

INTEGRATED RELIABILITY CENTRED MAINTENANCE APPROACH IN PUBLIC SECTOR FACILITIES MANAGEMENT

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ABSTRACT

Reliability Centred Maintenance (RCM) is focused on ensuring an asset continues to provide its designed function in its present operating context. Through a number of stages, RCM allows for thorough and constant monitoring of assets to maintain their level of performance, expand life cycle and improve efficiency. A conceptual holistic framework was developed embedding RCM approach and assessing the impact of maintenance strategies in four dimensions: business, functional, legal and context requirements to ensure optimum level of maintenance. A prototype spread-sheet model was developed encapsulating the concept and the model was evaluated using a case study. The preliminary evaluation has shown the potential of the model to realise benefits and improve reliability of the services of the assets to the clients/users. Further research and development is essential in order to calibrate model parameters to specific company requirements as well as to develop a database of assets with failure patterns and monitoring methods.

Keywords: RCM, Facilities Management, Public Contracts.

1 INTRODUCTION

The management of built facilities is a complex process and offers challenges to the managers in deciding on the optimal management strategies when trying to realise several objectives. The objectives include reliability in the use of facility, sustainability factors such as reduction of carbon footprint and minimum operational cost and/or whole life cycle cost. Furthermore, the facilities management decisions are perceived as resource intensive and time consuming where maintenance costs often spiral. Maintenance is a combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function. Over the past forty years, maintenance strategy has changed due to a huge increase in the number and type of physical assets including buildings, which must be maintained without much disruption on the services they provide. One of the new approaches to maintenance is Reliability-centred Maintenance (RCM), which is 'a process used to determine what must be done to ensure that any physical asset continues to do what its user wants it to do in its operating context' (Moubray, 1997). Through a number of stages, RCM allows for thorough and constant monitoring, so that an asset maintains a level of performance that expands its life cycle and improves its efficiency.

RCM is the optimum mix of reactive, time- or interval-based, condition-based, and proactive maintenance practices (Pride, 2010). The Chartered Institute of Housing (1997) describes the reactive (responsive) maintenance as day-to-day repairs and defines as 'repairs carried out on an ad hoc responsive basis as the need arises & which can't be deferred for inclusion in planned maintenance programmes.' These repairs can be classified as 'urgent' if they can not be deferred owing to health & safety, and security. These repairs are initiated when any faults are identified and reported. Planned maintenance or proactive maintenance, as defined by Chartered Institute of Housing (1997), includes the repairs organised and carried out with forethought, control and the use of records to a pre-determined plan. The time- or interval-based or condition-based are other strategies which are either done to comply with legislative requirements or the condition of asset warrants the maintenance. Thus the RCM is a process that is focused on ensuring the continuation of an assets requirement in its

present operating context. In general, reliability is the ability of a system to consistently perform its intended or required function or mission, on demand and without degradation or failure. The RCM can achieve this ability by specifically identifying and selecting appropriate maintenance tasks, thus preventing critical failure. RCM gives top priority to safety, security and environmental integrity by systematic reviewing the safety and environmental consequences in each failure modes before any other issues like cost savings.

El-Haram & Horner (2003) under the title of integrated logistics system investigated RCM in maintenance of existing housing stock, and concluded that, in particular Failure Mode & Effect Analysis (FMEA) and RCM, provide a robust framework for identifying the most cost-effective and appropriate maintenance strategy for existing building stock. The study suggested that more investigation is required to develop general conclusions.

A number of facility management companies provide support for major public sector assets to provide an efficient maintenance program that allows for the reduction of the risk of failure in these critical assets. The key questions include:

- Would the overall cost of outsourcing of critical assets be reduced through efficient RCM regimes?
- Is it possible for Facilities Management companies to extend the life of their clients' assets by undertaking the optimum level of maintenance at the right time, therefore supporting the public sector strategy to reduce capital expenditure?

In order to answer the above questions, a case study was conducted and existing RCM application data were collected and analysed. Following the study, a conceptual holistic framework was developed embedding RCM approach and discussed in this paper.

