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GEOGRAPHIC INFORMATION SYSTEMS AND FACILITY MANAGEMENT

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ABSTRACT

In industry and big organisations facility management has become a managing tool of more and more importance. In times of decreasing profit rates and harder competition every company is forced to develop better strategies for resource and facility management. In this context the questions arise: What is facility management, what offers GIS and how can Geographic Information Systems improve facility management?

In GIS we are focussing on how to import, manage, analyse and present spatial data. In facility management, however, the focus lies on the management of facilities, buildings and the rooms inside. Buildings have a 3D geometry and many attributes. Graphic Information Systems handle such data. We are trying to develop a concept that takes advantage of GIS functionality to implement a so called Building Information System. Spatial data of a building are stored and managed by a GIS DBMS. The Institute for Photogrammetry at the University of Stuttgart is responsible for the implementation of a facility management system for all rooms and buildings of the University. In order to establish such an environment several steps have to be done.

The evaluation process of existing systems is still in progress and CAFM (computer aided facility management) systems are still being developed. All these systems have to handle the problem of geometrical dimensions. Most of the systems represent databases only without any spatial link. For the management of a building, however, graphical data is required that is not thumb CAD data. It must be „intelligent“ graphic data. If e.g. you want to get an overview of all rooms in a building that are accessible for handicapped people you would prefer a map to a list. If you want to know to whom this particular room belongs, a mouseclick should deliver the results instead of offering endless lists.

Another crucial point in these systems is that you also need 3D data or even 4D capability. The time factor is very important in FM. The University of Stuttgart is located in more than 100 buildings, severals of them are rented. In order to plan renovation, controlling the functions of the building, analyse which parts are often damaged, re-renting of buildings... an instrument for analysing is an absolute necessity. At the moment those analyses take too much time and are for that not very suited.

The first step in order to get an operational Building Information System is to examine the requirements of the potential users. We created a questionnaire that helps us to examine the taskstock/requirements of the users . It was sent to a group of employees who were selected as a key group. In addition interviews were taken to maximize the feedback rate and quality of answers.

Secondly a market study is undertaken to get an overview of possible system candidates. In the meantime we sort all questionnaires by different criteria such as workflow, main topics, analyses with time, 2D, 3D and simple database queries. After the sorting we get an overview about the relevant criteria that help us selecting the appropriate system.

1 INTRODUCTION

Enterprises and administrations are confronted with budget shortcuts and the demand for higher efficiency, transparency and flexibility. The focus on Facility Management results from the fact, that buildings, plants and infrastructure during the long-term utilization phase (e.g. 40 years) cost about 80% compared to 20% of planning and construction. (*BRASCHEL, 1995*)

Computer aided facility management as a managing tool is taken into account most recently since computer technology offers cheaper memory capacities, faster access, stability and advanced capability. Information systems are now available in the sector of building maintenance, as large amounts of data can be handled easier in digital form than analog lists. The functionality of input, management, analysis and presentation ("IMAP" *BILL/FRITSCH, 1991)* that is covered by Geographic Informaton Systems is necessary for facility management tools as well. As the University of Stuttgart plans to implement Computer aided facility management in its administration the Institute for Photogrammetry respectively the GIS group is involved in the concept development.

An increasing consciousness for resources lies in the potential for reducing the costs of maintenance. The major tasks of space management and technical equipment should be handled by a single system or by a combination that integrates with existing applications.

2 WHAT IS CAFM ?

Computer aided facility management systems are computer programs that store, analyse and present information about the facilities of an enterprise. E.g. a yearly statistical update will be available by a button-click, movings and space planning are easier to simulate by getting the relevant data on the screen. Another point is the approach to optimize building cleaning specifications by offering complete and actual measuring of floors and windows. The facility manager also cares about cost statements for heating, electricity and water. The CAFM shall help the facility manager to rationalise his work and to provide the translucency for all processes and costs that arise in the buildings of the whole enterprise. Generating emergency plans, access plans for disabled persons, locations of departments, locations of equipment like overhead projector and so forth - all this signifies the daily workload for a facility manager. In order to deal with these tasks, a CAFM system has to contain and generate a lot of different information. In general you can divide between three basic functions in a CAFM:

