Synergetic

Facility Management

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Introduction

This session is an introduction to facility management concerning buildings and equipment.

Operating efficiency, optimisation of use and mutability are key characteristics of both good planning and realised projects. Especially in comparison to the systematic and integrated database supported planning as practiced in progressive industries such as automotive engineering, considerable potential for the backward building industry can be disclosed and bad planning can be prevented. Complex projects in industrial construction can profit to a great extend from the implementation of integrated methods of facility management with regard to location, building and equipment. According to [20] and a market survey carried out in 2001, consequentially 70% of installed FM-systems were put into practice at industrial projects such as factories or warehouses. The following remarks reflect the author’s experiences as an architect when conducting such projects from design to realisation.
As a basis for establishing the objectives of facility management later on, Chapter 1 analyses the general structuring of building data. The ever more important requirements to versatile buildings call for transparent planning with systematic collection of structure characteristics concerning location, building and facilities. The idea of a building being a performance model which can be optimised in various aspects ultimately leads to the methodology of synergetic planning (Synergetische Planung™). At this potential solutions to complex problems can vividly be simulated. Chapter 2 explains the terms lifecycle and utilisation rate which are essential for facility management. It also addresses frequent questions concerning possible FM-analyses. Herein the emphasis is on planning influenced (material) aspects such as location, building, building services (HVAC/R) and furnishings, as opposed to a more commercial (immaterial) approach to property. Chapter 3 is an introduction to the topic of available FM-software and explains the general structure of data models. Archibus/FM® is presented as an example of CAFM-systems. Chapter 4 points out the aspects of facility management regarding location, building, building services (HVAC/R) and utilisation/ process, on the basis of exemplary projects. This session is concluded by Bibliography, Solutions for the Exercises, Glossary and Index.

Learning Targets

Upon having studied these units you should

- be able to name essential requirements to the generation and structuring of building data,
- know about basic aspects of lifecycles and utilisation rates of buildings,
- know frequent questions und possible analyses of FM-Systems concerning location, building, building services (HVAC/R) and utilisation/ process,
- know about the general set-up of data models for facility management,
- be able to gather from examples given for location, building, building services (HVAC/R) and utilisation/ process for different tasks.

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1 General Information on Generation and Structuring of Building Data

1.1 Buildings in Flux/ Requirements

hard, soft factors

The construction of buildings is an extensive and complex single-piece production in our economy. Only a well-balanced consideration of all planning and operating criteria ensures a project's long-term success. These requirements are defined by quantifiable (hard) as well as qualitative (soft) factors. Figure 1.01 symbolically visualises the current requirements to buildings. Based on a vision, the hard requirements to a building need to be defined from technological, energetic and ecological points of view on the one hand. These are completed by the soft factors such as flexibility of equipment, communication among staff and appearance as contribution to corporate identity. Both views complement one another in a synergetic approach.

Figure 1.01: Buildings in Flux: Requirements

Vision

At every project there are people for sub projects who take action, are sceptical or indecisive. What is a vision? How is it put on record? Especially at the beginning of a project, when first workshops and presentations are being held, everyone involved ought to be brought together after discussing the alternatives developed. Ideally the most diverse objectives of a team can be merged into a vision that is supported by everyone. This vision is wishful thinking, projected into the near future with regard to the best possible solution to all tasks of a project.
A workable vision does not reflect hard factors only but it also incorporates soft factors of emotional consent into decision making. Coherence of instinct and reason is an essential condition for mutual consent. New ways and actions possibly call for outstanding courage and stamina. Decisive for a lasting acceptance of the general concept is the fascination that lies within it.

Computer Simulation

Computer simulation in form of anticipated reality is an important visual aid. Animated 3D-graphics through to virtual realities prove the feasibility of complex projects when supported by realistic illustration.

Technology

In the building industry technology is regarded as the methodology of procedures on a specific field of application. At industrial production implementation of technology always represents producing goods and solving tasks with least possible effort following the principle of maximum efficiency. As opposed to that buildings often seem backward in planning and implementation. One reason for this could be the building industry's traditional inertia. As opposed to more progressive industries the building industry is only hesitant in accepting new materials and intelligently combining materials in order to form systems of higher performance (wide span structures). Nonetheless also regarding buildings, in analogy to technical products, there is a similar coherence between efficiency, lifespan and appearance on the one hand and on the other hand costs of production and maintenance. After the object character of a building having been predominant in the past, it is now modified into an integrative performance during its lifecycle by applying those principals used on technical products. A suitable term for this would be performance model. Methodical proceeding, optimisation and simulation of characteristics during planning as well as choosing sub systems, building process and operation with project related facility management can therefore contribute to technologically higher-valued building structures.

Efficiency

Lifecycle

Energy

Energy appears in forms of mechanical energy, electrical energy, thermal energy, magnetic energy and nuclear energy. Energy is never used but only transformed from one form of appearance to another. Due to the available supplies of energy such as coal, oil and natural gas being exhaustible, regenerative energy sources such as solar energy, hydro energy, hydropower, wind power, bio energy and tidal energy, should be used increasingly.
Figure 1.02 according to [1] illustrates the immediate effect of a building's shape on energy consumption for heating.

Figure 1.02: Energy: Heat Requirement of different Volumes [according to Daniels]

The left part of the illustration shows a cube as reference shape. Cylinder and hemisphere have 2 respectively 4% less heat requirement. As opposed to that a pyramid needs 12% more heat. The right part of the illustration points out the influence of a built volume's structure. Again the compact cube is used as reference shape. Upon division into two slices, heat requirement rises by 33%. When arranged in one line 42% more heat is required. Finally the partitioning into eight equally sized cubes equals a rise in heat requirement of 200%.
With regard to choice of location, general development and building structures, intelligent building concepts mainly stand for deliberate alignment concerning sun and wind directions. According to [1], Figure 1.03 shows the influence on gained solar energy considering as example a building's alignment in our latitudes. As for tropical latitudes the aspect of energy spent on cooling applies accordingly.

Intelligent Building Concepts

Figure 1.03: Energy: Solar Radiation dependent on Building Alignment [according to Daniels]

Given a south, south-west alignment approx. 260 kWh solar radiations can be gained per square metre of window surface. Rotation of the building into a west, south-west direction reduces this radiation by nearly 70% to 89 kWh per square metre of window surface.

Energy Optimisation

Thus building structures and building services offer a variety of possibilities for energy optimisation by integral concepts for climate and technology. At this the main objective ought to be reducing energy consumption caused by traffic with the aid of cleverly organised logistics as well as providing for building services to make use of those energies used for and released by utilisation processes. In practice this means rooms in a building need not be heated, cooled, ventilated and artificially lit more than necessary. Therefore a building's outer shell – working as a dynamic shield for humans – as well as installed technology need to be laid out, taking into account operational utilisation, in a way so that low power requirement, little environmental pollution and optimum running costs become reality. An accordant structuring and interpretation of the building's 3D-model allows for energetic optimisation of design, building services (HVAC/R) and utilisation processes. Examples are distribution and intensity of daylight and artificial light, requirements for heating and cooling as well as draught-free workspaces by dynamic simulation of airflow.

Ecology

Resource Conservation, Waste Prevention

In its traditional sense the term ecology stands for teachings of the ecosystem. Ecological balance is to be defined as undisturbed ecosystem. Transferred onto the field of building it soon becomes apparent that the term ecological building is a contradiction in itself. Building always means interference with nature. However, it does not inevitably mean destruction of the environment. Therefore ecologically conscious building marks the highly efficient production, operation and reduction of built environment within the framework of the ecosystem. Buildings offer manifold potential for ecologic approaches such as resource conservation and waste prevention. According to [2] Figure 1.04 contrasts a conventional building with a more significantly adapted building from the ecological point of view.

Figure 1.04: Ecology: Conventional and Adaptive Building in Contrast [according to Althaus]

It becomes clear that there is a multitude of possibilities for saving technical investment costs as well as running costs with a possible reduction of building costs at the same time. Meanwhile Chambers of Industry and Commerce have set the course for a more conscious handling of ecological aspects in operation by implementing a voluntarily based procedure of certified eco-balance in accordance with EU-Environmental Management Auditing System. All single aspects such as airspace, ground, water surfaces, halls, construction, façades and roofs, as well as various facilities should be treated well balanced to start with. At the beginning of a project planners and users have to agree on which of the previously mentioned issues are to be prioritised. This calls for everyone involved to be woven into the planning process at the earliest possible stage.

Flexibility

Mutability

Adaptability within as wide a range of tolerance as possible determines the degree of constructional flexibility. With regard to growing utilisation this primarily means defining a mutability of all systems of constructional design as well as sufficient performance of supply and disposal systems.

This mainly applies to distance between pillars, clearance of storey or hall, allowed floor and ceiling loads, as well as providing options for future horizontal or vertical extensions. Supply and disposal systems need to allow for variable conditioning of rooms in analogy to structural alteration. Therefore installations ought to be independent from other structural systems. Also open routing should ensure easy access so that alterations can be carried out without ongoing utilisation being disturbed.

Flexibility in this context, however, does not stand for overdimensioning of areas, heights or connection values but it rather stands for the possibility of easily carrying out dimensional changes or quickly integrating altered components. The economic guideline in this is that provisions for future alterations, regarded as pre-investment, are to be less complex than first potential rearrangement.

Structural Analysis

Therewith former polarisation on inflexible standard solutions and flexible universal buildings turns into a finely membered structural analysis. This has to be set up for each project individually.

Communication

Networking Transparency

Besides error correction and permanent quality assurance, architecture geared at networking and transparency promotes opportunities for communication, self-determination as well as staff participation concerning work and surroundings. Better and better trained personnel increasingly expect their workplace to also offer high recreation and leisure qualities. Surveys have revealed that 80% of innovative ideas have come from informal and unintended personal communication. In order to support this process, buildings ought to be subdivided into private, semi-public and public rooms as well as local forums. Workshop atmosphere is beneficial to spontaneous use and swift variation of furniture and equipment. Corridors, galleries and staircases, however, also disclose new potential for communication. When upgraded in appearance they facilitate spontaneous exchange of ideas as well as informal communication and are therefore important mental spaces.

Identity

Recall Value

In the current surroundings of unmanageable variety of services and products on the global markets, a company's recall value for customers and staff becomes increasingly important. A company's accentuation and general presentation are not only defined by service or product but also and to a great extend by its building and its internal and external appearance. Insignificance as opposed to that augurs submersion in anonymous mass.

Corporate Identity

In the seventies design, conduct and communication have been amalgamated to form a strategic concept. This was the cradle of corporate identity which became increasingly included into designing buildings more consciously. Currently many companies recognise their potential in a hidden company history, try to establish a related self-consciousness and use it for forming an identity. Consequentially such guiding principles for conceptual design could be developed that support a positive first impression of particularly competitive companies.

Synergy

Synergy defines interaction of different powers, factors or bodies within a harmonised general performance. With regard to a building project synergy, based on a vision, stands for the skill of merging seemingly incompatible objectives into a comprehensive optimisation process. The achieved degree of synergy directly reflects a project's performance. Therewith synergy and a method supporting it become a key concept. Synergetic based concepts detect potential for improvements with network-like effect. They also bundle positive and mitigate negative factors.

Optimisation Process

Each building project offers varied potentials for such synergies. However, they rarely arise from conventional sequential planning processes. These potentials rather have to be combined by means of coordinated views on location, building, building services and utilisation, in the framework of cooperative planning right from the start. Based on rateable performance parameters for a building's elements, the method of synergetic factory design (Synergetische Fabrikplanung™) is introduced in the following.

Coordinated Views

1.2 Buildings as Performance Model

Which are the structure forming criteria for a building's shape? Which characteristics determine performance and mutability? Obviously those attributes decisive for this are established at designing a building already as well as by subsequent detailing. A shortcoming of traditional planning lies within the insufficient definition of suitable fundamentals of planning. While an industrial product is usually defined by requirement specifications that are developed in a team which establishes parameters for product design, buildings develop more or less randomly.

In the field of technical design, marketable and innovative products considering manifold requirements imposed on them by market, technology, production costs, formal quality, durability and production time, result from ideas.

Systematic Development Building Elements

In contrast to that the building industry very often lacks systematic development of a building's elements. Structural and technical systems for load bearing structures, outer shells, building services and finishings are mostly decided on without sufficient farsightedness.

Long-term investments in elements of a building that have specific operation and maintenance factors without prior definition of performance characteristics remind of 'buying a pig in a poke' (English proverb). Therefore the total of a building's elements ought to be understood as a rateable performance model.

The highest potentials for increase in quality and reduction of costs lie within comprehensive analysis and planning as well as integral operation of processes. This applies equally to buildings and technical equipment for production, heating, climate and ventilation.

Form Follows Performance

What's the relation between form and function at this? According to [3] architectural theory developed two apparently diametric positions of shape finding. Towards the end of the 19th century the slogan 'form follows function', based on American architect and theorist Louis Sullivan, marked the functional necessity, the nature of a task as cause and concept of a building's formal design. At the height of 'Bauhaus' the architects of the new way of building tried throwing off the restraints of eclectic styles with help of this slogan. In reaction to the architectural banality of box shaped buildings, many architects in the 20th century's second half thought the slogan 'function follows form' was promising for both an increase in creative diversity as well as formal dominance of their designs. Thus programmes and processes were being designed to fit into the prefixed geometries of a building.

Both strategies are not exactly purposeful with regard to versatile and therewith durable buildings at least. They each only concentrate one-dimensionally on a single criterion of the complex correlation of environment, human being, function and form. Very often in a project the question arises, which of the current functions and forms will endure in the long run. The transitory snapshot of a temporary programme or the fashion of a fugacious aesthetic zeitgeist is hardly suitable for a robust decision on shape.

Integral Approaches

Therefore integral approaches are called for which are to be developed in equal measure from the view on utilisation (function) as well as the view on space (shape). It is imperative to find a deliberate positive bundling of features with the aid of many partial solutions, as complementing one another as possible, to complex questions. The process of such way of developing a solution shall be characterised by the term 'performance'. The credo 'form follows performance' derived from this stands for the integral answer of shape finding to a comprehensively acquired question. In continuation of Figure 1.01, Figure 1.05 illustrates the vision of a performance model on the basis of industrial buildings implemented by the author.

Performance Characteristics

Figure 1.05: Performance Model: Examples for Industrial Buildings

According to [4] the specific shape is not fixed in advance but results from the spatial implementation of required performance features 'form follows performance'. Based on the visions underlying the projects given as examples, new construction technologies are to be used, energy consumption is to be optimised and ecological concerns are to be networked. According to [5] the necessary flexibility is to be ensured in the form of mutability on all levels of design. At this communication among staff must be promoted by appropriate interior design and furnishing.

Graphic visualisation of differentiated parameters of a building's structure in form of bar or curve diagrams has proven to be very helpful for communication among the planning team. Immediate visualisation of such performance profiles eases discussion on variants. In analogy to the DNA of biologic living beings, Figure 1.06 exemplary shows specific parameter values of load bearing structure, outer shell, media and equipment of a built genetic code: this way the performance characteristics called for in workshops on finding the objectives e.g. grid patterns a, b of span width in a hall, openings in the outer shell, more comfortable temperatures at workstations or degree of transparency regarding interior finishings, can be displayed very descriptively and comprehended at a glance.

Performance Profiles

Figure 1.06: Performance Model: Built Genetic Code

1.3 Design Levels, Structure Characteristics

Results-Oriented

According to the five traditional levels of design in factory planning it is highly advantageous, also with regard to spatial approach, for the steadily increasing focus to be assigned to the corresponding levels of design namely local positioning, general development, building, workspace and finally workstation. This enables joint and results-oriented rough to detailed planning. The special quality of synergetic operation occurs on each level of design in form of integrative compilation of determining factors (referred to as fields of design), joint structuring of parameters (elements of design) as well as evaluation and selection of those shapes conducive to a project's success (characteristics of design). Figures 1.07 and 1.08 depict structure characteristics of location and building, Figure 1.09 is an abstract illustration of the design levels, from site plan to workstation, that need to be analysed regarding the utilisation/process-related and spatial approaches.

Figure 1.07: Location: Example for Structure Characteristics

Figure 1.08: Building: Example for Structure Characteristics

Figure 1.09: Data Model: Design Levels/ Design Elements

Cooperative Planning

Structure Characteristics

The extra value of cooperative planning is displayed in a stronger joint focus concerning both the process-related and spatial approaches. Due to the variety of different factory projects an exhaustive list of all possible determining factors pointing out every possible parameter and shape is doomed to failure. The introduced structure characteristics rather try to answer reoccurring questions of mutability. Structuring geared at the example of implementation of industrial buildings helps in answering frequent questions regarding design phases such as basic evaluation, design, design for permission to build or detailed design on the one hand and on the other hand due to its systematic structure correlating with factory design it offers a comprehensive aid in project management or facility management, from development of a project to implementation.

1.4 Synergetic Planning (Synergetische Planung™)

Requirement Specifications

Workflow

Both, mastering the above mentioned requirements to buildings as well as the question relating to structuring project-defining requirement specifications, raise the question regarding a methodology for space planning. A critical view on the practice of building design reveals serious differences between 'state of the art workflow' in the automobile industry and the design and manufacturing methodologies of a building project. In the thirties of the last century already, masterminds like Buckminster Fuller referred to the traditional backwardness of the building industry as opposed to more progressive industries as 'cultural lag' and the head start in development of the automobile and aircraft industries at that time has been figured at 20 years. The focussing on traditional practice in the design methodology of factory buildings reveals serious differences especially in comparison to the 'digital' operation of progressive industries: the according to Figure 1.10 normally separated definition of sub-projects.

Figure 1.10: Planning/ Operation: Isolated Sectoral Planning by means of many Separated Sub-Projects

Isolated Solutions

Location, building, building services (HVAC/R) and utilisation/ process are carried out in a sequential planning method and therefore consecutive design phases as opposed to timesaving simultaneous engineering which is standard practice in the automobile industry. The logic consequence of this are independently developed isolated solutions to these sub-projects. As shown in Figure 1.11 a lack of interlocking leads to the well known risks and shortcomings of building projects, mainly a direct form of the difficulty of a 'sea of interfaces'.

Figure 1.11: Planning/ Operation: Frequent Shortcomings caused by Interfaces of Sub-Projects

In avoidance of the above, planning data of formerly separated views should be consolidated at the earliest possible stage in order to aim at constant matching of interfaces. At this a method could be of help that originates in physics and is referred to as 'synergy': excerpt from Merriam-Webster OnLine

> Etymology: New Latin *synergia,* from Greek *synergos* working together
> 1: SYNERGISM; *broadly*: combined action or operation
> 2: a mutually advantageous conjunction or compatibility of distinct business participants or elements (as resources or efforts).

Synergy Effect

The effect of synergy regarding the complex single piece production of a building is expressed in the use of all aspects of optimisation and creation of value reaching from planning, implementation and operation to dismantling. At this the control variables are material, information and communication, money and persons, which are in constant motion within an open system. The more comprehensive and complex the system is the higher are the synergy potentials due to an increase of relations.

Early consolidation of spatially contoured sub-projects

According to [6, 7] the new quality of cooperative planning regarding the utilisation/ process-related and spatial approaches lies within merging the spatially designed sub-projects such as location, building, building services (HVAC/R) and utilisation/ process at the earliest possible stage. Thus an integral operation continuously refines a project's 3D-structure as well as its textual planning data from rough (presumptions) to fine (specifications) and evaluates the decision making process by comprehensively discussing variants. (Compare Figure 1.12)

Figure 1.12: Synergetic Planning/ Operation: Integration of Sub-Projects

Performance Characteristics

At this the specific objectives of sub-projects regarding mutability or their designated performance characteristics can be clearly contoured by means of requirement specification, transformed into spatial models and effects on the project as a whole can be revised.

Universal 3D-Data Model

The set-up and maintenance of an integrated and universal 3D-data model utilises the potential of current CAD/ CAM/ database technology in favour of comprehensive project improvement and cyclic 3D-quality assurance.
With the aid of suitable software a variety of specific data evaluations, based on standardised file-formats, can be carried out. Figure 1.13 illustrates evaluation options for the 3D-data model regarding the process as well as spatial approaches at the example of factory design.

Evaluation 3D-Data Models

Figure 1.13: Evaluations provided by Synergetic Data Model: Example - Factory Design

Based on the spatial optimisation of this 'synergetic factory model' it furthermore enables interference check and continuous quality control for all trades. Especially those conflicts between location, building, building services (HVAC/R) and utilisation/ process that influence costs, time and quality can be detected at an early stage and are not only dealt with when already on site or during future operation. Another aspect of 3D-modelling which is not to be underestimated is the extreme graphicness of the processes as an element that encourages communication for everyone involved. Currently a tendency in CAFM-techniques to user-friendly information which is also put into graphs can be observed. These CAFM-techniques are introduced in the following.

Quality Cycle via Integrated Facility Management Data-Model

The so far static, object-oriented outlook on a building design project is increasingly transforming into a dynamic, process like view. The special quality of continuous provision of data reveals itself in connection with conversions, extensions or new buildings at the same or different location which are regarded as control loops. According to [8] a particular value of the synergetic building model as opposed to traditional planning mainly lies within higher precision regarding cost estimates, deadline dependencies, quality assurance and operation of the facilities. By re-evaluating the planning phases that are interlocked in the style of 'simultaneous engineering' it is possible, as early as directly following the phase of rough planning, to achieve a very high degree of planning reliability regarding capital appropriations as well as running costs that are to be expected. Thus new views arise on structuring and contents of interlocked cyclic planning phases. The information contained in an integrated facility management data model, by means of interpretation of strategic operating figures for example, allows for swift preparation of a workshop, a department's possible relocation or the preparation of an extension project. From the client's point of view transparency of data as well as the structured methodology of synergetic planning (Synergetische Planung™) stands for an extra added value, especially within the network of globally linked project cycles. Based on an integrated facility management data model Figure 1.14 illustrates the control loop of a six-stage project cycle from workshop to operation.

Synergetic Building Model

Strategic Operating Figures

Control Loop

Figure 1.14: Synergetic Quality Cycle by means of 3D-Data Model

As opposed to the former sequential operation of separated sectoral planning, experience shows that integrated planning enables comprehensive market research for an overall project as early as ten weeks following the first workshop. The interlocking of 'specific' fine elements and 'neutral' rough elements of the data model allows for a quick set-up of performance programs that are structured according to cost elements and serve as a base for market research. Upon evaluation of this market research it is possible to compile all relevant planning data concerning the overall project which enables a high degree of planning reliability regarding costs.

Rough Elements Fine Elements

Summary

Technological as well as cultural factors influence a building's future mutability. They ought to be collected and merged in a synergetic approach. The highest potentials for increasing quality and minimizing costs lie within integral analysis and planning as well as integral operation of process flow for location, building, technical equipment and utilisation. Such optimisation leads to property being regarded as performance model. The success of all planning and the long term quality of its results depend on accurate acquisition and preparation of data. The added value of cooperative planning is revealed in joint discussion of design levels and structural characteristics from the spatial as well as utilisation/ process point of views. Universal spatial planning techniques with integrated data models of facility management lead to synergetic planning.

Confirmatory Questions

1.1 Explain in a few words the terms technology, energy, ecology, flexibility, communication and identity!

1.2 What is the added value regarding synergetic planning?

Questions

1.3 Name frequent mistakes in planning and operation of buildings!

1.4 Briefly explain the term 'performance model'!

1.5 Which structural characteristics of a building are hardly changeable after completion and should therefore be meticulously checked with regard to mutability?

2 Facility Management for Location, Building and Equipment

2.1 History, Definition

Besides staff, capital and technology, real estate is increasingly recognised as a strategic resource for maintaining and enhancing a company's competitiveness regarding the globally increasing competitive pressure on the markets. Therefore facility management is referred to by many experts as 'hidden revolution' within companies. In the middle of the fifties the term facility management (FM) was coined for the first time by the Schnelle brothers of the Quickborner Team. Considering as example the seating manufacturer Hermann Miller the aim was to improve interaction among the company by means of implementation of an office landscape thus to increase productivity. This marketing concept quickly turned into a self-runner. In 1978 the Hermann Miller Corporation, Ann Arbour, Michigan and customers hosted a conference on 'Facility Impact on Productivity'. In 1979 this initiative lead to the founding of the Facility Management Institute (FMI) in Ann Arbour, Michigan. In October 1980 the National Facility Management Association was founded by 40 professional facility managers. Quick growth and expansion on Canada lead to the new name IFMA, International Facility Management Association, in 1982. Currently IFMA supports approximately 18000 members worldwide. The IFMA is recognised, in the USA at least, as a professional organisation and it sees to it that 75% of its members are active facility managers. In Europe facility management was at first introduced in Great Britain in the middle of the eighties. There it was the architect Francis Duffy who picked up the idea. Thereupon the AFM, Association of Facility Managers, and the Institute of Administrative Management/ Facilities Management Group (IAM/ FMG) were founded in 1985. In Germany as well as in other European countries a national association, German Facility Management Association (GEFMA), was founded in 1989. Its objective was the bundling of information in favour of a uniform statement for the users of facility management. In the following years the market of facility management services developed very heterogeneously in Germany. The leaders at this were suppliers of CAD-software as well as service providers who had previously offered sub-services such as operation, security or commercial cleaning. Such consultancies, however, were missing that had an integral approach to revealing a company's potentials in synergy and that could also put strategies into practice by means of facility management. Since 1996 GEFMA, being a primarily provider oriented association, tries to gain a closer relation to practice by increasing constituency-level work and developing guidelines. In December 1996 IFMA Deutschland e.V. was founded as antipole to GEFMA. As the German national committee of IFMA it tries to elaborate a model job-description for facility managers.

Increase Productivity

IFMA

GEFMA Bundling of Information

Definition Facility Management

The term 'Facility Management' is often used without clear definition. According to GEFMA guideline 100 [9] following definition is proposed in relation to location, building and equipment: 'Facility Management is consideration, analysis and optimisation of all processes relevant to costs and quality with regard to location, building, technical and other equipment.' Consequentially all of a company's premises, infrastructures, buildings, installations, machines and equipment, thus its total fixed assets, are being referred to as 'Facilities'. Therewith facility management encompasses all criteria of a project's long-term economic as well as utilisation-oriented efficiency. It so mirrors a project's performance, tying in with the term 'performance model' as introduced in chapter 1.2. Subsequently facility management comprises all domains that in some way are connected to the lifecycle of real estate, its running and marketing. Precisely it is about advise, planning, organisation, regulation and control of all processes, constructional activities as well as marketing activities that occur during the lifecycle of a location including its building and equipment. Owners and tenants make increasingly high demands on a property's quality, range of performance and rate of return. The formula for success being: regarding real estate not merely as an object but as an investment. Marketability, also on a cyclic real estate market, as well as adding value are key factors for a successful integral real estate strategy, that are combined in the term 'Facility Management'. Facility Management sees a building project through from planning through utilisation to dismantling. At this it immediately becomes clear that the net building costs are only a part of the costs that arise during the total useful life. Depending on the project the yearly costs for maintenance, infrastructure and operation, according to [10], range between 10 and 20% of the construction costs. Hence these are exceeded many times over during total useful life. The facility management market as a whole is very ample. A variety of providers offer services of different kinds. Cleaners or suppliers of building services components for example regard themselves as providers for facility management. 'Specialised companies' are currently offering internet-based software for e.g. maintenance work for technical control units or the awarding of tender performance contracts. There is still a lack of an interface minimizing, integral view on real estate. Adequate alignment provided, architects seem to be particularly suitable for this due to their diversified education.

Integral Real Estate Strategy

2.2 Tasks, Demarcation

In today's practice facility management regarding real estate deals with continuous change of operational requirements to location, building and equipment and provides for complex bases for decision making concerning their best possible planning, set-up, operation, change of use and recycling. As shown in Figure 2.01 this task complex can be roughly split into five sub-domains.

Figure 2.01: Tasks of Facility Management regarding Real Estate

Acquisition and Provision of up-to-date Data

This mainly comprises the collection and supply of up-to-date data on premises, buildings, building services systems and equipment, statement of utilisation degree as well as calculation of market value. Therefore effective facility management comes along with an elaborate infrastructure for communication in order to ensure a fast, economic and redundance-free collection and administration of data. Furthermore this ensures all information relevant to planning and decision making is at all times up-to-date and directly accessible from each concerned workstation.

Evaluation of Location, Building and Equipment

This is about the supply of data for developing, running and maintaining a safe, human and functional work environment. This task is not confined to the actual resources only but it can also apply to concepts for organisation and personnel development. Additional requirements are calculation of consequential costs arising from strategic investment decisions, maintaining appearance as corporate identity as well as continuous guarantee on security regarding resources, building and data.

Space Planning and Utilisation Planning

The objective of space planning and utilisation planning is set-up, control and adjustment of physical workstations according to legal, ergonomic, organisational and sociological criteria whereat particular attention should be paid to interaction of workspaces.

Operations and Maintenance Management

Operations and maintenance management are concerned with analysis of costs regarding utilisation and internal service, development of maintenance concepts in consideration of lifecycle data and costs as well as with maintaining economic operations.

Budgeting and Valuation

Contents of budgeting and operations are comparative financial valuation of individual measures as well as development of alternatives taking into account the respective lifecycle and ecologic consequences. Detailed explanations and practical examples regarding location, building, building services (HVAC/R) and equipment result from the author’s experience in design and construction of industrial buildings in particular. Industrial projects pose an exceptional challenge on everyone involved due to close interlocking of set-up planning on the one side and location and building on the other side as well as due to heightened deadline and cost pressures in comparison to other building projects. Consequentially, employment of new strategies is more advanced in this field as well. Factory buildings of the automobile industry take on a leading role with regard to implementation of facility management. In addition to optimising the substantial structural elements of planning and operations, integrative cost management of real

Substantial, Insubstantial Structural Elements

estate becomes increasingly important in view of growing cost pressure. Optimisation of insubstantial business processes in this field and the use of adequate integrated solutions help in improving work efficiency and cost transparency in particular. According to [11] Figures 2.02, 2.03 and 2.04 provide an overview of work flow regarding commercial facility management.

Figure 2.02: Project Controlling as part of Facility Management [according to Wildgruber]

Figure 2.03: Process Flow of Integrated Invoice Logging [according to Wildgruber]

Figure 2.04: Comparative Portfolio Analysis of Objects [according to Wildgruber]

Important fields of work are object controlling, corporate planning, budgeting, contract management, labour organisation and accounting. Effective controlling requires appropriate preparation of collected data. It supports generation of characteristics and portfolio analyses and it also enables evaluations on object level.
In any case, however, facility management is assigned to report on managerial competence and taking over responsibility for strategy oriented planning, construction, operation, service and maintenance, safety, change of use, closure, letting, leasing, selling etc. of premises, buildings, rooms, equipment, facilities and furnishings during the complete lifecycle. This fundamentally changes the view on the term 'planning' – planning is no longer a time-limited and isolated process that ends upon construction of a building but it is becoming a process that accompanies a building's lifecycle.

