Computerized system for hospital engineering service management

C A Centeno, E A Gonzalez, F J Cagnolo and C E Olmos
Clinical Engineering Group, National Technological University, Córdoba Regional Faculty, Maestro M Lopez St and Cruz Roja Argentina St, Córdoba, Argentina
E-mail: ccenteno@scdt.frc.utn.edu.ar

Abstract. When a Hospital Engineering Service (HES) is implemented within a health care environment, the idea is to improve service conditions and costs as well as to provide timely responses to equipment preventive maintenance and infrastructure requirements. An HES must, within the shortest possible period of time, meet the above requirements at the cost necessary to provide the service quality sought. In many cases there is a lack of minimal materials and staff who are qualified to attain the objectives that have been set. Therefore, external assistance becomes necessary. In this context, actions are often taken which, because they are not recorded, cannot be assessed in order to evaluate the HES. Since all action taken is appraised from the purely economic point of view, in the final analysis the contributions from staff remain invisible. This situation works against the possibility of quantifying the convenience of possessing an internal HES. The software support system we have developed here is oriented toward providing all the necessary data to address this issue.

1. Introduction
Management of a Hospital Engineering Service (HES) involves interaction among its staff and professionals of other disciplines in dealing with equipment, infrastructure, etc, to fulfill the objective that has been set; that of maintaining the overall hospital system at an acceptable operational level [1].

All these repair activities must be coordinated by a centralized management, and one of the key tools for this task is a computer system offering specific features for this type of management.

The maintenance of equipment and premises implies a cost in both money and time, whether internal or external agents are involved. Time-associated costs reflect on the annual budget of a public hospital, since it must be in line with the proportional indexes recommended by the WHO and the Pan-American Health Organization, that vary in accordance with hospital equipment complexity. These associated costs arise from the assessment of each and every one of the maintenance activities, all of which must be properly documented, something that seldom happens. Many instances of improperly documented work carried out by HES staff are for this reason not assessed by the economic management of the entity, thus preventing the evaluation of a correct distribution of economic resources. This drawback is the reason that very often the minimum items necessary to adequately respond to hospital demands are not available.

In the search for options to address the above needs, several customized systems were found, from spreadsheets to small systems running on DOS. There are also systems for WINDOWS platforms, such as HECS, produced by ECRI. Many of these systems permit to work with overall equipment at
the clinical engineering level, but do not consider in sufficient depth the problems of hospital engineering management within a public hospital.

Indeed, in some cases, these tools present the drawback of being designed for use in hospitals located in economic development environments that are totally different from that of our country, with everything this dichotomy implies.

By consulting with the people in charge of the HESs of some of the major health facilities in this province, we came to the general conclusion that there is a need for a modified version of this type of tool, adapted to the Córdoba Province public health system.

Responding to this perceived need, the Clinical Engineering Group (CEG) of the National Technological University, Córdoba Regional School (NTU-CRS) put itself forward to design the “Management System for a Hospital Engineering Service”. This project was presented at a contest sponsored by the Córdoba Science Agency, was evaluated, accepted and subsequently financed by this Agency.

2. Objectives to be attained through the design

2.1. General Objective
To develop a computer system capable of acting as support, easing hospital engineering service management for the public hospitals in the Province of Córdoba.

2.2. Specific Objectives
- The information system to be developed was defined as being low-cost and technologically compatible and, as such, was to be developed with the human resources and tools available in the Province of Córdoba and in the NTU-CRS.
- Due to the specified conditions of free use, ongoing maintenance and easy accessibility, the software had to be executable through the Province of Córdoba Health Ministry computer network by agreement with the computing center serving the network.

2.3. Specific Technical Objectives
For the development of this system, a proposal was made to endow HES with a computing support system enabling users to:
- Gain access to information on general features of the equipment.
- Issue the corresponding work orders (WOs), for the execution and follow-up for tasks carried out on the equipment, installations or premises.
- Discriminate between internal and external costs in the repair process.
- Get to know the timeframes involved in the repair process.
- Record the enabling and disabling of equipment for active service.
- Present the repair case history for the equipment.
- Stipulate timeframes for preventive maintenance.
- Store frequent repair procedures.
- Keep spare parts and inputs stocks updated.

3. General Development
The requirements of Hospital Córdoba, a major provincial hospital, were taken as the benchmark reference; at the diagramming and basic design stage, the administration officer of this hospital in charge of infrastructure, maintenance and quartermaster duties was called in for technical consultancy [2],[3],[4].