- Infrastructural Management
- Technical Management
- Business Management

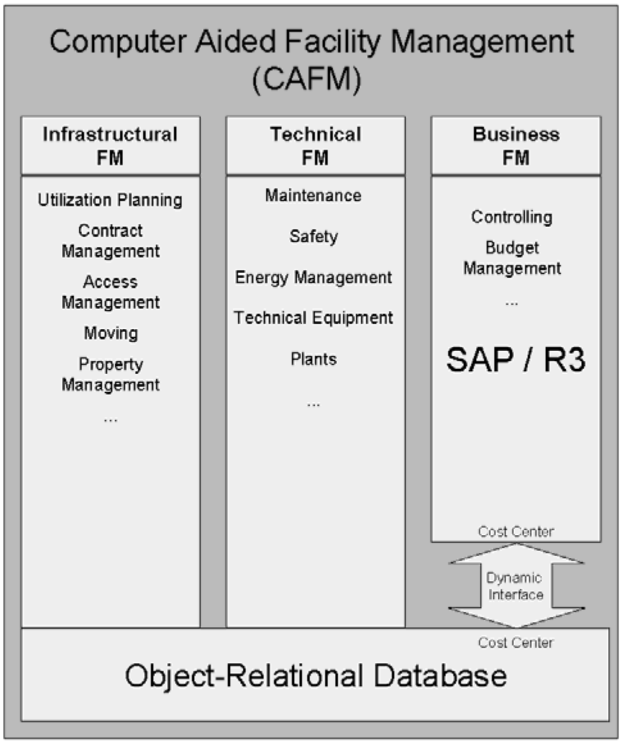

figure 1: CAFM

In this picture we illustrate a typical CAFM System. The core of the system is represented by the object-relational database. In this database all objects are stored. In our case we prefer a so called object-relational approach which means objects can be stored in a relational database. ORACLE 8 offers the possibility to store graphical information in a relational database together with simple query extensions that deal with spatial information. The main advantage is here that the objects include their graphics so the system is independent from fragile links between a CAD (Computer Aided Design) on one hand and a database on the other hand. The transaction concept of standard databases is in this case also valid for spatial data. This shows the important advantage compared to the common technology that most of the systems are build with.

Based on this database three main columns are shown that represent the three management factors of a CAFM which demonstrates the management functionality of a CAFM in comparison to a GIS.

Every company runs a business department to handle the administrative issues. In these departments SAP/R3 is a market leader. This leads to the fact that a successful integration of a CAFM is only possible if the CAFM can online communicate with the SAP-System. In SAP the cost centers are inflexibly defined so that the CAFM must overtake the cost centers from the business control program. The opposite way consisting in the communication of the business control program with the CAFM is also important, in order to "geocode" the costs. Only if such a dynamic link between these two systems is guaranteed a transparent cost calculation for big companies can be provided.

The next column is called "Technical FM" and deals with tasks like maintenance, safety management, energy management in sense of cost distribution per square meter. The distribution is dependant from the actual use of the rooms as well, e.g. different factors have to be applied to an office room compared to a storage room. It is also a major task to achieve transparency in the cost statements. For the current work in a company technical equipment is also of importance. E.g. if you need a meeting room with a flipchart, overhead and beamer you are not going to examine every room in order to find everything - these requirements are expected to be fulfilled by the help of the CAFM system. Nowadays it is even imaginable to offer an online tool for reservations in the intranet / internet.

In the third column management of infrastructure is our focus. Utilisation planning, contract management, access management, moving planning, property management and so forth are all topics we understand as infrastructure management. Most of the current CAFM Systems deal with these themes, which have the management of the area in common. For utilisation planning you need the forth dimension. In a university like the University of Stuttgart utilisation planning is very important for the daily lecture program, the examination times and also for the room planning of institutes. Here also the fourth dimension (time) is very important because some buildings are rented and substitutional rooms have to be rented or newly built. Furthermore, very often the problem of access gets complicated - in this case an efficient access management is very important. Here a CAFM can help to manage the distribution of the keys and visualise the rooms where people have access. Moving planning is also a very good example for infrastructural CAFM. Here the experts are supported by the CAFM, they can produce several versions of the moving and visualise them to

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support the decision process. Utilisation planning and property management are very strongly connected. If the space of a company or university is efficiently managed it is possible that some rented rooms can be released.

This division in three columns is only one representation of a CAFM. Another view on CAFM is the system architecture.

