Affectionately Dedicated

to

My loving

Grand Mother,

Mother, Father,

Brothers and Sisters

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In the name of Allah, Most Gracious, Most Merciful

All praise is due to Almighty Allah (SWT), whom we praise, seek help and ask forgiveness. Peace and blessings of Allah (SWT) be upon His slave and His Messenger, Prophet Muhammad (PBUH), his family, and his companions. Many thanks to Allah (SWT), the most Merciful, the most Gracious, for all the uncountable bounties, who gave me the courage and patience to successfully accomplish this work.

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THESIS ABSTRACT (ENGLISH)

Name	:	**Mohammed Abdul Moied**
Title	:	"Assessment of Automating Facilities Management Current Practices: Potential Framework Models for Saudi Arabian Universities"
Degree	:	Master of Science
Major Field	:	Architectural Engineering Department
Date of Degree	:	December 2004

Information technology has the potential to enhance the efficiency of conducting FM functions in any organization. The objectives of this thesis was to investigate the level of automation of FM practices in universities world-wide, followed by investigating the level of automation and soliciting the experience of staff carrying out the range of FM functions in the Saudi Arabian universities, and finally developing FM framework models for the purpose of facilitating automation of FM practices in Saudi Arabian universities. The framework models treated five major FM functions, including construction drawing creation and management, inventory management, space management, maintenance management, and emergency preparedness management. To achieve these objectives, previous studies and literature was reviewed to investigate the level of automation of FM practices in universities world-wide. A questionnaire survey was developed to assess the level of automation and solicit the experience of staff carrying out the range of FM functions in Saudi universities. A total of 7 questionnaires were distributed to projects & maintenance department of Saudi Universities. A total of 7 completed responses were received. The survey was statistically analyzed. The result indicated that great majority of the Saudi universities use computers. However, computer resources have not been employed to utilize the potential capabilities of IT in conducting FM functions. The survey showed a lack of awareness among facility managers on the subject of IT utilization in the facilities maintenance management domain. The final objective involved the development of FM framework models based on the findings obtained from analyzing the automation survey of FM practices in the Saudi universities.

ملخص الرسالة

الاســـــــــــم : **محمد عبد المعيد**

عنوان الرسالة : **تقييم آلية التطبيقات الحالية في إدارة المنشآت: نموذج إطار عمل قابل للتطبيق في الجامعات السعودية**

التخصــــــــص : **هندسة معمارية**

تاريخ التخــرج : **ديسمبر 2004**

تكنولوجيا المعلومات لديها الإمكانية لتعزيز فعالية إجراء وظائف إدارة المنشآت في أي منظمة. تمثلت الأهداف المبتغاة من هذه الرسالة في التحقق من مستوى آلية تطبيقات إدارة المنشآت في الجامعات في مختلف أنحاء العالم متبوعة بالتحقق من مستوى آلية و متطلبات الخبرة من الهيئة القائمة على أداء سلسلة من الوظائف المختلفة في إدارة المنشآت في جامعات المملكة العربية السعودية. احتوى الهدف الختامي للدراسة على تطوير نموذج إطار عمل لإدارة المنشآت و ذلك بغرض تسهيل آلية تطبيقات إدارة المنشآت في الجامعات السعودية. نموذج إطار العمل عالج خمس وظائف رئيسية في إدارة المنشآت. هذه الوظائف شملت إدارة و إنشاء الرسومات الهندسية و إدارة الجرد و إدارة الفراغ و إدارة الصيانة و إدارة الاستعداد للطوارئ. من اجل تحقيق هذه الأهداف تمت مراجعة الدراسات السابقة للتحقق من مستوى آلية تطبيقات إدارة المنشآت في الجامعات في مختلف أنحاء العالم. أعد استبيان لتقييم مستوى آلية و متطلبات الخبرة في الهيئة القائمة على إدارة المنشآت في جامعات المملكة العربية السعودية. وزعت سبع استبيانات على قسم المشاريع و الصيانة في الجامعات السعودية.جميع هذه الاستبيانات السبع استقبلت إجاباتها و قد حللت نتائج المسح الميداني إحصائيا. أشارت النتائج إلى أن اغلب الجامعات السعودية تستخدم أجهزة الحاسوب و لكن على الرغم من ذلك لم توظف موارد الحاسوب لاستغلال القدرات الكامنة في تكنولوجيا المعلومات في إجراء وظائف إدارة المنشآت. اظهر المسح نقصاً في إدراك مديري المنشآت حول موضوع استغلال تكنولوجيا المعلومات في حقل إدارة الصيانة للمنشآت. احتوى الهدف الختامي للدراسة على تطوير نموذج إطار عمل لإدارة المنشآت بناءاً على النتائج التي تم الحصول عليها من تحليل المسح الآلي لتطبيقات إدارة المنشآت في الجامعات السعودية.

ACRONYMS

BMS	Building Management System
BOMA	Building Owners Management Association
CAD	Computer Aided Design

CADD	Computer Aided Design and Drafting
CAFM	Computer Aided Facilities Management
CIFM	Computer Integrated Facilities management
CMMS	Computer Maintenance Management Systems
EMS	Engineered Management System
FCI	Facility Condition Index
FHWA	Federal Highway Administration
FM	Facilities Management
FMIS	Facilities Management Information Systems
FPA	Fire Protection Association
GIS	Geographic Information Systems
GPS	Global Positioning System
HVAC	Heating, Ventilation, and Air Conditioning
$IDEF_0$	Integration Definition for Function Modeling
IFMA	International Facilities Management Association
IMS	Inventory Management System
IT	Information Technology
NBCC	National Building Code of Canada
PASP	Physical Asset Strategic Plan
RDBMS	Relational Database Management System
SDLC	System Development Life Cycle

CHAPTER 1

INTRODUCTION

1.1 Background

Facilities are physical structures that support people, either individually or collectively, to achieve their goals. Facilities include universities, bridges, tunnels, ports, airports, industrial installations, sports stadiums and fields, parks and gardens, rivers and waterways, national parks and forests. All these types of facilities require maintenance if they are to remain aligned with their intended support function (Best *et al.*, 2003).

Constructed facilities can be considered as assets or real-estate investments that need to be maintained to ensure their optimal value over their life cycle (Hassanain *et al.*, 2003). Optimum operation of constructed facilities requires a methodology to efficiently and equitably allocate resources amongst valid and competing goals and objectives. In an organization responsible for managing a portfolio of building facilities, the operation of these buildings is subject to a number of conflicting management objectives as dictated by facility managers. These objectives were highlighted by (Best *et al.*, 2003) as improve quality, reduce cost, and minimizing asset's risk of failure. Treating these objectives, organizations need to apply management principles that can assist in decision making through considering complexities of technical, business and human issues (Vanier, 2000).

Facilities Management (FM) is defined by the International Facilities Management Association as "a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology" (IFMA, 2003). FM is the practice of integrating the management of people and the business process of an organization within the physical infrastructure to enhance performance (FMMA, 2002).

Facility managers are assigned a wide range of tasks in planning, designing, and managing facilities. They are responsible for coordinating the physical workplace with the people and work of an organization. This task requires integrating the principles of business administration, architecture, as well as the behavioral and engineering sciences. The role of facility managers is changing rapidly in today's world. Today's facility manager must deal with numerous of issues affecting the workplace. Although the specific tasks assigned to facility managers vary substantially depending on the organization, the duties fall into several categories.

Formalizing standard policies in FM domain requires defining the practices that assists facility managers in managing their portfolio of built-facilities. These FM practices are described as follows:

1. *Construction Drawing Creation and Management:* deals with significant portion of the organization information, especially for buildings, structures, utilities systems, real estate, and land improvements and available information for equipment in the form of shop drawings, schematics, photographs, and assembly drawing.
2. *Inventory Management:* deals with the systematic process of recording, valuing and assessing asset condition cost-effectively.
3. *Space Management:* deals with the delivery of space services and the management of the completed space plan.
4. *Building Maintenance Management:* deals with monitoring the maintenance, repair, and replacement of facilities and assets in order to prevent deterioration and breakdown and to resolve emergency maintenance problems.
5. *Emergency Preparedness Plan:* a plan for managing potential disasters including ability to respond efficiently and quickly to recover in the event of actual crisis.
6. *Furniture and Equipment Management:* deals with effectively managing physical assets, such as furniture and equipment.
7. *Telecommunications and Cable Management:* deals with maintaining an accurate and up-to-date electronic inventory of a cabling and communication network connections.

FM is therefore about empowering people through provision of infrastructure that adds value to the activities that they performed. Facility managers are responsible of ensuring that the infrastructure is available, operational, strategically aligned, safe and sustainable (Best *et al.,* 2003). Each of the above listed practices can be viewed as FM process. A process can be defined as “the series of actions, operations, or motions involved in the accomplishment of an end” (Merriam-Webster Thesaurus, 2003).

Universities can be viewed as FM organizations. They own a variety of assets ranging from buildings to road pavements and underground utilities. The role of an facility manager's in universities is multi-disciplinary and encompasses responsibility for the physical buildings, the integration of building services and equipment, the administration of property functions including management, maintenance, refurbishment, relocation and investment strategies (Vanier, 2000).

1.2 Statement of Problem

Organizations such as universities, municipalities, and manufacturing plant are responsible for managing a wide range of facilities, which would require undergoing of maintenance, repair and renewal activities. For the efficient operations of these facilities over their projected life cycle, organizations need to develop and implement standard policies to assist them in the systematic analysis and decision-making process of how to maintain, repair their facilities (Vanier, 2001).

To deal with limited resources and the increasing complexity involved in managing facilities, it is essential that practitioners have systematic fact-based tools and frameworks to produce the information decision makers need to effectively allocate resources using FM principles (DOT, 2003).

Relating to built-facilities, presently, the literature (Melvin, 1992; Coullahan and Siegried, 1996; Earl, 1996) indicates that managers are faced with rising demands and reduced resources, have few tools, either in the form of standard guidelines or information technology tools, to assist them in the analysis and decision-making process of how and when to maintain, repair their built-facilities.

Information technology has become, and will continue to be, a major driving force for conducting business, particularly as organizations pursue improvements in efficiency, effectiveness and business outcomes. Organizations are implementing information technology solutions to automate FM functions in order to manage their facilities and physical infrastructure in a cost-effective manner. The automation of FM functions can significantly improve their effectiveness in organizations. The extent of automation varies from including information on all buildings to be managed to information on maintenance records, repair data, and renewal information to give facility managers a complete picture of the extent of the existing portfolio (Keith, 1996).

1.3 Research Objectives

The objectives of the thesis are as follows:

1. To investigate the level of automation of FM practices in selected universities, worldwide.
2. To investigate the level of automation and solicit the experience of staff carrying out the range of FM practices in the universities of Saudi Arabia.

3. To develop a FM framework models for major FM functions for the purpose of facilitating the automation of FM practices in Saudi universities.

1.4 Scope and Limitations

The following describes the scope of the thesis:

1. The thesis focuses on buildings as a type of facilities.
2. Universities in Saudi Arabia that are involved in conducting the FM survey include:
    - Umm Al-Qura University
    - Islamic University of Al-Madinah Al-Munawarah
    - King Abdul Aziz University
    - King Fahd University of Petroleum and Minerals
    - King Faisal University
    - King Saud University
    - King Khalid University

1.5 Research Methodology

This section describes the general methodology adopted for investigating the level of automation and solicits the experience of staff carrying out the range of FM practices in the universities of Saudi Arabia and developing FM framework models based on the results of automation survey. The main sources of collecting the information for this research are through extensive literature review, survey of FM practices of projects & maintenance department, comptroller/ inventory department, telecommunication department and safety department of Saudi universities. It was planned and carried out in different phases. These phases include the extensive literature review on the subject, followed by analysis of the collected information has been carried out and recommendations proposed for automating FM practices in the universities of Saudi Arabia. Finally, developing a framework $IDEF_0$ (Integration Definition for Function Modeling) process model for illustrating FM practices based on the results obtained in the automation survey. The methodology set to achieve the research objectives will be undertaken in five phases

1.5.1 Domain Analysis and Description

The domain analysis and description phase in this research implies:

1. Reviewing the existing state-of-the-art of literature on FM practices, to achieve a thorough understanding of the domain. This review will provide a sound background for the exploration of various FM practices that are followed in various types of facilities and universities world-wide.
2. Reviewing Archibus/FM software leaders in automating FM practices world-wide.

1.5.2 Assessment of FM Practices in the Universities of Saudi Arabia

The questionnaire survey was chosen as a tool to investigate the level and extent of automation in the professional practice of FM in the universities of Saudi Arabia. The questionnaire was faxed, emailed and posted to the projects & maintenance department of Saudi universities which provided useful information. Their information, along with the respondent feedback, was useful in the indicating the level of automation found in the professional practice of FM in the universities of Saudi Arabia.

1.5.3 Data Analysis

A detailed analysis of the questionnaire has been conducted in the following chapter to obtain a clear picture of the FM practices in the universities of Saudi Arabia.

1.5.4 Development of FM Framework Models

The final phase was to develop a FM framework models for major FM functions, including construction drawing creation and management, inventory management, space management, maintenance management, and emergency preparedness management, for the purpose of facilitating the automation of FM practices in Saudi universities. The development of FM framework models was carried out based on the findings obtained from analyzing the automation survey of FM practices in the Saudi universities. The FM framework models will be described as an $IDEF_0$ (Integration Definition for Function Modeling) process model for illustrating FM practices. A process model (IAI, 1999) is representation of processes which occur in the real world, and it represents in a conceptual form the flow and content of information that is contained within a defined area of interest. Appendix-A provide a description of the process modeling methodology.

1.5.5 Conclusions and Recommendations

Finally, the results of analysis of the questionnaire and the existing FM practices will be assessed and evaluated to reach meaningful conclusions. Firstly, information was gathered from the literature to review the FM practices that are followed in projects & maintenance department, inventory department, telecommunications maintenance department and safety department. Secondly, feedback from the questionnaire survey regarding FM practices in the universities of Saudi Arabia. Finally, developing a framework models helps in analyzing and automating FM practices in the Saudi universities.

1.6 Structure of the Thesis

The thesis will be structure as follows:

- Chapter 1: (Introduction) gives an introduction to the topic investigated in the thesis. It presents statement of the problem and research objectives. It presents the scope and limitations of the thesis.
- Chapter 2: (Literature Review) presents the state-of-the-art literature review on topics related to FM.
- Chapter 3: (Automation of FM Practices) describes issues related to automation of FM practices.

- Chapter 4: (Level of Automation in Facilities Management Practices in Universities World-Wide) describes the level of automation of FM practices that are followed in different universities world-wide.

- Chapter 5: (Analysis of Automation Survey) discusses and reflects on the main findings of the survey carried out to solicit input from practitioners on automation of FM practices.
- Chapter 6: (FM Framework Models) provides the development of the FM framework models for built facilities based on the results obtained from automation survey.
- Chapter 7: (Conclusions and Recommendations) draws the main conclusions and summarizes them against the objectives set for the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Facilities Management

FM may be described as a business process and a decision-making framework by which an organization ensures that its buildings, systems, and services support core operations and processes as well as contribute to achieving its strategic objectives in changing conditions. It focuses resources on meeting user needs to support key role of people in organizations, and strives to continuously improve quality, reduce cost and minimize risk (Keith, 1996).

FM is a discipline of empowering people through provision of infrastructure that adds values to the process that they support (Best *et al.*, 2003). FM policies lay out an organization's response to important issues such as space allocation and charging, environmental control and protection, direct and contract employment. The policies will set a path for the organization and establish the values of and attitudes towards the facilities users (Keith, 1996).

The practice of FM was facilitated with the advent of increasingly powerful computer systems. With those systems came the possibility of more sophisticated analytical tools and techniques, as well as information technology that would support a comprehensive, fully integrated FM system (DOT, 1999).

2.2 Facilities Management Functions

Major FM functions include construction drawing creation and management, inventory management, space planning and management, building maintenance management, emergency preparedness, furniture and equipment management, and telecommunications and cable management. All these functions are performed to varying degrees by universities, hospitals, manufacturing, processing plants, office building complexes, and government agencies. These FM functions are described in the following sections:

2.2.1 Construction Drawing, Creation & Management

For many years building drawings were painstakingly created by hand using pen and paper on a drafting table. Any changes often required new drawings to be created or at the very least sections redrawn. The advent of the desktop computer soon gave rise to Computer Aided Design (CAD) drafting allowing drawings to be created on a PC and printed electronically. Changes could be made quickly without having to redraw the whole drawing.

Drawings is a significant portion of the organization information, especially for buildings, structures, utilities systems, real estate, and land improvements and available information for equipment in the form of shop drawings, schematics, photographs, and assembly drawings. Drawings may exist in many forms, including paper, photographs, video images, and computerized data. Computerized forms include Computer Aided Design and Drafting (CADD), Geographic Information Systems (GIS) or vector based drawings. Drawings can be linked to work orders through a computer maintenance management systems (CMMS) database (FM, 2003).

2.2.2 Inventory Management

Inventory is the representation of physical assets that an organization records or keeps on hand. Inventory Management can be defined as systematic process of recording, valuing and assessing asset condition cost-effectively. It contains a detailed inventory of all facilities and maintainable equipment subject to the FM system. An asset may be defined as a uniquely identifiable element or a group of elements that has a financial value and against which maintenance actions are recorded (IAI, 1999). Assets are managed through registers that list information relating to various aspects of an asset portfolio, in a form that allows data to be cross-referenced and retrieved as required. An asset register may be computer, card file or paper based and contains data relating to one or more asset categories including specification details, acquisition dates, serial numbers, monetary valuation, insurance, warranties, location, maintenance requirements and other information to maintain effective control (Best *et al.*, 2003).

Assets are a vital investment in the well-being of an organization. If they are not managed properly, the expected degradation of these assets could become a source of responsibility and a significant financial burden to an organization. Therefore, facility management requires reliable and accurate information. Monitoring facilities requires extensive data collection efforts. Because present data collection methods are costly and time-consuming, automated methods of data collection are needed to meet evolving management needs (Mastandrea *et al.*, 1995). The components of the inventory system are:

1. *Inventory Scope:* This includes definition of data to be collected and standards and guidelines to be used to obtain and define data.
2. *Data Recordings:* Method and procedures and formats for data collection.
3. *Data Storage:* This involves recorded data forms and inventory information files, preservation of site records (drawings) and plans and specifications and summarized data inventory on computer for quick retrieval and information use.
4. *Data Assessment and Analysis:* Utilizing the inventory data, an analysis is undertaken with regard to a condition rating or assessment of each system based on given criteria and standards.

Vanier's (2001) contribution to formalizing standard policies in inventory management domain consists of defining the practices milestones that assists facility managers in managing their portfolio of building assets. These milestones are described in the following paragraphs.

1. *What do you own? :* This is the essential element inventory to know what are the available assets, their location, service life, etc. Geographic Information Systems (GIS), CAD systems, and Relational Database Management Systems (RDBMS) are used to provide accurate picture of the extent of an inventory management portfolio. In GIS, the data about a particular asset related directly to their physical location on a map (GIAC, 1998). CAD Systems are used to provide sources of inventory management information for the engineering, technical and management staff (SommeHoff, 1999).CMMS is another tool that can be used to record assets. (PM, 2000).
2. *What is it worth? :* This is used to keep a system for recording the value of assets. It is necessary to establish the asset values, once an organization identifies the extent of their assets. Book value, appreciated historical value, capital replacement value, performance in use value, market value and deprival cost are different ways to calculate an asset's worth (Vanier, 2001).
    a. *Book value:* The historical value is the original "book value" of the asset.
    b. *Appreciated Historical Value:* The appreciated historical value of an asset is the historical value calculated in current dollars, taking into account annual inflation or deflation.
    c. *Capital Replacement Value:* The capital replacement value is the cost of replacing an asset in current dollars.
    d. *Performance in Use Value:* The performance in use value is the value of the actual asset for the user (Lemer, 1998).

e. *Market Value:* The market value is the value of the property if it were sold on the open market today. In many instances, the market value cannot be used for municipal infrastructure; however, it is applicable to many types of assets such as buildings or unoccupied land.

f. *Deprival Cost:* The deprival cost is the "cost that would be incurred by an entity if it were deprived of an asset and was required to continue delivering programs/services using the asset.

3. *What is its condition? :* Condition is a quantification of the current state of asset based on the evaluation of its physical characteristics. There are different condition assessment techniques that are used to asses the performance of an asset and/or its components. Condition assessment surveys are inspections used to assess the performance of a system, subsystem or component. The condition assessment survey method requires the periodic inspection of assets to determine their current condition and to estimate the cost to correct deficiencies. Facility Condition Index (FCI) is a standard benchmark in the inventory management industry which is used to objectively assess the current and projected future condition of an asset. It is a ratio of the total deferred maintenance cost to the replacement cost. A ratio of less than 5 percent indicates good condition, a ratio of 5-10 per cent indicates fair condition, and a ratio of over 10 per cent indicates poor condition. Condition index is an asset based on a number of factors including number of defects, physical condition, and quality of materials or workmanship. It is the numerical or descriptive rating to measure the facility condition that is calculated from the inspection data (Vanier, 2000).

2.2.3 Space Management

Space Management and space planning are separate but related processes. Space planning involves assisting user organizations to define their requirements for current or future space and providing methods and forms for recording requirements. Space management provides a range of working environment and space services for the business employees. Space management is the delivery of space services and the management of the completed space plan. Space management includes alternative offices, shared spaces, and on-off premises management (Best *et al.*, 2003).

Space management is an important part of FM process and can be considered a subset of FM functions. It is a process of projecting space requirements, identifying deficiencies, allocating available space to users in an equitable way; monitoring use, assisting users with concerned with the amounts of space, but must address the quality of space as well. Space management is the skill of maximizing the value of existing space and minimizing the need for new space. Space management depends on a clear understanding of organizational need and direction (Best *et al.*, 2003).

(McGregor and Then, 2001) explains space management is the professional discipline that incorporate the planning and management of workspace features in many business operations. In fact, almost every type of work environment the evidence space management can be seen. As the acceptance of FM as a professional discipline increases, it will strengthen the crucial role of facility managers in delivering innovative workplace solutions to meet users need in the organization. Space should be viewed as a set o tools critical to meeting the organization's objectives. The purpose of most facilities is to provide suitable workplace to the organization, as it involves the determination of space requirements, design, construction, adjustment as people come and go and as business demand changes (Best *et al.*, 2003).

(Langston and Lauge-Kristensen, 2002) describes that there are many types of functional plan that a facility managers might prepare, ranging from financial plans to those involved with specific areas of activities , such as inventories, maintenance, energy usage, space usage and the like. Function plans are the generic names given to the business documents that identify methods to deliver organization goals. Space and its efficient usage are one of the most important functional plans. Space management enables available physical resources to be allocated to ensure that business processes are properly supported. Too little space may result in inability to function to an appropriate standard, while too much space will carry cost penalties that the organization may not be able to sustain. Finding the right balance involves working properly closely with users and understanding the processes and workflow patterns.

Understanding user's needs is a primary role of a facility manager, and comprises collection of facts, opinions, judgment, knowledge of future directions and industry benchmarks. When a facility is designed, need analysis is used to determine the number and size of functional spaces. The duty of facility manager should be constantly concerned about whether available space is sufficient and where additional space, if necessary, can be readily acquired (Best *et al.*, 2003).

Space management is needed to ensure that: available space is distributed among organizational units so that missions can be performed, providing fair distribution of space among organizational units, establishing standards for space allocations, preventing unnecessary construction projects and identifying problems with current space inventories (Brauer, 1992).To accomplish these objectives, facility managers perform six major functions: planning, space assignments, support services, recordkeeping, reporting, and space audits and surveys. These functions are described as follows:

1. *Planning:* Planning involves assisting user organizations to define their requirements for current or future space, and providing methods and forms for recording requirements.
2. *Space Assignments:* Space assignment involves tasks such as receiving requests for space or changes in space, processing requests, and recommending a solution. Another key task of space assignment is making decisions about who gets what space.
3. *Support Services:* In the support services function, users are assisted in making good use of space, organizing contents effectively, and ensuring that a space has desirable features and characteristics. Users do not always have the knowledge and experience to recognize layout deficiencies and maximize space usage, and therefore, help should be available.
4. *Record Keeping:* Recordkeeping includes the compilation, verification, and maintenance of many kinds of data. Data compiled include an inventory of spaces, and possibly personnel and furniture; standards for many kinds of spaces, both quantitative and qualitative; floor plans and tabular data on what

space is assigned to whom; actual measurements of spaces and buildings; characteristics and features of particular spaces and facilities; and other data necessary to perform the space management functions. Recordkeeping includes periodic and special data collection to verify space assigned, usage, contents, and dimensions.

5. *Reporting:* In reporting function, data provided by users are analyzed to project the kinds and amounts of space needed, information is compiled, and reports are prepared on space usage and related matters.
6. *Performing Space Audits and Surveys:* The facility manager is responsible for evaluating and reporting on utilization of existing space. This requires that staff perform walk-through inspection and compile data to determine whether assigned space is being used, what it is used for, and how efficiently it is used. A part of this function is conducting surveys of quality evaluations of spaces to determine whether they support those assigned to use them.

Adding space to meet organization's needs is not always an option. But with the power and flexibility of the automation of space management application, can improve space efficiency and evaluate the true costs associated with space usage (CFI, 2003).

2.2.4 Building Maintenance Management

A building can be considered as asset or an investment that needs to be maintained to ensure its optimal value over its life cycle (Hassanain *et al.*, 2003). All building starts to deteriorate from the moment they are completed, and at that time the need of maintenance begins. Since the area of maintenance has a direct impact on the quality of the service a facility offers to its users throughout the service life, it can be concluded that maintenance management is a critical field that demands more attention (Arditi and Nawakorawit, 1999). In any organization , facilities and assets plays a vital role; they not only provide the physical working environment and reflect the organization's image, but also affect the organization; overall productivity . In order to prevent deterioration and breakdown and to resolve emergency maintenance problems, organizations need to monitor the maintenance, repair, and replacement of facilities and assets.

Facilities refer to the site, building, furniture and equipment that contribute to a learning environment. These services are in constant need of regular maintenance to ensure that they continue to function properly and that they retain value and good appearance. Maintenance may be defined as the preservation of a building so that it can serve its intended purpose or work undertaken in order to keep or restore every facility, i.e., every part of a site, building, and contents, to an acceptable standard'(Arditi and Nawakorawit, 1999). Maintenance, according to British Standard 3811(Glossary, 1984) is defined as "combination of all technical, administrative and managerial actions intended to retain an item or restore it to, a state in which can perform the required function".

(Korka *et al.*, 1997) defined maintenance as the orderly control of activities required to keep a facility in as-built condition, while continuing to maintain its original productive capacity. Maintenance management can simply be defined as managing these maintenance activities. Maintenance management can be defined as the effective and systematic management process of a maintenance activity in which profound applications are made of the three basic elements of management: organization, measurement and control (Haron, 2002). In this modern world, facilities have become more complex and the cost of their services forms a major portion of the initial cost, thus affecting the cost of maintenance. The responsibility of facility manager is to deal with the complexities of the facilities, and their continual use and environment.

(Magee, 1988) describes the specific maintenance objectives as follows:

- Perform daily housekeeping and cleaning to maintain a properly presentable facility.
- Promptly respond and repair minor discrepancies in the facility.
- Develop and execute a system of regularly scheduled maintenance actions to prevent premature failure of the facility and its systems and components.
- Identify design and complete improvements projects to reduce and minimize total operating and maintenance costs.
- Operate the facility utilities in the most economical manner while providing necessary reliability.
- Extending the useful life of assets
- Ensuring readiness of equipment needed for emergency use at all times.
- Ensuring the safety of personnel using facilities.

The major work tasks performed by facility managers in any maintenance work as inspection, troubleshooting, removal and replacement, repair, adjustment, and conditioning. Additionally these work tasks can be categorized as being either planned or unplanned maintenance. Figure 2.1 illustrates the various maintenance work classifications in any organization.

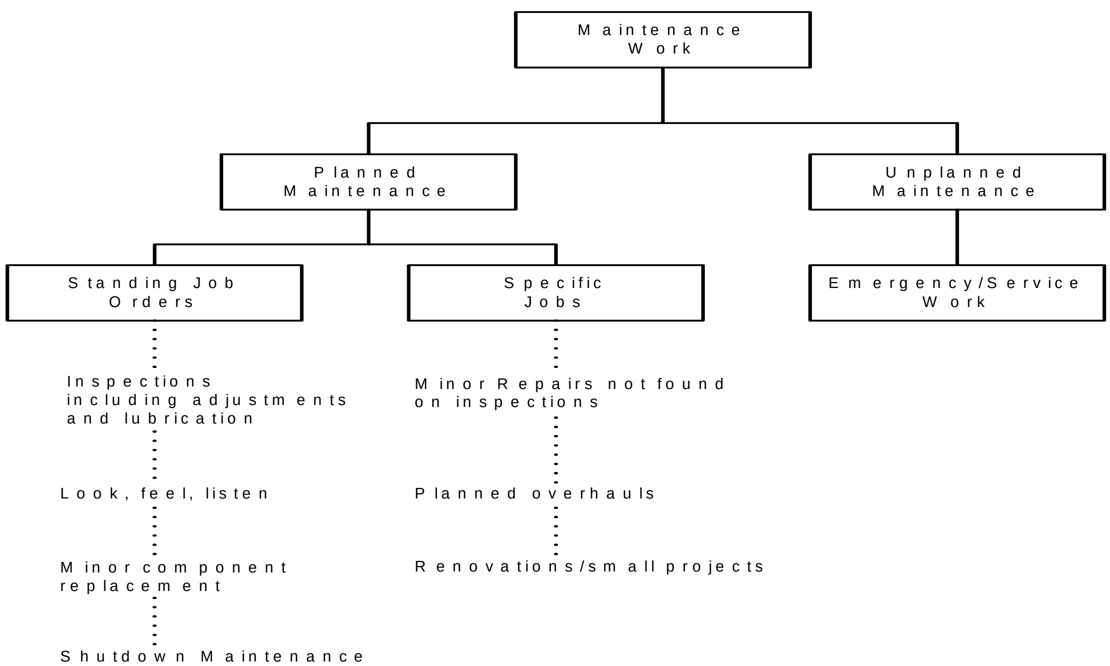

Figure 2.1: Various Maintenance Work Classifications (Korka et al., 1997)

Planned maintenance is organized and carried out with forethought, control, and records to a predetermined plan. Unplanned maintenance is work that must be performed immediately to avoid serious consequences and it is commonly referred to as emergency or service work (Patton, 1988).

