitive concerns set manufacturing/production goals, whereas decision concerns deal with the way these goals are to be met. Information systems 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. Information systems not only aid in decision support for outsourcing of lifecycle processes to third parties, but also provide for the integration of extra-organizational processes with the intra-organizational processes. Nevertheless, the primary expectation from information systems 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,

(i) Technology change/obsolesce,

(ii) Changing failure rates and risks these pose to the organization, and

(iii) 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.

In practice, information systems for asset management hardly provide the benefits stated above. An information enabled integrated view of asset lifecycle requires integration of asset management core business processes and IT related capabilities through policies and technical choices to achieve business standardisation, and technical integration and interoperability. Whereas what we have on ground is a technical landscape replete with isolated pools of data that is patchy and error prone; information systems possessing, processing, and communicating this data lack integration; there is a plethora of disparate technology platforms, which make interoperability almost impossible; and to cap it all automation efforts are littered with task technology mismatch (Haider and Koronios 2005). The following sections highlight some of the issues resulting from inept implementation of information systems for asset management.

Metaphor	**Information Technology**	**Operational Technology**
Purpose	Managing information, automate business processes	Managing the assets, technology controlling processes
Architecture	Monolithic, Transactional or batch, RDBMS or text	Event-driven, real-time, embedded software, rule engines
Interfaces	GUI, Web browser, terminal and keyboard	Electro-mechanical, sensors, coded displays
Ownership	CIO, Departmental managers, and knowledge workers	Engineers and technicians
Connectivity	Corporate network, IP-based	Control networks, hardwired
Examples	Finance, accounting, enterprise resource planning	SCADA, PLCs, modelling, control systems

Table 1: Scope of IT for asset management

Source (Steenstrup 2008)

3. Issues with IT Based Asset Management

3.1 Lack of Information and Operational Technologies' Nexus

In the technical dominion of engineering enterprises, operational technologies (OT) are as prevalent and important as information technologies. IT and OT are inextricably intertwined, where OT facilitate running of the assets and are used to ensure system integrity and to meet the technical constraints of the system. Operational technologies include control as well as management or supervisory systems, such as Supervisory Control and Data Acquisition (SCADA). Table

1 presents an overview of the characteristics of IT and OT infrastructure.

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, design of an asset has a direct impact on its asset operation. Asset 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; and asset failure notifications. There are numerous OT 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 or information 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, 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 organizations.

The convergence between IT and OT is a major issue with technical, management, and organisational dimensions. The root cause of this issue, however, is the fact that IT and OT have separate ownership and management. Divergence of governance and ownership of IT and OT presents a significant problem in contemporary asset management arena. In the absence of a common set of rules to govern the implementation and use of these technologies leads to formation of islands of isolated technologies within the organisation, which makes integration and interoperability of technologies cumbersome if not impossible. With limited or no integration, there is poor leverage of learnings and benefits and unintelligible decision support. Divergence of IT and OT management results is wastage of money and effort, as multiple strategies to manage technology cannot connect properly with the business strategy and operational plans resulting in lack of standardisation of practice. However, the most important consequence of this multiplicity of strategies results in lack of accountability around technological standards and policies.

3.2 Isolated, Unintegrated and Ad-hoc Technical Solutions

Technical infrastructure of an asset managing organisation consists of various off the shelf proprietary, legacy, customised systems and a number of ad hoc solutions in the forms of spreadsheets and databases (Haider and Koronios 2003; Haider 2007). Legacy systems evolve with the organisation; however, are generally weak in technological terms. These systems have been developed using old technologies and are not compatible with new technologies. On the other hand, off the shelf systems are developed on customised guidelines and supports proprietary data formats. Similarly, ad hoc solutions do not conform to any quality and technical standard. This results in isolated pools of data that may serve the needs of individuals or individual departments, but this information of little use for other departments or functions. As a result, there is lack of information integration, which contributes to lack of functional integration. In crux, the existing technical infrastructure does not conform to an information model or the organisational operating model. This means that the technical infrastructure in general and in particular information systems are not aligned with the strategic asset management considerations. This further gives rise to issues relating to lacking process maturity, varying degree of data quality, inadequate decision support and overall organisational efficiency.

