Mobile Technologies in Asset Maintenance

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Abstract

Assets are the lifeblood of most organizations. . Maintenance is critical in asset management. Whenever a machine stops due to a breakdown, or for essential routine maintenance, it incurs a cost. Unlike consumer applications, in heavy industry and maintenance, the uses of mobile solutions have not yet become very popular. However, it is believed that mobile solutions can bring maintenance management closer to daily practice in the field, and lead to more efficient maintenance operations. This research has adopted a multi-case studies in order to identify the role of mobile technologies in as-set maintenance activities. The findings will contribute to the development of mobile technologies in facilitating effective and efficient maintenance in engineering asset management organisations.

1 Introduction

Assets are the lifeblood of most organizations. They may include digital assets, human assets, and financial assets. Most companies also have physical assets. These physical engineering assets (e.g. machinery, plant and equipment, etc.) can be used to turn raw material into finished goods, supply electricity and energy, provide transportation services, or control huge utility operations. Many organizations rely heavily on these engineering assets to maintain and monitor daily operations. During the lifecycle of these engineering assets, an enormous amount of data is produced. The data is captured, processed and used in many computer information systems such as Supervisory Control and Data Acquisition (SCADA) systems, Facility Maintenance and Management Systems (FMMS), and Geographic Information Systems (GIS).

2 Importance of Asset Maintenance

Maintenance is critical in asset management. Whenever a machine stops due to a breakdown, or for essential routine maintenance, it incurs a cost. The cost may simply be the cost of labour and any materials, or it may be much higher if the stoppage disrupts production (Pintelon and Muchiri 2009). In order to define how

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far such interruptions (due to wear, tear, fatigue and sometimes corrosion) has impacted plant and/or machinery of engineering assets, systematic inspection is required. Routine or systematic maintenance plays an important role as a requirement to achieve certain production targets.

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

- Ensuring system function (availability, efficiency and product quality). For production equipment this is the main objective of the 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 or plant's life refers to keeping systems in proper working condition, reducing the chance of condition deterioration, and thereby increasing the system's life.
- Ensuring human wellbeing or equipment shine. This objective has no direct economic or technical necessity, but is primarily a psychological one of ensuring the equipment or asset looks good.
- Ensuring safety refers to the safety of production equipment and all engineering assets in general.

Gouws and Trevelyan (2006), and Soderholm, Holmgren and Klefsjo (2007) state that maintenance stakeholders are the individuals in the organisational structure involved directly or indirectly with maintenance. Some people are very visible in the maintenance workflow process (such as managers, maintenance engineers, maintenance supervisors, and maintenance technicians) while others are less visible, but not less important (e.g. reliability engineer inspectors, accountants, purchase buyers, and computerised maintenance management systems [CMMS] administrators).

Maintenance is a combination of actions intended to retain an item in, or restore it to, a state in which it can perform the function that is required for the item to provide a given service. This concept leads to a first classification of the maintenance actions in two main types: actions oriented towards retaining certain operating conditions of an item, and actions dedicated to restoring the item to supposed conditions. Retention and restoration are action types that are then converted into preventive and corrective maintenance types in the maintenance terminology by the European Committee for Standardization (CEN 2001).

The following sections present the European Committee for Standardization (2001) explanations of corrective, preventive and condition-based maintenance.

Corrective maintenance (CM), also called breakdown maintenance or run-to-failure (Koochaki, 2009), is maintenance carried out after fault recognition, and is intended to put the equipment into a state in which it can perform a required function.

Preventive maintenance (PM), also called planned maintenance or time-based maintenance (Koochaki 2009), is defined as maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of the equipment. It involves preventive actions such as inspection, repair or replacement of the equipment. It is performed in fixed schedules and regardless of the status of a physical asset. Condition based maintenance

Condition based maintenance (CBM), From Jardine, Lin and Banjevic's point of view 'Condition based maintenance (CBM) is a maintenance program that recommends maintenance actions based on the information collected through condition monitoring techniques' (Jardin, Lin and Banjevic 2006, p.77). CBM is PM based on performance and/or parameter monitoring and subsequent actions. Performance and parameter monitoring may be scheduled, on-request or continuous. CBM includes predictive maintenance that can be defined as CBM carried out following a forecast derived from the analysis and evaluation of the significant parameters of the degradation of the equipment.

As mentioned above, there are three types of assets maintenance including CM, PM and CBM. CM is a kind of maintenance method based on a failure shutdown, and its basic idea is not to repair until breakdown. PM is a proactive maintenance method, including predetermined PM. CBM is an effective PM that carries out equipment maintenance work based on the real-time status of and use plan of the assets.

