

**A Methodology for assessing computer software applicability to
Inventory and Facility Management**

by

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Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
Master of Science in Architecture
in
College of Architecture and Urban Studies

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December, 1989
Blacksburg, Virginia

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(ABSTRACT)

Computer applications have become popular and widespread in architecture and other related fields. While the architect uses a computer for design and construction of a building, the user takes the advantage of computer for maintenance of the building. Inventory and facility management are two such fields where computer applications have become predominant.

The project has investigated the use and application of different commercially available computer software in the above mentioned fields. A set of user requirements for inventory and facility management were established for different organizations. Four different types of software were chosen to examine their capabilities for fulfilling the requirements. Software from different vendors were chosen to compare and study the feasibility of application of each. The process of evaluation has been developed as a methodology for assessing different computer software applications in inventory and facility management. Special software applications and hardware considerations for developing computer-aided inventory and facility management, has also been discussed.

The documentation and evaluation of software shall provide a person the basic knowledge of computer applications in inventory and facility management. The study shall also help building managers and facility managers develop their own criteria for choosing computer software to fulfill their particular requirements.

Acknowledgements

Several people have significantly contributed to my educational development over the years. I would like to take this opportunity to express my gratitude to everybody whose collective efforts have enabled me to earn this master's degree.

I am indebted to Prof. John Wade, who served as my graduate committee chairman, for his encouragement, patient guidance and supervision throughout the thesis. I thank Prof. Francis Ventre, Prof. Robert Schubert and Prof. Dennis Jones for serving on my committee. Their continuous guidance, recommendations and constructive criticisms have significantly developed my research.

My warm appreciations go to all faculty members and staff of the College of Architecture who have contributed to my graduate studies. I thank Prof. Dixon Hanna for his help and encouragement in my research and providing financial aids from the school during my studies.

Finally, I wish to express my gratitude to my family and friends. I am most grateful to my parents whose encouragement, support and love have made it possible for me to travel to this country and complete my higher studies. I convey my special thanks to all my friends in Blacksburg for their friendship, support and help during my entire period of stay.

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Chapter 1. Introduction

1.1 General Statement

The world of computers have brought solutions to problems in various fields of architecture, building design and construction. Computers have introduced automation and flexibility in design, and helped manage a large amount of information. While CAD (Computer Aided Design) is one of the earliest application, the scope of automation has been added to two other related fields - inventory and facility management.

Inventory management, in this study, refers to managing inventory of spaces and objects within a building. Facility management as defined by the International Facility Management Association, is concerned with the tasks of "design, construction, maintenance and management of the physical environment as it relates to people in the work process".¹

This study deals with assessment of computer software applications in the field of inventory and facility management.

¹ Teicholz, Eric, and Sena, Michael, "Facility management is fertile ground for automation," Feb 1986, *Architectural Record*, (pp 35-38).

1.2 Background

The rapid developments in the field of A-E-C (Architecture-Engineering-Construction) CAD in the last few years have brought an ever increasing rate of change in the way architects design and draw. The trend toward PC (personal computer) CAD came in the 1980s and the emergence of Facility Management automation through the use of CAD systems occurred in 1986. Market statistics from McGraw Hill has shown that CAD is indeed recognized as a mature cost-effective production tool.²

The handling of large information was an early application of computers and over the years many programs were developed to deal with different categories of data. Database is such a technology used by architects both for administrative purposes and control aspects of job design.³

The two systems have been merged in many different ways for serving different functions. There are CAD systems and databases which allows merging of each very easily while others do not.

It is common to speak of CAD database when referring to drawing file because each object has information regarding its layer, color line thickness and other properties in addition to its location in the drawing. More sophisticated CAD applications offer methods of attaching information such as price, material, composition, and other data symbols in the drawing or even allow simple database application such as preparing Bill of Materials. Integrated CAD DBMS (Database Management Systems) can help facility planners to plan furniture and equipment acquisition, prepare cost reports, purchase requisitions and other kinds of required doc-

² Teicholz, Eric, "A watchful eye on A-E-C : Facilities Management leads the trends," Feb 1987, *Computer Graphics World*, (pp 91-94).

³ Reynolds, R., A., *Computing for Architects*, Butterworths, Great Britain, 1987.

umentations. The information available could be incorporated into an inventory management database with bar-coded accounting of materials consumption.⁴

Image processing techniques on computer can solve the problem of storing visual records of inventory items. There are imaging software which can import computer scanned or video captured images, manipulate them and store them in memory as a visual inventory. The emergence of automation in facility management saw the development of separate software packages dealing solely with facility management operations. These packages have either built-in CAD and database software or interfaces to such and help interlink textual information to graphic information in a building. The use has also been extended to managing of different facilities within a building complex.

1.3 Purpose

The purpose of the project was to develop a methodology for assessment of commercially available software packages that can be used in inventory and facility management. Different organizations were chosen and their requirements in inventory and facility management established. A survey of different software packages were done and evaluated for each requirement. The software survey and the evaluation methods will provide the knowledge of basic principles of computer applications and help to develop evaluation criteria for choosing software for use by different users to fulfill their specific requirements.

Fig. 1 explains the primary objective of the research.

⁴ Meyer, Ann, "The Database Dimension in CAD," *MicroCad News*, Feb 1989, (pp 15-19).

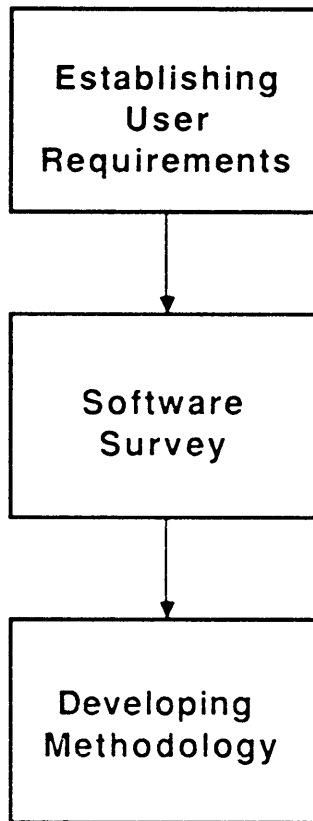


Figure 1.1. Objective of study

1.4 Scope of study

The scope of study of has been limited to or taken into consideration the following conditions :-

1. It is assumed that an organization shall incorporate Imaging and CAFM (Computer Aided Facility Management) systems along with CAD and DBMS and shall have the minimum programming ability needed for integrating the four systems as required. Based on these assumptions a methodology has been suggested for assessing the four categories of software.
2. The survey for user requirements has been limited to organizations within and nearby areas of Blacksburg, Virginia.
3. In the review of software
 - a. normally the IBM⁵ compatible software has been chosen for investigation
 - b. mostly the micro computer based software has been looked into
 - c. the software has been run on computer and tested whenever possible
 - d. the rest of the information has been provided from products literature or reports from articles in magazines.
4. Hardware considerations have been discussed in brief as detailed discussion is beyond the scope of this study.

⁵ International Business Machines - one of the earliest and largest computer hardware manufacturing companies.

5. The final evaluation of software has not considered the quantitative performance levels or cost effectiveness of each as detailed study of such are beyond the scope of this project.

Chapter 2. Literature Survey

2.1 General Statement

Very few books throw light on current information on subjects of study in this project. This is due to the rapid development of technology in terms of software and hardware. However, current technical journals - dealing with aspects in architecture, CAD, Database Management and computer applications in image processing - provide up to date information on the related topics. Information of products i. e. commercially available software and hardware as well as related research reports are also available.

Thus, a thorough literature search provided a lot of information of present technological developments and related research based on which the actual investigation was done.

2.2 Linking CAD and database management programs

The goal in combining these two types of software is to allow users to associate one of the attributes on a drawing to a database file that was completely and independently created by a database product.

Pyramid, a development and management company for shopping malls uses PRISMA (from IsiCAD) for development, leasing and facility management of its projects. PRISMA has a commercially available DBMS running within it, which allows such operations as changes made to the drawing are instantly reflected in the database and vice versa.⁶

The merging of the two have been done by other companies too, for enhancing mainly facility management. At K Street Architects in Denver, CO, CADVANCE (IsiCAD),⁷ which may be linked to databases like dBASE⁸ and Lotus,⁹ is used for lease and space planning analyses and their clients future facility management needs.

SQL¹⁰ (Standard Query Language), a database technology developed by IBM, is well suited for CAD environments. SQL systems are designed to allow to make complex queries interactively by its users. The query functions available with this help retrieve information about objects in a drawing by setting certain query parameters, set according to its own language syntax. The advantage is that it is available to support almost any kind of machines and operating systems from MS-DOS to OS/2.

⁶ Lang, Laura, "Intelligent Drawings : Linking CAD and database management programs gives architects a powerful new tool," **Computer Graphics World** Sept 1988 (pp 94-101).

⁷ ISICAD Corporation Inc., Anaheim, California.

⁸ Ashton Tate, Torrance, California.

⁹ Lotus Development Corporation, Cambridge, Massachusetts

¹⁰ Dowgiallo, Edward, "SQL Bridge to CAD/DBMS Union," **MicroCAD News**, Feb 1989 (pp 11-14).

AutoCAD Release 10¹¹ provides a new feature called entity handles, which allows creation of flexible interfaces to databases and other external system. Entity handles allow a unique identifier to be associated with any object in a drawing, including composite objects. This provides a means for linking of specific objects in a drawing with records in a database system. The operational capabilities can be defined by writing macro programs with the help of AutoLisp - AutoCAD's own macro language.

MUNMAP is an add-on product for AutoCAD which provides an interface to SQL database systems. The SQL database in this case also serves as an interface between the graphical data and more traditional processing oriented applications, which can extract the data from the DBMS. CAD/BASE is another add-on product for the advanced Revelation DBMS which provides an interface with any CAD system that reads and write a DXF (Data Exchange File) format.

2.3 CAD in Facility Management

For a computer aided facility management system to be effective, its database capabilities must be an integral part of its graphics. A change of an architectural feature or specification of an object should be updated in the database automatically by the system. Likewise if an item in the database changes, its graphical display should reflect the latest revision.¹²

Research and development have been done to reach such goals by combining Facility Management programs with databases and CAD systems. One approach is to assign the processing of nongraphical information to powerful relational databases like dBASE. The database

¹¹ Autodesk Inc., Sausalito, California.

¹² Teicholz, Eric, "Merging Data and Graphics on Desktop PCs are helping to make the connection in Facilities Management," *Computer Graphics World*, Apr 1988 (pp 45-48).

system executes such tasks as inventory, cost accounting and other management facility while the CAD package can handle the graphical tasks. Using software such as AutoCAD and VersaCAD,¹³ facility managers can produce and maintain as-built drawings, determine the best use of space, and obtain graphical display of building data.

The CADapult FM system from Mitchell Associates (Wilmington, DE), designed to link with Autodesk's AutoCAD, lets a user to move freely within the AutoCAD and database modules. The software is written in QBasic - a language which compiles and executes faster than AutoCAD's own macro-language, AutoLisp. The Drawbase system by Skok Systems (Cambridge, MA) performs similar function with somewhat different approach.

