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# DESIGN OF AN INTELLIGENT FACILITY MANAGEMENT SYSTEM FOR HEALTH CARE INDUSTRY

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## ABSTRACT

This paper describes the development of a decision support/management information system emphasizing management of physical plant and maintenance of equipment in the health care environment. The system is graphical oriented and integrate several modules. It is designed to reduce the cost associated with drawing management by minimizing reliance on existing drawings and documentation. The requisite information or intelligence associated with facility management may be added and manipulated independent of existing documentation. With the advance of medical technologies, many existing health care facilities are in need of renovation to meet current requirements for health and safety. The proposed system can be used by health care industry to significantly reduce the cost for facility management. Quality health care services can then be provided with reasonable cost, and the investment on advanced equipments/technologies becomes economically feasible.

## 1. INTRODUCTION

The continuing upward trend in health care costs has brought increasing social and political pressure on health care facilities to reduce costs, improve productivity, and emphasis quality of service [6]. The National Bureau of Standards established the Program of Federal Agency Workshops in building research in 1970, at the request of the Office of Management and Budget, to coordinate the various federal agencies' involvement in construction activities. In December, 1972 the First Federal Agency Workshop was held to present findings related to health facilities [11]. This session focused on design and construction issues, and was indicative of the increase in government agency activity in health and medical facilities spawned by the rise in costs and availability of new technology. As the level of government involvement has increased so has the level of compliance requirements for facilities involved in federal and other agency funding.

The physical plant and equipment cost of a typical health care facility is easily the most significant number in the design and construction planning phase and has been the focus of much research and discussion. However, as a component of operating cost it receives far less attention yet it is second in rank only to the labor/material component, from the standpoint of operation and maintenance [5].

The computing resources of existing management information systems of health care facilities are largely devoted to accounting tasks such as payroll, patient billing, material purchasing and inventory. Little attention is given to the management of the physical plant itself [7,8]. The continually changing profile of facilities in response to health care demands puts added pressure on facility management in terms of reallocation and alteration of space. Many existing facilities are old and in need of significant renovation to meet current codes and requirements for life safety. Regulations for funding and reimbursement impose a significant burden of space allocation and utilization reporting [9,10].

This paper describes a graphical and intelligent management information/decision support system developed for the management of physical plant and maintenance of equipment in a health care environment. The system is computer based and integrate several modules. The software system is called Graphical and Intelligent System for Management of Equipment and AUXiliaries (GISMEAUX). Section 2 of this paper addresses some of the design considerations. The system consists of several components or modules. The functions and the design approach for each of the major components in the system are discussed in section 3. Finally in section 4 some concluding remarks are drawn.

## 2. SYSTEM DESIGN CONSIDERATIONS

A new system to be introduced during times of economic pressure for cost reduction must be considered in light of its impact on the operating budget which it proposes to reduce. A facility management system, to be effective, must be "drawing oriented" as most information is a function of its location or size in relation to the primary facility.

A significant cost factor is associated with drawing management. Even if drawings exist in digital form, which is unlikely even in relatively modern facilities, there is no inherent information or intelligence associated with them to relate to the management of the facility. And what of the older plants where drawings have been damaged or destroyed over a number of years. Dimensional accuracy of existing drawings is also a question; i.e. are the drawings as-built and have they been updated as alterations and renovations have occurred?

Since the proposed system has a primary computer-aided drawing and drafting (CADD) module the issue of cost for drawing conversion, updating and/or digitizing must be considered the foremost issue. GISMEAUX is designed to minimize, and in many cases eliminate this requirement, by allowing new information to be layered over existing data. Alternatively, existing data may be left in paper format and used only as a guideline for entering new "intelligent" information. GISMEAUX only requires areas to be outlined in order to acquire its intelligence. Architectural enhancements may be added on an "as needed" basis determined by the requirements of the facility.