2.3 Lifecycle

Fee Structure for Architects and Engineers

Lifecycle

Integrative consideration of real estate over its entire useful life changes the view of formerly separated planning, departments, functions and operational processes. Collection and exchange of data have to be coordinated and repeated data acquisition causing longer planning periods ought to be avoided. In the majority of the cases such 'life' starts with consulting during a workshop. The subsequent stages of planning, implementation, operation, conversion, poss. refurbishment, recycling or demolition go far beyond the work stages as stated in the Fee Structure for Architects and Engineers. In retrospect to the explanations on planning techniques in chapter 1 the Fee Structure for Architects and Engineers mirrors the object like character of a building and ends upon a building's completion. As opposed to that integrative consideration of real estate comprises its usability over the entire span of life. Figure 2.05 exemplifies stages in the lifecycle of real estate.

Figure 2.05: Stages in the Lifecycle of Real Estate

Planning Phase

In the framework of planning phase such design outputs are being developed on the basis of task and objective that are put into practice during the following implementation phase. The main issue of target planning is elaboration of task and objective, costs for construction and operation are being fixed. Upon completion of a building an influence on e.g. heat or cooling requirements and therewith running costs, can often only be achieved by extensive and therewith costly alterations. Although planning phase is comparably short with regard to time, it is here that fundamental determinations concerning management of physical resources are made. This is why, when implemented at the early stage of defining the objectives, facility management can lead to new approaches by connecting planning and operation phases. In workshops, following an initial phase of analysis, user requirements are first of all established and subsequently elaborated to planning results during conceptual phase. Even integral basic evaluation should be carried out in a way suiting the facility management system; filing of graphic and textual elements should be in accordance with compulsory standards for documentation. Without CAD-support and the use of databases, planning and implementation of complex factory projects nowadays cannot be realised within the desired time span. Data exchange via data networks or data media among everyone concerned with a project during planning phase is state of the art. Planning phase is closely tied to the following implementation phase; tender documents form the basis for offers from executing contractors and are usually put together according to the results of planning. This is where, due to constraints regarding time and costs, an integration e.g. by internet actions of specifications for tenders with regard to buildings or piece lists with regard to plant construction is starting to prevail. Set-up of tender documents correspondent with cost-groups and cost-elements in accordance with DIN standard 276 as opposed to traditional set-up correspondent with trades offers the advantage of transparency regarding costs at all times. Furthermore instalment plans could be based on this respectively. The way in which tender documents are set up and construction performance contracts are awarded should be included in an integrative workflow comprising all documents concerning the building. Therewith future adjustments of the real estate during operation phase can be carried out on the basis of specifications for tenders as developed at planning stage.

Integral Basic Evaluation

Tender according to Cost-Elements

Implementation Phase

Contractors conduct construction of location, building and equipment according to the specifications contained in tender documents. At this they are directed by specialised planners. During implementation phase, problems for future maintenance management evolve from changes as opposed to planning not being recorded in planning documents. Ideally, during implementation phase, planning documents should be congruent with what is really being built at all times or at least be regularly updated. This is the only way to control work progress and consequentially manage costs and dates of projects. It is advisable to not pay progress payment invoices in a lump sum but according to work progress respective to trades or cost-elements. In the framework of future maintenance management one also has to resort to these planning documents, i.e. for calculation of areas needed for tenders regarding cleaning (floors, windows etc.) or service and maintenance (technical equipment). Updating of planning documents is still economic during implementation phase due to being close to action. Given that planning documents are not being kept up to date during implementation phase, very often the only way to obtain reliable as-built documents once the building has been completed is by extensive and costly survey of the existing building. It is exactly at this point where there evolves a responsible task field for project management against the background of facility management. Upon implementation all planning documents and specifications should be available updated and congruent with reality. The builder should be bound by contract to prepare these planning documents and specifications (compare Chapter 3.1, documentation) and they should be controlled by project management. While construction is underway planning errors also are reported to those concerned with planning. Very often this leads to delays in schedule. If not correctable, planning documents need to be worked over following implementation. In most cases there is exchange of information within the control loop executor – planner, which is reinforced by the normally strong involvement of the architect (planner) in construction supervision or the equipment supplier's (construction and planning) involvement in installation of equipment.

Reliable As-Built Documents

Operations Phase

The main objective of planning and implementation is operation of property. With regard to the entire lifecycle operations phase is of most significance due to both its duration and cumulated costs. The aim of this phase is to surely and economically meet the required functions as specified when defining the objectives. During this phase physical resources are subject to wear by usage. Operations phase is distinguished by physical resources not being considerably changed except from wear. The task of facility management herein is maintaining operations for which it is necessary to record and control wear processes and corresponding maintenance systems. In addition to problems resulting from delayed involvement of the operator in planning and implementation phases there are further difficulties during operations phase. Responsibility for management of physical resources lies in various hands partly in-house but also external. Therefore it is very painstaking to make a detailed statement on total cost of operation per property. Particularly in this phase the integrative view of facility management shows possible approaches for increasing transparency of costs and performance.

Documentation of Wear Process

Replanning Phase

Replanning phase interrupts operations phase, aiming at optimisation of physical resources regarding their functional requirements. Processes are alike those at planning phase with the difference being that given surroundings have to be considered at replanning. Provided tender documents have been filed properly at planning phase they can be followed up for new tender. There is another implementation directly following replanning. Basically the processes are the same as with implementation of new planning. In case of extensive replanning, as-built drawings cannot be done without because alterations (change of use, extensive constructional measures etc.), due to being subject to approval, have to be recorded and approved in drawings. So there is an external force to document alterations. For replannings of smaller scale this is not always necessary. Therefore there is a risk of alterations being implemented without as-built drawings and respective documents being updated. Due to missing as-built drawings or documents alterations are often implemented on call and as-built drawings are not being updated. It is exactly for the amount of these small scale alterations and adjustments that characterise the operational everyday life and extensive conversions being the exception that up-to-dateness is constantly decreasing. Many small undocumented alterations make as-built drawings useless in no time. Very easily a level of information is reached at which only an extensive survey can help reinstalling sufficient planning reliability.

Risk of Undocumented Alterations

Undocumented Alterations

Deconstruction Phase

Deconstruction phase rounds off a property's lifecycle. Property can no longer economically meet its function. Replanning and change of use are also pointless for the business. Property can either be sold and reused by the buyer or objects are dismantled (buildings) or scrapped (machines and equipment). In case of transfer of property facility management has the opportunity to offer to the buyer extensive information on the property in form of non-cash benefit. The entire lifecycle has practically been documented which is an added value concerning maintenance management for the following user. In case of objects being dismantled or scrapped the information supplied by facility management can help in planning dismantling phase to detail without prior extensive data acquisition or it can assist in obtaining accurate costs for dismantling and disposal.

Added Value concerning Maintenance Management

Mutability

Permanent improvement of organisation, production lines and production processes calls for direct, constant adjustments of property. Locations, floor space required, types of use, technical supply and disposal are modified by new technologies, new machines or reorganisation of personnel. In addition to adjustments imposed by the market continuous changes are caused by an increasing ecological awareness of customers as well as legislative regulations with regard to enhancing environmental sustainability. An example for the ongoing optimisation of buildings is the regular toughening of regulations for energetic optimisation of facades and building services (HVAC/R). New regulations concerning optimisation of thermal insulation (Wärmeschutzverordnung) and energy saving (ENEV), in force since 1995 resp. 2002, directly resulted in constructional and technical components being exchanged. Planning of alteration processes is of utmost importance particularly for production businesses. This is where a multitude of alteration processes with complex interaction are overlapping. Constant provision and evaluation of data starts at planning phase, continues on to implementation phase and during operations phase it has to prove those presumptions that have been made at planning stage. During replanning phase operations phase is interrupted several times in support of optimisation of functional requirements. In case that property is no longer able to meet its economic tasks, deconstruction rounds off its lifecycle. Figure 2.06 points out that with view on the entire existing property alterations are

Energetic Optimisation

being made in very different intervals and therefore regeneration rate of data is equally different.

Figure 2.06: Alteration Intervals regarding Existing Property, Examples

Alteration Intervals

Dependent upon type of use alteration intervals are as follows: Organisation - 2 yrs, EDP – 3 yrs, telecommunication – 5 yrs, furniture – 10 yrs, lighting – 10-15 yrs, building services – 5-20 yrs, interior fittings – 5-30 yrs, shell of building – 50-70 yrs.

2.4 Frequent Questions, Applications

2.4.1 Why Facility Management?

Change in Thinking concerning Building Management

Generally speaking operations of location, buildings and equipment is taken on by several internal departments partly as a sideline job in addition to core business of company tasks and partly as principle task (departments of real estate, building or administration). Whereas production processes (core processes) have been optimised time and again over the last years, buildings and their maintenance in many cases are still regarded as necessary evil for production of goods and providing services. As far as building management is concerned a change in thinking is mandatory due to:

- increasing cost pressure on core business,
- increasing maintenance costs,
- increasing energy consumption,
- increasing dynamic due to changing tenancies and uses

Tasks of Facility Management

This is where facility management sets in as strategic and integrative service with the following tasks:

- active management of real estate instead of reacting passively to requirements,
- reducing a real estate's maintenance costs,
- permanently safeguarding mutability and therewith constant marketability,
- reducing business disruptions, securing tenancy by increased availability,
- securing user-orientation and user-friendliness,
- guarantee cost transparency.

Facility for adjusting to requirements of a future tenant or buyer is becoming a lasting success factor for the owner. This is why a future-proof adjustment, incorporating a high degree of mutability with regard to changing uses, calls for constant modernisation of existing property. Not only does integrative property management ensure cost transparency and therewith directly helps in cost saving but it also puts staff in a position where they can concentrate on their job only rather than having to remedy technical and organisational deficiencies at their workstation as well. This is a core assignment of facility management. CAFM- (computer aided facility management) software aids in required speedier provision of information. In addition to that CAFM-software achieves transparency by linking information of most varied dimensions, e.g. area, personnel or process information, which allows meaningful analyses. Optimisation of processes which is aided by CAFM, however, is the most important process. It is due to this integrative view on planning, construction and maintenance management of buildings that 10 to 30% of all expenses arising during a property's lifecycle can be saved. Therewith facility management has become the driving force for reorientation around services concerning equipment and buildings over the last years.

Facility Management for New Building Projects

Facility management considers a building from planning through implementation, operations and change of use to demolition, therewith over its entire lifecycle. As opposed to conventional planning of buildings at which a project is conducted on condition that a fixed amount to be invested is not to be exceeded, facility management starts with optimising maintenance costs at planning phase already. Facility management can achieve this by pointing out crucial factors for maintenance costs at the earliest possible time. Provided facility management accompanies a new building project from planning phase on it is in a position to bring down operating costs and secure them as calculable value. With this support the owner makes his decisions not only based on investment costs but focussing on maintenance costs. At this it is not the optimisation of single factors which is decisive but more so the optimisation of all performances for a property's long-lasting usability.

Facility Management for Existing Buildings

Facility management offers savings potential not for new building projects only but for existing buildings as well. The focus here is on energy optimisation, costs transparency, operating procedures and company organisation structure because belated optimisations to building structure and building services can usually only be realised at high expenses. Many well-meant efforts of a multitude of service providers produce new isolated solutions with new interfaces (compare Chapter 1).

Occupational Qualifications

Among current occupational qualifications architects, adequate education provided, seem to have the most comprehensive knowledge about buildings. They are therefore predestined to merge the varied questions concerning construction and operation of buildings into a comprehensive view.

2.4.2 Location

Survey - Areas, Infrastructure

With regard to a real estate's location relevant parameters for facility management are e.g. land register data, topography, roads, car parks and paths, plantations as well as technical infrastructure. A thorough survey provides clarity about all media existing on as well as connecting to or leading to a plot of land. Basic evaluation should take into account location, quality, quantity and guaranteed delivery of media as well as current and estimated future tariffs. Important media for supply are electricity, gas and telecommunication. Decisive for disposal are mainly drainage and sewage. For determination of required energy quantities and an energy load profile a qualified integral energy simulation of the planned building should form the basis for negotiations with providers. If there are existing supply and disposal systems on the plot of land their (partly) suitability for new tasks needs to be checked. Especially if planning to partly use existing infrastructure when revitalising idle industrial real estates one needs to check the state of existing networks by using techniques like video inspection of drainage and sewage pipes. It is advisable to record the position of all media in plan and section in the scope of synergetic factory planning (Synergetische Fabrikplanung™) in form of a 3D-CAD-data model. Figure 2.07 shows excerpts from the 3D-data model of supply and disposal at an assembly plant.

Supply and Disposal Systems Location

Figure 2.07: 3D-Data Model of Supply and Disposal at an Assembly Plant

Early spatial recording of all existing and planned media networks for a location avoids future unpleasant surprises during construction and it is the condition for maintenance and adjustments to supply and disposal during the location's lifecycle which can exceed by far the useful life of a building placed on it. As specified in DIN standard 276 all media on the land outside of buildings are to be assigned to the outside facilities and all media inside buildings are to be assigned to the buildings. Therefore it is advisable to carefully record the location's entire technical infrastructure and incorporate it in the FM-database at planning phase already. By employing appropriate area and material listings all necessary cleaning and maintenance jobs such as winter maintenance or maintenance of outside facilities for example can be managed. Filing of location related approval procedures (e.g. BIMSCH-procedure regarding industrial buildings) under location criteria is advisable in order to fall back on them when planning an extension. Globally operating companies possess or run a multitude of locations. Strategic extensions or moving of parts of a business require constant data transparency of indices concerning e.g. utilisation and energy costs of areas. Due to location related structures having been developed over the years very often these costs cannot be assigned to the company's respective cost centres in accordance with the costs-by-cause principle. Facility management provides the opportunity to transparently register cost structures and separately itemise them according to locations or departments.

Area and Material Listings Location

Approval Procedures

Survey – Municipal Real Estate

Beyond the discussion about locations of companies there is currently a significant change in administration of real estate owned by federal states, communities and local authorities. The existing communal budgeting and accounting system of public administrations is traditionally more geared at economic optimisation and quality of services. According to [16] in times of tense or loss-making budgetary positions this compels a consequently optimised communal real estate and building management incorporating real budgeting of administration and budget funds of all departments. This is based on a systematic survey of all real estates. Figure 2.08 shows an input mask for property data as contained in a communal code of practice for building and real estate management [14].

Communal Code of Practice

Figure 2.08: Example for an Input Mask – Communal Real Estate

Currently North Rhine-Westphalia and Saxony take on the leading role in developing modern methods of real estate management. In charge of the preparation was amongst others 'Task Force Government Owned Real Estate' [Entwicklungsgruppe staatlicher Liegenschaften (EGSL)] which is to bring methods of geographic information to real estate management.

2.4.3 Building

Companies' major investments are often their real estates. It is imperative for the property owner to exactly know the data for calculation of market value in order to be in a position to responsibly decide on purchase, sale or leasing. Therefore it is indispensable for him to pinpoint such cycles and tendencies that have direct influence on real estate as well as to develop a strategic plan which illuminates potentials for savings as well as risk reduction. Nowadays facility management is employed in e.g. hospitals, factory buildings, airports, shopping centres or insurance companies. This is where according to Figure 2.09 facility management systems offer a multitude of data evaluations that aid in decision making, in particular:

Figure 2.09: Data Evaluations – Facility Management of a Building

Improving Space Utilisation

Efficient space utilisation cannot only lower operating costs but it can also increase profit. With the aid of appropriate applications such databases and drawings can be produced that ease and assist in monitoring space utilisation in buildings. Specific requirements to reports are supported by flexible methods which are used in order to gain information on acquisition and administration of information on rooms. In addition to that room utilisation can be optimised with regard to availability, accounting costs, equipment and capacity by planning of shared or temporarily used rooms. Depending on the facility management software chosen data evaluations provide:

- analysis of information on office furniture and equipment corresponding to departments,
- illustration of reports on gross areas, rooms, service areas, stairways and elevator shafts,
- trial runs in order to compare room utilisation respective to removal and room allocation scenarios,
- seamless interlocking with CAD-software such as industry standard AutoCAD, Microstation or Nemetschek, in order to easily and quickly link floor plans to room relevant data.

Excluding Allocation Conflicts

Usable areas within each department can be exactly determined. Benchmark reports show how much room and/ or which type of room is required for each employee or each department. The use of objective methods for allocating rooms leads to a better and faster acceptance of rooms that are allocated to staff. Room allocation plans aid new employees in quickly finding and occupying free rooms. Depending on the facility management software chosen data evaluations provide:

- production of room allocation plans and reports on average area respective to staff and personnel lists respective to building and location,
- carrying out settlements respective to group, room or employee,
- inserting symbols for employees in drawings,
- reservation of an available room for a given period of time in consideration of capacity and equipment,
- search facility for rooms with stationary equipment, e.g. projectors or video conferences.

Space Planning

Room and area management contain functions that display whether more space or restructuring of room allocation is required. Space required can be planned in accordance with number of staff, type of use and logistics and occupancy costs can be explained. Parts of room allocation data can often be transferred to Microsoft Excel® or Adobe Acrobat® or can even be web-enabled in order to make that information accessible for other departments within the organisation for read-only purposes. Depending on the facility management software chosen data evaluations provide:

- access to data on building and infrastructure for users within their organisation,

- efficiency of space utilisation can be compared to utilisation rates of other buildings,
- settlement of room costs can be carried out according to occupied area as well as respective to proportionate area of shared rooms,
- move management and planning of office furniture and equipment.

Access Management and Key Management

Access management provides for simultaneous administration of an arbitrary number of access authorisations with unlimited complexity. Group, single and central access authorisations are significant elements at illustrating the hierarchy of access authorisations. Thus consistent and clear administration of access authorisations to all rooms is guaranteed. Access management software features report and analysis facilities. Automatic set-up of lists for group, single and central access authorisations as well as transfer of these lists to Microsoft Excel is just as self-evident as a high-performance report generator for individual lists and reports. Integration of access management into CAD-graphic modules adds further analysis options.

Control over Costs and Condition of the Building

In order to obtain manageable and transparent costs it is a fundamental precondition that all costs concerning the building are accurately acquired and all planned expenditures are calculated. Operating costs for one’s own or rented real estate as well as taxes can also be registered. Shared costs e.g. council fees and costs for areas can easily and quickly be assigned to the respective departments or other units by means of distribution keys. Any payment can be controlled without any problem by means of budget and payment plans. Depending on the facility management software chosen data evaluations provide:

- compliance with contracted regulations and dates,
- control over past and future tax expenses,
- profitability assessment of real estate,
- report and analysis of tendency for each property and real estate.

Requesting Reports

Easy and quick access to precise area data aids in adjusting reports to external requirements. If area costs are reimbursed partially by the organisation or completely by external organisations there can be a significant difference between estimated and effective area costs within the range of a few thousand or even million euros in reimbursement. The use of respective distribution keys ensures that each department within the organisation is responsible for their respective area utilisation. All generated costs are being allocated according to the given distribution key. Depending on the facility management software chosen data evaluations provide:

- calculation of space percentages for partially or temporarily used areas,
- summary of each department's area with department oriented room-analysis reports
- provision of optional predetermined or adjustable allocation methods.

Fire Protection

Building regulations valid in the respective federal state lay down basic standards for preventive fire and industrial protection. Facility management in particular, due to its interlocked data structure, offers excellent potentiality for comprehensive illustration of necessary structural measures, readiness for operation of technical equipment as well as user responsibility. Especially in case of changing users and respective adjustments of a building it is essential to continuously update the documentation of a condition legally agreed on with authorities.

Constructional Fire Prevention

Constructional fire and industrial protection is mainly concerning demands on:

- distance of buildings,
- location and positioning of built structures on the property,
- access and areas for fire brigade,
- building material, building elements and overall construction,
- fire-retarding sealing,
- location and positioning of escape routes,
- location and positioning of key cabinets for the fire brigade.

Organisational Fire Prevention

Organisational fire and industrial protection contains measures such as:

- employment of plant, corporate or in-house fire brigades,
- generation of fire safety regulations,
- provision of property related deployment documents,
- limiting of fire loads,
- timely and effectively induced measures for averting dangers.

FM-suitable Planning of New Buildings

According to the majority of older specialist publications the best date for setting up a facility management system is upon completion of a building and its furnishings since all documentations are available at that point. This perception must strongly be objected to. The best point for introducing a facility management system has to be at the start of planning due to, amongst other things:

- many of a real estate's characteristics regarding operations, utilisation and mutability being determined at planning stage,
- zoning and modularity of a building and building services – considerate positioning of hard to adjust stairways, elevator shafts and installation cores in particular – being decisive for secure long-run tenancy,

- data structure of ‘documentations’ regarding realisation of location, building, building services and equipment usually being chaotic and its reorganisation being extremely costly,
- cost structure at new planning being continuously organised according to cost elements as stated in DIN standard 276 (compare Figure 2.10),
- total costs of a real estate during its lifecycle being synergistically controllable on the basis of transparent combination of those aspects regarding location, building, building services and equipment.

Cost Structure according to DIN Standard 276

Figure 2.10: Cost Structure of a Building according to DIN Standard 276

Therefore it is advisable not to go for the cheapest possible single solution for mere construction but to strive for that solution which offers best value for money regarding the combination of all aspects mentioned before. In the framework of synergetic planning (Synergetische Planung™) it is possible to consider alternatives for a new building project, ranging from choice of location to demolition, from many different angles. At this it is the aim to merge the ideas of owner, user and operator into the maximum possible performance model. Determinations and assumptions are linked in an iterative process in order to synergistically elaborate the best respective solution. Precious knowledge for other building projects can also be derived from interim solutions occurring during this process.

2.4.4 Building Services (HVAC/R)

The collective term building services (HVAC/R) shall comprise all necessary building services as well as process media for production facilities that are important with regard to industrial construction. In practice it is often found that building services (dimensioned by specialist planners in construction) and process technology (dimensioned by production planners) are dealt with separately which incorporates a high potential for loss in coordination and therefore rarely provides for the use of sensible synergies. In view of its increasing complexity the entirety of media systems should be integrally optimised especially under the primacy of possible savings of energy and resources. In continuation to the location’s infrastructure, from when supply and disposal enter the building, drawings, texts, data sheets and inspection sheets of

Integral Optimisation

- control centres,
- traces,
- networks,
- outlets

regarding all media are to be recorded and filed in the database provided by the facility management software. Therewith a multitude of graphic and alphanumeric data arise during the lifecycle of the respective building services components. Ideally CAD-drawings of location, building and building services should exist in 2D and 3D. By combining files regarding structural planning and building services one can provide for spatial illustration of segments that are critical due to their high information density such as control centres. It is advisable to assign media to the cost centres as defined in DIN standard 276 (compare Figure 2.11). This is where unambiguous analyses and allocations of costs provide for clear hierarchies from basic evaluation through planning, implementation, documentation and operation to recycling. Particularly with regard to operations and future adjustments of components it makes sense to further split up the cost centres into control centres, traces, networks and outlets.

3D-Illustration of Critical Segments

Figure 2.11: Cost Centres Building Services according to DIN Standard 276

Control Centres

For production of media, service and monitoring as well as filtering, the most relevant mechanical engineering components are combined in control centres. Their positioning within the building, required space, requirements to the room and options for extension ought to be integrated into a reasonable general concept. Requirements to the room for control centres comply with the respective regulations concerning the particular media. Enclosing structural elements and openings of the heating station for example have to meet fire-resistance grades. It has to be ensured that engines, ventilators and pumps do not convey structure-borne sound or vibrations to the building. Control centres should be easily accessible and provide for enough space regarding maintenance, replacement or extension of units. Switch cabinets should provide for enough reserve spaces for optional future installations. By adequate linking of building services to facility management software it is possible to monitor e.g.

Maintenance of Units

- energy consumption,
- temperature parameters,
- power supply,

and also emergency procedures can be induced in case of failure of units. The positioning of the control centres within the building is fundamental for maintenance as well as for the complexity regarding the replacement of units. Figure 2.12 shows examples for the positioning of control centres as penthouses or detached units on roofs as well as on galleries within the building. Control centres within the building offer the advantage of being accessible independent on the weather and they therefore ease maintenance in many cases.

Figure 2.12: Positioning of Control Centres, Examples

Traces

The main traces' vertical and horizontal collecting strands lead to further distribution systems of installation routes. Shafts adjacent to building cores often serve as ducts for vertical main traces while horizontal main traces are positioned within or underneath the load bearing structure of roofs or ceilings. Both vertical and horizontal traces should provide enough space for future retrofitting. In case of these vital connections being dimensioned too small they can considerably narrow or even hinder a real estate's further usability. The choice of positioning of the main traces has to be made with considerate view on possible horizontal or vertical options for extensions. Hard to re-locate media bundles often block off sensible structures for growth within a building and therewith literally strangle its further development. Shafts and ducts of main traces have to be planned in accordance with requirements to stability, fire protection, moisture protection, heat protection and hygiene. Furthermore easy access for maintenance and cleaning should be achieved.

Options for Extensions

Networks

After fixing the main traces it is necessary to set up an expedient network leading to the outlets. Further ramification of media is positioned along flexible vertical and horizontal structural paths. Clearance for retrofitting should be equivalent to that of the main traces as mentioned above. Another aspect which is of particular importance with regard to long term mutability is the geometric pattern of the different networks. A system design which coordinates all networks should comply with the modularity of the building's structure. Geometrical structure and density of area-wide and space-wide supply and disposal have to be set up prospectively. Figure 2.13 gives examples for basic patterns. Requirements to building services and process should be merged and all networks should be easily accessible as well as adjustable without disturbing utilisation.

System Design Modularity

Figure 2.13: Advantages and Disadvantages of Distribution Structures for Media [according to Reinhard]

Outlets

Outlets and control valves are interfaces of networks and rooms at which media enter or exit a room under control (e.g. thermostats to radiators, supply air outlets). They must be dimensioned and implemented with greatest accuracy in order to avoid disturbance (e.g. draught, glare, dirt) at the workstation. Basically media outlets should always be easily spatially adjustable and not hinder changing layout plans or new operating equipment. It makes sense to determine the positioning of outlets in area and space by 3D-system design which will avoid different media colliding at one point. At new planning particularly control valves, lights, data outlets and routing of air flow should be meticulously investigated and optimised prospectively for future uses in terms of a high degree of mutability.

Fire Protection

The importance of comprehensive illustration of all objects relevant to fire protection has already been pointed out in view of reports concerning the building. These are being complemented by active fire protection schemes for construction, operation and maintenance of fire and industrial protection regarding systems engineering for

- fire alarm systems,
- warning systems,
- smoke venting systems,
- heat venting systems,
- fire extinguishers and fire-extinguishing installations.

At industrial construction in particular process equipment is often reconstructed and rooms are necessarily adjusted to flow of material. Fire Brigades' experience confirms that fires with damage to persons very often occur during maintenance, service and reconstruction. In many cases fire compartments are penetrated by retrofitting of supply lines. They are only being sealed at a later point and not always professionally. This is where facility management offers an integral approach to identify risks and prevent damage by sensible management of building components, building material, systems engineering and organisation throughout a real estate's entire lifecycle.

Convenience and Comfort, Control Engineering

From the owner's and operator's points of view real estate is regarded successful when functionality, profitability and image are ensured. The decisive criterion from the user's point of view is comfort, which comprises the following aspects:

- technical comfort,
- hygienic comfort,
- acoustic comfort,
- visual comfort.

According to [15] extent and level of these criteria for comfort depend on the convenience provided by the building's equipment. The objective is to realise the respective level of convenience at the lowest total cost possible. Especially with regard to the mentioned mutability of rooms the simplest solution with e.g. window ventilation and plainest control of heating and light is not always the best solution. Glare and waste of energy for example are avoided by centre-lined thermostats for heating, daylight dependent control of lights as well as light guiding control of blinds. Additional required control can be carried out via BUS-systems which are linked to central building control systems. Generally there seems to be a persistent trend towards an overlapping of superior control and possible intervention for the

BUS-Systems
Central Building Control Systems

user's individual convenience and comfort. This indicates an increased importance of controlled registration and management of these processes.

Illustration of FM-Processes, Models of Operation

Whereas previously only single tasks have been executed facility management with regard to building services is distinguished by a comprehensive, results-oriented and integrative approach.
Dimensions of these processes are:

- costs
- information
- benefit.

Basic process flows are relatively identical and it therefore makes sense to modulate basic processes in order to adjust them to concrete, specific cases. Figure 2.14 shows aims and contents considering as examples malfunction management, energy controlling and repair order.

Figure 2.14: Examples for Processes of Technical Facility Management [according to Krimmling]

According to Figure 2.15 building services related reports call for interfaces of facility management software and building automation's central building control systems as well as danger management.

Figure 2.15: Interfaces to Building Automation and Danger Management

[15] portrays the process from notice of malfunction to trouble shooting considering as example a defective water tap in a public building. 24 hour on-call service receives notice of malfunction via telephone or email and records it in the web-based software for malfunction management (pit-FM). Alternatively the user himself can navigate through the structure provided by the CAFM-software (real estate – building – floor – room) and attach the event 'malfunction' to room '009 WC gents'. Following prioritisation an order will be placed. Upon repair a notice of completion is entered to the system and arising costs are assigned to the cost unit.

Performance Contracting

Avoidance of interfaces regarding building services related trades as well as coffers being empty at companies and local authorities leads to performance contracting or energy-saving contracting as well. These are new services in the fields of building services engineering and energy management as required by the market. The principle of performance contracting is to finance all measures of optimisation and modernisation of installation for

- measurement and control engineering,
- facility management system,

- heating, ventilation, climate,
- lighting,
- energy and building services

with the savings of energy costs achieved herein.

2.4.5 Utilisation, Process

Physical resources are decisive for a real estate's actual functionality and determine its utilisation as e.g. hospital, library, administrative building or production facility. Facility management comprises all views on these physical resources in a comprehensive graphic and alphanumeric data model. This data model gives information about:

- What is being managed?
- Who manages?
- How is being managed?