2.4 Integration of Video and Graphics

Rapid advances in personal computer technology have made it possible to integrate various software and hardware to produce totally integrated facility management system.

VersaSPEC facility design and management system by Eclat Incorporated (San Leandro, CA) have experimented with CAD systems and video imaging to create a furniture catalog as a library of 3-D images and also provide facility design operations for a major furniture company.¹⁴

VersaCAD was chosen as the CAD software for 2-D and 3-D facility layout and its macro features were used to modify the program to fit the requirements. MicroSpec an in-house software was used to link the video catalog images with the CAD system. AT & T's Targa 16 was used for video image capture and display. CD-ROM, using optical laser disc, can store more

¹³ Versacal Corporation, Huntington Beach, California.

¹⁴ Anderson, Bruce and Harlin, Scott, "Video and Graphics in Facilities Design," **Computer Graphics World**, Jun 1987 (pp 57-58).

than 500M of memory on a single disc, was used to store the images. MicroSpec allowed designers to perform such functions as facility layout design and preparing bill of materials for final specification.

2.5 Educational Research

The ongoing research at the School of Architecture and Planning's Computer Resource Lab at M.I.T., (Massachusetts Institute of Technology, MA)¹⁵ was conceived to encourage exploration of how computers can most effectively be used in education. Among other experiments done, the project provides an Electronic Studio that co-ordinates visual information. The basic infrastructure links PC CAD with database management of a visual visual information system which is a videodisc-based image library and an expert system. Images stored in the videodisc can be accessed and manipulated through database management software. The expert system uses the data obtained to draw inferences from a base of architectural knowledge and perform various analytical functions for which it is programmed.

The various components involved - expert system shell, database management software, video disc player and PC CAD software - are all obtained from the market rather than from in-house development. The visual information system and the expert system run under "Unix" while the videodisc player and the CAD system run under "DOS"¹⁶ on the network's XTs¹⁷ and ATs. But the Unix and DOS environments have been successfully bridged together so that the expert system, the visual database system along with the CAD system interact with each other easily.

¹⁵ Macmillan, Tom, "Teaching Tomorrows Architects - At MIT, Automation and Tradition merge in Hybrid Environment," **Computer Graphics World**, Aug 1986 (pp 40-44).

¹⁶ Unix is an advanced computer operating environment allowing multitasking. DOS is the operating environment for most microcomputers.

¹⁷ AT and XT are two advanced models of microcomputers by IBM (International Business Machines)

The office of the facility management system at M. I. T. has designed developed and implemented inventory systems to gather data on M.I.T.'s facility.¹⁸ INSITE (Institutional Space Inventory Techniques) is the system that that stores data of buildings, rooms, paintings, floor coverings and and thousands of pieces of equipment. Other uses of INSITE include indirect cost allocations, grant and project tracking, and equipment depreciations.

It is an hierarchical and mainframe based system that perform Boolean operations. A graphic representation of the Database is the INSITE-CAD, a micro-computer aided drawing/drafting system, which can be linked to a local or remote PC system where data files are digitized as drawings to be read on a CAD window.

2.6 Other technologies for linking graphic and text information

2.6.1 Hypertext

Hypertext,¹⁹ at its most basic level, is a DBMS that lets a user connect screens of information using associative links. At its most sophisticated level, it is a software environment for collaborative work, communication, and knowledge acquisition.

Hypertext programs, and the free flowing databases have been adapted for electronic publishing, project management, system analysis software development and CAD. Hypertext programs have different database structure than the conventional ones, consisting of screen size work spaces called *nodes*. The user can fill these computer index cards with text,

¹⁸ Cortes, Camila C., "Facilities Management : A Wealth of opportunities. " *MicroCad News*, Feb 1989 (pp 20-23).

¹⁹ Fiderio, Janet, "A Grand Vision : Hypertext mimics the brain's ability to access information quickly and intuitively by reference," *BYTE*, Oct 1988 (pp 237-242).

graphics, images and audio and video data. The link nodes allows manipulation of information from each other, either in hierarchical or non-hierarchical fashion, as allowed by the software.

2.6.2 HyperCard

HyperCard, a new programming language for the Apple family of computers, is a like a fourth-generation database-language that allows the user to create custom application as templates.²⁰ Since it can be of different use to different people, it is hard to describe HyperCard, accurately. It can be broadly described as a personal toolkit that give the power to use, customize and create new information using text, graphics, video, music, voice and animation. In addition, it offers an easy-to-use-English-language based scripting language, called Hypertalk, that gives the users an opportunity to write their own programs.²¹

The Apple version of VersaCAD, offers a HyperCard Database utility which creates a duplicate duplicate image of a drawing on a *card*, attaching buttons to text and symbols. The program also provides the X,Y co-ordinates of each item.

²⁰ Thornburg, David D., " The Power Of Hypercard, Part 1, " *Compute*, Jan 1988 (pp 25-27)

²¹ Williams, Gregg, "HyperCard : HyperCard extends the Macintosh user interface and makes everybody a programmer," *Byte*, Dec 1987 (pp 109-117).

Chapter 3. Methods of Research

3.1 Establishing User Requirements

The organizations chosen for survey are all based in and around Blacksburg, Virginia due to their accessibility and the size of their facilities involved.

Discussions with knowledgeable persons involved and interested in inventory maintenance helped establish the basic user requirements for an inventory. The basic user requirements defined at this stage were discussed with the the persons involved in the building maintenance and elaborated or modified by them. The information collected provided guidelines for studying and choosing the different software to be reviewed.

3.2 Survey of Computer Software

Literature survey, products brochure and interview with representative of software vendors provided review of computer software which may support the user requirement's established, for inventory management. Some of the software, which were available for testing, were run

on computers to study their working principles. Other vendors provided demonstration software packages on request. The software selected for review include CAD, Database, Imaging and Facility Management programs. A survey of software provided a picture of what kind operational functions are applicable in inventory and facility management.

3.3 Feasibility Study and Evaluation of Software

The four different types of software chosen for review were examined for a feasibility study of application of each. The categorized functional requirements were matched with each software category to determine which of the user requirements could be fulfilled by what type of software. A group of application criteria (for using and running the software) were also determined to study factors such as application ease and other technical aspects of each software type.

The initial feasibility study of software types was followed by evaluation of the several software packages of each category. The evaluation criteria were developed from the kind user requirements each category of software could fulfill. The same application criteria were matched with the individual software to study the technical advantages and disadvantages of each.

Chapter 4. Findings and Discussions

4.1 The User Requirements established

The following are findings from interview with persons responsible for maintaining inventory and/or facility management in different organizations. A total of eight organizations were studied out of which four of them are different departments of Virginia Polytechnic Institute and State University, (Virginia Tech) Blacksburg, Virginia. The rest are different local companies in and around Blacksburg. They are all medium to small organizations with approximate building area within less than 100,000 sq. ft. and number occupants at an average 100 people per day. The project was explained to each of them and each person was asked to put down their requirements - the items or nature of inventory and what kind of operations and functions they would expect to perform by a computer-based inventory and facility management system.

The requirements have varied from one user to another, according to the activities of the organization but all of them have shown certain common needs. The most common needs for the users were found to be space and equipment/furniture inventories. Maintaining record of space usage within their facilities and keeping track of equipment/furniture within the buildings has been observed as the foremost requirement. Related information on each has

been categorized differently by each user. Among the users, HCMF, the real estate corporation needs more of maintaining their space records than others. On the other the Fixed Asset control Department of Virginia Tech is more interested in maintaining equipment/furniture inventory. The New River Valley Mall's greatest concern is lease management and utility maintenance and Dominion Bankshares Corporation pointed out automated security systems as an important factor in maintaining their facilities. Thus the users provided different preferential hierarchy in their requirements. The study however has taken the common as well as the special requirements from each user and established one set of user requirements against which the software are evaluated.

The following pages provide the user requirements of different organizations in tabular form.

Table 4.1. User Requirements established.

Person/Institution	<i>College of Architecture and Urban Studies, Virginia Tech.</i>	<i>Virginia/Maryland Regional College of Veterinary Medicine</i>
Organization	Educational Institution	Educational Institution
Activity	Teaching, research,	Teaching, research veterinary medical services
Inventory Items	Furniture, equipment for teaching, administration and research	Furniture, equipment for college and special medical equipment home equipment
Information associated	Name, location, description id #, purchase date, value, source vendor, specific use, user and related information	Name, location description identification, source, usage, owner, and related information
Mode of manipulation of information	Storing basic information of items in database. and associating them to CAD drawings, day to day maintenance and budgeting	Maintaining upto date record of items, predict future requirement, day to day maintenance and budgeting
Special Requirements	Visual representation of objects, CAD floor plan showing location of item calculation of area, cost analysis	Visual record of items and location of such on floor plans
Current application of computers or automation	Maintain floor plans and equipment inventory on CAD and Database systems respectively	None for above requirements

Table 4.1. Continued

Person/Institution	<i>University Architect's Office Virginia Tech</i>	<i>Fixed Asset Control Dept. Virginia Tech</i>
Organization	Planning Department	In charge of fixed assets control
Activity	Maintenance, planning, renovation of buildings under Virginia Tech	Keeping record of fixed assets for Virginia Tech, budgetting new purchase
Inventory Items	Building plans space inventory	Land, buildings, equipment and fixed assets
Information associated	Location of space usage of space people assigned future requirement	Usage, identification location, accounting information, acquisition method
Mode of manipulation of information	Visual representation of usage of space renovation or future requirement prediction	Database reports according to different criteria, budgetting, accounting report
Special Requirements	Item in database can be linked visually to CAD drawings	Visual representation of fixed asset items with location within campus
Current application of computers or automation	Building plans maintained as CAD drawings,	Mainframe database used for inventory

Table 4.1. Continued

Person/Institution	<i>Blacksburg Marriot</i>	<i>HCMF Real Estate and Housing Management Corporation</i>
Organization	Motel	Real Estate Developer
Activity	Provides boarding and lodging to guests, resturant services	Real estate developing, acquiring/selling/leasing of property and housing complex, management
Inventory Items	Guest rooms, guest requirement items, utilities	Property holdings, selling lease and renting record, housing and nursing home equipment
Information associated	Guest occupancy record, guest requirement item list and related information	Current land holding, current market price of land or property, location, selling, buying, lease record
Mode of manipulation of information	Maintaining utility services predicting future requirements scheduling of repair/renovation, budgeting of future purchase	Landuse maps and pictorial representation of buildings on CAD, updating buying, selling and lease information equipment maintenance inventory
Special Requirements	CAD floor plans showing location of utilities and and service lines	Producing updated sales transaction reports, information on availability and value of property and buildings
Current application of computers or automation	None for the above requirements	Maintaining inventory on Database system

Table 4.1. Continued

Person/Institution	<i>New River Valley Mall</i>	<i>Dominion Bank</i>
Organization	Shopping Mall	Banking Corporation
Activity	Commercial - shopping complex, restaurants and theaters	Banking operations and other related financial activities
Inventory Items	Records of lease, maintenance, utility services, security systems	Buildings, furniture, banking equipment, utility services, security systems
Information associated	Building plans, lease information, maintenance, maintenance, renovation/repair information	Building plans, usage of space, equipment, maintenance, renovation/repair information
Mode of manipulation of information	Scheduling of rent, maintenance, renovation/repair, budgeting of such, budgeting of equipment or other service requirements	Scheduling of maintenance, renovation/repair, budgeting of equipment purchase, future facilities planning
Special Requirements	Automated HVAC maintenance and lighting facilities	Various inventory information to be easily related to CAD building plans
Current application of computers or automation	Computer controlled lighting and HVAC system	Computer controlled security system

4.2 Computer Applications by the Users

4.2.1 Building Maintenance and Facility Management

Among the organizations surveyed by the author, application of computers in building maintenance has been observed in most cases, but not all. The bigger and more resourceful organizations like the College of Architecture and Urban Studies and the University Planning Department of Virginia Tech maintain floor plans on CAD system and other information like fixed asset inventory on Database systems. The New River Valley Mall uses automatic lighting and HVAC system which are computerized. Blacksburg Marriott do not have any kind of computer application for building maintenance but the person in charge is eager to use computers. The most common mode of usage of computers are database software for maintaining inventory. The study show that user requirements and resources are the main factors that influence application of computers in building maintenance.

