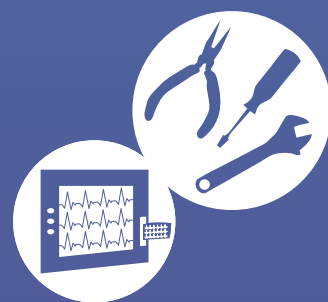
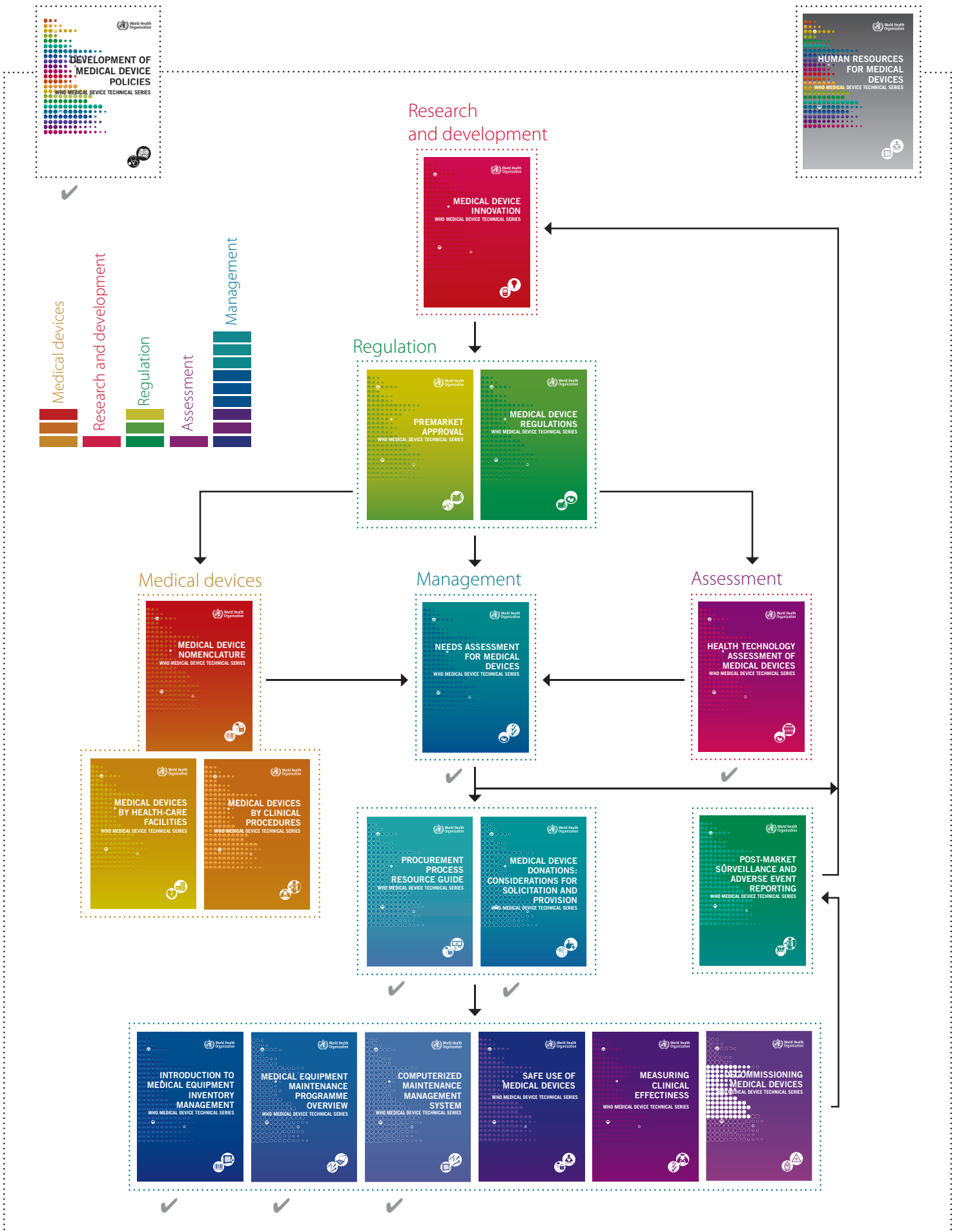


# Computerized maintenance management system

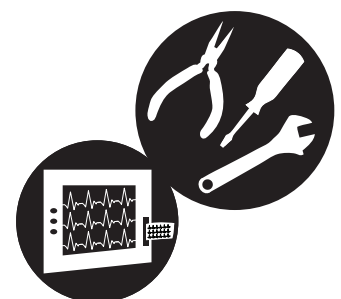
WHO Medical device technical series





# Computerized maintenance management system

WHO Medical device technical series



WHO Library Cataloguing-in-Publication Data

Computerized maintenance management system.

(WHO Medical device technical series)

1. Equipment and supplies. 2. Biomedical engineering. 3. Management information systems. 4. Biomedical technology. I. World Health Organization.

ISBN 978 92 4 150141 5

(NLM classification: WX 147)

**© World Health Organization 2011**

All rights reserved. Publications of the World Health Organization can be obtained from WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland (tel.: +41 22 791 3264; fax: +41 22 791 4857; e-mail: [bookorders@who.int](mailto:bookorders@who.int)). Requests for permission to reproduce or translate WHO publications – whether for sale or for noncommercial distribution – should be addressed to WHO Press, at the above address (fax: +41 22 791 4806; e-mail: [permissions@who.int](mailto:permissions@who.int)).

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

All reasonable precautions have been taken by the World Health Organization to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall the World Health Organization be liable for damages arising from its use.

Design & layout: L'IV Com Sàrl, Villars-sous-Yens, Switzerland.

# Contents

<b>Figures and tables</b>	2
<b>Preface</b>	3
Maintenance series and external guidance	4
Methodology	4
Definitions	5
<b>Acknowledgements</b>	6
Declarations of Interests	6
<b>Acronyms and abbreviations</b>	7
<b>Executive summary</b>	8
<b>1 Introduction</b>	9
<b>2 Purpose</b>	11
<b>3 CMMS structure</b>	12
3.1 Fields and tables	12
3.2 Modules	12
3.2.1 Equipment inventory module	13
3.2.2 Spare parts inventory and management module	14
3.2.3 Maintenance module	14
3.2.4 Contract management module	15
3.3 Screens and reports	16
<b>4 Implementing CMMS</b>	17
4.1 Evaluation	17
4.2 Selection	18
4.2.1 Commercial packages	18
4.2.2 Open source packages	18
4.2.3 Locally developed packages	18
4.3 Data collection	19
4.4 Installation	19
4.5 Configuration and customization	20
4.6 Data entry	20
4.7 Training	20
4.8 Follow-up and performance monitoring	20
4.9 CMMS documentation and back up	21
<b>5 Networking CMMS</b>	22
<b>6 Concluding remarks</b>	23
<b>7 References</b>	24
<b>8 Useful resources</b>	25
<b>Appendix A</b> Common fields included in medical equipment inventory	26
<b>Appendix B</b> Sample CMMS screenshots	27

<b>Appendix C</b>	Vendor specification table	28
<b>Appendix D</b>	Request for proposal and vendor proposal sample content	31
<b>Appendix E</b>	Examples of CMMS vendors	34
<b>Appendix F</b>	Examples of open source CMMS providers	35
<b>Appendix G</b>	CMMS software design plan	36

## Figures and tables

Figure 1.	CMMS functionality flowchart	10
Table 1.	Commonly used tables and related fields	12
Figure 2.	Table infrastructure for equipment inventory module	13
Figure 3.	Work order management flow chart	15
Table 2.	Types of reports that can be generated from a CMMS programme	16
Figure 4.	CMMS implementation flow chart	17
Table 3.	Advantages and disadvantages of a locally developed CMMS package	19
Table 4.	CMMS deployment solutions and related networking options	22

# Preface

Health technologies are essential for a functioning health system. Medical devices in particular are crucial in the prevention, diagnosis, and treatment of illness and disease, as well as patient rehabilitation. Recognizing this important role of health technologies, the World Health Assembly adopted resolution in May 2007. The resolution covers issues arising from the inappropriate deployment and use of health technologies, and the need to establish priorities in the selection and management of health technologies, specifically medical devices. By adopting this resolution, delegations from Member States acknowledged the importance of health technologies for achieving health-related development goals; urged expansion of expertise in the field of health technologies, in particular medical devices; and requested that the World Health Organization (WHO) take specific actions to support Member States.

One of WHO's strategic objectives is to "ensure improved access, quality and use of medical products and technologies." This objective, together with the World Health Assembly resolution, formed the basis for establishing the Global Initiative on Health Technologies (GIHT), with funding from the Bill & Melinda Gates Foundation. GIHT aims to make core health technologies available at an affordable price, particularly to communities in resource-limited settings, to effectively control important health problems. It has two specific objectives:

- to challenge the international community to establish a framework for the development of national essential health technology programmes that will have a positive impact on the burden of disease and ensure effective use of resources;
- to challenge the business and scientific communities to identify and adapt innovative technologies that can have a significant impact on public health.

To meet these objectives, WHO and partners have been working towards devising an agenda, an action plan, tools and guidelines to increase access to appropriate medical devices. This document is part of a series of reference documents being developed for use at the country level. The series will include the following subject areas:

- policy framework for health technology
- medical device regulations
- health technology assessment
- health technology management
  - › needs assessment of medical devices
  - › medical device procurement
  - › medical equipment donations
  - › medical equipment inventory management
  - › medical equipment maintenance
  - › computerized maintenance management systems
- medical device data
  - › medical device nomenclature
  - › medical devices by health-care setting
  - › medical devices by clinical procedures
- medical device innovation, research and development.

These documents are intended for use by biomedical engineers, health managers, donors, nongovernmental organizations and academic institutions involved in health technology at the district, national, regional or global levels.