3 Mobile Technologies in Asset Maintenance

Sokianos, Druke and Toutatoui (1998) emphasise that in order to manage the sophisticated AM process and to provide its data requirements, particular technology and systems are required. The system that captures, maintains, and manages all the needed asset information throughout the entire asset lifecycle is critical in providing effective AM.

In contrast, mobile technologies and solutions are very popular in consumer applications, and the exploitation of mobile technologies will keep on expanding. In heavy industry and maintenance, the uses of mobile solutions have not yet become very popular. One reason is the lack of competence and knowledge in adopting mobile solutions successfully for professional use. Many companies have poor experience of adopting mobile solutions in maintenance due to previously inoperative telecommunication connections, lack of suitable devices, or just because the organisation had insufficient preparation for the adoption and implementation process. Another reason is that the benefits of mobile solutions are unseen or unknown, for example, in the maintenance domain (Backman and Helaakoski 2011). Mobile technologies nowadays are mature enough to face the challenge and requirements of professional use in the engineering industry.

The use and implementation of mobile services has been studied globally and extensively from a context-driven organisational problem-solving view (Burley and Scheepers 2002). When considering the use of mobile solutions in industry, and especially in maintenance, the available studies and research focuses mainly on e-maintenance (Campos 2009; Koc et al. 2004; Muller, Marquez and Iung 2008). The term e-maintenance still refers to quite a large concept where mobile solutions can be just one part. Some e-maintenance specific case studies focus on mobile device architectures where the mobile device can, for example, help the maintenance engineer perform maintenance tasks (Campos, Jantunen and Prakash 2009). Mobile solutions can bring maintenance management closer to daily practice in the field, and lead to more efficient maintenance operations.

Some research has been conducted on the role of mobile technology in the workplace, but only few applied to asset maintenance works. Moreover, several mobile maintenance systems have been invested in by EAM organisations to enhancing their AM and maintenance systems. But these technologies/systems do not adequately support the maintenance collaboration requirements associated with different maintenance stakeholders.

4 Research Question and Design

A multiple case-study approach was adopted for the case-study methodology in this research. It is aim to identify the role of mobile technologies in asset maintenance activities with specifics focuses on

a. The current use of mobile technologies in asset maintenance
b. Collaborative asset maintenance requirements
c. Issues and problems associated with the current mobile technologies

The reasons for choosing a multiple case study approach over a single case approach was its capacity to handle the complexity of the phenomenon under study (Yin 2003), and the fact that it augmented external validity, helping guard against observer bias (Leonard-Barton 1998). It is recommended to be of assistance in capturing the complexity of social settings, and facilitating the comparison of activities across a variety of settings and situations (Adams, Day & Dougherty 1998). The multiple case-study approach uses replication logic to achieve methodological rigour (Donnellan 1995; Yin 2003), and triangulate evidence, data sources and research methods (Eisenhardt 1998).

Eight Australian and Indonesian engineering asset organisations were selected for the case study in this research. All were chosen from large sized organisations taking into consideration the complexity of maintenance process, such as having more functions, covering more operation and maintenance perspectives, involving more and variety of maintenance stakeholders, and more importantly, having strong motivation to improve their maintenance productivity. They truly reflect the engineering asset organisations that need, or have been implementing, collaborative maintenance systems in supporting their routine maintenance activities. The eight case-study organisations also represent the typical engineering industries of telecommunications, electricity, airline services, and oil and gas, in both the public and private sectors. In order to respect the privacy of the participating organisations and individual interviewees, they are not identified by their real names or actual position titles. The cases are referred to as Case A through to Case H. Table 1 provides an overview of the eight organisations. It includes a description of each organisation, the organisation's size, the main business, and the period when interviews were conducted. The cases include four public (government) organisations, and four private organisations. The case-study interviews were carried out between July 2013 and September 2013.

This study employed a pragmatism stance in the eight case studies in order to determine and identify the collaborative maintenance requirements for successful implementation. Therefore, the qualitative data were collected and organised using two different methods. First, interview responses were transcribed and tested for accuracy through a couple of run-throughs by comparing the recording with the transcriptions. Second, thematic analysis was performed to identify patterns and themes within the data. Thematic analysis is a method that allows the researcher to report the experiences of the study's respondents captured during the interview process. The interpretation identifies new information and findings based on the interview questions that become progressively focused towards the research questions.

All case study interviews were transcribed. A very intensive content analysis of those documents and interview transcripts was conducted. All transcript material was coded (Neuman 1997) according to the research developed framework and the refined interview protocol questions. Coding of the data made it easier for the researcher to detect trends and commonalities among the interviewees.