Physical Resources

At this physical resources are regarded as material objects such as fixtures in a sickroom, books and bookshelves, office furniture and folders or machine tools. Data evaluated by MIS (merchandise information system; e.g. SAP R/3) as well as simulations of production processes are increasingly provided for by facility management software. It is advisable to record references of these data to location, building and building services (HVAC/R) at basic evaluation and file it in the facility management database. A multitude of views on real estate and therewith a number of possible required reports becomes obvious at the example of factory planning. According to [23] there is following information demand concerning a factory project dependent on the respective view (compare Figure 2.16):

Figure 2.16: Information Demand concerning a Factory Project [according to Nävy]

Construction
- load per unit area
- height of machine
- noise pollution
- fire protection

Production
- efficiency
- capacity

Factory Planning
- floor space requirements
- manpower requirements

Logistics
- material supply
- material disposal

Occupational Safety
- hazard potential
- safety data sheets

Environmental protection
- emissions
- disposal

Manufacturer
- spare parts
- components

Infrastructure
- media consumption
- energy consumption
- building services related supply and disposal

Maintenance
- wear
- inspection cycle

Controlling
- operating costs
- amortisation, depreciation and impairments

Management
- profitability
- benefit

ID-Card Utilisation/ Process

Every factory planning optimises process and logistics related equipment components. This equipment, e.g. presses, require careful consideration of versatile interfaces to room planning. Bearing capacity of soil, clearance, positioning of columns, media supply and disposal as well as noise protection would be important requirements to the spatial surroundings of presses for example. In analogy to the systematic compilation of characteristics concerning a building's structure in the building log book (compare 2.2.2) an ID-card containing the graphic, alphanumeric and visual data of each process component in factory planning has been developed through cooperation with IFA (Institut für Fabrikanlagen und Logistik TU Hannover - Institute for Factories and Logistics, Technical University of Hanover). This ID-card merges 2D/ 3D geometrical data, dependencies on location, building and building services (HVAC/R) as well as questions concerning comprehensive management into an integral data set. Moreover the method of digital ID-cards for process and logistics provides networking of these elements for material flow simulations. Simulations of thermal load or colour schemes can also quickly be carried out on the basis of these ID-cards. Figure 2.17 shows the compilation of 3D-data and visual information on a cleaning robot for composite rubber parts as an equipment component to be considered at planning a new production line.

Material Flow Simulations

Figure 2.17: ID-Card Cleaning Robot

3D-design data are displayed in axonometric projection, layout and elevations as well as pictures to complete the element's graphicness. The right part of the card is reserved for description fields where required adjustments in case of taking over existing process components as well as physical characteristics and delivery dates can be documented according to requirements. An increasing depth in planning arises from the increasing information depth evolving from updating the ID-cards throughout the lifecycle of physical resources. Such interconnection of process components and room as well as building services related requirements avoids differing planning statuses. Furthermore it provides a database for scenarios of mutability since alternatives can be assessed integrally regarding their effect on location, building, building services (HVAC/R) and equipment. These ID-cards known from equipment planning are particularly suited for 3D-acquisition of all supply and disposal connections including all textual data such as required amount of compressed air, electric power capacity etc.. Figure 2.18 shows an overview of media connections considering as example a degreasing machine for rubber production. In further detailing the element's 3D-construction all necessary inputs, media connections and outgoings have been considered. This helps avoiding future problems in coordinating process technology and building services.

3D-Acquisition Supply and Disposal Connections

Figure 2.18: ID-Card Degreasing Machine, Media Connections

Optimisation of energy requirement is increasingly important in view of the global climatic catastrophe. Planning of new production lines should take into consideration an energetic cost analysis of all points of consumption within the process as part of the technical-economical operation analysis. By means of respective data-structuring operating costs can easily be allocated to their respective cost centre according to the costs-by-cause principle even during production. The advantages of the described procedure are obvious:

- Compact combination of all relevant data provides data transparency at all times for everyone involved during planning, implementation and operation.
- 2D/ 3D-illustrations of the object create great graphicness; object-oriented CAD-construction enables referencing of textual attributes to CAD-objects.
- By parallel connecting all datasets to the database provided by the facility management software up-to-date reports regarding various views can be requested at any time.

Visual Information Systems

Particularly the complexity of processes which is caused by the information flood regarding factory engineering equipment calls for such navigation in planning, implementation, operations and administration that is comprehensible for as many users as possible. At this spatial illustrations are of particular importance. In many cases engineering data provided by manufacturers can be used for a more simplistic visualisation of equipment components. By means of object-oriented CAD-construction textual attributes in form of alphanumeric datasets can be directly referred to the respective CAD-objects. In the framework of synergetic planning (Synergetische Planung™) retrieving e.g. energy consumption or maintenance cycles by clicking on an object is enabled by accordingly programmed processes in object related databases. The illustration's detailedness can be adjusted by filters to serve different views. A different application to be mentioned would be the use of PDA navigation systems for guiding visitors around extensive factory premises. By access to the ever extending facilities of visual information systems new applications for users, maintenance teams and visitors will be opened up in future. This is where there is a great backlog demand especially regarding traditionally 2D-dominated equipment planning.

Object-Oriented CAD-Construction

Simulation

Energetic Cost Analysis

Planning of new production lines should take into consideration an energetic cost analysis of all points of consumption within the process as part of the technical-economical operation analysis. For integral energy simulations those data provided by the respective ID-cards can directly be accessed in the framework of synergetic factory planning (Synergetische Fabrikplanung™). Utilisation profiles such as simultaneity factors have to be considered when digitally interconnecting performance characteristics. Figure 2.19 shows an example of process and energy optimisation at an industrial bakery in accordance with [17]. This is where amongst other things smart interlinking of process technology and building services, by making use of heat recovery technologies, led to the annual energy requirement for heating being reduced by 62% and that for ventilation by 39%. In a similar way such data regarding the ergonomics of workstations for instance can be simulated by means of 3D-models and process animation as shown in Figure 2.20. These datasets can be imported to the database provided by facility management software via respective interfaces.

Figure 2.19: Example – Energy Optimisation at an Industrial Bakery

Figure 2.20: Simulation of Assembly Workstation, Example

2.5 Utilisation Indices

Operating efficiency regarding the parameters of location, building and equipment arises from comparing market leading indices with indices of one's own company. Utilization rates detect weak points and allow for rapid initiation of improvements as well as for medium and long term strategic modification. The term 'benchmarking' originates from the USA where in land surveying it is referred to as a permanent reference point off-road. In the figurative sense the term benchmarking means striving for best performance within a comparable group of competitors. Currently the term 'best of class' is also common for describing these efforts. Benchmarking rests on the basis of the respective issue being assessed. With regard to real estate it is mainly the cost indices of buildings relating to their geometry, quality and use that are being compared and contrasted in diagrams. This provides a consistent framework for the views of investor, user or service provider within which their real estate's efficiency as well as the cost for this performance is portrayed. The aims of evaluating data material differ depending on the view. Investors are interested in the rate of return on capital employed whereas users are interested in economical utilisation and operators are interested in rate of return on resources employed. In Germany large commercial banks in particular started to collect extensive data on their own and rented real estate in the middle of the eighties. According to [12] the department of building and administration at the Bayrische Vereinsbank dealt with integral management of its real estates. In comparison with other businesses one was surprised to find out that an average of 40% of assets and 50% to 60% of annual material costs of German businesses was either bound to real estate or caused by running it. In 1995 591 branch offices covering a net assignable area of 780.000 m² were located in 189 owned and 402 rented properties. According to [13] benchmarking regarding real estate distinguishes between comparing indices for building economy, space provision costs, operating costs, consumptions and costs for infrastructure (compare Figure 2.21).

Benchmarking

Best of Class

Data Evaluation according to View

Figure 2.21: Table of Indices – Benchmarking regarding Real Estate, Examples [according to Neumann]

2.5.1 Benchmarking

Building Economy (Site Occupancy Index, Gross Cubage, Primary Usable Floor Area, Net Floor Area)

Area Data according to DIN Standard 277

According to DIN standard 277 areas are categorised according to their utilisation (compare Figure 2.22). Site occupancy index is calculated by dividing the land area by the area covered by the building. Therefore the utilisation of a site plays a crucial role in relation to the costs of the site. The higher this number the better the site's utilisation ratio. Site occupancy index is usually lower in rural areas than in metropolitan areas. The factor Gross Cubage/Gross Floor Area indicates the ratio of a building's cubature to its cumulative total of all floors. A high number indicates a large cubature in relation to the total floor area. Besides possibly creating a generous spatial impression, however, it also causes higher investments and operating costs.

Figure 2.22: Types of Areas according to DIN Standard 277

Productive Primary Usable Area

The ratio of primary usable floor area to net floor area indicates the proportion of 'productive' primary usable floor area to the building's total net floor area. With regard to high utilisation costs of buildings nowadays the proportion of primary usable floor area to net floor area is becoming a prominent factor concerning project development, purchasing or renting a real estate. According to [13] the respective value concerning administration buildings that optimally cater for their users is between 68% and 78%. At defining standards the employees' space entitlement depends on structural conditions (type of room, modular grid, depth of room) as well as corporate culture and function to be met. The ratio of net floor area to employees considers not only the actual work surroundings but traffic area, secondary usable floor area and operational area as well. The value primary usable floor area 2 is also referred to as actual 'office space' leaving out special areas such as foyers, canteens, training classrooms or underground parking. At optimising areas one nowadays aims at a standard size for workstations of about 6.5 m² in open-plan and combi offices and 10.5 m² in twin shared private offices. This equals an occupied area (primary usable floor area 2) of approximately 13-17 m² per office worker.

Workstation Standards

Utilisation of administration buildings is rarely homogenous and therefore periods of use vary. A counter-example for this is an electronic data processing centre which operates 24 hours a day all year round. In the scope of optimisation experiments more often different models of work (desk-sharing, telecommuting) and hours of work are being tested which influence costs regarding a building's usable area and useful life.

Space Provision Costs

Space provision costs are regular or irregular arising costs irrespective of a building being used or not such as e.g. interest, rental fees, taxes, dues and insurances. Short-term influence on space provision costs can be exerted by space optimisation (by creating space to sublet with regard to owned real estate, by changing tenancy agreements with regard to rented space) whereas long-term influence can be exerted by optimisation of location (sale or letting of owned real estate, changing location). Space provision costs are dominated by cost of capital. If the average rent of the buildings assessed is below market interest rate it shows that the rents to pay do not correspond to capital return in line with the market.

Operating Costs (Administration, Cleaning, Technical Operations/ Building Maintenance, Safety, Disposal…)

Operating costs are directly evolving costs in connection with buildings and their respective equipment from start to finish of utilisation. Not included are such costs concerning construction, conversion and removal of buildings and equipment. An overview of operating costs is compiled in DIN standard 18960. In dependence on the definitions of service processes and service intervals there is remarkable short-term and long-term savings potential to be realised by appropriate action.

Savings Potential

Consumptions (Heat Energy, Operational Energy, Water…)

Consumption comprises all costs for water/ waste water including cooling water, heat energy/ air conditioning and operational energy. Besides costs for consumed raw materials this also includes basic fees, rental of devices (e.g. meters) as well as costs for reading the meters and distributing the share of consumptions. With regard to office buildings the proportion of consumption costs to total costs is approximately 5-10%. When deducting space provision costs, however, the proportion of operating costs is approximately 15-20%.

- **Heat Energy**

  Regulations concerning energy saving that are cyclically being renewed about every 5 years aim at saving heat and cooling energy by imposing stricter energetic characteristics on facades and building services (HVAC/R) components. The hereby caused multiple alteration of existing real estate during its lifecycle clearly proofs the advantages of high mutability since prospective planning can avoid special hindrances of utilisation as well as high costs for conversions.

- **Operational Energy**

  With regard to operational energy it has to be taken into account that these costs often include costs for cooling or off-peak electricity that would actually have to be allocated to heat energy. Thereby an increasing mechanisation at the workplace leads to increased energy consumption and in many cases increased energy costs for necessary cooling loads as well.

- **Water**

  Unusual high costs for water can also be associated with air conditioning of partial areas because climate control units consume high amounts of water.

Infrastructural costs (Space Planning, Internal Moves, Communication)

Infrastructural costs are such costs of internal services that are being caused by organisation. This includes e.g. area management, communication (accounting communication, telecommunication), EDP, catering, fleet, in-house print shop, copy service, typing service, travel service and medical service. These depend on location, corporate culture as well as convenience demanded by employees. These infrastructural costs caused by organisation can make up 50% or more of total utilisation costs.

- **Space Planning**

  Costs for space planning can also be included in administration costs.

- **Internal Moves**

  So far costs for moves have rarely been accurately recorded. Besides varying moval rates and different classifications this can lead to significant differences in comparable evaluations.

- **Communication**

  This field should be further detailed due to the issues of accounting communication, telecommunication and EDP increasingly merging within businesses and therefore not being clearly allocatable on the one hand and on the other hand these services are referring to the business more than to the building.

According to [14] Figure 2.23 shows comparing, selected indices of communal administration buildings in Saxony. With regard to role, function and limitations of indices and comparing indices the following needs to be generally noted:

Figure 2.23: Comparing Utilisation Indices regarding Administration Buildings

Evaluation of Indices

- Indices are made up of two or more basic figures – e.g. ‘costs per case’ consist of the basic figures ‘total costs’ and ‘number of cases’.
- Indices represent facts, e.g. results, effects, qualities, costs.
- By comparison one can come to conclusions regarding achievement of objectives, proficiency level of one’s own and suggestions for improvements.

- Comparisons can range within different dimensions:
  - Target/actual comparison,
  - Comparison of time,
  - Comparison between similar equipment,
  - Comparison to extern service providers/ competition.
- Indices can be regarded as control device. Businesses and communes that pursue their goals based on indices are in a position to more precisely and more consequently control their performances, processes and input of resources.
- Indices, controlling and reporting belong together.
- Indices have limitations. They do not automatically indicate ‘good’ or ‘bad’ because many occurrences are incapable of accurate measurement.
- Therefore investigation of indices does not automatically provide the best basis for information.

2.5.2 Performance Indices, Building Log Book

There is a long tradition of benchmarking in several branches such as e.g. banks, insurance companies. Unfortunately aspects of rationalisation in connection with respective comparisons of costs have been the centre of attention in the past. With regard to high mutability and therewith strategic securing of a property’s outstanding usability throughout its lifecycle, such aspects as performance of a building’s structure should become the focus of benchmarking. According to [13] these performance indices, particularly with regard to industrially utilised real estate, will in future lead to a change from traditional administration of real estate to professional, active real estate management, incorporating:

Performance

Active Real Estate Management

- improved comparability provided by a standardised account system, standardised performance characteristics and differentiations,
- performance and costs transparency required for optimisation of such real estate and equipment that is essential for operation,
- stronger involvement of utilisation costs when assessing consequential costs for making investment decisions,
- involvement of those design elements in active real estate marketing that are favourable for mutability regarding location, building and building services (HVAC/R).

In addition to the conventional utilisation indices, at active real estate management there is need for such catalogues of requirements that are structured according to types of buildings and that feature comparing performance characteristics regarding buildings’ structures and technical infrastructure. Figure 2.24 shows catalogues of requirements, listing performance characteristics regarding load bearing structure, outer shell, media and finishings, as developed by the author within the framework of synergetic planning (Synergetische Planung™). In future systematic compilation of this data should be provided for by a ‘building log book’ in which a building’s

Building Log Book

essential elements are illustrated. In order to assess a real estate's future mutability it seems advisable to analyse the building's elements of load bearing structure, outer shell, media and finishings in form of diagrams, referred to as performance diagrams.

Figure 2.24: Catalogue of Requirements, Performance Characteristics of Building Structures

2.5.3 Performance Diagrams

The highest potentials for increasing quality and reducing costs are in integral analysis, integral planning and operation of processes. This is equally valid for planning and operation of buildings and technical equipment for production and heating, air conditioning and ventilation. It ought to be the task of all architects and engineers involved with management and planning of buildings to detect these potentials. At analysing a building's parameters for planning and operation the following aspects occur (viewed from inside to outside): process (fabrication procedures), load bearing structure, media (process/ building services), finishings and outer shell. These planning modules are interdependent; at this a step-by-step view from inside or outside is possible. Requirement specifications define a building's dynamic dependencies. Planning parameters can be illustrated in matrix-like tables. With regard to the question of mutability it is advantageous to develop a matrix as performance diagram which is similar to the illustration of benchmarks with regard to technical systems: the graphic implementation of differentiated parameter values in form of bars or polar coordinates directly visualises the degree of efficiency which is an important precondition for discussing alternatives. Figures 2.25 and 2.26 show examples of distinctive characteristics concerning load bearing structures, outer shells, media and finishings with regard to factory buildings.

Planning Modules

Performance Diagrams

Figure 2.25: Examples – Performance Diagrams Load Bearing Structure, Outer Shell

Figure 2.26: Examples – Performance Diagrams Media, Finishings

Load Bearing Structure

Important performance characteristics with regard to load bearing structure are amongst others positioning of columns in halls and storeys, permanent loads, live loads, suspended loads, special load areas, clearance in halls and storeys, requirements to fire protection/ fire safety, construction period, options for extension as well as economic efficiency.

Outer shell

Important performance characteristics with regard to outer shell are amongst others proportion of shell area to cubage, thermal protection, proportion of areas for daylight, flexibility of gates, doors and windows, proportion of heat extraction systems, noise protection, fire protection/ fire safety, ecology, energy generation, construction period, options for extension as well as economic efficiency.

Media

Important performance characteristics with regard to media systems are amongst others reserves supply, reserves distribution, flexibility of connections, modularity of systems, possibilities for energy optimisation, control options regarding central control technology, construction period, options for extension as well as economic efficiency.

Finishings

Important performance characteristics with regard to finishings are amongst others transparency towards halls, transparency towards storeys, flexibility regarding conversion of fixtures in halls and storeys, modularity, fire protection/ fire safety, conversion periods, options for extensions as well as economic efficiency.

Summary

Following an introduction to historic development, current tasks of facility management regarding real estate are introduced. The integral approach to buildings over their entire useful life changes the view of formerly separated planning, departments, functions and operational processes towards an understanding of lifecycles. A change in thinking with regard to building management is leading to new questions of owners and users concerning real estate. Applications of facility management to location, building, building services (HVAC/R) and utilisation/ process are mentioned. The operational efficiency becomes obvious upon comparison of market competing indices regarding geometry, quality and utilisation. In addition to the aspects of rationalisation mentioned it will be the long-term performance of a building's structure, illustratable by means of performance diagrams, that leads to active building management in future.

Confirmatory Questions

2.1 Explain in brief the different stages within a real estate's lifecycle!

2.2 Why is there a need for a change in thinking regarding building management?

2.3 Explain the term 'best of class' with regard to real estate!

Questions

2.4 Name basic tasks of facility management regarding real estate!

2.5 Explain an example of legally determined intervals for changes in building services (HVAC/R) with regard to buildings!

2.6 According to which criteria can indices in benchmarking with regard to real estate be structured?

2.7 Where is the difference between traditional administration of real estate and professional, active real estate management?

3 EDP-Systems for Facility Management

3.1 Basic Structure of Data Models for Location, Building and Facilities

Standardised collection of CAD-data, textual data and graphic data is the basis for each future evaluation in the phases of planning, implementation, operation, conversion and recycling. With regard to CAD-software graphic information is usually saved in file-formats dependent on the respective CAD-software used (.dwg – AutoCAD, .dgn – microstation, .dxf – exchange of drawings between different CAD-software of AutoDesk/AutoCAD). Concerning alphanumeric information the MS-office applications Word and Excel are regarded as industry standard. Graphics, photos and videos are usually pixel-based file-formats such as e.g. bitmaps. Computer aided facility management (CAFM) systems increasingly replace conventional data collections such as folders, card index boxes or lists by comprehensive databases. The advantages of CAFM systems mainly lie within both the networking and optimisation of most diverse information, e.g. areas, costs, personnel and processes.

CAFM Systems

Structuring data

Database Models

Database systems are used for saving large databases and such with complex structures. A significant advantage herein is the generation of varied (partial) views by means of specific alternatives for requests on data fields. According to [24] database models are distinguished according to their task-structure. With regard to CAFM-systems mainly relational, object-oriented and object-relational database systems are currently being used. Relational database systems file data in cross-referenced tables. These references are unambiguously identified by key attributes. Object-oriented database systems save object types with attributes attached to them. An example of this is the CAD-construction of a window element with additional textual reference concerning e.g. material of frame, glass characteristic or price when employing an object-oriented CAD-software. However, the amount of characteristics to be related to an object within a drawing is currently limited to 10 attributes. Object-relational database systems combine the advantages of different database models, offer flexible extension of file-formats and they are also suitable for administration of multimedia files such as documents, pictures, sounds or movies. As shown in Figure 3.01 GEFMA guideline 400 [25] distinguishes between inventory data, status data, consumption data and other data.

Inventory Data, Status Data, Consumption Data, Other Data

Figure 3.01: Distinction of FM-Data, Examples [according to GEFMA 400]

A real estate's inventory data is relevant for e.g. area management or commercial cleaning. Status data dynamically report temperatures, energy flux or failures. Consumption data are automatically or manually surveyed by building automation or meter-reading on site. At setting up data models it is imperative to filter such information the illustration, evaluation and ongoing maintenance of which is sensible for organisational and economical reasons. By concentrating on essential and operational relevant information a firm data pool is created which can be further detailed during the course of a project, an open database system provided.

Layer, Classification

Complex CAD-drawings require sorting to enable administration of all contained information. By modes of grouping it is possible to represent relations between different objects (e.g. storey, all load-bearing walls, all pieces of furniture) with the aid of layers or levels as well as by optional methods of referencing. At planning phase already all objects regarding location, building, building services (HVAC/R) and equipment, contained in a CAD-drawing should be organised according to a binding layer-structure. Persistence in integral planning relies on integrated coordination of all specialised planning by determining e.g. widths and colours of lines. Figure 3.02 shows excerpts of the layer-structure used at planning a small-scale industrial project. The structuring of media in accordance with DIN standard 276 as well as further classification regarding control centres, traces, networks and outlets as shown in Figure 3.03 makes allowance for the remarks in chapter 2.4.4, building services (HVAC/R).

Referencing

Figure 3.02: Layer-Structure, Example

Figure 3.03: Layer-Structure Building Services (HVAC/R), Example

With regard to documentation this structure is also binding for all specialised businesses that are involved in implementation. This is how on this basis the summary of all control centres' consumption data during future operation allows for a database-like connection to the 2D or 3D-spatial model. At this present consumption values will directly be displayed when clicking on the respective control centres. Combining similar objects in one class of objects is advantageous for structuring data in a CAFM-system because it allows for simultaneous access to all objects of the same type for evaluations. Usual classifications are data type, file format and frequency of changing. Following [21] Figure 3.04 shows examples of data types, file formats and frequency of changing.

Object Type

Figure 3.04: Data Classification, Example [according to Heß]

3D-Building Model

CAD-software based on the 3-dimensional building model is state-of-the-art. A building's structural elements such as ceilings or columns are filed including their

3-dimensional building model

Interoperability

complete geometry as well as including the relations between those elements. CAD-software should allow for looking at elements from different views. So far data-exchange between building model and database was problematic because in order to enable exchange of all information the database logic has to be congruent with that of the CAD-system. Currently a cooperation of leading software providers and members of the building industry is working on the file format IFC (Industry Foundation Class) in order to improve interoperability of data provided by building models. A few progressive CAFM-systems such as Archibus/FM® (introduced in chapter 3.5) combine Oracle's open database structure with the so-called 'overlay' function of importing and exporting AutoCAD drawings. This provides for up-to-dateness of database entries and drawing data at all times.

Room specifications

Matrix-Like Room Comparison Lists

The basis of all CAFM-systems is a list of all rooms within the respective building. At the phase of basic evaluation, room specifications aid in documenting user requirements. They are being kept updated throughout planning phase. These room specifications comprise such information regarding room number, utilisation, storey, floor area, height of room as well as information on the building's structure. In the framework of synergetic planning (Synergetische Planung™) matrix-like room comparison lists have been developed which can contain a number of additional characteristics. These also enable linking to cost elements regarding floors, walls, ceilings and building services (HVAC/R), which are further detailed at later planning stages. Furthermore a consequent structure provides for allocation of specific service with respective costs and cost centres to each room. Figure 3.05 shows an example for planning data comprised in room specifications.

Figure 3.05: Planning Data comprised in Room Specifications, Example

Coding

References to special utilisations, requirements to spatial geometry, floor, wall and ceiling systems as well as requirements to building services (HVAC/R) systems within floors, walls and ceilings are contained in Excel tables that are subdivided according to parts of the building and their respective storeys. Further on rooms are categorised regarding classes of similar rooms, e.g. wet rooms, by the way of coding employed. With regard to cost evaluations this allows for more general statistical values relating to mixed utilisation of gross floor areas to be further itemised regarding individual room types. Ideally project development of a real estate already is accompanied by results-oriented data modelling considering the detailed processes concerning location, building, building-services, function/ process. Basic evaluation phase in particular should be portrayed from the integral view of all specialised planners involved by means of such tables that have been clearly structured bearing in mind future operations. In case of no data being available regarding single aspects, such presumptions need to be made jointly, that are to be rendered more precisely during the course of the project. Direct import of data provided by digital room specifications to databases embodied in the CAFM-system is rarely possible due to the building-databases supporting the room specifications usually being founded on individual databases. In this particular case a macro tool provided for real-time import of all room characteristics to the Oracle database embodied in the CAFM-system Archibus/FM®.

Documentation

The advantages of implementing CAFM-software at planning phase have already been pointed out in detail. In case of existing built volumes it is often necessary to integrate old buildings into the database. How far existing as-built documents can be used for this depends on their condition, correctness and up-to-dateness. Facility management can only deliver correct results when precise original data are at hand. Clear guidelines for set-up of drawings and textual preparation of documentation at a later date need to be imposed on bidders at tender already. File formats, layer structures, widths and colours of lines, plan formats and numbering system should be bindingly specified and continuous for all graphic, alphanumeric and visual data. It is advisable to not only fix this 'assignment of integration' in the preliminary remarks of the respective invitations to tender but to query the effort for this as cost element for a precisely defined performance within the specifications for tenders. Figure 3.06 exemplary shows the classification of a building documentation. According to [18] meticulous documentation of building services related equipment in particular is highly rated in the automobile industry. At VW Wolfsburg the department of research and development covers 500.000 m²; quantity determinations for tender documents regarding maintenance, replacement procurements as well as arbitrary queries about specific structural parts shall in future be handled by the CAFM-system MORADA. At this it is also the aim to graphically visualise the positioning of complex technical equipment within the building. For this purpose catalogues of all

Assignment of Integration

- components of supply engineering,
- structural elements of technical building equipment,
- characteristics of technical equipment

are being developed incorporating a superordinate identification system. The systematics used for structural elements of technical building equipment follows GEFMA guideline 182 whereas the identification system is according to DIN standard 6779 which refers to power stations. In future a type plate in form of a barcode for each component shall be generated from the catalogues. A guideline for documentation commits all businesses involved with implementation to provide their data as specified.

Figure 3.06: Contents of Building Documentation

3.2 Virtual Project Space

At complex and interdisciplinary projects one more often uses internet-based technologies for managing planning and documents. Online provision of e.g. communication of businesses involved with a real estate's operation during planning or implementation, or maintenance and control processes of building services equipment seems to be suited for CAFM-systems in particular. This provides for extern service providers to continuously control equipment and sooner detect malfunctions without a technician having to be on site. High flexibility and openness regarding the system is achieved with setting up a building's own homepage. Authorised users can then access parts of the information provided online, possibly differentiated according to views, regarding location, building, building services (HVAC/R) and equipment. On top of that direct online input of e.g. data collected at reading meters of aggregates can be carried out via PDAs, laptops or mobile phones. Advantages being:

Building's Own Homepage

- Duplication of work and mistakes are reduced because it is guaranteed that everyone's work is based on the most up-to-date plans and documents.
- Online checking and commenting on plans provides for significant time saving in the process of assessing and approving.
- The danger of loosing important files is eliminated because up-to-date as well as previous versions of a document are centrally saved.
- Structured initiating and answering of queries provides for improved communication among the team.
- Pro-active task management eases process management.
- The process of repairing deficiencies is speeded up.

Online working with the CAFM-system is a cost-saving alternative to providing complete hardware and software installations for every individual user of the CAFM-system. Free viewer-software such as volo-view or DWF-viewer allow for viewing e.g. AutoCAD-drawings without the complete software having to be installed on the user's PC.

3.3 Navigation

Convenient User Guidance

The benefit of visual information systems for convenient user guidance has previously been mentioned. Figure 3.07 illustrates networking of information on location, building, building services (HVAC/R) and function/ process considering factory planning as an example. Parallel to the views of planners those of owner, operator and user have to be integrated. Their objectives could refer to e.g. elements of general development, parts of the building, storeys, areas, rooms or equipment/ furnishings.

Figure 3.07: FM Location, Building, Building Services (HVAC/R) Equipment, Specialised Views

The information merged in facility management could be pictured as a matrix-like structured data model. Figure 3.08 displays such a matrix.

Figure 3.08: Integrated FM-Data Model, Filing and Evaluation according to Views

Horizontal subdivision is in accordance with views of specialised planners, owner, operator and user on location, building, building services (HVAC/R) and function/ process. Vertical subdivision is in accordance with views regarding elements from general development to furnishings/ equipment. Diagonally positioned is the facility management software's access (in form of requesting evaluation) to data on drawings, texts and pictures which are filed in 'drawers'. This navigation system provides graphically enhanced, visually guided access to respective information and enables overlay of information in a simple way. At cross view e.g. overlay of a building services plan featuring ventilation traces on a storey plan featuring equipment layout is easy to find. At lengthwise view complete information on e.g. a fire sprinkler system is retrievable from infrastructure of the location down to the spray nozzle situated in a storage rack. Figure 3.09 shows examples of file modules containing information on graphics, texts or pictures.

Overlay of Information

Figure 3.09: Integrated FM-Data Model, Example of File Module, Graphic, Text, Picture

It is quite conceivable that within the next years organisational structures such as the navigation system introduced will be developed that feature user-adjusted graphic input masks and that are also voice-controlled which would serve as an individual data filter. This more intuitive user-specific requesting (and filing) of information could substantially support increasing application of facility management software.