4.2.2 CAFM software in Facility Management

None of the organizations surveyed have used any kind of commercially available CAFM software. A few of the maintenance personnel interviewed have heard or known about the software. The reasons for not applying any of these for their own use are that the software do not fulfill their own requirement, they do not have trained people for operating the systems or the expenditure for installing and running such systems are not within their building maintenance budget. Development of user friendly and less complicated and expensive Facility Management software will certainly enhance future application of such.

4.3 Survey of computer software

The four basic categories of software chosen were CAD, Database, Imaging and CAFM software. Six of each category were chosen for review and evaluation.

CAD software provide drawing tools for preparing building drawings including plan, elevation, section or three-dimensional views of building spaces. The CAD drawing provide information like simple dimensions to area and volume of a building, a room or a workspace. Building drawings may be easily plotted to obtain hard copies.

Database software provide records of inventory. Reports on Bill of Materials, specifications and estimation of cost may be obtained as output. While an item contained in a building may be located graphically located in a CAD building drawing, the database will provide other necessary information about the item in textual form. The generated reports vary from spreadsheet formats to customized formats.

Image processing software can provide a record of visual images of a building space or individual objects within it. The images can be scanned from photographs or still frames of video pictures. The images can be manipulated and stored as visual inventory. The output may be images on computer screen stored as a library, hard copy prints or even animated walk through sequences in a building.

Facility Management software provide linkup with CAD and Database software and provide advanced database and facility management functions.

Thus for a computer based inventory or facility management system, the above mentioned software may be used according to various functional requirements. The review and evaluation determines the different ways and options of application of each software. The infor-

mation provided is not exhaustive in all cases but subject to the availability during the period of this study.

The review tables are provided in the next sections. The evaluation results has been discussed in the next chapter.

4.3.1 Review of CAD Systems

A CAD system is a computer software used as a tool for design and drawing. The CAD drawings, unlike other graphics and paint programs can co-ordinate information about each line, arc, circle or other drawn objects. The CAD drawing can thus be also termed as graphic database, as well as a computer generated intelligent drawing.

The following are reviews of some well known CAD systems used by architects as computer aided design and drafting tools. The review has been done from, products' literature, vendors' brochure or studying the working principles of the CAD packages.

The survey include six PC based or micro-computer based software which are run on IBM or compatible computers. The following table gives the characteristics and functional capabilities of each CAD software

Table 4.2. Review of CAD Software

Software	Arris	AutoCAD Release 10	CADVANCE Version 3.0	MicroCADAM Cornerstone 1.3	Microstation PC Release 3.0	VersaCAD Version 5.4
Minimum hardware requirements	80286 system, 2MB RAM, 12MB hard disk, Math Coprocessor, Xenix 2.2	PC XT, 640K RAM, 10MB hard disk, Math Coprocessor, DOS 2.0	PC XT, 640K RAM, 10MB hard disk, DOS 2.0	PC AT, 640K RAM, hard disk, Math Coprocessor, DOS 3.3	PC XT, 640K RAM, hard disk, Math Coprocessor, DOS 2.0	80386 system, 3MB RAM, 80387 Math Coprocessor, DOS 3.0
Operating environment/s	Xenix, Sun workstation	DOS, Sun workstation, MAC II	DOS	DOS, OS/2	DOS, OS/2, VAX/MVS, UNIX, MAC II	DOS, UNIX, Sun workstation, MAC II
General characteristics	2D, 3D drafting system, 3D database	2D, 2.5D, 3D drafting system, 3D database	2D, 2.5D, 3D drafting system, 3D database	2D, 2.5D, drafting system	2D, 3D drafting system, 3D database	2D, 2.5D, 3D drafting system, 3D database
Drafting and editing features	lines, polygon, arc, circle, ellipse erase, move, copy, trim, scale, offset, redraw, change properties, zoom, pan, redraw blocks, overlays, windows	lines, polygon, arc, circle, ellipse, free hand sketch erase, move, copy, trim, scale, offset, redraw, change properties, zoom, pan, redraw blocks, overlays, windows, multiple views	lines, polygon, arc, circle, ellipse erase, move, copy, trim, scale, offset, redraw, change properties, zoom, pan, redraw blocks, overlays, windows	lines, polygon, arc, circle, ellipse erase, move, copy, trim, scale, offset, redraw, change properties, zoom, pan, redraw blocks, overlays, windows	lines, polygon, arc, circle, ellipse erase, move, copy, trim, scale, offset, redraw, change properties, zoom, pan, redraw blocks, overlays, windows	lines, polygon, arc, circle, ellipse erase, move, copy, trim, scale, offset, redraw, change properties, zoom, pan, redraw blocks, overlays, windows
3D features	Extruding 2D objects to 2.5D, isometric, perspective, wire frame, surface model, fly around, walk through	Extruding 2D objects to 2.5D, isometric, perspective, wire frame, surface model, 3D object library	Extruding 2D objects to 2.5D, isometric, perspective fly around, walk through	Extruding 2D objects to 2.5D, isometric, surface model	wire frame, surface model, isometric, solid 3D	wire frame, surface model, isometric
Information exchange with other CAD software		IGES, DXF format compatible	DXF, IGES, PRISMA format compatible	DXF and other CADAM formats compatible	DXF, IGES, IGDS and other VAX formats compatible	IGES, DXF format compatible
Programmability	Macros, user defined menus, Sigmac-macro language	Macros, user defined menus, Autolisp-macro language	Macros, user defined menus, programming language	Macros, (optional) programming language	Macros, user defined menus, MicroCSL - programming language	Macros, user defined menus, CPL - CAD programming language
Communication with other software, built in or third party interface		Lotus compatible database software, Archibus/IFM, CAPM software, TIPS imaging software	dBASE compatible database software	Lotus Manuscript and Freelance, Aldus Pagemaker, Xerox Ventura, publishing software	dBASE compatible database software	
Other Options	Interface with Sirgen, relational database, Space Design, blocking program, 3D modeling and rendering program	Autoshade and AutoSolid for shading 3D objects and solid modeling	Information Management package - dBASE interface for facility and property management		Interface with dBASE and other UNIX, VAX packages by Intergraph	

4.3.2 Review of Database Systems

A database system is basically a computerized record-keeping system, whose overall purpose

is to maintain information and to make the information available on demand.²² It can be used to store, sort, or search through this information, develop meaningful reports, textual or graphical, for decision making and simplify common tasks such as creating bills, budgeting and various kinds of data manipulation. Some of the database systems have additional capabilities like word processing and producing graphical representation of numerical data.

The review of the database software were done from products literature and/or studying the working principles. They include software from regular spreadsheets to relational databases. These software are also IBM compatible and micro computer based. Some of the following database programs have been known to be integrated with CAD systems while others are not.

²² Date, C. J., *An introduction to Database Systems*, Addison-Wesely Pub. Co., Reading, Mass.

Table 4.3. Review of Database Software

Software	dBASE IV	Lotus Symphony 2.0	Microsoft Excel	Paradox 3.0	Reflex	SuperCalc5
Minimum hardware requirements	IBM PC, 640k RAM, 10MB hard disk, Math Coprocessor DOS 2.0	IBM PC, 384K RAM, hard disk, Math Coprocessor DOS 2.0	PC AT, 640K RAM, hard disk, EGA card, mouse, DOS 3.0	PC XT, 640K RAM, hard disk, EGA card, mouse, DOS 3.0	IBM PC, 512K RAM, double disk drive, DOS 2.0	IBM PC, 512K RAM, hard disk, CGA card, DOS 3.0
Operating environment/s	DOS, Compaq, Deskpro, IBM PS 2, MAC II machines LAN systems	DOS, Compaq, Deskpro, AT & T machines	DOS, Compaq, Deskpro, IBM PS 2, MAC II machines	DOS, OS/2, LAN systems	DOS	DOS, LAN systems
General characteristics	spreadsheet, relational database management software	spreadsheet, word processor, database management software	graphic spreadsheet software	spreadsheet, relational database management software	spreadsheet database management software	3D spreadsheet database management software
Spreadsheet application features	records in cells copy, move, delete or insert cells edit records,	records in cells copy, move, delete or insert cells edit records, hidden cells	records in cells copy, move, delete or insert cells edit records multiple display of spreadsheets,	records in cells copy move, delete or insert cells edit records,	records in cells copy move, delete or insert cells edit records,	records in cells copy, move, delete or insert cells edit records, creation and display of pages
Database application features	extract, view, manipulate records, query by example, extraction from several files sort, search records in cells, mathematical applications	extract, view, manipulate records, query by example, three level sorting data, validation, mathematical, statistical applications	extract, view, manipulate records, query by criteria relating several files, on screen mathematical applications	extract, view, manipulate records, example, cross-tab search sort between different tables, mathematical mathematical	extract, view, manipulate records, logical numeric queries, simultaneous view of different forms cross tabulation, mathematical applications	extract, view, manipulate records, query, search from different spreadsheets relating several files, mathematical
Report/word processing features	columnar reports customized reports mail merger	spreadsheet report, page setup, script, advanced word processing spell checker, mail merger	spreadsheet report customized form template design on-screen display of layout features	spreadsheet report, customized layout, editing features reports	spreadsheet report, customized, summarized report, editing features in reports	spreadsheet report, customized report, printing sideways for wide spreadsheets
Other graphic capabilities	Chartmaster (optional package), business graphics, pie bar charts scatter diagram	line bar stacked bar, pie, exploded pie charts, X-Y, high low open close graphs	manipulation of graphic spreadsheet, 7 basic graph types 44 optional line pie bar graphs	line bar stacked bar, pie charts, XY graphs pie charts,	line bar stacked pie charts, scatter diagram polar charts	100 optional graphs types, line bar stacked bar, pie charts scatter diagram 2D charts
Information exchange with other database software	Lotus, PFS FILE, dIF formats compatible	Lotus formats compatible, readable by dBASE, Excel SuperCalc	import Lotus compatible, files,	import Lotus files, Reflex Quattro formats compatible	import Lotus, dBASE files, PFS FILE, dIF formats compatible	import Lotus, dBASE files, dIF format compatible
Programmability	Application of Structured Query Language, customized menus, mathematical statistical formulas, dBase-Link	user defined menus window management, macro library, Symphony Command Language - macro language mathematical statistical formulas	customized functions, help screens, dialog box, macro library, macros for customized C routines, mathematical formulas	user defined menus, macros, Personal programmer, Paradox Application Language - macro language, mathematical formulas		
Communication with other software, built in or third party interface	CADvANCE, AutoCAD, CAD software Archibus FM FM Space Management, CAFM software ASCII files	AutoCAD, CAD system		ASCII files	ASCII files	
Other options/Special functions	Developers Edition for enhanced datamanagement LAN Pack for local networking, RapidFile for file management	3D Graphics package for graphs, communication with other computers or network, XON XOFF, X Modem protocols	advanced window interface allows viewing of multiple spreadsheets, graphs, scaling of windows, superimposed graphs	mouse compatible, PARADOX LANPACK for networking PARADOX 386 for 386 machines	mouse compatible	LAN PACK for networking