This entity was chosen because it is the highest complexity public hospital in the province, having a large number of staff and pieces of equipment and, therefore, needing major creative systems solutions from HES management. It was, however, stated as a requirement that the solutions be perfectly transferable to other entities of smaller complexity.
The system consists of a database formed by a number of tables whose main operating agent is the inventory number of the specific piece of equipment. These tables are administered by the different software modules.

In the case of the building infrastructure a precise code system was devised for identifying the different rooms on each floor.

Since a management system has data storage capability, it may access this data at any time in order to deliver indicators that enable the spot evaluation of the hospital engineering system and contribute decision making information.

The first module of the Management Software System (MSS) administers a table whose records store data related to the equipment, infrastructure and premises, manufacturing information, dates, physical location and frequent operators, using the inventory number as a main access key.

The second module of the MSS administers the records related to external service suppliers, their phones and e-mail addresses, as well as the names of hospital staff and the pieces of equipment under their care, with the corresponding inventory numbers.

The third module administers technical repair work carried out. The key information in this module consists of each of the repair or maintenance tasks requested from the HES, giving its status of completion, date of commencement, date of termination, the spare parts used and the staff members involved.

The fourth module issues a report on the current operational status of all of the equipment, infrastructure and premises, i.e., a breakdown of those items that are in service and those that are undergoing repair work.

The fifth module, using statistical calculations, gives quick and simple information on repair and maintenance timeframes and costs, including accumulated costs, contributing to decision making in the implementation of policies of facility renovation and equipment modernizing.

So as to enhance information availability, an extra module was created with the purpose of offering alternative procedures adapted or designed by the HES staff of each user entity, or frequent execution factory-recommended preventive maintenance protocols.

4. Development-Management of a technical repair task
The system was designed as a result of a survey carried out at the reference hospital, and the implementation of a survey form which was filled out by HES staff members. This form enabled us to identify the engineering needs and the possible solutions proposed by service members. This information was extremely useful in designing a system to overcome service problems in order to achieve optimal performance.

Once this information was available, the databases and their respective administration modules were designed and implemented. All information necessary for system management development was included.

Once the information to be stored had been defined, the pathway to be followed in a technical repair task was diagrammed, enabling the proper knowledge of every stage in the process.

5. Development and implementation of the MSS

5.1. Pathway for a technical task
The pathway for a technical task may be seen in the diagram (figure 1). Based on it, the different windows and data comparison possibilities were designed. The aim was to have available the indispensable data, weighed according to importance, in order to comply with the request for technical repair work.
Once the windows and user interactivity with them had been defined, an Alpha version was created to be installed in the HES of the hospital for the purpose of evaluation by its end users. This prototype version only delivered minimal equipment data. The idea was to determine the degree of acceptance of MSS by HES members. Future users were asked to provide a written report, together with suggestions, which were evaluated in order to make suitable changes.

User reactions and their needs, which were not always easy for them to put into words, were considered important.

5.2. The Beta Version

After this stage, module two was completed, and a new trial version, the Beta version, was delivered for evaluation purposes.

In this way, we were able to adjust the system so as to obtain the smoothest and clearest possible user interactivity with the system (user-friendliness) (figure 2)(figure 3).

It is worth remembering that in an HES, as well as our own staff, there are external support staff, leading to interactivity which in some cases can introduce a delay in repair schedules. Because of this, it was necessary to bear in mind the presence of external support in the third module of the database.

To complete the third module, we resorted to engineering professionals in the local context so as to gain knowledge of their work procedures and, thus, together with information from hospital survey data, we were able to know the status of a repair task from information provided by the two agents involved in it.

5.3. Preventive Maintenance

All the foregoing procedures involved maintenance of a corrective nature, as requested by the services.

It should be borne in mind that preventive maintenance [5] in most cases reduces the number of machinery breakdowns and consequently also reduces total operating costs, if one compares breakdown-induced costs with preventive maintenance costs (figure 4).

The fifth system module enables the identification of pieces of equipment or facilities that, either due to their high frequency of breakdowns or their critical nature, merit preventive maintenance work. Under the above premise, a specific module was created to administer programmed preventive maintenance procedures.

In addition, in this case the user is also able to view on screen the programmed tasks, and is able to delay their execution as required, but not to eliminate them.
5.4. Statistics Module
The system can at any time issue a report containing statistical data related to HES operation, plus the
times involved and the cost of work carried out.

Additionally, a colour scheme enables rapid viewing of all the ongoing tasks and their status of
execution. It is also possible to obtain a listing of the corrective or preventive maintenance tasks that
remain to be executed.

With these data, it is possible for HES staff to determine the causal factors generating breakdowns,
instances of improper operation or work overloads on equipment operators.