2 METHODOLOGY

RCM requires maintenance decisions to be supported by sound technical and economic justification (NASA, 2008). So RCM programme can be fully implemented by the following seven steps, which include- 1: system selection and data collection; 2: system boundary definition; 3: system description and functional block; 4: system function functional failures; 5: failure mode and effect analysis (FMEA); 6: logic tree analysis (LTA); 7: task selection. As the collaborating company has implemented RCM on some of its facilities, the evaluation of effectiveness of the existing methods used was considered as a first step of the research. Three different type of buildings were selected in the research. In this paper, a boiler house has been used for discussion.

Preventive and corrective maintenance data for 5 years were collected for a boiler house, which has been maintained using RCM approach. For detailed cost evaluation, 13 months data for overall maintenance activities was collected for one of the sites of the collaborating company were collected, which were grouped under their functions such as: Structure, Heating, Electrical, Plumbing, Mechanical, Gas related Works, Communication, Aesthetic etc. as required, then summarised and used for the average for calculations.

The processes used in the implementation of RCM was studied and with 7 meetings and 3 half day workshops with managers involved in the management of facilities under public contracts from the collaborating company were used to develop an integrated model embedding RCM. The developed model will be introduced latter sections. A prototype Excel model was developed encapsulating the conceptual model. The details of the prototype and its validation is not included in the scope of this paper.

3 EVALUATION OF EFFECTIVNESS OF RCM APPROACH

The total cost saving after using the RCM in facilities management can be calculated by the following relationship:

$$\text{Total cost saving} = F_c + R_c - P_c \quad (1)$$

Where, F_c - Cost associated with the reduction (increment) in interval;
 R_c - Reactive maintenance cost;
 P_c - Cost of planned maintenance.

Initial costs in implementing the RCM is high as the cost of reactive maintenance tasks cannot be reduced immediately in comparison with the increment of the cost of condition-based and other planned maintenance tasks. Furthermore the technological tools, training and equipment condition baselines need a high initial investment to apply for a new RCM programme (NASA RCM Guide, 2008). Some applications have paid for themselves in as little as two weeks, although the payback period is usually a matter of months, (Moubray, 1997). Even more, Thompson *et al.* (1993) presented their research paper stating that the breakeven point of investment of RCM implementation for profit can be achieved after one to two years when the cost of reactive maintenance decreases as failures are prevented and preventive maintenance tasks are replaced by condition monitoring, thus reduces the overall cost of maintenance tasks. So the fully implemented RCM programme can make a significant savings in long run. The graphical presentation of this issue is illustrated in Figure 1. In the long run due to proactive RCM strategy, reactive maintenance activities will be reduced and overall cost of maintenance decreases with increased availability and functionality of facilities.

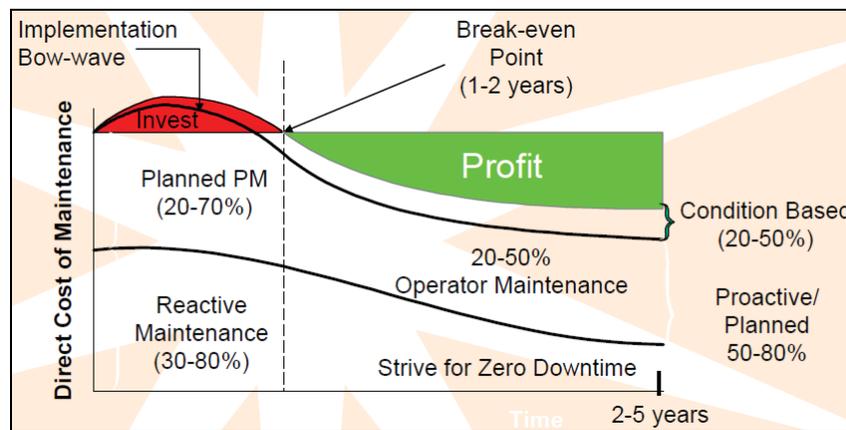


Figure 1: Changing Pattern of Reactive Maintenance to Proactive Planned Maintenance (Source: Thompson *et al.* 1993).

