# Improvement on the Functionality of Computerized Maintenance Management System in the Work Deployment of Multi-Complex Buildings

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## ABSTRACT

Computerized Maintenance Management Systems (CMMS) organise information on maintenance activities, but their functions do not always reflect the operational priorities of facility management personnel in multi-complex buildings. This study identifies the CMMS functionalities most valued by users and examines requirements for improving work order deployment. A cross-sectional questionnaire survey was conducted among 32 CMMS-experienced personnel from UTHM Pagoh, Sime Darby Property (Bandar Universiti Pagoh) and Bangi Health Clinic using purposive sampling. The questionnaire comprised respondent demographics, 35 five-point Likert items covering seven CMMS modules and their sub-functionalities, 20 dichotomous diagnostic items and open-ended comments. Preliminary instrument pretesting was completed before the main survey, and no pretest responses were included in the reported dataset. The reliability output for 36 scale-based items produced a Cronbach's alpha of 0.972. Work order management was the highest-priority CMMS function (86%). In addition, 90.6% of respondents believed that current CMMS software should be improved, while 90.6% indicated that it could not efficiently manage high volumes of work orders, assets and related data in multi-complex buildings. Work order deficiencies were concentrated in cost tracking, standardisation, prioritisation, communication, planning and scheduling and mobile access. The study therefore proposes user-centred design guidelines comprising standardised work order templates, rule-based priority assignment, mobile attachment and barcode support, real-time status notifications, integrated labour and material cost tracking and continuous user feedback. As the sample was limited to 32 respondents from three organisations, the findings should be interpreted as context-specific priorities rather than sector-wide generalisations.

**Keywords:** CMMS, facility management, work order management, multi-complex buildings, maintenance management

## INTRODUCTION

Computerized Maintenance Management Systems (CMMS) are specialised information platforms used to plan, record, monitor and evaluate maintenance activities. Their core functions commonly include asset records, preventive maintenance schedules, work order control, inventory management, vendor information, reporting and mobile access. By standardising maintenance data and workflows, CMMS can improve visibility of failures, repairs, inspections, labour use and service documentation across an organisation. These systems are widely applied in manufacturing, oil and gas, electricity, communications and facility management, although many basic or legacy systems provide only limited functionality (Jasiulewicz, Piechowski, & Piotr, 2017).

Maintenance teams in multi-complex buildings frequently manage large numbers of assets, locations, users and service requests. Paper-based records or fragmented digital systems make it difficult to monitor work before, during and after completion. Even when a CMMS is available, a mismatch between software functions and actual work practices can produce incomplete work orders, delayed communication, weak priority control and poor resource planning. The research problem is therefore not simply whether a CMMS is used, but whether its functionalities support the daily priorities of maintenance personnel.

A well-functioning maintenance department is essential to the availability, safety and cost performance of modern facilities (Shahin, Jamkhaneh, & Yarmohammadi, 2021). CMMS supports this role by consolidating technical, financial and historical maintenance information. However, the usefulness of a CMMS depends on the relevance and usability of its functions. Direct user assessment is therefore required to identify which modules should be prioritised and how the work order process should be redesigned for multi-complex building operations.

### RESEARCH OBJECTIVES

This study has two objectives: (1) to identify and prioritise CMMS functionalities and their sub-functionalities based on the assessment of experienced users and (2) to examine work order management requirements and formulate practical software design guidelines for work deployment in multi-complex buildings.

## BACKGROUND

Maintenance management in a multi-complex development involves a wider operational scope than maintenance of a single building. Multiple buildings may share infrastructure, service providers, access routes, utility networks and central management arrangements. Consequently, a failure or delayed work order in one location may affect several occupants, systems or business functions. Effective coordination of people, assets and maintenance information is therefore central to operational performance.

In this study, a multi-complex building environment refers to a development comprising several independent but operationally connected buildings or premises, such as institutional buildings, commercial spaces, residential units, transport facilities and leisure areas. The defining issue is not merely the number of structures, but the need to coordinate maintenance across different locations, asset types, users and service levels (Craighead, 2013).

As the number and diversity of buildings increase, manual maintenance control becomes less reliable. Technical personnel must manage work requests, operating costs, records, compliance information and data analysis while maintaining service continuity. A CMMS can support these activities, but only when the system is configured around the operational requirements of the facilities and the roles of its users.

Computer-based maintenance management is therefore important for efficient planning and control (Wienker, Henderson, & Volkerts, 2016). A CMMS provides the technical, financial and historical information required to schedule work, allocate resources, track asset condition and evaluate performance (Carnero, 2015). The present study focuses on the functional requirements that users consider most important in a multi-complex building context.

## LITERATURE REVIEW

CMMS capabilities can be extended through the integration of Industry 4.0 technologies. Sensors, connected devices and centralised databases can transmit operating information to the CMMS, support condition monitoring and trigger maintenance action with less manual data entry (Mohd Noor, Amrin, & Mazlan, 2019). This integration shifts CMMS from a mainly reactive recording tool towards a platform that can support proactive maintenance decisions.

Technology integration may improve operating efficiency, data quality and equipment availability, but it also creates implementation challenges. Organisations must consider initial cost, compatibility with legacy systems, data governance and the technical readiness of the workforce. A technically advanced system will not provide the expected benefit when users cannot understand its workflows or when the functions do not match maintenance priorities (Mohd Noor, Amrin, & Mazlan, 2019).