Maintenance of facilities can be classified into numerous types. Types of maintenance include the following (King *et al.*, 1984):

- *Service Maintenance:* It includes maintenance items requested by the tenants or occupants. It also includes emergency items.
- *Routine Maintenance:* It includes general maintenance to the common areas. These items are tenant requested, but are necessary to keep the building in good condition.
- *Preventive Maintenance:* Maintenance performed to retain an item or asset in its original condition, as far as practicable, by providing systematic inspection, detection and prevention of incipient failure. (Examples include servicing of plant and equipment, cleaning of gutters, grass cutting, testing and maintenance of fire evacuation systems and fume cupboards).
- *Corrective Maintenance:* Maintenance performed, as a result of failure, to restore an item or asset to its original condition, as far as practicable or work necessary to bring a building to an acceptable standard.
- *Emergency Maintenance:* Maintenance which it is necessary to put in hand immediately to avoid serious consequences.
- *Deferred Maintenance:* Maintenance that is due to be carried out in the current financial year but which intentionally will not be carried out because of a shortage of funds or unavailability of parts. Examples include painting, floor coverings, gutters and roof coverings and building façade maintenance.
- *Extraordinary Maintenance:* This task involves major rehabilitation, replacement or refurbishment of units, buildings, or grounds.

The basic steps of maintenance work management described by (Korka *et al.*, 1997) as follows:

1 *Work Request:* The user will phone, fax or email requests to the work reception center to perform maintenance work. Work reception accepts and records work requirements submitted by user.

2 *Work Identification:* The work order is given a unique identifier which help in tracking the work item through its life cycle of planning.

3 *Work Approval:* Simple job are handled by a maintenance supervisor. When large expenditures are involved, several levels of management approvals are required.

4 *Work Planning:* This involve the detailed planning and estimating of maintenance tasks or steps to be taken, available resources (material, equipment, tools and labor).

5 *Work Scheduling:* This involves scheduling the work based on available resources, priorities, and job assignment.

6 *Work Execution:* When all materials are available and coordination and scheduling are completed, the work order is executed by craftsmen.

7 *Work Documentation:* This involves recording the actual hours of consumed resources, equipment identification, work assigned and performed, and other pertinent data.

8 *Work Reports:* This involves recording the work completion and the resources used, and closing the work order.

Figure 2.2 illustrates the steps involved in processing maintenance work requests (NODIS, 2003).

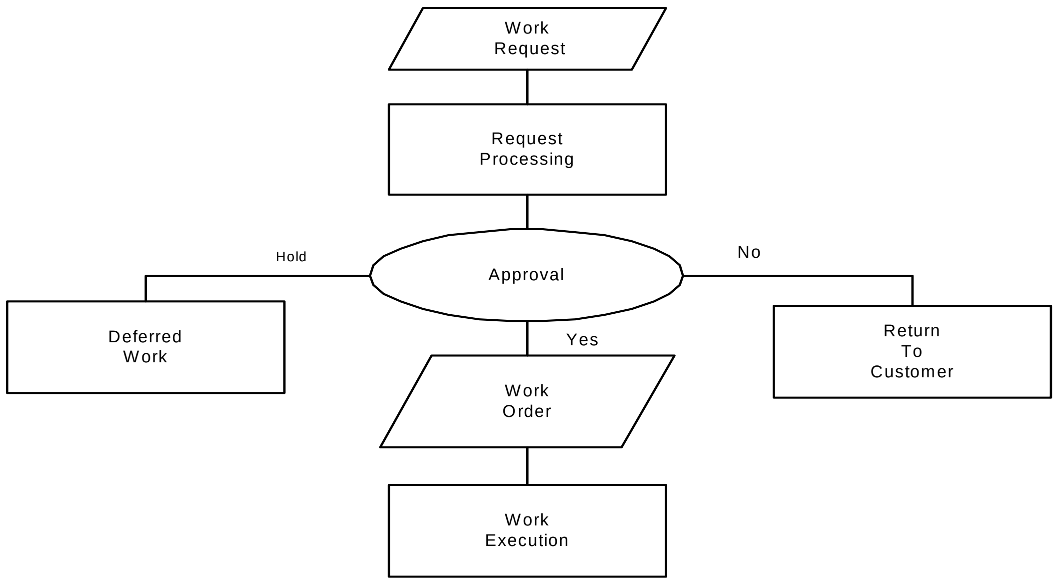

Figure 2.2: Work Request Processing (NODIS, 2003)

2.2.5 Emergency Preparedness Management

Every year, natural and man-made disasters affect millions of people and cause tremendous financial loss to organizations. In the event of an emergency, whether it is a system failure, natural disaster or act of violence, organizations need to ensure that life safety procedures are allowed, property is protected, and disruption to normal operations is limited. Fires are known to cause fatal and non-fatal damages to building occupants and inflict serious damages to buildings and their contents. Fire safety may be defined as "the reduction of the potential for harm to life as a result of fire in buildings" (CWC, 2002). The National Building Code of Canada (NBCC, 1995) has defined fire safety as "an objective to reduce the probability that a person in or adjacent to a building will be exposed to an unacceptable fire hazard as a result of the design and construction of the building”. A building may be considered to be very safe from fire if a sufficient low fire risk is associated with its structure, contents and occupants (Ramachandran, 1999).

Emergency preparedness management is an important area of concern for facility managers. The potential for loss of life or injury from disasters, fire-related incident is a serious risk. The main objectives of emergency preparedness management are to minimize the man-made disasters, to provide critical information in case of actual crisis, risk of fire, protect the means of escape, and limit the spread of fire. The facility manager of any facility, no matter how large or small, has a responsibility to maintain these objectives. Facility managers are required to comply with statutory requirements and implement procedures to ensure the safety of all persons on the premises and conduct regular risk assessments.

The buildings occupants and facility users expect to carry out their day-to-day operations in relative safe environment. Facility managers must ensure that appropriate levels of safety are provided and properly maintained. They must do so with knowledge of the occupancy profiles of their facilities and manage accordingly. The vast majority of fires are accidental and thus preventable. Facility managers and other personnel’s involved in safety concern of the occupants and buildings cannot be absolutely sure but they can be, and be seen to be, prepared and trained for the eventuality (Shields and Boyce, 1999).

The prevention of fire should be stressed as a major priority as describe by the Fire Protection Association (FPA, 1995), which through proper training should promote awareness of fire safety to the building occupants. (Hinks and Puybaraud, 1999) argued that facility manager's duty nowadays not only includes building services but also fire safety issues in buildings premises being altered or maintained.

A fire safety plan is typically developed with the input and support of facility managers, fire safety officer and local fire officials. A fire safety plan is a detailed emergency pre-plan to deal with all aspects of fire safety issues for a specific facility. The plan is a key reference manual outlining all the fire safety systems and procedures for the facility. Life safety is vitally important. Plans and procedures are formalized to enhance the chances of survival if there is a fire in the building, and to ensure that you are taking appropriate steps to ensure occupant safety. Formulating the fire safety plans and procedures are a part of good facilities management processes that will not only protect the occupants, but also protect the building. The fire safety plan includes a strong element of fire prevention.

The two-fold objectives of the fire safety plan are:

1. *Fire Prevention:* To prevent the incident of fire by the control of fire hazards in the building and the maintenance of the building facilities provided for the safety of the occupants. Fire detection systems may be defined as "any system designed to detect automatically the presence of smoke, heat, combustion products or flames and give warning of same." Fire detector systems are

primarily design to help ensure that building is safe to use, transform this response into a visual-audible signal that occupants are able to escape safely and quickly in the event of fire, and that appropriate control measures are rapidly initiated by fire department (Bryan, 1982).

2. *Emergency Evacuation:* To establish a systematic method of a safe and orderly evacuation of an area or building, by and of its occupants, in case of fire or other emergency. Every building should be so designed that occupants should finds safe route to escape in the event fire breaks out. The occupants must be able to reach place of safety before being overcome by the heat or smoke. Therefore the time needed to escape should be shorter than time it ill take for flames to spread. Furthermore the escape routes must neither be too long nor complex. The means of escape must be designed into the circulation routes within the building. The means of escape should form an integral part of the initial concept of the design phase (Thomson, 2002).

Even where fire event management has not been an explicit design issue and this applies to the majority of buildings of course planning for and managing such a provision for an occupied building will enter the domain of FM. In this situation, assumptions about the evacuation behavior of people and the effectiveness of safety support provisions for occupants during their escape or refuge from a building fire will contribute to the overall safety of the situation. Achieving success in a fire event can place a compensatory emphasis on FM to best exploit the active and passive provisions of the serviced building according to the assumed circumstances of the event. At this point, the quality of prior assumptions about the event, the fire and smoke, and the occupants each become critical, and interdependent (Hinks, 1999).

In particular, the realism of design-stage assumptions about behavior and the other fire safety provisions in the building, and the knowledge of the facilities manager about the event and the escaping occupants, are critical. Information is usually scarce and possibly ambiguous during the fire event. Problems arising from the unpredictability of the evolving fire event may severely tax the flexibility of the evacuation method and other facilities management provisions. Furthermore, and in spite of the possible centrality of management to life safety during a fire, there remains little in the way of authoritative commentary on that behavior (Hinks, 1999).

Every year, fire breakout affects millions of people and cause tremendous financial loss to organizations. In the event of an emergency, whether it is a system failure, or act of violence, organizations need to ensure that life safety procedures are followed, property is protected, and disruption to normal operations is limited. The automation of emergency preparedness activities can serve as a primary tool for providing critical information to those who need it most in the event of a fire hazards/risks in the facility.

2.2.6 Furniture & Equipment Management

Effectively managing physical assets, such as furniture and equipment, is vital to maintaining the financial health of an organization. The automation of furniture &

equipment management application helps to take control of moves, adds, changes, and more, in order to minimize costs and maximize productivity (CFI, 2003).

2.2.7 Telecommunications & Cable Management

The speed at which technology changes requires continuous system upgrades. These upgrades must be recorded to maintain inventory control that accurately reflects the physical condition of telecommunication network. The automation of telecommunications & cable management application provides the means to manage network information, including system capacity, physical locations of systems and connections, maintenance histories, and more. The application can also maximize information technology investments by helping to determine where surplus systems can be reassigned, rather than written off (CFI, 2003).

2.3 Facilities Management Case Studies

The practice of FM have been implemented in different types of infrastructure projects such as university projects, hospital projects, geotechnical projects, transportation projects. The following sections present case studies of current FM functions that are implemented in different fields:

2.3.1 Medical Facilities

In 1992, the Queensland government started work on preparing a state–wide health services to asses the structural condition, condition of engineering systems, functionality, age and potential for modification of all buildings, asset condition reviews were undertaken to define the role of the Herston Hospital complex. Queensland government recognized that asset maintenance is equal in importance in owing and operating health buildings to their procurement. To manage assets effectively and efficiently, a Physical Asset Strategic Plan (PASP) is required to be developed annually by all Queensland hospitals. The preparation of the PASP includes the following steps:

1 *Service Planning:* Identification of the service delivery objectives defined as part of the corporate strategic plan and the resources available to meet health service requirements;

2 *Asset Condition Review:* Assessments of how effectively existing assets meet service delivery objectives;

3 *Development, Maintenance and Disposal Plans:* Assessment of all options to secure necessary infrastructure, including replacement, refurbishment, corrective maintenance, preventative maintenance, disposal, and non-asset solutions.

The Institute of Hospital Engineering Australia has taken the initiative to develop a comprehensive hospital facility benchmarking process, called “AssetMark” to assist hospital engineers to improve the facilities management services they provide. The “AssetMark” benchmarking process comprises the following elements: the hospital engineer contacts the Institute with a request to become a participant in the benchmarking process; the Institute provides the participating engineer with a survey guide and questionnaire; the hospital engineer completes the questionnaire and submits it to the Institute; the Institute validates the data submitted by the engineer and enters it into the database for analysis; the Institute prepares 14 reports identifying the participating hospital engineer's hospital position relative to the national performance data; the hospital engineer reviews the survey results and if desired, seeks additional reports from the Institute; on request, the Institute will identify and contact benchmarking partners; the benchmarking partners will initiate the benchmarking process in accordance with the Benchmark Self-help Manual produced by the Enterprises Improvement Service, which is part of the Australian Government's Best Practice Program; finally, the hospital engineer can initiate a follow-up survey with the Institute to review his new level of performance and to undertake additional benchmarking exercises to continuously improve the performance of the facilities under his care (Geerlings, 1998) .

2.3.2 Municipalities

The city of Cockburn, Australia, developed an asset management plan for its drainage network, and examined a method to complete an asset register and link it to a GIS system. The city of Cockburn works division arranged a meeting with the staff and agreed that the all components of the drainage system had to be identified and recorded; a formal maintenance programs would be introduced; Information had to be readily accessed from the field and office; Information had to be easily updated by field staff. All assets needed to record into a consolidated assets register and the following priority list was agreed upon: roads, footpaths, drainage, parks, and buildings. An asset information services manager was employed together with two other support staff members. One staff member would develop the GIS so the drainage module could be added, and the other would coordinate the collection of the data and design the formats for inputting the data as well as design a system so the data can be shown on GIS. A real-time global positioning system (GPS) and vehicle were purchased and two casual field staff was employed to collect the data. GPS has emerged as an essential tool for collecting data. It provides the information in national grid coordinates so it can be accurately located on the plans. A maintenance management system module was developed to allow users to perform graphically: inputting and retrieving asset information, recording maintenance and rehabilitation works and general financial and statistical reports in both written and graphical forms. This maintenance management module allows the field staff to proceed with the planned and unplanned maintenance work that can be connected to the assets register module and valuation module from the other programs used (Greay, 2001).

2.3.3 Transportation Systems

The “InfraManage”, a GIS-based infrastructure management prototype system is developed for Champaign County, Illinois, USA to manage five highway components (pavements, bridges, culverts, signs, and intersections) in a coordinated manner at both a network and project implementation levels. The methodology for developing the prototype involves analyzing procedures for integrating data with GIS system-based software (Gharaibeh *et al.*, 1999). Figure 2.3 illustrates the system design for the “InfraManage” prototype, for managing highway infrastructure systems.

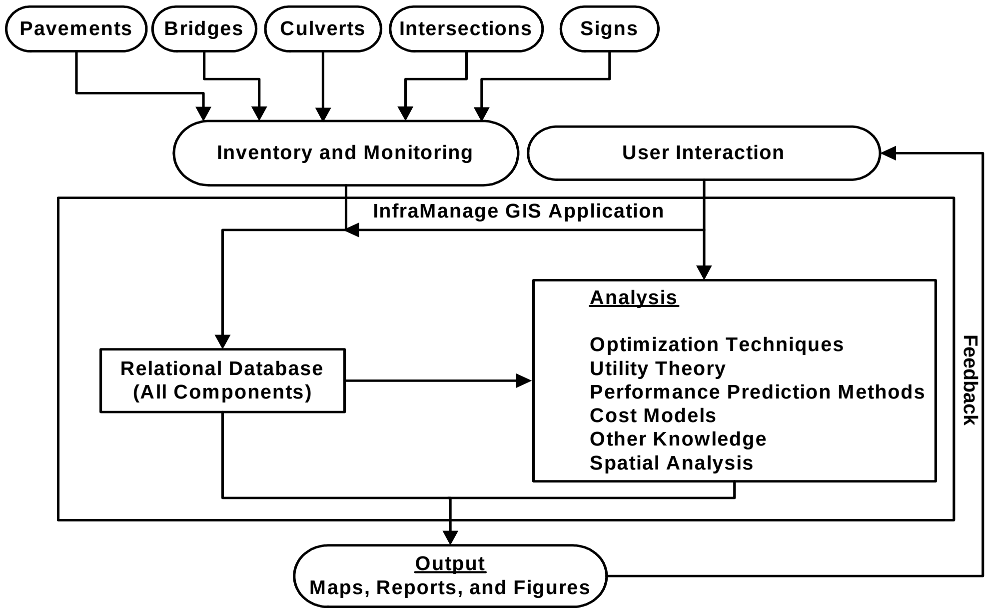

Figure 2.3: System Design for "InfraManage" Prototype System (Gharaibeh et al., 1999)

There are four major areas of integration considered in the methodology followed in developing the prototype system. These are listed below as follows:

1. *Integrated Computerized System:* The integrated system approach developed in this study for the management of highway assets was applied to five infrastructure components (pavements, bridges, culverts, intersections, and signs) of the state highway system in Champaign County, Illinois.
2. *Network-level Integration:* The network-level integration involves performing trade-off analysis to select candidate projects from various highway infrastructure components.
3. *Project-level Integration:* The project-level integration includes identifying adjacent improvement projects from various infrastructure components that can

be implemented simultaneously to reduce traffic disruptions. The project-level integration is performed in a spatial manner using GIS capabilities.

4. *Multiple Performance Measures:* It includes he selection of candidate infrastructure improvement.

Applying the above listed methodology in the development of the prototype system for Champaign County, Illinois showed that integration is beneficial to highway users and agencies (Gharaibeh *et al.*, 1999).

2.3.4 Geotechnical Infrastructure

(Sanford *et al.*, 2003) presents the development of framework for asset management of geotechnical infrastructure. The following are the issues and roles of these assets play in the transportation infrastructure, and the interaction among ‘‘geotechnical assets’’ and other types of assets such as pavements and bridges. Figure 2.4 shows the generic framework proposed by the FHWA’s office of asset management for asset management. Figure 2.5 shows a framework with the basic components subdivided into particular activities or types of data.

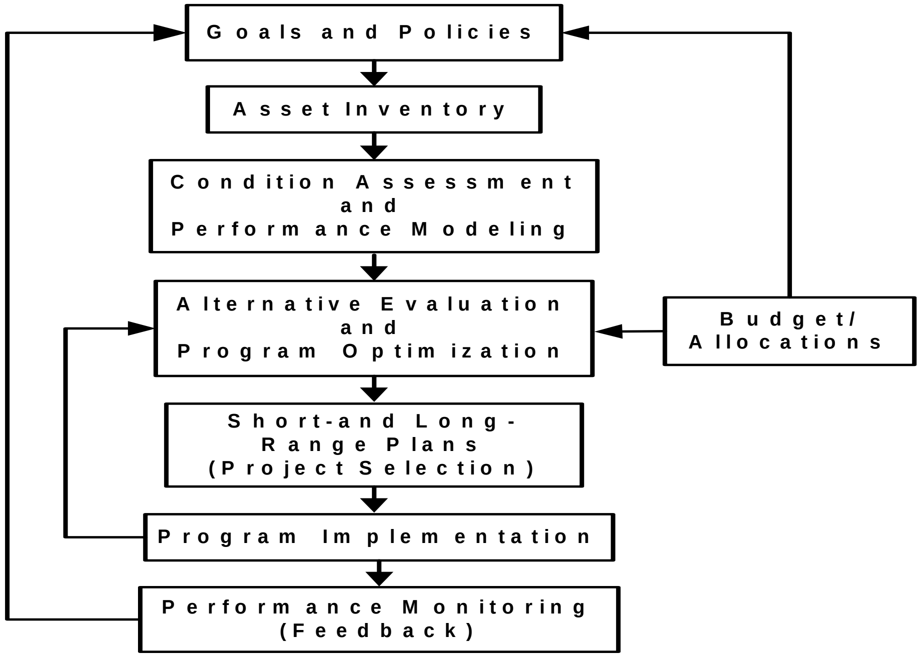

Figure 2.4: FHWA: Generic Asset Management System Components (Sanford *et al.*, 2003)

Framework for Geotechnical Asset Management

Agency Goals: Agency unlikely to have specific goals for geotechnical assets. Since the geotechnical related goal depend on the performance of other assets, geotechnical asset management must interact or be integrated with other primary asset management functions.

Data Collection

1. *Inventory:* Agencies collect some of the required data; many aspects of data collection that include location, extent, soil properties, etc will need to be improved if geotechnical asset management is to be implemented.
2. *Performance:* Most of the agencies quantitatively assess the condition of geotechnical assets on a routine basis. Performance indicators, which may reflect

physical condition, user cost, or other measures, are essential components of any infrastructure or asset management system.

3. *Value:* Variety of methods can be used to value physical assets, replacement cost may be most appropriate.

4. *Other:* Another issue that must be considered in data collection is identification of potential impacts of poor asset performance. Geotechnical failure can impact both the safety and mobility of the public.

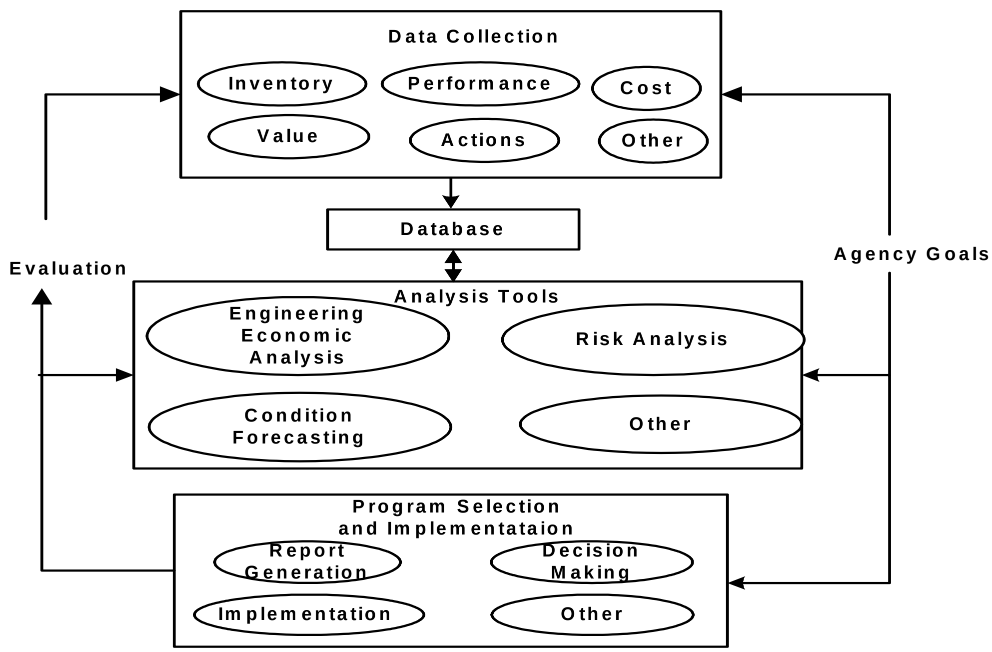

Figure 2.5: Asset Management System Components (Sanford *et al.*, 2003)

Analysis Tools

1. *Economic Analysis:* Calculate life-cycle costs to compare impacts of various maintenance and repair options, etc.

2. *Risk Analysis:* Evaluation risk of repair alternatives as well as risk of no repair, etc.

3. *Condition Forecasting:* It is based on deterioration models; predict future condition of slope, embankment, etc., based on current and historical information, etc.
4. *Other:* Another issue that must be considered in the analysis of alternatives is the maintainability of various types of geotechnical assets. Calculate level of hazard and factors of safety, etc.

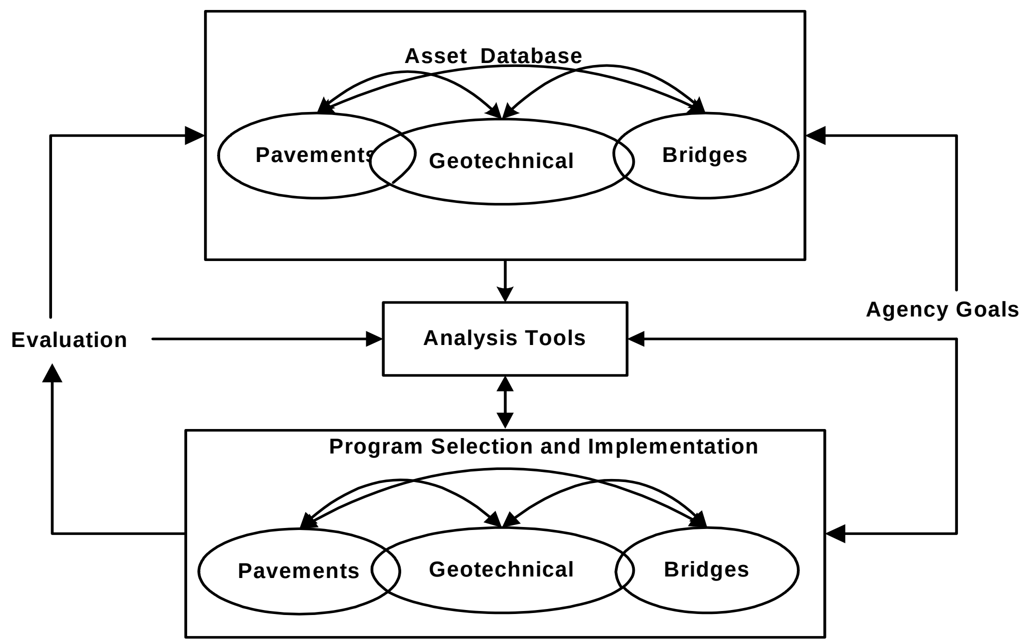

Figure 2.6: Interaction of Types of Infrastructure in Asset Management (Sanford *et al.*, 2003)

Program Selection and Implementation

Decision-making: Compare costs, benefits, and risks of alternatives under different budget scenarios and choose course of action.

Evaluation: Evaluate whether data and analysis tools are providing useful information and whether goals are being met (Sanford *et al.*, 2003).

CHAPTER 3

AUTOMATION OF THE FM PRACTICES

3.1 Overview of Automating FM Practices

The automation of FM practices can significantly improve their effectiveness in any organization by adopting, developing and maintaining an appropriate level of knowledge and skill in information management and technology. Many organizations don't fully realize how much work is involved in manually keeping their configuration database up- to-date. It involves a considerable amount of human effort and time, which costs an incredible amount of money.

Managers are faced with many obstacles: a lack of process and a lack of resources. Organizations have an ideal opportunity to re-define staff's roles in the FM domain by automating the process and using the software to update the records. They can release resources to deal with more diverse FM functions, providing much better management information and making staff more productive and pro-active (Forrester, 2003). There are currently a variety of computer applications on the market that were developed to solve specific components of the FM. In applying automation to FM diverse functions, vendors have taken approaches that originated from two different technical directions: either CAD or RDBMS.

Many solutions for managing space have generated from CAD based architectural applications. Database solutions have grown from financial, resource and asset tracking initiatives to include scheduling, inventory, and purchasing functions. Implementation of FM automation can occur at any scale, from a small spreadsheet to record preventative maintenance items, to a full corporate system with CAD capabilities that manage the complete maintenance-design-build process with all contracting, accounting, inventory, asset and personnel records integrated. CAD based products have normally been classified as CAFM, while the data base solutions, dealing with work order management without a CAD component, have been termed CMMS.

The FM user community reflects this polarization, since the majority of current implementations are oriented either one way or the other. Computer Integrated Facilities Management (CIFM) brings both CMMS & CAFM capabilities into synergy, thereby addressing the implementation of a true FM automation program. The core consideration is that, in practice, CMMS and CAFM capabilities augment and are essential to each other (Geotelec, 2003).

3.2 The Potentials of Using IT in Conducting FM Functions

The introduction of information technology (IT) promised access to data, provides intelligent rationalization of methods and processes which would improve the decision-making process in any organization. IT has been successfully employed in all fields of engineering, medicine, business that could help in enhancing the human capability of performing the work effectively and productively (Al-Rugaib *et al.*, 1999).

The rapid growth of FM as a recognized discipline has been paralleled by the rapid growth of IT as a tool for strategic development. The scope for IT applications in FM is diverse – IT can impact on strategic management, building and engineering services management, environmental management, domestic services, administration and service support. The challenge for the facilities manager is to bind the power of IT in order to enable and accelerate the achievement of organizational goals and objectives (ITCBP, 2004).

IT has an important role to play in this and today's facilities manager needs to have a sound understanding of fundamental IT applications, such as relational databases, and industry specific software's, such as CAD , CAFM and CMMS (ITCBP, 2004).

IT has a broad influence on FM organizations changing patterns of work, putting new demands on buildings, raising new technical and service management issues.

Assimilating new technologies, in particular the broad impact of IT on organizations and buildings is one on the key FM challenges (CFM, 2004).

The uses of IT in performing FM functions can significantly improve efficiency and productivity of the organization. Hence, FM may be defined in the IT industry as the provision of the management, and operation and support of an organization's computers and /or networks (Keith, 2001).

Workplace systems and facilities must be able to accommodate the rapid growth of business technology. It quickly becomes apparent that IT is becoming as important to the mission of FM as to the disciplines of architecture, business administration, and engineering (ITCBP, 2004). IT applications can be used to support FM in areas such as: tracking and managing assets, scheduling and monitoring tasks, real-time information sharing and transfer, business analysis, tracking accounts, CAD and space reports, maintenance surveys, and cost control.

3.3 Automated Systems

Automated systems are the man-made systems that interact with or are controlled by one or more computers. Intelligence with respect to workplace automation in an intelligent building consists of the use of high-tech office automation systems to render the operation of a company more efficient. This can be done at a reduced cost to tenants by virtue of the equipment being shared. Some of the factors involved in workplace automation in intelligent buildings include centralized data processing, word processing, CAD and information services. There are different kinds of automated systems as described by (Baldick and Dennis, 2001) as follows:

1. *Computer Hardware:* (CPUs, disks, terminals, and so on).
2. *Computer Software:* System programs such as operating systems, database systems, and so on.
3. *People:* Those who operate the system, those who provide its inputs and consume its.
4. *Outputs*: Those who provide manual processing activities in a system.
5. *Data:* Data is information that the system process by the computer.
6. *Procedures:* Formal policies and instructions people follow when using software, hardware, and data.

O'Leary (2002-2003) categorized automated systems as follows:

1. *Batch System:* A batch system is one which in it, the information is usually retrieved on a sequential basis, which means that the computer system read through all the records in its database, processing and updating those records for which there is some activity.
2. *On-line Systems:* An on-line system is one which accepts input directly from the area where it is created. It is also a system in which the outputs, or results of computation, are returned directly to where they are required.
3. *Real-Time Systems:* A real-time system may be defined as one which controls an environment by receiving data, processing them, and returning the results sufficiently quickly to affect the environment at that time.

4. *Decision-Support Systems:* These computer systems do not make decisions on their own, but instead help managers and other professional "knowledge workers" in an organization make intelligent, informed decisions about various aspects of the operation. Typically, the decision-support systems are passive in the sense that they do not operate on a regular basis: instead, they are used on an ad hoc basis, whenever needed.
5. *Knowledge-Based Systems:* The goal of computer scientists working in the field of artificial intelligence is to produce programs that imitate human performance in a wide variety of "intelligent" tasks.

3.4 Facilities Management Information Systems

Information plays a vital role in any organization. Facilities Management Information Systems (FMIS) are developed primarily to increase the productivity of the organization through the provision of automated tools and data concerning staff efficiency (Keith, 1996). A well organized information management system ensures that quality records are available, decision-making process can be traced and feedback and feed-forward mechanisms are in place to ensure effective communication amongst the facilities team. Apart from this information, information should be passed through user-friendly interfaces, using responsive software systems to user requirements. Keith (1996) described categories of information needed for such information systems as:

1. *Physical Resources:* Infrastructure (underground utility systems), buildings, land, roads.

2. *Support Services:* Administration, property maintenance, security, health and safety, catering, etc.
3. *Human Resources:* Personnel management, contracts, recruitment, training, etc.

