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INTEGRATING DOCUMENTATION FOR BUILDING OPERATION AND MAINTENANCE IN PLANNING AND DESIGN

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Abstract

A general platform for a lifelong database is fundamental for the integration of information between design and management. Documentation from design as part of a facilities management system is necessary to retain the technical and functional quality of a building through its lifetime and to reduce the lifecycle costs. The use of computers have given us the opportunity of reducing the gap between design and management, even if it so far has tended to reinforce rather to weaken the organizational fragmentation that already exists.

This paper focus on 10 important aspects for the devlopment of computer integrated systems: Define the need for information in different management organizations; Avoid unnecessary information; Design simple systems; Develop a general platform - a lifelong database; relate to common standards; Produce the necessary information for operation and maintenance in design and construction; The implementation of an automated system demands a working manaual system; An accurate database; A logical way of updating the database information and Link data to graphics.

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Introduction

Norwegian buildings and constructions represents approximately 70 percent of our real capital value, and it is estimated that nearly 50 percent of the activity in the building sector [SBI 184] relates to existing buildings. Over the last decades costs for operation and maintenance have been growing more rapidly than investment costs. In addition the facilites management profession has traditionally been an activity with low priority. This has led to growing awareness of the need for better management systems and the utility of computerized management systems.

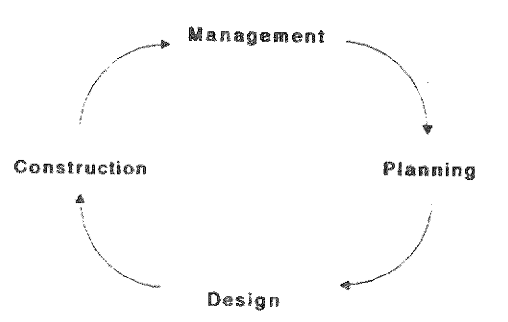

Fig. 1 The lifecycle of a building

Traditionally in Norway the horizontal fragmentation between specialists at a given project phase, e.g. in design, is less dominant than in many comparable countries. This is mainly caused by unique Norwegian Standards; NS 3420 Specification texts for buildings and constructions, NS 3451 Table for building elements and NS 3459 Computer-aided interchange of project data. The degree of vertical fragmentation between project phases, e.g. planning, design, construction, operation and maintenance is more dominant even if the construction industry has been focusing on these aspects in recent years in a large research and development program [Veierød 88].

This year a Norwegian standard (NS 3454) for calculating yearly life cycle costs was released, and we are working on guidelines and requirements describing which documentation should bedelivered together with "as built" drawings. But so far we do not have enough knowledge and systems to integrate information from design to future management, and to estabish a way of information feedback from management to new planning and design.

Computer assisted systems

The introduction of computer assisted systems in the construction industry is another factor which has lead to more attention towards design of lifelong databases. A Nordic project examining the utility of CAD in different management organizations, has shown that one of the main interests with respect to CAD is to reduce the gap between planning and management. So far there are very few systems in use that support both design and management aspects.

In the end of 1987 more than 2200 Norwegian companies had installed CAD-systems, a dramatic increase from only 200 installations in 1985. Most of these systems are installed in engineering and architectural firms, with a majority on 2 dimensional draftingsystems (e.g. AutoCad). A recent survey in Denmark [Cowi 87] also showed a dramatic growt in systems for building operation and maintenace. In 1988 30 different systems were sold, a growt from only 2 systems in 1985. Many of these systems are still under development, they cover only some aspects of the facilities management profession and there is no interface for digital information from planning and design.

Early facility planning and management systems supported only one of the major tasks - management, planning and design - in facilities management. Instead of word processors for management reports, mainframed-based databases for planning, and CADD systems for design of facilities, today [Teicholz 87] integrated CADD systems known as computer-aided facility management systems (CAFM) handles all theses tasks. CAFM systems have storage capacity and processing power to handle large databases and integrate word processing and data with CAD. In this way one can produce drawings, reports and numerical analysis in one system. Integrated systems link data attributes to graphics so that one can connect surface or function characteristics to a physical location in the building.

According to Howard, Levitt, Paulson, Pohl and Tatum [Howard 87] the use of computers in the architecture-engineering-construction (AEC) industry has tended to reinforce rather to weaken the organizational fragmentation that already exists. This is caused by computer tools used to optimize individual, specialized work areas and not to reinforce share of information with other participants.

