New Methods of Computer Aided Optimization of Investment and Operating Costs for Buildings During Their Useful Life

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Summary

Current software solutions for real estate planning, construction and use, do not model the complete life cycle of a building. Well-integrated software tools exist for the planning and construction phases. Data integrity exists throughout the planning and construction phases, but problems occur at the transition to the use-phase. At this interface, the complete data set of planning and execution gets lost. Another software deficiency is that current software solutions don't handle construction work and maintenance work equally. This is why a new software generation is demanded, which continuously covers the entire workflow process from the planning phase to the demolition of a building. New data concepts have to be developed, which allow bringing work items for construction together with work items for real estate use.

The analysis and results in the planning phase, for economic marketing of real estates, form the data foundation for supporting facility management processes. On the other hand, these FM processes provide realistic cost details of work items from the use-phase, which are important to a comprehensive cost consideration in the planning phase (picture 12).

Providing a solution for this requirement is a challenge for the software industry.
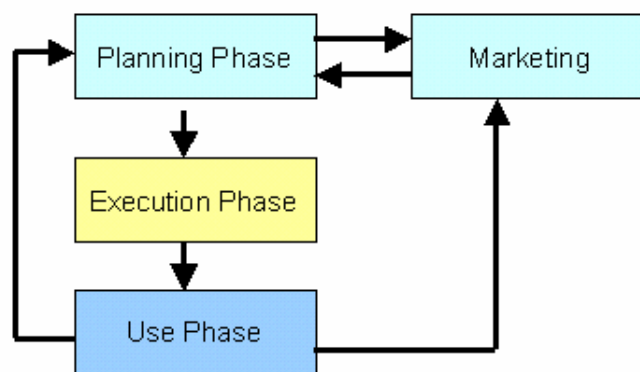
Picture 12: Process Cycle

The RIB Software AG has now made covering the entire lifecycle process, with its product family ARRIBA®, an objective. To achieve this innovative, and, in its entirety, complex approach within a homogeneous and open system, means developing a contribution to permanently improve the support of planners, construction companies and building users.

1   Introduction

Maintenance of buildings is, by far, more expensive than erecting them. Why then, are operating and maintenance costs not considered, when an investment decision is made? Realistic data for maintenance costs simply doesn't exist; only data for calculating the total job costs is available.

Software tools and data models are urgently needed for determining not only investment but also operating costs for buildings during their useful life. Thus, a contribution is made to build more economically and increase profit when selling real estate.

This lecture deals with professional and technical ideas concerning this subject, which come from a leading vendor of standard software for the construction industry.

2   Current Software Solutions for the Construction Industry

Today, there are Software Tools for all kinds of processes in planning and erecting buildings. These tools are used for larger construction projects in all industrial nations.

2D or 3D CAD systems are used in the planning phase. Not only do drawings result from this, but also digital 3D models arise from using a 3D CAD system. This model contains construction elements, quantities, parts lists and the structure of the building. Parts of the model can be transferred to tendering software. An Object Model is created based on this information. Cost elements and work items from the tendering software are assigned to data that comes from the CAD System. Afterwards, a Work Breakdown Structure (WBS) can be generated from the Object Model data. Quantities and numbers of WBS items are derived from the CAD data. Using standardized specification texts for tendering, which come from various data suppliers, creates item specifications. An online connection between CAD and tendering software permanently synchronizes modifications made in the planning phase, so that both systems use current data (picture 1).
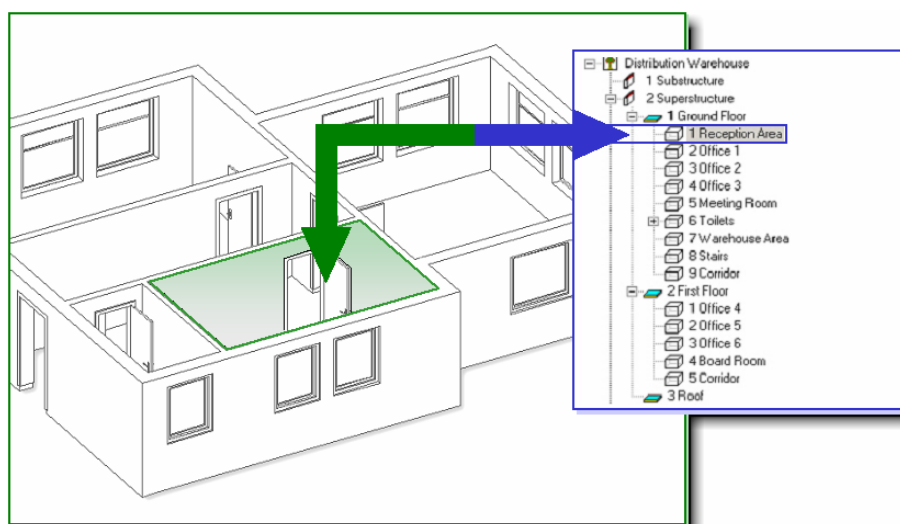
Picture 1: Online Connection between ARRIBA® CA3D and ARRIBA® Object Model