4.3.3 Review of Imaging software

An image processing software is a program that allows creation of graphic images on the computer screen using one or more primary colors and different combination of those to produce various hues and tints. They may be termed as *paint programs* that allows processing of *captured* video or television images, computer scanned images of photographs or printed matter, CAD drawings or any other computer graphic images. These images can be manipulated by the software adding or removing different graphics, drawn over or painted. The finally produced images may be used to create animation, fed back into a video tape or hard copies of them may also be obtained.

The review of the following Image Processing or Paint software are similar to that of the database software. The study also include report in articles from computer related magazines.

Table 4.4. Review of Imaging Software

Software	Aurora 75	IBM Storyboard Plus	LUMENA	Picture Maker	TIPS	TOPAS
Minimum hardware requirements	PC AT, 512K RAM, 20MB hard disk, EGA, 2 RGB analog monitors, monochrome monitor, mouse, digitizing tablet, DOS	IBM PC, 512K RAM, double disk drive, CGA, RGB analog monitor, monochrome monitor, mouse, digitizing tablet, DOS 2.	IBM PC, 512K RAM, hard disk, EGA, RGB analog monitor, monochrome monitor, mouse, digitizing tablet, DOS	PC AT, 640K RAM, hard disk, TARGA, (equivalent) RGB analog monitor, monochrome monitor, mouse, digitizing tablet, DOS 3.0	IBM PC, 512K RAM, hard disk, TARGA, RGB analog monitor, monochrome monitor, mouse, digitizing tablet, DOS 2.0	PC AT, 640K RAM, hard disk, TARGA, RGB analog monitor, monochrome monitor, mouse, digitizing tablet, DOS 3.0
General characteristics	paint, imaging, graphics software	paint presentation graphics software	paint, imaging, graphics software	imaging, 3D graphics animation software	paint, imaging, graphics software	imaging 3D graphics, animation software
Operating environment/s	DOS	DOS	DOS	DOS	DOS	
Drawing and editing features	line, rectangle, arc, circle, ellipse of variable line thickness, erase, cut and paste, zoom, rotate, flip, scale, editing features, various brush shapes, options 256 on-screen colors	line, rectangle, arc, circle, ellipse of variable line thickness, erase, cut and paste, zoom, rotate, flip, scale, editing features, various sizes of pen, brush shapes options 256 on-screen colors	line, rectangle, arc, circle, ellipse of variable line thickness, erase, cut and paste, zoom, rotate, flip, scale, editing features, various pen, pencil, chalk, air brush options effect 256 on screen colors	line, rectangle, arc, circle, 3D extrusion, cube, sphere and other, copy, move, rotate, shade, texture map, remove hidden lines from wire frame models various pen, options brush shapes, on screen colors	line, rectangle, arc, circle, ellipse, triangle of variable line thickness, erase, cut and paste, zoom, scale, flip, editing features, various brush sizes, shapes, air-brush options on-screen colors	line, rectangle, arc, circle, ellipse, 3D extrusion, cube, sphere and other, copy, move, erase, rotate, zoom, scale, shade of wire-frame models solid modeling, various line thicknesses, on-screen colors
Other graphic or special features	image tilt for perspective effect, color table animation adding text to graphics, import of scanned, digitized or video captured images	lighting, dissolve, shadow, special effects, animation, adding text to graphics, import of scanned, digitized or video images	3D model by extrude on cycle color, cycle brush animation adding text to graphics, import of scanned, digitized or video images	light and shade effect multiple views of model on screen, create motion effect for animation, adding text to graphics, import of scanned, video, digitized images	blend, tint area fill, distort shape, image tilt for perspective effect save windows from drawings, import of scanned, video, digitized images	light and shade, texture map, perspective, animation, import of scanned, digitized, video images
Information exchange and communication with other software, built-in or third party interface	import Picture Maker files	import Lotus database, PC CAD files, readable by PC paint programs,	import data from Lotus database files, PC CAD, DIF, ASCII files	import of TARGA compatible files,	import of AutoCAD, CAD drawings TGA (TARGA) format compatible	linkable to AutoCAD, CAD software (TARGA format compatible)
Other options	video compatible output,	video compatible, Graphics Partner for slide-show, Voice Communication for sound effects	film recorder, video compatible output, business graphics generator interface	video compatible output, TIPS derivative paint program	video compatible output TARGA software Tools, (C language utility library), PC Carousel for (slideshow) animation	video compat output

4.3.4 Review of Facility Management Software

A Facility Management software package contain a variety of software tools and interfaces that address a wide range of activities required for facility management. They include real estate management, building design and construction, building operations, short/long term space planning, interior layout and design, and furniture and equipment management. Some

of them have interfaces to link with industrial standard CAD software and DBMS software. Thus, on the whole these software packages are designed to help increase productivity and efficiency in facility management activities.

The study of software which provide functions as required in Facility Management, include review of products literature on the software. The survey, however, revealed that most of the well known CAFM software are IBM compatible and mainframe based, rather than micro computer based.

Table 4.5. Review of CAFM Software

Software	ARCHIBUS/FM	CADG + FM	Facility and Property Management System	Facility Management +	FM Space Management	INSITE
Minimum hardware requirements		IBM 370/30XX, IBM 3279 terminal, MVS/TSO	IBM computers PC, mainframe	50 Series Prime computer system, PT200 terminal, PRIMOS operating system	IBM PC, 640Kb RAM, 10Mb hard disk, EGA, DOS 2.0	IBM mainframe, 1Mb RAM, IBM OS operating system
General characteristics	Facility Management software package	Facility Management software package	Facility Management software package	Facility Management software package	Facility Management software package	Facility Management software package
Operating environment/s		MVS/TSO, VM/CMS VAX/VMS VT125 240/241 terminals		PRIMOS	DOS	IBM OS
System modules	Space Management, Design Furniture and Equipment Management, Facilities Information Management,	System Coordinator, Inventory Manager, Requirements Programmer, Master Planner, Location and Layout Planner, Drafting Coordinator, Intelligent Drawing Display	Facility Inventory, Space Utilization, Needs Forecasting, Capital Budgeting, Project Planning, Property Management, Cost Management	Planning Room Inventory and Maintenance, Tracking, Leasing	Space-Forecast, Space-Inventory, Stack and Block	Inventory, Cost Accounting Analysis and Planning
Database and Facility Management features, communication with other database software	furniture, equipment inventory, maintenance, construction schedule and documents, space inventory, forecasting, planning and layout, utility maintenance, energy reports interface to dBASE, Lotus, databases	furniture, equipment inventory, maintenance, facility space planning, assignment, forecasting, lease information, evaluate alternative facility strategies, cost analysis built-in relational database-System Coordinator	equipment, building, land inventory, allocation, space assignment, utilization, facility needs forecasting, analysis of capital plan, budgeting of project, operations, occupancy, development, built-in database management system, linkable to external databases	furniture, equipment, room inventory, analysis of space usage, assignment, forecasting, equipment, utility maintenance, budgeting of departmental projects, equipment lease management built-in database management software-Prime Information	space inventory, area calculation, markup for circulation, usage, rent factor, associate furniture, equipment, utilities to space forecast and analysis of future space and facility requirements use data files adaptable to dBASE	land, building room, equipment inventory, leasehold information, space usage, availability, maintenance, density information, cost analysis and budgeting of facilities, depreciation, energy analysis built-in database-ANALYST
CAD and other graphic features, communication with other CAD software	import of CAD drawings, stack diagrams, block plans, schematic layouts, library of architectural symbols interface to CAD system, AutoCAD	import CAD drawings, stack diagrams, block plans, colored visual display of database information business graphics interface to and graphics systems-Drafting Coordinator	linkable to CAD software packages IBM business graphics software packages	block plans, stack diagrams, business graphics design drafting package-Facilities Design uses PRIME MEDUSA CAD software interface to AutoCAD translate IGES, DXF CAD formats	block plans, stack diagrams, overlays by built-in CAD software-SPACE, transferred to other CAD systems interface to AutoCAD, CADVANCE (under development) translate DXF CAD format	linkable CAD system-INSITE CAD produce floor plans, display hatched areas, spaces produce translate IGES, CAD format
Other features or options	customized application in real estate, building design, construction, operations, equipment maintenance	CADAM Facility Integrator - interface to CAD software, CADAM		optional CAD modules with Medusa	uses programming language- AutoLisp, dBASE macro language	

4.4 Hardware considerations

Consideration of hardware is also an important aspect of developing an inventory system. Primarily a software is to suit a particular hardware system. A particular software may run on more than one hardware system, but the application of a hardware system depend on the user requirements. In this particular study the criteria for hardware selection has been identified as follows :-

- Quality of graphics
- The ease of manipulation of information
- Capacity of storage of information
- Multi-user and multi-tasking capabilities
- The mode of output available

The quality of graphics has been referred to as the kind of image that can produced on the computer screen. The development of graphics card or board, a piece of hardware, saw the development of any kind of graphic, CAD or image processing software. The choice of a graphics card is thus dependant on the type of software to be run and the level of performance requirement e.g. the clarity of picture or the number pixels that can be displayed on the computer screen. However, the choice of a particular monitor may also provide different quality of graphics available, e.g. monochrome or color or the clarity of screen image. Currently the different kind of graphics card or monitor available are various and by different manufacturers. The appendices at the end of the study provide the different hardware requirement by the respective software. An extensive survey of such are beyond the scope of this study.