Early CMMS applications concentrated on preventive maintenance scheduling and asset status records (Amadi-Echendu, 2015). As organisations moved from paper files to computer databases, CMMS expanded to support data entry, search, analysis and reporting. Current systems increasingly include web and mobile access, data synchronisation and integration with smart technologies. Figure 1 summarises this development in relation to the industrial revolutions.

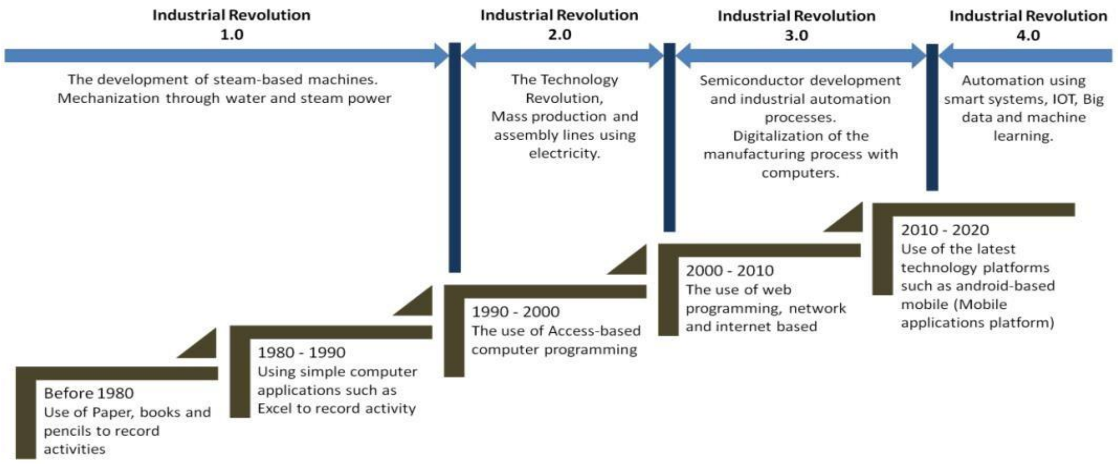


**Figure 1: The industrial revolution and the history of CMMS relate to one another (Mohd Noor, Amrin, & Mazlan, 2019)**

The Fourth Industrial Revolution is associated with connected systems, advanced analytics, automation and large-scale data exchange (Schwab, 2016). Internet of Things networks allow operational information to be transmitted rapidly from distributed assets and locations, enabling maintenance teams to monitor conditions and respond to emerging problems more effectively (Maldonado, Ameigeiras, Soler, Jonathan Garzon, & Ortiz, 2019).

The earlier industrial revolutions introduced mechanisation, electrical mass production and computer-based automation. Industry 4.0 extends these developments through cyber-physical systems that connect physical assets with information and communication technologies (Aleloul, Liew, Wan Abdullah Zawawi, & Mohammed, 2018). For CMMS, this development increases the importance of real-time data, system interoperability and user interfaces that translate complex information into clear maintenance actions.

## CMMS IN MULTI-COMPLEX BUILDINGS

CMMS has become an important facility management tool for tracking, scheduling and documenting building maintenance (Bouabdallaoui, Lafhaj, & Yim, 2020). It can be integrated with Building Information Modelling (BIM) and Building Energy Management Systems (BEMS) to improve fault identification and maintenance coordination (Shalabi & Turkan, 2020). In multi-complex buildings, the system must support multiple sites, different asset classes, large work order volumes and communication among requesters, managers, technicians and service providers. CMMS data may also support performance evaluation, occupant feedback and predictive maintenance analysis (Bortolini & Forcada, 2019; D'orazio, Giuseppe, & Bernardini, 2022).

## MAINTENANCE CHALLENGES IN MULTI-COMPLEX BUILDINGS

Multi-complex buildings contain numerous locations, asset types and interdependent systems. Their physical layout can make equipment difficult to identify or access, while the scale of operations increases the number of work requests, records and coordination decisions required from maintenance teams (Buitelaar, Moroni, & Franco, 2020; J Huang, Wang Y., & Li H., 2015).

The systems maintained may include HVAC, electrical distribution, plumbing, fire protection, security and specialised controls. Each has different maintenance requirements, tools and competencies. Interdependence between these systems means that work on one asset may require isolation or coordination with another, so work orders must clearly identify dependencies, access requirements and operational risks (Pang, Zhu, Wang, & Wu, 2018).

Advanced building automation and energy management systems can improve performance, but they also require maintenance personnel to interpret technical data and troubleshoot integrated systems. In buildings that operate continuously, maintenance must be planned within limited windows to minimise downtime and disruption. This places greater emphasis on priority rules, scheduling, resource availability and real-time communication within the CMMS.

Restricted access, confined spaces and complex layouts may extend task duration and increase the risk of incomplete information or human error (Sone & Yoshida, 2021). Effective CMMS deployment should therefore support accurate asset identification, standardised work order information, coordination across teams and continuous visibility of task status.