3.4 Choice of CAFM-System

Producers of CAD-software, system suppliers for building services, planning and consulting businesses and increasingly producers of more managerial software, such as SAP, offer CAFM-software. According to [25] 43 CAFM-systems were on the German market in 2002. 60% of these systems had not yet been on the market five years ago and compared to 1999 15 systems are no longer on the market. The development of CAFM-software is moving from CAD-dominated systems which

Industry Standards

System Specifications for FM-Processes

User-Groups

can only be used with special knowledge to database-oriented systems which offer variable surfaces for easy use. The dominance of industry standards AutoCAD (77%) and Oracle (81%) with regard to CAD-drawing system and central database is remarkable. In order to provide for guaranteed future of precious data stock it is advisable to prefer such CAFM-systems that possess long-time experience and employ industry standards for graphic and text. GEFMA guideline 400 clearly distinguishes between CAFM-software and CAFM-system. A CAFM-system is regarded as a complex and customised software-solution that transfers the respective processes to a specific database structure. Setting up a CAFM-system therefore requires for such system specifications to be elaborated that depict business-specific requirements and provide for evaluation surfaces from variable views. Requirements on a CAFM-system arise from the FM-processes to be supported. It has to be determined which tasks user-groups (e.g. FM-Team, owner, administrator, internal and external service providers, user, interested parties etc.) will take on at employment of the CAFM-system.

CAFM-Consulting

According to [22] following assignments arise at adoption of CAFM-systems:

- structured compilation and editing of requirements to a CAFM-system,
- moderation of discussion between different lobbies,
- valuation and prioritisation,
- development of a coordinated architecture regarding process, system and data,
- development of schedule according to prioritisation and determining of milestones,
- safeguarding the success of implementation by accompanying quality management.

CAFM-Consulting

It is sensible to employ advisors specialised in CAFM-consulting for moderating the implementation of CAFM-projects. According to [22] the following structure is well proven regarding large scale projects:

1. workshop: areas, organisation, equipment, move
2. workshop: maintenance, technical equipment, energy, building maintenance
3. workshop: disposal, cleaning, safety
4. workshop: data stock, identification system
5. workshop: interfaces to other DP-systems

In order to provide better transferability it is advisable to file these evaluations and process reports not only in form of protocols but also as spreadsheets in databases.

Development trends

Open Database Structure

A suitable CAFM-system can only be chosen upon clarification of required processes. The trend is clearly distancing from (closed) systems that were developed from CAD-construction and moving towards open, flexible database structures. These integrate widely spread CAD-systems such as AutoCAD to make use of their long-term experience on the market and to provide for guaranteed future. An alternative to this would be the combination of more managerial software such as SAP R3 and a suitable graphic visualisation tool. This is especially interesting for businesses that are already employing SAP for their core processes.

3.5 Archibus/FM®

With over 30.000 licences sold Archibus is the market leader both in the USA and worldwide. In Germany Archibus has only been marketed since 2002. For over 20 years now Archibus Inc. has been the worldwide leading provider for products and services relating to facility management and infrastructural management. This experience, combined with more than 1.600 Archibus/FM-trained specialists worldwide, provides for proven solutions regarding effective administration of physical assets for businesses of all sizes. Since 1987 the company's leading product Archibus/FM is holding a share of 66% in the worldwide market of integrated computer aided facility management (CAFM). In 2001 worldwide annual expenditures in connection with Archibus/FM products and services added up to over 1 billion US-dollars. More than half of the turnover was gained outside the USA. Archibus/FM is available in over 100 countries and implemented at more than 16.000 businesses comprising more than 1 million users. With continuous product improvement and a very broad customer base Archibus/FM is the worldwide number one in building and infrastructural management solutions. The system's modular set-up allows for customising. Archibus/FM is made up of seven application modules and two activity programmes the licences to which can be purchased separately. Open system architecture allows for producing new database fields and tables, and enables combined use of Archibus/FM and other application programmes such as ERP, human resource management and accounting system (there are several interfaces to SAP). Long-term cooperation with AutoDesk provides for high compatibility with CAD-system AutoCAD. Figure 3.10 presents the overlay function which allows for AutoCAD drawings to be revised and edited within Archibus.

Open System Architecture

Overlay Function

Figure 3.10: Archibus/FM, Integration of AutoCAD via Overlay Function

The special advantages of Archibus lie within simple menu structures and a database structure that is easy to adjust according to customer requirements:

- open system – Oracle, MS SQL Server, Sybase, AutoCAD, Windows,
- flexible reporting, many thousand standard reports,
- four user surfaces: Web, Process Toolbar, Navigator, EIS,
- customising, quick and cost-efficient,
- seamless upgrading and extension from small to large,

Integrated Application Modules

- real estate and rental management for financial and contractual analysis of real estate and rented property,
- strategic overall planning for substantiated business decisions regarding area and growth requirements,
- room and area management for optimal use of all rooms and areas; Room reservation for common used rooms, ‘office hoteling’ (part-time reservation of rooms) as well as disaster/ average plans are additional products based on the application for room management
- design management with overlay function for AutoCAD for quick set-up and updating of drawings to a building
- furniture and equipment management including move management in order to control costs of operating resources
- calculation of amortisation costs and removal costs as well as planning removal of employees and their operating resources
- telecommunication and cable management for stocktaking and modification of physical wiring and equipment connections
- maintenance and repair management for recording and controlling of total maintenance, particularly preventive maintenance and repair

The maintenance assistant is an effective additional product which aids in simplifying, automating and optimising work processes and work orders. Fleet management, another additional product, ensures optimal use of the fleet. The management information system Archibus/FM MIS assists users who do not have any programming knowledge with input and output of relevant data regarding building and operating resources. The graphically guided user surface can be customised. Archibus/FM Web Central enables the use of Archibus/FM via web browser. Therewith users can retrieve or enter data via internet or intranet. Short familiarisation phase, independence from location and low costs regarding the workstation make this product very attractive. Following businesses and local authorities are amongst the users of Archibus:

American Express, Bank of England, Shell, Hewlett-Packard, IBM, Silicon Graphics, Gilette, Nestle, Philipp Morris, Sydney Opera House, BBC, Sony Pictures, City of Calgary, Washington State Dept., U.S. Navy Europe, Ford, DHL, UPS, Siemens Medical Systems, Nokia, Vodafone, University of Hong Kong…

Summary

The basis for all future evaluations in the phases of planning, implementation, operation, conversion or recycling is standardised collection of CAD-data, textual data and graphic data by CAFM-systems. At setting up data models it is imperative to filter such information the illustration, evaluation and ongoing maintenance of which is sensible for organisational and economical reasons. The basis of all CAFM-systems is a list of all rooms within the respective building. Binding guidelines for documentation of all construction works involved in completion of real estate deserve special attention. Setting up a CAFM-system requires for such system specifications to be elaborated that depict business-specific requirements and provide for evaluation surfaces from variable views. Development trend regarding CAFM-systems is heading towards open, flexible database systems which include industry standards AutoCAD, Oracle and SAP.

Confirmatory Questions

3.1 What could be examples for distinction of FM-data?

3.2 What is data classification?

Questions

3.3 Which information can room specifications contain?

3.4 What is regarded as virtual project space and what advantages can that provide?

3.5 Name assignments of CAFM-consulting at adoption of CAFM-systems!

3.6 Why is integration of CAD-data into textual databases problematic and to what extent can an overlay function be helpful at this?

3.7 What are the advantages of CAFM-systems based on industry standards regarding CAD and textual data?

4 Project Examples

The field of work for facility management and real estate is extremely varied. As opposed to that there is not a great amount of significant and published case studies in Germany. The reasons for this are probably long project duration as well as partly restrictive public relations of businesses. According to [20] GEFMA workgroup 'CAFM' researched and compared a number of case studies following a standardised method in the years 2001-2003. These case studies comprise:

- Provinzial Versicherung, Düsseldorf,
- Innovationspark Wuhlheide,
- Schering AG, Berlin,
- Flughafen, München,
- Boehringer, Ingelheim

Success Stories

They were published under the title 'Success Stories' as a series of articles in the magazine 'Gebäudemanagement' 7/8 2001 to 1/2 2003.

4.1 Location

4.1.1 Municipal Real Estate Administration, The Free State of Saxony

The Free State of Saxony invested six billion Euros in construction over the last years. The formerly fiscal management of real estate in the Free State of Saxony will have to adopt modern methods of building management in future. Currently this change is being prepared and taken step-by-step. KMS Computer GmbH, Dresden, is integrating varied data into a database on the platform TOPOBASE™. Primarily two technological aspects have been integrated:

- Focussing on one database that comprises all components, i.e. documents, factual and graphic data, since they provide common and necessary aspects for factual information and evaluation.

Web-Technology

- Guaranteed comprehensive exchange of information via web-technology. The Free State of Saxony had already implemented an intranet which is interconnecting all state-run authorities and is now being extended on the municipal level.

Departments from criminology and disaster control to all types of services are interested in these data. In future users of real estate, particularly state-run offices, are to also take care of their own cost control. Therefore they have to be in a position to gather, compare and evaluate information on their locations' current cost status. For the first time an overview on the situation of all federal state owned real estate could therewith be realised as shown in Figures 4.01 and 4.02.

Figure 4.01: Municipal Real Estate Administration, Example – Location [according to KMS]

Figure 4.02: Municipal Real Estate Administration, Example – Floor Plan [according to KMS]

Geographic Data

Information starting from geographic data (map of Saxony, districts, municipalities, local subdistricts, parcels of land, buildings) to floor plans can now be requested and visualised via Internet Explorer at all workstations within the department of real estate administration. At this AutoDesk MapGuide technology is being used. For the first time the structure of real estate in the Free State of Saxony as it evolved throughout history can be displayed on the intranet state-wide. There is now a comprehensive communication platform for cross-departmental optimisation of use, communication with users and service providers as well as utilisation of areas no longer required. In future users of real estate, particularly state-run offices, are to also take care of their own cost control. Therefore they have to be in a position to gather, compare and evaluate information on their locations' current cost status. In future TOPOBASE™ provides for all information required for evaluations and benchmarking, urban development and planning or assessment of situation. So far approximately 2.3 million geographic objects have been entered into the system. In future cross-departmental utilisation will enable offering new services by answering queries beyond the traditional requirements of real estate management such as e.g.:

Cost Control

Urban Development

- How to get to civil services or authorities by public transport?
- Whereabouts are roadworks or closures within city limits?

4.1.2 Urban Development, Industrial Park M1 Essen

The area 'M1' is part of the former Krupp industry complex in Essen. Release and development of further areas within this former industrial zone offer a great chance for North Essen to become a trade and industry location of supra-regional significance in the future. The step-by-step iterative urban conversion comprising 40 hectares could not be realised by self-contained planning. The chronological process was rather developing dependencies that bore truths and accents at a later date. According to [27] 3D-visualisation of the project from the start allowed for this process by providing dynamic change from rough assumptions to more detailed structures:

- As construction proceeded, volumes formerly defined as placeholders were structurally condensed according to wishes and requirements.

Virtual Urban Model

- The hence continuously up-to-date virtual urban model served as spatial as well as creative 'living corrective' for future building projects.
- Individual project ideas were quickly developed from the rough volumes.
- Guidelines provided by a superordinate urban design handbook could therefore be followed in different scales at all times.

New Tools for Urban Planning

For the task of spatially accomplishing future trends of a vision up to realisation and beyond new planning tools have been established:

Data Unification

- Data unification:
  Different data that, according to Figure 4.03, were entered at production of zoning and legally binding land use plans, served as computation base for visualisation software at a later date (regional surveys, field boundaries, roads, topography etc.). Cadastral boundaries of marketable, modular zoned lots, utilisation indices of intention and preparation planning as well as regulations stated in the design handbook can directly be retrieved from the virtual 3D-model of master planning.

Figure 4.03: Urban Development, Building Law Regulations – Example

- Design aid at 3D-visualisation: computer animation enables optimisation of room order, positioning of buildings, eaves height or perspectives, walking through fictive streets of houses, taking round tours and considering the effect of plantation which could previously only be imagined (compare Figure 4.04).

Figure 4.04: Urban Development, Virtual Urban Model – Example

- Marketing a vision:
  Communicating attractive visions of a project to potential investors is crucial for the developer. Plots of land need to be sold at the time of preparation of land for building when there are no finished streets or parcels to look at. Thus an area's value to a great extend is subject to an investor's individual fantasy. Computer simulation allows for non-existing buildings to be inspected and evaluated regarding aesthetic and economic standards at planning phase. 2D/ 3D-drawings were produced with AutoCAD; urban textual attributes were connected to graphic data via G-Info.

Connecting Drawings with Textual Attributes

4.2 Building

4.2.1 Survey, Area Optimisation Phoenix AG Hamburg

Phoenix has been ranking among the biggest companies in Harburg for 150 years now. In 1856 the brothers Albert & Louis Cohen from Paris founded the homonymous rubber factory in Harburg, Germany. Phoenix AG emerged in 1872. The rubber factory in the middle of town is linked to Harburg's recent history and, being a major employer, it is significantly involved in the growth of town like hardly any other business. Today Phoenix AG is a leading supplier of high quality rubber products and acoustic systems. At the end of the nineties the company increasingly shifted its production to East-European states. The main factory in Hamburg currently employs 3.100 of the 10.000 employees worldwide. Company headquarters are located at Hannoversche Straße opposite the main station and its grown structure offers outdated production facilities with increasingly uneconomic processes only. The inner-city location inhibits extension to provide for new production facilities. In the long-run Phoenix AG will have to give up its location at Hannoversche Straße. There are several feasible alternatives for future utilisation of the existing buildings. Precondition for future utilisation scenarios of approximately 120.000 m² gross floor area is that precise documents to all buildings are at hand. Within the scope of a fundamental digital survey on the basis of available archived planning documents of Phoenix AG's core area in Hamburg-Harburg:

Digital Survey

- usable areas and net floor areas of the entire premises have been acquired and allocated to the nine companies sharing them,
- single buildings have been surveyed in more detail including area differentiation according to DIN standard 277,
- a 3D-building documentation has been established for the complete area as shown in Figure 4.05,

Figure 4.05: Survey, 3D-Building Documentation – Example

Object-Oriented Attributes to Building Elements

- for sub areas textual attributes containing information on ceiling load-bearing capacity, dimensions of construction, media routings, clearances or required refurbishment have been allocated to CAD-objects such as ceilings,
- a digital documentation of all elevations has been allocated to the respective building.

On this basis optimisations have been run through with several scenarios aiming at amongst others:

- eliminating vacancies on floors by merging departments,

- improving functional relations between process, logistics and administration,
- minimising operating costs,
- eliciting possible preferred areas with regard to letting or sale.

AutoCAD was employed for producing 2D/3D-drawings as well as calculating areas. Graphic and picture data were entered to the Oracle database provided by CAFM-system Archibus/FM®. As shown in Figure 4.06 the Archibus report generator enables area listings respective their allocation to companies or it displays functional relations between areas in an easy way.

Figure 4.06: Survey, Area Differentiation – Example

4.2.2 Factory Extension, Londa Rothenkirchen

A new factory hall with a gross floor area of about 6.000 m² was to be realised in extension to the grown structure of the factory in Rothenkirchen. Londa is a subsidiary of Wella AG, Darmstadt, which itself is now part of the global Procter + Gamble group. In the course of IT-networking all of Procter + Gamble's real estates the US-based owner attached great importance to relevant data on location, building, building services (HVAC/R) and equipment being filed in an Oracle database in accordance with CAFM-system Archibus. At factory extension the chance of planning accompanying FM-suitable documentation of all specialised planning was seized, and

- workshops,
- rough planning,
- detailed planning,
- planning for approval,
- construction planning and
- tender

were documented accordingly. Transfer of those Excel lists that have been maintained by every specialised planner in accordance with the method of synergetic planning is carried out by a macro tool. This tool systematically scans all Excel entries and, by means of a 'system table' programmed in Access, transfers them to data fields of the Oracle database which is provided by CAFM-system Archibus. Figure 4.07 displays the 'translation' of an excerpt from the room specifications into the Access 'system table'.

Figure 4.07: Transfer of Excel Room Specifications to Oracle Database Example

Due to the varied reports enabled by Archibus management is provided with readily accessible information on e.g. usable areas or costs. In terms of global benchmarking these values can then be compared to those of other factories. For better visualisation of the overall project a video simulation in form of an integral factory model regarding location, building, building services (HVAC/R) and equipment was produced in the scope of a pre-project. These 3D-datasets will be reused for a visual information system. Figure 4.08 shows how the virtual 3D-construction of a production line is generated straight from the respective floor plan. Recall of further characteristics, information on costs or suppliers is optional and provided for by linking information contained in the drawings to the CAFM—system.
Particularly with regard to global companies navigation this simplified, using unified data, offers special strategic advantages in decision making concerning investment control.

Figure 4.08: 2D/3D-Connection of Building Data and Equipment

4.3 Building Services (HVAC/R)

4.3.1 3D-Planning of an Industry Hall

3D-media planning, Database

3D-media planning is highly advisable for buildings carrying complex installations as it helps avoiding various possible collisions of building services' infrastructure with load bearing structure, outer shell, finishings and utilisation. 3D-construction software Microstation is often employed for plant construction. Schewior + Labus engineers for example specialised by order of clients such as Bayer AG, Leverkusen, in spatial detailing of all media routing components with the aid of Microstation and Triplan (application for building services). See Figure 4.09 for excerpts from 3D-media planning at an industry project.

Figure 4.09: 3D-Media Model, Industry Hall [according to Schewior, Labus]

Installation traces are routed collision free through the given gaps of the load bearing structure. For areas close to control centres the 3D-media model can be condensed according to requirements. Administration of object-data in the Oracle database provided by the CAFM-system is based on superordinate encoding of all building services components. Considering cisterns and taps/faucets as example Figure 4.10 shows a requested datasheet to a 3D-object stating:

- supplier,
- manufacturer,
- description,
- model number

as well as providing cross references to further accessories stored in the database such as inlet fixtures. Similar datasheets should be produced for e.g. thermostatic valves in office buildings that are activated by central building control systems. With projects of major insurance companies, temperature recording separated according to radiators alone can easily produce several thousand data entries.

Figure 4.10: Connection of 3D-Model and Database – Example [according to Schewior, Labus]

4.4 Utilisation/ Process

4.4.1 Production Unit Pharmaceutical Raw Materials, Schering AG

At the Bergkamen production site a modular factory for the final production stages of pharmaceutical products is projected on a land parcel provided for this purpose by Schering AG. The trendsetting feasibility study shall enable bolstering demand fluctuations on the global market by quick reactivity regarding new products. Defining of such building structures that enable process flow happens from 'inside to outside'. In principle the building is a highly versatile service provider for structural process requirements that are currently hard to meet. Therefore it is imperative that by clever configuration the systems of load bearing structure and building services in particular leave as much freedom as possible regarding ways of utilisation. Vertical stacking of process steps, which is common practice in comparable projects of the food processing or pharmaceutical industries, enables taking advantage of natural gravity at processing liquid or granular goods. Following conveying of raw materials to the upper level gravity activates vertical material flow of raw materials to picking on ground level. Figure 4.11 shows a section through a production module in which supply and disposal of process stations including a multitude of technical water, vapours and solvents can be seen. At this project a library of all process stations following the method of 'ID-process cards' was established. Each process section was recorded as 2D/3D-drawing object and allocated textual attributes. Figure 4.12 shows ID-card excerpts of an inverting filter centrifuge.

Figure 4.11: Example - Production Module, Production Media

Figure 4.12: Example – ID-Card of an Inverting Filter Centrifuge

While drawings for this library of process stations were produced with AutoCAD architectural desktop, Excel and Access were used to allocate attributes such as geometric data, information on maintenance or responsibilities. At systems practicing such GMP (good manufacturing process) special attention is being paid to emergency management. By respectively connecting information contained on the ID-cards about e.g. not to be underestimated operating repairs, immediate emergency procedures can be initiated via an online CAFM-system as introduced earlier on in Chapter 2.4.4.

4.5 Synergetic Factory Project

4.5.1 Assembly Plant for Coolant Systems, Wackersdorf

Modine Montage GmbH produces complete cooling systems for automobiles. From their factory in Wackersdorf they deliver amongst others all cooling systems for BMW's 3-series and Z4. Suppliers and customers have only recently elected it to be given the 'Fabrik des Jahres 2002' (factory of the year 2002) award for extraordinary integration. With regard to the upcoming new factory building for Modine in Wackersdorf, at the first workshops already, planners (rough planning – process: IFA, Hannover; overall planning – architecture: Reichardt Architekten, Essen) have been assigned to paying particular attention to precision in planning as well as aiming at modularity and mutability. Following systematic basic evaluation missing determinations were replaced by assumptions. Sensible variants and options were spatially run through. See Figure 4.13 for the building model which was to finalize conceptual phase. It illustrated the structural elements location, building, building services (HVAC/R) and processing equipment in 3D, also as video animation. First reconciliation of budget took place.

Figure 4.13: Example – 3D-Building Model

As early as ten weeks following the first workshop, interlocking of standardised elements from rough and detailed planning allowed for comprehensive market research for the overall project, based on tenders that were structured in accordance with cost elements. Upon evaluation of this market research it was possible to compile all relevant planning data concerning the overall project which provided for a high degree of planning reliability regarding costs. Thus decision-makers could quickly decide on the further course of the project. Secured by the results of the first market research and regarded as ‘fine-tuning’, general contracting tender took place shortly after this. At the same time approval procedures were underway. Based on spatial optimisation of the synergetic building model, collision control and continuous quality control for all trades were enabled during implementation phase. Cost, time and quality influencing conflicts such as e.g. traces colliding with load bearing structure, were detected in time and not only eliminated on site. See Figures 4.14 and 4.15 for 3D-steel construction and 3D-media models which were used to coordinate planning of building services related systems.

Figure 4.14: Excerpt – 3D-Model of Load Bearing Structure

Figure 4.13: Excerpt – 3D-Media Model

The structure of lists and tables which were determined at the first workshops of basic evaluation was carried all the way through to current operational phase with ever increasing density of information. Basic evaluation regarding processing equipment, load bearing structures, building services systems as well as room specifications, cost elements and cost control were entered into standardised Excel tables and constantly rendered more precisely by the planning team during the course of the project. Currently graphic and alphanumeric information are merged in an Oracle database provided by CAFM-system Archibus/FM®. An outstanding characteristic compared to conventional information systems is user guidance being controlled by spatial illustration of 3D-projects regarding process/ equipment, location, building and building services (HVAC/R). This allows for respectively authorised parts of the FM-model to serve as an information system for customers or visitors in support of public relations.

Summary

A GEFMA workgroup researched and compared ‘Success stories’ of case studies. Further single aspects are pointed out at project examples from the work of the author’s cooperative planning team. Current municipal real estate administration in the Free State of Saxony and virtual urban models for urban development of an industrial park in Essen approve the added value for owners and users in FM-database supported discussion on location. At Phoenix AG, Hamburg, CAFM-system Archibus was employed for survey and following area optimisation as well as compilation of all building planning’s parameters regarding room specifications for ‘cosmetic’ consolidation. Interaction of 3D- planning of building services and entering respective components into a database is exemplified by an industry hall. Based on ID-process cards a library of process sections is developed for a production module for pharmaceutical raw materials. Thereupon structure of the building as well as process media required are developed at 3D-model. At last the method of synergetic planning (synergetische Planung™) from basic evaluation to operation is exemplified by an assembly plant for cooling systems.

Confirmatory Questions

4.1 Why is evaluation of database models sensible for municipal real estate administration?

4.2 What advantages does an urban 3D-visualisation offer?

Questions

4.3 Name possibilities for visual surveying!

4.4 Give an example for an ID-card for production processes!

4.5 What is regarded as synergetic building model?

4.6 What is the advantage of applying continuous cost elements at a project?

Answers to Questions

Question 1.1

I. Technology

- Producing goods and solving tasks with least possible effort, principle of maximum efficiency/ productivity
- Methodical proceeding, optimisation and simulation of characteristics…

II. Energy

- Variety of possibilities for energy optimisation by integral concepts for climate and technology
- Increased use of regenerative energy sources such as solar energy, hydro energy, hydropower, wind power, bio energy and tidal energy

III. Ecology

- Ecologically conscious building marks the highly efficient production, operation and reduction of built environment within the framework of the ecosystem.

IV. Flexibility

- Adaptability within as wide a range of tolerance as possible determines the degree of constructional flexibility.
- defining a mutability of all systems of constructional design as well as sufficient performance of supply and disposal systems

V. Communication

- Architecture geared at networking and transparency promotes opportunities for communication, self-determination as well as staff participation in work and surroundings.
- Corridors, galleries and staircases open up new potential for communication.

VI. Identity

- a company's recall value for customers and staff
- corporate identity is increasingly included in designing buildings more consciously

Question 1.2

The use of all aspects of optimisation and creation of value reaching from planning, implementation and operation to deconstruction; control variables at this being material, information and communication, money and persons, which are in constant motion within an open system

Question 1.3

missed deadlines, budget overrun, failures, lack of mutability, lack of performance

Question 1.4

deliberate positive bundling of features with the aid of many partial solutions, as complementing one another as possible, to complex questions

Question 1.5

I. Structural Characteristics of the Load Bearing Structure:

- project requirements, load assumptions
- structural shape, static system
- choice of material

II. Structural Characteristics Media:

- control centres
- main traces

Question 2.1

I. Planning Phase

- objectives
- integral basic evaluation
- tender according to cost elements

II. Implementation Phase

- planning documents should be congruent with what is really being built
- securing of as-built documents

III. Operation Phase

- meeting the required functions as specified in the objectives in an economic way
- maintaining operations

- documentation of wear process

IV. Replanning Phase

- in principle processes are alike those at planning phase
- updating as-built documents

V. Deconstruction Phase

- rounds off a property's lifecycle
- obtaining accurate costs for dismantling and disposal

Question 2.2

- increasing cost pressure
- increasing maintenance costs
- increasing energy consumption
- increasing dynamic due to changing tenancies and uses

Question 2.3

- striving for best performance within a comparable group of competitors
- cost indices of buildings relating to their geometry, quality and use are being compared

Question 2.4

- acquisition and provision of up-to-date data
- evaluation of locations, buildings, equipment
- space planning and utilisation planning
- operations and maintenance management

Question 2.5

An example for the ongoing optimisation of buildings is the regular toughening of regulations for energetic optimisation of facades and building services (HVAC/R). New regulations concerning the optimisation of thermal insulation (Wärmeschutzverordnung) and the saving of energy (ENEV), in force since 1995 resp. 2002, directly resulted in constructional and technical components being exchanged.

Question 2.6

- building economy
- space provision costs

- operating costs
- consumptions
- infrastructural costs

Question 2.7

- involvement of those design elements in active real estate marketing that are favourable for mutability regarding location, building and building services (HVAC/R)
- stronger involvement of utilisation costs when assessing consequential costs
- performance and costs transparency
- standardised account system, standardised performance characteristics and differentiations

Question 3.1

- inventory data
- status data
- consumption data
- performance catalogue
- workflow data
- business data

Question 3.2

Combining similar objects in one class of objects is advantageous for structuring data in a CAFM-system because this allows simultaneous access to all objects of the same type for evaluations. Usual classifications are data type, file format and frequency of changing.

Question 3.3

room number, utilisation, storey, floor area, height of room as well as further information on the building's structure regarding floor, wall, ceiling as well as requirements to building services (HVAC/R) and utilisation

Question 3.4

Internet-based technologies for managing planning and documents and setting up a building's own homepage offer the following advantages:

- duplication of work and mistakes are reduced
- online checking and commenting on plans
- no loss of files

- improved communication among the team
- eased process management
- process of repairing deficiencies is speeded up

Question 3.5

- structured compilation and editing of requirements on CAFM-systems
- moderation of discussion between different lobbies
- valuation and prioritisation
- development of a coordinated architecture regarding process, system and data
- development of schedule according to prioritisation and determining of milestones
- accompanying quality management

Question 3.6

Due to different object codes most database systems do not automatically import object-oriented CAD-drawing data and their attributes. This can lead to redundancy of different planning stages. An overlay function provides for automatic transfer of CAD-drawing data and object-oriented attributes (compare CAFM-system architecture).

Question 3.7

Long-term experience on the market and compatibility with many specialised programmes due to open system architecture provide for guaranteed future.

Question 4.1

- There is now a comprehensive communication platform for cross-departmental optimisation of use, communication with users and service providers as well as utilisation of areas no longer required.
- Cost control provided by current cost status of locations and buildings.

Question 4.2

- dynamic change from rough assumptions to more detailed structures
- virtual urban model as spatial and creative ‘living corrective’ for future building projects
- possibility for developing individual projects based on rough volumes
- pursuance of a design handbook in different scales
- possibility for connecting urban textual attributes to graphic drawing objects

Question 4.3

- allocation of usable areas and net floor areas to their respective users
- differentiated calculation of floor area according to DIN standard 277 for single areas
- 3D-building documentation including textual attributes containing information on characteristics of building elements have been allocated to CAD-objects
- digital photo documentation of e.g. facades

Question 4.4

- merging of all relevant graphic, textual and visual information into one process element as a module of a library for all process sections
- IT-connection of ID-cards for e.g. emergency management (example: notice of malfunction and emergency management in case of failure of inverted filter centrifuge at pharmaceutical raw material production)

Question 4.5

- 3D-illustration of structural elements concerning location, building, building services (HVAC/R) and processing equipment
- virtual collision control and continuous quality control for all trades
- cost control provided by continuous evaluation of masses and qualities

Question 4.6

- continuous cost monitoring from basic evaluation through planning, implementation, operation and conversion to recycling
- unambiguous allocation of costs to their respective causers

Glossary

Benchmarking

comparing of such cost indices of buildings that relate to their geometry, quality and use, illustration in diagrams

best of class

striving for best performance within a comparable group of competitors

Building Log Book

illustration of structural characteristics regarding load bearing structure, outer shell, media and finishings for assessment of a real estate's future mutability

CAFM-System

Computer Aided Facility Management-System, use of database technologies for networking and optimising information of most varied dimensions, e.g. area, costs, personnel, processes

Central Building Control Systems

serve in controlling operational equipment such as e.g. refrigeration and heating technology equipment, air conditioning and electrictal equipment. They are employed for controlling and monitoring complex operational equipment at buildings and complexes of buildings. Basic functions of central building control systems are reporting, measuring, metering, switching and regulating (compare VDI 3814).

Core Business

all tasks that serve in achieving of one's own entrepreneurial goals (compare GEFMA 100)

Cost Elements

Structuring cost estimates, tenders and settlement in accordance with cost structure as stated in DIN standard 276

Database Models for CAFM-Systems

Currently relational, object-oriented and object-relational database systems are being used according to their task-structure.