Once the WBSs have been completed, jobs are tendered and finally awarded. Tendering software is then used. Standardized formats for electronic data exchange have been developed in Germany in order to easily provide bidders with WBSs. This enables the bidder to directly use quoted WBSs to determine the total job costs and, subsequently, to create a Tender/Bid. Estimation data, which was created during bid preparation, can be used and continually

modified in the execution phase for controlling and billing purposes. Integrated systems reflect this workflow of planning and construction processes. The appropriate tools support all phases of these processes. Thus, no interfaces are needed and the best possible transparency is guaranteed.

After completion of the construction project, software solutions for facility management processes are provided for running buildings economically. There are software tools used for floor/area management, cleaning, maintenance, and renting, leasing, or cost management.

Data, which has been created in the planning and execution phase of a building, by using these tools, forms a fundamental starting point for the further geometric and functional specifications of buildings.

Architects, engineers, commercial and facility managers are involved in planning, building and running buildings. High-end software companies, like RIB Software AG, provide software solutions today, which support important working processes for this group of users during the whole life cycle of a building. However, the possibility to consider costs for the investment, total job costs, operating costs and proceeds from the sale, renting, or leasing of the building, is still missing.
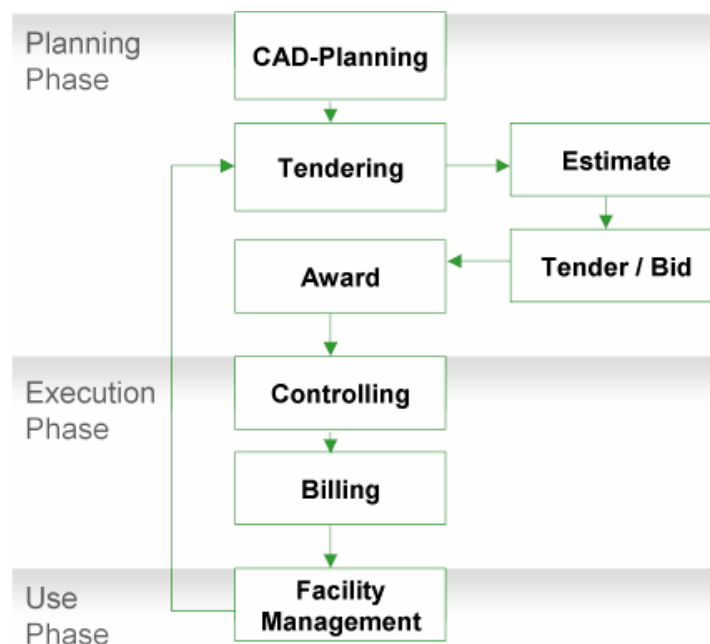
Picture 2: Lifecycle of a building

3   Future Software Solutions for the Construction Industry

## 3.1   Planning Real Estate and Considering Maintenance Costs

A building's planning phase starts with a draft determination of quantities, a definition of how the building shall be used and a decision on an appropriate piece of land. Based on this, the proposed total costs for the investment is calculated and compared with expected proceeds from the sale, renting or leasing of the building. Thus a temporary overview for the planned real estate's profit can be made.