The major components of the FMIS described by (Baldick and Dennis, 2001) and shown in Figure 3.1 are as follows:

1. *Infrastructure IT:* Infrastructure is the physical hardware used to interconnect computers and users, intranet, a local area network in the FM department, internet access, and related hardware.
2. *Computer Aided Design:* CAD systems for drawing management to an electronic document management system for accessing and managing records information in an electronic format associated with the facilities.
3. *Computer Aided Facilities Management:* A collective group of computer hardware and software systems used to automate typical FM operations such as leasing, maintenance, property management, space inventory, furniture inventory, and drawings production.
4. *Computer Maintenance Management Systems:* A computerized system to assist with the effective and efficient management of maintenance activities through the application of computer technology. It generally includes elements such as a computerized work order system, as well as facilities for scheduling routine maintenance tasks, and recording and storing standard jobs, bills of materials and applications parts lists, as well as numerous other features.
5. *Web Based Request:* A web based service request system for online submissions of service request and status queries by customers.

6. *Interface:* Interface to the core business systems of the organization.
7. *Website:* A website for the organization and linked webpage for the FM department.

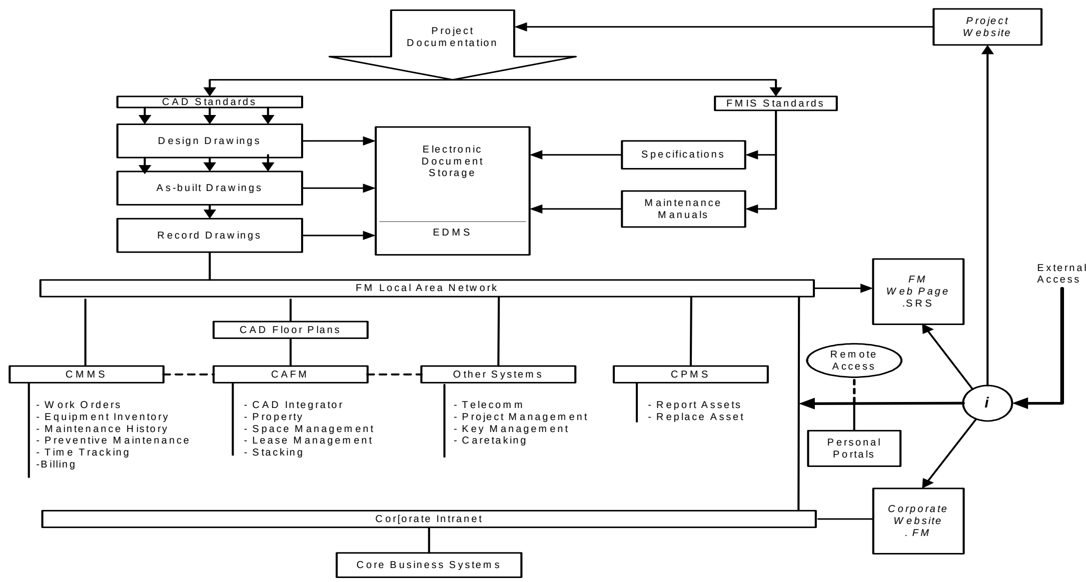

Figure 3.1: FMIS Components (Baldick and Dennis, 2001)

3.5 Types of Facility Management Information Systems

3.5.1 Building Management Systems

Building Management Systems (BMS) allow clients to monitor and operate all facets of a facility while keeping control of costs and tracking all of the information needed for effective building management. In addition to the traditional function of operating a facility's heating, ventilation, and air conditioning (HVAC) systems at optimum comfort conditions, a BMS may also provide a single interface for managing all of a facility's critical systems, such as lighting, fire protection, security, and access control. Additionally, clients with multiple facilities can take advantage of a central monitoring system. These types of systems can cover a wide spectrum of facilities, including: high-rise hotels, high-rise office buildings, medium- and low-rise office buildings and educational facilities (Kyle, 2001). BMS are capable of accessing, storing, and disseminating information using standard commercially available network, intranet, and internet technologies. Some of the features included with these systems as described by Kyle (2001) are as follows:

1. Display (including graphical representations such as floor layouts), alarm, and report capabilities.
2. Tools for displaying and reporting data.
3. Archiving and retrieving historical information.
4. Interfacing (using data links) a facility's security system with other management systems.
5. Facilities for accessing, processing, and reporting information using network-based computers that could be located anywhere in a facility or enterprise.

3.5.2 Computerized Maintenance Management Systems

CMMS are used to manage the maintenance schedules, warranties and work orders associated with the maintenance and repair of enterprise equipment and provide detailed tracking of maintenance schedules. Typically, automate the maintenance scheduling and management process.

CMMS uses Oracle on a client/server network to provide maintenance and inventory information to its users. Many of these are relational database applications that have been developed to meet the data handling needs of facility managers. The CMMS domain, at this time, is quite mature, and many stable, comprehensive, useful tools exist. The CMMS's capability to store inventory data is formidable; however, their capacity with respect to life cycle economics, service life prediction and risk analysis is considerably less sophisticated. These systems are currently not able to assist the manager in analyzing data or offering scenarios for long-term system readiness, capability, or performance; but the CMMS is becoming an essential tool for the asset manager (Kyle, 2001). Major vendors of CMMS are MRO Software (Maximo), J.D. Edwards, DataStream Systems, Mincom, and ARCHIBUS/FM.

3.5.3 Computer Aided Facilities Management Systems

CAFM is used to manage the physical space and assets within buildings leased or owned by the enterprise and tracks use of space, office layouts and furnishings. Typically, interacts with CAD systems that facilitate space planning, the management of moves, additions and changes to office arrangements, and the blocking and stacking of space assignments (Baldick and Dennis, 2001). The use of CAFM systems results in the following advantages:

1. The ability to accurately keep track of buildings, floor plans, personnel, departments, space, leases and assets.
2. The capability of easily producing customized facility reports and color-coded drawings for management.

3. Saving time, reducing costs and providing the data needed to make informed decisions.
4. Projects can be published on intranet and can be viewed by anyone with a web browser.
5. When objects are moved from one space to another the database is automatically updated.

Major vendor of CAFM systems are Archibus, Facility Information Systems, Aperture Technologies and Peregrine Systems.

3.5.4 Engineered Management Systems

Engineered Management Systems (EMS) are developed primarily to support technical expertise for research and development, implementation, inspection and analysis of infrastructure or FM. Current infrastructure or FM areas covered are PAVER for airfields, roads and streets, and parking lot pavements, RAILER for railroad trackage, ROOFER for roofing, BUILDER for building systems, W-PIPER for water distribution systems, and CP DIAGNOSTICS for cathodic protection systems. HEATER for heat distribution systems, WALKER for sidewalks, and SEWER for sewage and wastewater systems are currently under development. It helps to develop and mange comprehensive annual and long range plans covering all maintenance repair initiatives by using the principles and systems of infrastructure engineered maintenance management (Kyle, 2001).

3.6 System Development Life-Cycle

System Development Life Cycle (SDLC) is the overall process of developing information systems through investigation, analysis, design, development, implementation and maintenance. System development Life-cycle is a six-phased problem-solving procedure for examining and improving the information system (O'Leary, 2002-2003). These phases are described as follows:

3.6.1 Conduct Initial Investigation

This phase introduces the objectives of the initial investigation, the steps required to initiate an investigation; the tasks involved in the initial investigation, and the data gathering and interviewing techniques. The three task of this phase are:

1. *Defining the Problem:* The current information is examined to determine who needs what information, when the information is needed, and why.
2. *Propose Alternatives Systems:* Some possible alternatives systems are suggested. Based on interviews and observations made in defining the problem, alternative information systems are identified.
3. *Describe the Costs and Benefits:* Decide whether or not the benefits make the cost worthwhile.
4. *Preparing a Short Report:* Document all research and opinions for later viewing.

3.6.2 System Analysis

Systems analysis is the study of a current business information systems application and the definition of user requirements and priorities for a new or improved application. The key to understanding the analysis phase is to realize and trying to gain a rigorous understanding of the problem or opportunity which is driving development of the new application. Gaining a rigorous understanding requires strong people skills and strong technical skills. People skills will come to the fore as work with clients to help the team define requirements and resolve conflicting objectives. Technical skills come to the fore as rigorously document these requirements with process, data, and network models. This phase may be included some related sub-phases:

1. *Gathering Data:* Data is gathered by observation, interviews, questionnaires, and looking at documents. One helpful document is the organizational chart, which shows a company's function and levels of management.
2. *Analyzing the Data:* There are several tools for the analysis of data, including checklist, grid-charts, decision tables, and system flow charts.
3. *Document Systems Analysis:* Document all research and opinions for later reviewing. Incorporate how the existing system works, the problem it has, and the requirements for the new system with included recommendations.

3.6.3 System Design

In this phase, a new or alternative information system is designed. It consists of three tasks:

1. *Designing Alternative Systems:* Alternative information systems are designed. Each alternative is evaluated for technical, legal and regulatory, social, and economic feasibility.

    a. Technical

    - ❖ System should be possible, purchasable, and applicable
    - ❖ Staff should be able to build & run it
    - ❖ External factors should be considered
    - ❖ Compatibility & feasibility for future technologies

    b. Legal and Regulatory Feasibility

    - ❖ Constraints by law or regulations
    - ❖ Organizational feasibility
    - ❖ Distribution of authority: is it acceptable or manageable
    - ❖ Change should be rational, care for informal behavior & level of sophistication
    - ❖ Integrity of the organization should be protected

    c. Social Feasibility

    - ❖ Effects on the employees (health, fear, shift of power)
    - ❖ Effects on the customers

    d. Economic Feasibility

- Is it affordable?
- What are the benefits?
- Monetary Tangible Benefits (staff reduction)
- Non-Monetary Tangible Benefits (speedy operation)
- Intangible Benefits (quality increase)

2. *Selecting the Best System:* Fours questions considered when selecting the best system:
   a. Will the system fit into an overall information system?
   b. Will the system be flexible enough to be modified as needed in the future?
   c. Will it be secure against unauthorized use?
   d. Will the system's benefits exceed its costs?
3. *Writing the Systems Design Report:* Document all work and usually present the information collected to higher management at this point. It presents the costs vs. the benefits and outlines the effect of alternatives designs on the organization.

3.6.4 Systems Development

In this phase, software and hardware are acquired and tested. It consists of three steps:

Develop and Acquiring Software: Buy the software.

1. *Acquired the Hardware:* Once the software has been chosen, the hardware to run it must be selected. At this point users can either use existing hardware or purchase new hardware.

2. *Test the System:* The system should be tested, after the software and equipment have been installed.
3. *Complete System Testing:* Combine all components of the system for extensive testing with massive amounts of information.

3.6.5 Implement the System

Implementing the system or conversion is the process of changing to the new system and training people. The upper level managers decide whether to implement the system by direct, parallel, pilot and phased testing. Types of system Implementation includes:

1. *Direct Implementation:* User stops using the old system one day and the new the next day.
2. *Parallel Implementation:* Run the old and the new systems side by side until the new system is proven stable and reliable.
3. *Pilot Implementation:* It means that only a few users try out the entire system.
4. *Phased Implementation:* Parts of the new systems are phased in separately either at different times (parallel) or all at once in groups (direct).

3.6.6 Maintain the System

Maintain the system is the final phase of the system development life cycle. It consists of a system audit and periodic system evaluations.

1. *System Audit:* Once the system is operational, the systems analyst compares it to the original design specifications; some further redesign of the system may be required.
2. *Periodic System Evaluations:* Assess the capabilities, capacities, and whether or not the system is adequate for the required tasks and objectives.

The sixth phase is never ending maintenance includes not only keeping machinery running but also updating and upgrading the system to keep pace with new products, services, users, government regulations, and other requirements.

3.7 Review of Archibus/FM Software

Archibus/FM, developed by Boston based Archibus Inc., provides several tools for managing and accessing facilities information. It has capabilities to integrate drawings, databases, spreadsheets, bar-coding and graphics each designed to improve efficiency and help to make better business decisions. It allows an end user to display both AutoCAD drawings and related space and facility data simultaneously in the same screen. Archibus/FM offers a drawing editor that embeds AutoCAD technology. The drawing editor directly accesses drawings in DWG format, enabling to edit and view CAD drawings from Archibus/FM and connect database records to blocks and poly-lines in CAD drawings to form asset symbols, so that data is represented both graphically and alphanumerically. This allows the end user to integrate alphanumeric data such as inventory, lease, and telecommunications and personal information with the appropriate space detailed in an AutoCAD drawing. Once the information is entered into the system, it automatically reflected in other relevant areas, ensuring accurate, up-to-date information.

Archibus/FM works with a series of application modules that run on top of the Archibus/FM core program. A module is an application that addresses the problems of a particular facet of FM by dividing its major issues into a series of goals, and providing tasks for accomplishing these goals. A module includes tables for recording data in a database, a set of reports and graphic analyses, routines that run calculations and manipulate data, and specialized dialogs to work through the modules tasks (UI, 2003). Archibus/FM applications modules include:

3.7.1 Space Management Module

Space management module is a tool for creating space inventory that reports on different types of space and how these areas are used in an organization. Space inventory can be developed by creating and identifying floors areas and registering this information in the project database by linking the drawing representations of the areas to corresponding database records. Thus, a space inventory created with Archibus/FM space management module reports on space information both graphically and alphanumerically. Space inventory helps in documenting how organizations use areas and show the location of individual employees. Space inventories are usually prepared by facility managers and then shared information with other organization in a company. The Archibus/FM space management module is a decision support tool that helps to optimize the use of space within facility and can determine how efficiently space is being used, identify rentable and leasable areas, calculate space costs and charge backs, and draw up tenant and employee occupancy plans (Archibus/FM, 2002).

Space Management Issues

The following are some typical space management issues address by the Archibus/FM module:

1. ***Space Inventory Issues***

   A facility manager creates and maintains accurate and up-to-date space inventory information by showing each area of a building (rooms, stairs, elevators, and service areas) in a drawing and then shares this information with other departments in the organization. The following are the typical space inventory issues pertaining to the space management:

   a. *Store Floor Plans Electronically:* Archibus/FM provides many tools for creating facility drawings and generate space inventories with gross area, rooms, service areas, vertical penetrations, and departmental areas.

   b. *Record Data in Databases:* Archibus/FM connects items in drawings to records in a database, thereby representing data both graphically and alphanumerically.

   c. *CAD Drawings:* An Archibus/FM can create his own drawings, or import DWG-format drawings created with CAD programs and add space information to these drawings.

d. *Reports:* Space management module includes reports that analyze rooms, room types, departmental groups, service areas, and vertical penetration areas in terms of sites.

e. *Drawing Editor:* Archibus/FM drawing editor is specifically designed for developing facilities drawings and enables graphically represent areas in drawings without learning the details of a complicated CAD package.

f. *Distinguish Different Types of Vertical Penetration and Services Areas:* When classifying different types of areas, specify each areas, such as vertical penetrations and service areas. When changing an organization for the space it uses and include the organization's use of various service areas.

g. *Uniform Set of Information:* Space management module provides two methods of tracking space- the All Room Inventory and Composite Inventory methods. With the "All Room Inventory" method, every area in a facility (offices, lobbies), is treated as a room and stored in one table-the rooms table. With the "Composite Inventory" method track each type of information in its own table and on its own drawing layer. Gross areas, vertical penetrations, service areas, room areas, and departmental areas are each recorded in their own table and represented on a specific drawing layer.

2. *Financial Issues*

Once a facility manager develops a space inventory, an accountant can use this information to charge departments for the space they occupy and their share of the common areas. The following are the typical financial issues pertaining to space management:

a. *Internally Billing the Departments:* Space management module provides several methods of determining the space that an organization occupies and its proportion of common space. The process of charging an organization for the space it occupies and its share of common space is known as chargeback.

b. *Managing a University and Need to Distinguish Each Room's Use by the Division (Architectural Engineering Department vs. Architecture Department):* When a room is used by multiple organizations, the module's room percentage features can be used to record the percentage of space within a room that an organization uses, the percentage of time an organization uses a room, or both space and time percentages.

3. *Strategic Issues*

Space is a significant operating cost and strategic managers need to analyze space inventory data in terms of efficiency and planning. Strategic managers use space inventories reports generated by facility managers to make decisions regarding lease renewal, space expansion or reduction, space utilization, cost reduction, and so forth. The following are the typical strategic issues pertaining to space management:

a. *Company Making Most Use of Space:* Space management module provides the "Building Performance" report that documents two important ratios defined by International Facilities Management Association (IFMA): the rentable/usable ratio and the efficiency rate (the usable/rentable ratio). Higher efficiency rates indicate that organization devote little space to hallways, corridors, rest rooms.

b. *Overall Picture of the Entire Floor:* Departmental room analysis report provides summaries and analyses of each department's area in terms of floors, buildings, or sites.

4. Building Owner Issues

Building owners, tenants leasing space in a building, and companies that own their own buildings all can use the space management module. A building owner, who bills tenants for the space they occupy in the building and their use of common areas, can use the space management module to determine tenant rent, service areas, and rentable areas. The following are the typical building owner issues pertaining to space management:

a. *Building–Rent to Tenants:* Use the module's composite inventory method to first outline gross areas and vertical penetration areas, and then have the program automatically calculate the floor's rentable area.

b. *Distinguish Between Suites that Rent to Tenants and Areas that Own Company Uses:* With composite inventory method, using groups to outline suite areas that lease to tenants and use the group chargeback method to determine rents for these areas.

c. *Need to Use BOMA Conventions When Charging Tenants for the Space they Occupy:* Use the composite inventory method to charge each tenant for their occupied space, as well as their percentage of common space based on Building Owners Management Association (BOMA) standard.

5. Departmental Management Issues

Department managers, controlling a department's budget, office space, and employees, typically receive fundamental space inventory data from facility managers and analyze this data in terms of their specific departments. The following are concerns of department managers.

a. Department Area and Charging: The space module provides group inventory features, which can be used to track departmental areas. A group typically represents a set of offices used by a single department.

b. Department Expansion: Space management module includes the "Highlight All Vacant Rooms" queries, which graphically show each floor's vacant rooms.

6. Human Resources Management Issues

Typically, facility managers supply human resources managers with space inventory data, which they use to associate employees with space and generate employee occupancy plans. Human resources managers are interested in the following issues.

a. *Employees Location:* The module's personnel feature is used to associate employees with rooms and generate alphanumeric reports and graphical depictions of occupancy. "Locate Employee" report prompts to provide an employee name and then presents fundamental data about the employee and shows the employee's location on the floor.

b. *Adequate Working Environment for Employees:* Once a space inventory is developed and employees are assigned to areas, human resources personnel will find the module's "Employee Average Area" reports very useful. These reports analyze the average area assigned to employees by several factors.

Benefits of Space Management Module:

1. Facilitates improved space efficiency to lower occupancy costs.
2. Automates space charge-backs based on billing and reporting requirements.
3. Links architectural drawings with facilities and infrastructure data, ensuring information are always accurate.
4. Allocates space usage and reports charge-backs with accuracy to avoid external or interdepartmental billing disputes

3.7.2 Furniture & Equipment Management Module

It is a tool for creating and maintaining a inventory that include alphanumerically, and graphically listing of furniture and equipment holdings within an organization. Such an inventory is essential for producing accurate and up-to-date reports on furniture and equipment items, their locations, their monetary value, and their leases, warranties, and insurance coverage. It provides a complete set of data tracking features, enabling facility managers to effectively manage furniture and equipment assets throughout their life span. It also provides a number of planning features and features of comparing inventory to reality have employees been trading and moving items on their own, without informing the facility manager. It helps in tracking furniture and equipment according to bar codes or alphanumeric values. It also helps to choose inventory items in a database only, or link database records to entities in CAD drawings so that assets are documented both alphanumerically and graphically. Inventory tracking capabilities enable to easily monitor the costs of assets, calculate depreciation and churn rates, and plan moves of furniture and equipment. The module also helps to control costs on furniture & equipment layout, specification, and installation.

Furniture & Equipment Issues

Department managers, strategies , accountants ,move planners , surveyors , craftsperson's, and facility managers all work with furniture & equipment items and are affected by the inventory systems to implement. The following are the typical furniture & equipment issues of concern to employees at all levels in organization:

1. Inventory Issues

A facility manager typically creates and maintains inventories of furniture & equipment assets by documenting fundamental data in database and optionally linking this data to representations in CAD drawings. The following are the typical inventory issues concern to facility managers:

a. *Visually Presenting an Inventory:* Developing layouts of furniture & equipment items in CAD drawings and then link these layouts to a database to produce an inventory that documents assets both graphically and alphanumerically.

b. *Detailed Tracking in the Future:* With the Archibus/FM furniture & equipment module helps in tracking each individual asset, track sets of related assets according to classification (standards), or use both of these methods.

c. *Determine Discrepancies between the Electronic Inventory & Reality Inventory:* The module include activities for surveying the disposition of furniture & equipment items at site and comparing the survey results to official electronic inventory.

d. *Tracing the Item since Acquiring:* Using the module disposition history reports helps in examining how assets move between locations, employees, and departments. For each asset, helps examining its location, employee and department data, as recorded in each survey.

2. *Operational Issues*

Once the facility managers develop furniture & equipment inventories, movers, surveyors, craftsperson's, and technicians use this data in the course of their daily work. The following are the typical issues of operational users:

a. *Scanning Unusable Furniture & Equipment Assets:* Craftsperson's, technicians, surveyors often want to access inventory information by scanning bar code labels on physical items, rather than by selecting records from the inventory database.

b. *Scanning Bar Codes of Furniture & Equipment Items but still manually typing Other Information:* Using the room bar code labels reports to generate bar code labels and attach them to the door jambs of rooms. When surveyors enter room, they can record it room number by scanning the room's bar code label.

c. *Items Classification:* With module's facilities standards books, surveyors and other users can identify assets based on their appearance and do not know how to specific list of classifications (standards).

d. *Instructions on moving Furniture & Equipment Items:* With the module's move management features, movers can executes moves according to detailed printed instructions, supplemented with CAD drawings that graphically depict original and destination locations. To supply movers with these instructions, move planners can generate move orders and reports listing items to move, their current and destination locations, and item descriptions.

3. *Financial Issues*

Furniture & equipment assets typically account for a significant portion of a company's capital and operating budgets. Accountants and financial staff can use the furniture & equipment module's depreciation, general ledger and cost tracking features to manage the financial aspects of furniture & equipment inventories.

a. *Financial Reports:* Financial analysts can track original purchase prices and depreciated values of furniture & equipment item using the module's depreciation reports.

b. *Budget for Furniture & Equipment Purchases Next Year:* Determine the furniture & equipment budgets by using the module's depreciated and churn reports to first assess that need to be replaced. Next, determine new assets that will require given the company's average growth rate. Use the purchase price data of the equipment standards and furniture standards tables to determine the price of replacing and adding the required items to the inventory.

4. *Planning & Strategic Management Issues*

Strategic managers and planners analyze the long-term effects of furniture & equipment inventories in terms of reducing costs, improving productivity, and ensuring that furniture & equipment inventories accommodate the company as it changes. The following are the concerns of planners and strategic managers.

a. *Lease Expirations:* Planners can use the lease about to expire reports to generate a list of leased furniture & equipment items whose leases will expire within one month from the system date.

b. *Bar Code System to Improve the Speed & Accuracy of Data Collection:* The furniture & equipment module facilitates bar code surveys by providing reports for producing bar code labels, standards books for surveyors to use in identifying items, and audit tables for storing bar code values of survey results.

c. *Identifying Departments & Areas that are frequently changing & Increasing Expense:* The module provides several churns reports, which indicate the degree of change activity and show how furniture & equipment assets are being used. Strategic managers can use the churn reports to identify areas or departments that are experiencing high churn rates and more closely monitor requested moves and reorganizations for these areas.

5. *Department Issues*

In order to provide conducive environments for the employees and to understand how the departments are charged for furniture & equipment items, department managers need to access to the repository of furniture & equipment data.

a. *List of Furniture & Equipment items used by the Department:* All of the module's inventory methods – tagged furniture, equipment, and furniture standards, provides reports that break down furniture &

equipment use according to department and division. These reports present fundamental data about the assets used by each department and can be easily customized to focus on financial, condition, or use information.

b. *Access Information about Specific Furniture & Equipment Items:* With the modules locate furniture and locate equipment reports, users can quickly access fundamental data about a particular asset. When prompted, users enter the item's identification number, and the reports present information about the asset, including an image of the asset's classification and a graphical depiction of item's location on the floor plan.

Benefits of Furniture & Equipment Module

1. Executes moves and adds efficiently to reduce unnecessary churn and its impact on organizational productivity.
2. Facilitates trial layouts for analyzing various move options before executing them.
3. Assigns and manages asset ownership to increase accountability and reduce life cycle costs.
4. Reduces the need for write-offs by tracking the location and depreciation of asset.

3.7.3 Real Property & Lease Management Module

Real property and lease management module provides property owners, lease managers, real estate brokers, corporate real estate personnel with the tools require for maintaining electronic inventories of their leases and properties. It helps in electronically tracking and managing information on occupancy, parking spaces, taxes, regularly scheduled required actions, compliance with regulations, base rents, and other type of income and expenses. It produces meaningful reports about and accurate analyses lease and property data.

Real Property & Lease Issues

Properties and buildings, whether they are leased or purchased, are some of a company's most expensive and significant assets. The following are the real property & lease management issues concerns to personnel involved in lease and property management:

1. ***Real Estate Brokers***

   Property owners often hire real estate brokers to present and sell properties and lease to companies seeking places. To aid real estate brokers in selling space, property owners may provide the brokers with inventory and history data. Brokers use this historical information to support sales and disposition efforts.

   a. *Graphical Representation of Vacant Areas:* The module's vacant suites query presents fundamental information about vacant suites and highlights these areas on floor plan drawings. Run this query to present both alphanumeric and graphical vacancy data in one report.

b. *To Show the Clients Available Space:* Property abstract report to provide clients with detailed information about a property and its amenities. This report includes pictures of the property and its buildings, a larger-scale plan of the property, and a statistical summary of the property.

c. *Lease Expirations:* Use the vacant suites and suites lease expirations reports to determine current and upcoming vacancies.

d. *Measure Costs in Different Time Units (Per Month or Per Year):* The "Lease Benchmarks" report compares leases according to standard criteria, to measure leases against the same standards. Example: Cost per occupants, per square meter.

2. *Property Managers*

Property managers (which include project managers, facilities superintendents, and cost coordinators) often work for a property management firm, which is hired to manage a building.

a. *Project Operating Costs for a Building:* The manage property financials activity provides several projection reports to help plan future property expenses and income on monthly or quarterly basis.

b. *Overall Costs of Maintenance & Property Management Services:* To generate this report he needs to document maintenance and management costs. Once the costs are entered into the system and assigned to the property, can generate cost history reports and charge these costs to the tenants occupying the property.

c. *Track Depreciation of Leasehold & Furniture and Equipment Items:* The "Depreciation Property Type" table provides features for tracking depreciation and or appreciation of property assists; such as furniture, cars, computers, and arts.

d. *Manage Tenants Complaints:* To manage communication with tenants, the module provides the lease communication log items table; use this table to record conversations and written correspondence, register images of important documents in the table's graphic field.

3. *Facility Managers*

Those who are holding the post of project manager, facilities planning manager, superintendent of facilities are categorized as facility managers. While these people are may not handle leases, they are still responsible for parking, regulations, budgets, macro-scale space planning, and many other aspects of building and property management. As such, they may use many of the features of real property & lease management module. The area of a particular concern to FM is maintaining accurate area values that can generate important rentable/usable and other efficiency ratio.

a. *Developing Floor Plans to Show Areas that Lease:* Using the manage suites and department spaces activity to develop CAD drawings that graphically depicts gross, service, and vertical penetrations areas to enables to include graphical representations of space in queries and reports, and to calculate rentable area, usable area, rentable area/usable area ratios (which indicate building efficiency), and gross/usable ratios (which indicate design efficiency).

b. *Real Estate Group is Not Proficient with CAD and Should Not Edit Drawings:* With "View-Only" licenses, users can access drawings and database of facility managers without editing them.

4. Property Owners

Property owners (which include those with job titles such as project manager, cost coordinator, and superintendent of facilities) manage the spaces they own and lease.

a. *Profit on the Properties that Leases:* "Property Summary" and "Financial Profiles" reports offer a wealth of property financial statistics based on the costs generated from day to day operations.

5. Corporate Executives and Strategic Managers

Corporate executives and strategic planners require lists of property holdings and summarized statistics. These users scan this information to gain an overall understanding of their holdings, as well as spot trends and anomalies, which might indicate problems or poor management.

a. *General Overview of All Properties:* Use the "Property Financial Summary" report which presents the financial performance of each property in a summarized form.

b. *Operating Costs and Major Expenses & Outsourcing Maintenance:* The “Property Detail” operates costs which are broken out both by year and the period of the financial analysis. Additionally the “Property and Building Benchmarks” report documents operating and overall costs by square foot or square meter, which can help compare different properties on an even basis.

c. *Need to Track our Total Holdings in Different Countries:* The “Manage Property Abstract” activity provides lists of all properties, organized by geographic area: country, region, state, city, and site.

Benefits of Real Property & Lease Management Module

1. Accelerates property return-on-investment by optimizing space utilization.
2. Improves performance of leased and owned properties through financial and operational benchmarking.
3. Generates summary reports to forecast opportunities and identify investment risks.
4. Maximizes leasing or selling potential by comparing the market value of properties.

3.7.4 Telecommunications & Cable Management Module

Voice and data communication is vital to the smooth operation of any organization, maintaining an accurate and up-to-date electronic inventory of a company’s cabling and communication network connections is an important task of facility managers and information system (IS) managers. It provides a tool for developing an electronic inventory of telecommunications devices, recording how these devices connect to form a cabling system, and maintaining this inventory throughout repairs, upgrade projects, and employee's moves. The Telecom module provides a flexible solution for electronically tracking physical network. The module also helps in implementing the level of detail right from simple horizontal wiring to detailed backbone cabling and chooses which portions of network to document alphanumerically, and which to document both graphically and alphanumerically. The module provides work order and move order tools for managing changes to the telecommunication system. The Archibus/FM telecommunications & cable management module helps facility and information systems managers meeting three vital goals:

1. Create a living, electronic inventory of the physical cabling and the connectivity of telecommunications networks in facility.
2. Maintaining the most up-to-date connectivity information for troubleshooting, and capacity information for planning.
3. Facilitates moves of employees, equipment, and the contents of the room.

Telecom and Cable Management Issues

Facility managers, information system managers, and telecom technicians all work with telecommunications & cabling devices and require an accurate electronic inventory. The following section outlines telecommunications issues of concern to users and ways the Archibus/FM telecommunications & cable management module addresses their needs:

1. *Information System (IS) Managers*

Information system managers are typically responsible for overall configuration of the company's network, managing network traffic, and upgrading the network to new technology.

a. *Too Many Wires & Connections to Document:* Most installation is wired to standards, can take advantage of the consistency of installation to reduce the documentation effort.

b. *Easily Accessing Data:* Computer, telephone, jacks, faceplates, hubs, routers, cables, can document an item's position within the network by recording the device from which it connects.

c. *Minimize Traffic Network:* Using the develop inventory activity class, can augment inventory to show the network segments to which devices belong and software accessed by the various devices.

d. *Record Connections between Devices:* The telecom module provides a connect dialog box so that easily record how devices are connected by selecting a device and choosing the elements that connect from or to this device.