Facility Management (according to GEFMA guideline 100)

consideration, analysis and optimisation of all processes relevant to costs and quality with regard to location, building, technical and other equipment

ID-Card Utilisation/ Process

systematic compilation of graphic, alphanumeric and visual data of each process component

Industry Standard

guaranteed future of data stock by producing and filing graphic and textual data in file formats that have long-time experience on the market (e.g. AutoCAD, Oracle)

Integral Real Estate Strategy

Marketability and adding value regarding all success factors on a cyclic real estate market

Layers

grouping functions provided by constrcution software for representing relations between different objects (e.g. storey, all load-bearing walls, all pieces of furniture)

Lifecycle

integrative consideration of a real estate’s usability throughout its entire span of life

Navigation

visual information system for more convenient user guidance

Overlay Function

facility of revising and editing CAD-construction data within a CAFM-system

Performance Contracting

is a term used for a contract which aims at optimising building services engineering and its operation. The contract fixes savings of operational costs for its duration. These savings are then to be used for financing necessary investments e.g. measures to increase energy saving. Performance Contracting defines an integral performance with regard to planning, implementation and optimising operation of building services equipment (compare VDMA 24198).

Performance Model

deliberate positive bundling of features with the aid of many partial solutions, as complementing one another as possible, to complex questions

Performance Profiles

graphic visualisation of differentiated parameters of a building’s structure in form of bar or curve diagrams

Physical Resources

material objects such as fixtures in a sickroom, books and bookshelves or machine tools

Report of Malfunction

automatic or manual report of malfunction aiming at instant trouble shooting with the facility management system's aid

Room Specifications

list of all rooms within the respective building comprising information regarding the building's structure, requirements to building services (HVAC/R) and utilisation

Structural Characteristic

constructive parameter value decisive on a project's success regarding location, building, building services (HVAC/R) and equipment

Synergetic Building Model

as opposed to traditional planning it provides for higher precision regarding cost estimates, deadline dependencies, quality assurance and operation of facilities

Synergy

a mutually advantageous conjunction or compatibility of distinct business participants or elements (as resources or efforts) [excerpt from Merriam-Webster OnLine]

Virtual Urban Model

urbanistic 3D-visualisation with increasing structural condensation of volumes formerly defined as placeholders

Index

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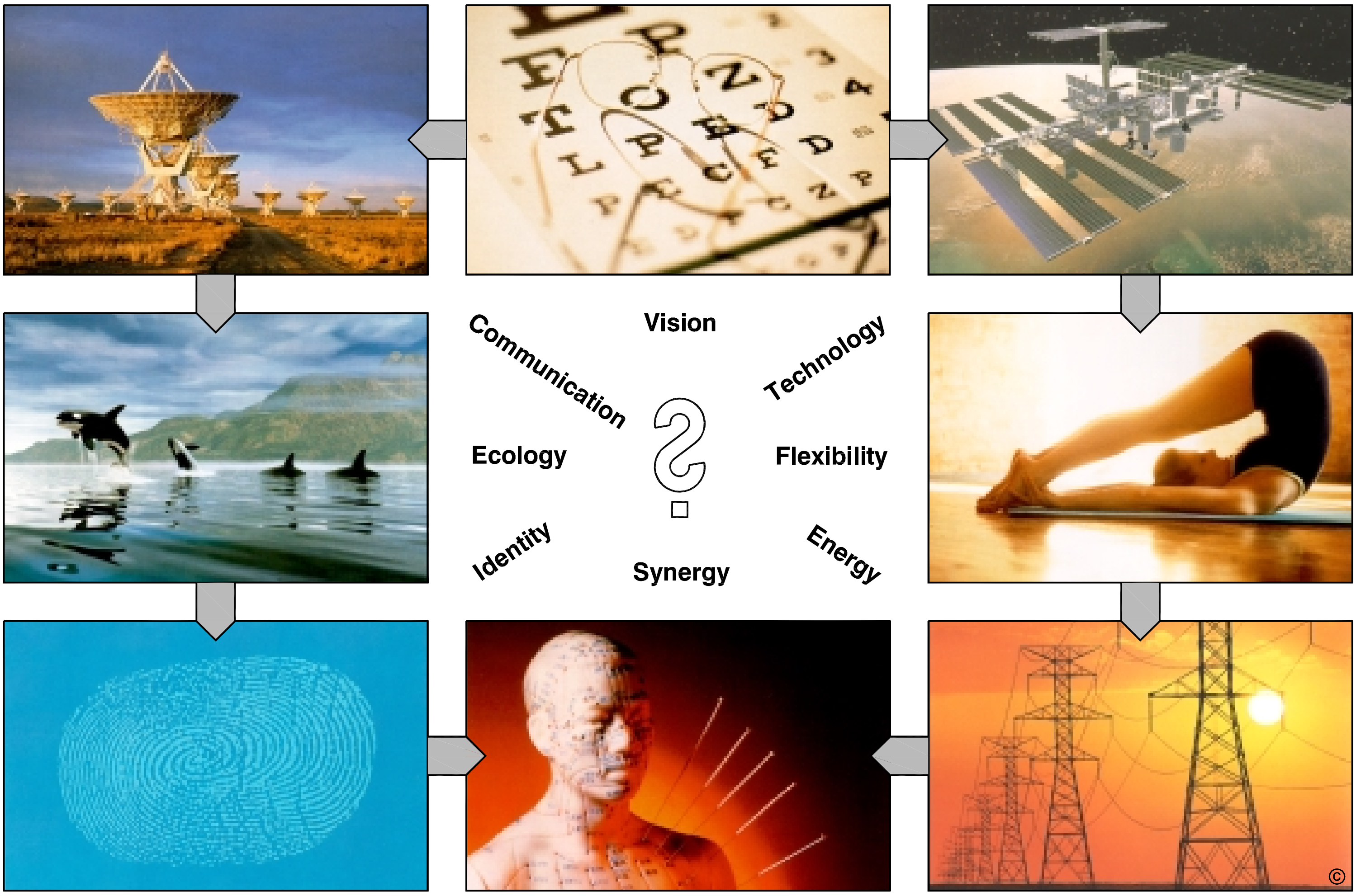
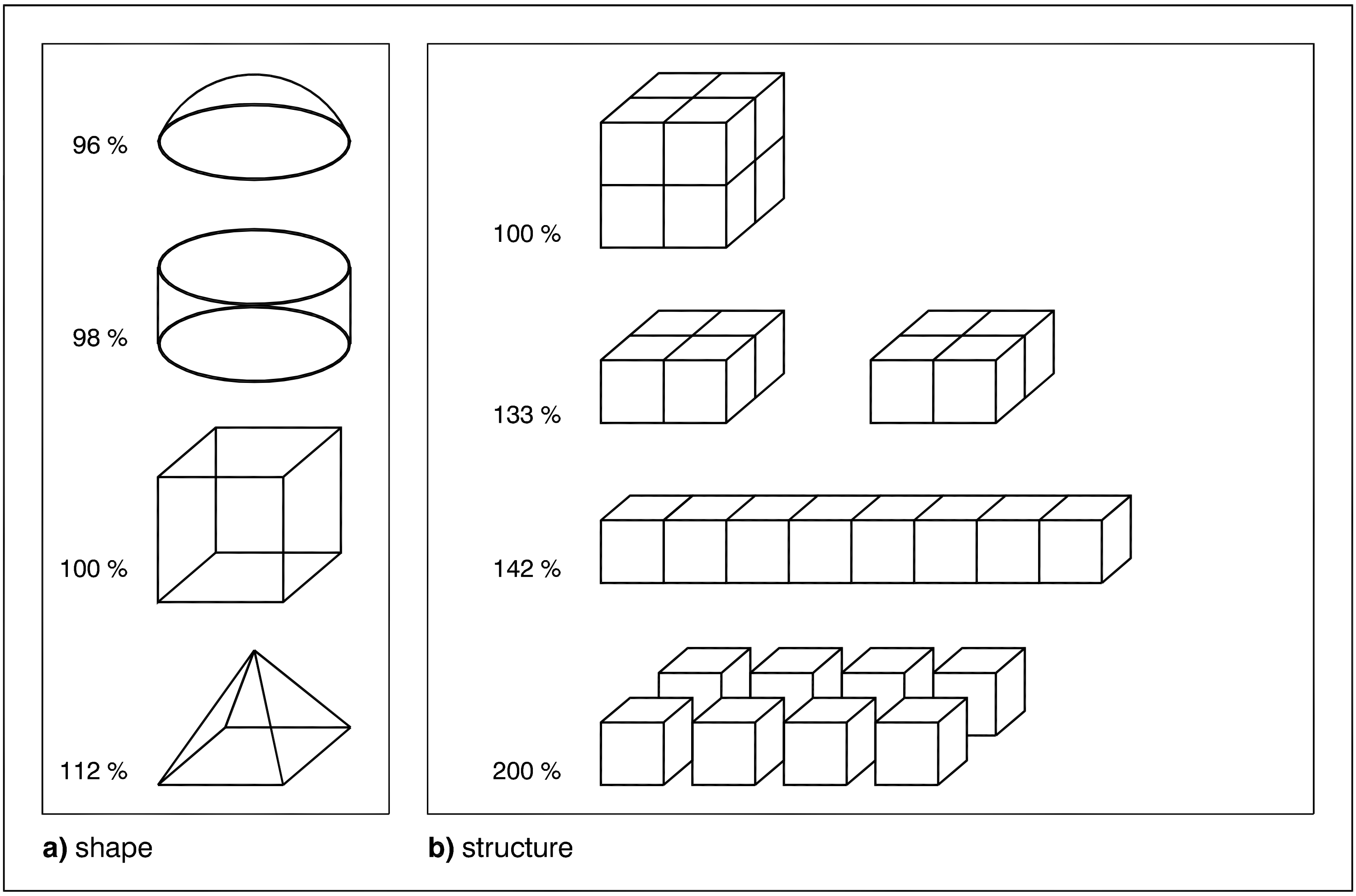
Buildings in Flux: Requirements



FM - figure 1.01

Energy: Heat Requirement of different Volumes

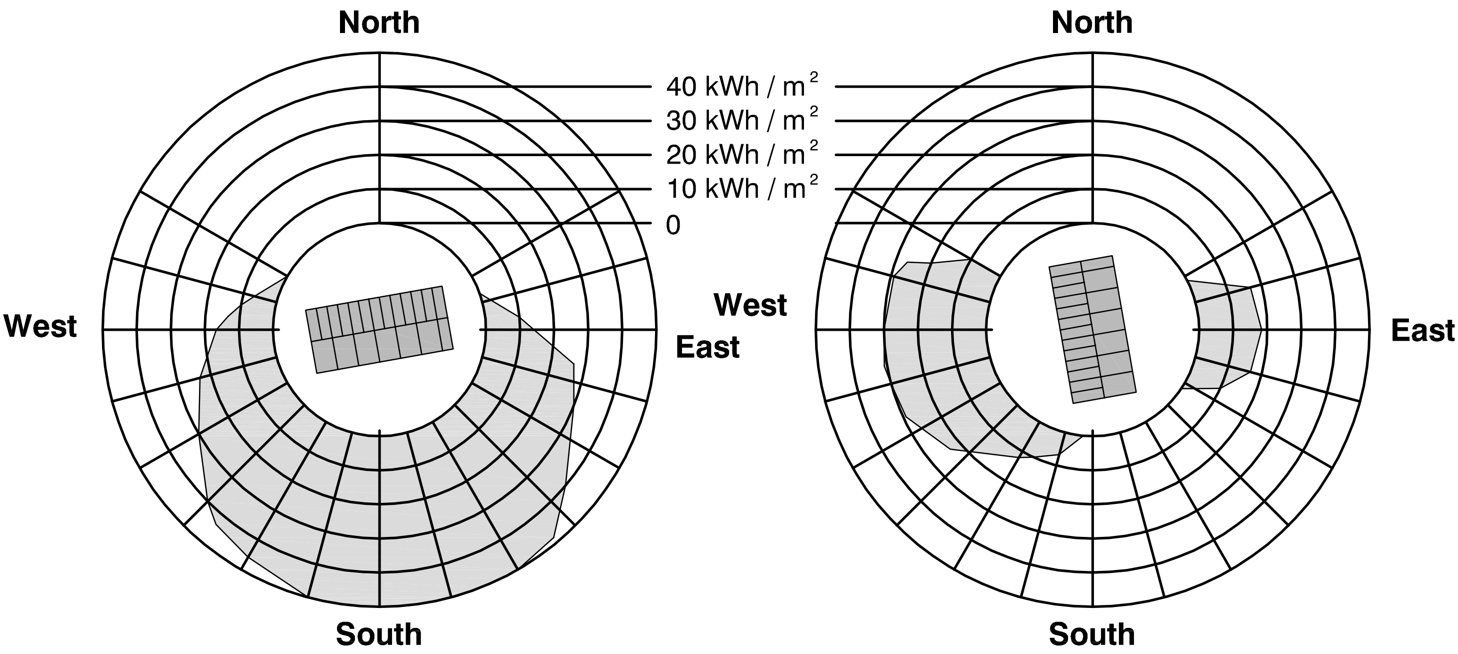
[according to Daniels]



FM - figure 1.02

Energy: Solar Radiation dependent on Building Alignment

[according to Daniels]



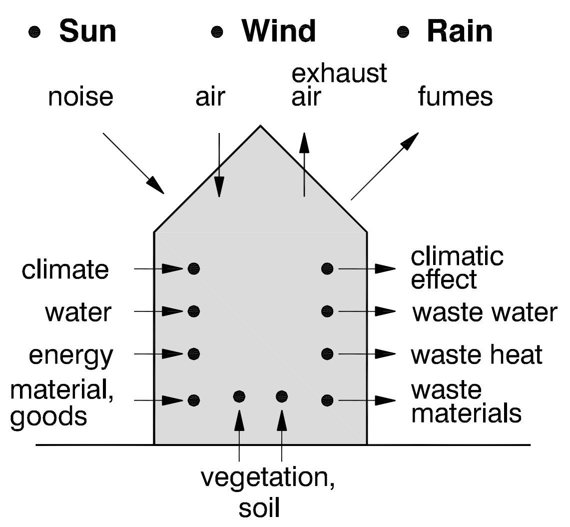
a) Solar radiation at twelve o'clock
Window orientation 170° (SSE)
Solar radiation gained in a day 255,9 kWh/sqm
window surface

b) Solar radiation at twelve o'clock
Window orientation 170° (WSW)
Solar radiation gained in a day 88,9 kWh/sqm
window surface

FM - figure 1.03

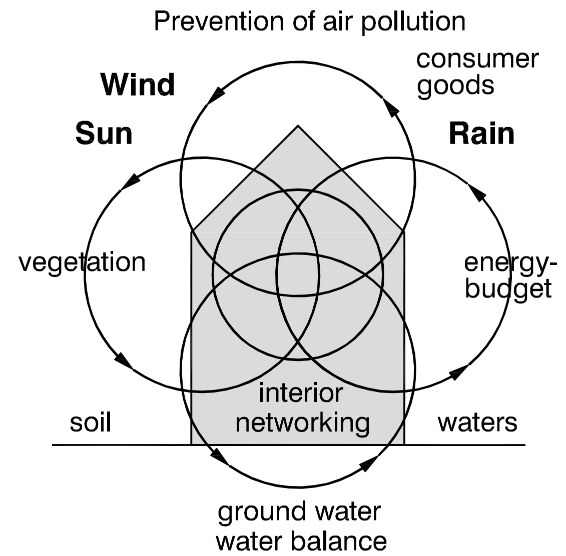
Ecology: Conventional and Adaptive Building in Contrast

[according to Althaus]



Insufficient use of Resources

- Consumption of energy, matter, waste material
- Image of our linear consumption economy



Use of Resources

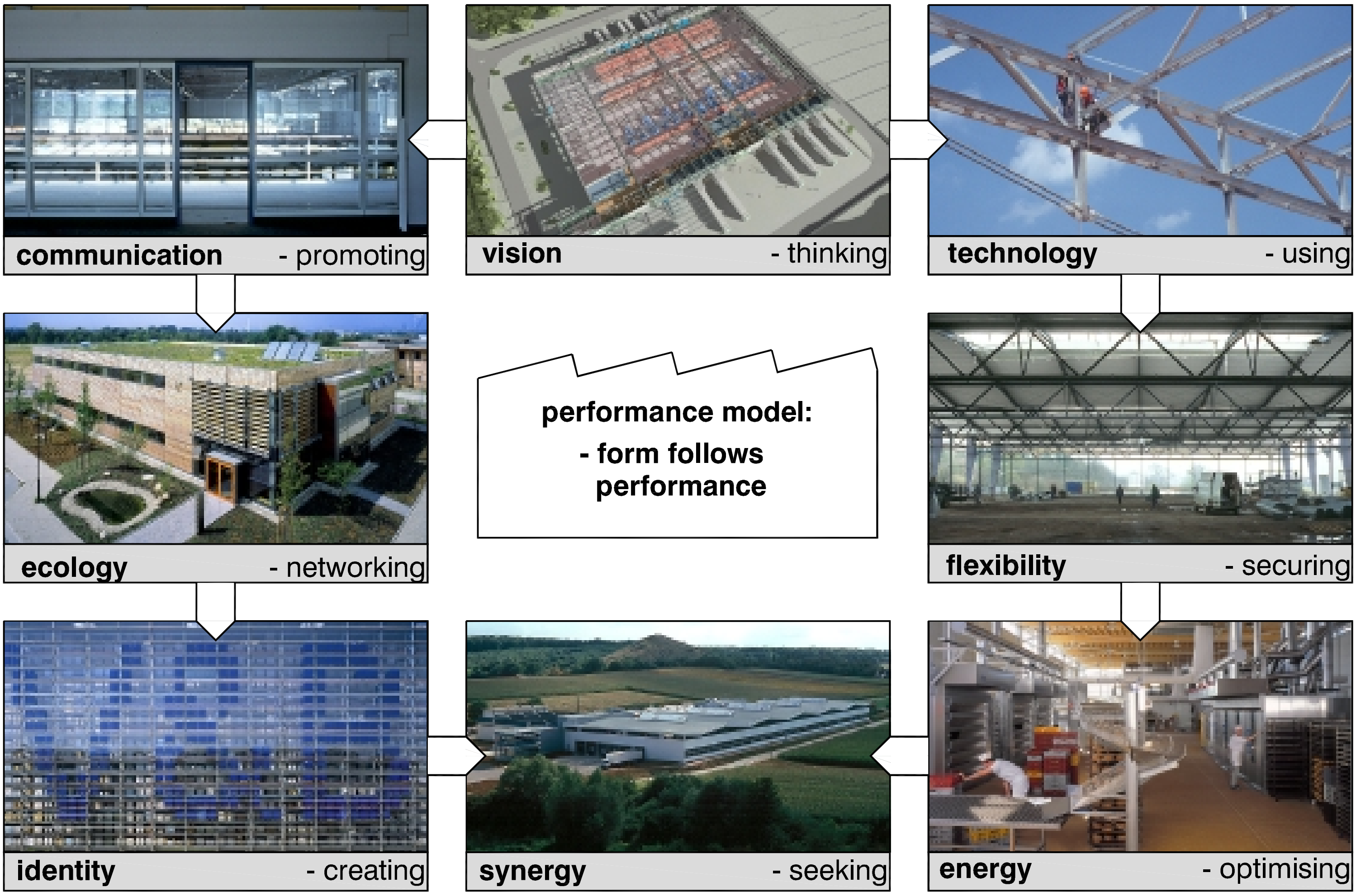
- Integrated into ecosystem
- Nature's main circulation system are interlinked and interdependent

a) Conventional Building

b) Adaptive Building

FM - figure 1.04

Performance Model: Examples for Industrial Buildings



FM - figure 1.05

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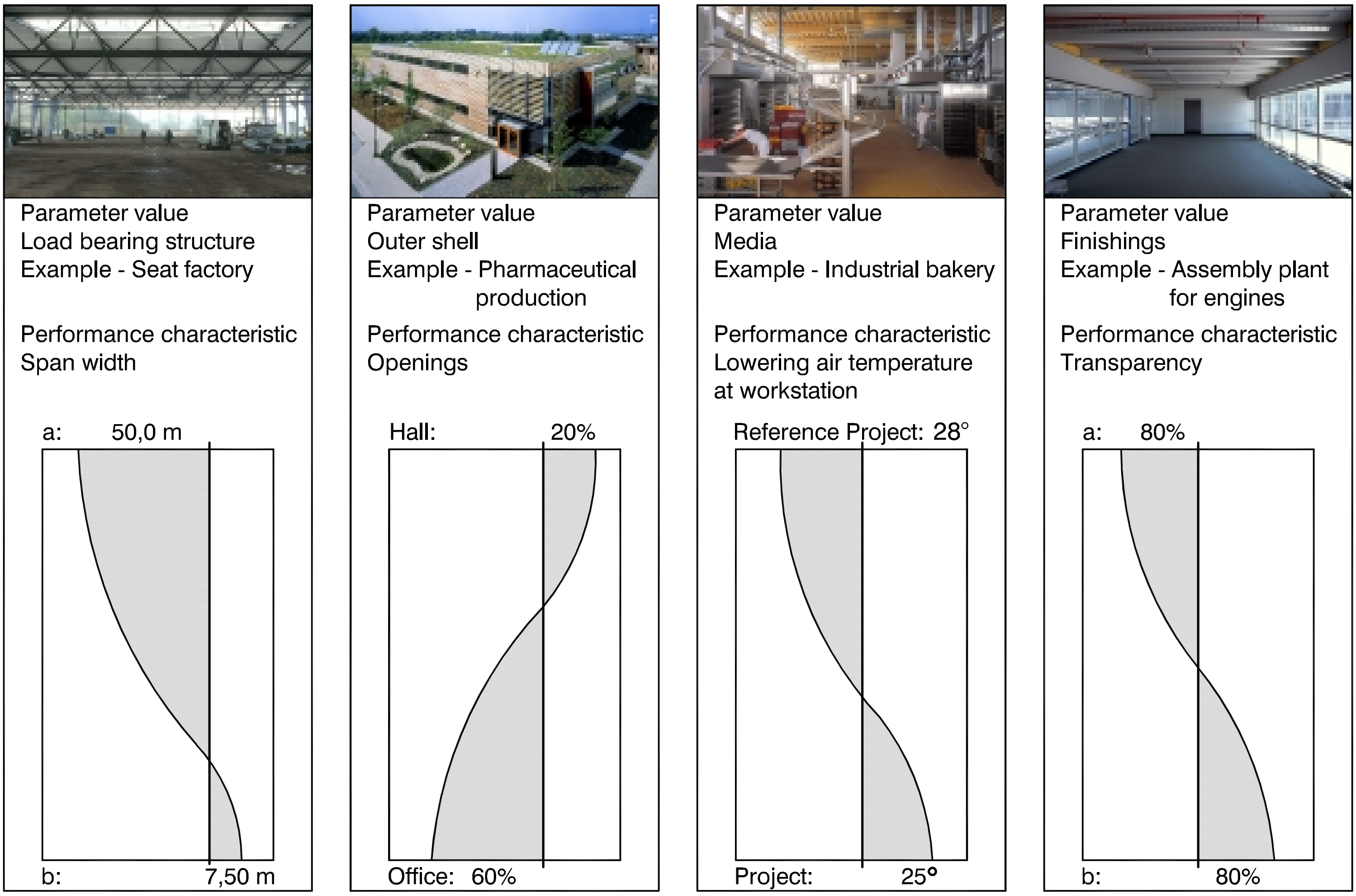
Performance Model: Built Genetic Code



FM - figure 1.06

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Location: Example for Structure Characteristics

Infrastructure
- road
- rail
- air
- sea

Supply, Disp. Media
- electricity
- water
- gas
- hot water, heating steam
- drainage
- waste water
- data networks

Site
- geometric shape / land register
- soil conditions
- obstacles existing buildings

Environment
- weather data
- ventilation
- plantation

Laws and Conditions
- zoning plans
- legally binding land-use plans
- design ordinances
- state laws
- special regulations
- master plan

Location Valuation
- prepation of land for building
- supply, disposal
- site
- labour market
- environment
- expandability
- planning and building laws
- purchasing price
- promotions

FM - figure 1.07

Building: Example for Structure Characteristics

Load Bearing Structure
- project requirements load assumptions
- structural shape / static system
- choice of material
- prinziples of joining
- profile columns, girders, ceilings

Outer Shell
- protective functions
- lighting / view
- process / logistics
- ecology / building climatisation
- energy generation
- communication

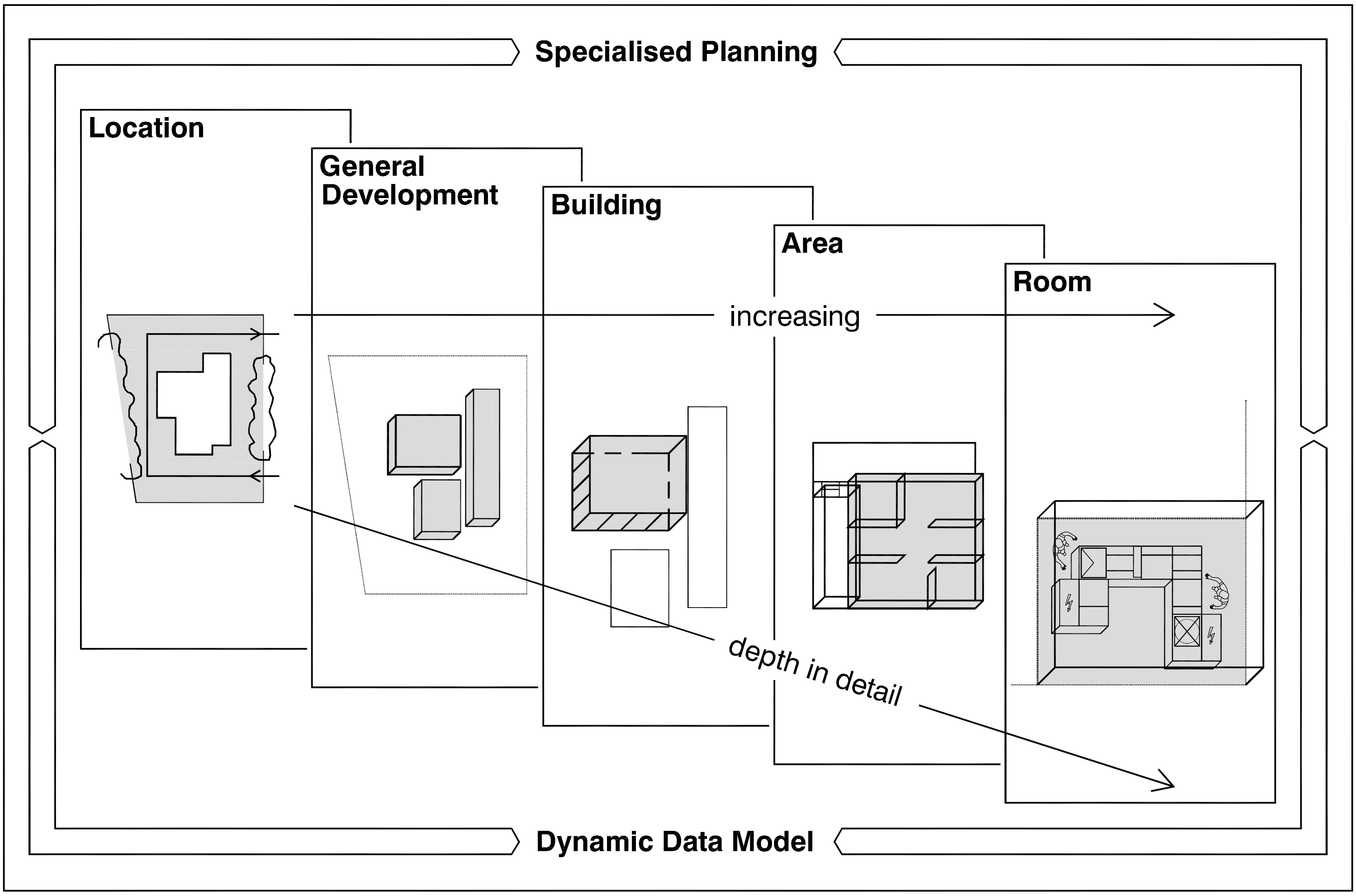
Media
- supply system process
- supply system building
- control centres
- main traces
- networks
- connections

Finishings
- floors
- walls
- ceilings
- cores
- staircases

Appearance
- structural order
- simplicity
- balance of simplicity and multitude
- distinctiveness
- emotional quality