3 SYSTEM ARCHITECTURE

Several system architectures are conceivable and implemented in running systems. One architecture that derives from the history of the CAFM systems is CAD (Computer Aided Design) driven. This means that the system comes from a CAD system which is extended by a database. This system architecture is very common in current systems. The disadvantage is that for data manipulation you always have to use a graphic workstation and users have to have a good know how in CAD. The next disadvantage is the dependence on graphic data. Only changes that are made in the graphic data are stored in the system. Changes that are only made in the database are overrided by the CAD system. Another possibility is to take only a database without any graphical component. This is suitable for almost 45 % of the queries that are made to a CAFM but the rest can only be solved with a graphic component.

To avoid these disadvantages another system architecture for a CAFM is proposed.

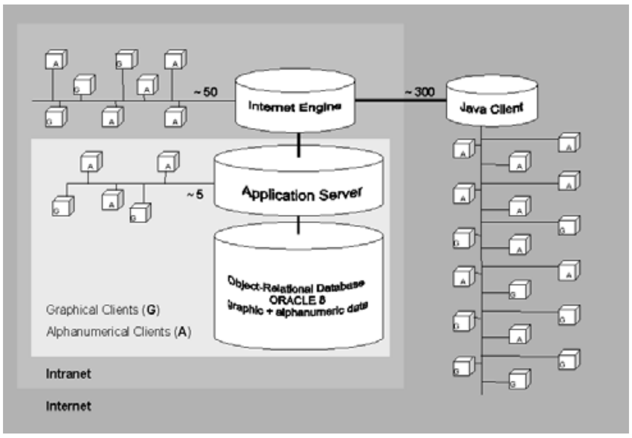

figure 2: architecture of CAFM

In figure 2 the basis of the CAFM is a so called object-relational database. Above this database is the application server. As you can see it is also a client - server concept. The clients here are alphanumeric and graphical clients. These clients are responsible for data collection, analysis and they are located directly in the CAFM department of the company. As shown above CAFM is not the work of only one department of a company, CAFM takes place in every unit of the company. Not every unit has experts in CAD or CAFM or in such graphical systems. A possibility has to be found to get these users also in the system and to encourage them to use it. If you take a common client - server product you need specific clients, that have to be maintained and installed. In this concept you use an intranet server and java plugins into a standard internet browser. With this concept you only have to put the plugin on the server and the users can install this plugin by themselves. Nearly no maintenance is necessary for the users and the next money saving point is the training of the users. In a university like Stuttgart you have over 200 institutes that are potential users of the CAFM. They only have to learn a new plugin of a browser and not a whole new program. Within the intranet you can use a java plugin also for change detection and also the java clients can report changes into the database and update the database.

For presentation of a company plans and information about location of departments, telephone registers and so forth are very useful to be put into the internet. The problem is to update this information on the web server. This can be done in a very time and money saving way. Not only the intranet also the internet can access the data via the internet engine, presupposed a working user control. This concept is very variable. If an intranet user gets to the point that the java plugin is too small he can consider to upgrade to an alphanumeric or a graphical client directly on the application server or vice versa.

4 PARALLELS BETWEEN GIS AND CAFM

The concept of import, management, analysing and presentation of spatial information in GIS fits also for CAFM. The aspect of management in CAFM is not only focused on spatial information, the management factor is much broader. As the name tells us CAFM is about facility management which explains the crucial difference between GIS and CAFM. Issues like document management, security management, access management and user management are not treated in GIS on such a detailed level. The major advantage of the GIS modelling is the data storage. In CAFM the costs for links between graphic and alphanumeric information are very high so the concept of storing data in different files is dangerous. In order to prevent a loss of linkage it is useful to take a different modelling for data representation.

The object-oriented modelling that prevents the loss of connection between the graphic and alphanumeric data as shown above comes from the GIS. In theory of GIS the object-oriented modelling is an old paradigma for a solid modelling of spatial information. In CAFM we profit from this experience as well. Another parallel between GIS and CAFM is the management of the data. GIS manages the spatial information and attributes of spatial objects. CAFM systems also manage the spatial information of buildings of a company. In GIS you can build thematic maps and analyse the information stored in it. CAFM systems are very useful for generation of especial maps of the facilities like rescue plans, information maps for visitors, maps for disabled persons how to reach a special room and so forth. These maps are also thematic maps. The generation of these maps in CAFM works the same way as in GIS. The spatial analysis is the same in both systems, the tools offered by the programs are similar in the two systems. For analysis on a database you have a query language like SQL (Structured Query Language) and all the queries to the database are made with SQL. The user interface normally hides the standard SQL behind masks and most of the queries in a CAFM are predefined, but the possibility to make user defined queries is also very important. Both the GIS and CAFM give the user special functions to analyse

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the spatial data. The functionality that is understood with GIS is also part of FM.