It was not possible to report cost savings through RCM as the cost information for each was not readily available. However, a simple cost analysis of reactive and planned maintenance data collected for 13 months highlighted that on average the cost per maintenance activity through planned maintenance was 16% less as compared to that of reactive maintenance. The planned maintenance costs did not include the cost of staff running RCM such as RCM manager's cost. However, it is fair to say that the savings percentage is higher than the cost of resources needed to implement RCM. The finding supports the published literature that RCM when implemented in its full potential would provide benefits such as reliability, total cost saving, safety and security etc.

Figures 3 and 4 show the evaluation of data for a boiler house. The data presented are in line with the expected results as discussed in Figure 2. The proportion of reactive maintenance activities will be less as the RCM application is matured. Figure 3 shows initial cost of planned maintenance is higher in 2009 when RCM was fully adopted for the boiler house, then cost of maintenance has been lower in the following years. Figure 4 shows that with increase in planned maintenance using RCM, overall maintenance activities have been reduced as expected showing the benefits.

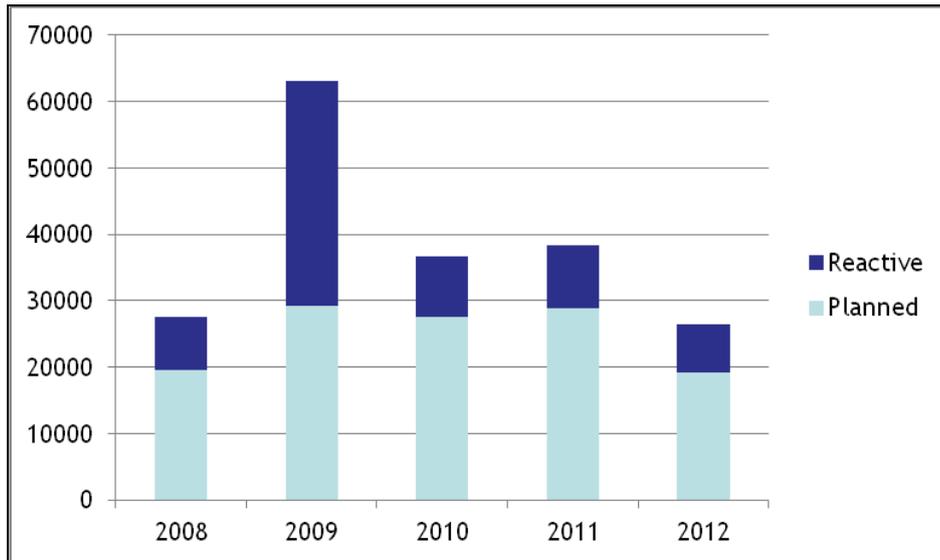


Figure 2: Cost information

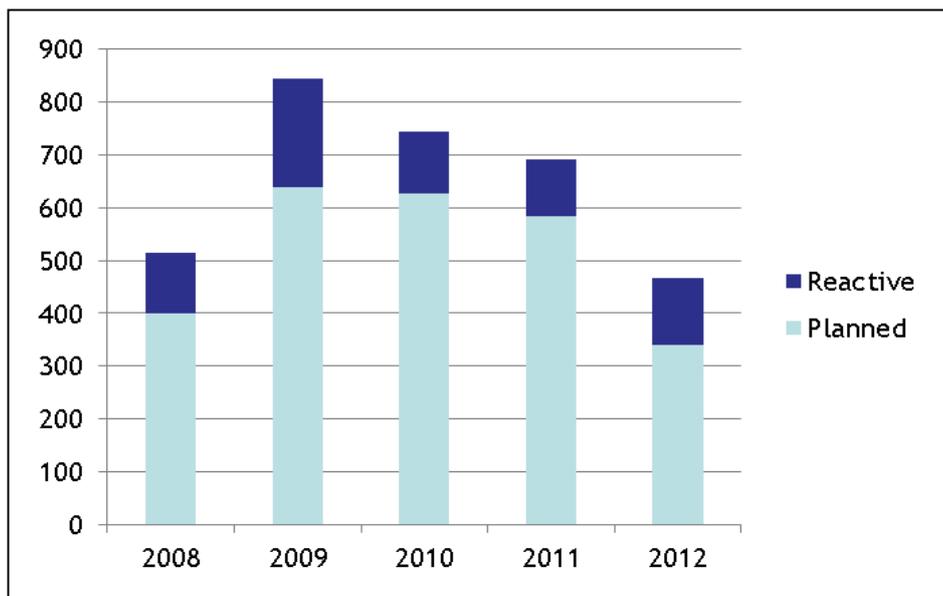


Figure 3: Number of orders for Reactive and Planned Maintenance.