## CMMS FUNCTIONALITIES

CMMS functionality was operationalised through seven modules and 35 sub-functionalities. Asset management comprised asset registration, asset tracking, asset accounting, availability tracking and performance management. Work order management comprised work order creation, approval, distribution, execution and evaluation. Preventive maintenance covered regular maintenance, repair history, modification of maintenance frequency and intervals, task tracking and assignment of multiple technicians. Reporting and analytics included data organisation, expense reporting, performance indicators, maintenance KPI tracking and revenue or profitability analysis. Inventory control covered supplies and spare-parts tracking, status and downtime review, stock-level reordering, inventory audits and warehouse stock transfer. Vendor support included supplier information, technical support, system updates, bug resolution and licence renewal. Mobile accessibility comprised easy access, barcode or QR scanning, real-time updates, offline functionality and integration or data synchronisation. Figure 2 presents the relationship between these modules and their sub-functionalities.

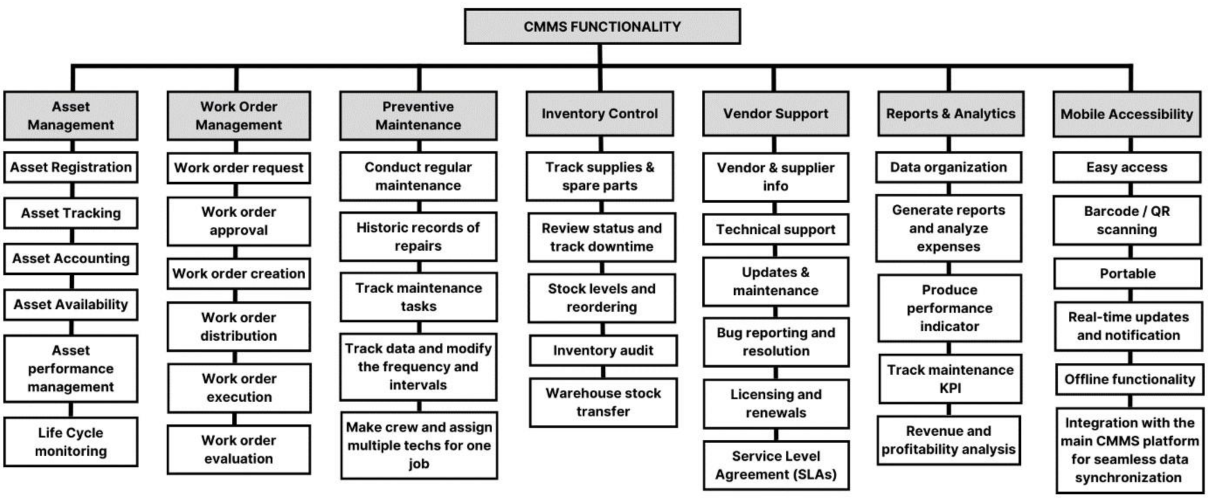


Figure 2: CMMS modules and sub-functionalities (Argawal, 2023)

# METHODOLOGY

This study used an exploratory cross-sectional survey design. Purposive sampling was applied because the research questions required respondents with direct knowledge or experience of CMMS. The target population was facility management personnel involved in maintenance requests, work order processing, system administration or maintenance execution. The study was designed to identify context-specific priorities and was not intended to produce population estimates for the entire facility management sector.

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The main survey obtained 32 usable responses from personnel at UTHM Pagoh, Sime Darby Property (Bandar Universiti Pagoh) and Bangi Health Clinic. The respondent group comprised 22 technicians, four facility executives, two system administrators, two assistant engineers, one facility manager and one information technology officer. All respondents reported some CMMS experience, ranging from less than one year to more than six years. The organisation-level distribution of respondents was not recorded in the analysed dataset, so no comparison among the three organisations was undertaken.

The questionnaire contained five components. The first recorded demographic information. The second included 35 five-point Likert items covering the seven CMMS modules and sub-functionalities listed in Section 3.3. The third comprised 11 dichotomous questions on general CMMS capability, including scalability, mobile access, training, data exchange and Industry 4.0 adaptation. The fourth comprised nine dichotomous questions focused on work order management, including completeness, communication, cost tracking, standardisation, priority, recurring work and planning. The final component invited open-ended suggestions from respondents.

The study proceeded in four sequential stages. First, the literature review established the CMMS modules and questionnaire content. Second, preliminary pretesting checked item clarity, coverage and operation of the online form; pretest responses were not included in the reported results. Third, the main questionnaire was distributed face to face and through email or WhatsApp using Google Forms. Fourth, the 32 main-survey responses were analysed using frequencies and percentages, while internal consistency was assessed in SPSS using Cronbach's alpha. All results in Sections 5 and 6 refer to the main survey rather than pilot data.

## RESULTS AND DISCUSSION

A total of 32 CMMS-experienced personnel completed the main questionnaire. The survey was distributed using Google Forms through email and WhatsApp, with limited face-to-face distribution where access permitted. Respondents represented operational, managerial and system-support roles at the three participating organisations. Table 1 summarises the completion rate for the targeted purposive sample.

Table 1: Number of respondents' rate

| Sample size | Number of respondents | Respondent rate |
|---|---|---|
| 32 | 32 | 100% |

All 32 individuals in the targeted sample returned usable questionnaires, giving a completion rate of 100% for the selected participants. This figure should not be interpreted as a population response rate because the sample was purposively selected and was not drawn from a complete sampling frame of the facility management sector.

### DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Table 2 presents the respondents' gender, age, job position and length of CMMS experience. These variables were used to describe the participating group and to support cautious interpretation of the functionality priorities.

Table 2: Summary of respondents' demographics

| | | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 23 | 71.9 |
| | Female | 9 | 28.1 |
| Age | 21-30 years | 9 | 28.1 |
| | 31-40 years | 20 | 62.5 |
| | 41-50 years | 3 | 9.4 |
| | 51 years and above | 0 | 0.0 |
| Job Position | Technician | 22 | 68.8 |
| | Facility Manager | 1 | 3.1 |
| | Facility Executive | 4 | 12.5 |

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| | | | |
|---|---|---|---|
| | System Administrator | 2 | 6.3 |
| | Assistant Engineer | 2 | 6.3 |
| | Information technology officer | 1 | 3.1 |
| CMMS experience | Less than 1 year | 3 | 9.4 |
| | 2-3 years | 7 | 21.9 |
| | 4-5 years | 12 | 37.5 |
| | More than 6 years | 10 | 31.3 |

The sample consisted of 23 men (71.9%) and nine women (28.1%). Most respondents were aged 31 to 40 years (62.5%), followed by 21 to 30 years (28.1%) and 41 to 50 years (9.4%). Technicians formed the largest occupational group at 68.8%, while the remaining respondents were facility executives, system administrators, assistant engineers, a facility manager and an information technology officer. In terms of CMMS experience, 37.5% had four to five years of experience and 31.3% had more than six years. The dominance of technicians means that the results primarily reflect frontline maintenance requirements.

## ANALYSIS OF LIKERT-SCALE QUESTIONS

The 35 Likert items asked respondents to rate the importance or adequacy of the sub-functionalities under asset management, work order management, preventive maintenance, reporting and analytics, inventory control, vendor support and mobile accessibility. Responses were recorded on a five-point scale, where higher values represented stronger agreement or priority. Table 3 reports the frequency and percentage for every response category, thereby providing the questionnaire detail requested for interpretation and replication.

Table 3: Distribution of responses for the 35 CMMS sub-functionality items

| **Questions** | **Frequency** | | | | | **Percentage (%)** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Scale | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| | | | | | | | | | | |
| **A. Asset Management** | | | | | | | | | | |
| Asset Registration | 1 | 0 | 7 | 12 | 12 | 3.1 | 0.0 | 21.9 | 37.5 | 37.5 |
| Asset Tracking | 2 | 2 | 8 | 10 | 10 | 6.3 | 6.3 | 25.0 | 31.3 | 31.3 |
| Asset accounting | 1 | 3 | 9 | 10 | 9 | 3.1 | 9.4 | 28.1 | 31.3 | 28.1 |
| Asset availability tracking | 0 | 3 | 7 | 10 | 12 | 0.0 | 9.4 | 21.9 | 31.3 | 37.5 |
| Asset performance management | 0 | 3 | 8 | 7 | 14 | 0.0 | 9.4 | 25.0 | 21.9 | 43.8 |
| **B. Work Order Management** | | | | | | | | | | |
| Work order creation | 0 | 0 | 9 | 9 | 14 | 0.0 | 0.0 | 28.1 | 28.1 | 43.8 |
| Work order approval | 0 | 0 | 8 | 8 | 16 | 0.0 | 0.0 | 25.0 | 25.0 | 50.0 |
| Work order distribution | 1 | 1 | 7 | 9 | 14 | 3.1 | 0.0 | 21.9 | 28.1 | 43.8 |
| Work order execution | 0 | 0 | 6 | 8 | 18 | 0.0 | 0.0 | 18.8 | 25.0 | 56.3 |
| Work order evaluation | 0 | 0 | 7 | 10 | 14 | 0.0 | 0.0 | 21.9 | 31.3 | 43.8 |
| **C. Preventive Maintenance** | | | | | | | | | | |
| Conduct regular maintenance | 1 | 0 | 6 | 8 | 17 | 3.1 | 0.0 | 18.8 | 25.0 | 53.1 |
| Maintenance history records | 0 | 1 | 3 | 10 | 18 | 0.0 | 0.0 | 9.4 | 31.3 | 56.3 |
| Modify maintenance frequency and intervals | 0 | 0 | 11 | 10 | 11 | 0.0 | 0.0 | 34.4 | 31.3 | 34.4 |
| Track maintenance tasks | 2 | 0 | 9 | 10 | 11 | 6.3 | 0.0 | 28.1 | 31.3 | 34.4 |
| Assign multiple technicians to one job | 2 | 0 | 8 | 10 | 12 | 6.3 | 0.0 | 25.0 | 31.3 | 37.5 |
| **D. Reporting and Analytics** | | | | | | | | | | |
| Data organisation | 0 | 1 | 4 | 11 | 16 | 0.0 | 0.0 | 12.5 | 34.4 | 50.0 |
| Generate reports and analyse expenses | 0 | 0 | 9 | 9 | 14 | 0.0 | 0.0 | 28.1 | 28.1 | 43.8 |
| Produce performance indicators | 0 | 1 | 6 | 13 | 12 | 0.0 | 0.0 | 18.8 | 40.6 | 37.5 |
| Track maintenance KPIs | 0 | 2 | 5 | 9 | 14 | 0.0 | 0.0 | 15.6 | 28.1 | 43.8 |
| Revenue and profitability analysis | 2 | 1 | 9 | 6 | 14 | 6.3 | 0.0 | 28.1 | 18.8 | 43.8 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **E. Inventory Control** | | | | | | | | | | |
| Track supplies and spare parts | 0 | 2 | 8 | 10 | 12 | 0.0 | 0.0 | 25.0 | 31.3 | 37.5 |
| Review asset status and track downtime | 0 | 1 | 7 | 10 | 14 | 0.0 | 0.0 | 21.9 | 31.3 | 43.8 |
| Stock levels and reordering | 0 | 3 | 5 | 8 | 16 | 0.0 | 0.0 | 15.6 | 25.0 | 50.0 |
| Inventory audit | 1 | 3 | 4 | 12 | 12 | 3.1 | 0.0 | 12.5 | 37.5 | 37.5 |
| Warehouse stock transfer | 1 | 2 | 9 | 10 | 10 | 3.1 | 0.0 | 28.1 | 31.3 | 31.3 |
| **F. Vendor Support** | | | | | | | | | | |
| Vendor and supplier information | 1 | 3 | 9 | 9 | 10 | 3.1 | 0.0 | 28.1 | 28.1 | 31.3 |
| Technical support | 0 | 2 | 11 | 8 | 11 | 0.0 | 0.0 | 34.4 | 25.0 | 34.4 |
| Updates and maintenance | 0 | 3 | 5 | 7 | 17 | 0.0 | 0.0 | 15.6 | 21.9 | 53.1 |
| Bug reporting and resolution | 0 | 0 | 9 | 8 | 15 | 0.0 | 0.0 | 28.1 | 25.0 | 46.9 |
| Licence and renewal | 3 | 2 | 7 | 5 | 15 | 9.4 | 0.0 | 21.9 | 15.6 | 46.9 |
| **G. Mobile Accessibility** | | | | | | | | | | |
| Easy mobile access | 1 | 4 | 6 | 6 | 15 | 3.1 | 0.0 | 18.8 | 18.8 | 46.9 |
| Barcode or QR scanning | 2 | 3 | 5 | 15 | 7 | 6.3 | 0.0 | 15.6 | 46.9 | 21.9 |
| Real-time updates | 1 | 3 | 7 | 10 | 11 | 3.1 | 0.0 | 21.9 | 31.3 | 34.4 |
| Offline functionality | 3 | 2 | 10 | 6 | 11 | 9.4 | 0.0 | 31.3 | 18.8 | 34.4 |
| Integration and data synchronisation | 2 | 5 | 6 | 8 | 11 | 6.3 | 0.0 | 18.8 | 25.0 | 34.4 |