2. *Facility Managers*

Facility managers are primarily concerned with maintaining the operation of voice and data networks.

a. *Tracking Telephone Extensions:* The telecom module provides telephone extension fields in the rooms, employees, and jacks tables and can complete these fields as appropriate to the organization needs.

b. *Access Telecommunications Information about Employees:* The “Locate Employee with Telecom Profile” query prompts for an employee name and then presents a report listing fundamental information.

c. *Voice & Data Communications Problems:* The module includes run help desk activity, with tasks for reporting problems, issuing work orders to address these problems, and updating the telecommunications inventory after work is completed.

d. *Work Request Status:* Run help desk activity‘s report convenient for analyzing the current workload and completed work. The “Review Telecom Work Requests” action and the “Unissued Work Orders with Request “ report are available for analyzing uncompleted work and immediately assigning it, if necessary.

e. *Operational Users:* Operational users typically include movers, network technicians, craftsperson’s, and other employees who follow the instructions on move and work orders to maintain a facility’s telecommunications network.

f. *Work Order Instructions:* Users reporting problems can list on work request complete circuit information for network devices, equipment, and jacks that are located in the room needing service with the telecom module’s work request and work order features.

g. *Update Connection Information:* Telecom workers use the module's update work request dialog to record details about a completed job.

h. *Connection Information on Move Orders:* The telecom module provides features for listing connection information on move orders as well as using the connect dialog box to update the inventory's connections after moves have been completed.

3.7.5 Building Operations Management Module

In any organization , facilities and assets plays a vital role; they not only provide the physical working environment and reflect the organization's image, but also affect the organization; overall productivity . In order to prevent deterioration and breakdown and to resolve emergency maintenance problems, organizations need to monitor the maintenance, repair, and replacement of facilities and assets. It provides fast, easy access to critical facilities information and cost-effectively manages on-demand work and preventive maintenance. Track all maintenance tasks to better allocate time and resources for future jobs. Ultimately, gaining more control over workload instead of letting it manage. It is a tool to help a facility to run smoothly and minimizes operating costs through automation.

Building Operations Issues & Users

Many different people in an organization may need to access building operations information. Office workers and building tenants requesting maintenance work, craftsperson's executing work, and upper-level management overseeing an organization's operations all require building operations data. The following section presents an analysis of typical users, and how the building operations management module addresses these concerns:

1. ***Strategic Users***

   Strategic users typically need to manage the entire building operations process in terms of forecasting work resources, analyzing budgets, and reviewing analysis reports. They are most concerned with the long-term effects of facilities management and aim to reduce costs, improve safety, and increase productivity. The following are the typical concerns of strategic users:

   a. *Root Cause & Frequency of Equipment Failures:* The module provides several summary reports documenting common causes of equipment breakdown, mean-time-between-failure statistics and determines equipment that should be replaced due to age or excessive maintenance costs.

   b. *Access to Maintenance Personnel:* Information system managers can establish user security groups so that all personnel in the company can use the building operations management module according to their needs.

   c. *Recording Equipment Failure:* The equipment table includes several fields for recording all types of breakdown information. Maintenance managers can track the most minor problems and develop highly detailed downtime and failure analysis reports which they can use to reduce the recurrence of problems.

d. *Manage Cost Analysis:* The building operations management module provides reports evaluating craftsperson's, equipment, and facilities to help plan a realistic maintenance budget for organization.

e. *Manage & Efficiently Control Spare Parts:* The module includes a comprehensive parts inventory system with which can track storage location cost, minimum quantity to store, quantity on order and vendor .

2. Business Users

Business users typically include maintenance managers, housekeeping managers, production managers, accounting staff, department managers, and work planners manage day-to-day building issues.

a. *Review all Reported Problems:* The module provides work request status reports that document the status of all requested work. To approve or reject work request, maintenance managers change their status, and if they wish, prioritize the work request.

b. *Backlog of Uncompleted Maintenance Requests:* The building operations management module includes reports for reviewing uncompleted and overdue maintenance work and spot the maintenance trends by sorting requested work by problem, cause, equipment , or location.

c. *Coordinate Preventive Maintenance Schedules:* The module offers tools for setting priorities based on criticality, and scheduling work based on the availability of personnel, equipment, and other resources to minimize conflicts when scheduling preventive and requested maintenance.

d. *Track Ongoing Maintenance Tasks:* The module provides reports and queries for determining the status of all maintenance work to improve maintenance productivity.

e. *Check History & Current Status of all Resources Information:* The module's manage equipment and resources activity class provides a series of reports that help to optimize productivity of resources and minimize direct and indirect costs.

f. *Generate Instant Work Orders:* The module enables maintenance managers and others with authorized permission to immediately generate instant work orders for addressing maintenance problems.

g. *Warrant Service Information:* The manage equipment and resources activity class includes reports that documents warranty and service contract information for equipment.

3. *Operational Users*

a. Operational users (trades people, housekeeping staff, building tenants, and regulatory compliance personnel) are the day-to-day users of building operations management systems.

b. *Bar Coding:* The building operations management module supports bar coding technology for data entry.

c. *Accessible from Employees & Tenants:* The module enables all occupants in a building to quickly request maintenance work to empower workers with communication tools for maintaining their work environment.

d. *Standards of Maintenance Regulation:* The module's PM procedures and PM steps tables to establish standard preventive maintenance procedures that can be assigned to equipment items and locations.

e. *Craftsperson Workload:* The module includes "Craftsperson's Workloads" report which analyzes how much work is assigned to each craftsperson per day.

f. *Report the Resources Consumed:* Craftsperson's can update work completion information and the resources used by selecting from the Archibus/FM program menu the update work order.

Benefits of Building Operations Management Module

1. Improves internal and outsourced service providers' performance by prioritizing tasks and avoiding work backlogs.
2. Enables evaluation of work order requests to optimize labor/materials and minimize operating costs.
3. Simplifies the work forecast and budgeting processes by easily accessing historic data.
4. Tracks preventive maintenance programs to validate expenditures and comply with internal standards or regulatory mandates.

3.7.6 Emergency Preparedness Activity

It provides collection and reporting tools for preparing for and to responding workplace emergencies. It helps in quickly deliver critical information to the right people during all phases of an emergency in order to protect life, minimize damage, and recover critical business functions.

Some of the main features of the activity are:

a. *Most of the Information Needed:* With the emergency preparedness activity, helps in managing existing Archibus/FM facilities data to develop a comprehensive set of drawings and reports to support emergency preparedness, disaster recovery, and business continuity plans.

b. *Keep Critical Data Current:* Emergency preparedness activity is a part of the space management module, much of the critical data need to respond to emergencies is updated whenever there is a physical change to space or employee locations.

c. *Access Data Remotely and Keep Employees and Managers Updated:* The Archibus/FM emergency preparedness activity taps into the power and reach of the World Wide Web. Using emergency preparedness in conjunction with Archibus/FM web central can access and update important data remotely over the web.

Benefits of Emergency Preparedness Activity:

1. Helps in planning, response, recover form disasters.
2. Leverages existing information to implement disaster recovery plans, including accounting for lost assets and filing claims.
3. Maintains accurate information with updates made in the course of normal operations.
4. Provides information needed to make time-sensitive decisions, minimizing downtime.
5. Provides details for negotiating more favorable insurance coverage.

3.8 Discussion

This chapter presents the need of automation of FM practices in various organizations and the impact of automation. It starts with the overview of automation of FM practices and followed by the key demand impacts which have both enabled and stimulated the growth of FM automation in the organizations.

The need for accurate and precise information on various FM functions is the principal reason for the high level of interest in automating FM practices. Decision makers in any organization require more data in terms of quality and quantity and want these data reported more often. FIMS are the tools that provide information on a whole range of FM practices enabling tactical decision- making performance and increases the productivity of the organization.

CHAPTER 4

LEVEL OF AUTOMATION IN FACILITIES MANAGEMENT PRACTICES IN UNIVERSITIES WORLD-WIDE

4.1 FM Practices in Universities World-Wide

The following sections present the level of automation of some of major FM practices found in selected five universities, located in Australia, Canada, UK and USA. These universities are as follows:

- Queen's University Belfast, UK
- Cameron University, USA
- Dalhousie University, Canada
- University of New Castle, Australia
- Queensland University of Technology, Australia

4.1.1 Queen's University Belfast, UK

The purpose of the Queen's University Belfast (QUB) inventory register is to record all assets owned, or located, within the university. There are procedures which deal with the input of information to the register and the subsequent maintenance of that record. Overall responsibility for the daily operation of the inventory register rests with the university's head of purchasing, who oversees the activities of the inventory officer and his/her, staff. Responsibility for the accuracy of information provided to the inventory officer by each school/unit rests with its head or director. The head or director may nominate an inventory liaison officer with delegated authority to carry out the day-to-day tasks associated with the maintenance of the inventory register, however, only the head/director has the authority to delete equipment from the inventory register.

The inventory register is a computer-based record system where each asset is identified by a discrete number. This discrete inventory number is used to track the piece of asset during its lifetime within the university. The register records information about the asset description, its purchase price, the date of purchase, details of its location within the university, and a classification code which categorizes the item. The physical number, an aluminum foil label bearing the discrete number is, whenever possible, affixed to the equipment. Where the equipment is such that it is not practical to affix the label, the inventory number should be allocated, then the label placed in a booklet which records the specific details of the item, e.g. serial number, precise description etc. All data is maintained by the inventory office, which is part of the purchasing office, and is based in the university administration building.

The daily maintenance of the inventory register falls into two main areas: changes in the location of the equipment and equipment to be removed from the register. The following procedures are intended to ensure that the data on the inventory register is correct, and in cases where equipment does change location, that this is recorded. The objective is that the university should be able to identify quickly the location of any of the equipment recorded on the inventory register.

Change of Location: Where an item of equipment is moved within the university, its new location should be advised to the inventory officer, either at the time of its relocation, or by maintaining a booking in/out register which is reported retrospectively to the inventory office on an annual basis.

Equipment Loaned to Another School/Unit within the University: This procedure should be used where the equipment is on long-term loan to another area within the university. Form (IMS-1) i.e., Inventory Management System should be completed by the donating school/unit detailing where the equipment is to be located and the project which will be responsible for its operation. While the equipment is located at the temporary location, it is the responsibility of that head of school/unit, or inventory liaison officer, of the receiving area to ensure that the information on the inventory register is correct. Whenever the equipment is returned, the returning school/unit should complete a new IMS-1 form. The completed forms should be forwarded to the inventory officer who will amend the records accordingly. Form IMS-1 must only be signed by the director of school/head of unit or the school's/unit's inventory liaison officer.

Equipment Located off the University Campus: This procedure should be used where the equipment is on long-term location off the university campus, i.e., on premises which are physically located away from the main site where the business of the university, solely or in conjunction with other bodies, is conducted. There are instances where equipment is located off-campus, for example, equipment may be required as part of on-going research or where members of staff are permitted by their head of school/unit to take equipment such as computers home. In all such instances, the location of the equipment must be recorded on the inventory register.

Booking In/Out Register: This should be used where the equipment is on short-term loan to another area within the university. Schools/Units should maintain their own internal record of equipment which is removed from its normal location. This record may be either computer-based or hand-written and should detail the inventory number, temporary location and the name of person (or project) that will be responsible for it while it is at its new location.

Equipment to be Removed from the Inventory Register: Equipment may be removed for several reasons - it is obsolete, it has been sold or it has been stolen. In each case, form IMS-2 should be completed, giving appropriate details. Items of equipment removed from the inventory register for reasons other than their sale will be reported to the purchasing policy group which will, at its discretion, report their deletion to the university's investment & finance sub-committee. Form IMS-2 must only be signed by the director of school/head of unit.

Equipment Which is Obsolete or Beyond Economical Repair: In instances where a piece of equipment is deemed to be obsolete or beyond economical repair, the following actions are required: Form IMS-2 must be completed and signed by the head of school/unit, before forwarding to the inventory officer, administration building. The form must be supported by documentation explaining the reasons for removing the equipment from the inventory register.

Equipment for Sale: In instances where a piece of equipment is deemed surplus to requirement, the actions to be taken are detailed on this web site under "Disposal of Surplus and Obsolete Equipment - Guidelines and Procedures". When equipment has been removed from the school/unit, form IMS-2 should be completed to remove the item from the inventory register unless it has been sold to another school/unit within the university, in which case from IMS-1 should be used, i.e., a change of location rather than a deletion.

Missing Equipment: In instances where a piece of equipment is missing and believed to have been stolen, the following actions are required: advise the security office immediately, advise the insurance clerk in the finance department and quote the item's inventory number, complete form IMS-2, have it signed by the head of school/unit, and forward it to the inventory officer who will take the necessary action.

Annual Review: Annually, at the end of the second semester, a summary of all items contained on the inventory register will be forwarded to each head of school/unit. It is the responsibility of the head of school/unit to validate the accuracy of the data contained in the listing. Any location amendments should be made using form IMS-1 and where deletions are required, form IMS-2 should be completed used. In the latter case, where equipment is to be deleted, a full written explanation should be provided. This annual summary document should be signed by the head of school/unit and, when signed and returned, will be held on file in confirmation of the accuracy of the register. The signed summary documents will be used for any subsequent audits, internal or external, and any IMS-1 or IMS-2 forms will be used as the basis for the audit.

Audits: The University’s internal auditors will, as part of their regular duties, conduct audits of schools'/units' equipment listed on the inventory register. These audits will be in the form of a random sample of items listed on the inventory register. The internal auditors will report their findings, as part of their audit report, to the university's audit committee. Where items cannot be sighted or items appear not to have been included on the inventory register, the inventory office may be asked to conduct a full audit of the area. The inventory office will conduct a scheduled program of random audits. Again, where items cannot be sighted or others appear not to have been listed, the inventory office may conduct a full audit of the area. The inventory office will report the results of its audits to the purchasing policy group which reports to the university's finance committee (QUB, 2004).

4.1.2 Cameron University, USA

Physical facilities administrative services of Cameron University are responsible in managing and controlling all university property and equipment. The following procedures assist in management and control of these university assets. Proper inventory management assures that resources are being used in the most efficient way for the people of Oklahoma. All university property with a value of $500 or more must have an identification tag attached to it.

Transfer of University Property or Inventory: When University property or equipment is to be transferred to another department on campus: Fill out an inventory transfer form and obtain an approving dean or department signature. Send the inventory transfer form to the business office by campus mail, or hand delivery. If the equipment or property needs to be moved by physical facilities, then a work order must be filled out in addition to the I-5 form. Send all three parts of the I-5 form and work order together to physical facilities. All three copies of the inventory transfer form must be received by physical facilities.

Disposing of University Property or Inventory: When University property or equipment breaks, is un-repairable, or becomes unusable by any department at Cameron University it must be disposed of properly and deleted from the University computer system. Fill out an I-5 deletion request form, and obtain an approving dean or department chair signature. Send the I-5 form to the business office by campus mail, or hand delivery. If the equipment or property needs to be moved by physical facilities, then a work order must be filled out in addition to the I5 form. Send both of these forms to physical facilities. They may be sent by campus mail, or hand delivery. After both work orders are turned in, physical facilities will schedule the equipment disposal. It is important that all of the information on the forms is filled out completely to prevent any potential problems. No equipment will be picked up until the paperwork is completed and been received (CU, 2003).

4.1.3 Dalhousie University, Canada

Space planning is responsible for the efficient and effective allocation of space throughout the organization through campus planning, space planning, site planning, space utilization, space programming, and space inventory. Campus planning recommends priorities for space improvement and capital projects through analyzing the campus facilities needs, developing proposals and recommendations while adhering to the campus master plan of the university. Space planning involves assessing all requests for space using the university space guidelines, determining the space requirement needs of its users and creating space solutions for the needs of the university. Space planning must approve any changes in use of space. For example, if it is proposed to change an office into a laboratory, space planning must approve this change in space use. Site planning identifies and assesses all site options for any new facility through the use of good planning principles in conjunction with the master campus plan. Space utilization examines, analyzes and reports on the current use of space on an annual and ad-hoc basis, to assist the university in making better use of its resources. Space programming is provided for any major capital project, alteration, renovation and space study. It provides a list of space requirements, square footage, and space data information for all academic, administrative and research functions. Space inventory is a computerized repository for all space related data of buildings and rooms. Dalhousie University has facilities involved in diverse and often complex teaching and research activities. To avoid inequities and to sort out competing demands for the same space among users, there must be space use policies or guidelines and space standards and procedures for allocating and reallocating space. The following are the guidelines for space use in the Dalhousie University:

All Space is Owned by the University: Although space is allocated to the faculties, departments and specific users, all space is owned by the corporation of the university. With this ownership, the university has the responsibility to keep this space in good order in terms of maintenance, services, cleaning, etc., and to provide the appropriate amount and type of space to approved university activities.

The University has the Responsibility To Allocate Space: Space is allocated to specific users for certain periods of time. For example, classrooms are allocated for hour-long slots whereas, at the other extreme, offices and research space are allocated for longer periods of time. This longest period should not exceed five years, and space use should be reviewed periodically, and space assignment reconfirmed accordingly.

Space Must be Allocated Equitably Among Users: For all users and all categories of space, space standards will be used to assess space needs. These space standards may be adjusted in accordance with the total amount of space available. In this way, an overall space shortage or surplus can be handled fairly. In many cases existing uses and space assignments may not meet the standards and subsequently will not face an unfair imposition of these standards. However, any reallocation, renovation, or provision of new building space shall conform to the university space standards as closely as possible.

Users Shall be Provided With Suitable Space and Adequate Furniture in the Appropriate Location: Space provided to every use shall be suitable in terms of size, quality, and location, and uses of a similar nature or uses which are functionally related may require proximity. University departments should not be fragmented and whenever practical, should have had their office, lounge, laboratory, and support activities located contiguously. Adequate furnishings and furniture must also be provided by the University.

Effective Use of Space: Each space allocated to a department or a user shall be used efficiently in terms of utilization of space over time. A space which is used infrequently may require introduction of a similar and compatible approved University use to increase its utilization to a level which is consistent with standards of utilization across the University. Final arbitration will rest at the vice-president level in inter-faculty disputes.

Sharing of Space and Functions: To avoid duplication of space, equipment, and staff services, and to avoid unnecessary costs, as much space as possible should be shared by the departments. This applies especially to machine shops, electronics shops, animal rooms, audio-visual areas, storage areas, etc. If there is more than one user, procedures should be developed for priorities of services if this is necessary.

Access to Space: Three categories of access are required. These are: general access, limited access, and restricted areas. General access space, including classrooms, lounges and other general University facilities are shared by all departments, students, and staff. Limited access space, which includes undergraduate laboratories, meeting rooms, study spaces, etc., can be made available to users on a limited basis. Restricted access space, which comprises research laboratories, offices, and specialized support areas is only available to certain individuals or to particular groups. When allocations are made, space can be designated "limited" or "restricted" access (DU, 2003).

4.1.4 University of New Castle, Australia

The house services group is responsible for all furniture, equipment and staff relocations for the University of New Castle including setting up facilities for examinations, graduations and functions of all types, relocating offices and various works. The group services all the buildings that the university manages including the central business district precinct and the David Madison Building. The movement of staff has to be firstly discussed and approved by the manager, space & facilities, which will ensure that the relocation is in line with the university policy and forward planning (UNC, 2003)

4.1.5 Queensland University of Technology, Australia

The Queensland University of Technology (QUT) issues and reviews annually a five-year asset management plan, which covers major capital works for the ensuing five-year period and provisions for the university's deferred maintenance program. Capital works is responsible for delivering the scheduled major projects in accordance with the university's financial and spatial priorities. The asset management plan identifies the following priority needs:

- Expansion of the university's capacity for teaching research and support areas.
- Improvement of the quality of existing accommodation.
- Efficient use of space.
- Maintenance of the university's physical fabric and a responsible balance between the objectives of the capital program and the ongoing teaching and research programs of the university.

The asset management plan is reviewed from time to time in the light of actual expenditure and the overall financial position of the university, e.g. the strategy is revised after a major building has been completed and the actual costs, as opposed to those estimated, are known. Deferred maintenance results from the deferring of repairs to plant, equipment or fabric due to a lack of maintenance funding. QUT's policy is to catch up on maintenance backlogs in a well defined, structured way, by establishing annual rectification programs through defining and prioritizing the backlog. It is the responsibility of facilities management to conduct detailed audits of building services and fabric every three years, thereby providing an opportunity to update the university's register of deferred maintenance works (QUT, 200

CHAPTER 5

ANALYSIS OF AUTOMATION SURVEY

5.1 Assessment of Automating FM Practices

A survey questionnaire was conducted to gain insight into the level and extent of automation in the professional practices of FM in the universities of Saudi Arabia. The questionnaire aims at evaluating current practices (objective information) and opinions concerning the FM practices, to determine how universities identify the areas where the improvement may be achieved for better performance from FM practices. The benefits of this study can help in managing maintenance activities, extends life of built-facilities and improve community safety.

The questionnaire design is described in the following section:

5.1.1 Questionnaire Construction

The questionnaire was designed into specific questions. Based on the available knowledge from the literature review, the questions were identified and formulated for easy understanding of the respondents.

5.1.2 Contents of Questions

The questionnaire shown in Appendix-B consists of five sections.

- The first section includes introductory part and the title of the thesis.
- The second section contains purpose of the study for carrying out questionnaire survey.
- The third section contains general information about the respondents such as name, position, experience and contact address. It also contains the general information about university, building function type, type of department and staff in the department.
- The fourth section contains instructions to respondents about the questionnaire.
- The fifth and the last section in the questionnaire contain fact and opinion questions to gain insight into the level and extent of automation in the professional practices of FM in the universities of Saudi Arabia. Fact questions are designed to elicit objective information from the respondents regarding their professional practice of carrying out FM day-to-day operations. Opinion questions are concerned with ideas, preferences and future implementation of FM practices. The questions concerned are related to the FM domain such as construction drawing creation and management, space planning and management, furniture and equipment management, building maintenance management, inventory management, and telecommunication and cabling management and emergency preparedness management.

5.1.3 Data Collection

The questionnaires were faxed, emailed and posted to concerned departments of the seven universities of Saudi Arabia.

5.1.4 Scoring

Scoring of the questionnaire was calculated using a frequency index. This frequency index is a qualitative-five (5) point scale with interval from ‘usually’ to ‘never’ for fact questions and ‘strongly agree’ to ‘strongly disagree’ for opinion questions is considered as interval from four to zero point. This scale was scored by assigning weights for responses. Table 5.1 describes the ratings of opinion and fact questions used in the survey.

Table 5.1: Ratings Used in Fact and Opinion Questions

Ratings used in Fact Questions	**Ratings Used in Opinion Questions**	**Assigned Weights**
Usually –U	Strongly Agree-SA	4
Often-O	Agree-A	3
Sometimes-S	Uncertain-UC	2
Rarely-R	Disagree-D	1
Never-N	Strongly Disagree-SD	0

Frequency Index (FI), of the fact and opinion questions was calculated as follows:

$$\text{Frequency Index} = \frac{\sum_{i=0}^{4} xi}{n}$$

Where:

x_i = the variable expressing the frequency of *i* , the responses for *i*= 0,1,2,3,4 and illustrated as follows:

x_0 : frequency for “N” or “SD”

x_1 : frequency for “R” or “D”

x_2 : frequency for “S” or “UC”

x_3 : frequency for “O” or “A”

x_4 : frequency for “U” or “SA”

n= number of valid responses

Fact and opinion of FM practices were ranked based on the score of their indices with the first rank assigned to the highest index.

5.2 Questionnaire Responses

5.2.1 Survey Respondents

The respondents who participated in this study are from the following departments in seven universities of Saudi Arabia:

1. Projects & Maintenance Department
2. Comptroller/Inventory Department
3. Telecommunication Maintenance Department
4. Safety Department

Table 5.2 describes the respondents of the various universities who participated in the survey.

Table 5.2: Survey Respondents

Universities	Respondents
King Fahd University of Petroleum & Minerals	Supervisor for Technical Affairs
King Faisal University	Manager, Maintenance Dept
Islamic University of Al-Madinah Al-Munawarah	Manager, Project Management
Umm Al-Qura University	General Supervisor Projects & Maintenance Mgmt.
King Khalid University	Manager, Projects & Maintenance Dept.
King Saud University	General Manager, Projects & Maintenance Dept.
King Abdul Aziz University	General Supervisor , Projects Dept.

5.2.2 Responses from the Projects & Maintenance Department

The following section describes the responses related to the automation of FM practices in projects and maintenance department of Saudi Universities. Table 5.3 describes the responses from projects and maintenance department of various universities who are dealing with the FM practices in performing day-to-day operations.

Table 5.3: Responses from the Projects & Maintenance Department

Fact Questions: Current Practices involved in the University						
	No. of Respondents					
Construction Drawing Creation & Management	**U**	**O**	**S**	**R**	**N**	**Frequency Index**
Computer Aided Design (CAD) systems are used in preparing architectural & engineering drawings	6			1		3.5
	85.71%	0%	0%	14.29%	0%	
Computers are used in sharing drawing information among other departments	1			1	1	2.0
	16.66%	50 %	0%	16. 66%	16.66%	

Space Planning & Management	U	O	S	R	N	Frequency Index
Computer applications are used to record space inventory	4	1		1	1	2.8
	57.13%	14.29%	0%	14.29%	14.29%	
Space Planning & Management	**U**	**O**	**S**	**R**	**N**	**Frequency Index**
University maintenance department performs internal billing of the space that the department uses	2		1	1	2	1.8
	33.33%	0%	16.67%	16.6.7%	33.33%	
Space inventory information is shared with others departments	2	1		1	2	2.0
	3.33%	16.67%	0 %	16.6.7%	33.33%	
Furniture & Equipment Management	**U**	**O**	**S**	**R**	**N**	**Frequency Index**
Computer methods are used to control furniture & equipment items	3			1	1	2.5
	50 %	0 %	16.67 %	16.67 %	16.67 %	
Layouts of furniture & equipment items are documented using CAD	2		2	1	1	2.1
	3.33 %		33.33 %	16.67 %	16.67 5	
Move orders are filed and processed using computers	1	2		1	2	1.8
	16.67 %	33.33%	0 %	16.67%	33.33 %	
Computers are used to generate reports		3		2	1	1.8
	0 %	50%	0 %	33.33%	16.67%	
Other departments can access furniture & equipment data			2	2	2	1.0
	0 %	0 %	50 %	50 %	50 %	
Building Maintenance Management	**U**	**O**	**S**	**R**	**N**	**Frequency Index**
Computer methods are used to file and process work orders	1	3	2			2.8
	16.67 %	50%	33.33%	0 %	0 %	
Computers are used for tracking scheduled and unscheduled maintenance activities	1		2		3	1.3
	16.67 %	0 %	33.33%	0 %	50%	
Computers are used for storing maintenance procedures as well as all warranty information by component.	1		2	1	2	1.5
	16.67 %	0 %	33.33%	16.67%	33.33%	
Computers are used to generate real-time reports of ongoing work activity	1	1	1	1	2	1.6
	16.67 %	16.67%	16.67%	16.67%	33.33%	
Computer applications are used to manage preventive maintenance	1	1		2	1	1.8
	20 %	20%	0 %	40%	20%	
Managers at different levels can retrieve maintenance reports via computers			1	2	3	0.6
	0 %	0 %	16.67 %	33.33 %	50 %	

Opinion Questions: Concern with ideas, preferences, and future implementation

Construction Drawing Creation & Management	SA	A	UC	D	SD	Frequency Index
Creation of CAD drawings improves work productivity	6					4.0
	100 %	0 %	0 %	0 %	0 %	
Data links to drawings (maps, floor plans) increase accuracy of information	6					4.0
	100 %	0 %	0 %	0 %	0 %	
	75%	0%	25%	0%	0%	
Space Planning & Management	**SA**	**A**	**UC**	**D**	**SD**	**Frequency Index**
Integrating data with CAD drawings helps in increasing space efficiency	4	2				3.6
	66.66%	33.34 %	0%	0%	0%	
Computer generated reports helps in making decisions regarding lease renewal, space expansion or reduction	4	2				3.6
	66.66%	33.34%	0%	0%	0%	
Furniture & Equipment Management	**SA**	**A**	**UC**	**D**	**SD**	**Frequency Index**
CAD drawings of furniture & equipment items links to database visually present an inventory	4		1			3.6
	80%	0%	20%	0%	0%	
Database linking with drawing track items alphanumerically and graphically	4	1				3.8
	80%	20%	0%	0%	0%	
Bar code technology is used in tracking warranty of furniture & equipment items	3		1			3.5
	75 %	0 %	25 %	0 %	0 %	
Building Maintenance Management	**SA**	**A**	**UC**	**D**	**SD**	**Frequency Index**
Work order information is saved for analysis Purposes	3	1	2	1		2.8
	42.84%	14.28%	28.60%	14.28%	0%	
Facility Maintenance Management System is used for reporting	3	2	1	1		3.0
	42.85%	28.60%	14.28%	14.28%	0 %	

Work orders are generated through one of the following methods (Tick one or more methods)

☐ Written form 5 ☐ Telephone 4 ☐ Computer Maintenance Management Systems 4 ☐ Web-based 4

☐ Others, please specify ______________________________

Which of the following software does your organization use for managing maintenance activities?

☐ Archibus ☐ Aperture ☐ Maximo ☐ Facility Information System

☐ Others, please specify : COS1 , Custom Made System

5.2.3 Responses from the Comptroller/Inventory Departments

The following section describes the responses related to the automation of FM practices in comptroller/inventory department of Saudi Universities. Table 5.4 describes the responses from comptroller/inventory department of various universities who are dealing with the FM practices.

Table 5.4: Responses from the Comptroller/Inventory Departments

Fact Questions: Current Practices involved in the University						
Inventory Management	**U**	**O**	**S**	**R**	**N**	**Frequency Index**
Computers are used to manage stores inventory	3		1			3.5
	75%	0 %	25%	0 %	0 %	
University storehouse collects and receives the inventory	2	2				3.5
	50 %	50%	0 %	0 %	0 %	
Inventory information shared electronically by other departments		1		4		1.4
	0 %	20 %	0 %	80 %	0 %	
Bar-coding technology is used in inventory control	2			2		2.5
	50%	0 %	0 %	50%	0 %	

Opinion Questions: Concern with ideas, preferences, and future implementation						
Inventory Management	**SA**	**A**	**UC**	**D**	**SD**	**Frequency Index**
Computers helps in maintaining an accurate history of assets	2	1		1		3.0
	50%	25%	0 %	25%	0 %	
Asset records are updated every	☐ 3 months 1	☐ 6 months 1		☐ 9 months	☐ Annually 3	

5.2.4 Responses from the Telecommunications Maintenance Department

The following section describes the responses related to the automation of FM practices in telecommunications maintenance department of Saudi Universities. Table 5.5 describes the responses from telecommunications maintenance department of various universities who are dealing with the FM practices.