The literature highlights that some RCM initiatives failed due to the factors such as: too low level of analysis, too much emphasis placed on failure data, the superfluous or hurried implementations, over reliance on computer driven processes, involvement of only a few individuals in the organisation or maintenance department/ manufacturers/ equipment vendors attempted to adopt RCM on their own, etc. Brainstorming sessions with managers involved in the RCM process were utilised to identify the ways to overcome the above shortcomings and achieve effective in the implementation of RCM. The discussions highlighted that the effective application of RCM would require considerations of business requirements, the context of the use of the facility and legal requirements in addition to the functional requirements of the facility. The following section introduces an integrated approach developed in the study to manage built facilities effectively.

4 INTEGRATED RCM APPROACH

The concept of the all four dimensions of any system/component is accommodated in the model developed through the complete life cycle of the asset. The detail architecture of the model presented in Figure 4 included four dimensions of analysis: Business, Context, Legal and Functional requirements. The business requirement of a component/system is decided by the impact assessment and the maintenance strategies and policies adopted for it. Similarly the contextual requirement of the component /system is decided mainly by the its use pattern by the users. The legislative value of the component / system is decided by the current acts, legislations, directives and terms and conditions of a contract. The functional requirement of any component / system can be found out by inspection, survey, and condition monitoring of the component / system. This is mainly performed using the RCM approach.