FM - figure 1.08

Data Model: Design Levels / Design Elements



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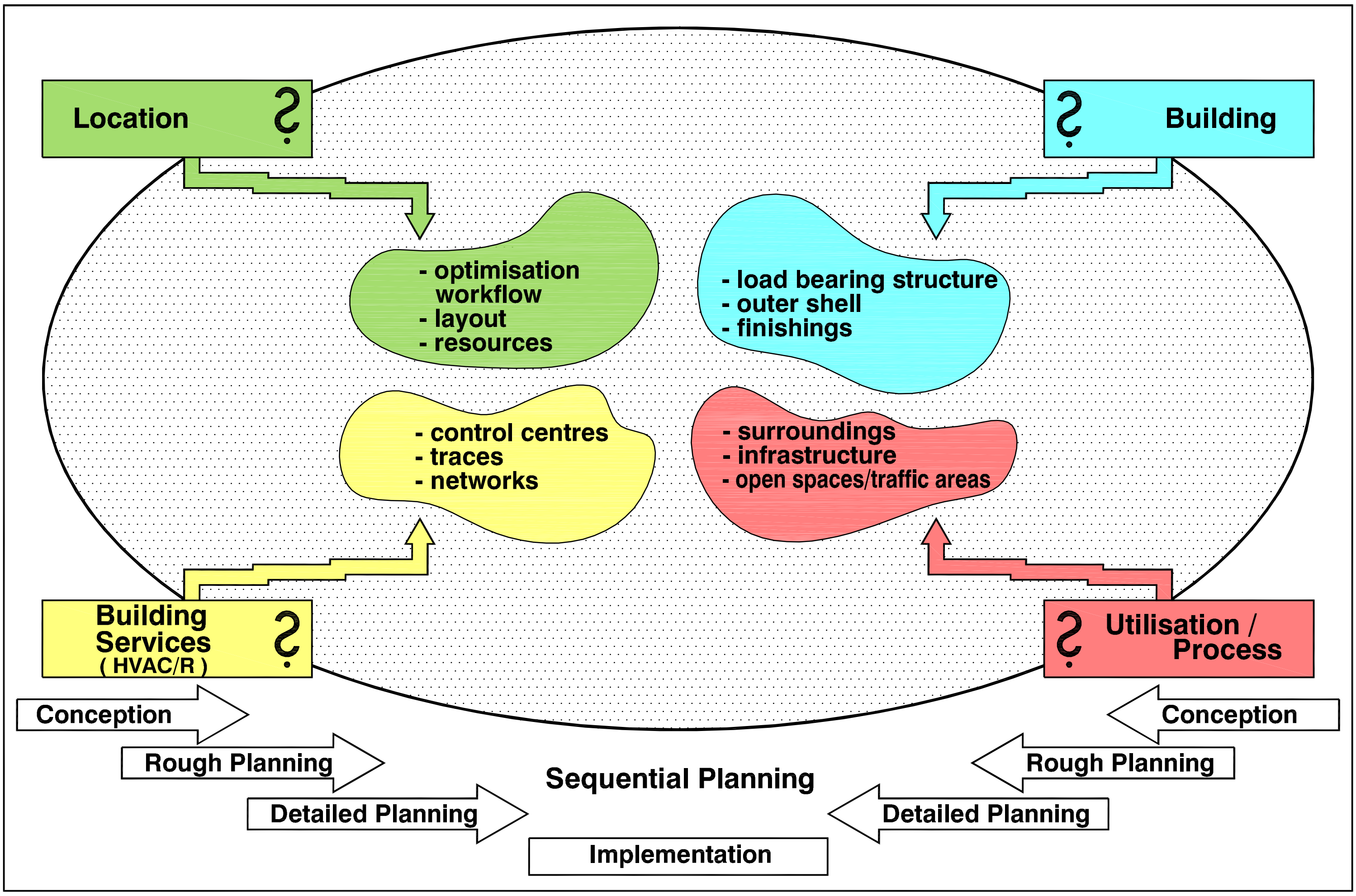
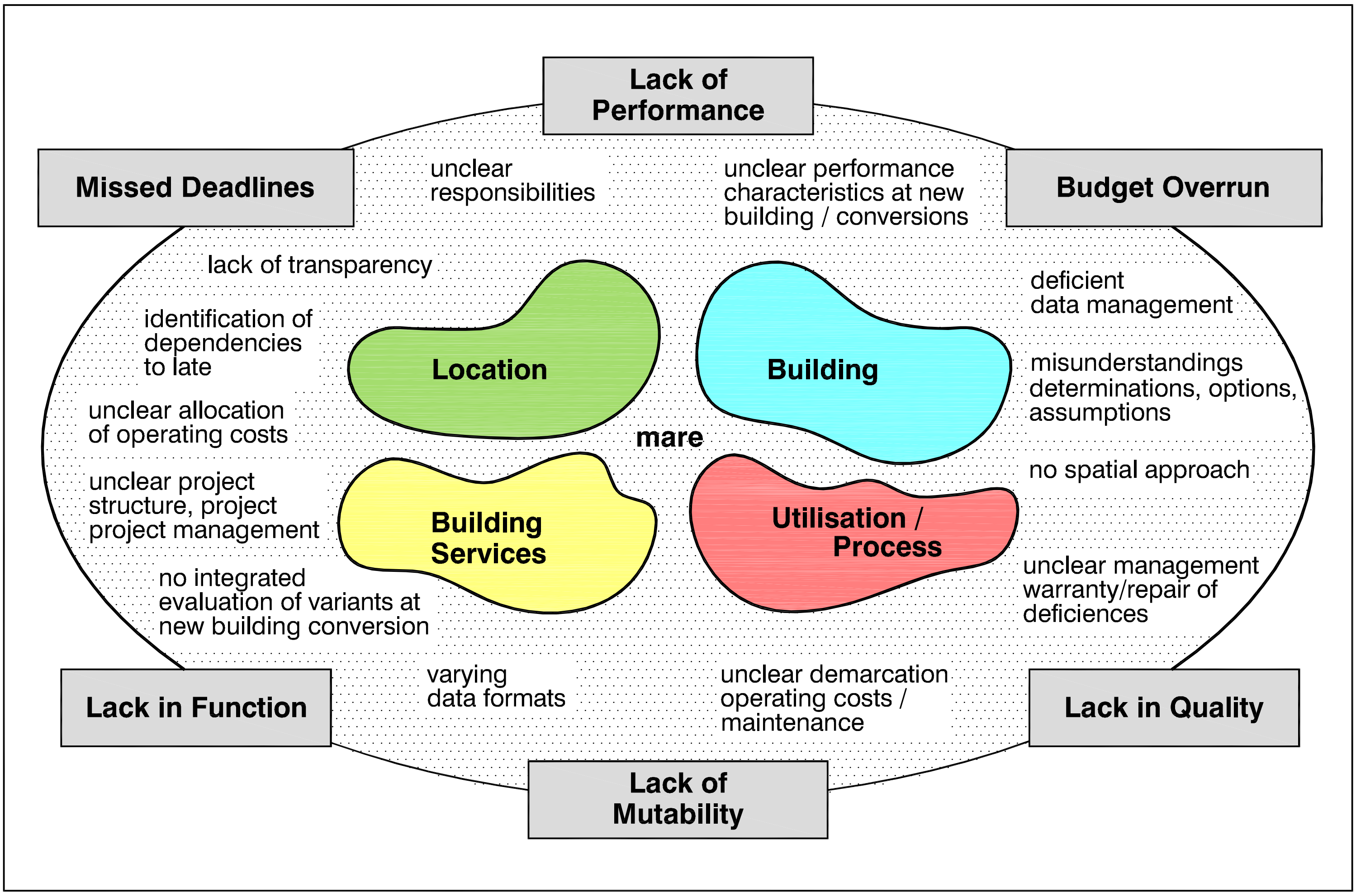
Planning / Operation: Isolated Sectoral Planning by means of many Separated Sub-projects



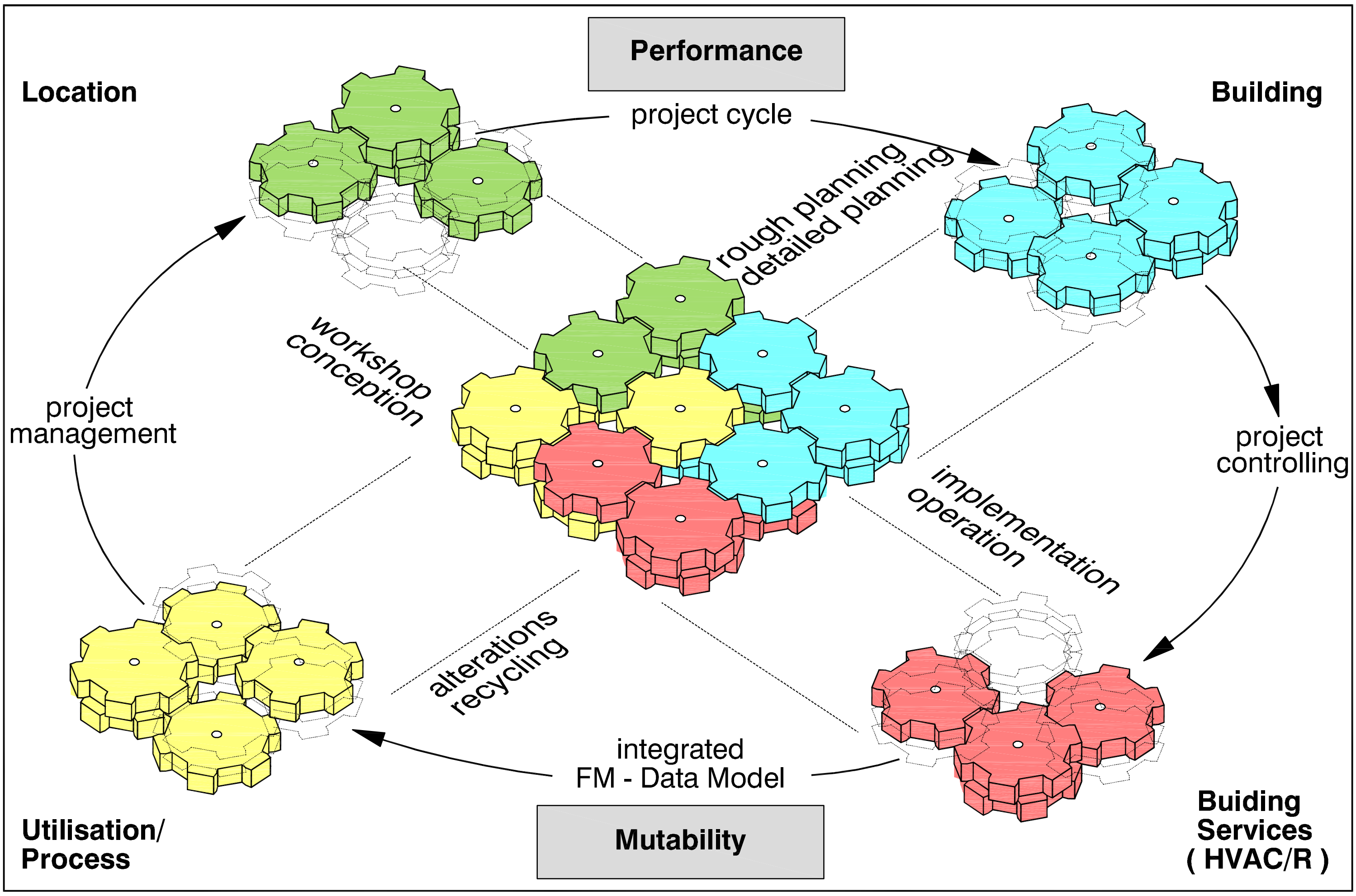
FM - figure 1.10 © J. Reichardt

Planning/Operation: Frequent Shortcomings caused by Interfaces of Sub-Projects



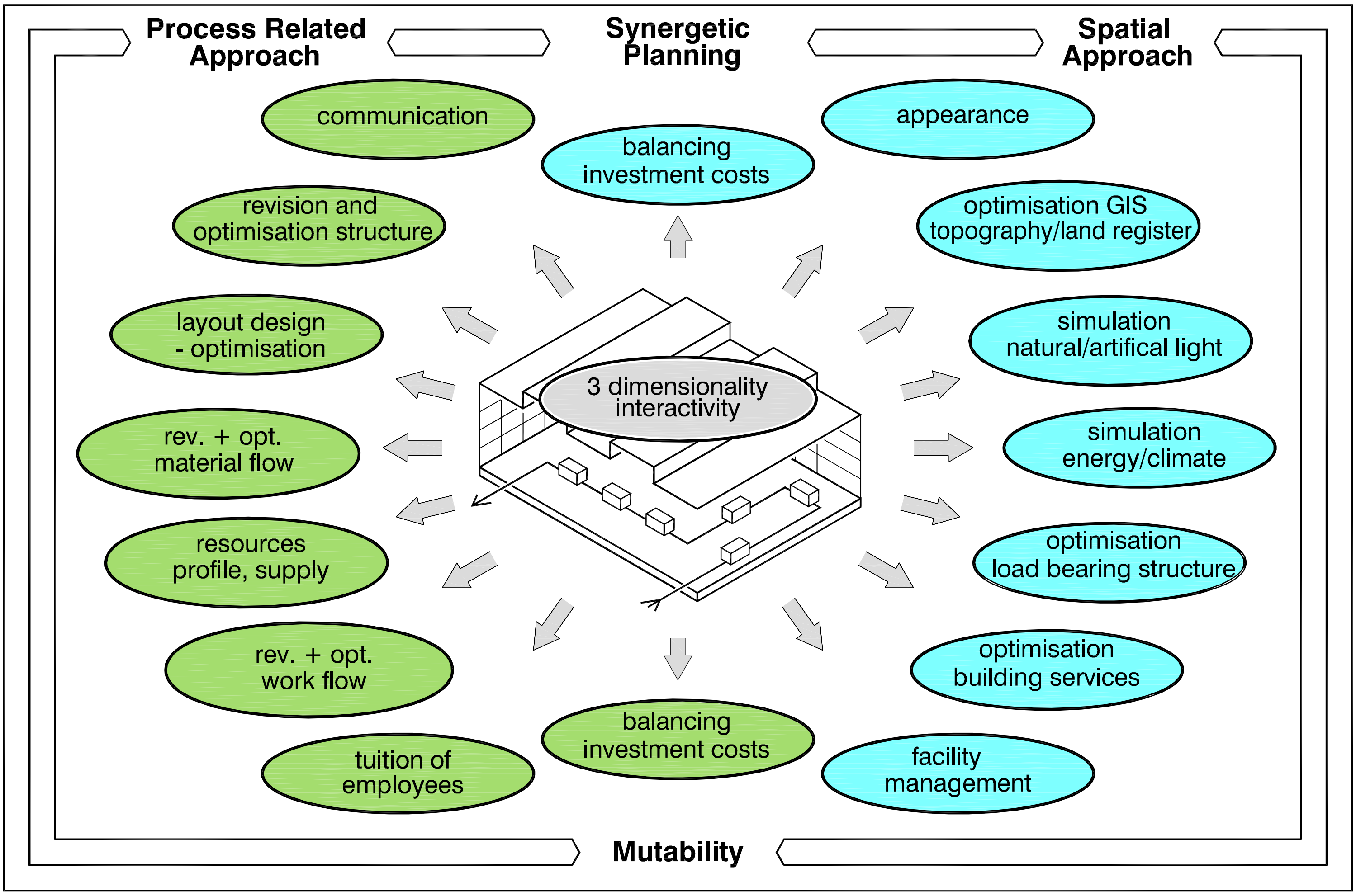
FM - figure 1.11

Synergetic Planning / Operation: Integration of Sub-Projects



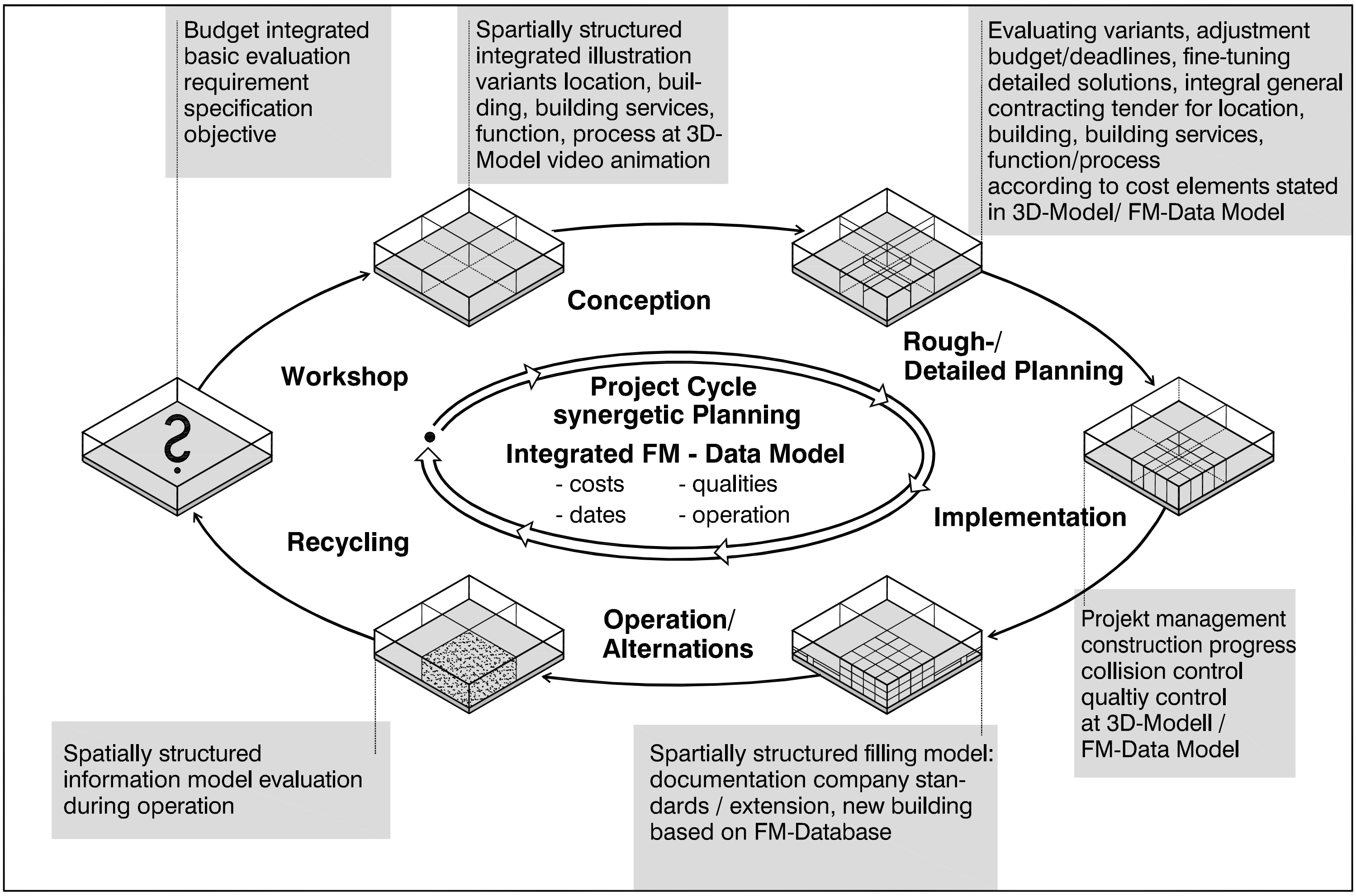
FM - figure 1.12

Evaluations provided by Synergetic Data Model: Example - Factory Design



FM - figure 1.13

Synergetic Quality Cycle by means of 3D-Data Model



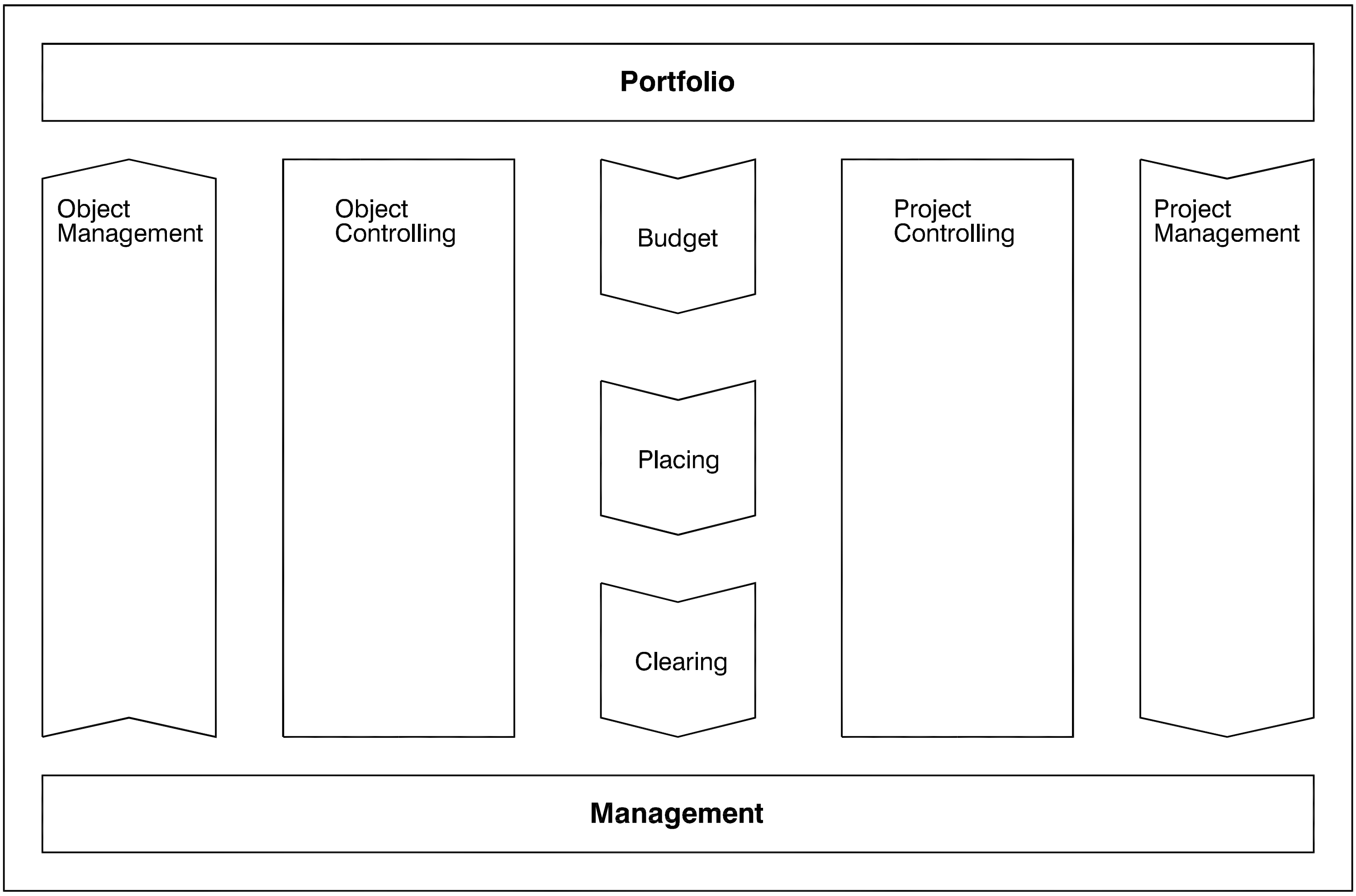
FM - figure 1.14

Tasks of Facility Management regarding Real Estate

Acquisition and Provision of up-to-date Data	Evaluation of Locations, Buildings and Equipment	Space and Utilisation Planning	Operations and Maintenance Management	Budgeting and Valuation
• premises	• work surroundings	• workstations	• utilisation costs	• valuation of measures
• buildings	• concepts for organisation	• physical	• service costs	• developing alternatives
• building services systems	• consequential costs	• legal	• maintenance concept	• consideration of lifecycle
• equipment	• appearance	• ergonomic	• lifecycle data	• consideration of ecologic consequences
• degree of utilisation	• security, safety	• organisational	• operations	
• market value		• sociological		

FM - figure 2.01 © J. Reichardt

Project Controlling as Part of Facility Management [according to Wildgruber]



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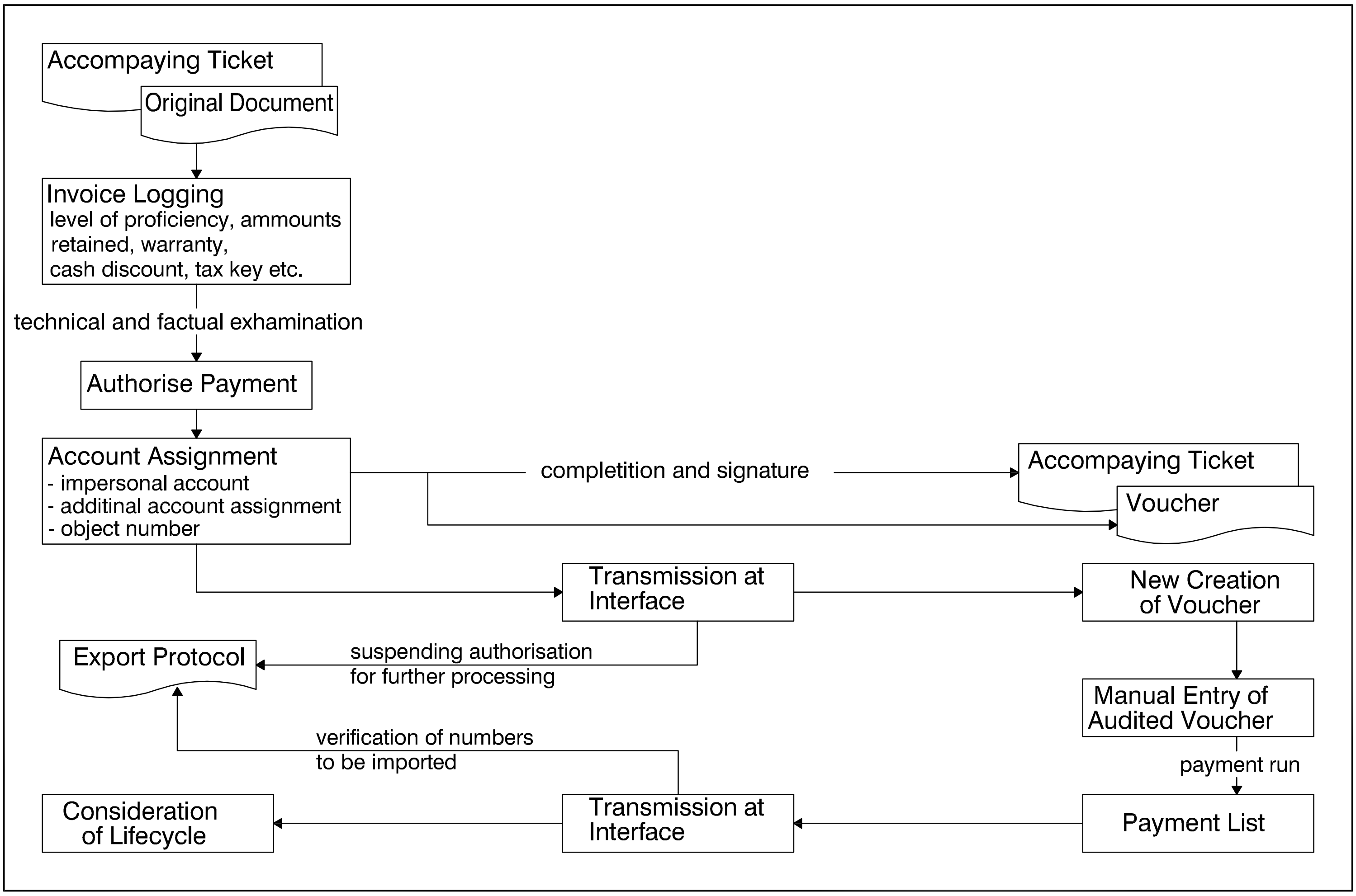
Process Flow of Integrated Invoice Logging

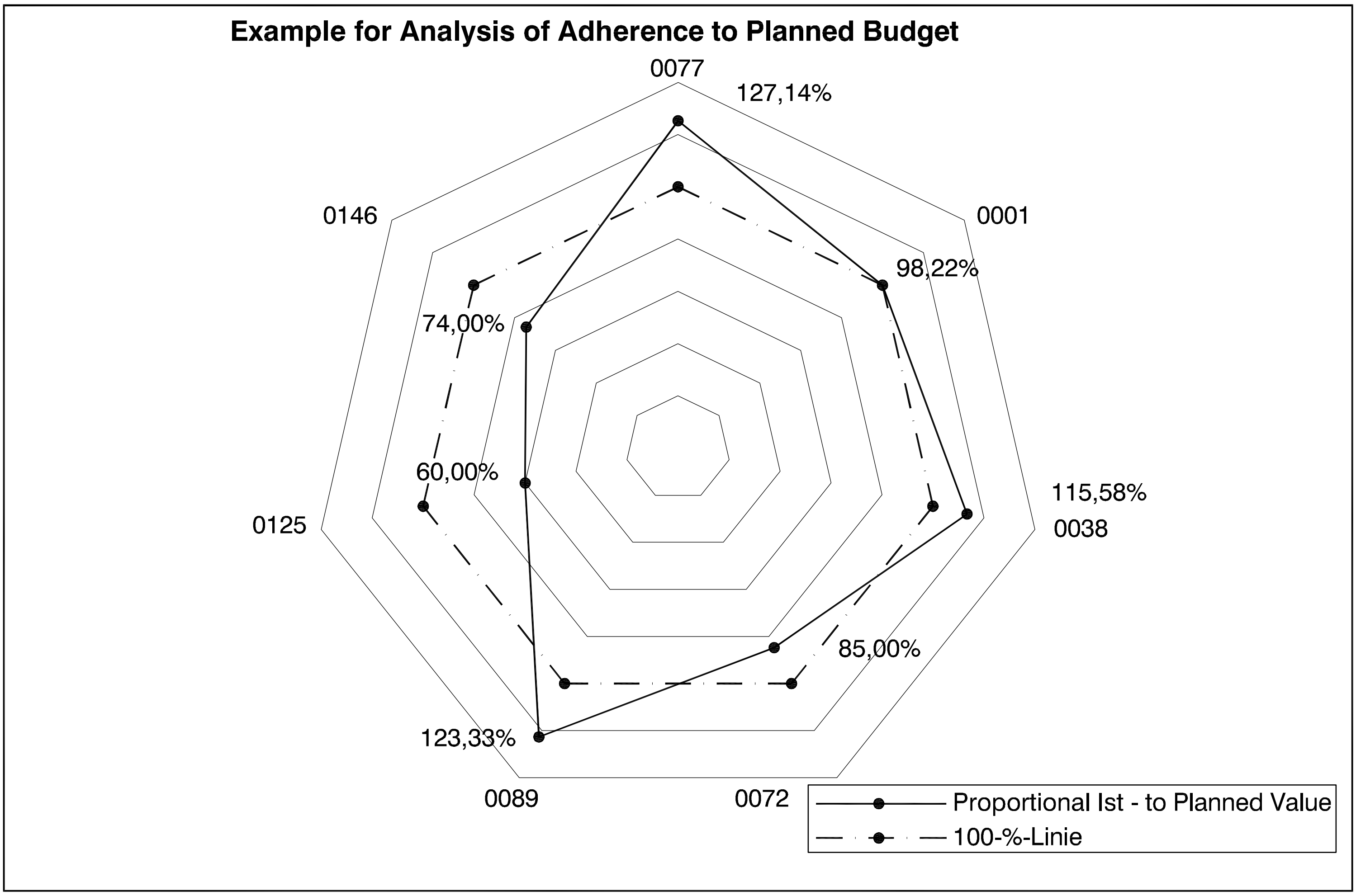
[according to Wildgruber]



