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UNDER THE THEME

"MANAGING MAINTENANCE WITHIN INDUSTRY 4.0"
CONICIDE WITH THE 16TH ARAB MAINTENANCE EXHIBITION

Building Maintenance Modelling and Planning

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A large, stylized graphic of the number "4.0" in white, set against a dark blue background. The background also features a faint image of a person in a white lab coat working on a piece of machinery.

4.0



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1. Introduction

- It is broadly appreciated that the cost of maintenance of a building over its life can be much higher than its initial construction cost.
- Evans et al (1998) study of the long term costs of owning and using buildings suggested a ratio of 1:5:200 relating the initial cost of the building to that of maintenance and operations respectively.

Introduction

- Maintenance cost over the life of the asset depends on the type of building and its use.
- According to Barbour Index (1998) the estimated market for Maintenance, Repair and Improvement (MRI) is £28bn compared with £10bn for new build.
- This figure has increased to £55 by 2015

(BCIS Economic Significance of Maintenance Report 2015. BICS is the Building Cost Information Service)

2. BUILDING MAINTENANCE APPROACHES AND TECHNIQUES

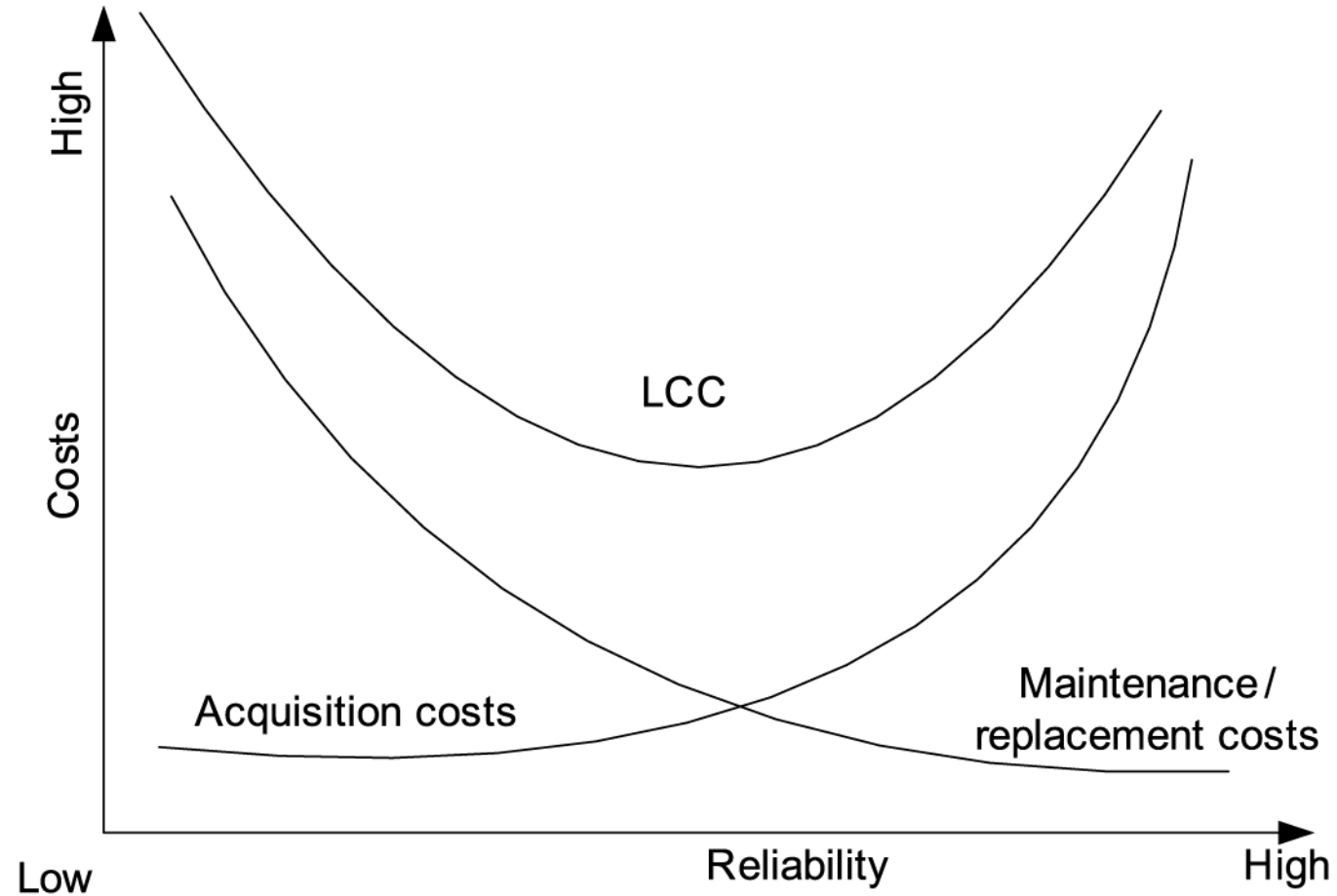
- There are variety of approaches and techniques published in literature for:
 planning,
 scheduling and
 budgeting building maintenance.
- The most notable of these approaches are discussed in what follows.