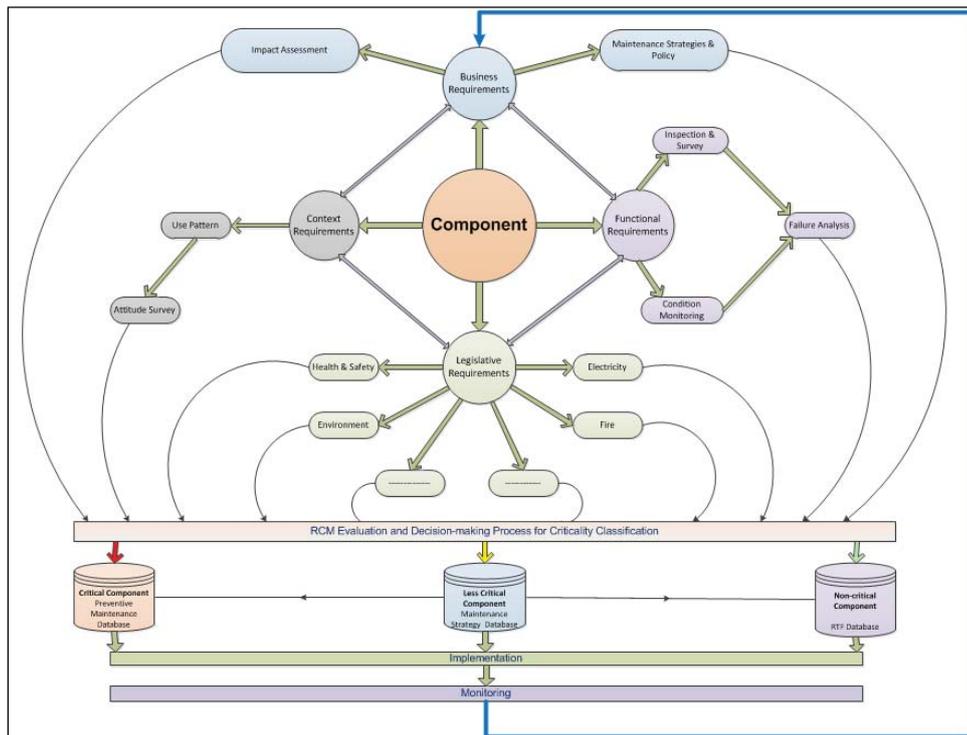


Figure 4: Detailed Architecture of an integrated RCM model

To select suitable facility or a component within the facility for planned maintenance using RCM, two stage approach is used as shown in Figure 8. In stage 1, using criticality evaluation of all four dimensions of the facility under consideration, whether full scale RCM analysis is required or not and what strategy will be suitable is established. If the item/system falls in the category of non-critical, no further analysis is sought, it is allowed to ‘Run-to Failure’ for reactive maintenance task. If the component/item/system falls in the category of critical and less critical, the second stage analysis is compulsory to identify planned and preventive maintenance tasks and its interval. The second stage analysis is carried out as Failure Mode and Effects Analysis (FMEA) or Failure Modes, Effects and Criticality Analysis (FMECA) as described. Some less critical items will be selected for ‘Run-to-Failure’ strategy and some, to the planned preventive maintenance strategy. This allows the companies to focus more on critical asset and do right maintenance at right time. Once maintenance activities are identified, it is seen essential to work out the economical and compliant maintenance interval in a systematic manner. For the reactive maintenance activities, clear identification of response time and development of guidelines for their execution would enhance the effectiveness of the facilities management.

A prototype spread-sheet model was developed encapsulating the concept and the model was evaluated through a case study, details not included here. The prototype required further testing and validation, the initial evaluation of the model has shown that the developed integrated model allows

FM companies to test and identify possible strategies for long term management of the assets with confidence so that they would be able to offer clients improved and reliable services. Further research and development is essential in order to calibrate model parameters to specific company requirements as well as to develop a database of assets with failure patterns and monitoring methods.

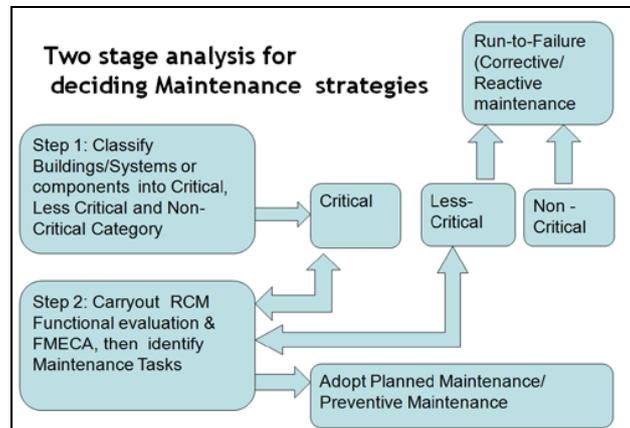


Figure 5: Two stage analysis to select maintenance strategies using RCM

5 CONCLUSIONS

Through the data analysis using a case study, it was justified that the use of RCM in public buildings could bring savings in maintenance cost up to 16% as compared to reactive maintenance. During the period of implementation and monitoring of the RCM strategy, the cost of reactive maintenance decreases as failures are prevented and the time-based preventive maintenance tasks are gradually replaced by condition-based preventive maintenance tasks. The break-even point starts after one/two years and gradually increases by minimising the cost of reactive maintenance and time-based preventive maintenance tasks. Through a case study and brain storming sessions with managers involved in the management of public sector facilities, an integrated RCM model was developed with clear provisions of criteria on business, function, context and legal aspects that makes decisions on maintenance strategy. It is envisaged that the integrated model presented will support FM companies to be able to assess the impact of maintenance strategies in four dimensions: business, functional, legal and context requirements to ensure optimum level of maintenance.

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