Information about the structure of the building, its geometry and further individual characteristics of rooms and areas, is collected and administrated in a so-called 'Object Model',

which is also known as 'Room Finishes Schedule'. The data model in this Object Model is derived from geometric information, which comes from CAD systems, and alphanumeric data, which is directly entered here. Total costs and proceeds, which are defined in the Object Model for various objects, are then calculated in a process called determination of costs and proceeds.

Furthermore, different views on costs and proceeds are required in the future, e.g. for special packages which can be sold or rented out.

Currently available software applications used for construction planning, principally only consider the total job costs and the real estate's selling price based on these costs. Since the building's total operating and maintenance costs are multiple times higher than its total job costs during its useful life (picture 3), building's operating costs as well as its maintenance costs, should be considered when figuring out the profit from the real estate.
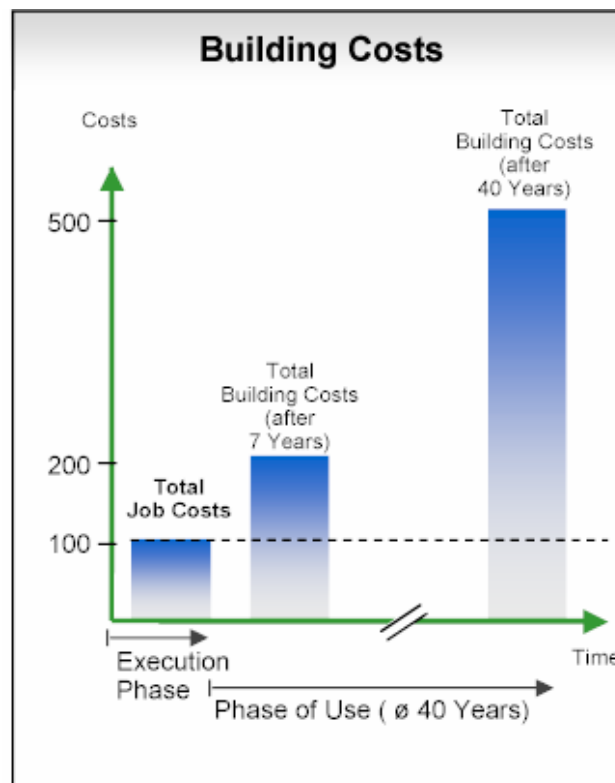
Picture 3: Building Costs During Useful Life

The German Institute for Research and Testing in Facility Management Ltd. (Forschungs- und Prüfinstitut für Facility Management GmbH), located in Metzingen near Stuttgart, states that the annual total costs for cleaning a building (windows and facades included) amounts to between 3-6% of its total construction costs. (Source: www.figr-gmbh.com).

The total amount of cleaning costs depends on the quality of floor covers or facades and on how intensively the building is used. Whether or not this approach is realistic is a matter of debate. It does, however, lend itself well as an example for demonstrating the possible savings potential.

Similar examinations for energy costs, which depend on the quality of a building's insulation, or maintenance costs, which in turn depend on the quality of its finishing, are reasonable.

A 10 million Euro building (value as new) is taken as an example. It is supposed, that an additional investment of 1 million Euro for easy-care floor coverings and facades reduces the annual cleaning costs related to construction costs from 6 to 3%. In this case, higher total job

costs, bearing 7% interest p.a., are compensated by lower maintenance costs after only 5 years (picture 4).

The example shows that profit from the real estate can be increased when maintenance costs are already considered in planning phase. It might be reasonable to invest more money in higher quality finishings at the beginning in order to decrease subsequent continuous costs for energy or maintenance.