The speed of manipulation of information is that speed at which a computer can perform the function it is required to do. The speed is dependable both on the software and hardware technology. A computer with a higher clock speed (measured in Megahertz) can run a software much faster than one with lesser clock speed. The clock speed is higher in mainframe computers than in microcomputers. In the case of microcomputers the more commonly available clock speed are 10 to 12 MHz. in systems at the the AT level and higher, though some hardware systems have clock speed upto 30 MHz. or higher on a microcomputer.

The advent of "386" (a particular hardware technology) computers has provided the scope of easier maneuverability and higher speed than the "286" machines. However, this technology is new and under development so that more advantages may be available in the future.

One important factor observed in computer usage is the amount of information needed to be stored in the computer memory (mainly during execution of the program) or external memory (usually the accumulated information produced, in the case, the CAD drawing or a database) required by the software or by the user. While a 2-D CAD drawing may require upto several hundred Kilobytes of memory a 3-D image or a scanned or video captured image may require more than several Megabytes. A superior software may require resident memory of more 1 Megabyte, known as RAM (Random Access Memory), while other less sophisticated software may be run on machines with 640KB. RAM. While floppy disks have information storing capacity of 360 KB or upto 1.2 MB., a Bernoulli's disk may store information upto 80 MB.. With the development of optical disc storage systems available commonly in three forms, CD-ROM (compact disc-read only memory), WORM (write once read many) and EOD (erasable optical disc). These storage systems can store a huge amount of information e.g. a CD-ROM can hold 550 MB. of memory. Though expensive initially, these can be useful tools as memory banks especially for complex graphic information, like digitized photographic images. Introduction of new operating systems like the OS/2 for the PS/2 class of computers can serve as better operating environments in terms of speed, virtual memory or disk memory.

One more issue that has been pointed by the users is the question of the software being able to be accessed by more than one user or accessibility of different software at the same time. One solution for a multiuser system would be to adopt a mainframe system. But the cost of such a system would be hardly feasible for a small or medium sized company. The introduction of Unix (an operating system like DOS) based "workstations" can serve as multi-task systems. LAN (Local Area Network) networking is another form of interconnecting multiple users to the same software or common database. The multi-task software are not the same as that run on microcomputers, but are written on a different format compatible to multiuser operating system like the Unix. Some of the CAD or database software commonly developed for microcomputers have their workstation or mainframe equivalents. The OS/2 operating system allows concurrent execution of multiple software applications.²³

The output form of the information from the computer is not frequently used but is quite relevant in terms of usable inventory. Thus, different groups of vendors have developed various type of printers, plotters and other forms of hard copy outputs. The plotters for graphic outputs like CAD drawings use pens (may be multicolored or as required) as plotting tools on media like paper or vellum, but the more advanced ones used are electrostatic plotters. Laser printers are available for monochrome or multicolor outputs of graphic or textual inventory. Outputs may also be produced on photographic slides by photographing off the screen or by the use of certain mechanical and electronic techniques directly from the CAD or picture files. The latest rapidly developing technology are video outputs where graphic information from CAD drawings or computer generated pictures produced by the image processing software can be converted by certain processes into television signals and put on video tape for demonstration or presentation.

²³ Teicholz, Eric, "The future of AEC CAD", May 1988, *Architectural and Engineering Systems*, (pp 18-22).

Chapter 5. Analyses and Discussions

5.1 General Statement

The research has developed a methodology for assessing and evaluation of computer software for specific user requirements. Discussion with representatives of the different organizations, though within a small sample of users, revealed varied user requirements for inventory and facility management. The software review provide information about different hardware and software technologies regarding their usage and functional capabilities. Later each individual software was evaluated with the evaluation criteria developed.

The analyses of the user requirements and software survey, projects the current trend of computer applications, the future application possibilities and the drawbacks of such in inventory and facility management.

In the analyses of individual software of each category the inferences drawn are based not only on the particular version of software package chosen for survey but also considering the capabilities by other versions or optional packages of the software.

5.2 The software and user requirements analysis

The analysis of usage of different software for different user requirement provide such information as which software may be utilized to fulfill the particular requirements. The results show the application trend of particular type of software, and thus provides the frequency of usage and the different ways the particular software may be utilized. The types of software has been categorized as CAD, DBMS, Imaging and CAFM systems.

5.2.1 *Application of Software of Different Categories*

The general analyses show that CAD and DBMS can be the most useful software used for inventory maintenance and facility management. CAD systems and DBMS is known to have been linked together frequently and some of the widely used CAD software has interfaces with other database software, either by the same company or by another third party.

The imaging software may be used for visual record of physical objects, the building plans (by importing CAD drawings into an imaging software), or computerized images of the buildings. Storage of such images is an important factor to consider as one of such image use up a lot of computer memory. CAFM software will be certainly helpful where extensive facility planning is required. The main advantages of facility management software packages are that they provide customized inventory and facility management operations which may be more easily applicable for the requirements.

The following matrix give the analysis between the established set of user requirements and the kind of software that may be useful for each particular requirement. The significances of the symbols used in the matrix and the other following ones are given below :-

[•] - strongly favorable

[o] - favorable

[] - not favorable

The analysis and evaluations of different software have been made from studying the functional capabilities and considering the current usage of the software. The performance levels for each operation has not been evaluated quantitatively. The inferences drawn are more of a feasibility study report.

Table 5.1. General analysis of User Requirements and Software Categories

	<i>CAD System</i>	<i>Database System</i>	<i>Imaging System</i>	<i>CAFM System</i>
Space				
Site plan	•		○	○
Building plans	•		○	○
3D representation of buildings, rooms	•		○	
Inventory of rooms, spaces	○	•		○
Usage of rooms, spaces	•	•		•
Lease information of rooms, spaces	•	•		•
Forecasting future requirements of rooms, spaces	○	•		•
Visual record of buildings, rooms, spaces			•	
Location of repair renovation	•		○	○
Scheduling, budgeting of repair, renovation		•		•
Object/item				
Inventory of equipment, furniture,	○		•	•
Location of equipment, furniture	•	○		○
Visual record of equipment, furniture			•	
Scheduling, budgeting of equipment, furniture purchase		•		•
Utilities				
Location of utilities, Electric, telephone, HVAC lines	•		○	○
Day to day maintenance record		•		•
Location of repair, renovation	•		○	○
Scheduling, budgeting of repair, renovation		•		•
Application				
Application complexity	•	•	•	○
Complexity of hardware	•	•	○	○
Multitruser facilities	○	•		○

5.2.2 Applications of CAD software

Application of CAD software has been found to be more useful than the others. The applications can vary from producing building plans, showing location of objects within the spaces to marking off different areas according to usage. Built-in symbol library can help in creating the location of objects or utilities on the building plans. Built-in database packages as in the case of Arris which provides Sigmac and VersaCAD which provides the customized Bill of Materials program can help in creating a linkage between the graphic and CAD database very easily. However, interfaces to external database systems can also provide the same advantage. A large number of third party software as in the case of AutoCAD, is also another criteria of choice of any software.

The following matrix gives the analysis and evaluation of the six different CAD systems.

Table 5.2. Comparative Analysis of CAD Systems

	<i>Arris</i>	<i>AutoCAD Release 10</i>	<i>CADVANCE Version 3.0</i>	<i>MicroCADAM Cornerstone 1.3</i>	<i>Microstation PC Release 3.0</i>	<i>VersaCAD Version 5.4</i>
2D drafting	•	•	•	•	•	•
3D drafting	•	•	•	o	•	•
3D modelling	•	•	•		•	•
solid modelling		•			•	
graphic database	•	•	•	•	•	•
textual database	•					•
overlays	•	•	•	•	•	•
hatch, areafill	•	•	•	•	•	•
symbol library	•	•	•	•	•	•
perspective, fly around, walk-through	•	o	•			
customized design package	•	•				
programmability, customization capability	•	•	o	o	•	•
linkage with databases	o	•	•		o	
linkage with imaging systems		•				
linkage with CAFM systems		•	o			
application complexity	o	o	o	o	•	•
complexity of hardware	o	•	•	o	•	•
multiuser facilities	o				•	

5.2.3 Applications of Database software

The following matrix gives a comparative analysis of the six different Database systems.

Table 5.3. Comparative Analysis of Database Systems

	<i>dBASE IV</i>	<i>Lotus Symphony 2.0</i>	<i>Microsoft Excel</i>	<i>Paradox 3.0</i>	<i>Reflex</i>	<i>SuperCalc5</i>
spreadsheet application features	•	•	•	•	•	•
customized spreadsheet format			•	o	•	•
multi-dimensional spreadsheet						•
multiple display, manipulation of spreadsheet			o			o
relational database	•			•		
report generation features	•	•	o	o	•	o
word processing features		•			o	
business graphics features	•	•	•	•	•	•
programmability, customization capabilities	•	•	•	•	•	o
linkage with CAD systems	•	•				
linkage with imaging systems		•				
linkage with CAFM systems	•	•				
application complexity	•	•	•	•	o	•
complexity of hardware	•	•	o	o	•	•
multiuser facilities	•			•		•

5.2.4 Applications of Imaging software

The following matrix gives a comparative analysis of the six different Imaging systems.

Table 5.4. Comparative Analysis of Imaging Systems

	<i>Aurora 75</i>	<i>IBM Storyboard Plus</i>	<i>LUMENA</i>	<i>Picture Maker</i>	<i>TIPS</i>	<i>TOPAS</i>
2D drawing	•	•	•	•	•	•
3D drawing			o	•		•
light and shade effects		•		•		•
business graphics features			•			
slide-show, animation features	o	•	o	•	•	•
digitization, scanning of images	•	•	•	•	•	•
television, video input/output	•	•	•	•	•	•
linkage with CAD systems.		o	o		•	•
linkage with database systems.		•				
linkage with CAFM systems.						
application complexity	•	•	•	o	•	•
complexity of hardware	•	•	•	o	•	o
multiuser facilities						

5.2.5 Applications of Facility Management software

The following matrix gives a comparative analysis of the six different CAFM systems.

Table 5.5. Comparative Analysis of CAFM Systems

	<i>ARCHIBUS/FM</i>	<i>CADG + FM</i>	<i>Facility and Property Management System</i>	<i>Facility Management +</i>	<i>FM Space Management</i>	<i>INSITE</i>
stack diagrams features	•	•	•	•	•	
block plans features	•	•	•	•	•	o
built-in CAD system		•			•	
built-in database features	•	•	•	•	•	•
business graphics features		•				
customized inventory application features	•	•	•	•	•	•
customized CAD features		•				
customized space usage tracking features	o	o	•	•	•	o
customized lease maintenance features	o	o	•	•	•	o
customized space forecasting features	•	•	•	•	•	
customized scheduling of work	•	o	o	o	o	
customized cost analysis, budgeting		•	•			•
linkage with CAD systems	•	•	o	•	•	o
linkage with database systems	•	•	o	o	•	o
linkage with imaging systems						
application complexity	•	o	o	o	•	•
complexity of hardware	•	o	o	o	•	o
multiuser facilities		•	•	•		•

5.3 Communication between different software packages

Communication between different software packages of the same type or different types are available in most cases. In the case of files of the same nature e. g. CAD files, one drawing may be converted from one format to another. Some software may be able to directly import files from another software format or through the conversion to a common format. IGES is such a common format for file transfers from different CAD systems. In the case of databases most of the packages can import Lotus formatted files.