3.3 Technology Push as Opposed to Technology Pull

A contributing factor to the above issue is the technology push strategy for information systems implementation as opposed to technology pull. Haider and Koronios (2005) argue that engineering enterprises seldom engage in taking stock of their technical infrastructure and the business processes enabled by it. As a result, these organisations are unable to find how well their business processes are performing, how effectively these processes are coupled with technology, and what are the gaps or requirements that technology has not fulfilled. As a consequence of this, new technology is pushed into the technical infrastructure of the organisation. The organisation then has to adapt or adjust itself to ‘absorb’ technology. As a result there is task technology mismatch. On the other hand, a better approach would be to evaluate the performance of the business processes and enabling technology so as to find out the gaps. These gaps are actually the information requirements not fulfilled by existing technologies. When a technology is selected to fill these gaps, it has a ‘pull’ impact and fits in well with the operating logic as well as the enabling technical and non-technical infrastructure of the organisation. Another factor that contributes to this issue is the fact that asset managing organisations do not have a specific enterprise technical architecture and choices relating to technology are not standardised (Haider 2008). Consequently, there is lack of technical compatibility and information and technology interoperability across the organisation.

3.4 Narrow View of IT Capabilities

Traditionally, asset managers focus on developing the technical foundation for asset lifecycle management around operational technologies and leave the selection, adoption, and maintenance of information technologies to IT managers. This may be attributed to the propensity of asset managers to view IT utilisation in general as a secondary or support activity to execute business. Their emphasis is more on the substitution of labour through technology utilisation rather than business automation and integration for internal efficiency and overall strategic advantage. However, as has been discussed before IT is prime enabler of the business and has the capacity to influence and even alter the course of primary activities in the value chain of asset lifecycle management. Since the level of input from asset managers regarding choice of IT is inadequate and has a narrow focus, IT infrastructure is inwardly focused, not responsive, and at best is only geared at internal automation. It lacks in addressing competitive considerations and forces acting on the asset management strategy, plans, and processes from the broader business environment. There needs to be closer interaction between CIO (Chief Information Officer), CTO (Chief Technology Officer), and CEO (Chief Executive Officer) or the COO (Chief Operating Officer). Only such a nexus allows for a coherent whole of methods and models could be used in the design and realisation of an enterprise’s organisational structure, business processes, information systems, and infrastructure that is both internally and externally responsive to change and competitive forces (Lankhorst 2005).

3.5 Lack of Risk Mitigation for IT infrastructure

Asset managing organisations rarely evaluate or audit their IT infrastructure and the processes enabled by them on a formal basis. Although, almost all of these organisations conform to a follow a risk management strategy, standard, or plan, yet the scope of risk management does not include the risks posed by or posed to information systems (Haider 2010a). Even within the IT function, the risk management is centred on securing the information systems from unauthorised access, intrusion, and malicious codes like viruses. There is no risk assessment, control, and management in terms of business losses occurring as a result of lack of information availability, quality, and integration. In terms of information a fundamental issue with asset managing organisation is that they do not emphasise on information ownership within the organisation (Haider 2010b). It is due to the same reason that there is no accountability assigned to inefficiencies resulting from information management issues. Asset management, by nature, is information driven and in the absence of requisite quality and volume of information sound asset lifecycle management cannot be materialised.