This makes sense, especially when the investor himself uses the building or rents it out. Lower maintenance costs can also be a good argument when selling a new building if the vendor can show that a higher purchase price for the investor is off-set by the savings from lower maintenance costs.
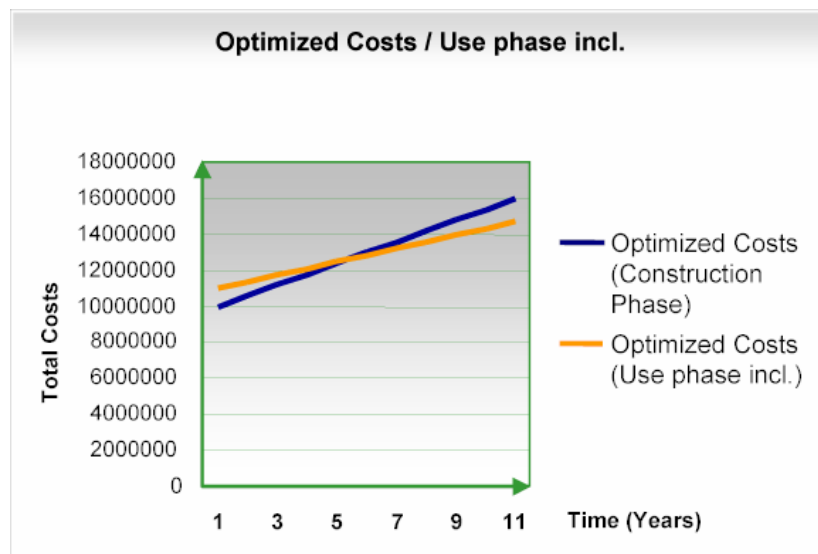
Picture 4: Increase of Profit When Maintenance Costs are Considered

3.2 How to Handle Maintenance Costs with Cost Planning/Budgeting and Cost Determination

In order to consider the costs for using a building in the planning phase, services for the construction and services for the maintenance have to be treated equally. That is, certain finishing objects or construction elements, which have been used for finishing, shall automatically generate a whole series of recurring jobs for the whole life cycle. This applies to finishing objects and construction elements used in real estate, where services for maintenance occur at different intervals and with different costs during useful life (picture 5).

The recurring work items (jobs) must not only provide the usual information such as Work Category, Specification, Unit of Measure, Quantity, Unit Price and Item Total, but must also provide information concerning time intervals. This interval describes the number of periodic job repetitions during the real estate's useful life. A corresponding work item catalogue could look like this:

Catalogue	Code	Trade	Outline Specification	UoM	UP	Interval	Unit
DBD	111276	Floor Covering	Grinding of Parquet Floor	m²	€	10	Year
DBD	111276	Floor Covering	Sealing of Parquet Floor	m²	€	5	Year
DBD	111276	Cleaning	Basic Cleaning	m²	€	1	Day
DBD	111276	Cleaning	Intensive Cleaning	m²	€	1	Week
DBD	223212	Painting	Facade Painting	m²	€	10	Year
DBD	182736	Roofing	Check Roof Tiles	m²	€	2	Year

Picture 5: Example of Work Items for Maintenance

A traditional project WBS describes jobs, which are needed for construction. In the future, such a WBS must be supplemented with jobs, which are created in relation to the maintenance of the building. What makes these items so special is the fact that they are linked to regular items, and describe the corresponding, recurring service and maintenance jobs.

Costs can be determined for both item types in the planning phase. The pure construction part, and the service and maintenance part, are then considered jointly. Thus, the result is now a consideration of total costs for the useful life of the planned real estate (picture 6).
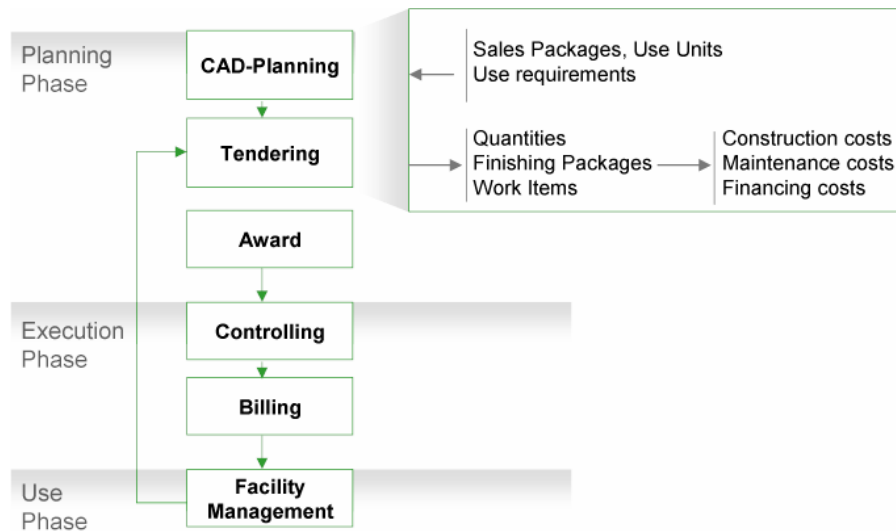
Picture 6: Comprehensive Consideration of the Costs of a Real Estate

Possible alternatives in construction include construction costs, costs for use and financing expenses. Clear statements can be made concerning the most economic solution, taking use-costs into consideration, when various alternatives are compared with each other. With this, uncertainties in selling and renting should be considered as well. Those cost-benefit-analyses form the basis for calculating profit and determining finishing details, which have to be installed.