FM - figure 2.03

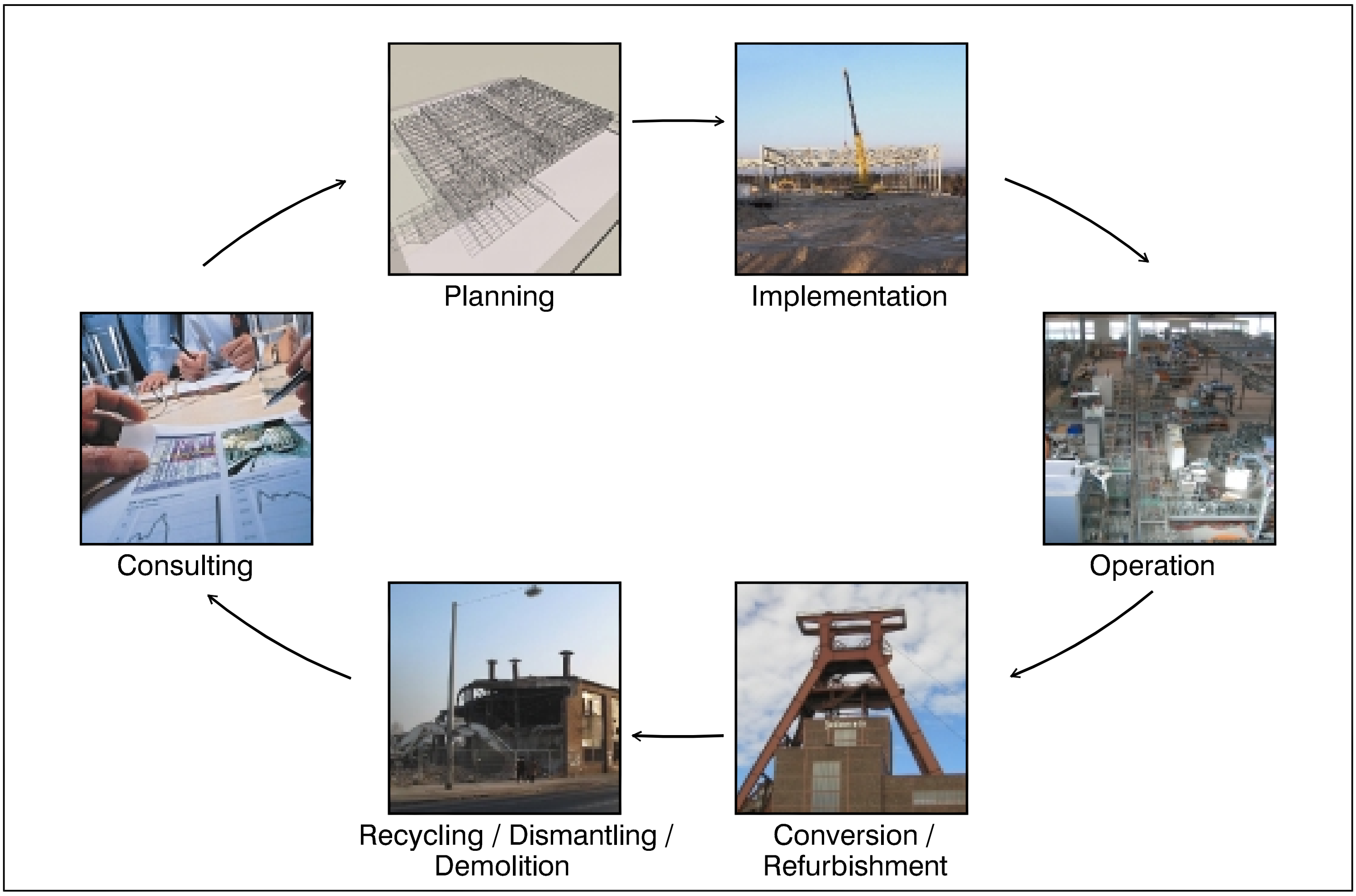
Comporative Portfolio Analysis of Objects

[according to Wildgruber]



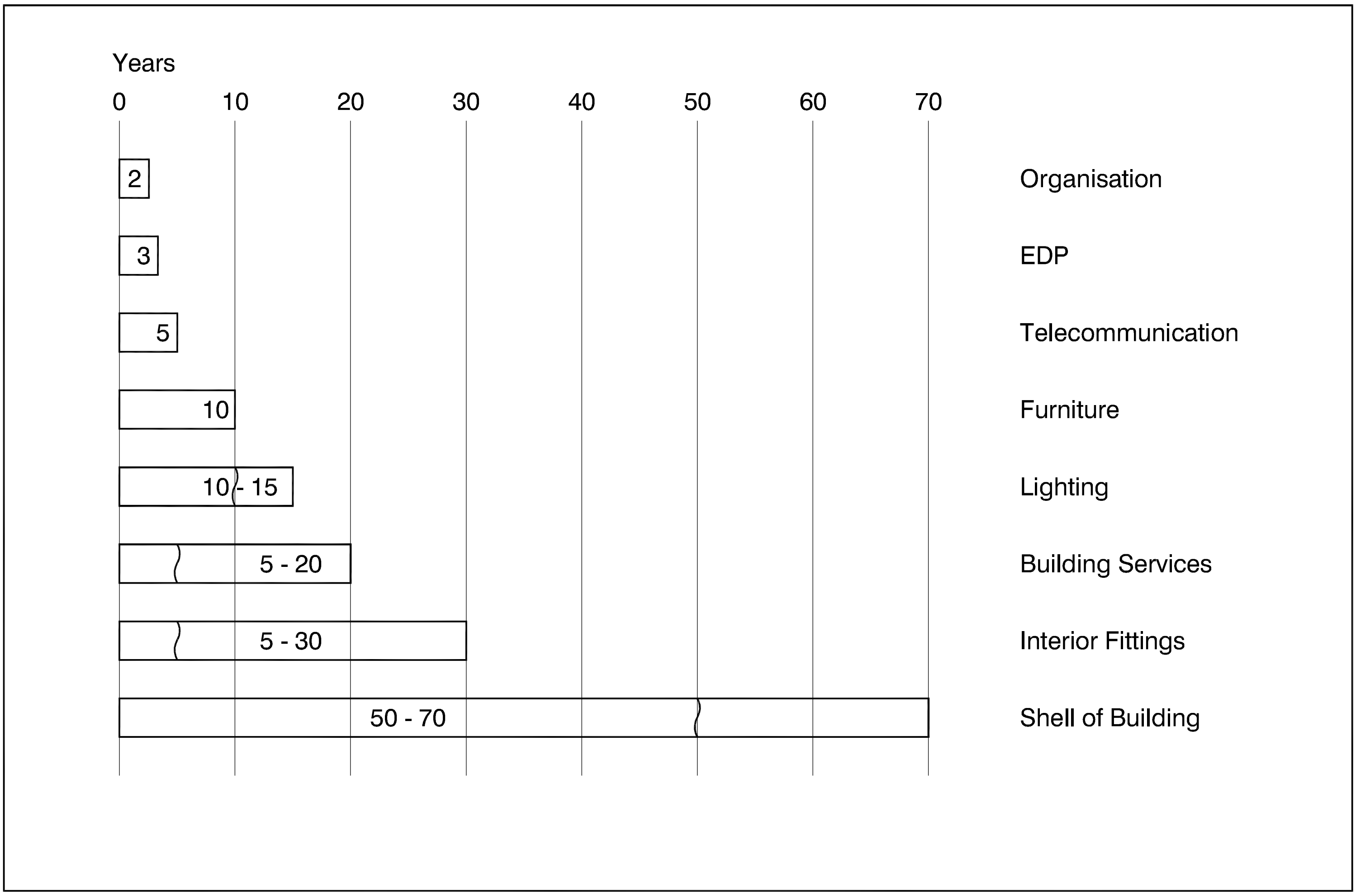
FM - figure 2.04

Stages in the Lifecycle of Real Estate



FM - Abb. 2.05

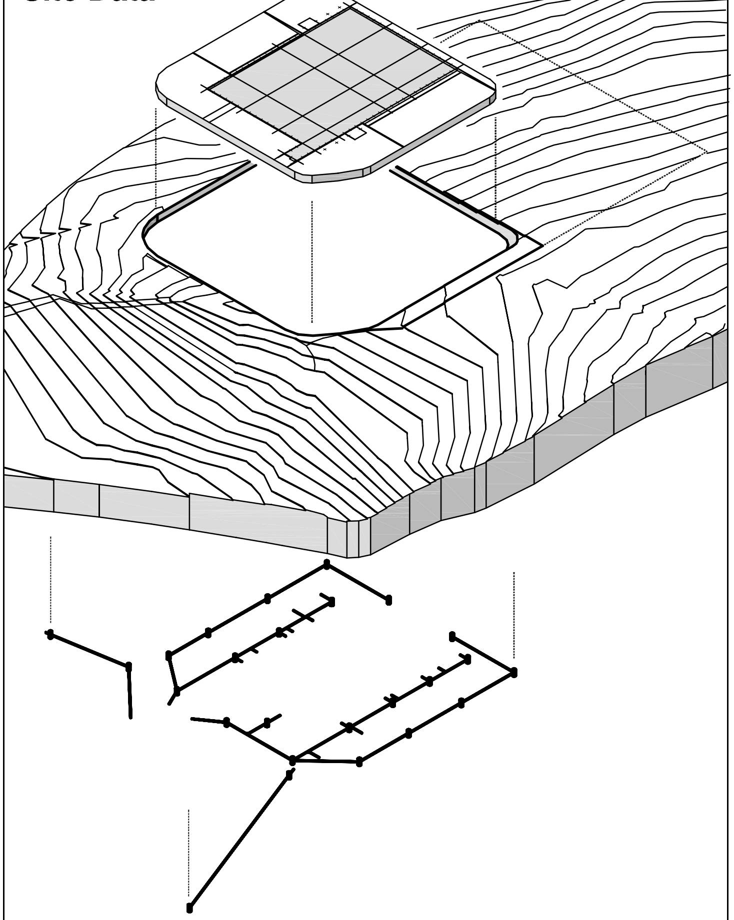
Alteration Intervals regarding Existing Property, Examples



FM - Abb. 2.06

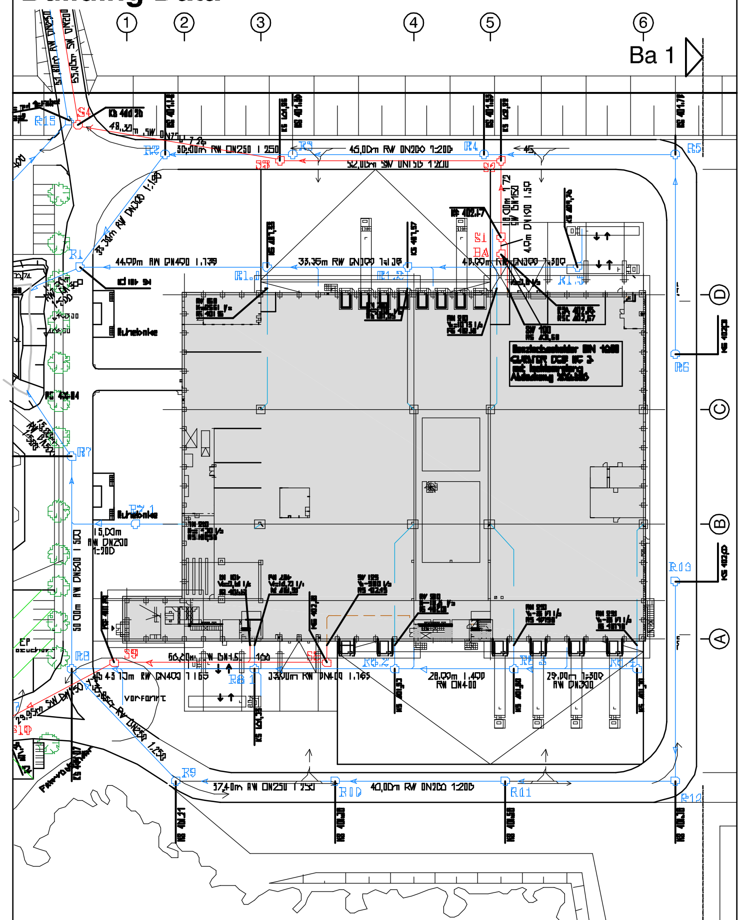
3D-Data Model of Supply and Disposal at an Assembly Plant

Site Data



3D-Data Model Media

Building Data

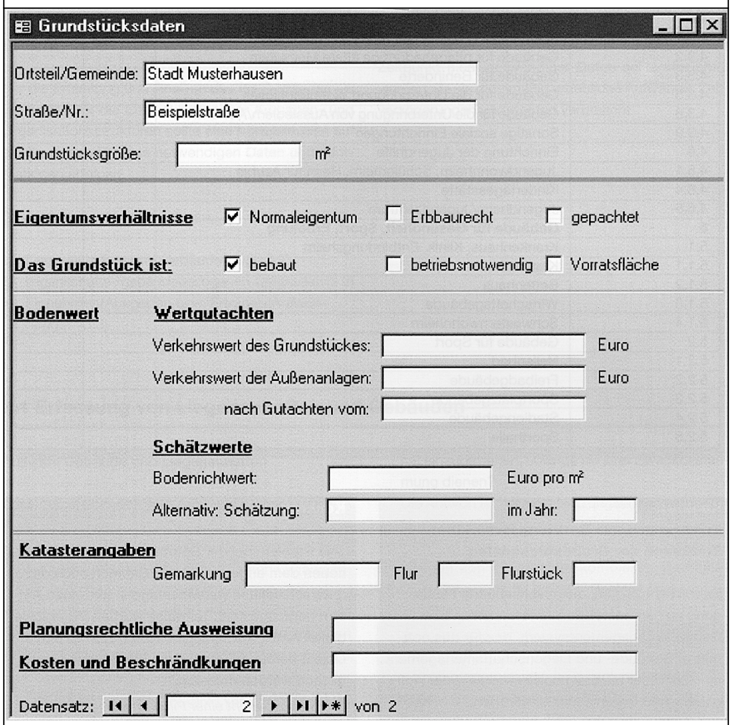


2D-Excerpt Media

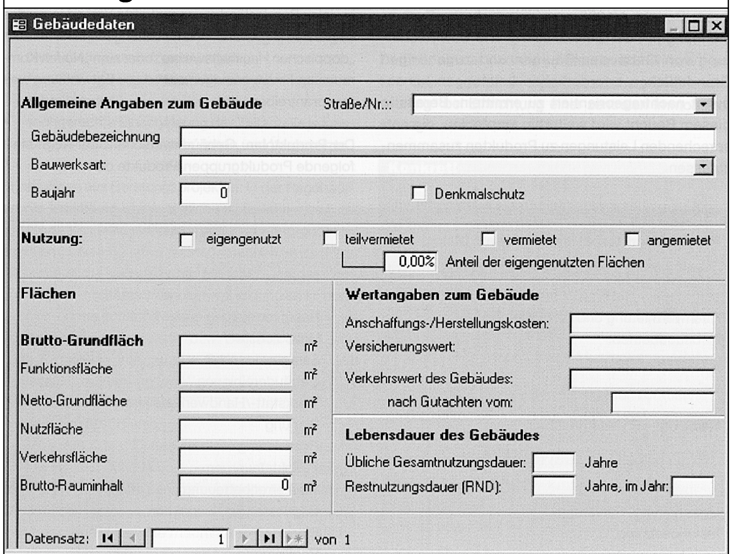
FM - figure 2.07

Example for an Input Mask - Communal Real Estate

Site Data

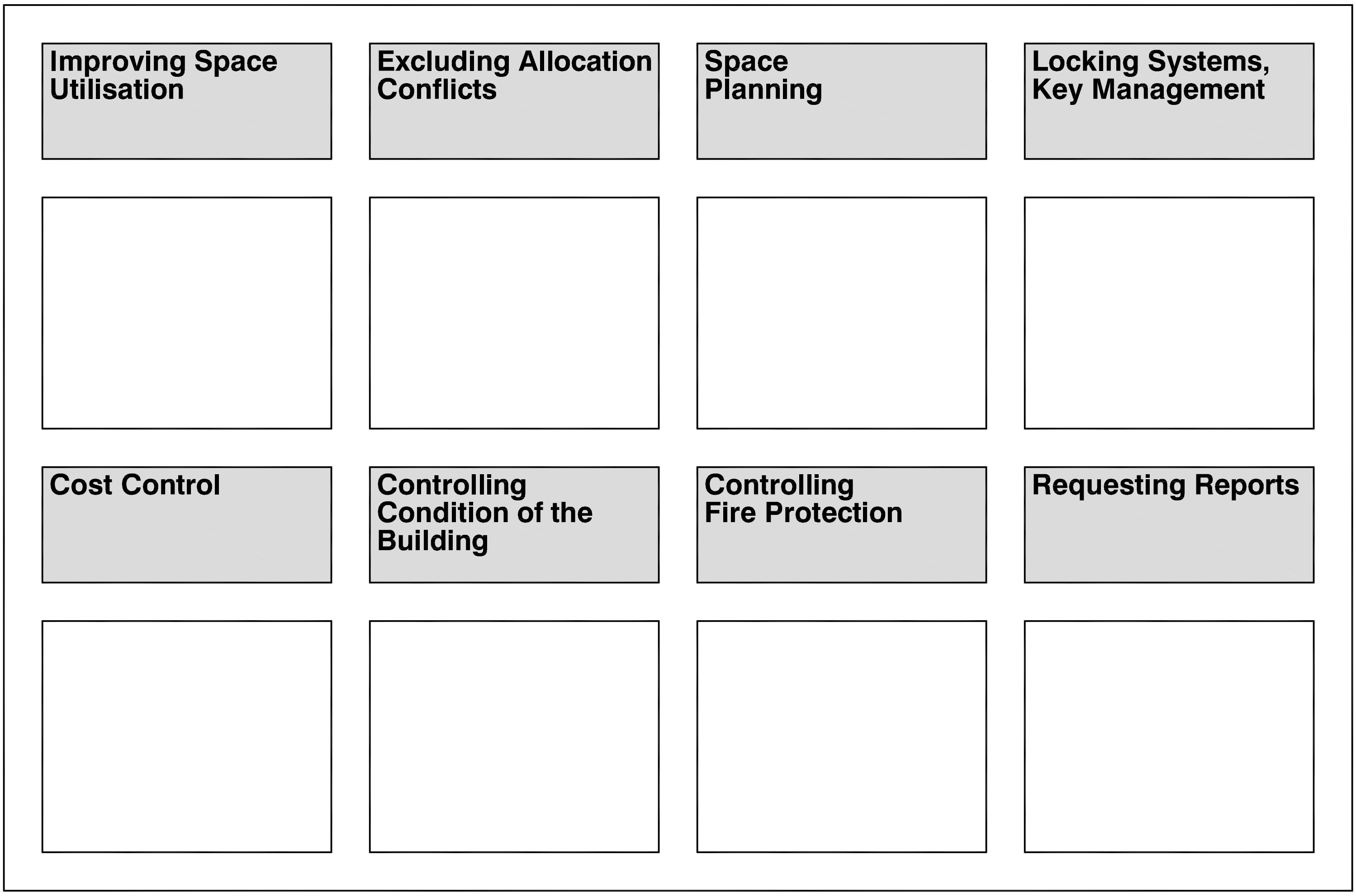


Building Data



FM - figure 2.08

Data Evaluation - Facility Management of a Building



FM - figure 2.09

Cost Structure of a Building according to DIN Standard 276

300 Building - Construction
310 Excavation Pit
320 Foundation
330 Exterior Walls
340 Interior Walls
350 Ceilings
360 Roofs
370 Constructive Fixtures
390 Miscellaneous

100 Site

200 Preparation of Land for Building

300 Building - Constructions

400 Building - Technical Equipment

500 Outside Facilities

600 Fittings and Artwork

700 Ancillary Construction Costs

			Flächen				Cubature			Guide Value Costs€ Net Sub-Project			
Code	DIN	Sub-Proj. New Factory	Outside F	Areas A1	Areas A2	Gross Floor	Factor	SOI	GC	Construction	Building Service	Open Space	Total
	276	excl.Conv.of exist.Bldg	qm	Bereich qm	Rest qm	area qm	F1/BGI	FSR	m3	Cost Group 300	Cost Group 400	Cost Group 500	Cost 3-500
		converted area				6.016,00							
		sealed outs.area logistic	2.640,00										
		sealed outside area	1.440,00										
		unsealed outside area	0,00										
		Total Side	**4.080,00**										
		production		4.750,00									
		despatch dep.		519,00									
		adaption/ ramp		328,00									
		workshop		40,50									
		spare parts inventory		40,50									
		qs - lab		40,50									
		dayroom		20,00									
		first-aid room		20,00									
		(finish.cont. room option		42,00	plus								
		gs-loading room		44,00	total								
		wc - gents		10,00	operation area								
		wc - ladies		10,00	construct. Area								
					traf.area,stairs								
		Total Ground Floor		**5.862,50**	154,00	**6.016,00**							
		shell of building only, gal											
		lery, ceiling, connections											
		staircase / core 1		20,00									
		staircase / core 1		20,00									
		Total First Floor		**40,00**	0,00	**40,00**							
		contr.centr. air conditions											
		contr.centr. compr. air			plus								
		contr.centr. heating			total								
		(mainten. runways option			operation area								
					construct. Area								
					traf.area,stairs								
		Total Second Floor		**500,00**	80,00	**580,00**							
		Total Areas Project		**6.402,50**	234,00	**6.636,00**				**6.636,00**	**6.636,00**	**4.080,00**	
		Summe Cubature Proj.							80.963,00				
		Gui.Val./m2 Open Space										**55,00**	
		Gui.Val./m2 Gr.Fl.Area								**405,00**	**100,00**		**505,00**
		Gui.Val./m3 Gr. Cubage								44,09	10,89		54,97
		Total Gui. Val. Project								**2.687.580,00**	**663.600,00**	**224.400,00**	**3.575.580,00**
	zus.	plus conversion/extension Existing								50.000,00	225.000,00	25.000,00	300.000,00
		control centres / assumptions											

FM - figure 2.10

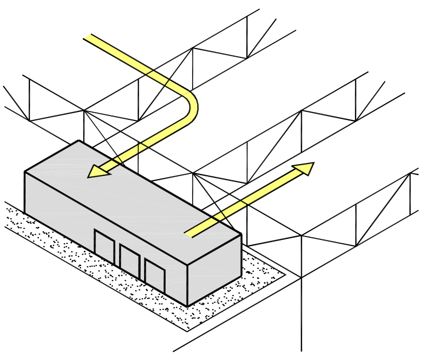
Cost Centres Building Services according to DIN Standard 276

400	**Building - - Technical Installations**	Costs of all technical installations or their components fitted, connected or fixed to a building
410	**Wastewater, Water, Gas Installations**	drains, wastewater pipes, wastewater collectors, wastewater treatment,
411	Wastewater Installations	water harvesting, water conditioning, pressure-increasing systems, piping, local water-heating installations,
412	Water Installations	sanitary ware
413	Gas Installations	gas installations for operational heat: gas storage and gas production plants
420	**Heat Supply Systems**	fuel supply, heat transfer stations, heat production by fuel or inexhaustible energy sources
421	Heat-Producing Appliances	radiators, heated surfaces
422	Heat Distribution Networks	
423	Space Heating	
430	**Aerial Engineering Plants**	plants with and without ventilation function
431	Ventilation Systems	exhaust air plant, supply air plant, exhaust and supply air plants without or with thermodynamic air conditioning function
432	Partial Air Conditioning System	plants with two or three thermodynamic air conditioning functions
433	Air Conditioning System	plants with four thermodynamic air conditioning functions
440	**High Voltage Installations**	
441	High and Medium Voltage Systems	switchgears, transformers
442	Individual Power Supply Plant	power generators including cooling, exhaust gas systems and fuel supply
443	Low Voltage Switchgears	low voltage main distributors, idle current compensation plants
		individual systems include respective distributors, wires and conductors
450	**Telecommunication and IT-Systems**	
451	Telecommunication Systems	
452	Paging and Signalling Systems	onsite paging systems, visual and audible signals, door phones and door openers
453	Clocking Systems	time and clocking systems
460	**Conveyor Plants**	
461	Lifts	lifts, goods lifts
462	Escalators, Conveyor Belts	
463	Maintenance Lifts	building maintenance systems and other maintenance lifts
470	**Installations for Specific Uses**	Costs of those installations fixed to a building that serve special purposes, however excluding structural fixtures (cost group 370)
471	Kitchen Technology	equipment for preparing, handing out and storing of food and drinks, respective cooling systems including respective water conditioning, disinfection and sterilisation systems
472	Laundry and Purification Plants	
473	Media Supply Systems	medical and technical gases, vacuum, liquid chemicals, solvents, demineralised water; including storage, production plants
480	**Building Automation**	costs of inter-equipment automation including respective distributors, wires and conductors
481	Automation Systems	automation stations, operating and monitoring facilities, programming facilities, sensors and actors, communication interfaces, software at automation stations
482	Performance Components	switch cabinets with performance modules, control units and fuse modules
483	Central Facilities	control stations with peripheral equipment, equipment for system communication to automation stations
490	**Miscellaneous Measures for Technical Installations**	comprehensive measures concerning technical installations that cannot be allocated to individual cost groups of technical installations or cannot be recorded in other cost groups
491	Site Facilities	set-up, provision, operation and vacation of superordinate site facilities
492	Scaffolding	set-up, provision, alteration and dismantling of scaffolding
493	Safeguarding Measures	safeguarding measures at existing buildings, e.g. underpinnings, supports

FM - figure 2.11

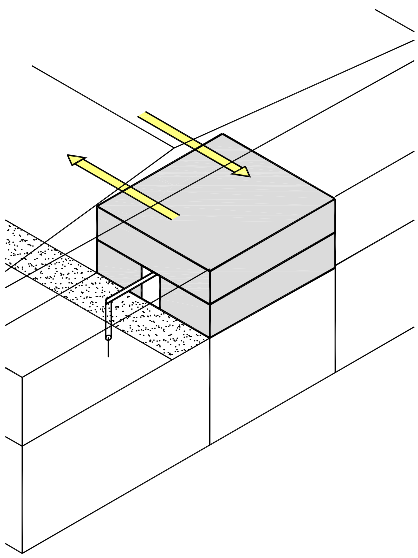
Positioning of Control Centres, Examples

Assembly Plant for Coolant Systems



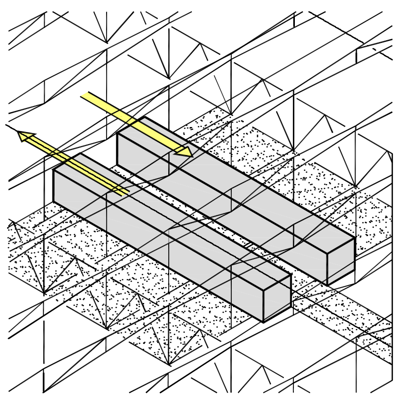
Access/Maintenance partially via interior of hall

Assembly Plant for Engines



Access/Maintenance exterior only

Tyre Fabrication: Gallery incorporated in Load Bearing Structure

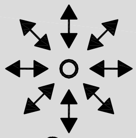
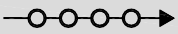
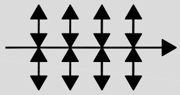
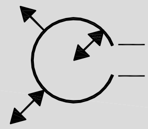
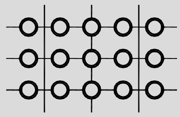
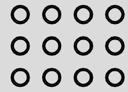


Access/Maintenance interior via gallery and maintenance runways

FM - figure 2.12

Advantages and Disadvantages of Distribution Structures for Media

[according to Reinhard]

	 **Star**	 **Ordinary Longitudinal Flow**	 **Ramified Longitudinal Fl.**	 **Ring**	 **Network**	 **Punctual, Vertical**
Reliability	+ +	− −	+	−	+ +	+ +
Dependency Machine Positioning	enables flexible positioning of machines	machine pos. sensible linear only	branches optional extensible (low dependency)	adding branches optional limited by ring	no dependency	supplying as needed
Extension Flexibility	central point extension limited (poor extensibility)	good extensibility within lines further structures impossible	very good extensibility	circular shape extension limited (poor extensibility)	circular shape extension limited (poor extensibility)	very good extensibility
Extension Complexity	duplication of structure as of certain level (high complexity)	duplication of line (low extension complexity)	low extension complexity	low extension complexity	construction kit principle (low extension complexity)	high extension complexity
Conveying Distance	short	short - medium	medium	long (encircling production)	very long	very short
Installation Complexity	star structure devi-ant to hall structure many modules (medium to high installation compl.)	straight lines in accordance with hall structure (low installation complexity)	many outlets and intersections (medium installation complexity)	many outlets and intersections (medium to high installation compl.)	very high installation complexity	high installation complexity
Suitability	central	central / local	central / local	central	central / local	local
Blocking Off Levels	very adverse - area-wide structure in one level	low at advantageous positioning (linear structure)	adverse - area-wide structure in one level, linear structure good	adverse - area-wide structure in one level	adverse - area-wide structure in one level	no blocking off
Maintenance	many single modules	good	many single modules	many single modules		intensive of staff, because wide apart

FM - figure 2.13

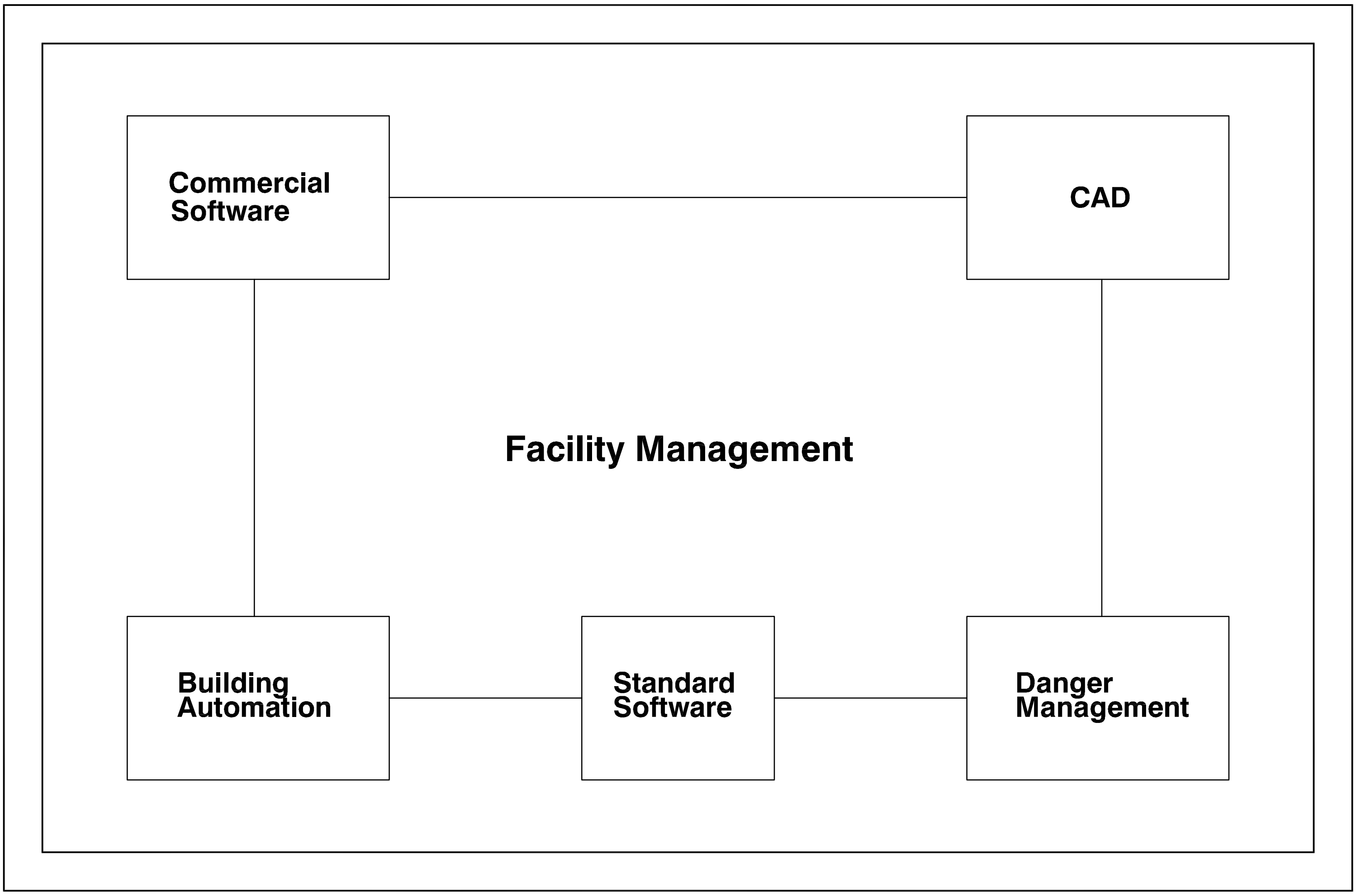
Examples for Processes of Technical Facility Management