Important aspects for computer integrated systems

There is a lack of common definitions of activities and tasks that are related to existing buildings. In Scandinavia we have mainly been speaking about administration, operation and maintenance of existing buildings. In England these activities are a part of "whole-life property asset management", which include both maintenance and modernization. In the US the most widely definition of facility management is provided by International Facility Management Assn: "Facility management coordinates the physical workplace with the people and the work of the organization".

We will here leave the question about getting uniform definitions, as the problems and tasks that need to be solved before complete and intimate integration are achived will be the same. According to Fenves [Fenves 86] the 3 main research topics needed to be solved relate to development of database management systems, development of standards interchanging information and the need of convincing the different participants in the building sector.

With repect to the development of computerized systems and the integration of documentation for building operation and maintenance in planning and design, we have found that the following 10 aspects are of vital importance.

1. Define the need for information in different management organizations
2. Avoid unnecessary information
3. Design simple systems
4. Develop a general platform - a lifelong database
5. Relate to common standards
6. Produce the necessary information for operation and maintenance in design and construction
7. The implementation of an automated system demands a working manual system
8. An accurate database
9. A logical way of updating the database information
10. Link data to graphics

1. Define the need for information in different management organizations.

In the USA the International Facility Management Asssociation has determined through polling that the following nine functional areas represents the job responsibilities of between 80 to 95 percent of facility professionals: long-range facility planning; annual facility planning; facility financial forecasting and budgeting; real estate acquistions and/or disposals; interior space planning (workplace specifications, furniture and equipment installation, and space management); architectural and engineering planning and design; new construction and/or renovation; maintenance and operation management; and telecommunications integration, security, and general administrative services.

We have experienced that the tasks and need for information are very dependent on the management organization. On one hand one might have a cooperative housing organization, where this organization only have a supporting function. All major decisions have to be approved first by the board representing the owners and secondly by the general assembly. After establishing the cooperative the main function will be management, and the main interest will be information that supports operation and maintenance of the buildings.

The operation and maintenance work are coordinated through a common service center, and figure 2 shows the documentation required for this center [Eide 86]. The documentation should be graphical information in form of master and floor plans, and mostly non-graphical information in building element forms. These forms list specifications from the producer, instructions for operation, instruction for maintenance and references to drawings and documents.

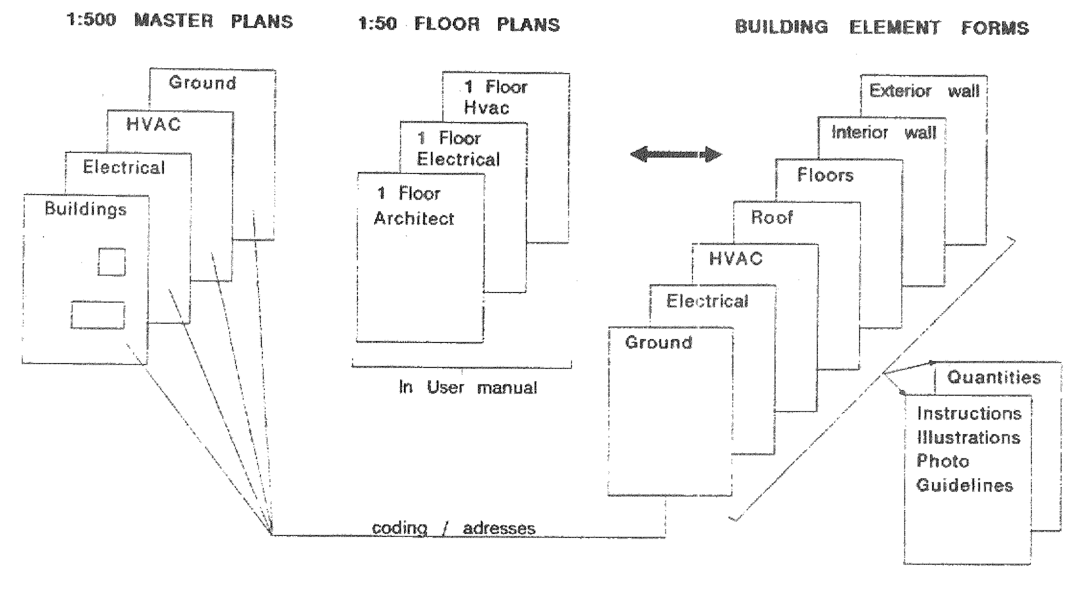

Fig. 2 Documentation for operation and maintenance in housing

A management organization responsible for all buildings owned or hired by county authorities will require data for long- and shorttime area planning, systems that support design and databases that handles vast amounts of data. The aspect of operation and maintenance planning will be only one of the management tasks. There is a need for computerized systems even to handle necessary documentation if the structure of the building are complicated and the variation of components and materials increases.