The introduction of a CADD system into any organization invites a resistance on the part of management as well as the proposed users in terms of time and training required to operate and maintain the system. GISMEAUX is designed to insulate the user from the "design and drafting" aspects of CADD and to provide an intelligent user interface [4] that will allow operation at a moderate level of efficiency after very little training. There is some assumption of user "familiarity" with computers, but no requirement for expertise in nor familiarity with CADD to use the system. Personnel in most plant maintenance positions will have the requisite knowledge of architectural and mechanical systems to input data and maintain the system.

Several benefits of the proposed GISMEAUX for facility management have been enumerated above. These all consider that there is indeed a benefit to using any facility management system. The utility of management information/decision support systems is well documented in the literature. GISMEAUX or a similar system can provide a useful function in improving the effectiveness of the

person or group responsible for day to day management operation of the physical aspects of a facility. There are many existing maintenance management systems which can be utilized for a similar purpose. However, a maintenance management system in the conventional sense has no knowledge of the geometry or physical layout associated with the facility.

Consideration must be given to the situations requiring the use of a drawing or actual field location and inspection of a physical item of plant or equipment in order to plan or maintain facility operation. In fact it is not unusual to find a facility relying on the expertise or experience of an individual for support of facility management. This is probably an individual who has "been here for years and knows where everything is". The loss of that individual can be devastating to the ongoing operation. The replacement of that individual can be an expensive proposition and may not even be feasible in many cases.

The ability to have on-line graphical representation supported by detailed non-graphical data describing all parts of the buildings, systems and equipment in a facility is an important tool for effective management of the second largest component of operating cost in a health care facility. GISMEAUX provides this and allows its use by relatively untrained personnel with no extensive computer system or architectural/mechanical background.

With the advance of medical technologies, many existing health care facilities are in need of renovation to meet current requirements for health and safety. The proposed system can be used by health care industry to significantly reduce the cost for facility management. Quality health care services can then be provided with reasonable cost, and the investment on advanced equipments/technologies becomes economically feasible. Several health care facilities in Louisiana have shown interests in the proposed system.

## 3. SYSTEM COMPONENTS

The system design is based on CADD software and uses database management software (DBMS) along with an interface modelled after a rule based expert system. The expert system component is used primarily as a front end to the system to provide a user interface which does not require actually working the CADD or DBMS system for most user tasks. It also provides a data integrity check by applying rules to the data entry and query process.

The major components of the proposed GISMEAUX system and their relationship are shown in Figure 1. The following sections describe the functions and features to be designed for each of these components.

### 3.1 CADD

The CADD component is based on the AutoCAD (ACAD) software system by AUTODESK [1]. This system is selected primarily because of its widespread industry acceptance, large user base, open architecture, portability across many hardware platforms and relatively low cost. ACAD in its native state is a very powerful but somewhat intimidating system. However, it is highly customizable both in terms of user interface and operation. It provides an internal programming language, AutoLISP [1], which is a derivative subset of Common Lisp and a menu interface which can be customized or completely replaced.

These features provide the key to an easily managed system requiring a minimum of training. GISMEAUX makes full use of a custom user interface within ACAD for those functions requiring direct use of the CADD module. An extensive inventory of AutoLISP routines and functions are designed to provide single pick menu operated selection of complex graphic data entry and modification as well as reporting via file or hard copy output.

Graphical representations of architectural and mechanical systems are entered by the user independent of existing drawing information. As each graphical entity is entered it is assigned a "handle" by ACAD. This is a guaranteed unique hexadecimal number, within the file, which does not change from session to session and is not re-used for entities that are later deleted. Although these handles may be duplicated in other drawings, and a typical facility may have

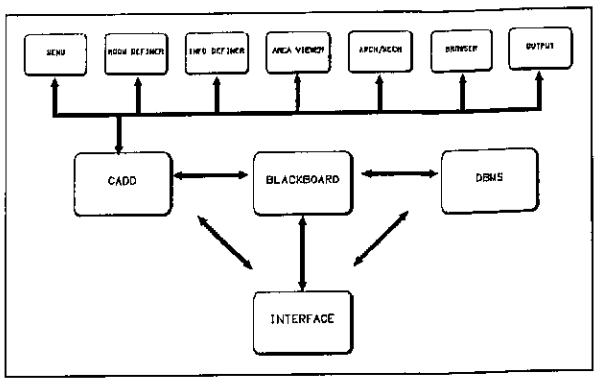


**Figure 1** - System Structure

several drawings, the combination of drawing number and entity handle provides a unique identifier for each entity in the facility. GISMEAUX automatically acquires and categorizes the data as the user defines the graphical entities.