Table 1. Overview of case organisations

Case	Description	Organisation size	Business nature	Interview period
A	Government organisation	Large	Telecommunications	July 2013
B	Private enterprise	Large	General trades (multi areas)	July 2013
C	Government organisation	Large	Petroleum	August 2013
D	Private enterprise	Large	Telecommunications	August 2013
E	Government organisation	Large	Electricity	October 2013
F	Government organisation	Large	Airline services	October 2013
G	Private organisation	Large	Electricity	June 2013
H	Private organisation	Large	Oil and gas	September 2013

5 Research Findings

Current maintenance circumstances are more complex because engineering assets having an increasing number of functions, requiring maintenance processes to be managed by multiple and interlinked activities. Hence, an integrated high-level maintenance system, which contains multiple sub-systems, requires interdepartmental collaboration of multiple stakeholders. Operation and maintenance is the longest and most complex lifecycle stage, thus needing additional attention. Due to complexity, long process, and multiple stakeholders and departments involved, coordinating and sharing AM data from all disparate sources into operational business intelligence requires many skills in intra-organisation and inter-partner collaboration (Snitkin 2003). Through the interview, it can be clearly identified that mobile technologies play an important role in facilitating collaboration activities in maintenance (Syafar, Gao and Tina 2013; Syafar and Gao, 2013). Some findings are summarised below.

***Table** 2. Collaborative maintenance requirements*

No.	Requirements	Frequency
1.	Mobile technology competence	14
4.	Clear maintenance vision (maintenance strategy-business objective)	11
5.	Data and information accessibility	10
6.	Cross-organisational management communication	10
7.	Common understanding of maintenance processes	10
8.	Specific mode for each specific maintenance roles	9
9.	Mobility of the users, devices and services	9
10.	Trust and commitment the other crews will do their part	9

***Table** 3. Current mobile technologies being used to support asset maintenance*

No.	Statements	Frequency
1.	Preventive maintenance expert availability	15
2.	Job information library	13
3.	Copy and printing facilities	12
4.	Display data/information in the form of text, audio, picture, visual and video format	11
5.	Hyperlinks	11
6.	Work list	11
7.	Expandable	11
8.	Document in the form of Word, Spreadsheet and pdf file.	10
9.	Wireless (3G or LTE)	10
10.	Wi-Fi	10

***Table** 4. Current problems with mobile enabled collaborative maintenance systems*

No.	Problems	Frequency
1.	H/W and S/W limitations or lack of functions	10
2.	Lack of responsiveness of skilled maintenance people	9
3.	Unavailability of skilled maintenance people	9
4.	Establishing common ground is a crucial activity for collaboration	9
5.	Difficult to access the history of previous maintenance work	8
6.	System security become even more important and complex	8
7.	Lack of support from corporate offices	8
8.	Lack of commitment on maintenance resources	8
9.	Technology does not operate as expected in real world, energy is still an open problem for many contexts, e.g.: bridge maintenance shifts have to be adapted to battery availability/charge.	7
10.	Limited use in large industry in developing countries only	7

***Table 5**. Perceived mobile technology roles supporting collaboration technology systems*

No.	Statements	Frequency
1.	Mobile technology allows at the right place to access directly to a set of information coming from all the potential actors involved in the decision (CMMS, ERP, sensors, etc.).	11
2.	Visualising of collected data, parameter history and trending	11
3.	Contextualising access over remote data and services: task-related services and data entry ubitously available to authorised users.	11
4.	Critical for response time for data or information that can lead to early correction and or identification of failures.	11
5.	Allowing to take the right maintenance decision, at the right time, at the right place, from the right information.	10
6.	Comprehensive failure report	9
7.	Reports actual working hours and availability	8
8.	Enhancing accuracy of critical data entry for maintenance history	8
9.	Detecting the location of skilled maintenance personel nearby an asset that has experienced a failure through GPS.	8
10.	Resources management (material, maintenance people) facilitator for continous task monitoring/assignment/reporting.	8

6 Conclusion

Engineering asset organizations will be better able to identify problems associated with the current mobile technologies as well as critical requirements includes be better able to understand the relationships among these key requirements for effective and efficient mobile maintenance operations. The research findings have suggested that by utilising mobility solutions, maintenance crews (as the users) can access vital information as and when they need to. The mobility of devices enables faster access to critical information for informed decision-making on the fly. On site they can monitor workload, fill in expenses and work done, and continuously report job progress so an engineering organisation's entire workforce can be optimised on the right job at the right time, and meet its service level agreement. However, in order to fully take advantages of mobile technologies, it is an ongoing journey for asset management organisations to undertake.

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