In theory one can say that the management of spatial data in CAFM is the GIS part of facility management. Without this functionality one can't talk of a CAFM. If the system has only a database system and the spatial information is only stored in standard databases no graphic information can be generated. In fig. 2 the architecture of a CAFM system is shown. Without any change you can use this as an architecture of a GIS. The CAFM extends a GIS to a management system of a whole company and not only for spatial information.

5 APPLICATION

In this part we want to show the first steps that we took to begin with the implementation of a CAFM system at the University of Stuttgart. In order to understand the situation it is important to understand the structure (infrastructure and management structure) of our university.

The University of Stuttgart is located in about 120 buildings spread over two major parts in Stuttgart - the campus at Vaihingen and the city center. There are about 16.000 rooms in a whole of about 700.000 square meter of gross storey area.

The administration of the university is headed by the chancellor followed by six departments. According to their main tasks they are named department of structure, students matters, security, personnel, finance and last but not least the technical and building department: the "Dezernat VI".

Starting with the examination of the actual situation including potential users, taskstock and workflow, the first step was to declare a group of persons that should be consulted in this topic. We defined the technical and building department as the key group because of the fact, that most information about rooms and spaces is actually filed there. They collect and provide drafts and floor plans of each building and property in a 1/200 scale.

The list of interview partners includes 20 employees, half of them belonging to the key group including the head of the department, five employees of the building section and four in the technical section. The other departments are represented by their heads, who were asked to inform their co-workers and inquire about their needs and ideas concerning a building information system. We expanded the group with persons, who are especially interested or involved in the decision about a future system.

Therefore we created a questionnaire (figure 3) that deals with general questions about queries that should be handled by the CAFM system in the future. The employees were asked to fill out as many questionnaires as needed to demonstrate typical questions and crucial requirements of their specific department.

These questions can be sorted into several parts. On the one hand we distinguished between data structure (alphanumeric and graphic data) and content (security aspects, time dependencies, 3D requirement); on the other hand we asked for already digitally existing data and where it was advised at the present. Time aspects are examined by different criteria like the update rate, the required topicality and the general viewing rate. We interviewed the employees personally, in order to increase their interest, to achieve a high quality of answers and intensify their motivation to deal with the topic of CAFM. We laid an emphasis on the acceptance of the system in this case, because a broad variety of users will have to work with the system in the future. The quality of the data stock is highly dependant from the user activity.

Requirements for a CAFM System at the University of Stuttgart

The aim of this questionnaire is to collect the requirements and ideas for a future Building Information System.
Please list all queries that are done manually at the present, but also queries you expect to be handled by the system in the future.
Use a single survey sheet for each query .

1. Register your query / topic:

2. Which basic data do you need to answer the above question?
☐ graphic data: (Drafts, Floor Plans) — ground plans ☐ cable plans ☐ More:
☐ alphanumeric data: (lists, charts) e.g. room chart, ...

3. Do you touch protected data with your query? (e.g. personal data) ☐ yes ☐ no
if yes, which data?

4. What kind of documents do you use and who is in charge of them? (Department, section, computer center)

4.1 Are these documents accessible in digital form ? ☐ yes ☐ no
if yes, which format and where?

5. Please estimate the minimum topicality of the documents that are necessary to answer your query?
☐ daily currency ☐ 6 – 12 months ☐ 1 – 3 years ☐ > 3 years

6. Is a 3D-description necessary or desirable? ☐ yes ☐ no
if yes, is a 3D-Analysis necessary or desirable? ☐ yes ☐ no
if yes, please explain your answer:

7. Is there a regular update cycle for the data? ☐ yes ☐ no
if yes, how often is the data refreshed or complemented?
☐ daily ☐ weekly ☐ monthly ☐ once per year

