Development of a Framework for Adoption and Implementation of Mobile Collaboration Technology in Engineering Asset Management

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Abstract

Today's engineering asset maintenance practices rely on access to information and team expertise from different locations. Many engineering asset organisations have several interdependent departments and sub-systems that collaborate on various productions and maintenance. Maintenance personnel in the form of individual and/or teams communicate, coordinate, integrate and distribute tasks as integrated high-level maintenance comprising multiple sub-systems requires the collaboration of many stakeholders including multiple systems and departments. Collaboration using computerise maintenance information systems can generate a strategy to enhance operational effectiveness, even to adding budget, particularly if internal and external collaboration plays a major role within maintenance departments. Several of specialised technical, operational and administrative systems have been invested by engineering asset organisations to enhancing their asset management and maintenance systems, however there is no common ground among engineering asset organisations about what are collaborative maintenance are required for adoption/implementation. The lack of systematic approach, together with the lack of specific requirements to implement mobile collaborative maintenance requests a comprehensive framework for guiding engineering organisation to implement of new mobile technologies that meet all maintenance collaboration requirements. This research proposes to develop an appropriate mobile collaboration framework based on Delphi and Case Study investigation. This framework is concerned with adopting and implementing new mobile technologies that meet all maintenance collaboration requirements, where organizations can expand the existing technology they are using.

Keywords: **Mobile technology, Collaboration, Engineering asset, Framework**

1. Introduction

One of the primary goals of engineering asset management (EAM) is to increase the amount of time an asset is used. Sun et al. (2006) and Yao et al. (2005) claim that operating and maintaining today's physical assets are more complicated due to their having more functions than ever before. Damage to assets and ineffective asset management are the result of improper maintenance and human mistake. Total output and potential human achievement are thus diminished under such conditions. Amy et al. (2005) found that unexpected troubles cannot be addressed by self-maintained base on experiential rule. The importance of maintenance function has increased because it plays an important role in retaining and improving system availability and safety, and product quality (Tsang, 2002). Hodkiewicz (2006) states that engineering assets in industries rely highly on their maintenance division to maintain and ensure assets are delivered properly. This author also revealed that in the last 30 years, the practice of doing maintenance has significantly changed due to developments in equipment design, information and communication technology, cost pressures, customer acceptance of risk and failures (Hodiewicz, 2006) and the existence of multiple stakeholders and departments (Snitkin, 2003). Moreover, current working circumstances are more complex and therefore need to be managed by multiple and interlinked activities (Camacho et al., 2008). Therefore, in order to enhance resources, information exchange, and maintenance practices, a streamlined, superior maintenance method that incorporates numerous subsystems demand the cooperation involving several parties.

Based on a review of some relevant references (Fernando & Smyth, 2001; Besten, Dalle & Galia, 2006; Rein, 1993) it is found that many organizations already have a collaborative maintenance system in place. But with the right amount of effort and cooperation, that system can be made far more comprehensive and powerful. The very popular maintenance information systems that have been implementing for engineering asset maintenance are Computerised Maintenance Management Systems (CMMS) (Tam & Price, 2006). However, although such system makes a great volume of information available for reliability and efficiency analysis of the delivery of the maintenance function, most experts agree that successful CMMS is less than 30% of total applications (Zhang et al., 2006). The main reasons according to Bradshaw (2000) and Olszwesky (n.d) are: selection errors, insufficient commitment, lack of training, failure to address organizational implications, underestimating the project task, lack of project resources and lack of demonstrable use of system output. While most literature volumes examine the technological needs for infrastructure, software, and connectivity. Clearly, organizational and human requirements are the leading causes of implementation failures, as outlined above. Due to the lack of a systematic approach and A comprehensive framework for guiding engineering organizations in the implementation of new mobile technologies that meet all Maintenance Collaboration Requirements, including Technology, Organization, and Personnel Perspectives, is needed to implement computerized Maintenance Information Systems, such as a mobile collaborative asset maintenance system.

The first half of this paper discusses the significance of asset maintenance and the research gaps. In the second part, we take a quick look back at engineering asset maintenance and the mobile collaboration technology that supports it. Afterwards, a summary of the study's procedures and structure are provided, and finally, a conclusion is drawn.