2. Avoid unnecessary information

Through planning, design and construction we have traditionally been producing piles of paper documentation. And the flow of information is still increasing due to more fragmentation and specialization in the construction industry, and as paper documentation can be produced more and more easily. "As built" drawings are supposed to be delivered together with the building, but this is still more an exception than a rule. We also have to be aware that we do not need the same information through management, operation and maintenance as needed in design and construction.

We do not solve these problems by digitizing all information, but the technology will help us to handle the "hidden" information in an integrated database system. In Norway we have so far been focusing on the manual system; What information is needed in operation and maintenance, How should it be presented and When in planning and design should it be produced.

With respect to existing drawings a survey of a technical-drawing archive [ELDAK 88] concerning the use of raster or vector in scanning, showed that only 20 percent of the archive were active and that only 10 percent needed modification. The vectorization problem was valid for only 0.5% of the total archive.

Most facilities management organisations say that they manage with simple 2-dimensional drawings in scale 1:100 or smaller. The management department at the Norwegian Institute of Technology is using floorplans (220 floorplans for 55 buildings) reduced to a scale so that each floorplan fits into A4 format. These reduced floorplans are used for area planning, custodial services, new design etc. In addition they keep and update scalemasters of all plans and elevations in mostly A0-format. They are also keeping a system of maintenance feedback that is related to the main external surfaces i.e. roofs, facades and outdoor areas.

3. Design simple systems

In Sweden computerized maintenance planning systems have been used for 15 years and a survey [Brochner 1988] among different user organizations list some problems with computerized maintenance planning. Common complaints were "excessive detail", "updating of maintenance plans is difficult or demands considerable resources" and "true utility of computerized maintenance systems is comparatively small".

This are caused by lack of communication between design, construction and management; unfriendly front end interfaces, lack of coding table for facilities management and lack of cost databases [3B-31 86]. Many of these systems are running on mainframe computers and they are almost solely using alphanumerical information.

Systems developed today both in Norway [Acropolis 88] and Denmark, [Nielsen 88], are constructed as modular systems. They integrate different aspects of facilities management as shown in figure 3 (i.e. economics, energy, operation and maintenance), they are using fourth generation programming languages, are userfriendly and have in some cases interface to CAD.

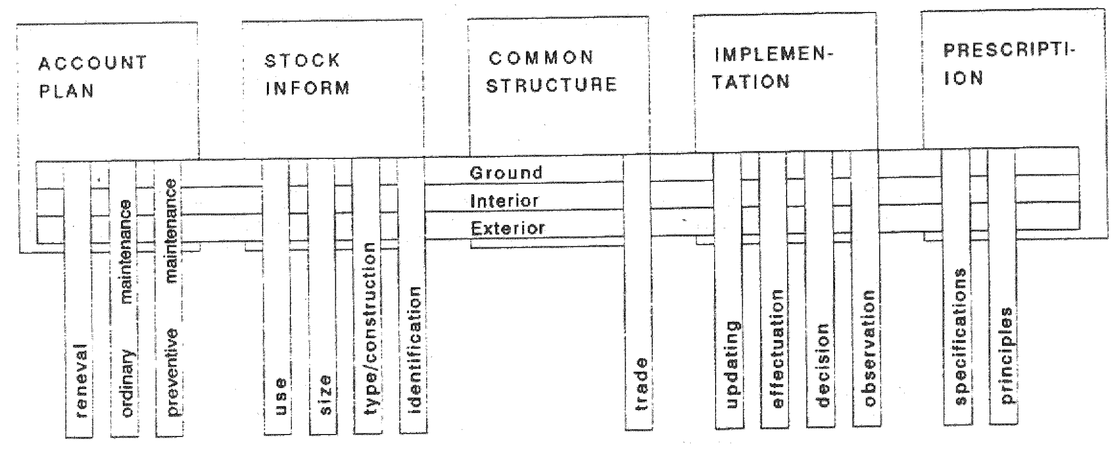

Fig. 3 Danish maintenance model with localization as standard principle

4. Develop a general platform - a lifelong database

A general platform for a lifelong database is fundamental for the feedback of information. Designers generally, and in particular architects, need feed-back from experiences in use [Nicholson 1988], including maintenance, economic returns and building efficiency in order to design future generations of buildings. Feedback at the moment consists of static information relating to initial design details and costings. There is no long-term overview or collection of in-use data. Futhermore, according to Nicholson, the use of computers and information technology has exploded into a myriad of separate packages which have no unification.