## **Maintenance series and external guidance**

Three documents in this technical series have been developed specifically to aid a health facility or a national ministry of health to establish or improve a medical equipment maintenance programme. The documents address medical equipment inventory management, maintenance, and computerized maintenance management systems. Each of these documents can be used as a stand-alone document, but together they present all of the factors to consider when developing a medical equipment maintenance programme. Furthermore, a six-volume comprehensive series of manuals for the management of healthcare technology, known as the 'How To Manage' series, exists for people who work for, or assist, health service provider organizations in developing countries and are publicly available.<sup>1</sup>

## **Methodology**

The documents in this series were written by international experts in their respective fields, and reviewed by members of the Technical Advisory Group on Health Technology (TAGHT). The TAGHT was established in 2009 to provide a forum for both experienced professionals and country representatives to develop and implement the appropriate tools and documents to meet the objectives of the GIHT. The group has met on three occasions. The first meeting was held in Geneva in April 2009 to prioritize which tools and topics most required updating or developing. A second meeting was held in Rio de Janeiro in November 2009 to share progress on the health technology management tools under development since April 2009, to review the current challenges and strategies facing the pilot countries, and to hold an interactive session for the group to present proposals for new tools, based on information gathered from the earlier presentations and discussions. The last meeting was held in Cairo in June 2010 to finalize the documents and to help countries develop action plans for their implementation. In addition to these meetings, experts and advisers have collaborated through an online community to provide feedback on the development of the documents. The concepts were discussed further during the First WHO Global Forum on Medical Devices in September 2010. Stakeholders from 106 countries made recommendations on how to implement the information covered in this series of documents at the country level.<sup>2</sup>

All meeting participants and people involved in the development of these documents were asked to complete a declaration of interest form, and no conflicts were identified.

<sup>1</sup> Available at [http://www.healthpartners-int.co.uk/our\\_expertise/how\\_to\\_manage\\_series.html](http://www.healthpartners-int.co.uk/our_expertise/how_to_manage_series.html)

<sup>2</sup> *First WHO Global Forum on Medical Devices: context, outcomes, and future actions* is available at: [http://www.who.int/medical\\_devices/gfmd\\_report\\_final.pdf](http://www.who.int/medical_devices/gfmd_report_final.pdf) (accessed March 2011)



## Definitions

Recognizing that there are multiple interpretations for the terms listed below, they are defined as follows for the purposes of this technical series.

**Health technology:** The application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of life.<sup>3</sup> It is used interchangeably with health-care technology.

**Medical device:** An article, instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health purpose. Typically, the purpose of a medical device is not achieved by pharmacological, immunological or metabolic means.<sup>4</sup>

**Medical equipment:** Medical devices requiring calibration, maintenance, repair, user training, and decommissioning – activities usually managed by clinical engineers. Medical equipment is used for the specific purposes of diagnosis and treatment of disease or rehabilitation following disease or injury; it can be used either alone or in combination with any accessory, consumable, or other piece of medical equipment. Medical equipment excludes implantable, disposable or single-use medical devices.

---

<sup>3</sup> World Health Assembly resolution WHA60.29, May 2007 ([http://www.who.int/medical\\_devices/resolution\\_wha60\\_29-en1.pdf](http://www.who.int/medical_devices/resolution_wha60_29-en1.pdf), accessed March 2011).

<sup>4</sup> Information document concerning the definition of the term “medical device”. Global Harmonization Task Force, 2005 (<http://www.ghhf.org/documents/sg1/sg1n29r162005.pdf>, accessed March 2011).

# Acknowledgements

*Computerized maintenance management system* was developed under the principal authorship of Iyad Mobarek, Technical Officer, World Health Organization (WHO) Country Office, Amman, Jordan and under the overall direction of Adriana Velazquez-Berumen, WHO, Geneva, Switzerland as part of the Global Initiative on Health Technologies project funded by the Bill & Melinda Gates Foundation.

The draft was reviewed by Matthew Baretich (Baretich Engineering), Jennifer Barragan (WHO), Hashim El Zein (WHO), Victoria Gerrard (WHO), Adham Ismail (WHO), Joel Nobel (ECRI Institute) and Frank Painter (University of Connecticut), and edited by Inis Communication.

Special thanks to the director, heads of departments and staff of the Directorate of Biomedical Engineering in Jordan for sharing their data and for their support. Thanks are also due to all administrative staff at the WHO Country Office in Jordan, namely Miranda Shami, Julinda Kharabsheh, May Khoury, Samia Nawas, Banan Kharabsheh and Layan Al Kindi, for their administrative support.

We would like to thank Aditi A Sharma for assistance in proofreading and Karina Reyes-Moya and Gudrun Ingolfsdottir for administrative support throughout the development of this document.

## **Declarations of Interests**

Conflict of interest statements were collected from all contributors and reviewers to the document development. No conflicts of interest were declared.

## Acronyms and abbreviations

<b>CMMS</b>	computerized maintenance management system
<b>IT</b>	information technology
<b>HTM</b>	health/health-care technology management
<b>IPM</b>	inspection and preventive maintenance
<b>WHO</b>	World Health Organization



## Executive summary

As health facilities expand and the number of medical devices they depend on to provide quality health care increases, a need to manage health-care technology more effectively and efficiently becomes evident. A computerized maintenance management system (CMMS) is a tool that can improve overall medical equipment management at the facility level. The information included in a CMMS varies depending on the individual situation but always includes the medical equipment inventory and typically includes information such as service history, preventive maintenance procedures, equipment and performance indicators, and costing information.

A CMMS is made up of fields, tables and modules populated with data from the clinical engineering or medical equipment department of a given facility. Using a CMMS, critical data can be accessed, manipulated and analysed using user-friendly interfaces. Reports can be generated from the system to help policy-makers reach decisions regarding health technologies. However, it is important to take into consideration multiple factors when deciding to adopt and develop a CMMS. Factors such as financial and technical resources are important when determining whether to purchase a commercial product, use open-source software, or to develop a system locally. Implementation requires proceeding through a number of phases that will allow the system to be planned comprehensively. By completing this multistep process, the options for deployment will be thoroughly evaluated; a suitable package will be selected, installed and customized; data will be entered; and training on the CMMS will be provided.

For organizations with the appropriate resources to implement this tool, CMMS can be very beneficial. It is a highly flexible tool that when properly implemented has the ability to transform the management of medical equipment while also improving the availability and functionality of the technology required to prevent, diagnose and treat illness.

# 1 Introduction

Technology plays a key role in the effective delivery of health care. The selection of appropriate medical technology and the organization of keeping that technology in good working order fall under the remit of health-care technology management (HTM) programmes (1). HTM is often the responsibility of the clinical engineering (or medical equipment) department, which tests, repairs and maintains diagnostic and therapeutic clinical equipment to ensure that it can be used safely and effectively (2). Computerized maintenance management systems (CMMS) have evolved to provide support to HTM managers to maintain medical equipment and monitor their associated costs automatically.

A CMMS is a software package that contains a computer database of information about an organization's maintenance operations. In HTM, the CMMS is used to automate the documentation of all activities relating to medical devices, including equipment planning, inventory management, corrective and preventive maintenance procedures, spare parts control, service contracts, and medical device recalls and alerts. The collected data can be analysed and used for technology management, quality assurance, work order control and budgeting of medical devices (3).

The decision to automate a HTM system or replace an existing CMMS depends on the individual circumstances of the health facility, including working procedures, information technology (IT) infrastructure and available budget. In order to effectively assist in the management and maintenance of medical equipment, a CMMS must comprehensively meet the needs of the user. Although major vendors strive to develop a system that universally meets the needs of all HTM

managers, no available system presents a complete solution. Most, however, can be customized to meet the specific needs of the health facility. Alternatively, an IT firm can be contracted to develop a CMMS package tailored to local requirements. A customized CMMS package is generally more expensive but if well designed and maintained will often produce a more satisfactory solution that meets local need.

A CMMS can be used to:

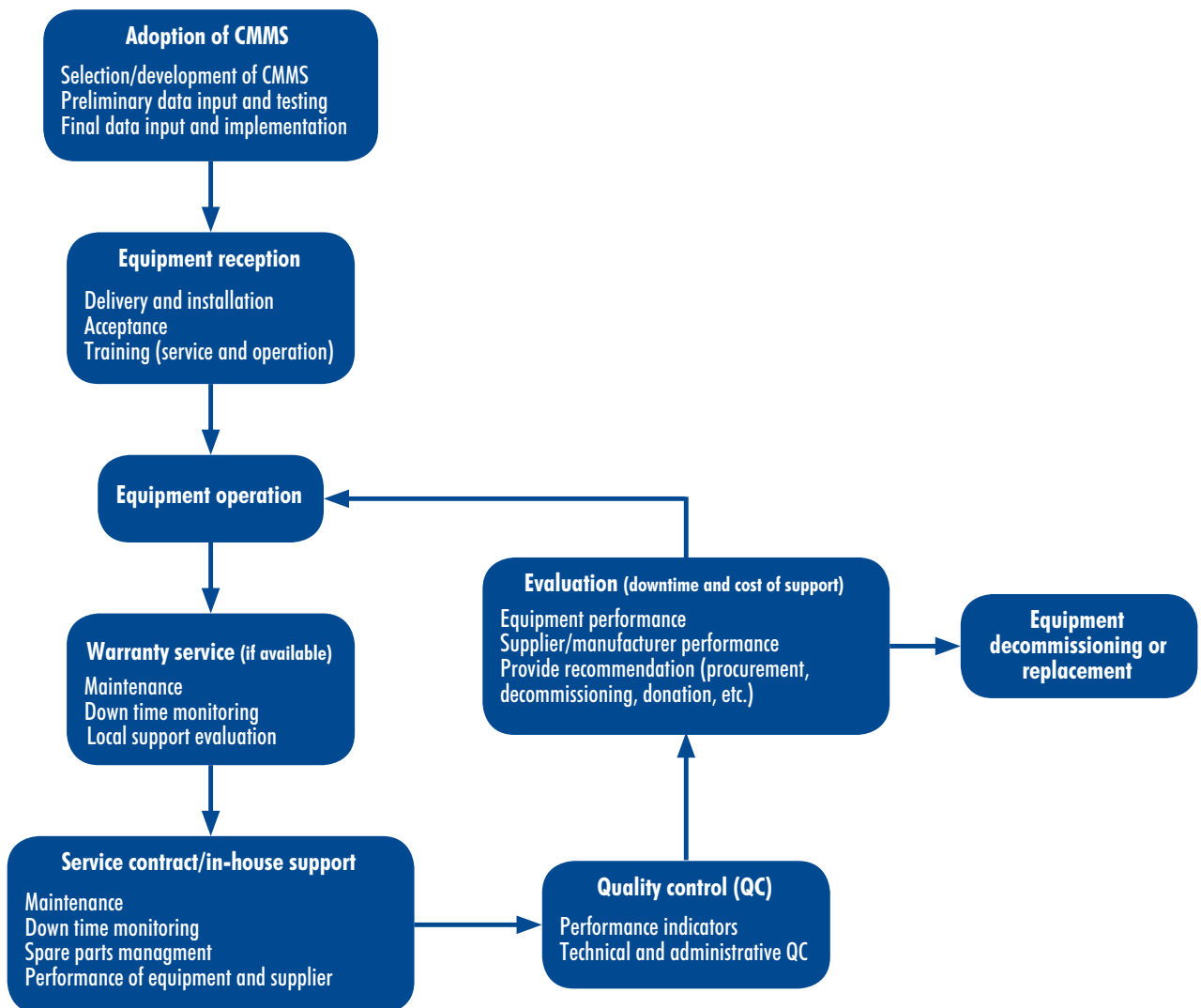
- standardize and harmonize information within a HTM programme;
- assist in the planning and monitoring of inspection and preventive maintenance, and schedule and track repairs;
- monitor equipment performance indicators such as mean time between failures, down time and maintenance costs for individual or equipment groups of the same model, type or manufacturer;
- monitor clinical engineering staff performance indicators such as repeated repairs by the same staff member for the same problem, average down time associated with individuals, and productive work time for individuals or groups;
- generate reports that can be used to plan user training programmes based on equipment failure trends in certain departments or health facilities;
- host libraries of regulatory requirements and safety information;
- generate the appropriate documentation for accreditation by regulatory and standard organizations;
- generate reports to assist in the monitoring and improvement of the