## MOST PRIORITISED CMMS FUNCTION

Figure 3 shows the overall prioritisation of the seven CMMS modules. Work order management received the highest priority at 86%. Asset management, preventive maintenance, reporting and analytics and vendor support each recorded 65%, followed by mobile accessibility at 62% and inventory control at 59%. The result indicates that respondents placed greatest emphasis on the process that converts maintenance requests into approved, assigned, executed and evaluated tasks. This priority is consistent with the operational profile of the sample, in which technicians represented 68.8% of respondents.

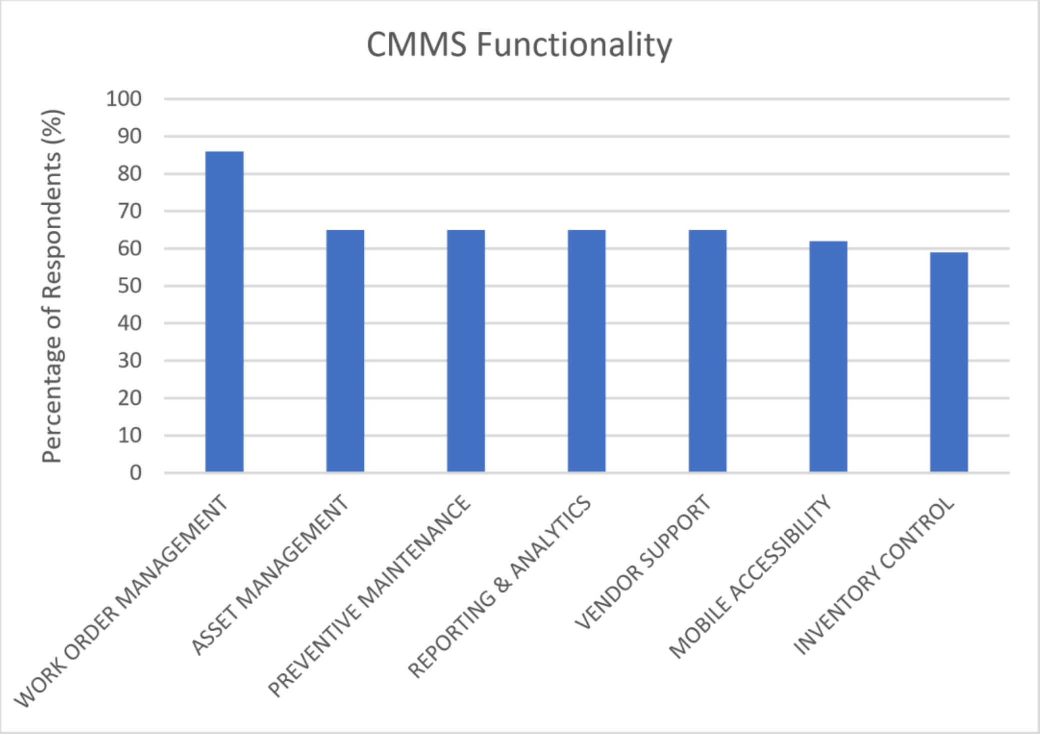


Figure 3: Prioritised CMMS functionality

## GENERAL CMMS CAPABILITY QUESTIONS

The general diagnostic component contained 11 yes-or-no questions concerning respondents' experience of current CMMS software, its sufficiency, scalability, mobile capability, training requirements, data exchange and readiness for Industry 4.0 technologies. Table 4 presents the complete wording and response distribution for these questions.

Table 4: Summary of general CMMS capability responses

| Questions | | Frequency | | Percentage (%) | |
|---|---|---|---|---|---|
| | | Yes | No | Yes | No |
| Question 1 | Have you encountered any problems when using a CMMS? | 4 | 28 | 12.5 | 87.5 |
| Question 2 | Do you consider current CMMS software in the market sufficient? | 16 | 16 | 50.0 | 50.0 |
| Question 3 | Can CMMS adapt to Industry 4.0 technologies? | 23 | 9 | 71.9 | 28.1 |
| Question 4 | Should current CMMS software be improved and upgraded? | 29 | 3 | 90.6 | 9.4 |
| Question 5 | Have you heard of an Intelligent Computerized Maintenance Management System (I-CMMS)? | 2 | 30 | 6.3 | 93.8 |
| Question 6 | Can current CMMS software handle diverse maintenance tasks in a multi-complex building? | 21 | 11 | 65.6 | 34.4 |
| Question 7 | Can current CMMS software efficiently manage a high volume of work orders, assets and associated data in a multi-complex building? | 3 | 29 | 9.4 | 90.6 |
| Question 8 | Can CMMS enable seamless data exchange and provide a comprehensive view of the building's operations? | 23 | 9 | 71.9 | 28.1 |
| Question 9 | Is mobile CMMS sufficient for technicians to access work orders and update information in real time? | 10 | 22 | 31.3 | 68.8 |
| Question 10 | Does the current CMMS require user training? | 24 | 8 | 75.0 | 25.0 |
| Question 11 | Can the current CMMS generate automated work orders and track compliance with maintenance schedules in a multi-complex building? | 26 | 6 | 81.3 | 18.8 |

The results show a distinction between routine use and perceived system adequacy. Although 87.5% reported no general problem based on their experience, only half considered current market software sufficient and 90.6% believed it should be improved. A further 90.6% indicated that current CMMS software could not efficiently manage a high volume of work orders, assets and associated data in a multi-complex building. These findings suggest that users may be able to complete routine tasks while still recognising limitations in scalability and functionality.