Facilities management are a multidisciplinary profession handling technical, functional and economical aspects. There is a need for a base-model that coordinate the information within an organization from the tecnical level to the political or top executive level. The system should also be a platform for exchanging information between different organizations. In March 1988 a working-group finished the official Danish recommandation on "Principles for building maintenance management" [BPS 88]. The report is part of a larger project, bringing structure, standards and quality into the building process. The Danes are not only focusing on existing buildings, but expressing the necessity of bringing the aspects of operation and maintenance into the project from the very start.

5. Relate to common standards

The Norwegian standards for specifying buildings elements and components together with standards for project documents and yearly life cycle costs have been fundamental for the implementation of computer assisted systems in Norway. The standards have reduced the gap between developer, architect, engineers and contractors. Furthermore if the standard for project documents (NS3450) are updated, we might have a "living set" of data instead of dead paper documentation. The data about a project should be a two dimesional matrix, one dimension covering the geometrical model of the building and another the administrative part (e.g. profession, chapters etc.) [Ziolko 88].

The relations between the different project phases and the relation to Norwegian standards are illustrated in figure 4. The NS 3420 Specification texts are the linking element between design/construction and operation/maintenance. In design we are using the standard table for building elements (NS 3451) and the standard for specification texts (NS 3420). NS 3459 are used for interchange of data between architect and contractor. In operation and maintenance we will be using the standard for specifying yearly life cycle costs. NS 3454 might be linked to table for building elements and specifications texts. In this way we might use the building specification from design in future management, as illustrated for a window component. There will be an optional coding for operational and maintenance work describing either demolition, demounting or reparation. This optional coding will be only a guideline, and the example shown in figure 4 illustrate the way this coding is implemented in a Norwegian computerbased system for facilities management [Acropolis 88]. The new standard for specifying yearly life

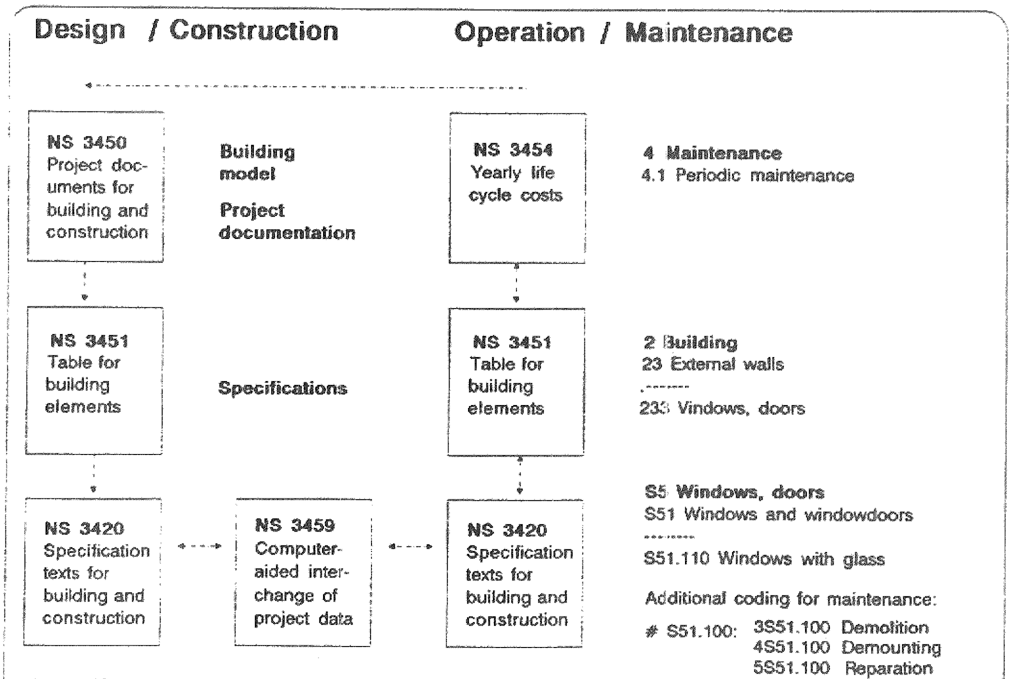

Fig. 4 Relation to Norwegian Standards

cycle costs will give us the opportunity of comparing different buildings and have feedback from experiences in use.