productivity, effectiveness and performance of HTM. Examples of these reports include:

- › the percentage of the cost of maintenance compared with the total cost of equipment in the inventory;
- › compliance with the inspection and preventive maintenance programme;
- › mean productive working hours;
- › identification of medical equipment affected by hazard and recall alerts.

Figure 1 presents a flowchart of CMMS functionality. The CMMS, whether commercial or customized, can be used by clinical engineers as a tool to complement their current HTM programme and help them fulfil their departments particular objectives. Effectively implementing a good CMMS will improve patient care through the efficient management and maintenance of medical equipment to ensure that it functions reliably.

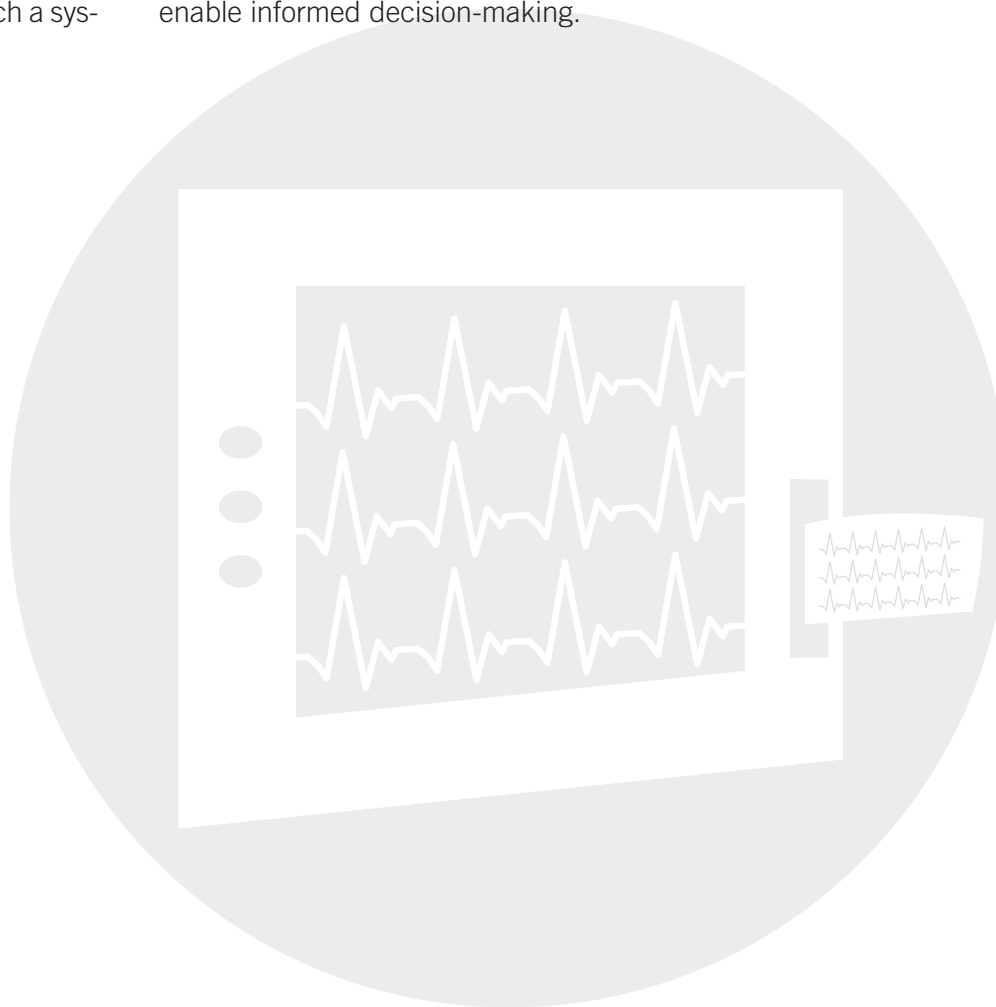
**Figure 1. CMMS functionality flowchart**



## 2 Purpose

The purpose of this document is to provide a tool to guide health-care workers, particularly biomedical and clinical engineers, in adopting and implementing a computerized method of managing their maintenance system. It is specifically aimed at those with the technical and financial resources to support such a sys-

tem. The reader will get an understanding of the components of a CMMS and how to select or develop a system that best suits their needs. High-level managers and policy-makers may wish to read this document to further their understanding of managing medical equipment and to enable informed decision-making.



## 3 CMMS Structure

A CMMS package integrates all medical equipment services into a database made up of fields, tables, modules and screens. The following section gives a brief introduction to this basic structure, which can be used by HTM managers to help choose or develop a system that is suitable for their needs.

### 3.1 Fields and tables

A field is a single piece of information, for example an ‘equipment serial number’. A table is a collection of related fields, for example an equipment location table might be made up of the fields ‘building’, ‘department and ‘room’ where a piece of equipment is stored.

To avoid long descriptive text, it is useful to develop a comprehensive, consistent and simple coding system for the various activities of the database. A single code is a field, and a collection of fields can be organized into tables. Coding of tables can be developed for equipment inventory, personnel, maintenance procedures and equipment locations. Commercial CMMS packages normally have a set of generic codes that can be adapted or customized according to the needs of the health facility. For ‘equipment type’ coding, standard nomenclature such as the Universal Medical Device Nomenclature System and the Global Medical Device Nomenclature System should be considered. Implementing appropriate nomenclature can also facilitate the management of alerts and vigilance reports.

Appendix A provides a list of fields that are commonly included in a CMMS inventory for health technology management.

Commonly used tables with their related fields are shown in Table 1.

**Table 1. Commonly used tables and related fields**

Table	Fields
Equipment type	<ul style="list-style-type: none"> <li>Equipment type</li> <li>Inspection and preventive maintenance (IPM) procedures</li> <li>IPM frequency</li> <li>Risk level</li> <li>Responsible staff</li> </ul>
Equipment model	<ul style="list-style-type: none"> <li>Model number</li> <li>Serial number</li> <li>Parts list</li> <li>Parts code and name</li> <li>IPM procedures</li> </ul>
Manufacturer/seller	<ul style="list-style-type: none"> <li>Manufacturer code and name</li> <li>Seller code and name</li> <li>Manufacturer email, telephone and address</li> <li>Seller email, telephone and address</li> <li>Manufacturer contact name</li> <li>Seller contact name</li> </ul>
Stores/spares	<ul style="list-style-type: none"> <li>Store code and name</li> <li>Parts code and name</li> <li>Parts order number</li> </ul>
Staff	<ul style="list-style-type: none"> <li>Employee code</li> <li>Employee name</li> <li>Employee position</li> <li>Access level</li> <li>Training details</li> </ul>
Maintenance	<ul style="list-style-type: none"> <li>Inventory number</li> <li>Work order number</li> <li>Service provider</li> <li>Service engineer code</li> <li>Fault code and name</li> <li>IPM procedures</li> </ul>
Health facility	<ul style="list-style-type: none"> <li>Facility code and name</li> <li>Building code and name</li> <li>Department code and name</li> <li>Type of facility</li> </ul>

### 3.2 Modules

A module is a collection of tables and data screens. The inventory module, for example, is made up of the ‘equipment



type' table, the 'manufacturer information' table and the 'equipment location' table. The following sections describe the basic modules of a CMMS package.