i. Reliability analysis

- Wu et al[2006] argue that the use of reliability analysis can lead to improved building performance over its whole life.
- Increasing construction cost and reducing maintenance cost are expected with increasing the reliability level target.
- There is need to carefully select the maintenance policy including the frequency of interventions in order to minimise the LCC

LCC Vs Reliability

Source Wu et al(2006)



LCC Life Cycle Cost

- Wu et al[2006] analysed the impact of reliability on each stage of the whole life cycle of the building system including:
 - 1) client requirements and briefing
 - 2) design
 - 3) installation
 - 4) operations and maintenance
 - 5) disposal/ reusing and recycling.

ii. Reliability Centred Maintenance RCM

- RCM is an approach for identifying effective and efficient PM tasks and intervals according to specific procedure(IEC 1999)
- El-Haram and Horner[2002] provide one of few application of RCM in building maintenance.
- They applied integrated logistics support to the development of cost effective maintenance strategies for existing building stock using RCM approach tailored for application to construction projects.

RCM

- A pilot study was undertaken on 18 residential properties. The study details the four steps used including:
 - 1) carrying out building condition survey
 - 2) apply FMEA and RCM
 - 3) evaluate the maintenance costs
 - 4) comparing the results of the condition survey with RCM.

RCM

- The condition survey identified 4 building elements where 74% of failures occurred:
Floor, Windows, Services & Plasterwork.
- The study showed that the potential benefit of applying RCM is a reduction of maintenance cost by 18.5%.
- Other benefits including higher levels of health and safety, help in establishing maintenance programmes and in preparing maintenance budget.

iii. Key Performance Indicators

- Maintenance Performance Indicators (MPIs) are the means to measure the performance of a maintenance process.
- MPIs can act as early warning system for maintenance processes indicating the present status of the process in order to make prediction and take corrective action.
- Shohet[2003] presents an interesting application of KPIs for maintenance in health-care facilities.

KPIs

- The aim of that study was to quantify the effects of users, building parameters and systems on the performance and maintenance of hospital complex buildings and to develop a model for the prediction of performance and maintenance costs.
- One of the significant findings is the high fluctuations of maintenance requirements between 33% and -45% of the multi-year average value

iv. Condition Based Maintenance

- Straub [2002] presents a condition based approach using six-point condition scale.
- Different types of performance loss are identified e.g. technical performance and fire and social safety with each linked to specific maintenance actions.
- The condition assessment method adapted involves visual inspection followed by deciding the type, intensity and extent of defects.

v. Operational Research Models

- Several approaches for building maintenance originated in the field of OR.
- These include delay time analysis, Markov models and simulation.
- The pioneering work of Christer[1982] on delay time modelling was applied in the area of using inspection in building maintenance.