5.5. General management of a maintenance task
Due to the reference hospital possessing an internal network of computerized data, for this purpose we
designed a customer module to be installed at the available terminals in each management software
service. The system enables authorized staff in each service to request repair work from the HES. In
this way, a repair request-order is generated that can be printed out as a voucher. Likewise, one is able
to check instantly on the status of the repair job, enabling service staff to reschedule studies if
necessary.

Requests made by intranet or personally are individually evaluated for their execution as a function
of their critical nature or available economic or staff resources. If the fault requires only a minor
adjustment not necessitating shutdown, the repair may be scheduled at a moment of low demand for
the equipment concerned so as not to cause any unnecessary delays in the service.

When major repairs involving more than one service are necessary, they must be programmed
jointly with the heads of the services concerned, so as to reschedule study appointments and allocate
the resources needed so that the hospital’s overall smooth functioning remains unaffected.

Once the task has been completed, the resulting cost and time data is loaded into the software
system so as to generate a report on compliance with the procedures requested from the HES and also
to keep this information for statistical purposes.

5.6. Management of infrastructure work
The work to be carried out on infrastructure and facilities requires a different kind of treatment in
many cases, involving the planning of the time, staff and materials required, since these are not always
available over prolonged periods of time, for example, in the cases of an operating theater or an ICU.
The same is valid for critical facilities such as the drinking water supply system or central steam
generating facilities, in which complex processes are interrupted. Normally, these tasks are carried out
when the demand for the facilities is at a low point, due to which planning is the first activity to be
undertaken.
6. Development Platform

For the development of the software system, the C++ Builder platform[6],[7] was used, because it allowed us to generate simple user interfaces and also to work with different database engines. For the Alpha version, we used the Paradox platform as a database, due to its easiness of use.

After carrying out the modifications for the Beta version, we changed to the Interbase data platform, with which we developed the Customer module.

Handling of information on the intranet is done by the use of SQL commands, affording greater transactional speed between the customers and the server.

All the information stored in the database can be filtered, so as to offer the user only the most relevant data.

7. Conclusions

At the moment of tackling the development of a management system, availability of the greatest number of parameters to manage and evaluate an HES was sought. As a basis, we used the accumulated experience of the members of the HES. After installing the different versions of the MSS in the reference health services establishment, the following were evaluated:

- Software system acceptance by users.
- The cutting down of red tape involved in requests for repairs.
- The time involved and the response quality of the internal and external services hired.
- The operating status of the equipment.

A survey was carried out on the market offer of software systems, thanks to which we were able to compare the MSS with the other systems and determine its advantages:

- Integration of equipment management with infrastructure and facility administration.
- The ability to work in a customer server environment on an intranet.
- The diversity of database platforms that one can work with. The fact is that the Province of Córdoba has an inter-hospital network serving as an Oracle database platform. Since the system offers the possibility of switching platforms, if needed, this change can be made quite simply.
- No extra modules are needed to obtain specific services, for example customer modules.

As a next stage in the medium term, we seek to obtain data on:

- The improvement in service quality in regard to the number of staff and time periods employed.
- The correlation between the available economic resources and the standards recommended by international health organizations.

The Beta version of the software system has been installed in Hospital Córdoba’s intranet since late March 2007, as a way of fine-tuning the software to create the final version.
8. References
[1] Illecas Blanco F 1999 *El control integrado de gestión : Iniciación a la dirección por sistemas* (Córdoba, Argentine, EDUCO)
[2] Bronzino J 2000 *The Biomedical Engineering Handbook* (NY, USA, CRC Press and IEEE Press)
[3] Webster G 1988 *Encyclopedia of Medical Devices and Instrumentation* Volume 5 (NY, USA, Wiley Interscience)
[4] Dyro J 2004 *Clinical Engineering Handbook* Chapter Information Systems Management (NY, USA, Elsevier Academic Press)
[5] Tizio R 1980 *Filosofía del Mantenimiento Preventivo* (Buenos Aires, Argentine, Sociedad Argentina de Organización Industrial)
[6] Marteens I 1999 *La Cara Oculta del C++* (Madrid, Spain)
[7] Charte Ojeda F 2000 *Programación con C++ Builder 5* (Madrid, Spain, Anaya Multimedia)

9. Acknowledgments
We wish to thank the people in charge of HES in the provincial public hospitals, especially those graduate students in the specialization course of Clinical Engineering at the NTU-CRS. A special vote of thanks goes to the HES of the Hospital Córdoba and its Director, Dr. Carlos Simon. Finally, we thank the Córdoba Science Agency for its appraisal and financial help.