### 3.2.1 Equipment inventory module<sup>1</sup>

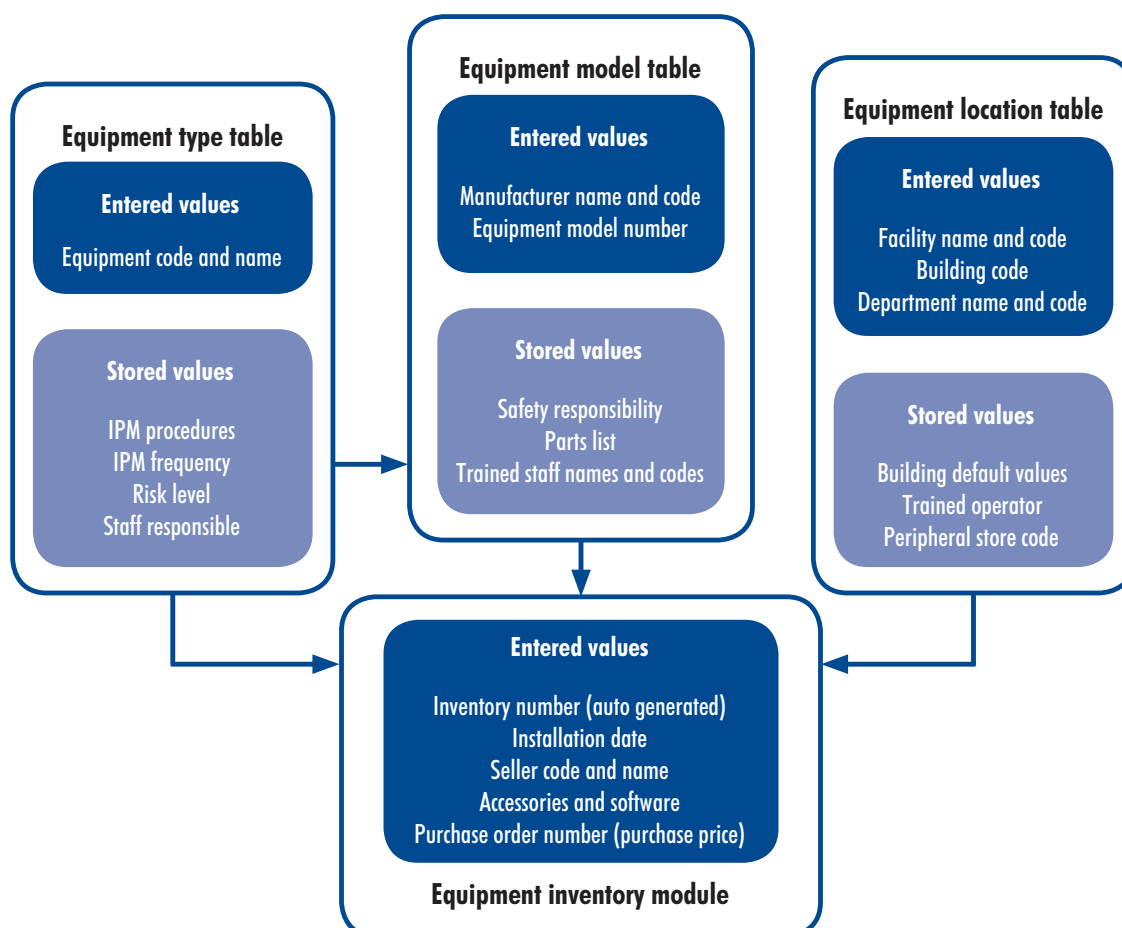
The inventory module is the core of any CMMS and the first to be constructed. It is therefore very important to include all fields necessary for effective HTM. When new equipment is added to the inventory, the equipment is registered within the CMMS database through a data entry screen.

Figure 2 presents a basic table infrastructure for an equipment inventory module. In this figure there are three tables that contribute information to the final inventory list. It is common practice

to use stored default values to build inventory records for new equipment, as it reduces entry time and avoids human error. For example, the table holding information about equipment type includes pre-stored values such as the relevant inspection and preventive maintenance (IPM) procedures, risk level and responsible staff for every type of medical equipment. It is therefore only necessary to enter the equipment code of a new piece of equipment into the equipment table and all pre-stored values associated with this code will be added to the inventory. Similarly, the other areas illustrate default values associated with the equipment model, location of medical equipment and inventory number, respectively. This allows modules to be built with maximum efficiency and maintains data integrity (3). Although an initial time investment

<sup>1</sup> Please refer to *Introduction to medical equipment inventory management* in this technical series for more details on developing an inventory.

**Figure 2. Table infrastructure for equipment inventory module**



is required to construct coding tables before the inventory data can be added, the long-term time and error savings are significant.

### 3.2.2 Spare parts inventory and management module

The spare parts management module is an extension of the inventory module that tracks the spare parts related to equipment and helps to maintain stock levels.

Stocked parts include those that are common to a number of different pieces of equipment such as fuses, wires, batteries and basic electronic components, and those parts that are more specific to a particular model such as circuit boards, power supplies, X-ray tubes and ultrasound probes. Fields in the spare parts inventory might include:

- part description (name);
- stock (inventory) number;
- manufacturer's name, serial and part number;
- link to equipment model;
- minimum stock level;
- current stock level;
- part storage location;
- price and date purchased.

Depending on the maturity of the system, these data can be entered manually or by scanning a part-specific barcode, which populates the appropriate fields within the database. The data can be used to generate screens that:

- alert the user to minimum stock levels for particular parts;
- create reports regarding the frequency of part replacement, which can help with predicting maintenance schedules and future stock levels;
- list all the parts required for certain pieces of equipment;
- report on the consumption of reused parts.

Some CMMS packages provide a fully automated operation that includes all phases of spare parts management from procurement to delivery, acceptance testing and use.

### 3.2.3 Maintenance module<sup>2</sup>

The maintenance module assists the user of the CMMS programme to effectively manage their maintenance schedule. Figure 3 provides an overview of how the CMMS integrates with a standard maintenance system in a hospital. As demonstrated in this figure, the CMMS can be used for both planned preventive maintenance and corrective maintenance.

#### Planned preventive maintenance

With the appropriate inputs, the computerized system can calculate when a piece of equipment will require maintenance and advise which parts might need to be ordered and when. The package can also monitor the maintenance process and log when it has been completed. Fields required for this module may include:

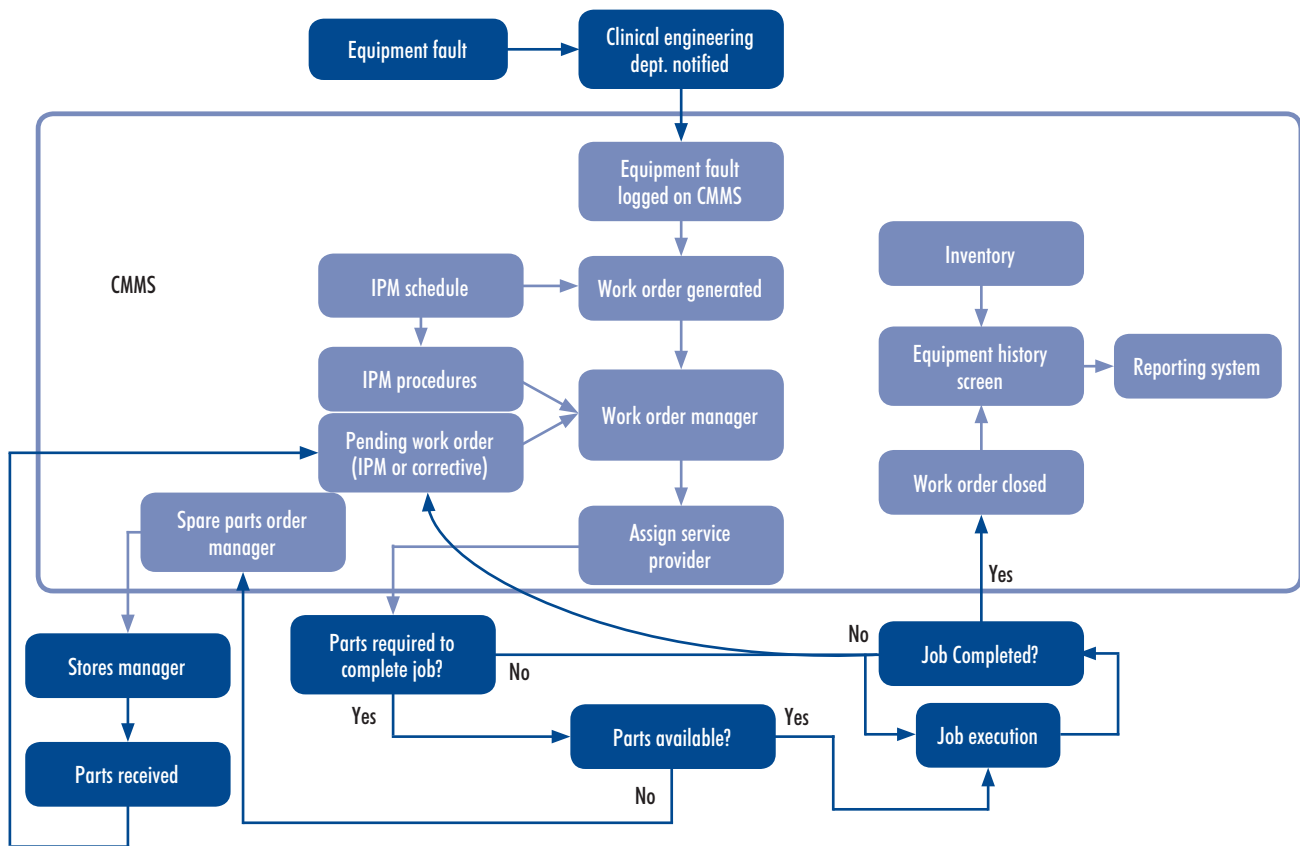
- equipment-specific inspection and preventive maintenance procedures;
- equipment-specific inspection and preventive maintenance schedule;
- frequency of equipment fault;
- estimated equipment running hours.

#### Corrective maintenance

When an equipment user reports a problem with a piece of equipment, the clinical engineering department can log the fault in the CMMS system. The programme will automatically generate a work order and allow the manager of the system to assign an engineer to the job. The CMMS programme can provide information regarding workload, training and expertise of individual engineers to assist with this decision. If an initial evaluation of the fault identifies that a specific part is required

<sup>2</sup> Please see *Medical equipment maintenance programme overview* in this technical series for more information on planning, managing, and implementing maintenance.

**Figure 3. Work order management flow chart**



to complete the job, the computerized system can record this and provide the appropriate ordering information about the part. When the job is complete the status of the equipment can be logged in the system.