The base-model developed in Denmark [BPS 88] also introduces a two dimensional matrix: 1. Location (the place) and 2. Activity (the work). Activity - because the most basic in every maintenance job, is the work including materials and methods. This work then relates to the pysical location. As a new standard principle the model defines only 3 possible localizations: 1. Ground, 2. Exterior of building and 3. Interior of building.

This way of describing operational and maintenance work are not in accordance with the C.I.B./W74 classification system, and in the Danish report it is not recommended to use the C.I.B classification. Though it can be extended to include building parts.

One of the major aspects in the future will be the integration with the AEC Model classification in product modeling standards (PDES and STEP).

6. Produce the necessary information for operation and maintenance in design and construction

The documentation for operation and maintenace should be considered and produced in planning, design and construction. As shown in figure 5 this documentation is to be produced by designers, engineers and contractors. The example relates to the documentation shown in figure 2. From the intial design phase master plans should be produced, in the main design phase master plans for specialized subjects; in the detailed design phase specifications on buildings, elements and components and from the construction phase specifications on operation and maintenance of both the building and technical equipment.

PLANNING	DESIGN		CONSTRUCTION
Master plan 1: 500	Plans 1:500 Buildings Electrical HVAC Outdoor	Plans 1:50 Materials Codes Specification Quantities	Building element forms User manual

Fig. 5 Documentation produced in design and construction

7. The implementation of an automated system demands a working manual system

The property asset management has traditionally been an activity with low priority and in many organisations there is a lack of structure for efficient facilities management. Implementing a computer-based system in such an organization without going through an analysis of the organization, will mostly fail.

8. An accurate database

When using existing drawings one should be aware that they seldomly match reality. The drawings were never updated to "as built" and conversions are done without updating the drawings.These problems will also be representative if one are planning to keep a lifelong building database. As refered from Stanford University [Tyson 1988], where they have been trying to digitize key utility and building data from an existing file of some 45,000 paper drawings to get up to date in managing their existing files, the worst thing to have is an inaccurate database. There need to be guidelines and systems for both updating and access to the database.

1. General Information

* GENERAL DESCRIPTION
* ADMINISTRATIVE DATA
* BUILDING ELEMENT CODING

2. Documentation

* MASTER DRAWINGS
* FLOORPLANS
* BUILDING COMPONENTS
* DRAWING LIST

3. Instructions

* INSTRUCTIONS FOR OPERATION
* CONTROL AND SECURITY SYSTEM
* CONDITIONS SURVEYS
* USER MANUALS
* PREDICTED LIFETIMES / MAINTENACE INTERVAL

Fig. 6 Information for facilities management

At MIT they have solved the problems with updating the space database with inspections of all buildings once a year. The Facilites management office at MIT has since 1971 developed the alpanumerical database management system INSITE - Institutional Space and Inventory Techniques [INSITE 1988]. The fundamental use is to create and manage a space and equipment inventory system. In more recent years a computer-aided drafting system is developed especially for management tasks and the system provides a graphical response to database queries. To keep the database accurate, the changes made in the drafting system will not automatically update the database.

9. A logical way of updating the database information

According to Fenves [Fenves 86] the research topics that need to be solved before complete and intimate integration can be achived will be on tecnical, professional and societal level. At the societal level one will have to convince more of the owners, designers, constructors and regulators to view the design as the generation of an initial version of a life-cycle project database, to be subsequently updated to reflect "as built" conditions and all later modifications. Here it will be important that updating of later modifications are done as an integrated part of the system at no additional workload.

10. Link data to graphics

Information for management, operation and maintenance can be devided into 3 main parts [BUR 1983]; 1. General information, 2. Documentation (e.g. drawings) and 3. Instructions. The information listed in detail in figure 6, will be both graphical and nongraphical. The documentation (drawings) represents the main graphical information, to which both the general information and the instructions relate.

We believe that alfanumerical information should be a part of graphical information system and not the other way around. The geometrical representation, the one dimension of a 2 dimensional matrix should be presented graphically, and used for the presentation of the administrative data.