Table 5.5: Responses from the Telecommunications Maintenance Department

Fact Questions: Current Practices involved in the University						
Telecommunication & Cabling Management	**U**	**O**	**S**	**R**	**N**	**Frequency Index**
Computer applications are used to manage electronic inventory of the cabling & telecommunications network connections		4		1	2	1.8
	0 %	57.14 %	0 %	14.26%	28.60%	
Data is shared electronically among other departments	1	2	1	1	2	1.8
	14.28%	28.60%	14.28%	14.28%	28.60%	

Opinion Questions: Concern with ideas, preferences , and future implementation						
Telecommunication & Cabling Management	**SA**	**A**	**UC**	**D**	**SD**	**Frequency Index**
Graphic symbols are used to track devices	1	2	2	1	1	2.1
	14.28%	28.60%	28.60%	14.28%	14.28%	
Mapping connection graphically helps in cable Connection	1	1	3	1	1	2.0
	14.28%	14.28%	42.86%	14.28%	14.28%	
Maintaining an electronic inventory of physical network simplifies trouble-shooting tasks	3	2	1		1	2.8
	42.86%	28.60%	14.28%	0%	14.28%	
People in the university exchange information via ☐ Telephone 4 ☐ E-mail 1 ☐ Web-based 1 ☐ Others, please specify__________						

5.2.5 Responses from the Safety Department

The following section describes the responses related to the automation of FM practices in safety department of Saudi Universities. Table 5.6 describes the responses from safety department of various universities who are dealing with the FM practices.

Table 5.6: Responses from the Safety Department

Fact Questions: Current practices involved in the university						
"An emergency preparedness plan developed for managing potential disasters including ability to respond efficiently and quickly to recover in the event of actual crisis."						
Emergency Preparedness Plan	**U**	**O**	**S**	**R**	**N**	**Frequency Index**
Previous electronic generated reports are used to manage emergency preparedness plan	2		1	1	1	2.2
	40%	0 %	20%	20%	20%	
Facilities data links with drawings supports emergency preparedness, disasters recovery, and business continuity plan	1	1	1	1	1	2.0
	20 %	20%	20%	20%	20%	

Opinion Questions: Concern with ideas, preferences , and future implementation						
Emergency Preparedness Plan	**SA**	**A**	**UC**	**D**	**SD**	**Frequency Index**
Organization has emergency preparedness plan	2	1	1		1	2.6
	40%	20%	20%	0 %	20%	
Emergency preparedness plan is integrated with facilities management system	2		1	1	1	2.2
	40%	0 %	20%	20%	20%	
Emergency preparedness plan in conjunction with world wide web helps in accessing and updating data remotely	2			2	1	2.0
	40%	0 %	0 %	40%	20%	

5.3 Analysis of Automation Survey

The following section provides an analysis of findings of the survey:

5.3.1 Production of Drawings

Construction Drawing Creation and Management

- **Fact Questions**
  - ✓ Responses show that, most of the Saudi universities use computers in the production of architectural and engineering drawings. Analysis shows also that 85.71% draw their architectural and engineering entirely by computers and the rest i.e.,14.29% still draft their architectural & engineering drawings manually. Fig 5.1 illustrates the responses of respondents in the field of production of drawings.

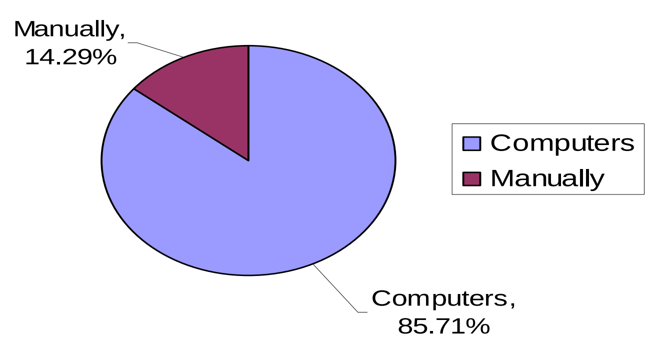

Figure 5.1: Production of Drawings

- **Opinion Questions**
  - ✓ All the respondents strongly agree that creation of CAD drawings results in increase work productivity.
  - ✓ They also agree that data links to drawings results in increase accuracy of information.

Furniture and Equipment Management

- **Fact Questions**
  - ✓ The results also show that 33.33 % of respondents use CAD systems for preparing the layout of furniture & equipment items.
- **Opinion Questions**
  - ✓ Most of the respondents strongly agree that integrating data with CAD drawings helps in increasing space efficiency and visually presents furniture and equipment inventory.
  - ✓ The respondents were asked about database linking with drawing track items alphanumerically and graphically of the furniture & equipment items, majority of them strongly agree.

Emergency Preparedness Plan

- **Fact Questions**
  - ✓ When asked about data links with drawings supports emergency preparedness plan, majority of the respondents indicated that they disagree with that idea.

Although, the above results indicate that Saudi universities are moving towards automation of their FM activities in the area of construction drawing creation and management, space planning and management, and furniture and equipment items. The results show that automation of FM activities is still in operational level and the other two decision levels managerial and strategic are still to be implemented by the

Saudi universities. The benefits of automating FM activities begin with time savings, and include greater accuracy and efficiency in performing day-to-day operations.

5.3.2 Levels of Using Computers in Sharing Information

Construction Drawing Creation and Management, Space Planning, Furniture & Equipment, Building Maintenance, Inventory and Telecommunications & Cabling Management

- **Fact Questions**
  - ✓ This part measures the level of computers usage in sharing information in FM activities (construction drawing creation & management , space planning & management, furniture & equipment management, building maintenance management, inventory management and telecommunications & cabling management) within the universities of Saudi Arabia.
  - ✓ The result is shown in Table 5.7. The results show that computers and internet are widely used in sharing information that includes drawing, space inventory and inventory of items with other departments of the universities.
  - ✓ Some of the respondents prefer to exchange information via telephone.
  - ✓ The results show that construction drawing creation and management, space planning and management of FM activities comes first, with a frequency index of 2.0, indicating the range of usually and often computers are used in sharing information.

- ✓ The telecommunications and cabling management comes second, with a frequency index of 1.8, indicating the range of often and sometimes computers are used in sharing information.
- ✓ The inventory management comes third, with a frequency index of 1.4, indicating that computers are rarely used in sharing information.
- ✓ The furniture and equipment management comes fourth, with a frequency index of 1.0, indicating that computers are never used in sharing information.
- ✓ The building maintenance management comes last in the FM activities, with a frequency index of 0.6, indicating that computer are never used in sharing information to other departments.

Table 5.7: Level of Using Computers in Sharing Information

FM Activities	Usually	Often	Sometimes	Rarely	Never	Frequency Index	Rank
Construction Drawing Creation & Management	16.66%	50 %	0%	16. 66%	16.66%	2.0	1
Space Planning & Management	33.33%	16.6.7%	0 %	16.67%	33.33%	2.0	1
Telecommunications & Cabling Management	14.28%	28.60%	14.28%	14.28%	28.60%	1.8	2
Inventory Management	0 %	20 %	0 %	80 %	0 %	1.4	3
Furniture & Equipment Management	0 %	0 %	33.33%	33.33%	33.33%	1.0	4
Building Maintenance Management	0 %	0 %	16.67%	33.33%	50%	0.6	5

The above findings indicate that internet and computers are widely used tools to exchange information within the universities. The findings also indicate that the respondents of different departments lack knowledge of IT in FM domain which could help them to enhance productivity and improve work efficiency.

5.3.3 Computer Use in Recording Inventory

Inventory, Space, Telecommunication and Cabling Management

- **Fact Questions**
  - ✓ This part investigates the usage of computers in recording inventory of assets, space, telecommunications & cabling.
  - ✓ The result is shown in Table 5.8. The results show that computers usage in recording inventory of assets comes first with a frequency index 3.5 indicating that this is usually used.
  - ✓ The space inventory comes second, with an index of 2.8, indicating that it is often used.
  - ✓ Telecommunications & cabling inventory comes third with an index value of 1.8, indicating that it is never used computers.

The above results indicate that computers are widely used to record inventory of assets and space inventory. The results also indicate that respondents of telecommunication and cabling management are not aware of potential of IT in FM domain.

Table 5.8: Computer Use in Recording Inventory

FM Inventory	Usually	Often	Sometimes	Rarely	Never	Frequency Index	Rank
Inventory Items	75%	0 %	25%	0 %	0 %	3.5	1
Space Inventory	57.13%	14.29%	0%	14.29%	14.29%	2.8	2
Telecommunications & Cabling Inventory	0 %	57.14%	0 %	14.26%	28.60%	1.8	3

5.3.4 Managing Work Orders

Building Maintenance, Furniture and Equipment Management

- **Fact Questions**
  - ✓ This part investigates on a subject that computers are used in managing work orders to carry-out their FM activities.
  - ✓ The results show that most of the respondents indicated that they never used computers in moving the furniture & equipment items from one location to another.
  - ✓ About 50% of the respondents indicated that often they used computer methods to file and process work orders as shown in Figure 5.2
  - ✓ Majority (50%) of the respondents indicated that they never used computers to track scheduled and unscheduled maintenance activities as shown in Figure 5.3.

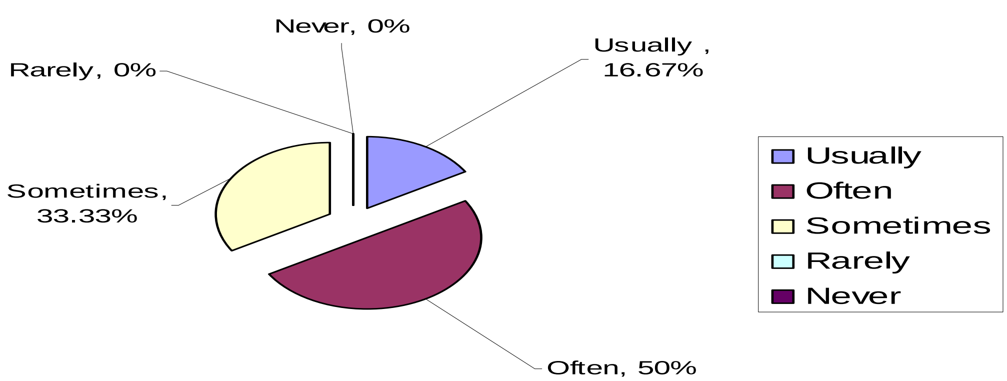

Figure 5.2: Managing Work Orders

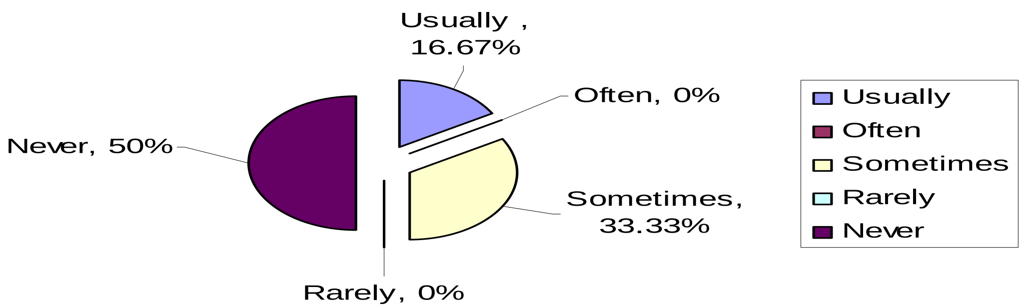

Figure 5.3: Track Scheduled and Unscheduled Maintenance Activities

- **Opinion Questions**
  - ✓ Analysis shows that majority of the respondents agree that work order is saved for analysis purposes.
  - ✓ The respondents were asked about what methods they used to generate work orders. Most of the respondents used written form followed by telephone, computer maintenance management system and web-based.

The above results show that Saudi universities partly automate their FM activities and the rest of the activities they manage manually.

5.3.5 Managing Information Systems

Inventory Management

- **Fact Questions**
  - ✓ The respondents asked about whether university storehouse collects and receives the inventory. The respondents indicated that storehouse often

manage the inventory.

- **Opinion Questions**
  - ✓ Most of the respondents agree that computers should be used in maintaining accurate history of assets.

Building Maintenance Management

- **Opinion Questions**
  - ✓ To examine the use of maintenance computerized system within the universities of Saudi Arabia.
  - ✓ The respondents were asked about software used in the Saudi universities to manage their information systems. Some universities responded that they use COS 1 and custom made system to manage their information systems.

Emergency Preparedness Plan

- **Opinion Questions**
  - ✓ Respondents indicated that they are uncertain of integrating emergency preparedness plan with FMS.

The above findings indicate that the respondents are in favor of using computer and software to be custom made system to mange their information systems. The above result also shows that respondents are not in favor of integrating emergency preparedness plan with FMS.

5.3.6 Warranty Identification

Inventory Management

- **Fact Questions**
  - ✓ When asked about bar-coding technology should be used in inventory control. The respondents indicated they rarely used bar-coding in inventory control.

Furniture and Equipment Management

- **Opinion Questions**
  - ✓ This part measures that use of computers in checking warranty of the items in different aspects of FM activities.
  - ✓ Majority of the respondents indicated they strongly agree that bar-coding should be used to track warranty of furniture & equipment items.

The above results indicate that Saudi universities used bar-coding technology for one activity and for other activities they manage manually.

5.3.7 Computer Use in Report Generation

The respondents were asked about reports that are generated using the data they maintain and whether the reports were created with computers or prepared manually.

Furniture and Equipment Management

- **Fact Questions**
  - ✓ The respondents indicated that rarely use computer to generate reports for

furniture & equipment items.

Building Maintenance Management

- **Fact Questions**
  - ✓ For building maintenance management, respondents indicated they never used computers to generate reports.
- **Opinion Questions**
  - ✓ They are in favor of using facility maintenance management system for report generation.

Emergency Preparedness Plan

- **Fact Questions**
  - ✓ The respondents indicate that computers are sometimes used in managing emergency preparedness plan of previously generated reports.

The above findings indicate that there are discrepancies among respondents about using computers to retrieve data. This shows that respondents are not aware of use of computers in performing their FM functions. This indicates that Saudi universities are least interested in using computers to generate reports which could them in analyzing maintenance work, helped them in responding and recovering from disasters, fire hazards/risks and natural calamities.

5.3.8 Billing Occupied Space

Space Management

- **Fact Questions**
  - ✓ The results show that majority of Saudi universities do not perform internal billing of the space that the department uses.

The above findings show that Saudi universities are least interested in performing internal billing of occupied space within the department. Performing the billing of occupied space could bring the universities better space utilization, allocation, use and occupancy space is validated and unauthorized use is ended, and available space is distributed equitably among all users of the universities.

5.3.9 Safety Management

Emergency Preparedness Plan

- **Opinion Questions**
  - ✓ This part covers whether the Saudi universities are having emergency preparedness plan to tackle fire safety hazards/risks, disaster and natural calamities.
  - ✓ Most of the Saudi universities agree that there should be an emergency preparedness plan to tackle the problem arises from fire hazards, natural calamities.

5.4 Discussion

This chapter presents the results and analysis of automation survey of the FM practices in the universities of Saudi Arabia. The following paragraphs will discuss the way in which IT is practice in FM domain of Saudi universities.

- ✓ *Drawings:* Majority of the respondents are using computers in the production of architectural and engineering drawings. This indicates that the automation of FM activities is still in operational level. The other two decision levels managerial and strategic are still to be implemented by the Saudi universities.
- ✓ *Sharing Information:* The majority of the respondents preferred internet and telephone as a tool to exchange information within the universities. Other respondents preferred to exchange information through web, e-mail. This shows that the Saudi universities are moving towards automation of their activities.
- ✓ *Recording Inventory:* The respondents use computers to record inventory of assets, space inventory and telecommunication & cabling inventory. This indicates that Saudi universities are interested in automating FM activities.
- ✓ *Managing Work Orders & Report Generation:* The respondents vary on using computers in managing work orders in different departments. This shows that computers are not fully utilized in managing work orders and in report generation which could help them in analyzing work.
- ✓ *Managing Information Systems:* The respondents indicated that they utilized computer to manage their information system. They also are in favor of using

custom made software according to their requirements. This shows that Saudi universities are managing their information systems using computers.

- ✓ *Warranty Identification:* The respondents indicated that they use bar-coding technology to track furniture and equipment items. They rarely used bar-coding technology in tracking assets. This shows that Saudi universities automate only for one activity and other activities they manage manually.
- ✓ *Billing Occupied Space:* The respondents indicated that they do not perform the internal billing of the space that the department uses.
- ✓ *Safety Management:* The respondents agree that there should be an emergency preparedness plan to tackle disasters, calamities, fire hazards/risk in the facility. The results indicated that computers are sometimes used in managing emergency preparedness plan of previously generated reports. This shows that Saudi universities are not aware of potential of IT in tackling fire hazards, risk involved in the facilities.

CHAPTER 6

DEVELOPMENT OF FACILITIES MANAGEMENT FRAMEWORK MODELS

6.1 Introduction

This chapter presents the development of a FM framework models for major FM functions, including construction drawing creation and management, inventory management, space management, maintenance management, and emergency preparedness management. The main purpose of developing these models is to facilitate the automation of FM practices in Saudi universities in particular and business organizations in general. The FM framework models have been developed based on the results obtained from the automation survey of FM practices, literature review and the operational characteristics of leading commercial FM software.

Facilities are physical structures that require a broad spectrum of services in order to run properly and efficiently. FM as a discipline emerged out from the integration of three professional disciplines – property management (real estate), property operation and maintenance and office administration – mainly because organizations needed to focus on the elaborate and expensive facilities and infrastructure which crucially support their activities. These three disciplines have in common the fact that they all exist to support the main activities of the organization (Kincaid, 1994). FM is a fast growing professional discipline that depends upon the skills, vision and experience of its practitioners and, most recently, upon a powerful computer-aided methodology that can provide, with pinpoint accuracy, a daily picture of how all the FM activities are functioning in the organization (Best *et al.*, 2003).

Facility managers need a formalized, methodical approach that facilitates identification of the scope of management processes, the activities within these processes and the content of information required to achieve these processes. A series of FM framework models presented in this chapter, have been developed to provide such a formalized and methodical approach. A model (IAI, 1999) may be defined as a representation of processes which occur in the real world, and it represents in a conceptual form the flow and content of information that is contained within a defined area of interest.

Modeling is one of the techniques to represent organization activity and its allied processes. Modeling helps in analysis and design of a process and its activities. This in turn, reduces the cost and time that could be wasted due to wrong implementation of the process. Models helps in better understanding and communicating information to all type of people. The framework models developed herein, are presented as $IDEF_0$ (Integration Definition for Functional Modeling) process models (Federal, 1993). A process model displays the interactions between activities in terms of inputs and outputs while showing the controls placed on each activity and the types of resources assigned to each activity. Appendix-A provides a description of $IDEF_0$ process modeling methodology. These models can act as policy guidelines for conducting FM activities in organizations, and provides a way for of bridging the gaps in FM practice. An added value of these framework models is that each activity is seen in its proper context relative to the other activities, and the facility manager can identify the impact of any change upon the whole business process (Hassanain *et al.*, 2003).

6.2 Construction Drawing Creation and Management Model

Traditionally building drawings were painstakingly created manually by using pencil and paper on a drafting table. Any changes made often required new drawings to be created or at the very least sections redrawn. The advent of computer soon gave rise to CAD drafting allowing drawings to be created on a PC and printed electronically. Changes could be made quickly without having to redraw the whole drawing. The most commonly used computer tools for construction projects are word processors, spreadsheets, simple databases, image processing, presentation software tools and CAD systems (Froese *et al.*, 1997).

Construction drawing creation and management deals with the production of facilities drawings administered by the organization. The construction industry is characterized by having many actors of multiple disciplines who are brought together at various stages throughout a single project. The result is a dependence on a large body of information produced by many sources at many levels of abstraction and detail, which contributes to the fragmentation of the industry. This fragmentation, in turn, contributes to the poor record of overall productivity improvement in the industry (Froese *et al.*, 1997). A construction drawing creation and management framework has been developed as part of the objectives of this thesis to provide facility managers with a formalized and methodical approach to formally record the complete design information on the construction process.

The construction drawing creation and management model is described schematically as an $IDEF_0$ process model, as shown in Figure 6.1. It consists of four management processes. For each of the processes, a number of supporting activities have been defined, with their logical sequence and information requirements. The four processes forming the construction drawing creation and management model are as follows:

- Develop Preliminary Drawings (referred to as node "C1")
- Produce Construction Documentation (referred to as node "C2")
- Record As-Built Drawings (referred to as node "C3")
- Maintain Building Database (referred to as node "C4")

The following sections describe the processes involved in the construction drawing creation and management model, and the activities that are carried out to complete each process.

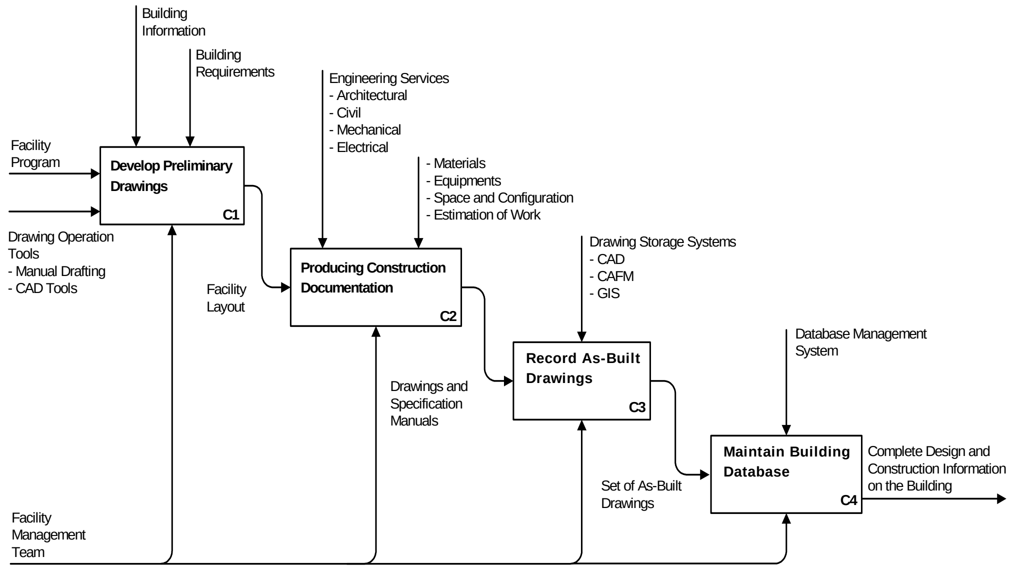

Figure 6.1: General Processes Involved in Construction Drawing, Creation & Management Model

6.2.1 The 'Develop Preliminary Drawings' Model

Process Definition

The 'Develop Preliminary Drawings' process (node "C1" as shown in Figure 6.1) involves the development of preliminary sketches for the facility layout for later elaboration. The input to this process is a facility program and drawing operation tools, including manual drafting and CAD tools. The output is a facility layout to be constructed.

6.2.2 The 'Produce Construction Documentation' Model

Process Definition

The 'Produce Construction Documentation' process (node "C2" as shown in Figure 6.1) involves the production of working drawings, specifications, contract documents, and bill of quantities. This process also provides information in sufficient details to enable the estimation of resources consumed, labor work and construction of the work (Garba and Hassanain, 2004). The input to this process is a facility layout to be constructed. The outputs from this process are a detailed set of working drawings and specifications for the facility to be constructed. This process is broken into three functions as shown in Figure 6.2. The following paragraphs provide as description of the functions involved.

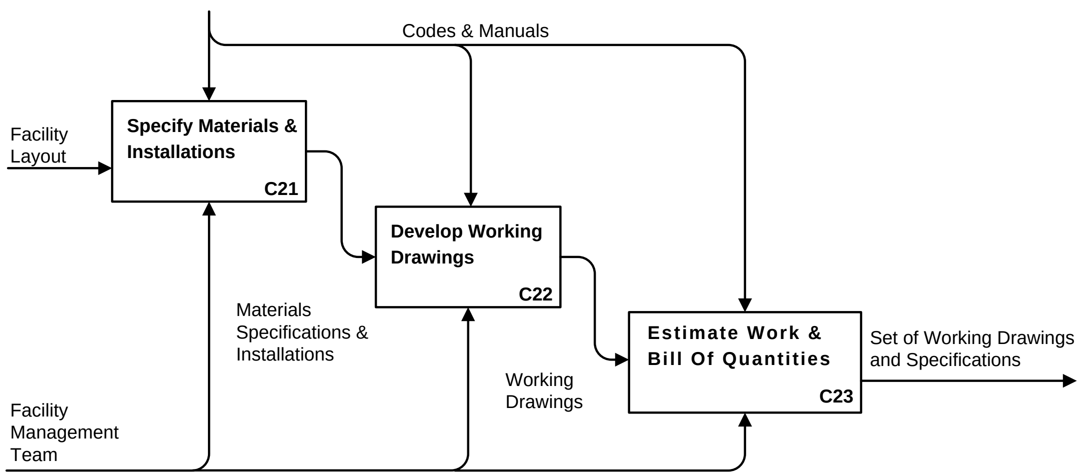

Figure 6.2: Node C2, Produce Construction Documentation

Process Activities

Specify Materials & Installations (C21): This function serves to specify the materials and installations for the facility to be constructed.

Develop Working Drawings (C22): This function serves to describe the set of drawings used for securing building permits. This set of drawings is handed to contractors for constructing the facilities as specified.

Estimate Work & Bill of Quantities (C23): This function serves to determine the amount of work and material involved in constructing the facility.

6.2.3 The ‘Record As-Built Drawings’ Model

Process Definition

The ‘Record As-Built Drawings’ process (node “C3” as shown in Figure 6.1) involves updating the drawings that were used to start the construction process. The inputs to this process are a set of working drawings and specifications for the facility to be constructed. The output is a set of as-built drawings that reflect the changes made during construction, on the original set of drawings of the facility that is already constructed.

6.2.4 The ‘Maintain Building Database’ Model

Process Definition

The ‘Maintain Building Database’ process (node “C4” as shown in Figure 6.1) involves the development and maintenance of the building database. Functions carried out include collecting, updating, retrieving, storing, and transmitting information about building (Sanvido, 1990). The input to this process is a set of as-built drawings for the facility that is already constructed. The output is complete building database that include design and construction information on the building. This process is broken in to five functions as shown in Figure 6.3. The following paragraphs provide as description of the functions involved.

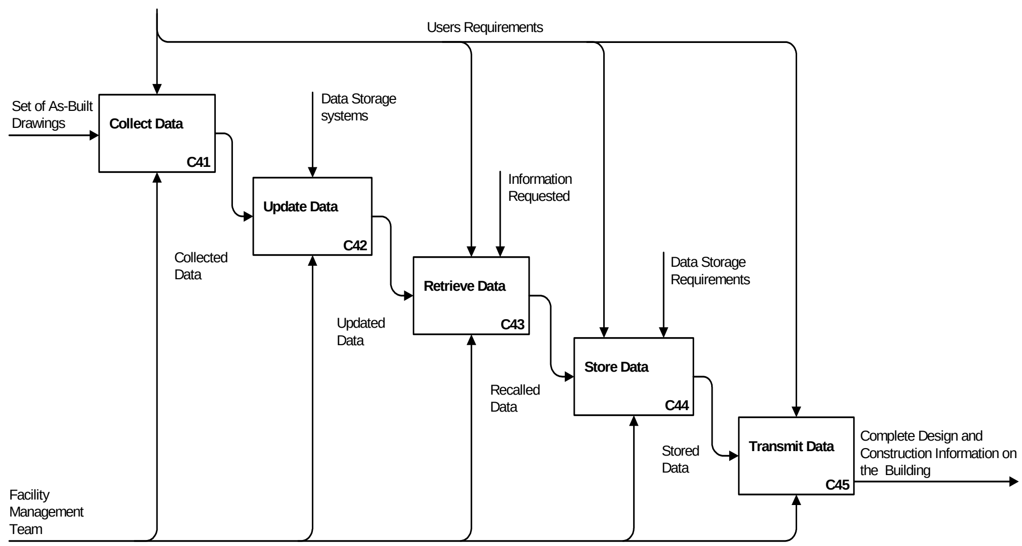

Figure 6.3: Node C4, Maintain Building Database

Process Activities

Collect Data (C41): This function serves to collect raw data on changes generated by various processes during the operation activities.

Update Data (C42): This function serves to update data when new information is incorporated into an existing set of information or existing information is transformed.

Retrieve Data (C43): This function serves to retrieve data from some party , the data is recalled from storage and prepared for processing of some kind into information generated.

Store Data (C44): This function serves to store data manually, or electronically where it is available for future processing if required.

Transmit Data (C45): This function serves to deliver useful data to the valid user who requested it.

6.3 Inventory Management Model

Organizations and businesses, regardless of population, have maintained over the years, systems for the inventory of physical assets. Growth has prompted the need to formally record all necessary information concerning organizational assets. To meet the needs of organization, facility managers need to identify the assets, asset location, and factors affecting asset performance (Behm *et al.*, 2001). The inventory is the foundation of an effective FM process. It is the baseline for what is to be maintained. An inventory management framework has been developed as part of the objectives of this thesis to provide facility managers with a formalized and methodical approach to formally record the inventory of an organization. The framework is a balanced assessment of the following key elements:

- *Asset Record:* Records the assets owned by the organization.
- *Asset Functionality:* Assesses purpose of the asset.
- *Asset Condition:* Assesses the level of asset performance against an agreed set of condition service standards.

Inventory management deals primarily with creating an inventory of all assets owned by the organization. CAD, GIS and RDBMS are used to provide accurate picture of the assets portfolio. The basic approach was to extend a standard CAD system by providing capabilities for automated area measurement and recording of assets, primary and support space measures, furniture and equipment used or stored in each area. CAD systems emerged out as a prerequisite for many automation systems due to the fact that the building procurement process needs drafting technology to aid construction procedures. GIS used to give data about a particular asset related directly to their physical location.

The inventory management model is described schematically as an $IDEF_0$ process model, as shown in Figure 6.4. It consists of three management processes. For each of the processes, a number of supporting activities have been defined, with their logical sequence and information requirements. The three processes forming the inventory management model are as follows:

- Record Assets (referred to as node "I1")
- Identify Asset Worth (referred to as node "I2")
- Record Original Asset Condition (referred to as node "I3")

The following sections describe the processes involved in the inventory management model, and the activities that are carried out to complete each process.