First, only items, which are relevant to construction, are tendered and awarded. Items for service and maintenance are not carried out until the real estate is used.

At this point, the question arises: Why isn't work carried out like this?

The answer is: The feasible data and software tools do not exist.

They need to allow profitability studies for real estate based on total job costs and maintenance costs. Dependencies between investment, financing expenses, maintenance costs and proceeds

from the sale, renting or leasing of the building must be re-thought and presented in a very understandable way. Outside financing by banks or investors can be secured in less time, if not only minimizing investment costs is in the foreground, but also optimizing total profit throughout the lifetime of the real estate.

Derived from this, there are requirements for a new generation of improved planning software. Currently existing data structures and functionality have to be enhanced and optimized:

- The Object Model needs to provide functions to handle selling packages and use units.

- During cost planning/budgeting, investment and maintenance costs must be regarded equally.

- Comparisons of construction alternatives have to provide clear results in order to find the most economic construction method, considering the use and operating costs.

- It has to be possible to estimate and calculate proceeds from the sale and renting- out, for selling packages and use units.

- The software has to provide functions for calculating profitability considering invested capital as well as profit and loss for use units, which are sold, rented-out or leased.

- The software must make evaluations possible regarding risks and uncertainties in sales and renting out.

- Results of software analysis must be useful as a substantial basis for a qualified decision on the investment. In doing so, it must be possible to evaluate risks and other effects on profit and loss.

3.3 Handling of Maintenance Costs while Building Real Estate

Quantities and finishing elements of the real estate, which are determined and defined in the planning phase, lead to budgets for the execution phase and to jobs, which need to be tendered.

Those budgets form the basis for the entire subsequent process of execution and project control. We will not take a closer look at this during the course of this lecture. Nevertheless, it is important to point out, that any modifications to budget, finishing elements and quantities which arise in the execution phase, have to be entered, documented and analyzed.

There is a large number of standard software solutions already available for this approach

In Germany, usually architects are responsible for planning and managing construction projects as client's representatives. Software packages for Tendering, Award and Invoicing ("TAI Software"), which are designed for architects, provide functions for planning and the execution phases. Thus, it is ensured, that data, which has been created in the planning phase, can subsequently be used and updated in the execution phase (picture 7).
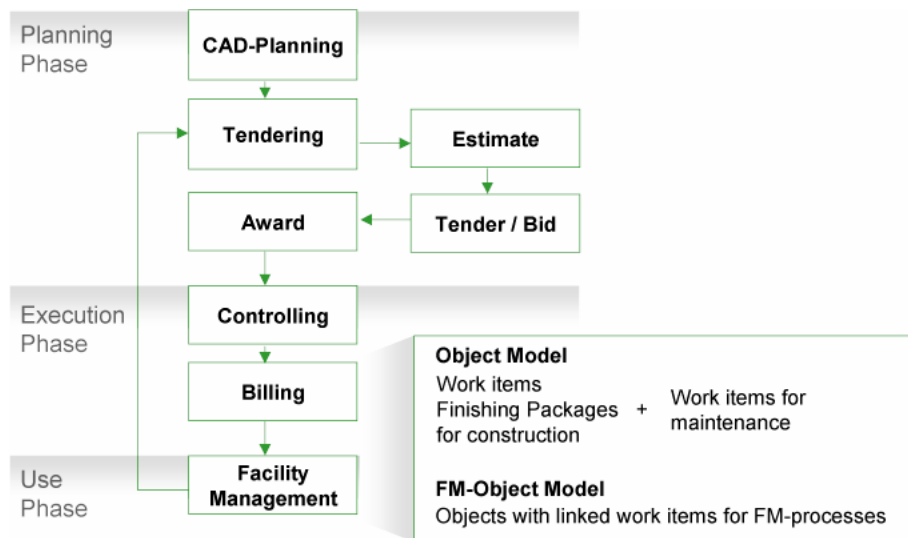
Picture 7: Data Transfer from Planning and Execution into Facility Management

Cost details for maintenance and running real estate can change during the execution phase because data from the planning phase is continuously updated. Consequently, the analysis of profitability described in the last chapter, is also demanded in the execution phase.