Two different kind of software may be able access and exchange information between each other. As in the case of CAD system and databases, graphic attributes in a CAD drawing, can be linked with textual information in a database. A vector based CAD image can be imported into a raster based image by the help of a specific interfaces. The communication capability helps in exchange of information between the same type of software and in combination of different type of software to obtain enhanced functional advantages. The latter has been discussed in the next sections of this chapter.

5.4 The combination of different software

The study showed that different types of software packages may be linked or combined together to produce enhanced functions. A CAD software package may be linked with a DBMS, or a CAFM package may have an interface software which allows exchange of inventory to from another CAD system or another database system. In some cases CAD drawings can be imported into an image processing software for further rendering or manipulation. Often, the main software package provide the interface with another software package, but there are also third party software providing the the linkage between two well known software. The study revealed that while there are a large number of third party software for AutoCAD, others

like CADVANCE provides a built-in interface with dBASE. The results showed in the next following tables were obtained from actual experiment, studying the products literature and from other reports.

5.4.1 Combination of CAD system and Database systems

CAD and Database systems can more easily communicate with each other than the other combinations. This combination is the most desirable by the users surveyed and this constitute the basic rudimentary concept of linking graphic information from a CAD drawing to textual information. The following table shows which of the CAD and Database software may be combined together or can communicate with each other.

Table 5.6. CAD systems combined with Database systems

	dBASE IV	Lotus Symphony	Microsoft Excel	Paradox	Reflex	SuperCalc5
Arris						
AutoCAD		•				
CADVANCE	•					
MicroCADAM						
Microstation PC	•					
VersaCAD						

5.4.2 Combination of CAD and Image Processing systems

The utility of linking a CAD system to an Image Processing software is that the vector based CAD drawings can be converted to raster based images in the other system and further manipulation can be done to produce presentation drawings. Image Processing software can store visual inventory captured from other forms like video capture, which may be used for visual inventory. The following table show which of reviewed CAD and Image Processing software can communicate from each other.

Table 5.7. CAD systems combined with Image Processing systems

	Aurora 75	IBM Storyboard	LUMENA	Picture Maker	TIPS	TOPAS
Arris						
AutoCAD				•		•
CADVANCE						
MicroCADAM						
Microstation PC						
VersaCAD						

5.4.3 Combination of CAD and CAFM systems

The Facility Management systems essentially have their own version CAD software or interfaces with the more widely used CAD systems. The CAD drawings are imported into the CAFM software package and used for manipulation. The following table shows the communications available between the CAD and CAFM programs reviewed.

Table 5.8. CAD systems combined with CAFM system

	ARCHIBUS FM	CADG + FM	Facility and Property Management	FM +	FM Space Management	INSITE
Arris						
AutoCAD	•		•	•		
CADVANCE					•	
MicroCADAM						
Microstation PC						
VersaCAD						

5.4.4 Combination of Database and Image Processing systems

The communication of databases with the Image Processing software has not been observed much. The following table shows the possibility of exchange of information of the two types of software reviewed.

Table 5.9. Database systems combined with Image Processing systems

	Aurora 75	IBM Storyboard	LUMENA	Picture Maker	TIPS	TOPAS
dBASE IV						
Lotus Symphony			•			
Microsoft Excel						
Paradox						
Reflex						
SuperCalc5						

5.4.5 Combination of Database and CAFM systems

As in the case of CAD software, the link between databases and CAFM software packages are also essential for facility management. While some of the CAFM systems have their own database or interfaces with widely used Database software. The following table shows the communication availability between the two kinds of software reviewed.

Table 5.10. Database systems combined with CAFM system

	ARCHIBUS FM	CADG + FM	Facility and Property Management	FM +	FM.Space Management	INSITE
dBASE IV	•				•	
Lotus Symphony	•					
Microsoft Excel						
Paradox						
Reflex						
SuperCalc5						

5.4.6 Combination of Image Processing and CAFM systems

The link between a CAFM software package and Image Processing system has not been observed within the the software surveyed in the study. The possibility of using computerized images in an Image Processing system for inventory and facility management is feasible but needs further study to develop.

5.4.7 Other Combinations

The multiple combination of the four basic types of software packages has not been reviewed in detail in this project. It is observed that all four types may be interlinked together in a several combinations, all at the same time or lesser ones. The linkage can be a topic of further study according to different criteria of user requirements.

Chapter 6. Conclusions and Recommendations

6.1 General Statement

The study showed that there are many scopes of applications of computers in inventory and facility management. Among the users included in the study, computers are not exclusively used for inventory or facility management. However, persons in charge of building maintenance or facility management of different organizations, who were interviewed by the author, feel that application of computers would be very beneficial. Development of user friendly and less complicated and expensive software will certainly enhance future use of computers.

The survey of user requirements and software available in the market showed that both are diverse and varied. All users have some similar requirements though some have special ones different from the others.²⁴

The requirements will certainly vary more widely if a larger sample of users is taken. The variety and amount of software available in the market is also large. Among the software categories chosen CAD (Computer Aided Design) and DBM (Database Management) systems

²⁴ See Appendix 2 for user requirements.

have been found to be more useful than Imaging and CAFM (Computer Aided Facility Management) systems. While a CAD and a database system can be termed as the first stages of computer applications for inventory and facility management, the inclusion of an imaging system would be highly useful for a visual inventory.²⁵ The customized application features of different CAFM systems can also be very helpful for organizations with large facilities. Due to the variety of user requirements and the variety of software available, no single software or software package can be stated as the most useful. The selection of software will be determined by the needs of an organization and its resources.

6.2 Developing a Methodology for assessing Computer Software

Applicability to Inventory and Facility Management

The study for assessing computer software applications has determined the following basic guidelines and considerations for developing a methodology. The basic principles used in the methodology may be used assessing CAD, Database, Imaging and CAFM software according to different user requirements.

The first step for choosing computer software is to identify the needs of the user. A careful study of the user needs will help identify the the specific kinds of software that may be used to satisfy the requirements. The requirements will help establish criteria for evaluation of the software packages to be chosen.

It should be determined whether only the existing hardware platform is to be used or not. A possibility of expansion of the hardware platform will provide more flexibility in choosing the

²⁵ Visual inventory has been referred as a graphical inventory on the computer, where graphical images of objects can be used instead of textual records, for an inventory.

software. The addition of hardware components could also provide enhanced functional capabilities.

If the choice of the computer programs is dependant on the existing hardware, only the software packages compatible to the existing hardware should be chosen for further evaluation. A large number of software packages can be taken when the existing hardware is not a binding factor.

The software packages are then to be tested by the evaluation criteria determined. The study has determined the more important factors of evaluation of software packages for inventory facility management, which are described in the following paragraphs.

The capability of exchanging of information between software packages of the same category is an important factor of evaluation. Computer data or output are in different formats for different software packages. However, certain generic formats have been developed for each of different categories of software packages. The use of a software is more flexible when when it can produce or convert its own files to the standard formats, so that another software package can import files into it's own formats. While "DXF" and "IGES" are generic formats of CAD files, "PICT", "GIF" and "TIFF" are generic formats of pixel or raster²⁶ files. "ASCII" is a generic format into which most textual data can be converted. "dBASE" or "Lotus" formats can be termed as more generic formats of database files as most database file formats can be converted into the above two.

Communication between software of different categories will allow exchange of information and data between the two. The capability of a CAD system to communicate with a Database system is thus very important as textual and graphic information can complement each other. The integration of textual and graphic information can be done in different ways. One proce-

²⁶ Computer images produced by illuminating pixels on the computer screen are called raster images.

dure suggested in the study would be to use software technologies like Microsoft "windows".²⁷

Different software can be simultaneously run on the same micro-computer and viewed on the same screen through different "windows". This helps in increasing productivity as concurrent applications of more than one software is possible. More time intensive tasks could be done in the background, while another program can be run on the foreground.

Other considerations should be such factors as conversion of vector based computer images,²⁸ to pixel or raster based images. CAD drawings are termed as vector based images, while raster or pixel based images will include scanned or video captured images. A merging of the two kinds of images will involve conversion of the former to pixel or raster format. Translators (software packages) are available for conversion of vector images to raster images.

The hardware platform on which the software will be run is also a very important factor. The different hardware factors concerning this study has been discussed in Section 4.4 of Chapter 4. The primary considerations for a hardware platform for developing an inventory and facility management system, suggested in the study, has been discussed in the next paragraphs.

The first consideration would be to choose the proper operating environment for the system. "Unix" an operating system which allows multi-tasking facilities would be preferred to "DOS" operating environment, normally used in micro-computers. Multi-tasking facilities allows more than one kind of software to be run on the same machine simultaneously.

²⁷ "Window". is a computer environment that allows concurrent applications and access of several software, through a graphical user interface (GUI), on the the same computer with the help of appropriate processor.

²⁸ Computer images such as CAD drawings where each line, curve, or surface has associated geometric information stored in the memory of the computer are called vector images.

The working capability of a software package can also depend on the kind of processors used. The introduction of advanced processors like the "80386" and "80486" or "68030" and "68040" (different types of hardware technologies) processors, which provide easier maneuverability of software and higher application speeds than the previous processors can provide advanced functional capabilities. The functions available can be integration of multiple media e.g. graphics, text, audio and video. The integration of such media will provide advanced functional capabilities to an inventory and facility management system.

The input of data and information into the system can be done by different methods. The principal devices are keyboard for entering numeric or textual information, mouse and digitizer for entering graphical information. Flat bed and slide scanners can be used for entering various graphic information from photographs, printed matters or slide photographs. Video cameras and recorders can be used import video pictures of inventory items in the system.

Mass storage problems of computer data, especially in the case of graphic inventory (in the range of 500 Mb. of memory or more), can be solved to a great extent, by using compact disc or laser disc storage systems. Further discussions has been done in Section 4.4 of Chapter 4.

The output options for different kinds of information also needs attention. While textual information can be obtained as printed output from a printer, graphic information like a CAD drawing has various output options of hardcopies. Drawings can be printed, plotted or as slide or printed photograph. Output on film or videotape are also two more options.

Figures 6.1 summarizes the different steps suggested to be followed in the proposed methodology for assessing computer software applicability to inventory and facility management.

Figure 6.2 describes a model of the hardware platform on which a computer aided inventory and facility management system can be made to work.

6.3 Recommendations for further study

The study in this project was conducted under many limitations.²⁹

The sample of users (eight) and software packages (six from each of four categories) were small in number. The software analyses also has limitations. In evaluating the software no quantitative performance evaluation was done. Further studies on the same topic can be done by overcoming these limitations. A larger sample of users and software with more experimental studies will provide more detailed information about the software, and the scope of application of each. Statistical analyses will determine the number of sample of users as well software to chose for further studies.