6.3.1 The 'Record Assets' Model

Process Definition

The 'Record Assets' process (node "I1" as shown in Figure 6.4) involves carrying out an inventory of facility's assets. An asset may be defined as any item of physical plant or equipment that has financial value and against which maintenance actions are recorded (IAI, 1999). Assets are recorded in registers that list all information associated with them such as manufacturer, vendor, model, specifications, insurance,

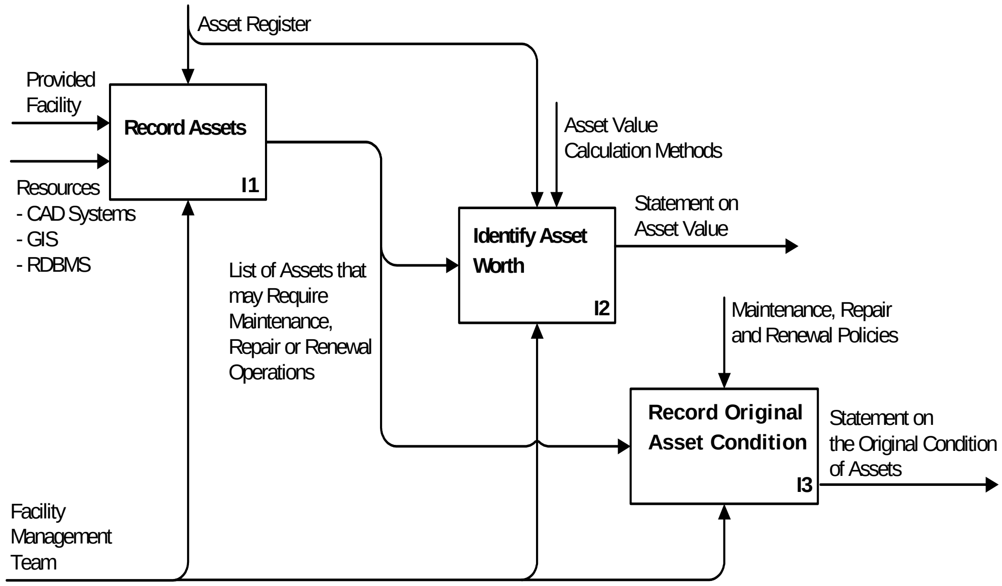

Figure 6.4: General Processes Involved in Inventory Management Model

warranties, maintenance requirements (Best *et al.*, 2003). The inputs necessary to carry out the 'Record Assets' process is an existing facility and a set of resources, including data storage and retrieval systems such as Geographical Information System (GIS), Computer Aided Design (CAD) systems and Relational Database Management Systems (RDBMS). The output of this process is a list of assets that may require maintenance, repair or renewal operations during their service life. This process is broken into three functions, as shown in Figure 6.5. The following paragraphs provide a description of the functions involved.

Process Activities

Identify Facility (I1.1): Serves to identify the facility and/or area in which specific building is located.

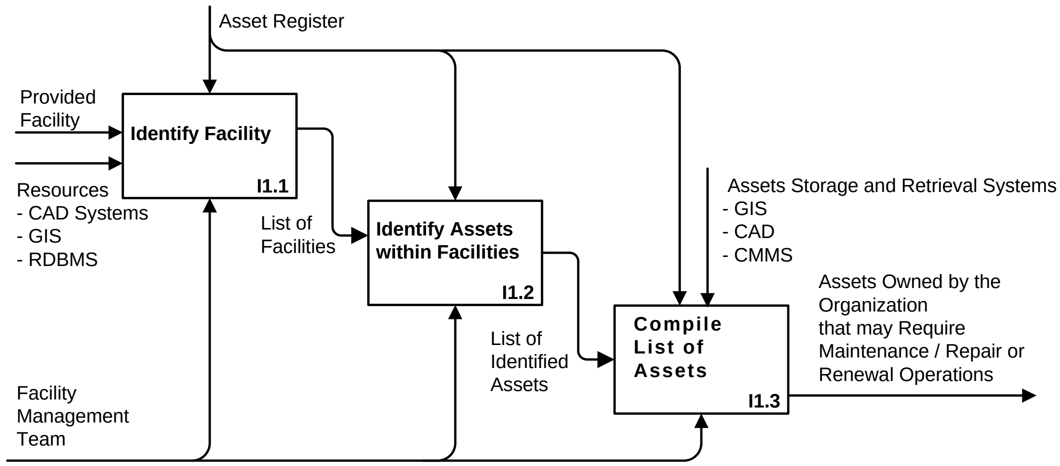

Figure 6.5: Node I1, Record Assets

Identify Assets within Facilities (I1.2): Serves to identify the assets and their types within the facility in which maintenance, repair or renewal operations might be taking place. Data on these assets may include asset name, identifier, location, expected service life, incorporation date, commissioning date, specification details, serial numbers, insurance, and warranties.

Compile List of Assets (I1.3): Serves to compile a record of the identified assets that are owned by the organization, in a facility management information system for the purpose of data storage and retrieval.

6.3.2 The 'Identify Asset Worth' Model

Process Definition

The 'Identify Asset Worth' process (node "I2" as shown in Figure 6.4) involves establishing a system for recording the value of the assets. The input to this process is a list of assets that may require maintenance, repair or renewal operations during their service life. The output is a statement on asset value. This process is broken into three functions, as shown in Figure 6.6. The following paragraphs provide a description of the functions involved.

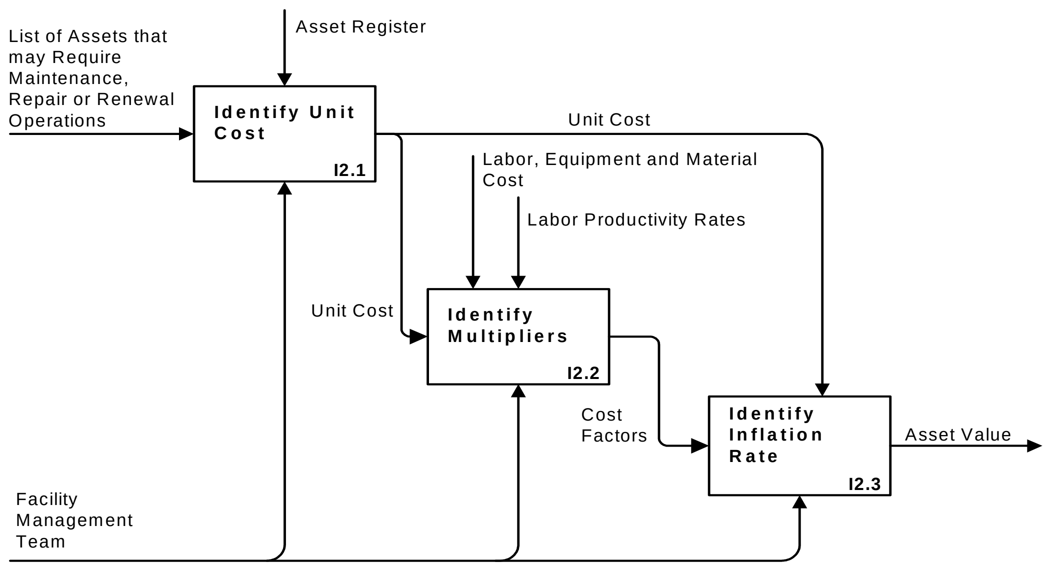

Figure 6.6: Node I2, Identify Asset Worth

Process Activities

Identify Unit Cost (I2.1): This function serves to estimate the unit cost of every item in the inventory. Unit cost may be defined as the total direct labor cost by work quantity (Adrian, 1982).

Identify Multipliers (I2.2): Serves to determine the factors that relates to local cost of labor, equipment, materials, labor availability, and labor productivity. Multipliers may be defined as the product to account for variations in the size of the building relative to the typical size associated with the unit cost (Builder, 2002).

Identify Inflation Rate (I2.3): Serves to identify inflation rate when costs are computed. The inflation rate is the rate of increase in the price of assets over a given period of time (Builder, 2002).

6.3.3 The 'Record Original Asset Condition' Model

Process Definition

The 'Record Original Asset Condition' process (node "I3" as shown in Figure 6.4) involves recording the original condition of assets at the time of acquisition or purchase based on the evaluation of their physical and/or operational characteristics. It includes functions required to establish condition assessment protocol, assess asset condition and compile list of asset condition. The input to this process is a list of assets that may require maintenance, repair or renewal operations. The output to this process is statement on the condition of assets recorded in the inventory. This process is broken into three functions, as shown in Figure 6.7. The following paragraphs provide a description of the functions involved.

Process Activities

Establish Condition Assessment Protocol (I3.1): This function identifies the condition assessment technique and practice that would be followed to assess the current condition of an asset and/or its components.

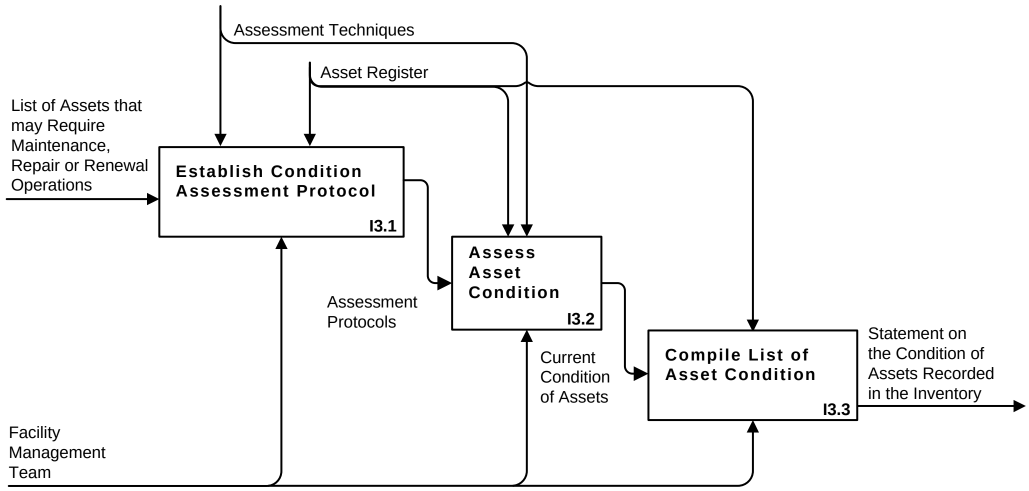

Figure 6.7: Node I3, Record Original Asset Condition

Assess Asset Condition (I3.2): This function serves to evaluate the physical condition of an asset, its ability to perform as planned, and its continued usefulness. Evaluation of an asset's condition requires knowledge of the asset, its performance capacity, and its actual ability to perform, and expectations for its continued performance. The condition of a long-lived asset is affected by its durability, the quality of its design and construction, its use, the adequacy of maintenance that has been performed, and many other factors, including: accidents (an unforeseen, unplanned, or unexpected event or circumstance), catastrophe (a momentous tragic event ranging from extreme misfortune to utter ruin), disasters (a sudden calamitous event bringing great damage, loss, or destruction) and obsolescence (Vanier, 2000).

Compile List of Asset Condition (I3.3): Serves to disclose the current condition of every recorded asset in the compiled list of assets forming the inventory.

6.4 Space Management Model

Effective space management is a vital skill and a major part of FM processes. The type of work that people undertake, the ways it is carried out and the location of that work are changing continuously. Organizations and businesses must constantly reassess their work practices to remain competitive. New patterns of working have emerged, driven by the requirement to control costs. Flexible working and variations in the way people work has created a different type of workspace leading to new spatial and building concepts. Facility managers are required to provide accommodation to satisfy the needs of these new work practices. They should be able to advise on the efficient management of space and to provide effective solutions which relate to the organization's business requirements. The interaction of facility managers with the user's space problems and resolving space problems requires a formalized and methodical approach. A space management framework has been developed as part of the objectives of this thesis to support such an approach.

Space management deals primarily with tracking and reporting space and occupancy changes and surveying facilities to determine use, classification and capacity of any organization. The ability to manage plans for space utilization, availability, and occupancy is becoming a critical part of financial and organizational planning. The role of facilities manager is complex, requiring control over a wide range of diverse activities, which are necessary to support the organization in achieving its business objectives. A key aspect of this role is the ability to access, manipulate, store and report information that is fundamental to space management. Adding space to meet organization's needs is not always an option. Therefore, to stand a chance of meeting space requirements a facilities manager need to be equipped with appropriate tools like CAFM. CAFM tools are used to managing physical space and assets within buildings leased or owned by the organization and tracks use of space, office layouts and furnishings.

The space management model is described schematically as an $IDEF_0$ process model, as shown in Figure 6.8. It consists of five sequential processes. For each of the processes, a number of supporting activities have been defined, with their logical sequence and information requirements. The five processes forming the space management model are as follows:

- Review Organization Structure (referred to as node "S1")
- Plan Space (referred to as node "S2")
- Assign Space (referred to as node "S3")
- Record Space Inventory (referred to as node "S4")
- Perform Space Audit & Surveys (referred to as node "S5")

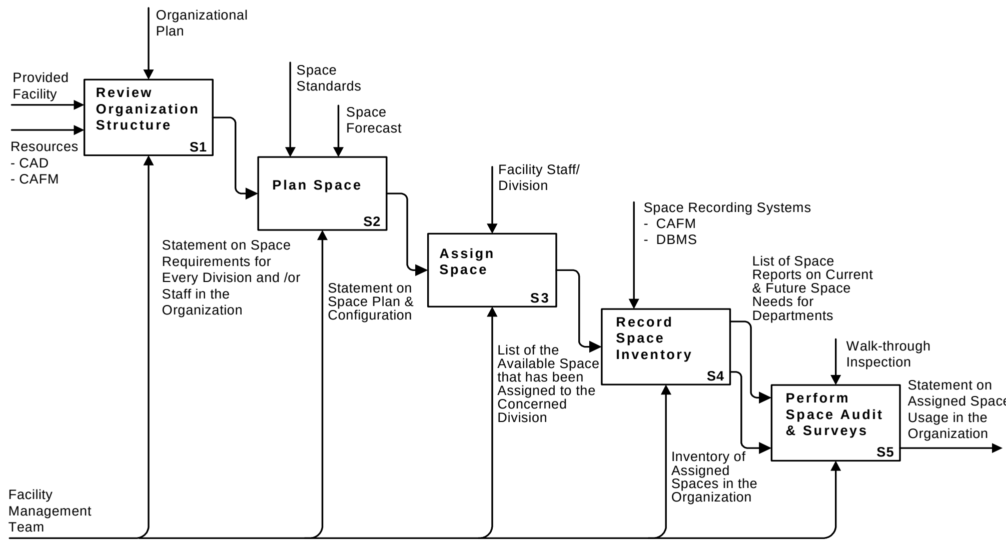

Figure 6.8: General Processes Involved in Space Management Model

The following sections describe the processes involved in the space management model, and the activities that are carried out to complete each process.

6.4.1 The 'Review Organization Structure' Model

Process Definition

The 'Review Organization Structure' process (node "S1" as shown in Figure 6.8) involves the diagrammatic representation of the FM organization, which helps in showing the areas of responsibility, departmental sub-divisions, and total number of employees for the purpose of planning, assigning spaces for the employees (Molnar, 1983). The inputs necessary to carry out this process are an existing facility and a set of resources, including space storage and retrieval systems such as CAD systems and CAFM Systems. The output of this process is statement on space requirements for every division and/or staff in the organization. This process is broken into three functions, as shown in Figure 6.9. The following paragraphs provide a description of the functions involved.

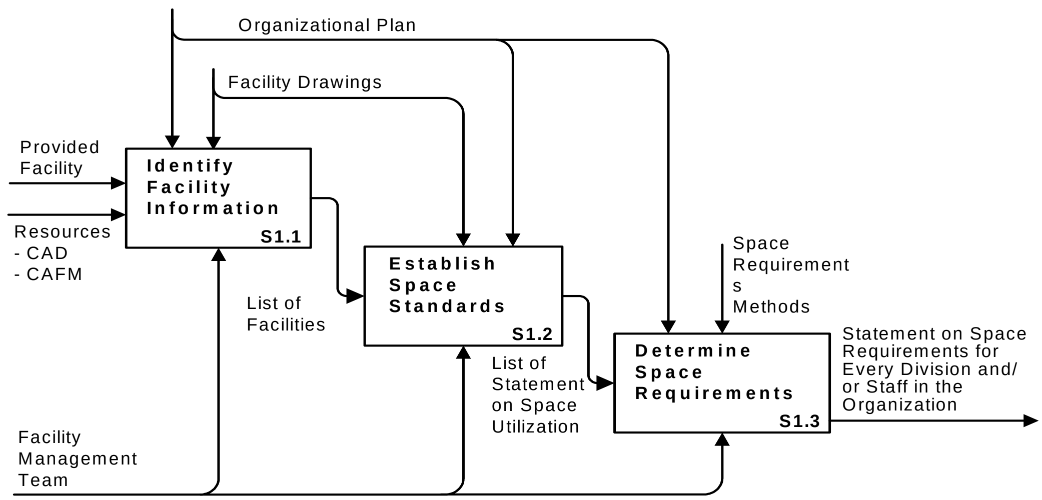

Figure 6.9: Node S1, Review Organization Structure

Process Activities

Identify Facility Information (S1.1): This function serves to identify the facility information such as building names, department names, and division names.

Establish Space Standards (S1.2): Serves to establish space standards which are essential in order to maximize space utilization for every staff and/or division in the organization. The purpose of establishing space standards is to develop a consistent program that can be utilized throughout the organization for the assignment of uniform space areas. For example, a president space standard requires 400 square feet, Vice-president – 300 to 320 square feet, a manager - 200 square feet, a conference room space - 900 square feet, etc (Molnar, 1983).

Determine Space Requirements (S1.3): Serves to determine current and projected growth for space and developing current and future space needs. There are a number of techniques that is useful in meeting space requirements. The approaches are either administrative methods or facilities methods. Administrative methods may not eliminate the need for a space, but they often reduce the amount of space needed and improve utilization. Such methods include housekeeping, housecleaning, temporary storage, use of vertical space, and use of proper equipment.

- *Housekeeping:* Housekeeping is keeping things picked up and in their place. It is not uncommon for people and organizations to take equipment and materials out and never put them away. Part of housekeeping is planning for storage shelving, storage pin racks, cabinets, etc.
- *Housecleaning:* Housecleaning is closely associated with housekeeping. Housecleaning is getting rid of items that are no longer needed. Obsolete and out of date papers, equipment, furnishings, and material should be thrown away, returned to general inventory, or processed through surplus procedures.
- *Temporary Storage*: Organizations may have items (records, equipment, materials) that are used only seasonally or occasionally. Providing temporary storage space for such low-use items means that they will take up less high-cost space.
- *Use of Vertical Space:* Available floor space is consumed by furniture, equipment and supplies. Wall-mounted shelves, vertical storage racks can reduce demand and improve utilization for floor space.

- *Proper Equipment:* Proper equipment records storage can be converted from standard file cabinets to movable files and powered filing systems that reduce the amount of floor space required or improve use of vertical space.

Facilities Methods deal primarily with making good use of available space in an organization. This method includes consolidation, good layouts and shared space.

- *Consolidation:* When two or more buildings contain unused space, it may be possible to combine occupants into fewer buildings, or occupants may be combined to empty a floor, wing, or bay. The main advantage of consolidation is reducing energy and maintenance costs.
- *Good Layouts:* Getting the most out of a space is not an easy task. Many persons have difficulty organizing activities, personnel, equipment, and furniture in a space to make maximum use of it. Good layouts can reduce circulation problems, traffic congestion, disturbances, and open space for important uses.
- *Shared Space:* Use of shared spaces, such as conference and meeting rooms, can be increased through scheduling. Shared space use might also be increased by analyzing attendance and considering subdividing a larger room (Brauer, 1992).

6.4.2 The ‘Plan Space’ Model

Process Definition

The ‘Plan Space’ process (node “S2” as shown in Figure 6.8) involves the action of translating space needs of an organization onto business needs and at the same time taking into account the defined adjacencies between business units (Best *et. al.,* 2003). The input necessary to carry out this process is a statement on space standards and requirements for every division and/or staff in the organization. The output is a statement on space plan and configuration. This process is broken into three functions, as shown in Figure 6.10. The following paragraphs provide a description of the functions involved.

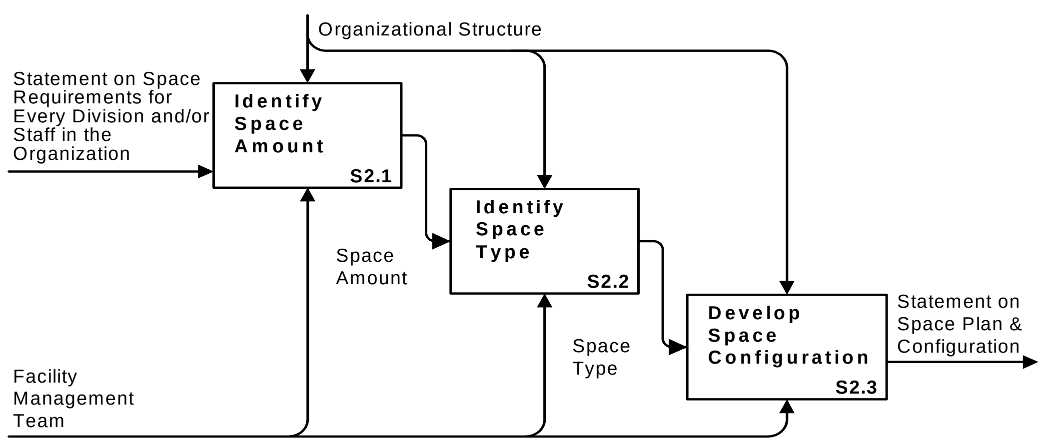

Figure 6.10: Node S2, Plan Space

Process Activities

Identify Space Amount (S2.1): This function serves to identify how much space is available within the facility.

Identify Space Type (S2.2): Serves to identify space type within the facility. For example office space types includes: ceiling high for executive offices and conference rooms, screen partitioned cubicles for supervisors offices and open floor space for clerical workstations (Molnar, 1983).

Develop Space Configuration (S2.3): Serves to develop space layout that translates user requirements into a floor plan for the space to be occupied.

6.4.3 The ‘Assign Space’ Model

Process Definition

The ‘Assign Space’ process (node “S3” as shown in Figure 6.8) involves designation of a particular space to a specific user for specific uses over a defined or indefinite period of time .The input to this process is the organization space plan. The output from this process is a list of the available space that has been assigned to the concerned division and/or staff in the organization. This process is broken into three functions, as shown in Figure 6.11. The following paragraphs provide a description of the functions involved.

Process Activities

***Receive Space Request (S3.1*):** This function involves submitting a formal request for the space.

Examine Space Request (S3.2): Serves to verify that the requirements in the request are valid and that they are within the company space standards.

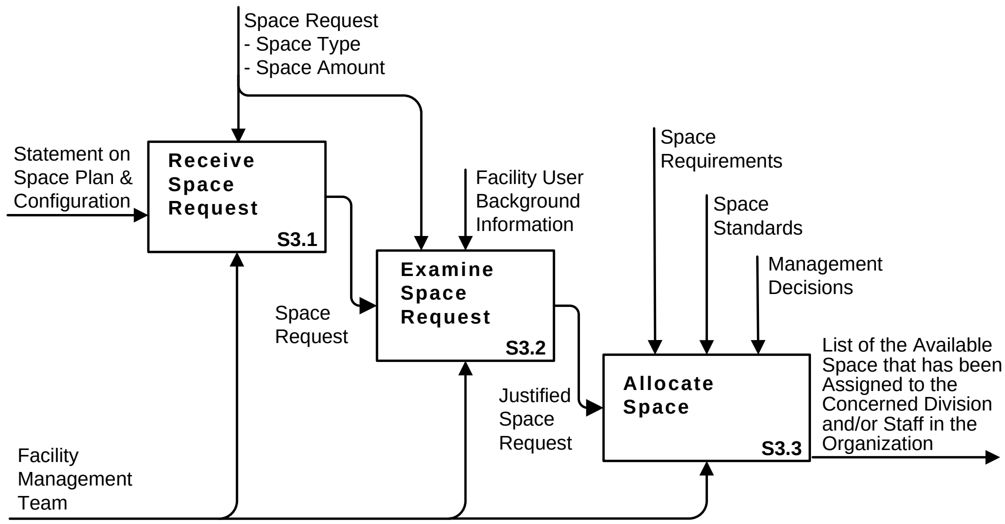

Figure 6.11: Node S3, Assign Space

Allocate Space (S3.3): This function is an essential part of space management in deciding what space a division and/or staff in the organization gets.

6.4.4 The 'Record Space Inventory' Model

Process Definition

The 'Record Space Inventory' process (node "S4" as shown in Figure 6.8) involves carrying out an inventory of the allocated facility's space and amounts of space within them. The input to this process is a list of assigned spaces to every division and/or staff within the organization, and a set of resources, including data storage and retrieval systems. The output from this process is an inventory of assigned spaces in the organization and a list of space reports on current and future space needs for organizations. This process is broken into three functions, as shown in Figure 6.12. The following paragraphs provide a description of the functions involved.

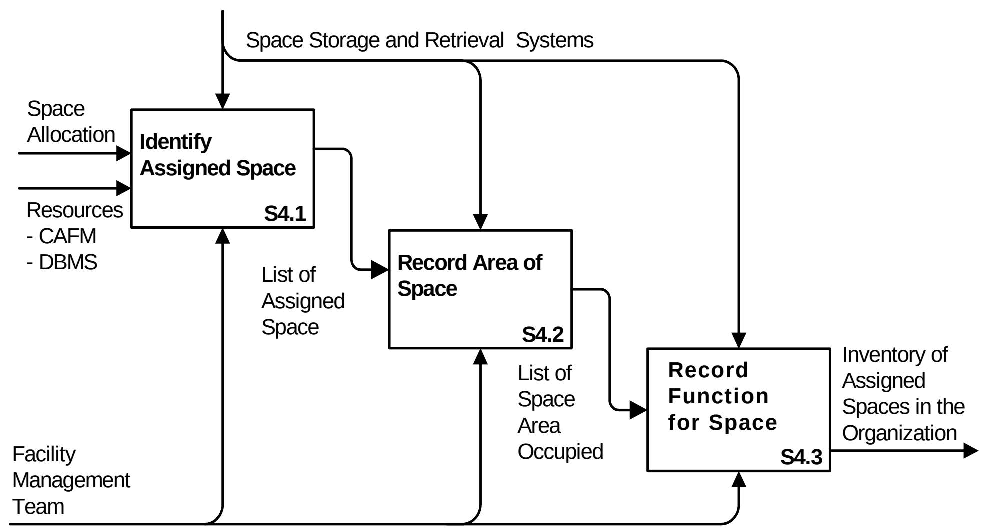

Figure 6.12: Node S4, Record Space Inventory

Process Activities

Identify Assigned Space (S4.1): Serves to identify the assigned space in which a specific building is located.

Record Area of Space (S4.2): Serves to record the area of assigned space. Areas of space may include rooms, vertical penetrations and service areas which are located within the facility. Rooms may include assigned rooms that are directly attributed to a department (house personnel or support space) and common areas rooms such as lunch rooms, and conference rooms that are shared and paid for by multiple departments. Vertical penetrations may include elevators, shafts, and pipes that serve more than one area of building. Service areas are areas required for the building's operation but are not available for general occupancy; rest rooms, lobbies, primary circulation and mechanical closets (AFM, 2002).

Record Function for Space (S4.3): Serves to record function for space by developing reports on space assignments, runs tabulation of what spaces are assigned to what organization for what use, and prepare utilization reports of various kinds of space (Brauer, 1992).

6.4.5 The 'Perform Space Audit & Surveys' Model

Process Definition

The 'Perform Space Audit & Surveys' process (node "S5" as shown in Figure 6.8) involves carrying out an evaluation and report on utilization of existing space, which required staff to perform walk-through inspection and compile data to determine whether assigned space is being used, what it is used for, and how efficiently it is used (Brauer, 1992). The input to this process is an inventory of assigned spaces in the organization. The output from this process is a statement on assigned space usage in the organization.

6.5 Maintenance Management Model

Modern facilities have become more and more complex. The discipline of FM has evolved to deal with the complexities of buildings, and their continual use and environments. It is now widely accepted that the process of FM commences upon the completion and commissioning of the building, and ends when the building ceases to be useful and is abandoned or demolished. Managing the maintenance of built assets requires a formalized and methodical approach. A maintenance management framework has been developed as part of the objectives of this thesis to provide facility managers with such an approach.

Building maintenance management is responsible for organizing and implementing planned maintenance programs, unplanned maintenance issues, refurbishments, alterations and extensions, building services control and management. In any organization , facilities and assets plays a vital role; they not only provide the physical working environment and reflect the organization's image, but also affect the organization; overall productivity. In order to prevent deterioration and breakdown and to resolve emergency maintenance problems, organizations need to monitor the maintenance, repair, and replacement of facilities and assets. The benefits of automating building maintenance management provides easy access to critical facilities information, cost-effectively manages on-demand work, track all maintenance tasks to better allocate time and resources for future jobs.

Building Management Systems (BMS) allow clients to monitor and operate all facets of a facility while keeping control of costs and tracking all of the information needed for effective building management. In addition to the traditional function of operating a facility's heating, ventilation, and air conditioning (HVAC) systems at optimum comfort conditions, a BMS may also provide a single interface for managing all of a facility's critical systems, such as lighting, fire protection, security, and access control (Kyle, 2001).

The maintenance management model is described schematically as an $IDEF_0$ process model, as shown in Figure 6.13. It consists of four sequential processes. For each of the sequential processes, a number of supporting activities have been defined, with their logical sequence and information requirements. The four processes forming the maintenance management model are as follows:

- Receive and Process Work Order (referred to as node "M1")
- Plan Maintenance (referred to as node "M2")
- Perform Maintenance Work (referred to as node "M3")
- Manage Reports (referred to as node "M4")

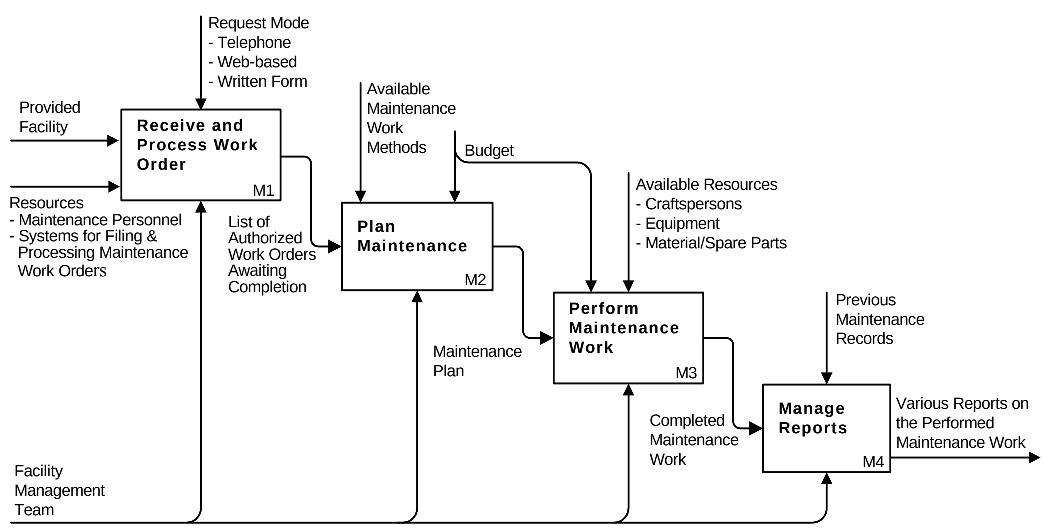

Figure 6.13: General Processes Involved in Maintenance Management Model

The following sections describe the processes involved in the maintenance management model, and the activities that are carried out to complete each process.