Regarding technology and accessibility, 71.9% believed that CMMS could adapt to Industry 4.0 technologies and 71.9% considered seamless data exchange possible. However, 68.8% judged mobile CMMS insufficient for technicians to access and update work orders in real time, while 75.0% stated that the current CMMS required training. Although 81.3% reported that automated work orders and maintenance-schedule compliance could be supported, the findings indicate that mobile usability, system scaling and user support remain important areas for improvement.

## WORK ORDER MANAGEMENT DIAGNOSTIC QUESTIONS

Table 5: Summary of work order management responses

| Questions | | Frequency | | Percentage (%) | |
|---|---|---|---|---|---|
| | | Yes | No | Yes | No |
| Question 1 | Is mobile CMMS sufficient for technicians to access work orders, update information and retrieve asset details in real time? | 18 | 14 | 56.3 | 43.8 |

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| | | | | | |
|---|---|---|---|---|---|
| Question 2 | Can the CMMS generate a simple work order that supports barcodes, handheld terminals and future technological applications? | 27 | 5 | 84.4 | 15.6 |
| Question 3 | Is the current CMMS incomplete or capable of providing inaccurate information? | 20 | 12 | 62.5 | 37.5 |
| Question 4 | Have you experienced communication breakdown when receiving a work order or ineffective communication among maintenance teams, managers and requesters? | 23 | 9 | 71.9 | 28.1 |
| Question 5 | Can the current CMMS track the total cost of a work order in a simplified manner? | 3 | 29 | 9.4 | 90.6 |
| Question 6 | Does the current CMMS lack standardisation in the format and procedure used to create and manage work orders? | 25 | 7 | 78.1 | 21.9 |
| Question 7 | Does the CMMS fail to prioritise work orders according to urgency, criticality or resource availability? | 26 | 6 | 81.3 | 18.8 |
| Question 8 | Can the CMMS support recurring work orders for routine maintenance tasks? | 19 | 13 | 59.4 | 40.6 |
| Question 9 | Can the CMMS provide adequate planning and scheduling for efficient resource utilisation? | 11 | 21 | 34.4 | 65.6 |

The nine work order questions revealed several specific weaknesses. While 56.3% considered mobile CMMS sufficient for work order access and updates and 84.4% supported simple work orders that could be linked to barcodes or handheld devices, 62.5% stated that current work orders were incomplete or contained inaccurate information. Communication breakdown was reported by 71.9% of respondents. In addition, 90.6% indicated that the system could not track total work order cost in a simplified manner, 78.1% reported inconsistent formats and procedures and 81.3% experienced difficulty prioritising work by urgency, criticality or resource availability. Recurring work orders were considered supported by 59.4%, but 65.6% judged planning and scheduling inadequate. These results identify cost control, information completeness, standardisation, priority rules, communication and resource planning as the principal work order design requirements.