Whether preventive or corrective, priority levels for the maintenance to be done can be assigned with reference to the equipment risk, the strategic value to the health facility, and the availability of back-up equipment. In addition, maintenance work order forms can be generated in electronic or paper format to include the relevant maintenance procedures required to complete the work order (3,4).

### 3.2.4 Contract management module

The contract management module is used to track all externally provided maintenance services. The main factors to

monitor are cost and performance of both vendor and equipment.

If the medical equipment is under contract, either through warranty, comprehensive service contracts or partial support service contracts, the vendor is required to provide technical support to the equipment over an agreed period. The CMMS programme can automatically generate alerts addressed to vendors when a piece of equipment is logged as faulty or is scheduled for inspection and preventive maintenance. The terms and related costs of any contract should be stored in the system for reference.

If possible, interfacing the CMMS programme with the accounts department's IT system is useful. All payments to external vendors can then be approved electronically through the main financial

IT system of the health institution. If this is not possible, approval forms for communicating with the accounts department could be printed from the CMMS.

### 3.3 Screens and reports

A screen allows the user to add, collect and analyse data from a selection of fields, tables and modules through a user-friendly interface. For example, the 'equipment history' screen is a collection of data from various modules summarizing the HTM activity related to a certain piece of equipment. It is the main feature of a CMMS and includes information such as the inventory details, service activities, work order details, spare parts used and associated costs, and recall information. Screens can be used to generate reports that will assist in monitoring the activities

related to the management of medical equipment. This helps managers to evaluate the overall performance of their HTM system. Appendix B presents screenshots from typical CMMS software, including an equipment history screen.

As with other CMMS functions, the reports generated can either be predefined standards or be customized for a particular application or use. An easy-to-use interface allows the user to select the information they would like to extract and analyse from the database. The data generated can be exported into other programmes for further evaluation or presentation, such as Excel, Access and Fox Pro.

Examples of the types of reports that can be generated by CMMS are outlined in Table 2.

**Table 2. Types of reports that can be generated from a CMMS programme**

Report type	Examples
List	<ul style="list-style-type: none"> <li>• Lists of equipment by health facility, department or manufacturer</li> <li>• Lists of faults caused by operators in a certain department or health facility</li> <li>• Lists of work orders completed by specific clinical engineering personnel</li> <li>• Lists of all stock received in the past month</li> </ul>
Summary	<ul style="list-style-type: none"> <li>• Equipment-specific reports to monitor work done on a piece of equipment, record any down time experienced and assess the general availability of the device</li> <li>• Dashboard report, which gives an overview of how the HTM programme is running. Information presented might include key performance indicators such as mean time between failures, down time and response time</li> </ul>
Activity	<ul style="list-style-type: none"> <li>• Maintenance activities for certain selected health facilities or departments</li> <li>• Maintenance activities for a specific piece of equipment</li> </ul>
Workflow	<ul style="list-style-type: none"> <li>• Corrective maintenance work orders</li> <li>• Planned preventive maintenance schedule</li> <li>• Individual staff activity with respect to work orders that need completing</li> <li>• Upcoming inspections, parts replacements, upgrades, etc.</li> </ul>
Human resources	<ul style="list-style-type: none"> <li>• Annual/monthly staff working hours</li> <li>• Staff response time to work orders and time taken to diagnose fault</li> <li>• Service provider details and working hours</li> </ul>
Financial	<ul style="list-style-type: none"> <li>• Equipment life-cycle cost</li> <li>• Cost of service ratio, i.e. maintenance cost against equipment value</li> </ul>
Regulatory	<ul style="list-style-type: none"> <li>• Summary of medical device recalls</li> <li>• Information related to equipment failures and adverse incident reports</li> </ul>

## 4 Implementing CMMS

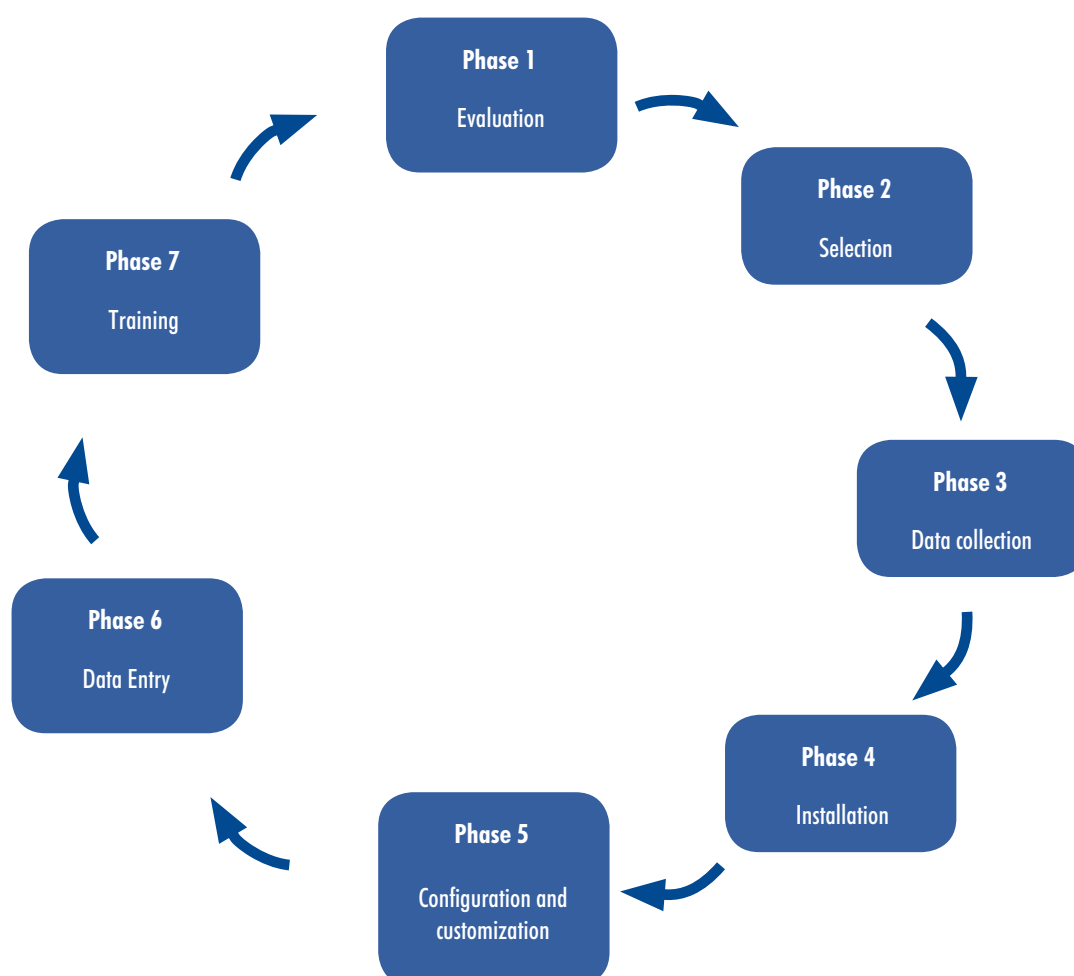
Clinical engineering staff must be included in the entire CMMS planning and implementation process. Figure 4 summarizes a basic seven-step process for implementing a CMMS.

### 4.1 Evaluation

It is important to conduct a feasibility study to evaluate and assess the need for a CMMS. During this phase, a complete analysis is conducted and the scope of the system is defined. Decisions are made

regarding the function of the system, and the data required to meet this function are identified (3,4,7). This analysis can be used to develop a clear technical specification for the CMMS that includes all mandatory and optional features. Other factors to consider at this stage might include the current IT infrastructure, the structure of the existing HTM system, the staff skill level, the number of health facilities that will use the system, and the level of staff buy-in (3). It is also useful to identify any obstacles to implementing the system that might be encountered.

Figure 4. CMMS implementation flow chart



## 4.2 Selection

An HTM programme may range from fully paperless to fully automated using a CMMS. Therefore, the amount of features in a CMMS can vary and selection of those features will be based on the needs of the user, who may wish to fully or perhaps only partially automate the management system. Once specifications for a system have been identified, an appropriate package can be selected. It may be one that is commercially available, customized to the health facility's needs or designed specifically for the user.

### 4.2.1 Commercial packages

There are several commercial CMMS packages on the market, offering a range of features. Most commercial CMMS include the option of a personal digital assistant and barcode scanner to allow for full automation of the HTM system. Radio-frequency identification systems are also becoming more popular and may soon be part of a typical CMMS package. It is therefore important to ensure the programme is sufficiently flexible to accommodate the specific needs of the clinical engineering department in which it is to be used. Selecting a CMMS package that is rigid and forces the user to significantly modify their existing workflow will give poor results. It is therefore prudent to compare current HTM procedures with those of the CMMS being considered. Appendix C provides a vendor specifications table that can be used to guide the selection process. In addition to these specifications, it is important to consider vendor reputation and experience in automation of HTM programmes and the number of health facilities that will be using the CMMS.

The final and total cost of the CMMS is a significant factor when selecting a CMMS. In addition to the start-up costs, hidden

charges must be taken into account, such as annual licensing fees, extra data storage fees, upgrade fees, password fees and technical support costs. Whether tailor-made or commercially purchased, the vendor's responsibilities during all phases of CMMS implementation must be clearly defined and documented. Appendix D provides sample content for a request for proposal and a vendor proposal. A non-exhaustive list of CMMS vendors is provided in Appendix E.

### 4.2.2 Open source packages

There are a number of open source CMMS packages developed by different institutions or personnel. Appendix F provides a list of such CMMS packages and their websites. The general challenge of open source CMMS is the lack of technical support and updates and hidden technical support charges.

### 4.2.3 Locally developed packages

If no commercial package meets the needs of the user, a CMMS can be developed locally by an internal software development team or with a contractor. If the decision is to go with an internal team, it is important to recognize that a team of professionals will be responsible for defining the requirements for the application, testing, and eventually maintaining and updating the software. If such support will not be available in the long term, it is better to consider an external contractor or a commercial product. In either case, during development, a significant amount of staff time is required for design and testing of the system. Any additional work expected of staff should be planned with regard to their normal work activities. Once designed, the institution must ensure that the source code is updated and stored securely.