2. Literature Review

2.1 Engineering Asset Maintenance

According to Tsang (2002), maintenance is a critical support function in industries where companies own engineering assets. Maintenance is essential for companies to achieve their goals. In a similar vein, Al-Sultan and Duffua (1998) Maintaining or repairing machinery and equipment to ensure that they continue to perform their intended functions is dependent upon maintenance, you say. Currently, servicing is recognized as a key approach for the long-term maintenance of an engineering assets organization's productivity.

Maintenance has a significant impact on the economic success of industries. Costs are incurred whenever a machine is stopped due to a breakdown or for necessary periodic maintenance. The cost may simply be the costs of labour and the cost of any materials, or it may be much higher if the stoppage disrupts production (Pintelon & Muchiri, 2009). Systematic examination is essential to determine the extent to which this interruption (due to wear, strain, fatigue, and occasionally corrosion) has affected the plant and/or machinery of engineering assets. Routine or systematic maintenance is a crucial necessity for reaching specified production goals.

As explained by Dekker (1996) the maintenance’s role could be defined by the four objectives it seeks to accomplish. They are:

- Guaranteeing system operation. For manufacturing equipment this is the main objective of maintenance function. Here, maintenance has to provide the right reliability, availability, efficiency and capability to produce at the right quality for the production system, in accordance with the need for these characteristics.
- Ensuring the system's longevity refers to maintaining systems in good functioning order, decreasing the likelihood of condition degradation, and so extending the system's lifespan.
- Guaranteeing human well-being or equipment luster has no direct economic requirement, but is essentially a psychological necessity for ensuring asset seems to be in good condition.
- Ensuring safety include the safeguarding of production equipment and all engineering assets in general.

The asset lifespan involves several dependent cycles. Snitkin (2003) has an overview of all stages including planning for acquisition of new capital assets, acquisition of assets, installation, operation and maintenance and retire as presented in Figure 1.

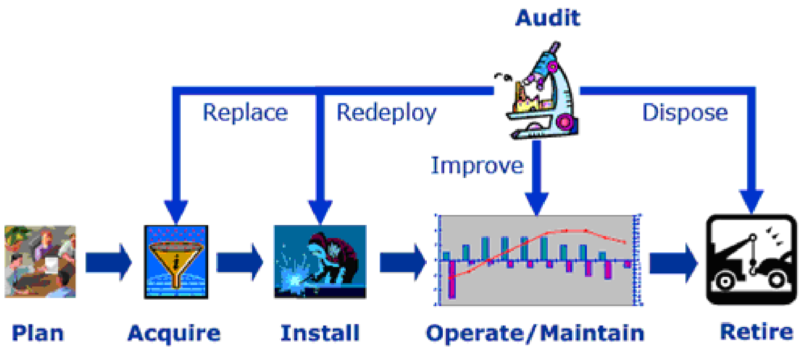

Fig 1. Asset lifecycle stages (from Snitkin, 2003)

Engineering assets generate value during this stage and demand care so that their best performance is maintained. Performing this task efficiently demands close attention to labor and component inventories. During this time, the demand for collaboration among organizational processes impacted by asset performance reaches its pinnacle. Due to the complexity, long process, and multiple stakeholders and departments involved in operations and maintenance, coordinating and sharing asset management data from all disparate sources into operational business intelligence requires many skills in intra-organization and inter-partner collaboration (Snitkin, 2003).

Individuals and groups must communicate, coordinate, integrate, and share tasks in order to collaborate. This task can be performed independently and later shared, which could result unforeseen cooperation. These activities can be facilitated by people and integrated computer systems (Hardi and Whittaker, 2000).

2.2 Collaboration Technology in Engineering Asset Maintenance

Collaboration Technologies (CT) are technologies that enable People and groups are able to communicate, collaborate, and interact in order to exchange knowledge and information, with a particular emphasis on those that facilitate dispersed participation across time and/or space. Collaboration technology is designed to support two or more people to work cooperatively at the same place and time (synchronous) or at different places and/or different times (asynchronous) (Dennis et al., 1988; DeSanctis & Gallupe 1987).