## RESPONDENT SUGGESTIONS

Table 6: Summary of respondent suggestions

| **Job Position** | **Comments** |
|---|---|
| Assistant Engineer | Provide direct upload and structured retrieval of photographs or PDF evidence within the relevant work order. |
| Facility Executive | Develop a mobile application for clients and service providers to raise and monitor work orders. |
| Technician | Use a clear interface with softer display colours to improve readability. |
| Technician | Retain monitoring capability but strengthen access control and protection against information leakage. |
| Technician | Allow complaints and work orders to be submitted and updated directly through a mobile application. |
| System Administrator | Provide requesters with clear visibility of the status and progress of submitted reports. |

### RELIABILITY ANALYSIS

Cronbach's alpha was used to assess internal consistency among the scale-based questionnaire items. Alpha values range from 0 to 1, with higher values indicating that the items provide a more consistent measurement.

Following the interpretation presented by Hair, Page and Samouel (2007) and the commonly applied minimum of 0.70 (Nunnally, 1978), values above 0.90 are interpreted as excellent internal consistency.

The reliability analysis was conducted in SPSS on the 36 scale-based items recorded in the final questionnaire dataset. The dichotomous diagnostic questions and open-ended comments were analysed descriptively and were not treated as equivalent to the Likert-scale construct scores. Table 7 provides the interpretation thresholds.

Table 7: Interpretation of Cronbach's alpha coefficient (Hair, Page, & Samouel, 2007)

| Alpha coefficient range | Interpretation |
|---|---|
| Less than 0.60 | Poor |
| 0.60 to less than 0.70 | Moderate |
| 0.70 to less than 0.80 | Good |
| 0.80 to less than 0.90 | Very good |
| 0.90 and above | Excellent |

The SPSS output produced a Cronbach's alpha of 0.972 and an alpha based on standardised items of 0.973 for 36 items, as shown in Table 8. This result indicates excellent internal consistency in the final dataset. However, high internal consistency does not by itself establish content validity, construct validity or generalisability beyond the participating group.

Table 8: Reliability statistics for the final questionnaire dataset

| Cronbach's alpha | Cronbach's alpha based on standardised items | Number of items | Internal consistency |
|---|---|---|---|
| 0.972 | 0.973 | 36 | Excellent |

## DISCUSSION

This section interprets the results in relation to the two research objectives. The first objective concerns the relative priority of the CMMS modules and their sub-functionalities. The second concerns deficiencies in work order deployment and the corresponding requirements for software improvement in multi-complex buildings.

### PRIORITISED CMMS FUNCTIONALITIES

The literature review and questionnaire operationalised CMMS through seven modules and 35 sub-functionalities, allowing respondents to assess specific features rather than CMMS as a single undifferentiated system. The highest overall priority was work order management at 86%. Within the Likert items, respondents also placed strong emphasis on work order approval, execution and evaluation, preventive maintenance history, data organisation, stock reordering and system updates. These features directly support daily task control and maintenance accountability.

The main survey followed preliminary instrument pretesting. The pretesting stage was used only to check clarity, coverage and online-form operation, whereas all percentages, demographic results and reliability statistics reported in this article were calculated from the 32 main-survey responses. This separation clarifies that the findings are not pilot results and that the main study objective was to derive operational priorities from experienced CMMS users.

The prioritisation result should be interpreted in light of the respondent profile. Technicians formed 68.8% of the sample and are directly involved in receiving, executing and closing maintenance tasks. Their work is therefore particularly sensitive to incomplete instructions, delayed approvals, weak status information and poor scheduling. Other occupational groups may place greater weight on reporting, financial analysis or vendor management. The study identifies a strong frontline priority, but it does not establish that the same ranking would occur in a manager-dominated or nationally representative sample.

## WORK ORDER MANAGEMENT REQUIREMENTS

The second objective was addressed through the general CMMS and work order diagnostic questions. The finding that 90.6% wanted current CMMS software to be improved is consistent with the reported weaknesses in work order cost tracking, standardisation, prioritisation, communication and planning. These problems affect the full work order life cycle, from initial request and approval to assignment, execution, cost capture, closure and feedback.

The findings also show that technology integration must be accompanied by usable workflows. Respondents recognised the potential of Industry 4.0 adaptation and data exchange, but many considered mobile access insufficient and stated that training was required. A CMMS should therefore present sensor, asset and maintenance data through clear task-oriented screens rather than simply adding more technical functions. Scalability, interoperability and user experience should be treated as connected design requirements.

Awareness of Intelligent CMMS was low, with 93.8% of respondents reporting that they had not heard of I-CMMS. This does not demonstrate opposition to artificial intelligence; rather, it indicates limited exposure to the term or its applications. Advanced functions such as automated classification or predictive maintenance should therefore be introduced with transparent rules, user guidance and the ability for authorised personnel to review or override system recommendations.