8. Who advises the data at the present? (Department,..)

9. Please estimate your access rate to the data ?
☐ daily ☐ weekly ☐ monthly ☐ once per year

10. What kind of data output do you require? (screen, plot/print, graphics, lists)

11. Please tell us a contact for further requests. (name, department, phone number and email)

Thanks for your collaboration!
Questions? Don't hesitate to contact us! -4094 (Schürle) or 4092 (Boy)

figure 3: questionnaire

6 RESULTS OF THE QUESTIONNAIRE

The feedback rate of the survey was very satisfying with 120 questionnaires from 20 persons. It shows that the supplementary interviews in combination with the opportunity of further requests enlarged the amount of answers and reduced misunderstandings or faults on the survey sheets. A first result in general is that a CAFM system is needed and desired.

The questionnaires were sorted by different criteria. One topic deals with the necessity of 2D, 2.5 D or 3D data. Hereby we divide the graphic data requirements into ground plans and line plans. Both types of information can be stored eventually in 3D data (x,y,z) or in 2D data (x,y or x,z) in addition with attributes of the third coordinate position. In line plans, however, topology is of great importance, as pipes and cables are located between ceilings and walls and thus cannot be directly assigned to a single room.

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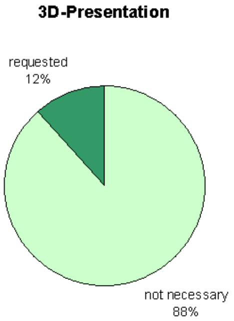

figure 4: 3D presentation

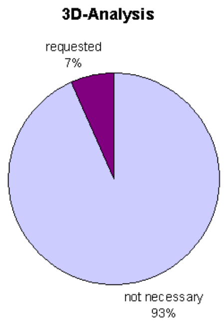

figure 5: 3D analysis

The pie charts above (figure 4 and figure 5*)* show the amount of requests concerning 3D presentation and 3D analysis. 88 % (105 of 120) answered that 3D presentation was not necessary, 93% (112 of 120) replied that they would not analyse any 3D data. Figure 6 illustrates that again only 8 requests out of 120 expected line plans in the system.

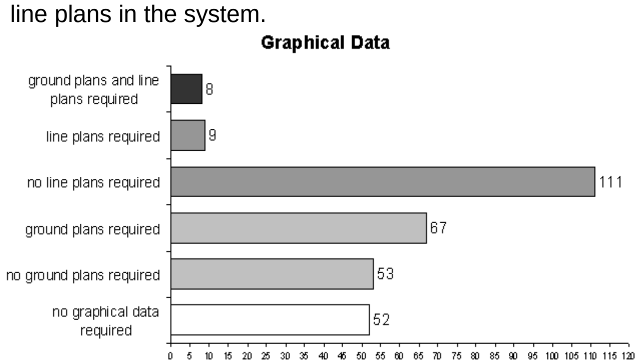

figure 6: graphical data

A correspondence, however, between these eight requests to the eight of 3D analysis is not given. The demands for a 3D presentation or analysis are caused by the desire for a quick overview and the visualisation of where a room is located in the building. To ease navigation in a building, 3D-graphic is helpful. On the other hand replacing the 3D-presentation by a photo or 3D-sketch in pixel format might fulfil that requirement as well.

Another topic is the 4D-data which arises from the fact that in rented buildings the original condition has to be restored after the contract run out.

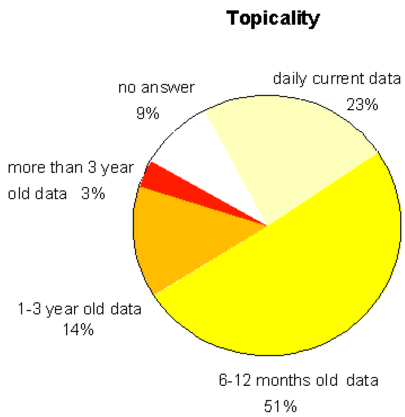

figure 7: topicality

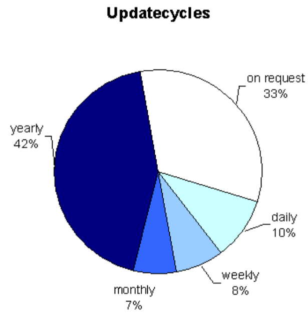

figure 8: updatecycle

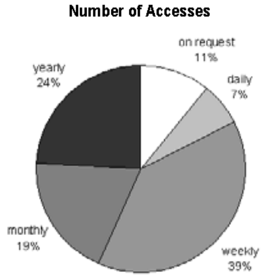

figure 9: access rate

We examined more aspects related to the time: for one there was the actually needed topicality of the data (figure 7). Of special interest was the difference between the update cycles (figure 8) and the access rate that shows how often the relevant information was needed for the daily workflow (figure 9).