Eden and Ackerman (2001) indicated several forms of collaboration technology that provide special benefits to users. Building on this theme, Knot et al. (2006); Dennis, Wixom, and Vandenberg (2001); Oslon, Malone and Smith (2001); DeSanctis and Gallupe (1987); Nunamaker et al. (1991); Zigurs and Buckland (1998); and Rein (1993), all concluded that generally, collaboration technology is a package of hardware, software, people, and/or processes that can offer one or more of the following:

- Support communication among participants, such as electronic communication to enhance or replace spoken communication;
- Support for information processing, such as mathematical modeling or voting tools;
- Support to help participants embrace and utilize technology, such as agenda tools or real-time training.

Collaboration technologies enable members to communicate and collaborate as they deal with the opportunities and challenges of asset maintenance tasks (Massey, 2008). Collaboration technologies enhance the efficacy and productivity pertaining to organizational work procedures and determination-making while lowering expenses. In the process of problem-solving and decision-making, dispersed knowledge workers from various divisions and roles may contribute input, share information, negotiate, and coordinate activities utilizing technology.

2.3 Mobile Collaboration Requirements by Asset Maintenance' Stakeholders

Jones (2006) contends that employees will do their duties from home or at a firm as "corridor warriors". Personal computers will not be replaced by mobiles, but mobile devices, according to Zuellig and Meckel (2008). Smartphones, PDAs, and networks, for instance, will be highly centralized, will improve and expedite work processes through the prompt delivery of information, and will better support the communication and collaboration roles. Moreover, Smith (2005) states that each single organization uses a specific set of tools that is designated to support team collaboration to perform tasks in certain projects.

Through the advancement of mobile technologies, technical professionals may execute information processing away from the central production office or location. Maintenance personnel, when doing their tasks, require relevant information in different sites and need to communicate interactively with experts in the back office (Emmanoulidis, 2009). In regard to this task, Sinha et al. (2007) state that using mobiles allows maintenance personnel to continuously receive a daily schedule from the head office. This results in time savings and enhanced revenue and customer care. Luff and Heath (1998) and Campbell et al. (2006) agree that mobility of special artefacts can enhance tasks and responsibilities. Hence, Emmanoulidis (2009) argues, in order to support maintenance task, the use of mobile collaboration technologies is a visible and effective approach. The maintenance task that can be supported by mobile collaboration technologies, are for example: information about machine state, process state, work orders and scheduling, a list of experts and their availability, condition monitoring and data diagnosis (Emmanouilidis, 2009).

Emmanoulidis (2009) explains that with reference to production machinery the right information and tools are present but they, typically, are not available at the right time, at the proper place or given to the right personnel. The development of mobile technology enables mobile technical staff and maintenance specialists to cooperate from various places. This technology makes data/information and technical tools accessible to anybody, anytime, and everywhere. Furthermore, as stated by Emmanouilidis (2009), maintenance practice involves doing complex tasks such as maintenance planning, inspection, diagnostics, requires cooperation with another person. This partnership is not novel, but rather a common practice in technical companies. The availability of mobile collaboration technology in place makes a new perspective to support the asset maintenance action (Emmanouilidis, 2009). Maintenance activity that needs collaborative effort including inspection, monitoring, routine maintenance, overhaul, rebuilding, repair (Marquez, 2007), considered the MCT to be a necessity (Emmanouilidis, 2009).

To improve maintenance management and execution across three primary business activity levels, the mobile collaboration technology that is required for maintenance operations needs to be capable of simultaneously handling, processing, and delivering technical and operational information to multiple maintenance crews in multiple locations at any given time. The criteria include technological, organizational, and personal factors.

3. Research Methods

This research will be a qualitative and quantitative interpretative investigation. Klein and Myers (1999), Deetz (1996), and Orlikowski and Baroudi (1991) have reasoned that interpretive attempts to understand phenomena through the meanings that people assign to them are relevant. This understanding is especially relevant to this research because of this. The findings of this case study, together with those of the survey, the Delphi research, and the findings of an additional case study, will be combined in order to develop a comprehensive list of requirements for the maintenance of collaboration in engineering organizations. Triangulation is the use of more than one research strategy to explore the same phenomenon so that the credibility of research results is improved (Greene, 1989).