Several benchmark tests has been suggested from the analyses of the current study. These tests will be a further topic of study and will provide a more detailed comparison of current software packages. The benchmark tests for software should include attributes like speed of application, accessibility of inventory from the CPU (Central Processing Unit), the amount of RAM (Random Access Memory) required, the ease of data transfer to and from similar computer files of other formats. Other considerations should be factors like the amount of memory required to create a single raster image and the number of different standard formats, as discussed earlier, a software can support. For hardware the benchmark tests should include features as the resolution of a monitor, the processor clock speed available and the operating environment that can be supported.

²⁹ The considerations for the choice of users and software survey has been explained in Section 1.4 of Chapter 1.

One of the software categories, the imaging systems, are still under constant experimentation. Because of the capability of a graphic image to contain a large amount of information, visual inventory systems should be a further topic of study.

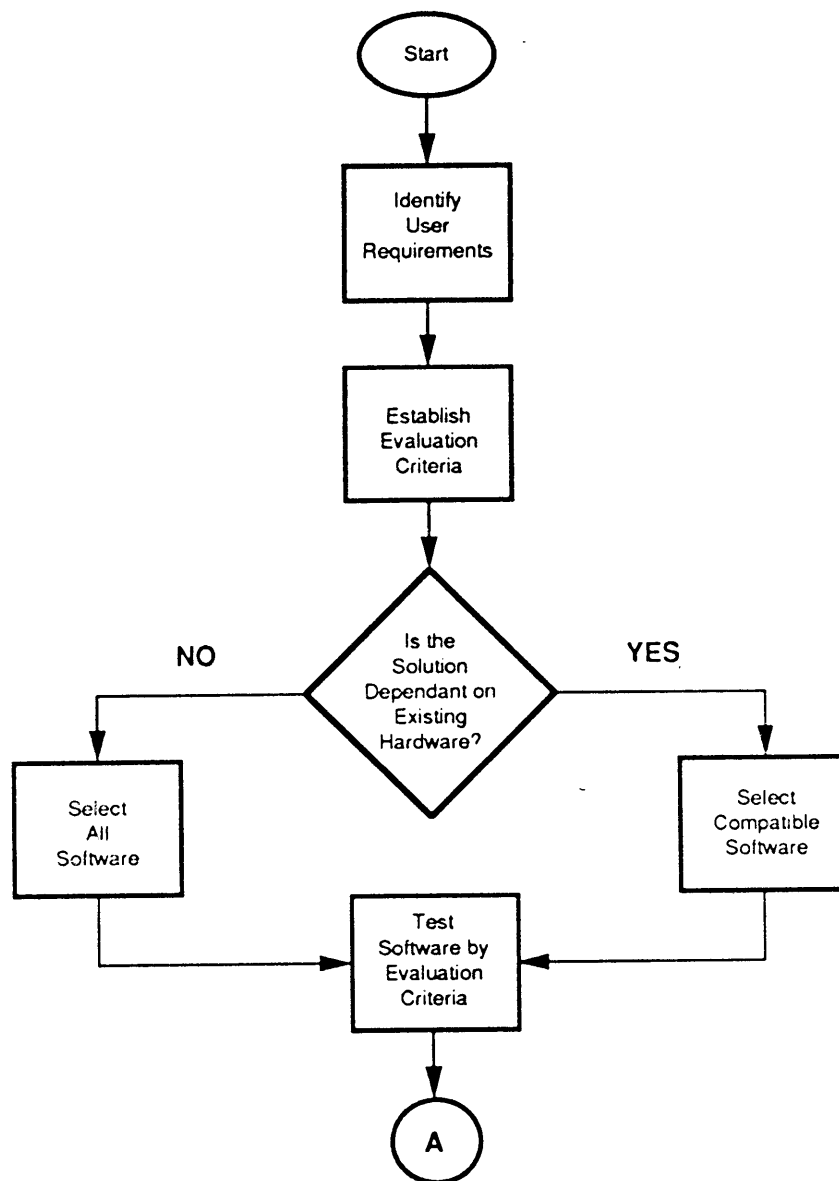


Figure 6.1. A proposed methodology for assessing computer software applicability in Inventory and Facility Management

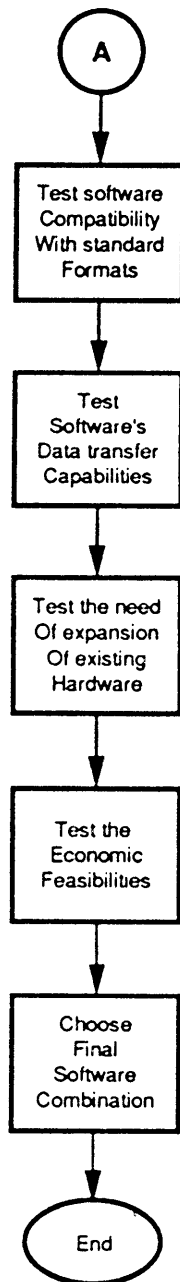


Figure 6.1. Methodology continued

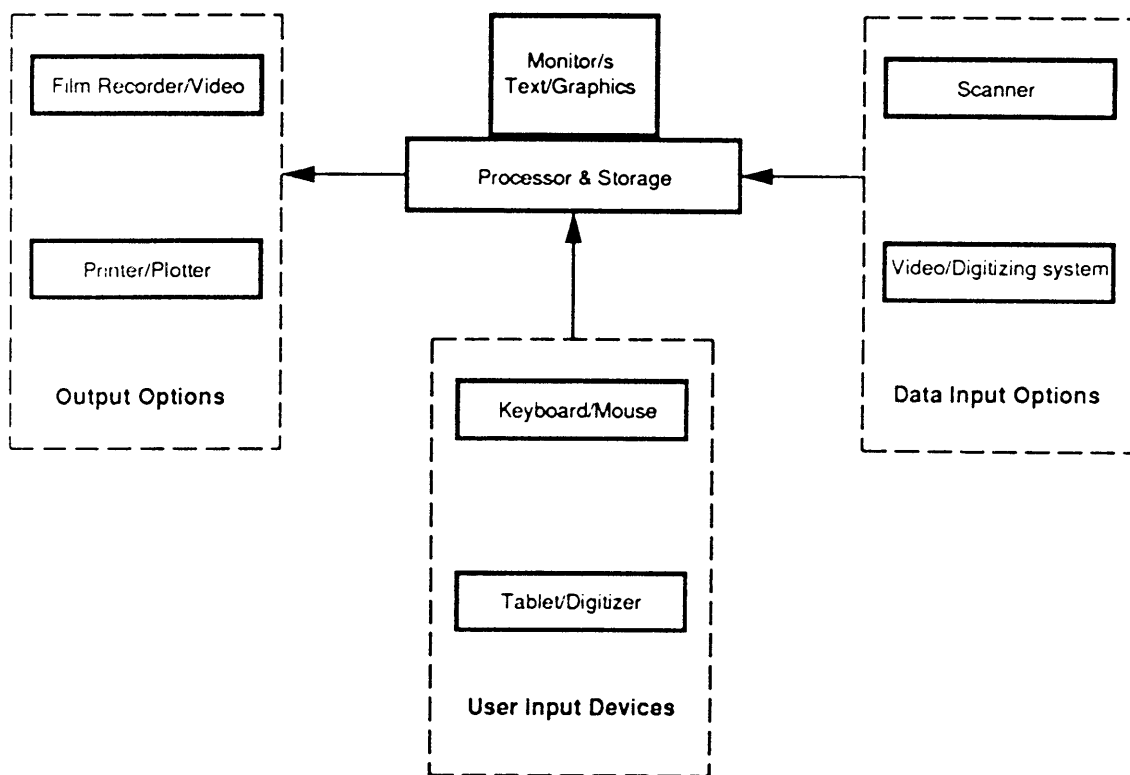


Figure 6.2. A proposed model of the hardware platform for a computer aided Inventory and Facility Management system

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SUBJECT INDEX

1. Computer Aided Design
2. Database Management
3. Facility Management
4. Image processing

APPENDIX 1. Glossary

algorithm A set of rules for solving a problem

artificial intelligence A mode for working in which a computer mimics human intelligence.

ASCII (American Standard Code for Information Exchange) A method of representing alpha-numeric *characters* as numbers for computer storage.

binary Having two possible states; the concept is appropriate to electrical circuitry as current may be flowing or not flowing.

bit (binary digit) The basic unit of information in a computer. A number of bits may be taken together to form a character.

byte A sequence of binary digits (*bits*) that the computer operates on as a single unit. It is eight *bits* and is the basis of comparison used in describing various systems and manufacturers. One byte is a character of memory.

CAAD Abbreviation for Computer-Aided Architectural Design.

CAD Abbreviation for Computer-Aided Design.

CADD Abbreviation for Computer-Aided Design and Drafting.

CAFM Abbreviation for Computer-Aided Facility Management.

CPU (Central Processing Unit) The part of the computer system that carries out the calculations and co-ordinates the other parts.

cursor A visual indication on screen giving the currently referenced position. It usually takes the form of a cross in graphical applications and a flashing characters in textual applications.

database A *file* which contains information structured into a logical form.

DBMS (Database Management System) A program which manipulates a *database* in order to read or write information.

digitizer, or tablet A data input device which will generate co-ordinates when touched with a special *pen, puck or mouse*.

expert system A computer program that mimics a human expert in a field.

field A part of a *record* in a *database* which contains a single item of information.

file A distinct set of information stored in computer memory.

flowchart A diagrammatic representation in which a computer program is structured.

FM Abbreviation for Facility Management.

hard copy Output printed on paper or other similar material as distinct as that appearing on screen.

hard disc. A form of disc storage in a computer in which the magnetic surface is rigid as opposed to a floppy disc.

hardware Computers and computer circuitry.

icon A symbol representing a concept, used for giving instructions to computer program.

IGES (Initial Graphic Exchange Specification) The most developed interface standard for the transmission of drawings in alphanumeric form.

Kb (Kilobyte) A group of 1024 *bytes or characters*.

LAN (Local Area Network) A system of passing information at high speed between computers. A dedicated wiring system is involved.

LISP (LIST Processing language) A high level language often used in artificial intelligence work.

macro A group of commands which is named and can be invoked by giving that name.

mainframe A large computer.

Mb (Megabyte) A group of 1,048,576 (2^{20}) *bytes or characters*

menu A list of alternatives (commands of a computer programs) from which a user can choose.

microcomputer A computer based on a *microprocessor*.

microprocessor A complete *central processing unit* constructed on a single *integrated circuit*.

microcomputer A computer in which the *central processing unit* is constructed of discrete elements, but which is not physically large and does not require a controlled environment.

RAM (Random Access Memory) The system used for the main memory of the computer. Data can be read or written at any point in a constant time.

RGB (Red Green Blue) A color monitor is also referred to as RGB monitor.

raster screen A screen where the image is built by repeatedly placing dots in parallel lines.

record A set of data items (*fields*) in a *database* that relate to a particular entity.

relational database A type of *database* in which information is stored as a set of tables which are related to each other through common *fields*.