6.4.1 The 'Receive and Process Work Order' Model

Process Definition

The 'Receive and Process Work Order' process (node "M1" as shown in Figure 6.13) involves receiving the work request from the facility user via various ways including: telephone, internet, memorandum, or a personal visit (AFM, 2002). This process also enables processing the work requested from the time it has been received until it is completed (NODIS, 2003).The inputs necessary to carry out the 'Receive and Process Work Order' process are an existing facility and a set of resources, including maintenance personnel and systems for filing and processing maintenance work orders. The output from this process is a list of authorized work orders awaiting completion. This process is broken into four functions, as shown in Figure 6.14.

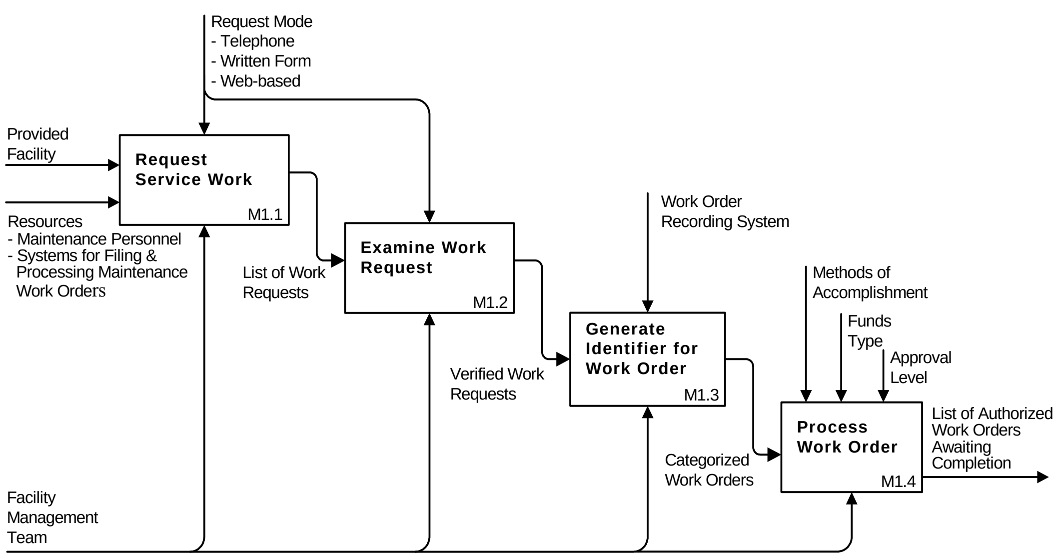

Figure 6.14: Node M1, Receive and Process Work Order

The following paragraphs provide a description of the functions involved.

Process Activities

Request Service Work (M1.1): This function serves to communicate the need for carrying out maintenance work requested by the facility user. A service request is work requested by a facility user and it may be either a small job that does not require planning and estimating or a large job that requires planning, estimating and scheduling.

Examine Work Request (M1.2): Serves to verify that the requirements in the request are valid and that they are within the facility standards.

Generate Identifier for Work Order (M1.3): Serves to identify work, location where problem exists within the facility in which a maintenance operation will be taking place. Each item of work is given a unique identifier or designator, muck like a serial number. This identifier permits tracking the work item through its life of planning, approval as a work order, execution, and historical documentation.

Process Work Order (M1.4): Serves to identify various necessary aspects of information required for completing the work order. These aspects involve determining the following information (NODIS, 2003):

- *Funds Type:* Funds type describes whether the work is reimbursable or non-reimbursable. If the work is reimbursable, the fund citation normally identifies the user; if non-reimbursable, the funds citation normally identifies the appropriation of project or program.

- *Approval Level:* It identifies who has the authority to approve the work. The designation of individuals authorized to approve work is based on a hierarchy of cost, urgency, or other management considerations.
- *Methods of Accomplishment:* The method of accomplishment identifies whether the work will be accomplished by service staff, by established support service contractors, or under a separate, new contract.

6.4.2 The 'Plan Maintenance' Model

Process Definition

The 'Plan Maintenance' process (node "M2" as shown in Figure 6.13) involves identifying specific maintenance tasks to be performed, phasing those tasks, identifying the skills and crafts required for the tasks, and specifying the material and equipment for the tasks (Palmer, 1999). It includes identifying specific health, safety requirements, coordination, and equipment availability. This process also involves budgeting for completing the work required. The inputs necessary to carry out the 'Plan Maintenance' Process is a list of authorized work orders awaiting completion. The output is a list of planned for and authorized maintenance work orders awaiting completion. This process is broken into three functions, as shown in Figure 6.15. The following paragraphs provide a description of the functions involved.

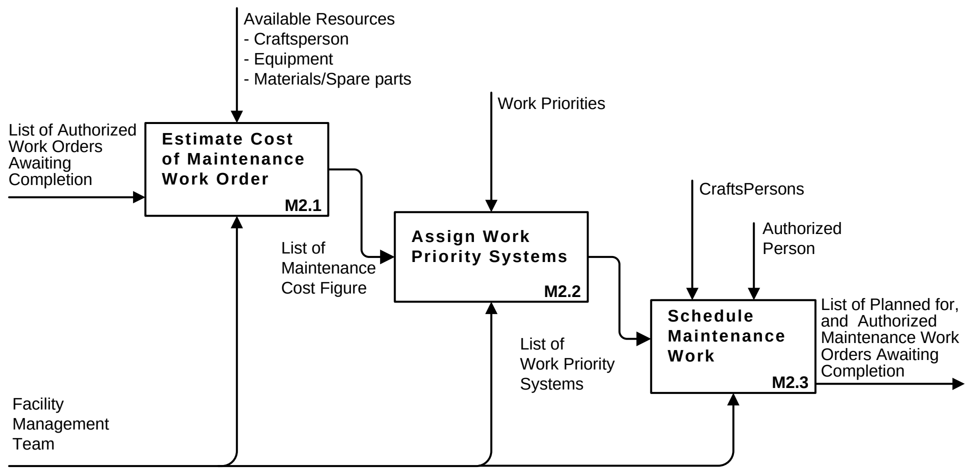

Figure 6.15: Node M2, Plan Maintenance

Process Activities

Estimate Cost of Maintenance Work Order (M2.1): Serves to estimate the costs for carrying out the requested maintenance work. Cost estimates are developed by multiplying unit labor, equipment, and material costs by job task quantities and adding the appropriate adjustments for overhead and indirect costs. The exact form of the cost estimate depends on its intended use. The process of estimating cost of maintenance work orders comprises of the following four sub-functions (Hassanain *et al.*, 2003), as shown in Figure 6.16.

Estimate Number and Trade of Workers (M2.11): Serves to estimate the number and the trade of workers needed to perform the maintenance work requested. Some maintenance jobs require a crew of a single trade. Some jobs require multiple crews of multiple trades.

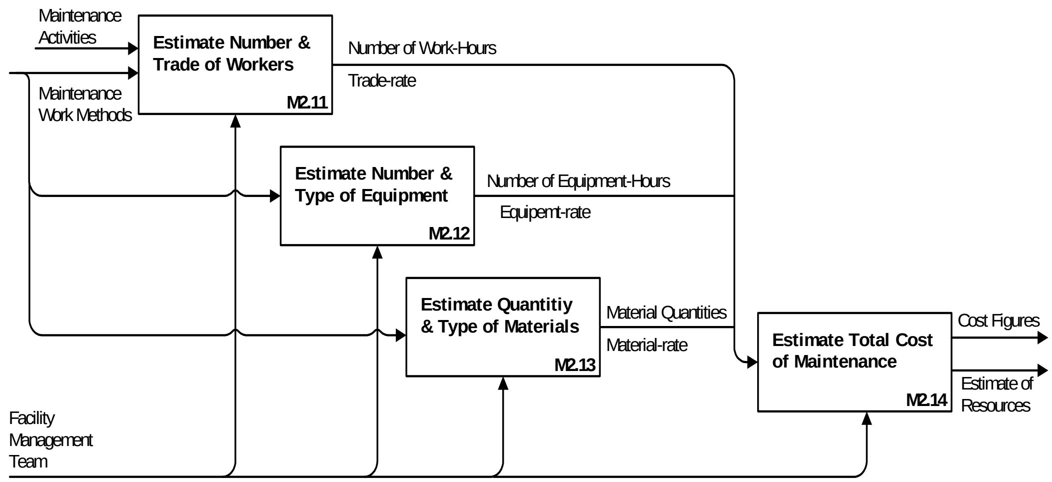

Figure 6.16: Node M2.1, Estimate Cost of Maintenance Work Order (Hassanain *et al.*, 2003)

***Estimate Number and Type of Equipment (M2.12)*:** Serves to estimate the number and type of equipment needed to execute the maintenance work. The number of hours the equipment is going to be used can be estimated. The hourly rate for using the equipment can be determined.

Estimate Quantity and Type of Materials (M2.13): Serves to estimate the quantities and the type of material needed to perform a requested maintenance work. Some maintenance jobs are simple and require only one type of material. Some jobs are complex and require the combination of several materials.

***Determine Total Cost of Maintenance Activity (M2.14)*:** Serves to estimate the total cost of carrying out the requested maintenance job. The estimated cost would be the summation of the following cost items: man-hours, equipment/tools, and materials needed to perform the work.

Assign Work Priority Systems (M2.2): Serves to indicate high-priority work to be completed first while managing all work to ensure its accomplishment in accordance with facility needs. The priority is normally determined as part of the work review process. It guides material procurement, scheduling, and work execution. A priority sequence is necessary in any maintenance system. The originator of the work order specifies a finish date to complete each work request, and a coordinator assigns a priority. The following are the possible priority definitions (Mann, 1983):

- *Priority 1:* Designates emergency or safety work. Emergency work is defined as work necessary to stop a serious loss or safety of life or property threatened; immediate mission impact; loss of utilities. This priority covers any work that must start within twenty–four hours after the need for it becomes apparent. This priority carries automatic approval of overtime, and work will go on until it is completed.
- *Priority 2:* Designates as urgent work. Maintenance or repair work required for continued facility operation; should be completed to ensure continuous operation of the facility and to restore healthful environment. Respond upon completion of current work but within a specified period of time.
- *Priority 3:* Designates as routine work. The facilities maintenance work can be scheduled routinely within the capability of the facilities maintenance organization. Facilities work is subject to availability of resources, and may be consolidated by facility or zone or as directed to obtain efficiency of operation.
- *Priority 4:* Designates as discretionary. Work that is desired but not essential to protect, preserve, or restore facilities and equipment; typically, new work that is not tied to a specific mission milestone.
- *Priority 5:* Designates as deferred work. Work that may be safely, operationally, and economically postponed. The work should be done, but

cannot be scheduled because of higher priority work, funds shortage, work site access, or conditions outside the control of the maintenance organization.

Schedule Maintenance Work (M2.3): Serves to schedule the maintenance work requested based on the availability of resources, priorities, and job assignments. Scheduling work orders is necessary to ensure a balanced flow of work to the shops in accordance with priorities, external factors (such as weather), and operational considerations. It facilitates optimum use of resources and provides information to optimize the distribution of shop staffing by craft. The following factors should be considered in scheduling maintenance work (NODIS, 2003):

- *Preventive Maintenance:* An effective preventive maintenance program minimizes the need for work request and repair. Efficiencies can be obtained by using staff dedicated to preventive maintenance work because they become familiar with the equipment. Preventative maintenance work orders should be scheduled and grouped by facility or geographical area to minimize travel.
- *One-time Work Orders:* Work orders for one-time jobs require the greatest scheduling coordination and management effort. This is due to the unique requirements of each job.
- *Repetitive Work Orders:* Repetitive work orders include predictable level of effort and repeating work requirement such as grounds care, street sweeping, and re-lamping. Like preventive maintenance, they are scheduled as part of the baseline shop workload.
- *Small Jobs:* Small jobs, typically those requiring less than 20 work hours and issued on work order, are normally worked on a first-come, first-served basis, subject to the availability of material. Because they can represent a fairly

constant level of effort and normally involve routine methods and materials, it is common practice to have a shop dedicated to this size work.

6.5.3 The 'Perform Maintenance Work' Model

Process Definition

The 'Perform Maintenance Work' process (node "M3" as shown in Figure 6.13), involves craftsmen executing requested and planned for maintenance work orders. It includes functions required to manage material, schedule maintenance, and work execution. The input to this process is a list of planned for, authorized maintenance work orders awaiting completion. The output is the list of statement on recording work completion and closing work order. This function is broken down into three functions, as shown in Figure 6.17.

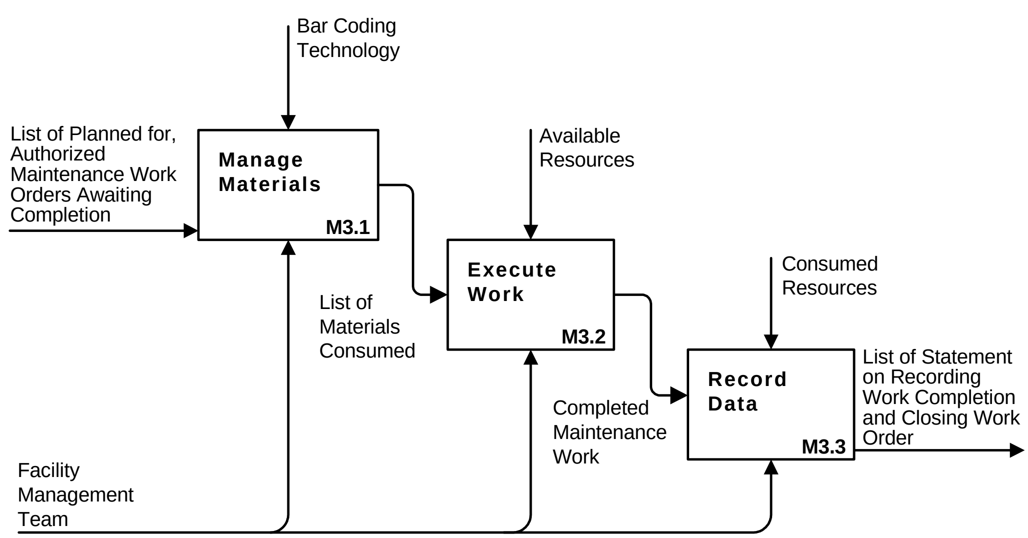

Figure 6.17: Node M3, Perform Maintenance Work

The following provide a description of the functions involved:

Process Activities

Manage Materials (M3.1): Serves to include ordering, stocking, storing, issuing, and receiving materials for use on work orders. Bar coding is used extensively in material management to speed data entry and reduce data entry errors (NODIS, 2003).

Execute Work (M3.2): Serves to execute work orders when all resources become available and coordination between these resources is in place. Quality control and quality assurance functions are used to perform work. Quality control is a responsibility of the organization executing the work. Shop supervisors usually have the primary responsibility for work quality control based on policies and procedures of the organization responsible for the work.

The following factors should be considered in work acceptance (NODIS, 2003).:

- *Final Inspection:* Final inspections are performed as appropriate depending on the nature and size of the completed work. If the work to be inspected is for a customer, the customer should participate in the final inspection in order to accept the work. If customer expectation goes beyond the work order scope, the job should be referred promptly to the facilities maintenance manager for resolution.
- *Defective Work:* Defective or rejected work occurs for a number of reasons, including poor workmanship, an incorrectly scoped and prepared work order, defective material, or poorly defined customer requirements. When defective work is discovered, it should be corrected to satisfy the

operational needs and to meet safety requirements. Correction of safety related deficiencies should be accomplished immediately.

- *Rework Causes and Correction:* A decision to rework a job should be based on cost-benefit considerations, including operational commitments; cost to rework the job, expected added benefit as a result of rework, and availability of resources. Separate work orders should be established to accumulate rework data. Other factors, which would require rework, are jobs that do not meet safety regulations and/or other mandatory laws. The evaluation process should address causes of defective work and methods of reducing rework. Remedial actions may include revising internal procedures such as quality control procedures, providing additional employee training and skill development, changing material specifications, adding early material acceptance inspections, revising facilities maintenance standards and requirements, and increasing customer involvement with work order preparation and approval.

Record Data (M3.3): Serves to record the work completed and the resources used for closing the work order. When the work has been completed and accepted a completion report is submitted. Care must be exercised to identify and record all of the work accomplished, particularly when the initial request is sketchy or incomplete. The labor and material used are recorded for record and accounting purposes. The results are recorded in the facility or equipment history files, and evaluation action is initiated. The information reported should include unanticipated conditions encountered, a concise description of the work accomplished, and additional material used but not listed in the work order (NODIS, 2003).

6.5.4 The ‘Manage Reports’ Model

The ‘Manage Reports’ process (node “M4” as show in Figure 6.13), involves reporting performed maintenance work, resources consumed, and time taken to complete the work. The input to this process is a list of completed maintenance work orders. The output is a document that could report on various aspects of the work performed. The following paragraphs provide a description of the various types of reports that could be generated (NODIS, 2003).

- **Status Reports**
  - *Inventory:* This report could include displays of facilities and maintainable equipment inventory statistics, use, user, age profiles, and similar data. Significant portions of this information can be used in space management and planning.
  - *Status of Funds:* This type of reports would provide an up-to-date status of funds by source, including amounts authorized, reserved, and obligated. It also includes a comparison of planned to actual expenditure rates.
  - *Status of Work:* This type report indicates the state of work progress in a facilities maintenance management system. It includes the identification of actions completed, actions pending, responsible parties, and milestone dates. Variations of this report could include arranging the information by user, work classification, status, or facility. It could take the form of a history of selected work items showing their progress through a facilities maintenance management system.

- *Status of Major Projects:* This report would include major undertakings such as construction of facilities projects, major facilities maintenance projects, and projects of special interest. The reports should reflect cost estimates, project milestones, and progress against those milestones.
- *Materials:* This report could include the status of materials inventory, orders, and jobs awaiting material.

- **Work Performance Reports**
  - *Work Input:* Reports on work input include statistics on work generation and the characteristics of that work. They may include information on service requests (arranged and tabulated by date of request, facility user, special interest area, facility number, and craft) and work orders generated by the inspection program.
  - *Work Execution:* Reports on work execution include information on shop schedules, planned work, and job status, estimated versus actual job performance, delayed or late jobs, and related performance indicators.
  - *Utilities:* This report would contain information on production, consumption, costs, conservation measures and targets, and related factors such as weather profiles.

6.6 Emergency Preparedness Management Model

Facility managers are trained either in buildings studies or building services engineering. Their training background may influence their attitude towards the priority setting on individual maintenance items and their judgment in the importance of emergency preparedness of facilities may not be the same (Lo *et al*., 2000). This requires a facility manager to have a formalized and methodical approach. An emergency preparedness management framework has been developed as part of the objectives of this thesis to provide facility managers with such an approach.

Emergency preparedness is responsible for providing critical information and reporting tools to the concerned people during the phases of disasters, natural calamities and fire hazards/risk involved in the facility. The building occupants and/or facility users expect to carry out their day-to-day operations in relative safe environment. Facility managers must ensure that appropriate levels of safety are provided and properly maintained. They must do so with knowledge of the occupancy profiles of their facilities and manage accordingly. The need for automating emergency preparedness activities such as disasters, natural calamities and fire safety helps in delivering critical information to the right people during the period of emergency in order to protect life, minimize damage, and to recover critical business functions.

The emergency preparedness management model is described schematically as an $IDEF_0$ process model, as shown in Figure 6.18. It consists of four processes. For each of the processes, a number of supporting activities have been defined, with their logical sequence and information requirements. The four processes forming the emergency preparedness management model are as follows:

- Establish Safety Department (referred to as node “E1”)
- Identify Safety Requirements (referred to as node “E2”)
- Develop Emergency Preparedness Plan (referred to as node “E3”)
- Conduct Risk Assessment (referred to as node “E4”)

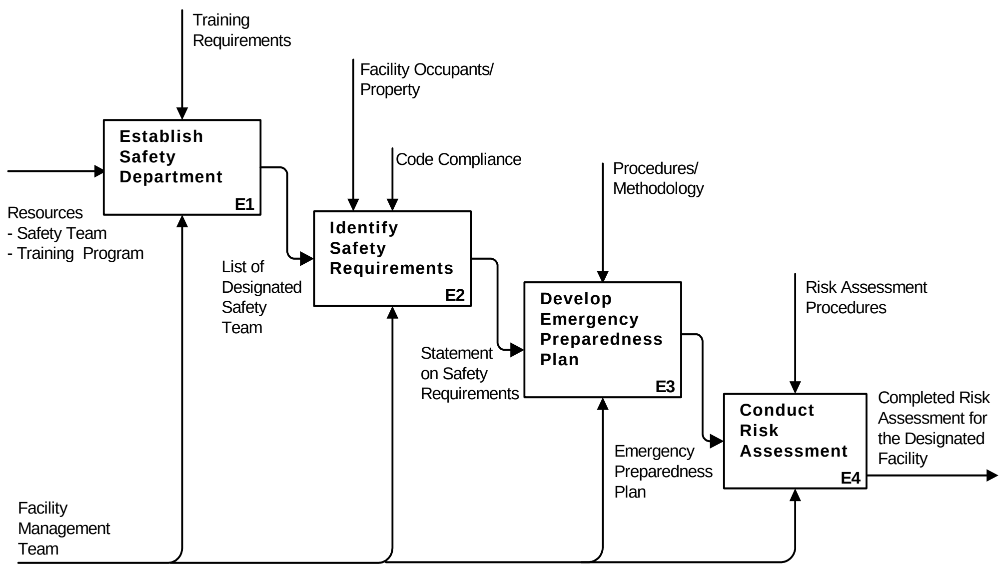

Figure 6.18: General Processes Involved in Emergency Preparedness Management Model

The following sections describe the processes involved in the emergency preparedness management model, and the activities that are carried out to complete each process.

6.6.1 The ‘Establish Safety Department’ Model

Process Definition

The ‘Establish Safety Department’ process (node “E1” as shown in Figure 6.18) involves the establishment of a safety department in the organization. This department is primarily concerned for the safety of the facility occupants and the properties. The inputs necessary to carry out the 'Establish Safety Department' process is a set of resources, including safety team and training program. The output is a list of designated safety team. This process is broken into three functions, as shown in Figure 6.19. The following paragraphs provide a description of the functions involved.

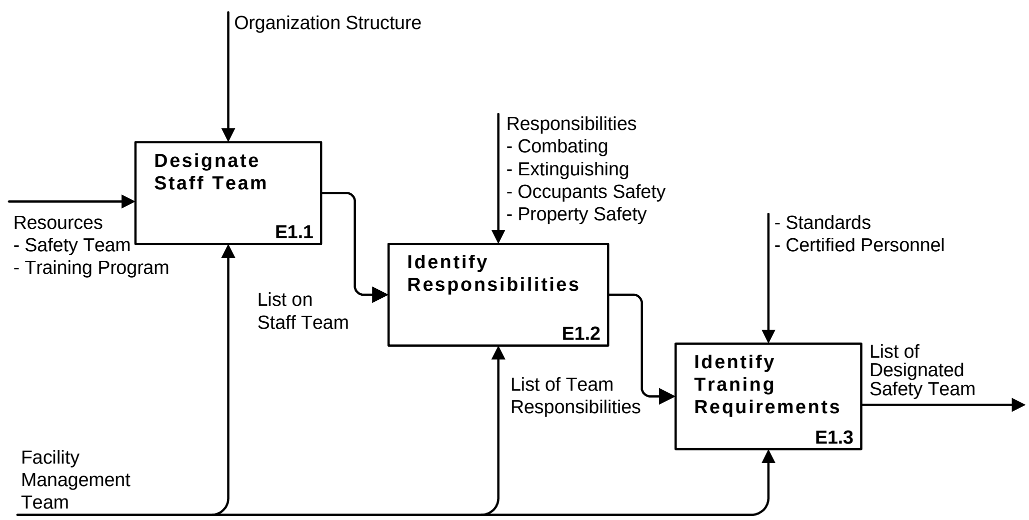

Figure 6.19: Node E1, Establish Safety Department

Process Activities

Designate Staff Team (E1.1): This function serves to set the formal organization of designating staff team to perform specified duties in the event of a crisis by appointing division head, safety advisor and inspector.

Identify Responsibilities (E1.2): Serves to identify responsibilities of a safety team. A safety team is responsible for developing plans to combat, extinguish, and prevent fires, tackle disasters, natural calamities, life and property of facility in the event of actual crisis.

Identify Training Requirements (F1.3): Serves to identify training requirements given to the team, which are essential in order to protect the life of occupants and property.

6.6.2 The 'Identify Safety Requirements' Model

Process Definition

The 'Identify Safety Requirements' process (node "E2" as shown in Figure 6.18) involves the inspection of facility to identify safety protection and prevention activities. The input to this process is list of designated safety team. The output is a statement on safety requirements in the facilities. This process is broken into three functions, as shown in Figure 6.20. The following paragraphs provide a description of the functions involved.

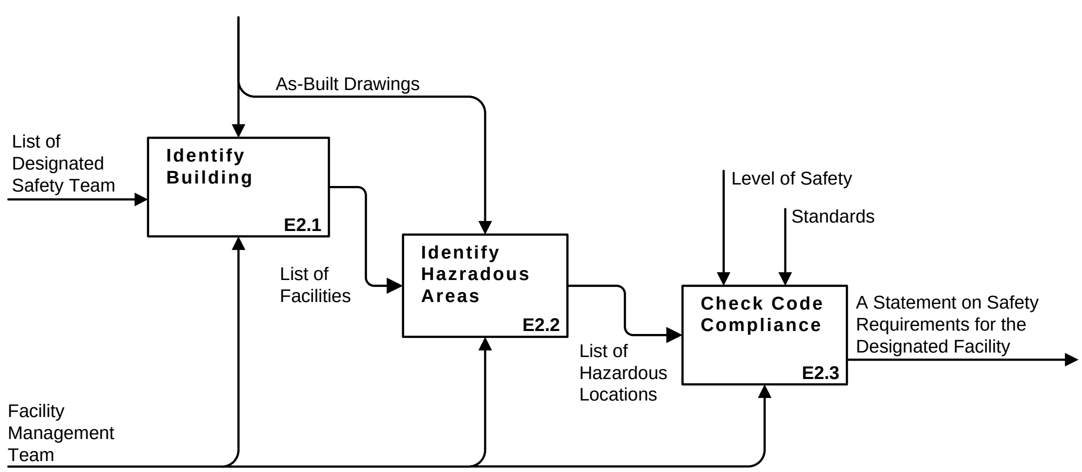

Figure 6.20: Node E2, Identify Safety Requirements

Process Activities

Identify Building (E2.1): Serves to identify the facility in which specific building is located which is going to be the subject for safety protection and prevention measures.

Identify Hazardous Areas (E2.2): Serves to identify the hazardous areas in the facility. There are the limited access area and the evacuation area. A limited access area may be defined as the area in which personnel are potentially in immediate danger from a hazardous condition. Access to this area will be rigidly controlled and only personnel with proper protective equipment and an assigned activity will enter. The evacuation area is the larger area surrounding the limited access area in which a lesser degree of risk to personnel exists. The area to be evacuated depends on the nature and amount of the material and type of risk it presents to unprotected personnel (PFDO, 2004).

Check Code Compliance (E2.3): Serves to assist design engineers with understanding and meeting the intent of the building code hazardous occupancy requirements and the fire code requirements relating to the storage and use of hazardous materials. Fire codes are designed to achieve a minimum level of safety; even though the level of detail in the codes is extensive they can't possibly cover every hazard or combinations of hazards A builder or designer considering safety in a residential building must consider an intricate balance of measures, many of them contained in the building and fire codes, to achieve minimal risk to the occupants of the residence (EORM, 2004).

6.6.3 The 'Develop Emergency Preparedness Plan' Model

Process Definition

The 'Develop Emergency Preparedness Plan' process (node "E3" as show in Figure 6.18) involves the development of a plan to protect the life and property of the facilities (FSP, 2004). The input to this process is list of safety requirements in the facilities. The output is a developed emergency preparedness plan for implementation. This process is broken down into five functions as show in Figure 6.21. The following paragraphs provide a description of the functions involved.

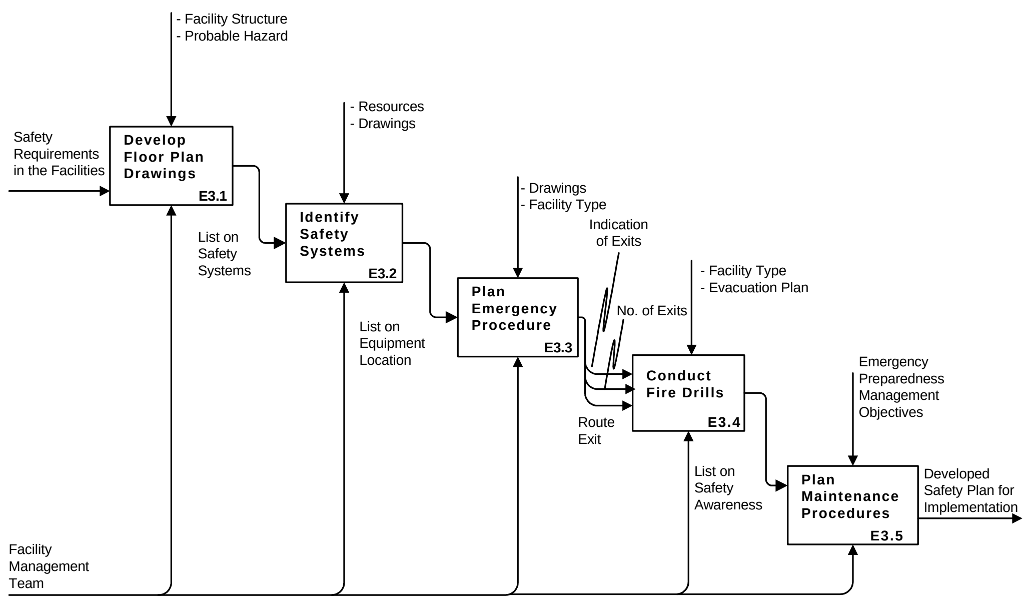

Figure 6.21: Node E3, Develop Fire Safety Plan

Process Activities

Develop Floor Plan Drawings (E3.1): This function serves to develop floor plan drawings that will show the location of all life safety and fire suppression equipment, all exits, door swings, location of hazardous materials.

Identify Safety Systems (E3.2): Serves to identify safety equipment in the building, the location and operational instructions for fire alarm, voice communication, elevator, and smoke control system.

Plan Emergency Procedures (F3.3): Serves to develop procedures to be followed by the occupants in case of emergency. The following are emergency procedures to be followed in case of crisis:

- Sounding the alarm to notify the facility users.
- Notifying the safety department.
- Instructing occupants on procedures to be followed when the alarm sounds.
- Evacuating endangered occupants, including special provisions for the disabled.
- Confining, controlling and extinguishing a fire, and
- Estimating the time required to complete evacuation.

Conduct Fire Drills (E3.4): Serves to perform fire drills at least annually and in buildings over six floors they are to be held quarterly. Occupants must be notified at least 48 hours in advance of fire drills and they should be asked to participate.

Plan Maintenance Procedures (E3.5): Serves to include checks, test, and inspection procedures for each type of fire and life safety equipment in the building.