3.1 The Delphi Technique

This research identifies cooperation needs, present Methods of collaborative maintenance and the responsibilities that mobile technology plays in the support of collaborative engineering asset maintenance are discussed. The Delphi approach is utilized to more precisely arrive at a consensus based on the perceptions of the panel experts. The Delphi study is a group process to solicit expert responses toward reaching consensus on a particular problem, topic, or issue by subjecting them to a series of in-depth questionnaires, interspersed with controlled feedback (Dalkey & Helmer, 1963).

Several different goals may be accomplished by utilizing the Delphi method. Mobile collaboration technology in engineering asset maintenance is a relatively new topic of discussion, complicated, a few literature series have been discovered, and there is a dearth of empirical data. These are the advantages of using a Delphi research to confront a panel of mobile maintenance experts. Delphi study is carried out in this research which comprised three rounds (Linstone & Turoff 1975).

3.2 Multiple Case Studies

Multiple case studies based on semi-structured interviews will be done to investigate the cooperation needs for asset maintenance procedures and to identify the inadequacies in the present collaboration requirements. These criteria apply to the existing requirements about the importance of mobile technology for facilitating maintenance planning coordination. Case study research provides the advantage of presenting a holistic view of a process (Yin, 2009). An in-depth investigation allows different aspects of a research topic and their relationships to be analysed (Markus, 1983). The case study's key goals are to assess the relevance of the needs, validate the Delphi results, rate the requirements for asset maintenance cooperation, pinpoint the most critical conditions that must be fulfilled, and look into the linkages between the specifications. The replies to the research questions provided by the respondents will be sorted, kept, and then analyzed. In this case study, qualitative data will be collected and analyzed with NVivo utilizing qualitative data analysis techniques.

To build a comprehensive list of needs for cooperation maintenance in engineering firms, the results of this case study will be compared to those of the Delphi research in a triangulation. Triangulation is the use of more than one research strategy to explore the same phenomenon so that the credibility of research results is improved (Greene, 1989).

3.3 TOP Approach

Mitroff & Linstone (1993) suggest that each phenomena, subsystem, or system must be analyzed using what they refer to as the Multiple Perspective technique - applying diverse ways of perceiving the problem in order to discover viewpoints. These different ways of seeing are demonstrated in the TOP model of Linstone (1999) and Mitroff & Linstone (1993). The TOP model enables analysts to examine the context of an issue from either the Technical, Organizational, or Personal perspectives.

- Organizations are seen as hierarchical structures or linked networks of people, groups, other organizations, and systems from the perspective of the Technical viewpoint (T). Science and technology, optimization, requirement validation, and cause and effect are some examples.
- The organizational viewpoint (O) evaluates the performance of an organization based on how effectively and efficiently it accomplishes its goals. This viewpoint looks at the world through a different lens, from the perspective of organizations that are both affected and effecting other organizations. For example, the perspective of a select group or institution, reliance on subject-matter experts, the need for standard operating procedures (SOP), institutional compatibility, etc.;
- The individual's problems are highlighted via the lens of the personal standpoint (P). Consider, for example, knowledge, experience, position, intuition, the requirement for confidence, and so on.

Mitroff & Linstone (1993) believe that these three viewpoints might be utilized as "three ways of perceiving" any obstacles that arise for or within a specific phenomenon or system. Werhane (2002) further notes that the dynamic exchanges of ideas which is emerge from using the TOP perspectives are essential because they take into account "the fact that each of us individually, or as groups, organisations, or systems, creates and frames the world through a series of mental models, each of which, by it, is incomplete". To put it another way, a singular point of view on the issue situation is insufficient to provide a deep understanding of it.

The TOP multiple-perspectives method is shown to be the most suitable for describing the collaborative maintenance requirements. Incorporating technology-organization-personnel needs for collaborative maintenance demonstrates that the sum of its pieces is greater than the whole. Having only one point of view is like perceiving something in three dimensions as one representation.