In order to benefit from the experiences of others, a review of the literature on locally and commercially produced CMMS is best performed before locally developing a package (3). Appendix G presents a proposed sequence of software design steps for the local development of a CMMS. Once the basic design is accomplished, the automated procedure is operated with test data and the whole design is improved according to feedback obtained from system users. This process is repeated for all activities; once all activities are automated, the complete system is put into operational testing until all remarks have been considered and all problems are solved.

The advantages and disadvantages of locally developing a CMMS are outlined in Table 3.

In general, the decision to develop a local CMMS is justified only when commercial packages do not meet the specific requirements of the health-care institution

and when major modifications to HTM are required to implement commercial systems.

### 4.3 Data collection

A comprehensive survey and analysis of all available data should be conducted before implementing the CMMS. This information may already be available at the health facility, but some may need to be collected from other sources.

### 4.4 Installation

Before installing the system, a system administrator is assigned who is responsible for the technical maintenance of the system and for managing data security.

The CMMS can be implemented as a complete system, by individual modules, by equipment type or by location. This is

**Table 3. Advantages and disadvantages of a locally developed CMMS package**

Advantages	Disadvantages
The system is tailored to meet the exact needs of the institution without requiring any modification to the functions and procedures of the department.	There are limitations with regard to testing the system and collecting user feedback. In contrast, commercial packages are able to perform complete professional testing before they are made available to clients. In addition, they have access to a large user group and the ability to hold conferences to gather user feedback.
The system may be modified continuously according to new operational needs.	Source code for locally developed CMMS is sometimes poorly written, which makes the system slow.
The institution has full ownership of the source code if properly written and updated.	Development time may be long compared with commercial packages.
New reports can be easily designed according to requests from the clinical engineering department or health facility managers.	The system is dependent on the IT personnel and other staff who developed it. The knowledge might be lost when those staff members leave the organization.
Staff are more familiar with the system since they have participated in its development.	Recurrent costs must be paid to an individual, team of individuals, or company to develop and regularly update the software.

Source: Cohen T et al.(2003) (3)

the decision of the clinical engineering department and will depend on the resources available.

The software is installed on the health facility server or on the individual user's personal computer. All other hardware devices such as line printers and scanners must also be installed and configured.

#### **4.5 Configuration and customization**

Configuration and customization with existing mechanisms and procedures are performed before data entry. Configuration of the system could cover areas such as simple workflow, access and security, and user preferences. Customization refers to the technical functional requirements of the system including custom screens and tables, facility-specific workflow and additional data fields (3,8).

#### **4.6 Data entry**

This phase consists of initial data entry of common fields such as equipment model number, inventory code, human resources, equipment locations, manufacturer information and nomenclature classifications. User security levels and associated passwords, access levels and access types are also set at this stage (3,8). It is beneficial for clinical engineering staff to be assigned to populate the database, as they are familiar with the terms being used.

Complete functionality of the system can be tested with one set of data. Functions to be tested include the creation of maintenance requests, generation of work orders, completion of work orders, ordering of spare parts and generation of reports.

Data entry can be completed when the CMMS is working as required (3,7).

#### **4.7 Training**

It is important that each staff member of the clinical engineering department is fully confident and familiar with all functions of the CMMS. It is useful to begin staff training in the early stages of implementation to increase staff buy-in and improve confidence. In order to manage expectations, it is also important that basic generic database training is provided for key senior clinical engineering staff. Specific user training follows system installation and testing. If other personnel such as clinicians and nurses are expected to use the system, additional training should be provided for them. A periodic review to assess and evaluate training needs is highly recommended, as there is often a steep learning curve when using such systems.

Most vendors provide comprehensive manuals for their CMMS and a help menu to enhance usability. Online help is also available for some systems. It is worth noting that the implementation of CMMS is more effective if support is provided in the local language; most commercial CMMS packages are available with support in a range of different languages.

#### **4.8 Follow-up and performance monitoring**

Continuous monitoring of the system is conducted to ensure that it is directly contributing to the improvement and effective running of the HTM programme. Elements to be monitored include:

- the system's ability to effectively produce all needed performance indica-



tors for the HTM programme, such as down time and inspection and preventive maintenance compliance;

- evaluation of the speed of activities such as generation of reports and inputting of data;
- usability and user satisfaction (collected using a questionnaire).

In addition to this, large vendors hold annual conferences where user feedback is collected and analysed to make improvements to their system.

#### **4.9 CMMS documentation and back up**

Clear, accurate and comprehensive documentation for all components of the system, including full details of hardware,

software, operating procedures, upgrades and backup policies, should be kept by the clinical engineering department. For customized packages the source code should be documented and updated with every upgrade to the system. Several CMMS programmes use open source systems or are delivered with the source code in order to avoid problems of ownership and code complications (3,7).

It is advisable to establish a periodic back-up policy to protect data in the event of an emergency or system crash. Automatic back up to more than one storage media can be used; if this is not possible, a daily manual back up is sufficient. In addition to all back up and recovery policies, it is advisable to use mirror-image servers to enhance data security, if and when available.



## 5 Networking CMMS

Depending on the IT infrastructure available and the size of the clinical engineering department, the CMMS can be networked in a variety of ways. In general there are two main deployment options:

the on-premise and the on-demand solutions (5). Table 4 describes the features of these solutions and the networking options available for each.

**Table 4. CMMS deployment solutions and related networking options**

Solution	Description	Features	Networking options
On-premise	CMMS installed and runs on premises of health facility	<ul style="list-style-type: none"> <li>• Customer responsible for the technology infrastructure</li> <li>• Customer pays licensing fee to use and customize software</li> <li>• Customer may customize features and functions to meet requirements</li> <li>• Customer has full control of infrastructure and data</li> </ul>	<ul style="list-style-type: none"> <li>• Standalone workstation base system, which is useful only in small single workshops at small hospitals</li> <li>• Local area network system within clinical engineering department</li> <li>• Deployment over Internet at customer's site (self-hosted online solution)</li> <li>• Open architecture with integration to other applications on similar or different platforms</li> <li>• Built using standard Microsoft Web Technologies</li> </ul>
On-demand	Software As A Service (SAAS)	<ul style="list-style-type: none"> <li>• Vendor provides application licence to multiple customers</li> <li>• Infrastructure and application managed by vendor</li> <li>• System delivered over Internet</li> <li>• User does not maintain hardware or software</li> <li>• Customer pays for access to application</li> </ul>	<ul style="list-style-type: none"> <li>• 100% Internet-based application requiring no installation on client's machines</li> <li>• Deployment over Internet (hosted online solution)</li> <li>• Open architecture with integration to other applications on similar or different platforms</li> <li>• Built using standard Microsoft Web Technologies</li> </ul>
	Customized SAAS	Customizable version of SAAS	

## 6 Concluding remarks

Whether it is a commercially available package or a custom-designed option, a CMMS has several benefits. Much less staff time is needed for data entry, maintenance tracking and reporting; it minimizes human errors; and it allows more effective monitoring of performance indicators and staff productivity (3,6,7). The CMMS provides electronic documentation

of equipment inventories, tests, repairs, maintenance and equipment histories. If implemented correctly, it can be used as an effective tool by health facilities and their clinical engineering departments to complement their existing programmes and improve the overall management of the technology, while also contributing to the more effective delivery of health care.



## 7 References

1. Cohen T. Computerized maintenance management system. *Journal of Clinical Engineering*, 2001, 26:200–211.
2. *Duke University Health System, Clinical Engineering*. Durham, NC, Duke University Health System Department of Clinical Engineering, 2010 ([http://clinicalengineering.duhs.duke.edu/modules/ce\\_pols/index.php?id=1](http://clinicalengineering.duhs.duke.edu/modules/ce_pols/index.php?id=1)).
3. Cohen T et al. *Computerized maintenance management systems for clinical engineering*. Arlington, Association for the Advancement of Medical Instrumentation, 2003.
4. Barta RA. A computerized maintenance management system's requirements for standard operating procedures. *Biomedical Instrumentation and Technology*, 2001, 35(1):57-60.
5. *On-demand or on-premise: Understanding the deployment options for your new business management system* (White Paper). Richmond, Sage North America, 2009.
6. ECRI Institute (<http://www.ecri.org>).
7. Non-published articles by the Directorate of Biomedical Engineering of the Jordan Ministry of Health (<http://www.dbe.gov.jo>).
8. Data available from Maintenance Connection CMMS ([http://www.maintenance-connection.com/mcv18/online/mc\\_home.htm](http://www.maintenance-connection.com/mcv18/online/mc_home.htm)).

## 8 Useful resources

*Medical equipment management manual*. Arlington, VA, Association for the Advancement of Medical Instrumentation, 2005.

Cram N. Computerized maintenance management systems: a review of available products. *Journal of Clinical Engineering*, 1998, 23:147–223.

Kullolli I. Selecting a computerized maintenance management system. *Biomedical Instrumentation & Technology*, 2008, 42:276–278.

Mobarek I et al. Enhanced performance and cost-effective clinical engineering system for Jordan. *Journal of Clinical Engineering*, 2005, 30:42–55.

Mobarek I et al. Fully automated clinical engineering system. *Journal of Clinical Engineering*, 2006, 31:46–60.

Staker T. A paperless computerized management information system for clinical engineering. In: Cohen T et al, eds. *Computerized maintenance management systems for clinical engineering*. Arlington, VA, Association for the Advancement of Medical Instrumentation, 2003.

Wickens CD, Sallie EG, Yili L. *An introduction to human factors engineering*. New York, Addison-Wesley Educational Publishers, 1998.