The issues discussed here regarding information systems implementation for asset lifecycle management are diverse. These issues have technical, human, and organisational dimensions and significant consequences for business development. Information systems implementation should, therefore, not be treated as support activity. It should be pursued proactively and aim to continuously align strategic business considerations with technology. Information systems implementation needs to be all encompassing and must consider organisational, technical, and human dimension so as to realise soft as well as hard benefits for the organisation. When information systems will be physically adopted, and socially and organisationally composed, there will be consensus on what the technology is supposed to accomplish and how it is to be utilized. These systems could, thus, be viewed as a feedback embedded arrangement that builds on the organisational evolution and changes brought about by technology implementation, the way technology is institutionalised in an organisation, and recognizes technology adoption as an enabler as well as translator of the asset management strategic considerations. Such an implementation would be best suited to meet the information demands of asset lifecycle and increase responsiveness of the organisation in terms of improvements in asset management processes and overall competitiveness of the asset managing organisation.

4. Discussion

IT implementation for asset management has narrow focus and scope, which emphasises technical aspects and does not give due attention to organisational, social, and human dimension of technology implementation. This approach to technology implementation at best serves as process automation and does not contribute to the cultural, organisational, and technical maturity of the organisation. Technology is a passive entity and its use is shaped by the interaction of technology with organisational and human factors. Implementation exercises that do not account for the cause and effect relationship that shapes technology are unable to institutionalise technology in the organisation. There is an evident lack of commitment from top management to institutionalise technology. As a result, IT implementation in general and information systems implementation in particular has been disorganized and is not driven by the strategic business considerations. Most of these technologies have been implemented due to the pressure from regulatory agencies. Thus, these technologies have been pushed into the IT infrastructure of the organisation, without considering the fit between business processes and technology. This lack of cultural, organisational, and technical alignment; and user or technology stakeholders' involvement in technology adoption hampers development of a collaborative, creative, and quality conscious organisational culture; and impedes organisation wide coordination and horizontal integration. Information systems implementation, thus, is heavily predisposed towards a technology push rather than technology pull strategy.

Institutionalisation of IT is strongly underpinned in the political, economic, and cultural context of the organisations, which bring together individuals and groups with particular interests and interpretations and help them in creating and sustaining information systems as socio-technical systems. Institutional isomorphism is a process in which organizations aim to excel in their practice of social rules, ideals, and practices by aligning themselves with the environmental conditions. These institutional pressures push organizations to adopt shared notions and routines. Thus, the interpretation of intention to adopt technology and the prevailing context of the organization is affected by its perception of these pressures. Coercive, normative, and mimetic are three isomorphic mechanisms which influence organizations in gaining operational efficiency, similarity with peers, and success (Greenwood 2008). Regulative, cultural-cognitive, and normative are three institutional views representing theses isomorphic pressures which are not mutually exclusive and are interdependent (figure 2). It is important for the asset managing organisations to strike a balance between these mechanism, in order to be able to create the shared understanding of the use and value of IT and to align it with the social, cultural, and organisational institutions that constitute the context of asset lifecycle management.

The coercive isomorphism occurs by organizational desire to conform to laws, rules, and sanctions established by institutional actors or sources. The existing backdrop of IT in asset managing organizations represents a fragmented approach aimed at enabling individual processes in functional silos. These organisations are aiming to mature technologically along the continuum of standalone technologies to integrated systems, and in so doing are aiming to achieve the maturity of processes enabled by these technologies and the skills associated with their operation.

It has to be acknowledged that most of the asset management specific technology initiatives have been in response to the legislative pressure from the government. Thus asset managing organisations are under significant pressure for compliance. However, there is no technology that uniformly covers every aspect of asset management; therefore, the coercive pressure to adopt particular technology creates asymmetry of power within the organization, where some functions are well automated and some are not. On the other hand, generally asset managing organizations adopt technology without accounting for their information requirements, contextual strengths and weaknesses, and other factors such as maturity of existing technical infrastructure (Haider 2007), they spent a lot of resources in fire fighting rather than utilizing technology for their optimum advantage. In actual affect, in most cases there were two set of technologies working in parallel in the organization, where one was forced upon the organization by external pressure, and the other set of technologies that the users felt comfortable with. A good example is utilization of SAP and the same time scores of ad-hoc spreadsheets developed in Microsoft Excel (Haider 2009).