3.4 Proposed Framework

To design the mobile collaboration PAM framework, it is necessary to address the research questions. How might MCT support AM in an EAM organization? is the central question. Then follow four sub-questions:

Q1. What are the cooperation needs for asset maintenance tasks in engineering management organizations?
Q2. What is the current status of collaborative technology utilized for asset maintenance in engineering management organizations?
Q3. What function do mobile technologies now play in the aforementioned cooperation technologies?
Q4. What is the complete framework for integrating cutting-edge mobile technologies that satisfy all needs for maintaining collaborative efforts?

As illustrated in Figure 2, a conceptual research framework was constructed based on the substantial literature study. It includes the fundamental notion of Linstone's (1999) TOP model as a method for analyzing cooperation requirements from technological, organizational, and personal aspects. It also includes the alignment of maintenance processes with three levels of business activities: strategic, tactical and operational (Márquez, 2007). This theoretical framework will direct the preparation and actions of future research into the partnership required for physical asset maintenance.

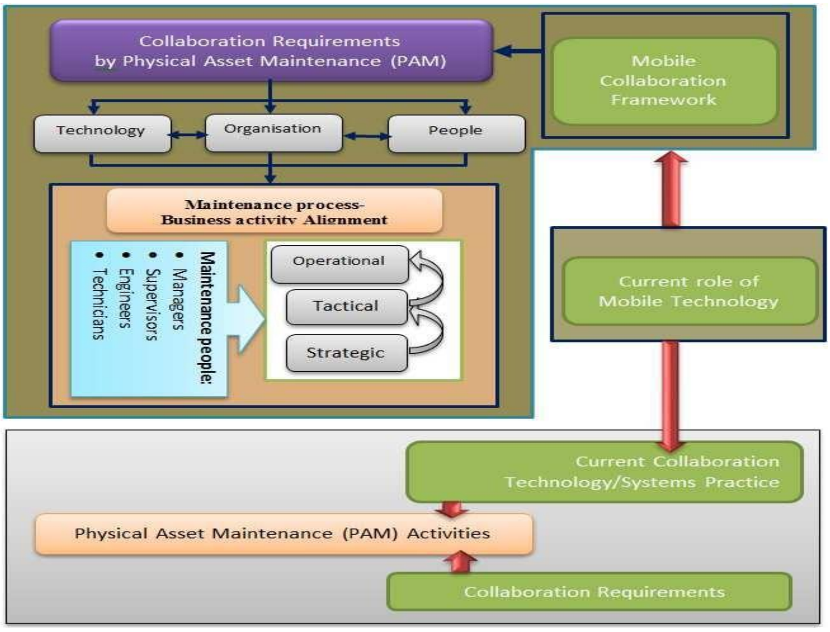

Fig 2. Preliminary Maintenance Collaboration Framework

3.5 Future Framework Development

In this part of the project, the framework for mobile cooperation in engineering asset maintenance will be developed. In order to construct the study questions, the first part consisted of a review of the relevant literature and previous theory. A list of needs and related data gathered from the literature research will be expanded using a Delphi survey. All of the key demands and maintenance collaboration subgroups in asset management will be covered by this integrated, logically organized system of priority requirements. The findings of the case study and the Delphi research will be combined to provide a comprehensive list of requirements for collaboration maintenance in engineering organizations. Triangulation is the use of more than one research strategy to explore the same phenomenon so that the credibility of research results is improved (Greene, 1989). By using quantitative and qualitative approaches, this method provides a powerful means for analysis and interpretation of data (Sieber, 1973; Jick, 1979). Similarly, Smith (1975) argued that researchers can enhance the accuracy of their decisions by gathering different kinds of data on the same phenomenon.

Conclusion

Through the advancement of mobile technologies, technical professionals may execute information processing that is carried out separately from the main manufacturing office or location. When performing their duties, maintenance employees need access to site-specific information and must interface with specialists in the back office. Utilizing mobile devices enables maintenance employees to obtain a daily schedule from the headquarters on an ongoing basis. This results in time savings and enhanced customer service and revenue.

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