About half of the data is updated from course to course the other is refreshed once to twice a year. Thinking about contracts and supplementary attributes it is obvious that data can be topical although it has not been updated in more than three years. Daily current data is required in about one fourth of all cases, although a small daily access rate is shown. This concludes to topics like temporary assignments of meeting rooms and their reservations, which have to be reliable information.

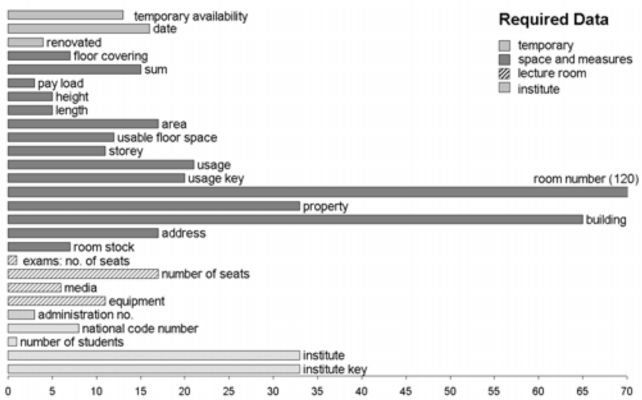

figure 10: required data

The results of the questionnaire offer a first insight in the specifically required data. (figure 10)

It is apparent to connect single requests to themes which can be distributed to the user groups. Every data applies strictly to a single room number. One line of information consists in the room number, storey, building, address and situation (where), the other in the room number, person, working group, institute and faculty (who). The next field is information about the extensions of the room: length, width, height, area,... (how much) In addition to the measures we include lecture room information like the number of seats, media,... (which). Changes, altering dates and former-present-comparisons are the next field (when) including the overview about temporary assignments. Furthermore supplementary object attributes like contracts, photographs, sketches etc. are related to the room number as well.

The CAFM system has to handle all these kinds of data. Again GIS offers wide experience to transform, digitize and import data.

7 DISCUSSION

The implementation is divided into several steps. As CAFM is seen as a tool for data analysis, the quality of the first integration is crucial. Any report or analysis result depends on the consistency and reliability of the basic data. Redundancies and inconsistencies have to be avoided. At first compulsory guidelines must be developed. Then a small but complete group of data (basic information like room number, institute, property,...) should be integrated into the system for every room.

CAFM affects a variety of issues at the administration of the university. The central supply of information collides with aspects of data protection in different ways. First of all, the integration of personal data has to be in accordance with the specific rules. Then the data base access has to be distributed to the individual user and strictly supervised. A concept concerning the different steps of internal use, intranet and internet accesses has to be developed. Aligned to the data admission specific modifying rights, viewing rights, etc. follow. We will have to estimate the suitability of the different solutions supplied by CAFM products.

In addition to the user group requirements we examine and evaluate existing software systems. The German market offers about 60 software products concerning CAFM at the present (*WELLER, 1997).* The lack of standardization in the presentation and naming of system structures in CAFM causes difficulties in the evaluation of such systems. After a closer look at the different products at exhibitions like the Cebit98 and the CAT98 we selected five enterprises for a presentation of their CAFM system at the university. Still the offered functionalities have to be adjusted in a customizing process or a first benchmark to the specific requirements of the university (e.g. space planning) will be made.

Criterias for the selection are system technology and CAD- or GIS background, references (experience with complex buildings) and the longterm suitability for university requirements.

The key group (building and technical department) provides information about most of the space relevant data. The property and utilization of each room is digitally stored in lists but rarely updated. Parts of the technical plants are being reported in excel or access files, but most of them are still documented manually in file cards. An overview over the sites of the lecture halls e.g. is up to the present listed in the general directory of the university. There is no general information available to know which institute is located in which building. An important fact about cost reduction is the integration of existing data compared to the new data collection.