It must be possible to document all modifications made during execution in a comprehensive and understandable way. Effects of these changes shall be used for forecasts concerning the use of the real estate and its profitability. Further requirements for a new software generation for the planning and execution phases are derived from this. Existing functions have to be enhanced and improved as follows.

- The Object Model has to administrate several states for sales packages, and use units in the planning and execution phases.

- Effects on budgets, financial requirements and profitability of the real estate coming from total job costs and use costs, which have changed, need to be shown in each planning or execution stage.

- It must be possible to re-evaluate, in each stage, uncertainties in the building's sale and renting, and to determine their consequences for profit and loss

3.4 The Phase of Using Real Estate

Data, which originates in the planning phase, and is updated in the execution phase, becomes the foundation for facility management processes in the using phase. In the meantime, architects in Germany provide so-called "Building Books" to investors. Planning-data and data from the execution phase of the real estate are documented in such a book. The objective is to make real estate sales and value preservation easier.

Unfortunately, most of the investors are currently not willing to pay the architect for compiling "Building Books". In addition, appropriate software tools for handling facility management processes, based on data from planning and execution, are still missing. As a consequence, valuable real estate data gets lost after its completion. Data has to be re-entered when the building's use-phase starts. This causes high expenses.

New software solutions are required in order to ensure a best possible support in all work processes during the planning, execution and use phase. They need to ensure, that all building-data, from planning to demolition, can be used permanently (picture 8).

This leads to further requirements for improvements and enhancements of currently available software tools:

- The Object Model has to become the basis for the Facility Manager

- Costs, which have been defined in the planning and execution phase for sales packages and use units must be not only the basis for sales, but also for different processes in Facility Management:

    + Area Management
    + Maintenance Management
    + Cleaning Management
    + Settlement of Rents or Leases
    + Settlement of Heating Costs
    + Settlement of Extra Costs
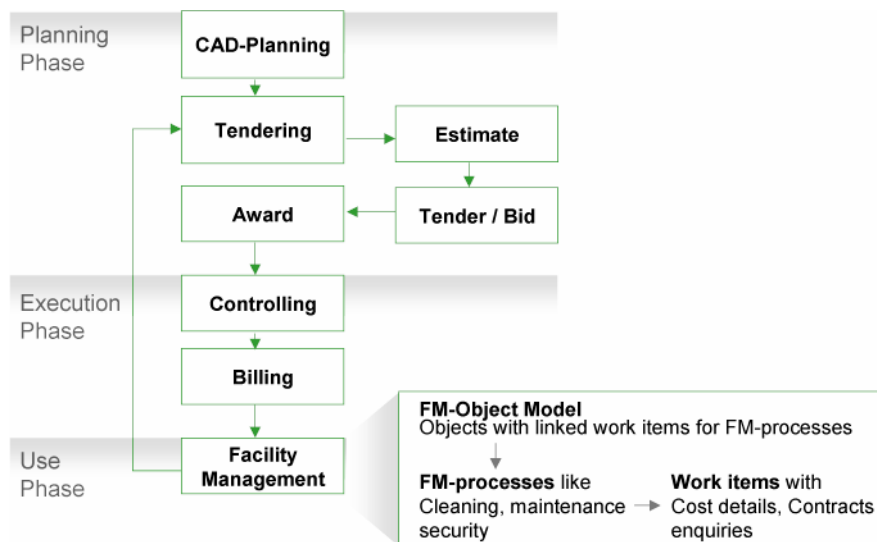
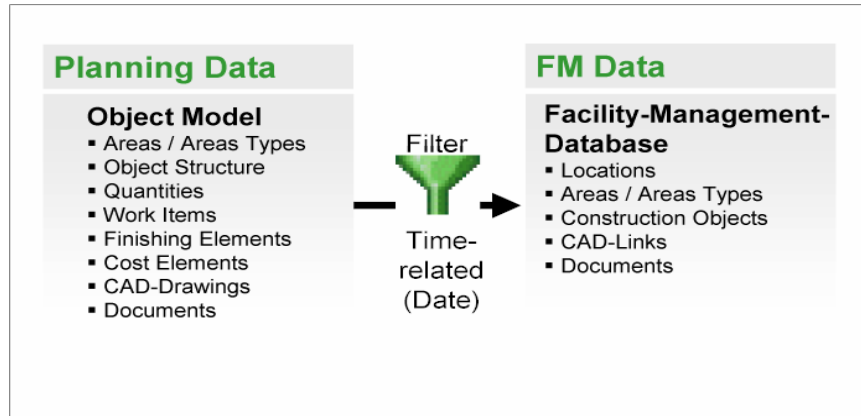Picture 8: Work Items for Service and Maintenance in FM Processes