# Appendix A

## Common fields included in medical equipment inventory

Field	Description
Equipment inventory number	Unique number assigned by a health facility to identify individual pieces of equipment
Equipment description (type) and class code	Code that describes equipment in terms of relevant nomenclature system
Manufacturer's name and CMMS-generated code	Name of manufacturer of equipment and code that identifies the manufacturer
Model number	Code assigned by manufacturer to identify equipment model
Manufacturer's serial number	Code assigned by manufacturer that helps to identify equipment during a recall; also used to locate equipment if inventory number is removed
Current software revision	Name of software device is running on; assists in identification of devices affected by a recall; also used to identify equipment that needs a software upgrade
Vendor (seller) name and code	Name of vendor of equipment and code that identifies the vendor
Location description and code	Building, department or room where equipment is installed, and code that identifies this location
Purchase price	Exact amount of money paid for equipment and currency used for payment
Installation date	Date when equipment was officially accepted and put into operation by medical staff and clinical engineers
Warranty expiration date	Date warranty expires; usually indicated on purchase order
Inspection and preventive maintenance procedure reference	Code that assigns specific inspection and preventive maintenance procedure for equipment, including frequency of procedure per year
Maintenance responsibility	Name and code of institution or department, whether an external, central or peripheral workshop or organization responsible for maintenance of equipment
Status flag	Indicates current status of the equipment (e.g. operational, out of order, awaiting spares, due for replacement)
Other customizable fields	Fields relevant to individual technical management programme

# Appendix B

## Sample CMMS screenshots<sup>1</sup>

### Equipment history

The screenshot shows the 'Equipment Control' window with the following data:

Name Plate	
Tag/Asset	150
Description	Defibrillator
Type	Defibrillators
Serial No.	124789214
Manufacturer	Cardiovascular Products, Inc.
Model	345-0842113577
Model Name	Life Pack 6
Orig. Manufacturer	Cardiovascular Products, Inc.

Administration	
Cost Center	Cardiac Care Unit
Responsible Center	Cardiac Care Unit
Risk/Inclusion Factor	19
Location	Emergency Room
as of	04/03/2006
In Service	04/03/2006
Status	In Use
as of	04/03/2006
Condition	Good
as of	05/01/2006

Purchase Information	
Supplier	Cardiovascular Products, Inc.
Purchase Order	9100085
Purchase Cost	6000.00
Estimated Acquisition Cost	<input type="checkbox"/>

Service Information	
Warranty Expires	07/31/06

Buttons: OK, Previous, Next, Undo, Save

### Work order

The screenshot shows the 'Work Order Control' window with the following data:

Request	
Work Order	56154
Date	30/07/2009
Time	15:14
Status	Open
Type	CM

Reason	
Requester	Rob Davies
Contact	Rob Davies
Problem	Will not charge

Item Information	
Tag	5678
Type	Defibrillators, Ex
Type	Defibrillators, External, Auto
Model/Serial	HEARTSTREAM
Building	District General Hospital
Cost Centre	Cc-Bedwen Ward
Location	Outpatients Reception
Condition/Status	Good-1
In Service	<input type="checkbox"/>

Dispatch	
Job Type	
Service Dept.	Clinical Engineering
Specialty	
Employee	
Priority/Est. Time	0 Priority Level 0.00
Due Date/Time	30/07/2009 15:14

Buttons: OK, Previous, Next, Undo, Save

<sup>1</sup> Reproduced with permission from the ECRI Institute web site (6).

# Appendix C

## Vendor specification table

Vendors can fill in a table such as this one but may choose to include additional features. Minimum requirements are filled in by the user based on their specific situation. Those seen here are simply examples.

Technical specification	Minimum requirements	Supplier specifications
Vendor information	Please specify name, address and country of origin	
Is vendor specialized in CMMS dedicated to health technology?	Please answer yes or no	
Name or version number of CMMS	Required	
Where marketed	Please provide full list of countries, hospitals, etc.	
Quality standards supported	Please specify	
Year first sold	Please state year first sold and locations for: <ul style="list-style-type: none"> <li>• First sold CMMS version</li> <li>• This offered version</li> </ul>	
User-friendly with minimal learning curve	Required; please explain	
Training support	Required; please explain	
Nomenclature system	Required; please specify	
Number of users	Please specify maximum limit	
Access groups/security levels	Required	
Document library	HTML and document editor	
Accounts/budgeting	Preferred	
Price	Please specify clearly your price, including all components, such as annual subscription fee and licence cost	
Automated financial system interface	Preferred	
Inventory management	<ul style="list-style-type: none"> <li>• Inventory management module</li> <li>• Barcode tracking</li> <li>• Online recording and tracking</li> </ul>	
Spare parts management module	<ul style="list-style-type: none"> <li>• Inventory control</li> <li>• Minimum stock order</li> <li>• Spares order</li> <li>• Costing</li> <li>• Parts exchange</li> </ul>	



Technical specification	Minimum requirements	Supplier specifications
Work order module	<ul style="list-style-type: none"> <li>• Work order manager</li> <li>• Scheduling</li> <li>• Priority</li> <li>• Service charges (e.g. labour time, spares)</li> <li>• Integrated fields</li> <li>• Customized fields</li> </ul>	
Contract management	Required	
Project management module	Required	
Generate purchase orders	Required	
Work order request over the Internet by clinical staff	Optional	
Multisite asset tracking and work orders	Required	
Close work orders instantly using a handheld personal digital assistant/barcode scanner	Preferred	
Technical support	24 hours, 7 days a week	
Remote diagnosis	Required	
System upgrades	<ul style="list-style-type: none"> <li>• Please explain policy and cost</li> <li>• Advantage given to free upgrades or cost included in annual fee or licence</li> </ul>	
Maintenance management	<ul style="list-style-type: none"> <li>• Scheduling</li> <li>• Inspection and preventive maintenance library (forms)</li> <li>• Customizable forms</li> </ul>	
Equipment life-cycle management	<ul style="list-style-type: none"> <li>• Tracking of purchase</li> <li>• Evaluation</li> <li>• Auto-receiving</li> <li>• Full history record of equipment</li> </ul>	
Operating systems	Please specify	
Integrated reporting system	<ul style="list-style-type: none"> <li>• Run quick, standard, technical and managerial reports</li> <li>• Create customizable reports</li> </ul>	
Invoice matching	Optional	
Automatic alerts and recalls	Required	
Create tasks and planned events	Required	
Print, email or fax reports	Required	
Database system	Please specify	
Considerations for local environment	Local language, currency, calendar	

Technical specification	Minimum requirements	Supplier specifications
Required deployment and connection of CMMS	<ul style="list-style-type: none"> <li>• Local-area network</li> <li>• 100% Internet-based application requiring no installation on client's machines</li> <li>• Deployment over Internet (hosted online solution) or at customer's site (self-hosted onsite solution)</li> <li>• Open architecture with integration to other applications on similar or different platforms</li> <li>• Scalable connection. (design and architecture to be used regardless of whether application has 10 or 10 000 concurrent users?)</li> </ul>	
Network supported	Please specify hardware and operating systems supported	
Multiple site support	Required	
Use of SQL or other by CMMS	Please answer yes or no	
Updating mechanisms	Please specify mechanisms used to prevent simultaneous or erroneous updating	
Import and export utilities available	Please specify	
Other system features	Please specify	

## Appendix D

### Request for proposal and vendor proposal sample content

The following is based on documents found on the ECRI Institute website (6). It is intended as a reference only and should be modified to fit individual requirements.

#### **Request for proposal (RFP)**

All software components of the CMMS supplied by the vendor shall be part of the vendor's normal currently produced CMMS product.

All other costs such as licensing fees for the use of the vendor's software components or database must be included within the quoted price of the CMMS or an annual fee.

All CMMS components provided according to the terms of this RFP shall be of the latest production.

If the vendor plans to halt production of its CMMS referenced herein and to produce improved models before the delivery date, the vendor shall immediately notify the user in writing of this fact and provide the option of upgrading the purchase.

All support services must be provided by qualified full-time employees working exclusively for the vendor on a continuous basis, 24 hours a day, 7 days a week.

On-site training must be provided by a qualified instructor of the vendor who is not a sales representative. This training must be sufficient to ensure optimum utilization of the CMMS.

The order in which these selection criteria are listed is not necessarily indicative of their relative importance. It is expected that any vendor submitting a proposal will demonstrate extensive and substantial qualifications, capabilities and experience in developing, installing and supporting the CMMS, including successful provision of the same products and services to health institutions worldwide.

The user intends to select a vendor on the basis of the proposal received in response to this RFP and any other information it obtains from other sources regarding the CMMS and the vendor. Site visits to vendor installations may also be made by user staff. The user reserves the right to make its final decision independent of any or all of the above factors.

**Proposals shall be delivered on or before: [date].**

**Offers shall be delivered to:**

**Attention of:**

**E-mail:**

**Telephone:**

**Fax:**

**Address:**

**The proposed installation date[s] for the CMMS is/are: [dd/mm/yyyy].**

## **Vendor proposal format**

### **Price**

The first section of the proposal shall be a total price quotation including all system components for the purchase, including installation, start-up, training, testing and annual licensing fees of the CMMS.

Evaluation of the price shall be based on the total cost of CMMS over 10 years.

### **Installation and schedule**

A proposed delivery and installation schedule for the CMMS shall be given, including time required for installation, start-up, vendor and user acceptance testing. Both vendor and user shall work together to install and operate the CMMS in pilot units identified by the user.

### **Payment**

Proposed CMMS payment terms, including any cancellation fees and any alternatives or offers that result in a cost saving to users must be clearly stated. Full prepayment at the time of order placement, for example, is not acceptable to the user. Furthermore, penalties for late or inadequate delivery, installation or training are included in the terms.

### **Substitution**

The vendor shall supply at no extra cost the latest or any new version of the CMMS introduced by the vendor after the award, but before delivery, that more suitably meets the user's requirements. The vendor should specifically address potential technical differences.

### **Implementation plan**

Vendors shall submit as part of the proposal the main elements of their implementation plan. They are also expected to demonstrate their CMMS at the request of the user.

### **Required IT infrastructure**

The vendor shall provide a complete and detailed description of all IT requirements (hardware and software) that will be required to install and operate the system.