The facility may determine its own requirements for drawing content and accuracy but GISMEAUX requires only basic physical information to initiate the system design. This information can be updated in any reasonable sequence or GISMEAUX itself may be used as the primary drawing system for the facility. In order to maintain reasonable accuracy in the cost estimating module the spaces defined should be at least roughly field measured if there are no existing drawings. However, this need not be done until a requirement for alteration of the space exists. If no drawings exist, a relatively accurate grid can be constructed using outside building dimensions along with corridor and vertical access (elevators, stairs and mechanical trunks) locations. This grid system can be related from floor to floor and the individual space sizes can be added with a minimum of field measurement.

If there are existing paper drawings the cost of scanning these into a compatible system can be quite modest depending on the quality and accuracy desired (from about $10 for a "D" size sheet). If high quality and accuracy are desired, this process can become quite expensive. GISMEAUX works as an overlay system and does not require any existing drawing geometry for its operation. Obviously, the more accurate the drawing the more accurate GISMEAUX's parameters. This requirement must be gauged by management but the basic system is quite useable and the results acceptably accurate without requiring an expenditure on drawings revision or digitizing. A sample scanned image is shown in Figure 2.

As time and circumstances permit, an accurate field-measured system may be produced using GISMEAUX and its drawing system. In fact, the module for renovation and permitting produces accurate drawings in double-line format with appropriate scaled openings and architectural and mechanical features.

### 3.2 BLACKBOARD

Although ACAD is capable of output in a format readable by some programs, it is not capable of producing or reading files in the proprietary format of a DBMS (Note: AutoCAD R12, recently announced, does have direct data reading capability of several DBMS formats). An intermediate stage, or "blackboard" is provided for data exchange between ACAD and the DBMS module (or other programs).

This blackboard system is based on American Standard Code for Information Interchange (ASCII) format files as required for the various reporting and data management features of GISMEAUX. These files are directly readable by both modules and require no user intervention or modification. As the data may be modified by either the DBMS or ACAD, flags must be set to notify the respective programs of the current state of the data files in relation to modifications made or pending.

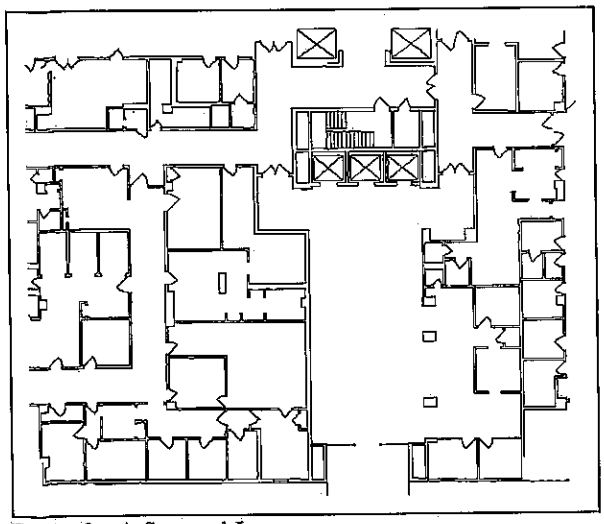

**Figure 2** - A Scanned Image

3.3 DBMS

The DBMS module requirements will be designed to be compatible with most systems in the personal computer environment. This can be accomplished primarily by using the previously mentioned blackboard system and secondarily by using a "relatively standard" database format - dBASE III [2]. The DBMS module can be easily adjusted to suit most existing systems or, lacking an existing system, an inexpensive system can be furnished with GISMEAUX. The primary design consideration for this module was to minimize the data entry requirement and maximize the potential use of any existing systems in a facility. Since it would be very probable to find an existing database this is an important consideration for GISMEAUX.