4 Possible Solutions for Integrated Planning, Construction and Operation of Building

4.1 The Object Model as a Basis for the "Building Book"

WBS items or jobs need to be related to rooms or areas of the object model in order to be able to transfer data from the planning to use phase. This relation is defined in the Object Model. It is an essential prerequisite for further use of the data in a Facility Management System. It contains the room/building structure, specifications of areas, and a description of the construction by construction elements, work items, cost elements and finishing elements. A large part of this data is required for FM processes in the later use phase, and must be provided to FM software systems.

Construction elements, work items, cost elements and finishing elements define the inventory in FM systems and are called construction objects there. It is a common way in FM software to link locations and construction objects. So, objects that come from the Object Model can now be edited and administrated together with other objects and equipment, which come directly

from FM. Thus, planning data can be transferred into use phase. Money can be saved since data, which already exists, doesn't need to be re-entered (picture 9).


Picture 9: Transfer of Planning Data

4.2 Work Items for Service and Maintenance in FM Processes

Work items form the basis for Facility Management Processes like cleaning, security, maintenance, service and changes in how areas and rooms are used. These items, specifying work, which needs to be performed, are used for tendering and the award process. This leads to small contracts for maintenance jobs. If maintenance costs are determined in the planning phase for profitability checks in addition to pure investment costs, data of construction objects already contains work items from the Object Model, which can be utilized for planning and realization of maintenance work in the use phase.

Since solutions, like those previously described, don't currently exist, the list of work items, which are required for Facility Management, can be created just before they are needed in the use phase. Construction objects, finishing objects and equipment shall be treated similarly. All relevant work items have the corresponding source catalogue (Standard Work Item Catalogue, FM Catalogue etc.) and are assigned to a work category or a group of objects. This is for structuring data and allows creating packages for subcontracting and activities for maintenance work.

Software systems for Tendering, Award and Invoicing (TAI), which are currently offered, are laid out as self-learning systems. Planned costs are permanently surveyed in the execution phase and synchronized with actual costs. This is how work item- and commodity-catalogues with actual unit rates are developed, which are used for cost determination/budgeting in future projects. Work item catalogues, which are related to use, are built up in the same manner for Facility Management (picture 10).
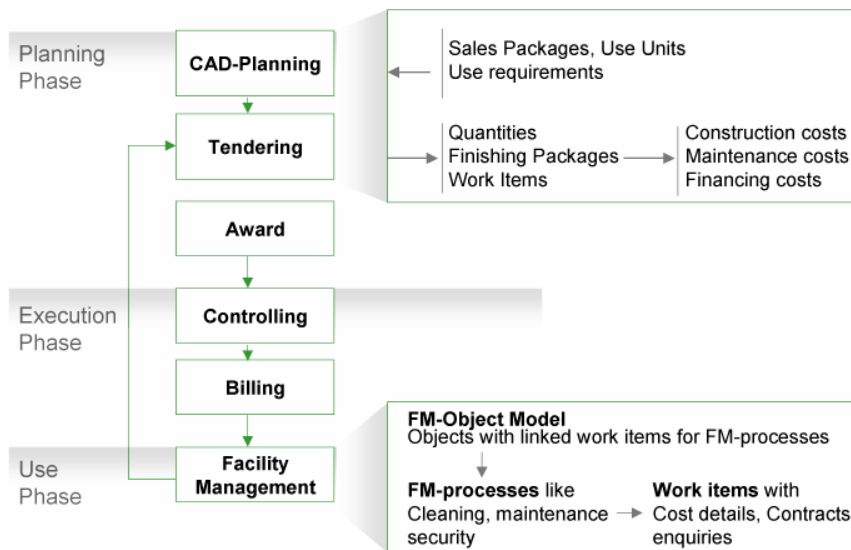
Picture 10: Work Items in Facility Management Used as the Basis for Planning