We have to investigate closer about the data sources that are available for the first input into the CAFM system in a next step - the survey only provides a very general view on the existance of digital data. The blanks even emphasize the lack of information in this topic.

The information is distributed over various departments and institutes and not organized centrally. The implementation of CAFM will have effects on workflow, and as a consequence will change the areas of responsibilities. The actual effects, savings (e.g. fast access to centrally provided data) and additional work (e.g. updating data) are hard to compare.

8 CONCLUSION

The data modeling and storage concepts applied to GIS products are suitable for CAFM products. An important fact is that changes can be made as well in graphical as in alphanumerical data. Thus any person who is used to work with alphanumerical lists at the present is not forced to change the work. The consciousness for the easier use of data by graphically presented (visualised) data grows in the long run. Technical aspects provide an easier access if supported with visualized and roomspecific data.

The topic of 3D presentation is of great importance in the graphical requirements, 3D analysis only in the technical FM sector. We conclude that in the first 2D data is already satisfactory and useful.

As some systems with client and server structure offer the application of an internet engine various advantages arise. There is the standardized internet browser which is already known by many employees - thus training programs are reduced to a minimum aligned with the costs. Furthermore many companies aim at the presence in the internet - the data stored in the CAFM are a good possibility to achieve this representation within the university using the intranet and outside the university in the world wide web.

The combination of a well structured document management with the facility management tool offers a high efficiency that helps to get the expected overview. The SAP connection provides transparency of costs from energy consumptions and area distribution to cost centers, that will help to convince the institutes to reduce their area demands.

At a whole the preparation of the employees at the university is considered very strongly, as we expect a sensibility increase with the interviews and questionnaires. The motivation and acceptance of the whole staff is a condition for a successful implementation. With each conversation about this topic of CAFM we are "spreading seeds".

9 PROSPECTIVE

3D information is an upcoming topic that gains more and more importance considering the fact that computer technology develops in a short term. Even faster access, higher storage capacities, and stronger capability at a whole show that 3D storing of data will soon be possible in an efficient and stable way. Here new concepts have to be developed together with powerful tools for the graphic data collection.

Companies will have to deal with facility management sooner or later. It is obvious that cost reduction by cutting personal is no longer acceptable and useful - here facility management will help to align with budget shortcuts in an adequate way. Facilities will be used more efficiently and with a higher consciousness.

The internet accessability for extern users or also intranet users at the university is a strong and forward looking concept. The implementation concept will consider these facts. In the next term we will terminate with the software evaluation and decide about the recommendation of a suitable system.

10 REFERENCES

BILL R., FRITSCH D. 1994 - *Grundlagen der Geo-Informationssysteme* Wichmann-Verlag Heidelberg

BRASCHEL R. 1995 - *Facility Management*, Vortragsunterlagen I Energiemanagement, IFB-Planungsgruppe Dr. Braschel, *p 2*

BRAUN H.-P., OESTERLE E., HALLER P., 1996 - *Facility Management: Erfolg in der Immobilienbewirtschaftung*; Berlin, Heidelberg : Springer-Verlag, *pp 141-156*

FRUTIG D., MESSERLI T., 1998 - *Facility Management - als zukunftsweisende Verwaltungsfunktion der öffentlichen Hand?* Facility Management, Forum Verlag Herkert GmbH n° 1/98, *pp 30-33*

KREUER B., 1998 - *Intranet - das Firmennetz der Zukunft* Facility Management, Forum Verlag Herkert GmbH n° 1/98, *pp 50-52*

RUNNE H., 1993 - *Geodätische Datengewinnung für Gebäudeinformationssysteme unter Anwendung reflektorloser tachymetrischer Verfahren*, Geodätische Schriftenreihe TU Braunschweig, *pp 1-6, 99-100*

SCHEIB R., 1998 - *CAFM-Systeme* Facility Management, Forum Verlag Herkert GmbH n° 3/98, *pp 64-66*

ULMER F. 1996 - *Erstellung eines Gebäudeinformationssystems für das Rektoramt der Universität Stuttgart auf Basis eines kommerzielen GIS-Produkts*, Master's thesis, ifp, Universität Stuttgart

WELLER R., 1997 - *CAFM Marktübersicht* Facility Management, Forum Verlag Herkert GmbH n° 5/97, *pp 51-58*