The DBMS is used primarily to manage the data generated by GISMEAUX in the CADD module and to relate that to any existing database. In the case of no existing database the majority of the work is done by GISMEAUX and only requires the user to enter any none-geometrical data desired. Again, this may be done during initial systems definition or at any other available time. GISMEAUX will provide several standard fields as well as spare fields to be utilized as required, but none are essential for the system to work. Room numbers are used as a key field by GISMEAUX and are requested from the user as spaces are defined. However, these may later be changed without affecting operation and an error handler in the CADD module prevents duplicate numbers from being used. Changes or additions to data in the DBMS module will trigger corresponding changes in the CADD module so that a user familiar with the DBMS can control most of the system without having to learn the CADD module. An exception would be alteration of any geometry. Although this is a feasible operation it is can be very complex in terms of the various options available and is best done in the graphical CADD module. A selection of standard reports is available by menu selection from the DBMS or the user may customize a report. An option is available to export data to a spread sheet program for more intensive mathematical manipulation. However, most requirements can be satisfied by the DBMS. An exception might be cost estimation for a large modification project.

3.4 INTERFACE

A rule-based interface module based on the VP-Expert [3] shell is provided primarily for data entry and reporting by users unfamiliar with or unqualified to use the other system modules. Data integrity can be controlled through the use of rules to define its definition and use. These rules should be determined by the facility management "expert" and can be edited by the system. Many definitions of expert systems specify some degree of inference by the system during its operation. By that definition this may be a true expert system in every sense. However, rules are included here as well as in the CADD module for the purpose of providing expertise to the user to assist in the decision making process. This provides a type of knowledge base which allows a less sophisticated or less knowledgeable user to operate the system.

## 4. CONCLUDING REMARKS

The research described in this paper was conducted for the purpose of developing the GISMEAUX prototype, a graphical information management and decision support system. The system design considerations were based, in part, on information gained in interviews with facility and plant management personnel in Louisiana public health care facilities. The indications are that advantage is not being taken of the benefits of computerized facility management. In many cases this is due to the reluctance of management to commit training time and money to implementation.

Existing graphical computer-aided facility management systems are becoming more common and less expensive. However, many of these systems are very broad in application and consequently difficult to learn. The proprietary nature of many of these systems causes compatibility problems in trying to integrate with existing applications and exchange of data may not be a possibility. If a complete database must be built to make a system functional then the cost and time frame for implementation is truly significant. A proprietary system also raises the issue of dependency on a specific vendor for maintenance and upgrade.

The GISMEAUX prototype provides a means of integrating industry standard hardware and software components into an affordable and easily used system of data management. It can be used as a planning tool to study the alternatives in a proposed facility modification, as a management tool to control an equipment and systems maintenance program and as an information management tool for documentation and presentation of facility related issues. All of these functions can be performed utilizing the ability of graphics models to make the state condition readily apparent to the viewer. The GISMEAUX functions developed are summarized as:

- Maintain separate spatial and alphanumeric data
- One time data entry shared by modules
- Training cost reduced by utilizing standard, proven software and custom user interface
- Interface across modules allows semi-automatic operation of activities

The system was developed in a prototype mode that resulted in a solution to meet the specifications; not necessarily the most efficient or elegant solution and certainly not one beyond improvement. The primary specification, that of utility was the over-riding consideration in the solution. This utility specification considers the concept of "ease of use" as being of considerable importance to the ultimate success of the system. The evaluation of ease of use is subjective and certainly subject to debate. The test of the system core, the CADD module, was conducted to lend credence to this aspect of GISMEAUX.

The utility and economy of the GISMEAUX system, beyond the ease of use, lies in its ability to integrate existing applications and make use of their database and user familiarity with their operation. In a facility with no existing computer applications, GISMEAUX can provide the basis for future computerization. Further iteration of the system design and documentation of operation as well as testing in a health care facility is planned for GISMEAUX.

REFERENCES

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