The open-ended comments reinforce the quantitative results. Respondents requested direct attachment upload, mobile access for clients and service providers, clearer report-status visibility, a less visually demanding interface and stronger protection against information leakage. Together, these findings support a user-centred work order design that combines standardised data, real-time communication, mobile usability, cost and resource controls and continuous feedback.

## LIMITATIONS OF THE STUDY

The study has several limitations that affect the interpretation of its findings. It used a small purposive sample from three organisations and was designed as an exploratory assessment of user priorities. The results therefore provide practical evidence for the participating contexts but should not be generalised to the entire facility management sector.

Access to respondents was constrained by operational duties, so much of the questionnaire distribution was conducted through email and WhatsApp. Limited completion time may have reduced the depth of reflection, particularly for open-ended questions. Remote administration also prevented the researcher from observing how respondents used the CMMS while answering the survey.

## SAMPLE AND GENERALISABILITY

Only 32 respondents participated and technicians represented 68.8% of the sample. The organisation-level distribution was not recorded in the analysed dataset, which prevented comparison among UTHM Pagoh, Sime Darby Property and Bangi Health Clinic. The ranking of CMMS priorities may therefore differ in a larger sample with more facility managers, administrators, financial personnel or external service providers.

## DATA COLLECTION AND MEASUREMENT

The study relied on self-reported perceptions collected at one point in time. Some yes-or-no questions may simplify complex experiences and do not measure the severity or frequency of a problem. Future evaluations should combine questionnaires with interviews, direct usability observation and CMMS transaction data, such as response time, closure time, rework rate, missing fields and cost-record completeness.

## SCOPE OF EVIDENCE

The study identified user requirements but did not develop or experimentally test a redesigned CMMS. The proposed design guidelines are therefore evidence-informed specifications rather than validated software performance claims. An independent pilot sample was not included, and the reliability result was calculated from the final survey dataset. Subsequent research should validate both the instrument and a functional prototype in additional building types.

# CONCLUSION

This study identified the CMMS functions most relevant to work deployment in multi-complex buildings and examined specific weaknesses in work order management. Work order management was the highest-priority module at 86%, while 90.6% of respondents believed current CMMS software should be improved. The most important deficiencies concerned incomplete information, communication breakdown, weak cost tracking, inconsistent work order formats, difficulty assigning priority and inadequate planning and scheduling.

The findings show that CMMS improvement should focus on the usability and completeness of everyday workflows rather than on adding features without operational justification. A system for multi-complex buildings must connect requesters, managers, technicians and service providers while maintaining clear data ownership, status visibility and auditability. Because the evidence is based on 32 respondents from three organisations, the proposed priorities should be validated in larger and more diverse settings.

## SOFTWARE DESIGN GUIDELINES

The following software design guidelines translate the survey findings into concrete requirements for restructuring work order functions so that they are more usable for everyday maintenance personnel.

1. Standardise the work order record. Use a consistent template with mandatory fields for asset identification, location, fault description, safety or operational impact, priority, instructions, required materials, responsible person, target date, attachments and closure evidence. Validation rules should prevent submission of incomplete or contradictory information.

2. Apply transparent priority rules. The system should calculate or recommend priority using urgency, asset criticality, safety risk, service impact, statutory requirements and resource availability. Users should be able to view the basis of the priority and authorised managers should be able to override it with a recorded reason.

3. Provide mobile-first task access. Requesters and technicians should be able to create, receive and update work orders from mobile devices, upload photographs or PDF evidence directly, scan barcodes or QR codes and work offline where connectivity is weak. Attachments should be stored against the relevant asset and work order rather than in an unstructured shared folder.

4. Make workflow status visible. The interface should show each stage from request, approval and assignment to execution, verification and closure. Real-time notifications, escalation rules and a feedback channel should inform requesters and maintenance personnel of delays, changes and completion.

5. Integrate cost, resource and schedule controls. Labour hours, materials, contractor charges and downtime should be captured within the work order. Recurring work templates, preventive maintenance schedules, resource calendars and conflict warnings should support realistic planning and simplify total cost tracking.

6. Design for usability, security and continuous improvement. Screens should use clear terminology, consistent navigation and readable visual presentation. Role-based access, audit trails and data-protection controls should address information leakage concerns. Usage analytics and periodic user feedback should be used to refine the system after deployment.

# RECOMMENDATIONS FOR FUTURE RESEARCH

Future research should test the revised questionnaire with an independent pilot sample and then apply it to a larger stratified sample across different facility types. Greater representation of facility managers, system administrators, finance personnel, service providers and requesters would allow role-based and organisation-based comparisons.

A functional prototype should also be developed from the six design guidelines and evaluated through task-based usability testing, interviews and operational CMMS data. Relevant performance measures include work order completion time, missing-data rate, response and closure time, scheduling compliance, cost-record completeness, mobile task success and user satisfaction. The contribution of artificial intelligence should be assessed only after the core workflow, data quality and governance requirements are established.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

## AUTHOR CONTRIBUTION

All authors contributed to the conception of the study, data collection or interpretation, manuscript preparation and critical revision. All authors reviewed and approved the final manuscript.

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