Thus, it is possible to generate plans for maintenance, service, actions or cleaning schedules for a group of construction objects. Because the maintenance to preserve the value of the real estate and its elements is carried out in intervals in many Facility Management processes, this function is of great importance. When cleaning work is planned, various cleaning scenarios can be estimated e.g. by changing cleaning intervals.
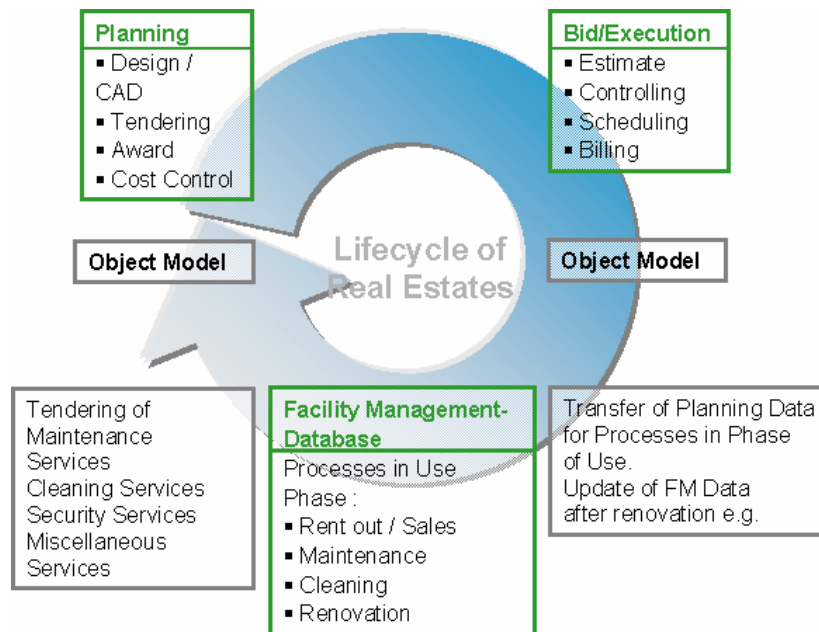
This is very important since, for preserving the value of a real estate and its construction objects, a lot of services are provided in intervals. This concerns the following subjects:

- Cleaning Management
- Service Management
- Maintenance
- Controlling

Software solutions for Facility Management, which are state of the art, administrate data in hierarchical structures, mostly catalogues. Catalogues are used for putting persons, organisations, documents, CAD drawings, cost centres, cost codes, sales packages etc. in structured order. Construction objects are structured as well.

Linking structured data together, it is possible to assign costs for maintenance of a real estate to sales packages or persons. That's fundamental for determining rates for rent and necessary allocations of extra costs.

Based on what has been explained so far, we realize that the boundaries between TAI applications and FM must be eliminated in the future. Both applications must be combined to form an integrated solution. This also includes commonly used data, which, in addition to the construction jobs, also contains maintenance services and assigned recurring intervals. This makes it possible to have a comprehensive view on processes in planning, execution and Facility Management (picture 11).

Planning
- Design / CAD
- Tendering
- Award
- Cost Control

Bid/Execution
- Estimate
- Controlling
- Scheduling
- Billing

Lifecycle of Real Estates

Object Model

Object Model

Tendering of Maintenance Services
Cleaning Services
Security Services
Miscellaneous Services

Facility Management-Database
Processes in Use Phase :
- Rent out / Sales
- Maintenance
- Cleaning
- Renovation

Transfer of Planning Data for Processes in Phase of Use.
Update of FM Data after renovation e.g.

Picture 11: Process Cycle in the Use-Phase