OR Models Markov Models

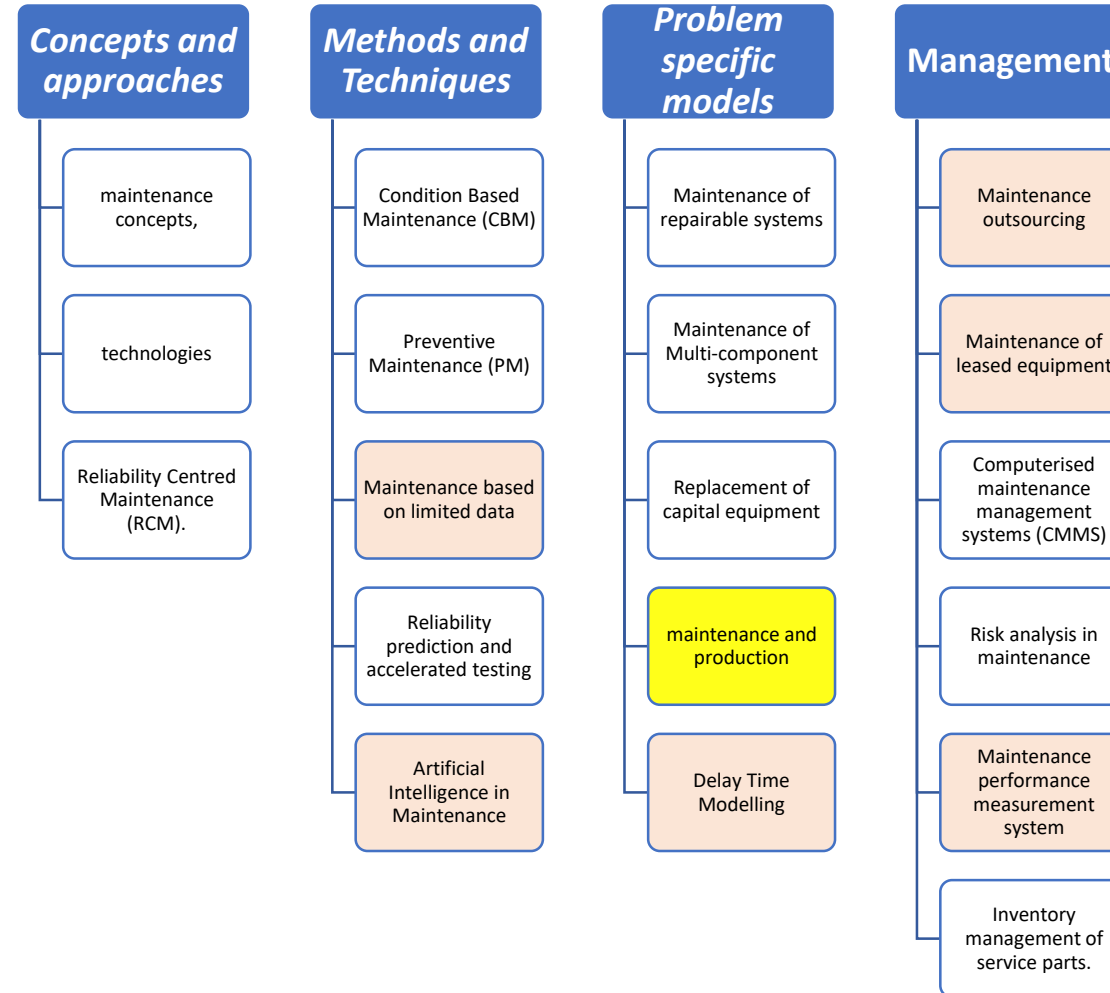
- Winden and Dekker[1998] presents model for using Markov decision process in modelling the maintenance of four building elements, viz. masonry, pointing, window frames and painting.
- The model can determine the maintenance policy that ensures a specific average quality level at minimal cost.

OR Models Simulation

- Al-Zubaidi and Christer[1997] uses simulation to model building maintenance manpower for hospital to investigate the potential gain of using different manpower management and operational procedure.
- The model can simulate various situations accounting for daily variation in maintenance demand, sickness and holidays and the characteristics of different trades.

The state of the art and gaps in building maintenance

(highlighted boxes indicate potential area of development in building maintenance)



BIM

- the availability of this integrated system will lead to consideration of maintenance requirements at the design stage and hence maintenance cost will influence building design.
- This means that BIM will provide appreciation of maintenance requirements from the design stage.

3. Building Information Modelling, BIM

- BIM is a digital representation of the physical and functional characteristics of a facility that covers all stages of a building from design and construction to operations and maintenance.
- It is expected that maintenance data in BIM models will build-up over the coming few years with the use of BIM which can potentially help more effective building operations and maintenance.

BIM, CAFM and CMMS

- Three categories of computerised systems can help achieve effective building maintenance:

1. BIM

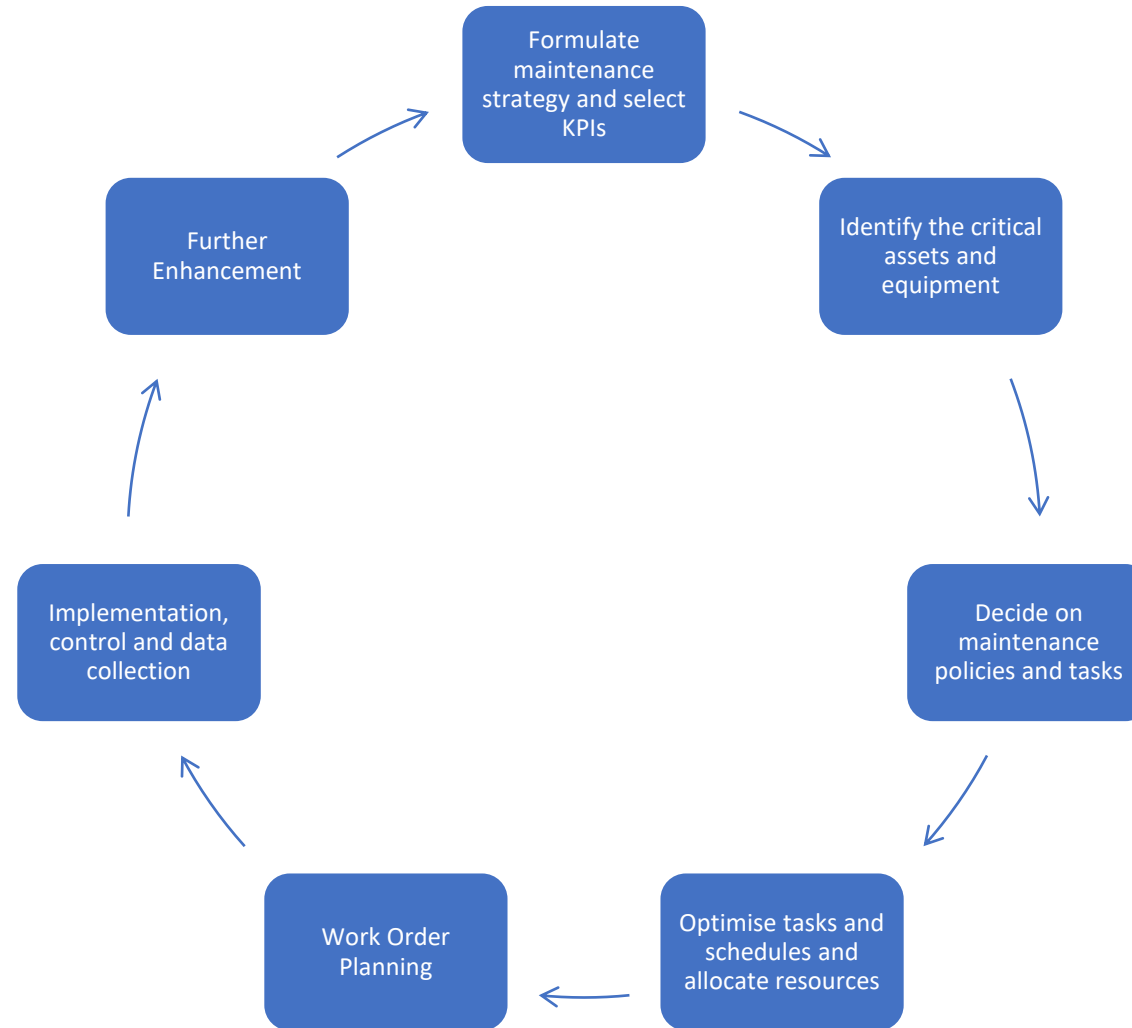
2. CAFM which automat many of the FM functions and results in cost savings and improved utilization of assets throughout the entire lifecycle

3. CMMS is a computer software developed to provide support to maintenance managers in planning, management, and administration of the maintenance function

4. Proposed Building Maintenance Framework

- There are a number of approaches for maintenance planning in Literature. Here we propose a building maintenance framework in the next Figure.
- ***Formulate maintenance strategy and select KPIs***
Maintenance strategy and objectives must be consistent and should support the organization strategy in achieving its objectives. Maintenance objectives can include : maximise building/ equipment availability, minimise operations, maintenance cost or energy consumption etc.

Building Maintenance framework



Building Maintenance framework

- ***Identify the critical assets and equipment***

This can be rather complex process and there are different approaches to achieve it. In general the maintenance manager must decide on types and levels of risks for asset criticality analysis.

- ***Decide on maintenance policies and tasks***

Various approaches can be used to decide on selection of maintenance policy e.g. Decision Making Grid (DMG), Decision Tree and RCM.

Building Maintenance framework

- *Optimise tasks and schedules and allocate resources*

This is an essential step in order to achieve efficiently maintenance objectives e.g. minimizing cost, maximizing availability. Models can vary from simple analytical models to decide on optimal spare parts ordering and stocking policies to complex simulation models

- *Work Order Planning*

This area is seldom discussed by academics though it is of great practical importance. It deals with the operational/ action planning and scheduling of maintenance activities.

Building Maintenance framework

- ***Implementation, control and data collection***

Monitoring, recording and reporting of maintenance execution is essential to ensure achieving maintenance objectives. A precursor is the collection of appropriate data about the various aspects of maintenance possibly using.

- ***Further enhancement***

This starts with Maintenance Performance Management (MPM). Utilization of emerging techniques and technology such as e-maintenance will enable continuous improvement. The use of life cycle analysis is particularly useful in understanding the different elements of asset costs over its entire life

Conclusions

- In this paper we have identified in literature 5 main approaches that are used in building maintenance research. These were discussed and evaluated.
- We believe that over the coming few years with the implementation of BIM significant amount of maintenance data will be accumulated which will enhance building maintenance modelling and planning.
- An outline design of building maintenance concept is presented. This is a prerequisite for developing effective and efficient maintenance.