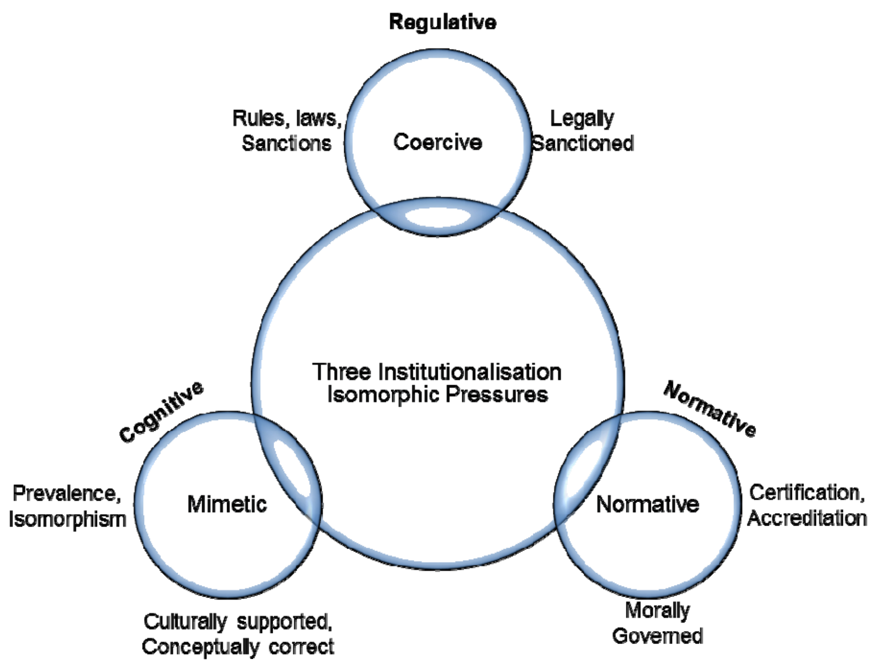

Figure 2 - Institutional Isomorphism Mechanisms
Source (Scott 2008)

The normative mechanism concerns the moral and pragmatic aspect of legitimacy by assessing whether the organization plays its role correctly and in a desirable way. It can refer to the positive pursuit of valued ends, as well as negative deviations from goals and standards (Scott 2008). The disparity in the way technology is used at each stage of asset lifecycle explains the normative influences. For example, maintenance has traditionally been the focus of asset lifecycle management. It is not surprising that in asset managing organizations maintenance function is the most technology intensive. However, the normative pressure created by the maintenance function for technology enablement has not transcended to other function, due to the fact that the case organization is a hierarchical and operates in functional silos. There is little interaction between different functions of asset lifecycle; consequently, themes relating to success and effectiveness of technology seldom cross the functional boundaries that could stimulate the same of view of technology by decision makers in other functions.

The mimetic isomorphism is a cause of organizational tendency to remain similar to its peers in order to get a positive evaluation from the organizational environment. This mechanism results in reducing uncertainty, improving predictability, and benchmarking organizations that are performing at or near optimum level (Teo *et al.* 2003). There is no culture of taking stock of their technical infrastructure in asset managing organisations (Haider 2007). As a result, these organisations are unable to find how well their business processes are performing, how effectively these processes are coupled with technology, and what are the information gaps or requirements that technology has not fulfilled. Technology is ‘pushed’ into the technical infrastructure of these organisations based on its reputation rather than its applicability or usefulness. Consequently, there is task technology mismatch that gives rise to issues such as lacking information integration and interoperability across these organisations.

5. Conclusion

This paper has presented a case on the state of IT implementation in asset managing organisations. It concludes that issues of IT implementation range from technical issues to social, cultural, managerial, and organisational issues. However, the origin of these issues can be traced back to two factors, i.e. inadequate planning for institutionalisation of technology in the organisation; and disregard of organisational and social change associated with technology adoption. IT for asset management calls for consideration of organisational, technical, structural, and people dimensions of IT to create the ‘shared understanding’ and ‘meaning’ of the use and value of IT.

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