ROM (Read Only Memory) A type of main memory which always contains a fixed set of information.

software Computer programs.

spreadsheet A computer program that manipulates a matrix of data where the matrix may be interconnected.

subroutine, or subprogram A distinct block of computer instructions to carry out a certain process. Reference can be made to the block whenever the process has to be carried out, thus avoiding duplication.

touch-sensitive screen A screen which when a point on its surface is touched, will transmit the co-ordinates of that point to the computer.

track-ball A ball-like device which when turned by hand will transmit the amount of movement and its direction to the computer.

user-friendly A *software* that may be operated easily by persons with less computer literacy

VDU (Visual Display Unit) A screen equipped with a keyboard. It is used to input data into the computer and show the results.

word processing A system used to create and modify text files.

APPENDIX 2. User Requirements Established

1. College of Architecture and Urban Studies

Organization Educational Institution

Activity Teaching, research, administration

Buildings/Rooms Offices, teaching classrooms, studios, conference, research laboratory

Items of Inventory Furniture, equipment - teaching or administration.

Requirements

General

- storing basic information about objects like name, location, size etc. (user defined)
- storing graphic information regarding configuration, size, shape and location of objects in a building (to scale, referenced)
- providing easy accessibility of these records i. e. information may be easily retrieved, new record may be easily added to the database or new object image may be easily added to a drawing
 - keyword access (title)
 - hierarchy search
 - related equipment
 - date of purchase
 - main schedule
- storing images of objects which may be associated with the textual information in the database

- allowing change made in the configuration or location of objects associated with a CAD drawing to be reflected in the database
- capable of handling a huge amount of information associated with the records in the database or object images
- performing special functions like calculating area and volume etc.
- producing flexible reports - giving updated information

Basic fields required by an equipment inventory would be :-

- item
- id#
- purchase date
- purchase value
- source vendor
- present value
- location
- specific use (electrical, mechanical, etc.)
- user defined attributes.

2. Virginia/Maryland Regional College of Veterinary Medicine

Organization Educational Institution and Research Organization.

Activity Teaching, research and providing veterinary medical facilities.

Buildings/Rooms Teaching Classrooms, laboratories, medical rooms.

Items of Inventory Medical equipment, laboratory equipment, furniture

Requirements

General

- Inventory base created by bar-code tagging each piece of equipment, and recorded on video.
- Each piece of equipment thus recorded should be entered into DBMS.
- Visual record made of each room and the DBMS programmed to locate the individual piece or compare records of the visual and textual database.
- The DBMS should be able to generate list of equipment of which the life has expired or needs replacement.
- The fixed asset values for building campus or the whole college could be determined for maintenance costs purposes.

The database system should contain the following information for each inventory item.

- Item Description
- Inventory #
- Purchase price
- Purchase date
- Useful life and associated replacement date
- Ordering individual
- Purchasing Account Code
- Assigned Owner (i.e. Dept #)
- Current location (Campus, Building, Room #)

Other requirements

- Calculate and prepare yearly lists of equipment due for replacement, value of inventory by department, account code, owner or building, the database should be accessible by different users.

3. University Architect's Office, Virginia Polytechnic Institute and State University

Organization Planning Department of University

Activity In charge of planning, renovation of building under Virginia Tech

Buildings/Rooms All buildings - academic, office, recreation, residential etc. Offices, teaching classrooms, studios, conference, research laboratory dormitories, dining halls

Items of Inventory Space Inventory

Requirements

General

- Maintaining record of spatial information of all buildings under the University :-
 - location within a building
 - the use of each room
 - people / persons assigned to each room
 - objects / item within each room
- Information to be recorded in DBMS and associated with information within a CAD drawing of a building.
- Keyword information should be able to bring up a window in CAD system to show the location of desired room or area in building.
- Provide information like length, breadth, height, area, volume of a space.

Fields of the space inventory are :-

Building #	Room #	Room use
Floor Level	Grade Level entrance	No. of Stations
College #	Department Number	No. of Graduate Students
Functional use code	Room use code	Program classification
% Instruction	% Research	% Extension
2nd College	2nd College	% Shared
Room width	Room length	Area

Some of the information associated with each room, given a numerical value are as follows :-

Accessibility	(score)	
	0: completely accessible	3: room not accessible
	1: building not accessible	4: no workstations
	2: floor not accessible	
Suitability	(score)	
	0: 90-100 percent suitable	3: 25- 49 percent suitable
	1: 75- 89 percent suitable	4: 0- 24 percent suitable
	2: 50- 74 percent suitable	

Wall	(coded value)	
	0: concrete block	5: brick
	1: gypsum board	6: ceramic tile
	2: plaster	7: wood
	3: panelling	8: concrete
	4: fiberglass	9: metal
Floor	(coded value)	
	0: vinyl tile	5: carpet
	1: wood	6: terrazzo
	2: concrete	7: marble
	3: sheet vinyl	8: stone
	4: ceramic tile	9: metal
Ceiling	(coded value)	
	0: lay-in tile	4: wood
	1: metal	5: gypsum board
	2: exposed	6: concrete
	3: plaster	7: ceramic tile

4. Fixed asset control Department, Virginia Polytechnic Institute and State University

Organization Department in charge of fixed assets

Activity Maintaining and controlling of purchase of fixed assets, and properties belonging to the University

Buildings/Rooms Offices, teaching classrooms, studios, conference, research laboratory

Items of Inventory

Requirements

Asset Inventory/Control

A. Asset Categories

1. Land
2. Buildings
3. Improvements other than buildings
4. Equipment
 - a. Office Equipment
 - b. Scientific Equipment
 - c. Vehicles
 - d. Computing Equipment
 - e. General support Equipment
 - f. Special Fixed Equipment
 - g. Farm/Agricultural Equipment

B. Identification data

1. Description data
2. Manufacturer
3. Model
4. Serial Number

C. Location Information

1. FIPS Location
2. Building
3. Floor and Room

Accounting and Financial

A. Historical information

1. Acquisition date
2. Original acquisition cost and cost basis
3. Last Inventory date
4. Disposal Date

B. Ownership Data

1. Ownership

- a. Agency (Va. Tech) and responsible department
- b. Federal
- c. Leased
- d. Other

C. Acquisition Methods

1. Methods

- a. Purchase
- b. Lease
- c. Constructed
- d. Donated
- e. Acquired by Trade

D. Accounting Information

1. Funding

- a. Agency
- b. Fund Group (State Federal and Non-Fed Sponsored, Overhead, Auxiliary)
- c. Program and Sub-Program
- d. Sponsored Project Number
- e. Funding Source - (Specific State or Federal Sources, e.g. : (NSF, NASA,))

2. Depreciation/Replacement

- a. Useful Life
- b. Accumulated Depreciated Expenses
- c. Last Inventory date

- d. Use of allowance Rate for indirect cost allocations
- e. Replacement Index
- f. Year-End Replacement Value
- g. Financial Reporting
- h. Transaction Code and Capitalization Indicators (drives General Ledger Account Totals)

5. Blacksburg Marriot

Organization Motel, Maintenance Department

Activity Provision of boarding/lodging, restaurant and swimming pool facilities

Buildings/Rooms Guest rooms, dining rooms, kitchens, conference rooms, stores, offices, restaurants and swimming pools

Items of Inventory Utility services, furniture, kitchen utensils and equipment, carpet, guest services - linen, lamps

Requirements

General

- maintenance of HVAC : regular and for individual guest rooms
day to day inspection, repair and maintenance
- maintenance of parking areas and outside compound
- maintenance of swimming pools : water supply, cleaning, temperature control
- maintenance of water supply, electric supply and other plumbing lines
- minor repair renovation jobs within the compound
- maintenance of inventory of equipment and items
- budgeting of expenditure for renovation, repair or replacement
- keeping record of inspection, repair or renovation and scheduling of work
- maintenance of vehicles used for service to guests

Housekeeping department

- day to day upkeep of guest rooms including repair or replacement of guest room items
- day to day maintenance of kitchen, dining and restaurant areas
- inventory maintenance of guest room items : furniture, linen, room carpeting, draperies

6. HCMF Corporation

Organization Real Estate Developer

Activity Real Estate developing, acquiring and selling property, managing apartment complex, leasing and selling property and apartment, managing nursing homes.

Buildings/Rooms Property, residential buildings, nursing homes etc.

Items of Inventory Property holdings, sales and lease, buildings to be managed, rent records

Requirements

Real Estate

- maintain record of current property holdings - landuse maps
- maintain record of market price
- maintain record of buying and selling, lease
- landuse records : size, location, owner, availability

Development and construction

- market statistics on land development
- construction management
- liaison with developer/contractor
- housing development and sales, renting and management

Property Management

- managing housing complexes
- management and maintenance facilities of each building
- facility management of nursing homes
- inventory of equipment, maintenance records, rental account

7. New River Valley Mall

Organization Shopping Mall

Activity Commercial - Shopping complex restaurants and theaters.

Buildings/Rooms Shops, restaurants, theaters and management offices

Items of Inventory Utilities, lease records

Requirements

General:

- Records of lease of different areas in mall
- Maintenance of common areas within mall and exterior compound, including parking areas.
- Repair or renovation (within buildings according to agreement lease, external repair of lot)

Utilities:

- Water supply
Maintenance of supply lines, collection of monthly expenses from individual owner
- Electric Supply
Maintenance of supply lines, maintenance of automatic lighting system collection of monthly expenses from individual owner,
- HVAC
General maintenance, temperature control, scheduled inspection, documented record, collection of monthly expenses from individual owner
- Fire protection
General maintenance, control, scheduled inspection, documented record

Budgeting:

- Maintenance cost is an important factor, proper estimation of maintenance cost and repair cost needed to be done periodically.

8. Dominion Bankshares Corporation

Organization Banking Corporation

Activity Operation of Banking Corporations and related financial organizations

Buildings/Rooms Operation centers, office buildings, branch banks, Automatic Teller Machine buildings, warehouses, and associated parking areas

- Lobby, teller area, offices, computer room, print centers, mechanical equipment rooms, money rooms, vaults, cafeterias, credit card production areas

Items of Inventory Equipment : office, security, check processing, mailing, data processing, money handling, communication

Other : furniture, automatic teller machines, paper products and forms, signage, credit cards, credit cards, art, area and space inventory

Requirements

A CAD/DBMS based facility management program should

- record of all building drawings owned by the corporation
- provide current floor plans with electrical, plumbing, and mechanical plans of all buildings
- be able to graphically locate and describe all fixed assets and capital equipment within the buildings
- record purchase dates, costs and current value of those items
- project future purchase requirements of equipment
- project future requirement of renovation, repair and construction
- budgeting of expenditure for for the above

The facility management system should also be user-friendly to the extent that

- it could be updated by trained clerical personnel
- the initial loading process (entering initial information into the system) could be accomplished by in-house employees within a reasonable time

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