6.6.4 The 'Conduct Fire Risk Assessment' Model

Process Definition

The 'Conduct Fire Risk Assessment' process (node "E4" as shown in Figure 6.18) involves the systematic evaluation of a task or environment to identify hazards and risks with the objective to eliminate the hazards or to reduce risk to the lowest acceptable level (Ramachandran, 1999). A risk assessment helps to identify all the hazards and risks in the workplace. The purpose of risk assessment is to create a safe and healthy workplace and help the facility manager to determine what measures should be taken to comply with the duties under the relevant statuary provisions (Pitcher, 2002). The input to this process is the developed emergency preparedness plan for the designated facility. The output is the completed risk assessment for the designated facility. This process is broken into six functions, as shown in Figure 6.22.

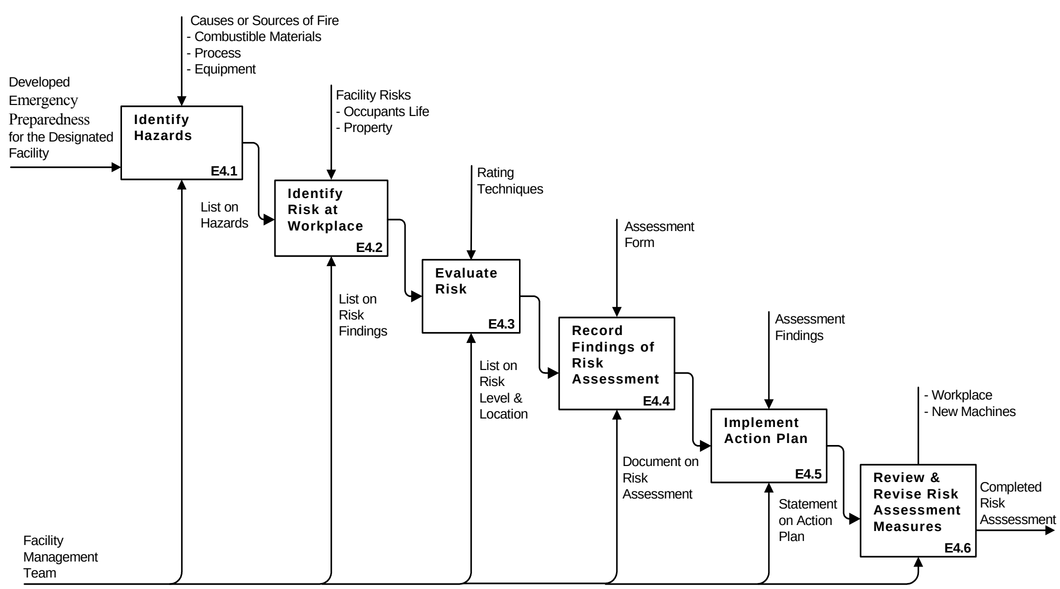

Figure 6.22: Node E4, Conduct Risk Assessment

The following paragraphs provide a description of the functions involved.

Process Activities

Identify Hazards (E4.1): Serves to identify the causes or sources of fire, disasters, and accidents in the workplace. A hazard is something with potential to cause harm. These include potential sources of ignition which can contribute a rapid spread of fire, smoke, toxic gases, substances or equipment used, work processes or work organization which have the potential to cause harm (HAFED, 2004).

Identify Risk at Workplace (E4.2): Serves to identify people at risk, identify property at risk and identify risk at workplace. People at risk may include staff and visitors. Property at risk relates to plant, equipment, fabric of the building, contents of the building, manufactured product, and power source, location, obtaining new machinery, maintenance and cleaning. Risk may be defined as "the likelihood of potential harm from a hazard being realized". This will depend upon the likelihood of harm occurring, the impact of harm and population, which may be affected by hazard (HAFED, 2004).

Evaluate Risk (E4.3): Serves to evaluate risks and decide whether existing precautions are adequate or more should be done. These may include impact of harm, likelihood of harm, and risk action level (Pitcher, 2002).

- *Impact of Harm:* The impact of harm includes parts of body affected, and the nature of harm or risk impact ranging from insignificant to catastrophic. Table 6.1 provides a description of the terms used to express the levels of harm.
- *Likelihood of Harm:* The likelihood of harm includes number of people exposed, frequency and duration of exposure, the impact of failure of the

system or equipment, exposure to the elements. These subjective assessments of the impact of harm and it likelihood should take into account all people exposed to the hazard. Table 6.2 provides a description of the terms used to express risk likelihoods

- *Risk Action level:* By lining up the likelihood of risk against the impact of risk facility manager can evaluate the risk action level, low (L), medium (M), high (H) or extreme (E) and allocate properties. Table 6.3 provides a description of the terms used to express levels of risk. Table 6.4 provides a matrix illustrating the various levels of risk resulting from the combination of a specific risk likelihood of occurrence with a specific level of harm.

Table 6.1: Description of the Terms Used to Express the Levels of Harm (Pitcher, 2002)

Term Used to Express Harm	Description of Term
Insignificant	No injuries, low financial loss
Minor	First aid treatment, on-site release immediately contained medium financial loss
Significant	Medical treatment needed, on-site release contained with outside help, high financial loss
Severe	Extensive injuries, loss of production capability, off-site release with no detrimental effects, major financial loss
Catastrophic	Death, toxic release off-site with detrimental effect, huge financial loss

Table 6.2: Description of the Terms Used to Express Risk Likelihood (Pitcher, 2002)

Likelihood of Risk	Description of Term Used to Express Likelihood of Risk
Very Likely	Is expected to occur in most circumstances.
Likely	Will probably occur in most circumstances.
Unlikely	Might occur at some time.
Improbable	Could occur at some time.

Table 6.3: Description of the Terms Used to Express Levels of Risk (Pitcher, 2002)

Levels of Risk	Description of Term Used to Express Levels of Risk
L(ow)	Acceptable Risk. Low priority
M(edium)	Medium priority. The organization's business could be adversely affected if this initiative were not taken forward. The associated risk in not taking the initiative forward could be justified.
H(igh)	High priority. The organization's business could be adversely affected if this initiative were not taken forward. The associated risk in not taking the initiative forward might be justified.
E(xtreme)	Top priority. The organizations would be vulnerable if this initiative were not taken forward. The associated risk in not taking the initiative forward could be unacceptable to the organization.

Table 6.4: Matrix of Various Levels of Risk Resulting from Combining a Specific Risk Likelihood with a Specific Level of Harm (Pitcher, 2002)

Risk Likelihood	Levels of Harm				
	Insignificant 1	**Minor 2**	**Significant 3**	**Severe 4**	**Catastrophic 5**
Improbable	L	L	M	H	E
Unlikely	L	M	M	H	E
Likely	L	M	H	E	E
Very Likely	L	M	H	E	E

Record Findings of Risk Assessment (E4.4): Serves to record the significant findings of the assessment together with the details of any persons identified as being at particular risk. Records should include the significant hazards, the staff groups exposed to risks, the safe working arrangements to control the risks, including the physical controls, systems of work, and the training requirements, date of the assessment and the latest date for review. (HAFED, 2004).

Implement Action Plan (E4.5): Serves to include action plan that will be used to identify control measures that are required to control risk to a reasonably practicable standard. An action plan with target dates for completion is often the most appropriate way of ensuring that the necessary arrangements are put into place effectively. The risk control measures include remove or eliminate the risk, substitution of a hazardous material or process with a non-hazardous one, separate or isolate the non/ employee from the hazard, develop and use safe systems of work, train, instruct, supervise, and provide personal protective equipment to minimize risks (HAFED, 2004).

Review & Revise Risk Assessment Measures (E4.6): Serves to review and revise the measures of risk assessment if there is a significant change in the workplace, inclusion of new machines structural alterations to buildings, or new building work. From time to time, changes in the workplace will be introduced which have an effect on fire risks and precautions, e.g. changes to the work processes, furniture, plant, machinery, substances, buildings, or the number of persons likely to be present in the workplace. Any of these could lead to new hazards or increased risk. If there is any significant change, the assessment will need to be reviewed in the light of the new hazard or risk (HAFED, 2004).

6.7 Discussion

This chapter deals with the development of FM framework models for major FM functions, including construction drawing creation and management, inventory management, space management, maintenance management, and emergency preparedness management, for the purpose of facilitating the automation of FM practices in Saudi universities. These models describe a collection of knowledge areas including construction drawing creation and management, inventory management, space management, maintenance management and emergency preparedness management. The knowledge areas described in the framework models have previously existence in practice and documented in literature, but they have not been introduced to the FM domain in a formalized and methodical approach which facilitates the identification of FM processes as presented through the development of process models in this thesis. This framework encompasses one of the contributions of this research work to the FM domain.

The framework was motivated by the desire to develop IT solution for the FM organizations such as universities, municipalities. The framework models are described schematically as an $IDEF_0$ process model for illustrating FM practices. A process model is a graphic representation of a business process that exhibits the activities to any desired level of detail. A process model reveals the interactions between activities in term of inputs and outputs while showing the controls placed on each activity and the type of resources assigned to each activity. Illustrating the framework in the form of $IDEF_0$ helps facility managers in identifying what functions are be performed, what is needed to perform these functions, what the current system does right, and what the current system does wrong.

The following paragraphs provide the brief description of specific aspects in the framework:

1. *Construction Drawing Creation and Management:* This model is first in series of FM models. This models deals with developing preliminary drawings,

developing construction documentation, recording as-built drawings and finally ends with the managing information database of the construction facility.

2. *Inventory Management Model:* This model is the foundation of FM domain. It deals with key elements of inventory by assessing the assets owned by the organization, valuation of assets and the level of asset performance against an agreed set of condition service standards.
3. *Space Management Model:* This is the second FM model which deals with the process of reviewing the organization structure, projecting space requirements, assigning space, recording occupied space by users, and carrying out surveys to determine whether space users support space which are assigned to them.
4. *Maintenance Management Model:* This is the third FM model which deals with the requesting work order, planning and estimating of maintenance tasks, scheduling the work based on available resources, work execution by the craftsmen, documenting the work, and preparing the report of the work completion and closing the work order.
5. *Emergency Preparedness Management Model:* This is the last FM model which deals with establishing the safety department, safety requirements, developing the emergency preparedness plan, and conducting risk assessment.

CHAPTER 7

CONCLUSIONS & RECOMMENDATIONS

7.1 Summary

This research is divided into seven chapters. Chapter 1 (Introduction) gives an introduction to the FM domain and need of FM in organizations to manage their built-facilities. It presents statement of the problem, research objectives, the scope and limitations of the research work, the methodology adopted in achieving the stated objectives

Chapter 2 (Literature review) describes with the overview of FM and FM practices followed in various organizations such as hospitals, municipalities, and transportation. The case studies also included to provide a base for carrying out this research and help in decision-making in the FM domain.

Chapter 3 (Automation of FM practices), presents the need of automating FM practices in the organizations. The potential growth of automating FM practices resulted with the introduction of IT. Facility managers demand more data in terms of quality and quantity and want these data reported more often. Automation provides information on a wide range of FM functions that enables facility manager's performance in making vital decisions of the organization.

Chapter 4 (Level of Automation in FM practices in Universities World-Wide), presents the level of automation of FM practices that are followed in different universities that are located in countries like Australia, Canada, UK and USA.

Chapter 5 (Analysis of Automation Survey), discusses the detailed data analysis of automation survey of FM practices in the universities of Saudi Arabia. It also highlights on the main findings of the survey and solicit the input from the practitioners on automation of FM practices in Saudi universities.

Chapter 6 (Development of FM Framework models) presents the development of FM framework models for the purpose of facilitating the automation of FM practices in Saudi universities. The FM framework models deals with the collection of diverse knowledge for four critical areas of practice. These models are: construction drawing creation and management, inventory management model, space management model, maintenance management model and emergency preparedness management model. The four FM models are described as IDEF0 (Integration Definition for Functional Modeling) for illustrating FM practices. Today facilities have become more and more complex. Facility managers faced problems in managing these built-facilities. Managing these facilities facility manager requires a formalized and methodical approach. Hence the need to develop a framework model for FM domain is realized based on the findings obtained from analyzing the automation survey of FM practices in the Saudi universities and that lead to facilitate automation of FM practices in Saudi universities.

7.2 Conclusions

The following conclusions were developed from this research:

1. FM will help organizations in achieving their goals and evaluate the process relative to the goals.
2. The investigation of level of automation in FM practices in universities that are located in countries like Australia, Canada, UK and USA, found a number of applications for decision-making in the domain of FM and solutions that addresses the current and future needs for developing FM practices.
3. The need of automating FM practices is to make organizations more competitive by adopting, developing, maintaining an appropriate level of knowledge and skill in IT, increasing work productivity and improving decision-making processes. This study found that the great majority of the Saudi universities use computers. However, computer resources have not been employed to utilize the potential capabilities of IT in carrying out the FM practices. In the process of producing drawings, it was found that vast majority (85.71%) of the Saudi universities draft their architectural and engineering drawings using computers and the rest (14.29%) manage

manually. The results also show that 33.33% of respondents use CAD systems for preparing layout of furniture & equipment items and 40% of respondents use computers in the activity of emergency preparedness management. This indicates that automation of FM activities is still in operational level and the other two decision levels managerial and strategic is still to be implemented by the Saudi universities.

4. In terms of sharing information with other departments, the survey findings indicated that 50% of the FM departments are sharing information via computers. Some are using telephone to share information with other departments. This indicates that Saudi universities varied on sharing information with other FM departments.
5. In the managing work orders using computers, the Saudi universities users record their work request via telephone, followed by computer based management system and then by web-based. The results also show that 50% of the respondents indicated that they never used computers and 33.33% of the respondents use computer sometimes to track scheduled and unscheduled maintenance activities. This shows that the Saudi universities use computers for one activity and manage other activities manually.
6. 33.33% of the respondents indicated that never use computers to generate reports for maintenance activities and 50% of the respondents rarely use computers in the case of furniture and equipment. This shows that Saudi universities are least interested to use computers in preparing reports on maintenance activities, furniture and equipment items.
7. The development of FM framework models for major functions, including

construction drawing creation and management, inventory management, space management, maintenance management, and emergency preparedness management, helps in analyzing current FM practices based on the findings obtained from analyzing the automation survey of FM practices and facilitating the automation of FM practices in Saudi universities.

7.3 Recommendations

The following recommendations were developed from the research stated in this thesis:

1. Saudi universities are well equipped with computer resources. Unfortunately, Saudi universities partly automated their FM activities and the rest they manage manually. Therefore, Saudi universities should design their automation strategies to implement and utilized the available resources.
2. From the analysis of the automation of FM practices of the Saudi universities, it is clear that projects & maintenance departments are managing different departments such as inventory, space and safety under one division. Therefore, Saudi universities should separate the activities of inventory, space and safety from projects and maintenance department into inventory department, space department and safety department.
3. The development of FM framework models provides useful information to an organization for self-evaluation, for identifying useful directions for improvement in automating FM functions and recommends for using the

framework to facilitate and improve implementation of such a system in the organizations.

7.4 Directions for Further Research

The possibility of future research in this area is to conduct automation survey of FM practices in the technical colleges of Saudi Arabia. As there is a rapid increase in the utilization of computers in the FM practices and growing number of technical colleges in the kingdom, which are new and have limited resources to manage their diversified set of facilities. The development of FM framework model for technical colleges helps in implementing IT solutions to automate FM functions in order to mange their facilities in a cost-effective manner.

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APPENDIX A

$IDEF_0$ Process Modeling Notation Guide

This section describes the notation for $IDEF_0$ process modeling language used to present graphically the proposed FM framework of inventory management, space management, maintenance management and fire safety management. IDEF refers to Integration Definitions for Function Modeling. $IDEF_0$ is one such method of modeling that permits the construction of models comprising system functions(activities, actions, processes, operations), functional relationships , and data (information or objects) that support systems integration(NIST , 1993).

A.1 Background

IDEF was developed by the U.S. Air Force's Integrated Computer-Aided Manufacturing (ICAM) project in the late 1980's, to improve manufacturing productivity through systematic application of computer technology. There are many different IDEF methods. Each method is useful for describing a particular perspective of an enterprise (NIST , 1993).These methods are defined as follows:

1. *$IDEF_0$:* $IDEF_0$, used to produce a 'function model' .It is a structured representation of functions, activities or processes within the modeled system or subject area. It is a graphical modeling tool that can be used to analyze and design complex systems.
2. *$IDEF_1$:* $IDEF_1$, used to produce a 'information model'. It represents the structure and semantics of information within the modeled system or subject area.
3. *$IDEF_2$:* $IDEF_2$, used to produce a 'dynamic model'. It represents the time-varying behavioral characteristics of the modeled system or subject area.

A.2 Components of IDEF$_0$

The components of IDEF$_0$ function model are show in the Figure A.1. The activity (or function) is represented by boxes corresponding to activities, processes, operations, or transformations. Inputs are represented by the arrows flowing into the left-hand side of an activity box, which undergoes a process or operation, and is typically transformed. Outputs are represented by arrows flowing to the right-hand side of an activity box, which results from a process or objects which are created by a function. Mechanisms are represented by arrows flowing to the bottom of the activity box that carry out the activity. The node is in the bottom right-hand corner of the box, a unique identifier to every function. The data entities are illustrated schematically in Figure A.1 and Table A.1 (NIST, 1993).

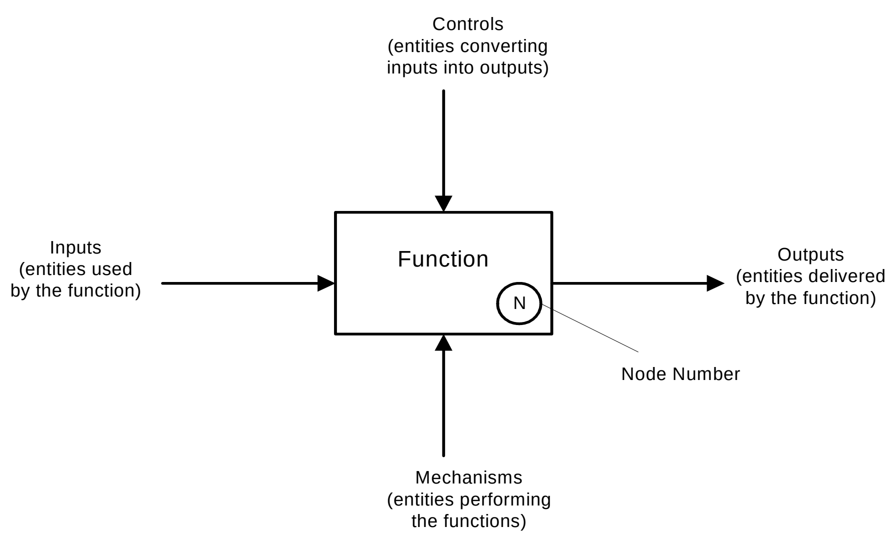

Figure A.1: IDEF$_0$ Nomenclature (NIST, 1993)

Table A.1: Data Entity Descriptions

Entity	**Description**
Function	An activity, action, process, operation, or transformation, which is described by an active verb. A function is shown as a box.
Input	An entity, which undergoes a process or operation, and it typically transformed. Data or material used to produce the output of an activity. It enters the left of the box, and may be information or material resource.
Output	An entity which results form a process or objects which are created by a function. Data or materials produced by or resulting from the activity. An output is shown exiting the right hand side of the box.
Control	An entity which influences or determines the process of converting inputs into outputs. Data that constrain an activity, regulating the transformation of inputs into outputs. A control is shown entering the top side of the box.
Mechanism	An entity such as people, machines, or existing systems that perform or provide energy to the activity. A mechanism is shown entering the bottom side of the box.
Node	A unique identifier to every function, which is shown in the bottom right-hand corner of the box.

A.3 Hierarchy of $IDEF_0$ Diagrams

In $IDEF_0$ the whole system is represented as a single box with arrow interfaces to the environment external to the system. The function in the box is decomposed into between three to six functions, each of which may be further decomposed into sub-functions. This top-down decomposition may be continued, resulting in three to six 'child' or detailed diagrams for each function at any given level (NIST, 1993). A schematic view of the hierarchy of the diagrams is illustrated in Figure A.2.

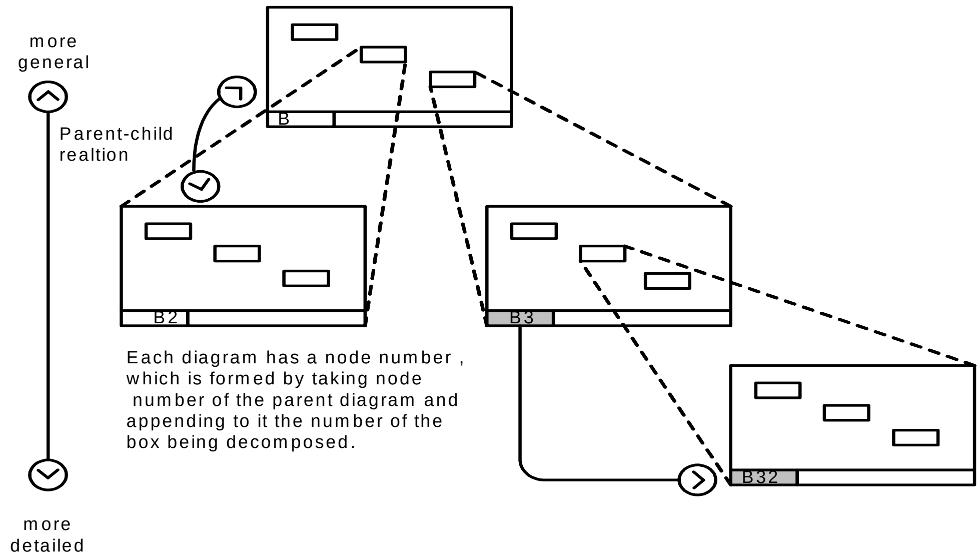

Figure A.2: The Hierarchical Structure of the IDEF$_0$ Modeling Methodology (Svensson,1998)

A.4 Decomposition

The number of functions within each diagram is limited to a minimum of three and maximum of six. These constraints limit the level of detail and complexity in any diagram, yet prevent the diagram from being trivial. Further, the level of detail is controlled by the position of the diagram in the hierarchy of diagrams. The amount of detail increases through each level of decomposition.

A.5 Modularity of IDEF$_0$ Diagrams

When a function in a box is decomposed the scope of the function and its interface arrows create a bounded context for the sub-functions. The scope of the detail or ‘child; diagram fits completely inside its ‘parent’ function. The interface arrows of the “parent’ box match the external arrows of the detail or ‘child’ diagram. Thus, arrows entering and exiting the detail diagram must be the same arrows interacting with the parent diagram (NIST, 1993)

A.6 Numbering the $IDEF_0$ Diagrams

Each major function in the system is assigned a node number, which acts as unique identifier for the function in the process model. The node number is shown in the bottom right-hand corner of the box. Decomposition of each box leads to a number of diagrams. Each diagram has a node number, which is formed by taking the node number of the parent diagram and appending to it the number of the box being decomposed (Svensson, 1998; NIST 1993). The node numbering system allows the reader to trace the steps of decomposition back through the parent function of each diagram.

APPENDIX B

Survey of Automating FM Practices

Survey to Assess the Level of Automation of Facilities Management Practices in the Universities of Saudi Arabia

To Whom It May Concern

SUBJECT: Questionnaire Survey for Thesis Research

As-Salaam Alaikum Wa-Rahmatullahi Wa-Barakatuhu

MOHAMMED ABDUL MOIED is a graduate student in the Architectural Engineering Department at King Fahd University of Petroleum and Minerals. He is currently collecting data for his Masters thesis titled "ASSESSMENT OF AUTOMATING FACILITIES MANAGEMENT PRACTICES IN THE UNIVERSITIES OF SAUDI ARABIA". To this end, he needs to collect data from your university through a questionnaire survey. I hope that you will extend any help you can, to make his research successful. The data will be used for educational purpose only. Respondent's information will remain anonymous. Your co-operation in the research will be greatly appreciated.

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Questionnaire Survey

Purpose of the Study

A survey questionnaire is being conducted to gain insight into the level and extent of automation in the professional practices of facilities management in the universities of Saudi Arabia. The questionnaire aims at evaluating current practices (objective information) and opinions concerning the professional practices of facilities management in the universities of Saudi Arabia. Please fill in the questionnaire and send it to the appropriate department, which is to be used for educational purpose only. Respondent's information will remain anonymous. The questionnaire can be dispatched or fax to the following address.

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Questionnaire Survey

University Name ______________________________

Location ______________________________

Respondent Information

Name: ______________________________
Position: ______________________________
Number of Years of Experience: ______________________________
Address: ______________________________
Phone No: ______________________________
E-mail: ______________________________

Building Type

☐ Educational ☐ Housing ☐ Recreation ☐ Medical Facility
☐ Sports Facility ☐ Administration ☐ Research Institute ☐ Library
☐ Information Technology Centre ☐ Auditorium
☐ Others, please specify ______________________________

Type of Department

☐ Projects & Maintenance Dept. ☐ Housing Dept. ☐ Comptroller / Inventory Dept.
☐ Telecommunication Dept. ☐ Safety Dept.
☐ Others, please specify ______________________________

Staff in the Department

☐ 50 ☐ 100 ☐ 200 ☐ More than 300

Questionnaire Survey

INSTRUCTIONS: *For each of the following questions please mark (√) the answer that comes closest to the way you feel about your FM practices. We greatly appreciate your co-operation for the successful completion of this study.*

Projects & Maintenance Department

Fact Questions: Current Practices involved in the University					
Construction Drawing Creation & Management	**Usually**	**Often**	**Sometimes**	**Rarely**	**Never**
Computer Aided Design (CAD) systems are used in preparing architectural & engineering drawings	○	○	○	○	○
Computers are used in sharing drawing information among other departments	○	○	○	○	○
Space Planning & Management	**Usually**	**Often**	**Sometimes**	**Rarely**	**Never**
Computer applications are used to record space inventory	○	○	○	○	○
University maintenance department performs internal billing of the space that the department uses	○	○	○	○	○
Space inventory information is shared with others departments	○	○	○	○	○
Furniture & Equipment Management	**Usually**	**Often**	**Sometimes**	**Rarely**	**Never**
Computer methods are used to control furniture & equipment items	○	○	○	○	○
Layouts of furniture & equipment items are documented using CAD	○	○	○	○	○
Move orders are filed and processed using computers	○	○	○	○	○
Computers are used to generate reports	○	○	○	○	○
Other departments can access furniture & equipment data	○	○	○	○	○
Building Maintenance Management	**Usually**	**Often**	**Sometimes**	**Rarely**	**Never**
Computer methods are used to file and process work orders	○	○	○	○	○
Computers are used for tracking scheduled and unscheduled maintenance activities	○	○	○	○	○
Computers are used for storing maintenance procedures as well as all warranty information by component.	○	○	○	○	○
Computers are used to generate real-time reports of ongoing work activity	○	○	○	○	○
Computer applications are used to manage preventive maintenance	○	○	○	○	○
Managers at different levels can retrieve maintenance reports via computers	○	○	○	○	○

INSTRUCTIONS: *For each of the following questions please mark (√) the answer that comes closest to the way you feel about your FM practices. We greatly appreciate your co-operation for the successful completion of this study.*

Projects & Maintenance Department

Opinion Questions: Concern with ideas, preferences, and future implementation					
Construction Drawing Creation & Management	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
Creation of CAD drawings improves work productivity	○	○	○	○	○
Data links to drawings (maps, floor plans) increase accuracy of information	○	○	○	○	○
Space Planning & Management	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
Integrating data with CAD drawings helps in increasing space efficiency	○	○	○	○	○
Computer generated reports helps in making decisions regarding lease renewal, space expansion or reduction	○	○	○	○	○
Furniture & Equipment Management	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
CAD drawings of furniture & equipment items links to database visually present an inventory	○	○	○	○	○
Database linking with drawing track items alphanumerically and graphically	○	○	○	○	○
Bar code technology is used in tracking warranty of furniture & equipment items	○	○	○	○	○
Building Maintenance Management	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
Work order information is saved for analysis Purposes	○	○	○	○	○
Facility Maintenance Management System is used for reporting	○	○	○	○	○

Work orders are generated through one of the following methods (Tick one or more methods)

☐ Written form ☐ Telephone ☐ Computer Maintenance Management Systems ☐ Web-based

☐ Others, please specify____

Which of the following software does your organization use for managing maintenance activities?

☐ Archibus ☐ Aperture ☐ Maximo ☐ Facility Information System

☐ Others, please specify____

INSTRUCTIONS: *For each of the following questions please mark (√) the answer that comes closest to the way you feel about your FM practices. We greatly appreciate your co-operation for the successful completion of this study.*

Comptroller/Inventory Department

Fact Questions: Current Practices involved in the University					
Inventory Management	**Usually**	**Often**	**Sometimes**	**Rarely**	**Never**
Computers are used to manage stores inventory	○	○	○	○	○
University storehouse collects and receives the inventory	○	○	○	○	○
Inventory information shared electronically by other departments	○	○	○	○	○
Bar-coding technology is used in inventory control	○	○	○	○	○

Opinion Questions: Concern with ideas, preferences, and future implementation					
Inventory Management	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
Computers helps in maintaining an accurate history of assets	○	○	○	○	○
Asset records are updated every ☐ 3 months ☐ 6 months ☐ 9 months ☐ Annually					

INSTRUCTIONS: *For each of the following questions please mark (√) the answer that comes closest to the way you feel about your FM practices. We greatly appreciate your co-operation for the successful completion of this study.*

Telecommunications Maintenance Department

Fact Questions: Current Practices involved in the University					
Telecommunication & Cabling Management	**Usually**	**Often**	**Sometimes**	**Rarely**	**Never**
Computer applications are used to manage electronic inventory of the cabling & telecommunications network connections	○	○	○	○	○
Data is shared electronically among other departments	○	○	○	○	○

Opinion Questions: Concern with ideas, preferences, and future implementation

Telecommunication & Cabling Management

People in the university exchange information via

☐ Telephone ☐ E-mail ☐ Web-based

☐ Others, please specify ____

Telecommunication & Cabling Management	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
Graphic symbols are used to track devices	○	○	○	○	○
Mapping connection graphically helps in cable connection	○	○	○	○	○
Maintaining an electronic inventory of physical network simplifies trouble-shooting tasks	○	○	○	○	○

INSTRUCTIONS: *For each of the following questions please mark (√) the answer that comes closest to the way you feel about your FM practices. We greatly appreciate your co-operation for the successful completion of this study.*

Safety Department

Facts Questions: Current practices involved in the university					
" An emergency preparedness plan developed for managing potential disasters including ability to respond efficiently and quickly to recover in the event of actual crisis."					
Emergency Preparedness Plan	**Usually**	**Often**	**Sometimes**	**Rarely**	**Never**
Previous electronic generated reports are used to manage emergency preparedness plan	○	○	○	○	○
Facilities data links with drawings supports emergency preparedness , disasters recovery, and business continuity plan	○	○	○	○	○

Opinion Questions: Concern with ideas, preferences , and future implementation					
Emergency Preparedness Plan	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
Organization has emergency preparedness plan	○	○	○	○	○
Emergency preparedness plan is integrated with facilities management system	○	○	○	○	○
Emergency preparedness plan in conjunction with world wide web helps in accessing and updating data remotely	○	○	○	○	○

VITA

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