### **Upgrades and enhancements**

The vendor shall provide a copy of the vendor's policy for newly developed versions of the software, software modifications for improved performance and reliability, and correction of design. The vendor should indicate whether such modifications, upgrades and enhancements are no-charge items. Privilege shall be given to vendors with free upgrades and enhancements.

### **Training**

Vendors shall provide a detailed description of the training to be provided for clinical engineering personnel specified by the user. This could include a description of the programme length and format, content, the qualifications of the instructors, and written or electronic materials. The description should address the need for refresher training and training for new users specified by the user over the lifetime of the CMMS.

### **Operator manual**

Vendors shall make available a fully descriptive operating manual online and on CD.

### **Technical support**

A description of online, local or regional technical support capabilities, including the number and qualifications of technical support staff, as well as their training, their base locations, the locations of support staff, and approximate response time for emergency (both during and outside of regular business hours), shall be included.

### **Annual subscription fees**

A full description of annual subscription fees must be included. This includes the exact period this covers, in addition to all terms, conditions and fees, system enhancements and upgrades, software maintenance, technical support, software licence, and any other factors that could be of interest to the user in evaluating the vendor's proposal. The price for each annual period and penalties for delayed response time to service requests are clearly indicated.

## Appendix E

### Examples of CMMS vendors

The following is a list of vendors and products offering CMMS software. This list is not meant to be exhaustive. Inclusion on this list does not imply endorsement or recommendation by WHO. It is meant only as a guide when searching for a database that best suits your organization's needs.

Vendor	Website
Azzier	<a href="http://www.azzier.com">http://www.azzier.com</a>
Drawbase Software, Inc.	<a href="http://www.drawbase.com">http://www.drawbase.com</a>
Eagle Technology, Inc.	<a href="http://www.eaglecmms.com">http://www.eaglecmms.com</a>
ECRI Institute	<a href="http://www.ecri.org.uk/ecriaims.htm">http://www.ecri.org.uk/ecriaims.htm</a>
eMaint Enterprises, LLC	<a href="http://www.emaint.com">http://www.emaint.com</a>
EQ2, Inc.	<a href="http://www.eq2.com">http://www.eq2.com</a>
Facilities Technology Group	<a href="http://www.factech.com">http://www.factech.com</a>
FM Works	<a href="http://www.fmworks.com">http://www.fmworks.com</a>
Four Rivers Software Systems	<a href="http://www.frsoft.com">http://www.frsoft.com</a>
GE Healthcare	<a href="http://www.gehealthcare.com/euen/services/asset-management-solutions/asset_plus/index.html">http://www.gehealthcare.com/euen/services/asset-management-solutions/asset_plus/index.html</a>
ISES Corporation	<a href="http://www.isescorp.com/services/operationsmaintenanceprogramming.aspx">http://www.isescorp.com/services/operationsmaintenanceprogramming.aspx</a>
Maintenance Connection	<a href="http://www.maintenanceconnection.com">http://www.maintenanceconnection.com</a>
MicroMain Corporation	<a href="http://www.micromain.com/">http://www.micromain.com/</a>
MPulse Maintenance Software	<a href="http://www.mpulsesoftware.com">http://www.mpulsesoftware.com</a>
Nuvek, LLC	<a href="http://www.vectr.com">http://www.vectr.com</a>
PEAK Industrial Solutions, LLC	<a href="http://www.cmms4hospitals.com">http://www.cmms4hospitals.com</a>
Phoenix Data Systems, Inc.	<a href="http://www.goaims.com">http://www.goaims.com</a>
Predictive Service	<a href="http://www.predictiveservice.com">http://www.predictiveservice.com</a>
Simple Solutions FM	<a href="http://www.simplesolutionsfm.com">http://www.simplesolutionsfm.com</a>
St. Croix Systems Corporation	<a href="http://www.stcroixsystems.com/asset_manager.aspx">http://www.stcroixsystems.com/asset_manager.aspx</a>
Thinkage Ltd.	<a href="http://www.mainboss.com">http://www.mainboss.com</a>
TISCOR	<a href="http://www.tiscor.com">http://www.tiscor.com</a>
TMA Systems, LLC	<a href="http://www.tmasystems.com">www.tmasystems.com</a>

## Appendix F

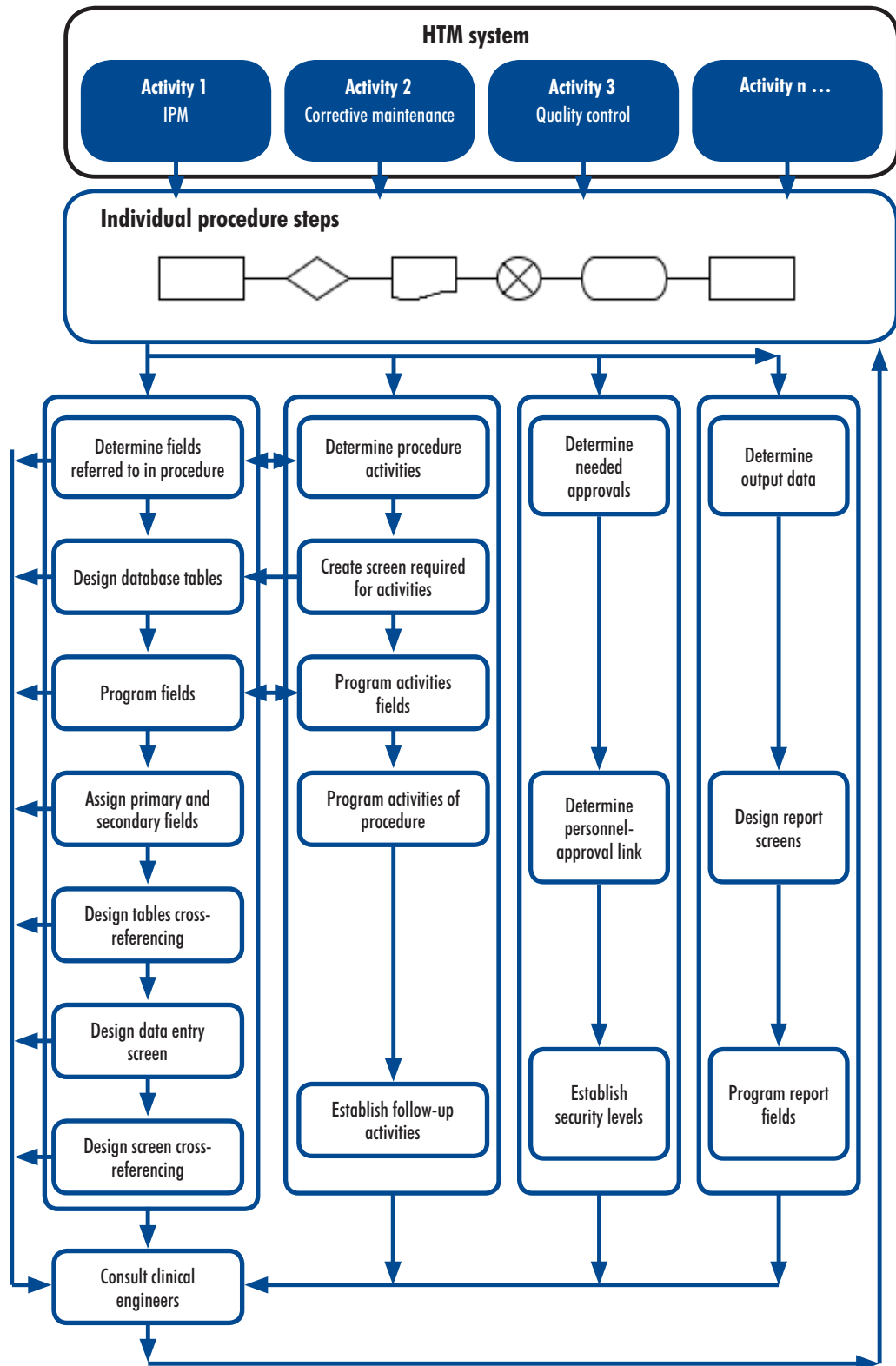
### Examples of open source CMMS providers

The following is a list of open source CMMS providers. This list is not meant to be exhaustive. Inclusion on this list does not imply endorsement or recommendation by WHO. It is meant only as a guide when searching for a database that best suits your organization's needs.

CMMS	Website	Notes
Aware	<a href="http://www.pninc.com/maint/aware.htm">http://www.pninc.com/maint/aware.htm</a>	Platform-independent
Facilities Desk	<a href="http://www.manageengine.com/products/facilities-desk/index.html">http://www.manageengine.com/products/facilities-desk/index.html</a>	Windows XP, 2000, Vista, Linux
Maintenance Assistant	<a href="http://www.maintenanceassistant.com">http://www.maintenanceassistant.com</a>	Web base and other options
Maintenance Parts Bin	<a href="http://www.nhuntsoftware.biz">http://www.nhuntsoftware.biz</a>	Windows 95/98/ME/XP/2000/NT
Maintenance Tracker	<a href="http://www.mtrackcmms.com">http://www.mtrackcmms.com</a>	Windows XP, Win 98, MS Access 2002
Mantra	<a href="http://www.bmstech.com/mantra/download.htm">http://www.bmstech.com/mantra/download.htm</a>	Windows XP/2000/NT4/9x/ME/Windows 3.1x/DOS
PLAMAHS	<a href="http://www.healthpartners-int.co.uk/our_expertise/plamahs.html">http://www.healthpartners-int.co.uk/our_expertise/plamahs.html</a>	Windows 95 or later

# Appendix G

## CMMS software design plan







**Department of Essential Health Technologies**

World Health Organization

20 Avenue Appia

CH-1211 Geneva 27

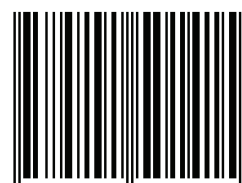
Switzerland

Tel: +41 22 791 21 11

E-mail: [medicaldevices@who.int](mailto:medicaldevices@who.int)

[http://www.who.int/medical\\_devices/en/](http://www.who.int/medical_devices/en/)

ISBN 978 92 4 150141 5



9 789241 501415