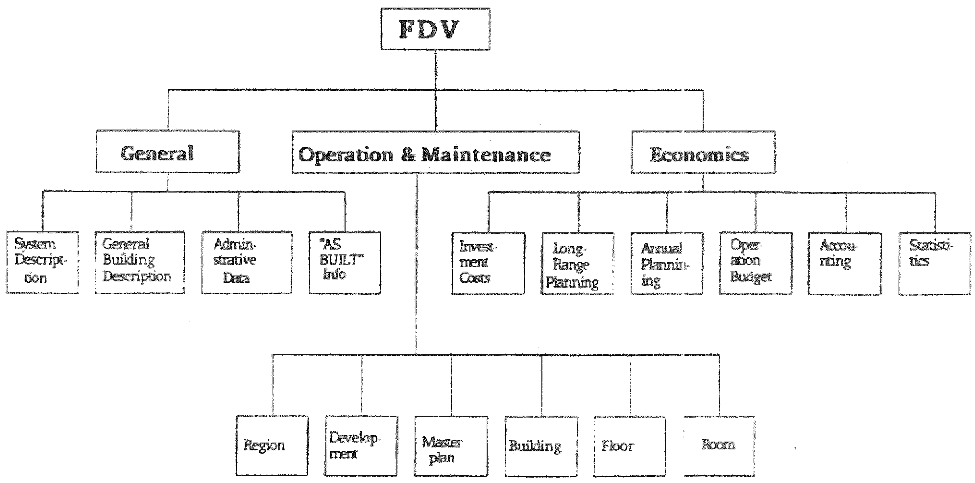

Fig. 7 Main structure, Cadraw-FDV

This idea is behind the development of CADRAW-FDV, a CAD system with an integrated alphanumerical database. The protoptype was developed as a part of a thesis work [Flyen 88] at the Norwegian Institute of Technology together with the software firm CADNORDIC.

The Facilities Management Application shown in figure 7 consists of 3 modules: General Information, Operation & Maintenance and Economics. All information for operation and management are linked to plans with increasing level of detailing; ranging from master plan, building, elevation, floor plans and rooms.

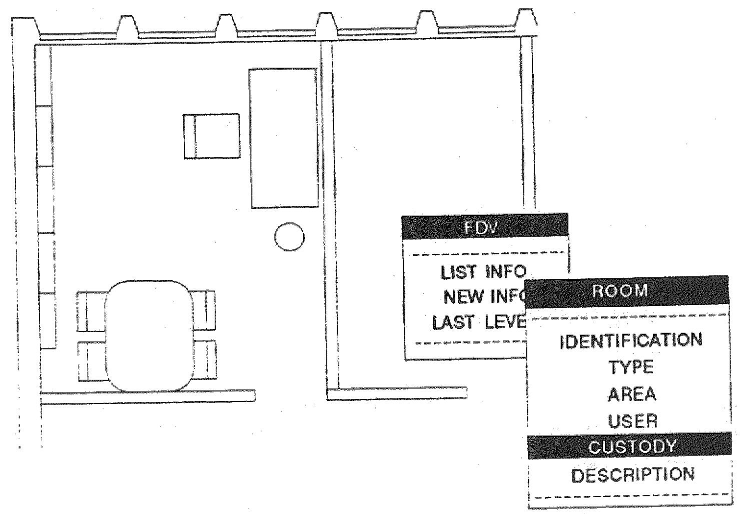

Fig. 8 Information on room, CADRAW- FDV

Data for operation and maintenance can be classified according to 3 principale different systems [BPS 86]; a room model, a profession model and a building element model. The main element in CADRAW-FDV is the room, and the information are linked directely to the room or the components in the room. Components are defined as walls, ceiling, floor, doors, windows, mecanical equipment and inventory.

The main attributes structured to room will as shown on figure 8 be: Identification, areas, user, type, custody and room description. Information about rooms and components can be found by pointing with the cursor.

Conclusions

The emerging and existing computer technologies gives us new possibilities in reducing the gap between design and management of buildings, and we have in this paper adressed specific aspects that should be considered in the development of computer-integrated design and management systems. So far we do not know enough about which information is needed in different organization from a lifelong database, how and when to produce this documentation in design and production. There is also lack of standards for project documentation and computer aided interchange of project data. This has in Scandinavia led to considerably ongoing research and development focusing on these aspects.

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