[according to Krimmling]

Process	Objectives	Contents
Malfunction Management	• Shortening of downtime • Increase of availablelity	• Objective / Definition of malfunctions • Recording malfunctions • Evaluation / Classification • Reaction subject to evaluation • Control • Documentation
Energy Controlling	Lowering of energy costs	• Presetting Budgets • Recording Deviations • Evaluation / Classification • Reaction subject to evaluation • Control • Documentation
Repair Order	On schedule and efficient execution of repair work	• Determining requirement • Placing of order (internal or external) • Execution • Control • Costs Allocation • Documentation

FM - figure 2.14

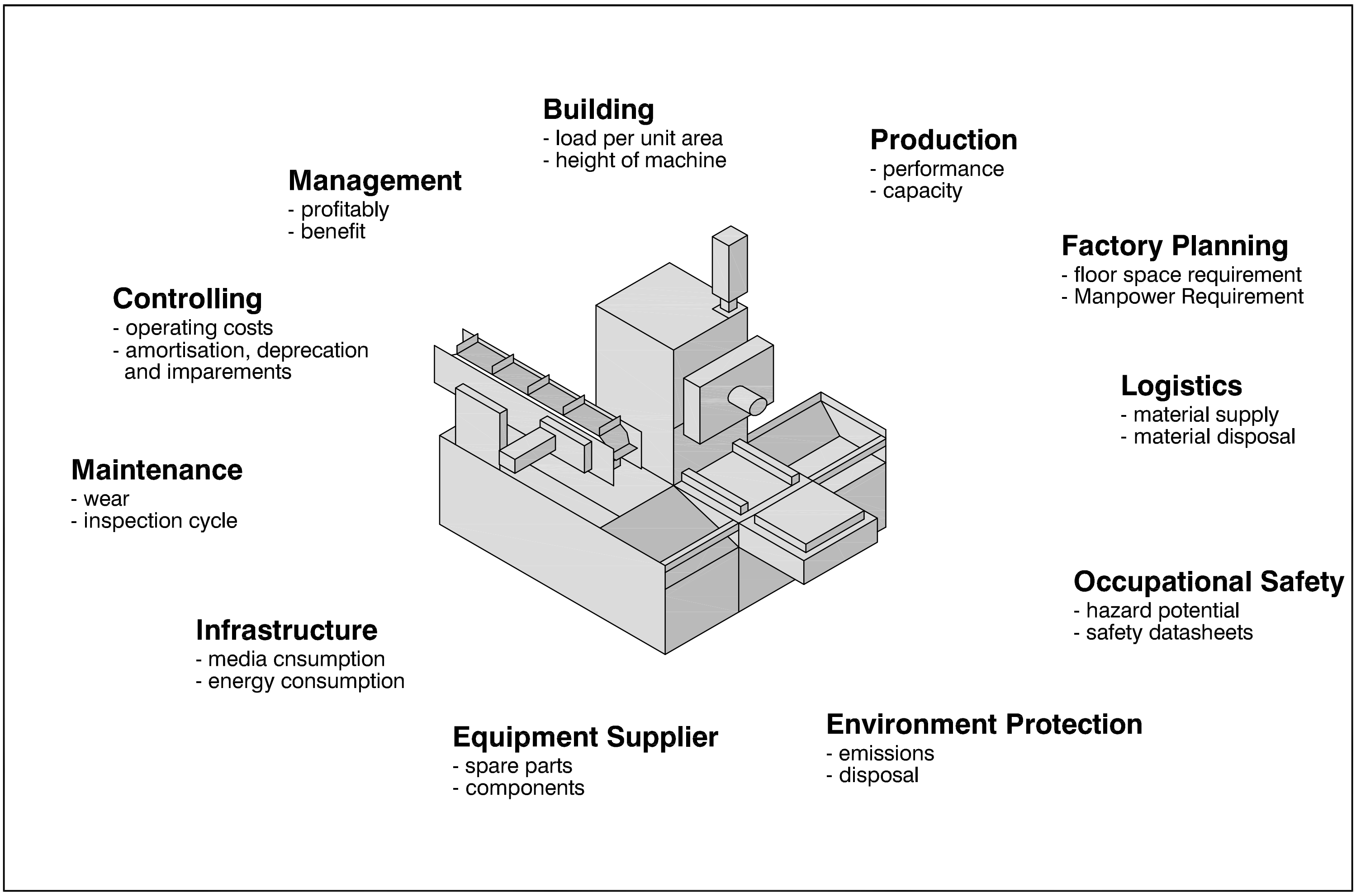
Interfaces to Building Automation and Danger Management



FM - figure 2.15 © J. Reichardt

Information Demand concerning a Factory Project

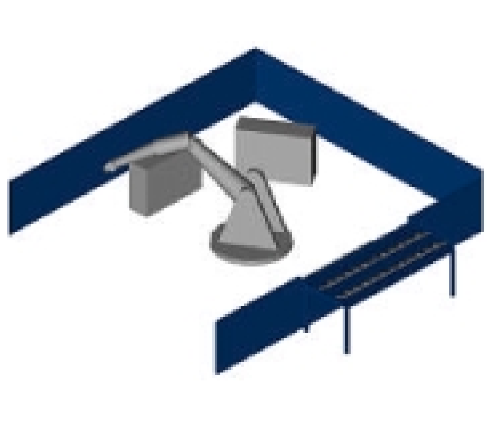
[according to Nävy]



FM - figure 2.16 © J. Reichardt

ID - Card Cleaning Robot

3D - Illustration



Side Elevation

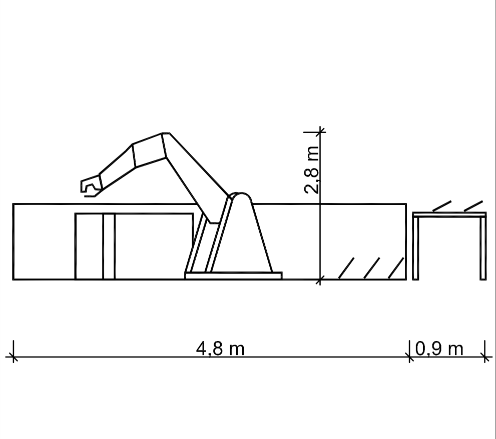
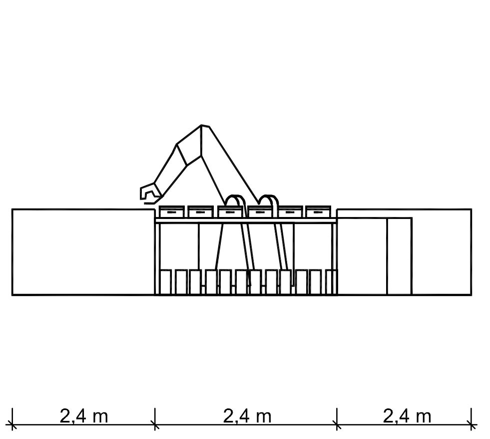
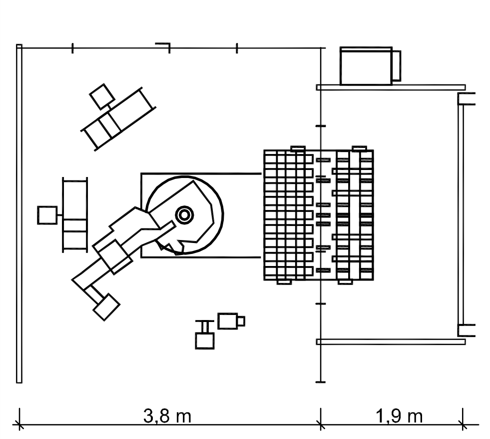


Photo / Picture

Side Elevation



Floor Plan

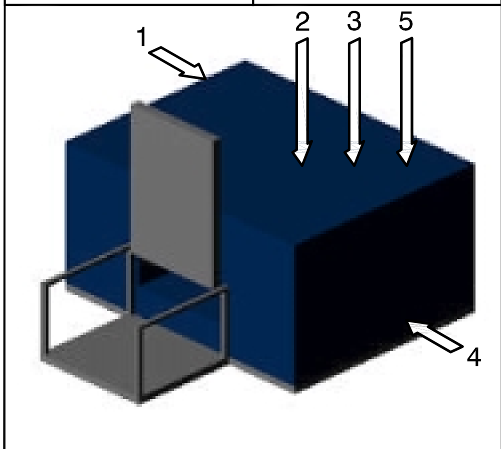


Geometry		Handling	
Length	7,2 m	Crane	10 t
Width	5,7 m	Belt	
Height	2,8 m	Forklift	
Floor Space	41 m^2	Tools	
Operating Space	41 m^2	Operating Space	
Total Space	41 m^2	Set-up Time	15 min.
Weight	<50 kN/m^2	Cycle Time	

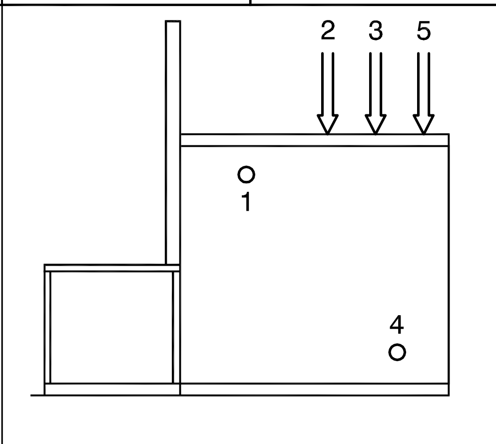
FM - figure 2.17

ID - Card Degreasing Machine, Media Connections

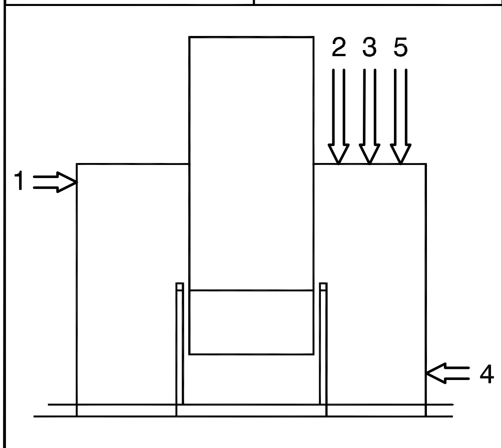
3D - Illustration **Media Connec.**



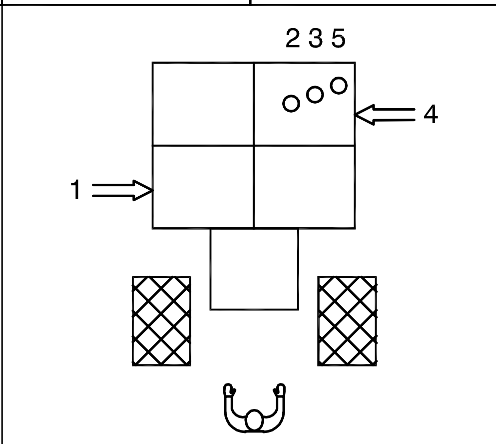
Side Elevations **Media Connec.**



Side Elevations **Media Connec.**



Floor Plan **Media Connec.**



Media		Energy Requirem.	
1	Electric	Connec-tions Value Electricity	
2	Steam		
3	Compres-sed Air	Connec-tions Value Heating	
4	Gas		
5	Process Water	Connec-tions Value	
6			
7		Synchrony Factor	
8			

Emission		Miscellaneous	
Exhaust Air	Conden-sate	Mainte-nance	
Sound		Fire Pro-tection	
		Explos.-Protection	
		Air Condition	

FM - figure 2.18

Example - Energy Optimisation at an Industrial Bakery

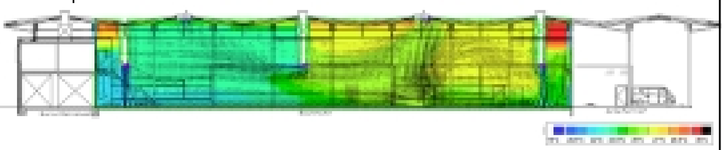
Energy Balance

Thermal Loads in Hall	Qel [kW]	Waste Heat [%]	Thermal Load [kW]
Mixing Dough			
Mixing Weighing	2	0,22	0,44
Kneading	30	0,09	2,70
Processing Doug			
Roll Divider Rounder	11,5	0,13	1,50
Press	1	0,28	0,28
Dough Divider	2	0,22	0,44
Dough Divider	5,5	0,15	0,83
Fried Pastries	10	0,5	5,00
Confectionery	10	0,5	5,00
Miscellaneous	5	0,25	1,25
Fermentation Room	5	0,5	2,50
Total [kW]			**19,93**
Area [m^2]	816		
Synchrony	0,8		
Total specific Energy [W/m^2]			**19,54**

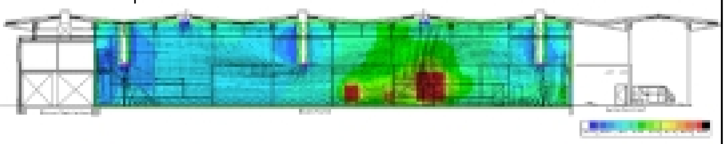
Lower annual Energy Requirement

	Heating Performance		**Ventilation Annual Need**	
	Perform. in kW	Annual Need in kWh/a*m^2	Perform. in kW	Annual Need in kWh/a*m
Starting Situation	90	32	192	576
Optimised Situation	34	31	117	449
Improvement in Percent	62 %	4 %	39 %	22 %

Air Temperature

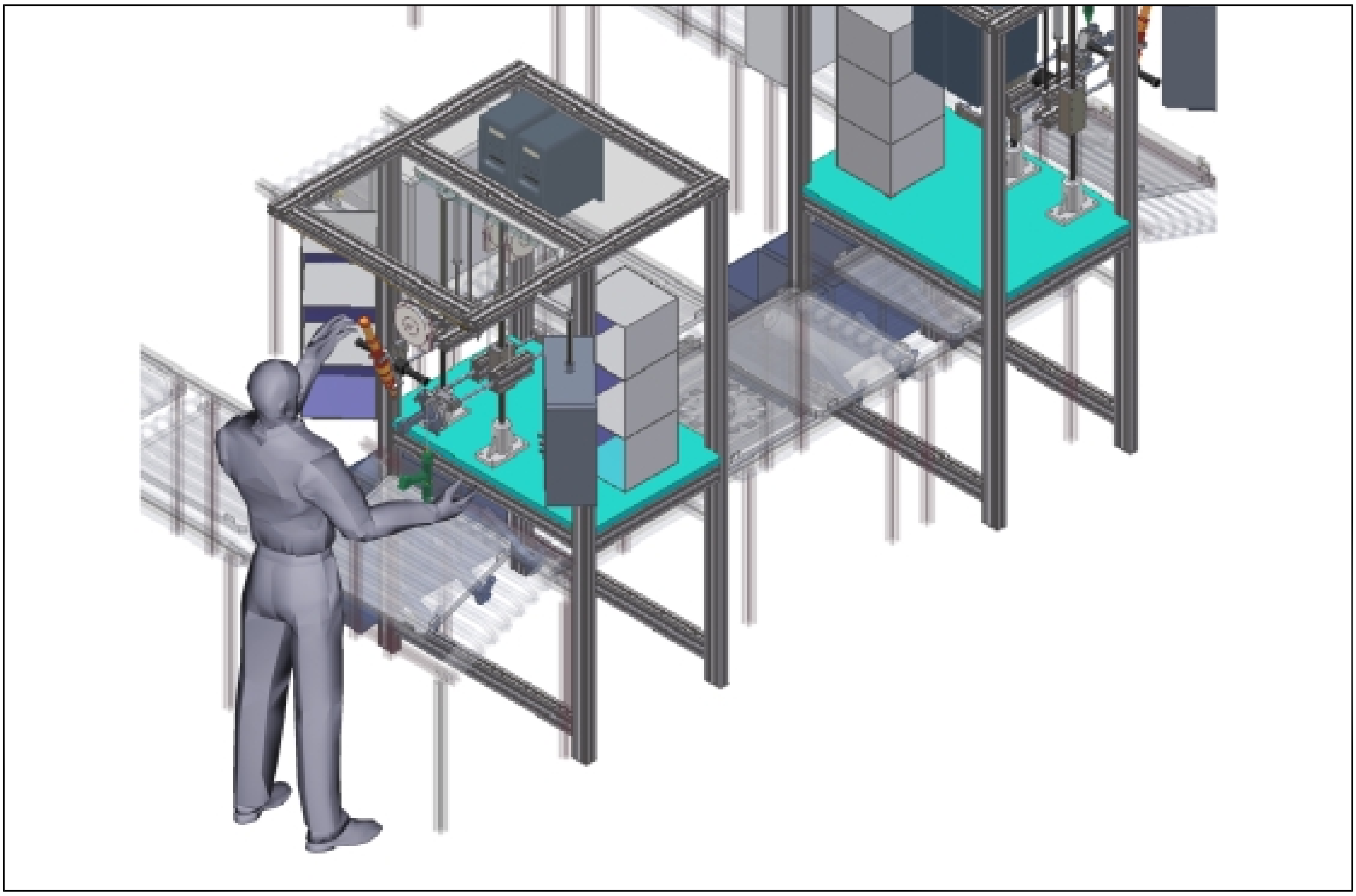


Radiation Temperature



FM - figure 2.19

Simulation of Assembly Workstation, Example



FM - figure 2.20

Table of Indicies - Benchmarking regarding Real Estate, Example

[according to Neumann]

Building Economy	Space Provision Costs	Operating Costs	Consumption	Infrastructural Costs
• site occupancy index • gross cubage • primary usable floor area • net floor area	• interests • rents • lease payments • taxes • duties • insurances	• administration costs • cleaning costs • technical operations / building maintenance • safty • disposal according to DIN Stand. 18960	• water • waste water • cooling water • heat energy • air conditioning • operational electricity • rental of devices (e.g. meters) • costs for reading the meters and distributing the share of costs	• area management • communication • EDP • catering • fleet • in-house print shop • copy service • typing service • medical service

FM - figure 2.21

Types of Areas according to DIN Standard 277

Gross Floor Area	Gross Floor Area is the total of all areas of all floors within a building. Excluded are such areas of unusable roofs and constructive voids. Gross floor area is subdivided into construction area and net floor area.
Gross Cubage	Gross Cubage is the built volume, its bottom limit being undersite the bottom slab and its other limits being the outline of exterior walls/roofs.
Operational Area	Operational Area is regarded as that part of net floor area which houses central operational equipment within a building. Provided that it is a building's purpose to house one or more parts of operational equipment which serve for supply and disposal of other buildings.
Construction Area	Construction Area is the total of all areas that are covered by rising constructional elements on all floors within a building, e.g. walls, columns. Construction Area includes such areas covered by chimneys, non-accessible cores, doorways, recesses as well as slots.
Net Floor Area	Net Floor Area is the total of usable areas between rising constructional elements of all floors within a building. Net Floor Area also comprises those areas of open installations and fixtures.
Net Cubage	Net Cubage is the total of all volumes of all rooms whose area is included in net floor area.
Usable Area	Usable Area is that part of net floor area that provides for a building's purposeful utilisation. Usable area is subdivided into primary usable area and secondary usable area.
Traffic Area	Traffic Area is that part of net floor area that provides for access to rooms, traffic within the building and leaving the building in case of emergency. Areas needed for moving within rooms that count as usable or operational area, e.g. paths between furniture, do not count as Traffic Area.

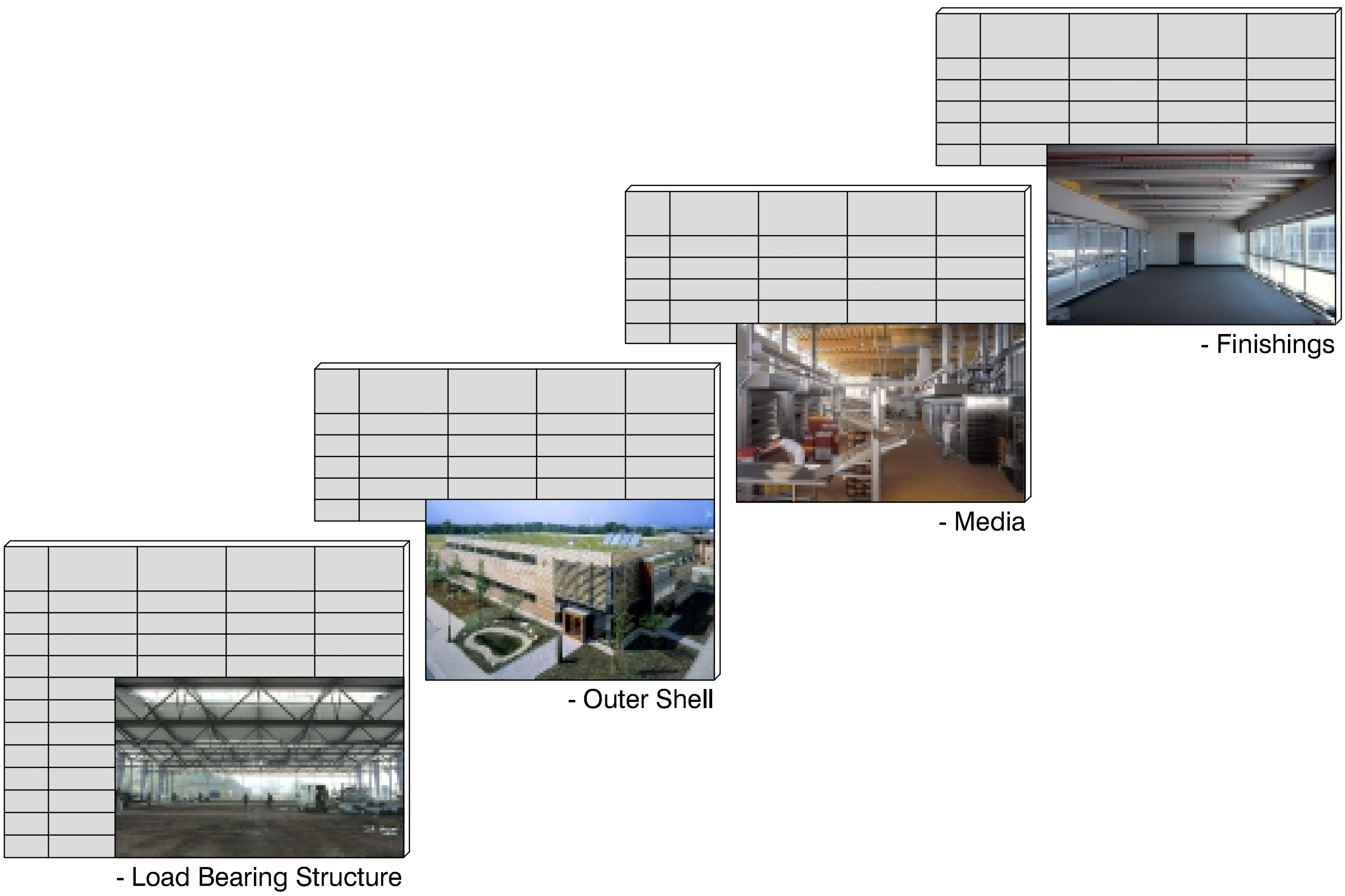
FM - figure 2.22

Comparing Utilisation Indices regarding Admistration Buildings

Values (1999) Relatings to Gross Floor Area, Indices/Unit	Best Values		Worst Values		Average Value
• Building Maintenance and Repair (DM p.a.)	9,49	10,24	23,85	24,53	16,06
• Heat Energy Consumption (kWh p.a.)	77,25	79,42	99,63	114,04	89,04
• Consumption of Electricity (kWh p.a.)	18,15	23,60	31,03	62,29	30,99
• Water Consumption (cbm p.a.)	0,14	0,15	0,19	0,39	0,20

according to:
Leitfaden Gebäude- und Liegenschaftsmanagement in Kommunen
Ostdt. Sparkassen- und Giroverband 2002

Catalogue of Requirements, Performance Characteristics of Building Structure



Examples - Performance Diagrams Load Bearing Structure, Outer Shell

Example Load Bearing Structure	Performance ⇐		Value Respective Basic Requirement		⇒ Performance
Column Grid Hall [m]	60	logitudinal	5	cross	60
Column Grid Storeys [m]	30	longitudinal	5	cross	30
Live Loads [kN/m²]	3	ceiling	0.5	bottom slab	8
Special Load Areas [kN/m²]	3	control centre	0.5	machine	8
Suspended Loads [kN/m²]	3	media traces	0.5	materials handling	25
Clearances Hall [m]	15	bottom level	5	bottom level	15
Clearances Storeys [m]	5	load bearing structure	2.5	roof	5
Extension/Option [Direction]		hall	0	hall	

Example Outer Shell	Performance ⇐		Value Respective Basic Requirement		⇒ Performance
Compactness	0.4	surface/cubature horizontal	0.2	surface/cubature vertical	0.1
Thermal Protection [kW]	0.4	outer shell hall	0.8	outer shell storeys	0.4
Flexibility [%]	100	gates relocating	0	windows/doors relocating	100
Daylight [lux]	1000	hall	0	storeys	1000
Smoke and Heat Venting [%]	5	hall	0.5	storeys	5
Sound Insulation [dbA]	55	hall closed	30	hall open	55
Fire Protection/Security [Min]	180	facade	0	roof	180
Ecology [%]	100	green facade	0	green roof	100

FM - figure 2.25

Examples - Performance Diagramms Media, Finishings

Example Media	Performance ⇐		Value Respective Basic Requirement		⇒ Performance
Reserves Supply [%]	150	connection values	25	control centres	150
Reserves Distribution [%]	150	main traces	25	networks	150
Flexibility [%]	100	retro fitting	10	extension	100
Modularity [%]	100	maintenance	10	exchange	100
Low Energy [kW/m²]	50	heat requirement	150	cooling requirement	0
Natural Ventilation[LW/h]	0	air renewal mechanical	5	air renewal air conditioning	0
Emission [%]	0	supply/disposal Process	20	supply disposal building	0
Energy Optimisation [kW]	100	energy abundance	0	heat recovery	100

Example Finishings	Performance ⇐		Value Respective Basic Requirement		⇒ Performance
Transparency Hall [%]	100	proportion walls logitudinal	0	proportion walls cross	100
Transparency Storeys [%]	100	proportions walls in hallway	0	proportion partitions	100
Flexibility Hall [%]	100	fittings	5	partitions	100
Transparency Hall [%]	100	proportion walls longitudinal	0	proportions cross	100
Transparency Storeys[%]	100	proportions walls in hallway	0	proportion partitions	100
Flexibility Workstation [%]	100	outlets media	20	equipment	100
Sound Insulation Hall [dbA]	50	floor, wall, ceiling	30	equipment	50
Sound Insulation Storeys [dbA]	50	floor, wall, ceiling	30	equipment	50

FM - figure 2.26

Distinction of FM-Data, Examples

[according to GEFMA 400]

Inventory Data	Status Data	Consumption Data	Performance Catalogues	Workflow Data	Buisiness Data
• CAD - Data • Room Specifications	• Operating Statuses • Notices for Malfunction • Danger Alarms	• Energy Consumption • Automatic Meter Reading • manual Meter Reading	• Tender for Industrial Cleaning	• Regular Evaluation of Indices	• Tenancy Agreements • Prices for Catering

FM - figure 3.01

Layer-Structure, Example

Site	11	Cadastral Boundaries	cadastral bound. / required set-rack line	d (Documents)	yellow
	12	Roads, Sealed Surfaces	roads / paths / carparks / fencing		yellow
	13	Topographic Lines	topographic lines		white
	14	Building Outline	existing / new buildings		cyan
	15	Plantation	trees / bushes		white
	16	Greens	lawn / shrubs		white
	17	Water	lakes / ponds / rivers / streams		cyan
	18	Rails	db / public transport / factory owned		cyan
	19	Symbols			
	20	n.n.			
Load Bearing Structure	21	Bottom Slab / Foundations	bottom slab / foundations	d (Documents)	yellow
	22	Ceilings	ceilings		red
	23	Roofs	roofs		white
	24	Columns	main columns / secondary columns		yellow
	25	Load Bearing Structure	main girders / secondary girders		yellow
	26	Walls Exterior	brickwork / concrete		yellow
	27	Walls Interior	brickwork / concrete		yellow
	28	External Staircase	external staircase		
	29	Symbols			
	30	n.n.			
Outer Shell	31	Roof Lights	smoke and heat venting system domes	d (Documents)	white
	32	Roof Membranes / Coverings	roof constr. / covering / green / proj. r.		white
	33	Facade, Closed	sandwich wall elements / panels		white
	34	Facade, Transparent	structural glasing / cast glass		green
	35	Facade, Windows	tilt-and-turn window / top-hung window		cyan
	36	Sun-Protection Devices	vertical / blinds		white
	37	Doors	entries / emergency exits		cyan
	38	Tore	Gliedertore / Schnellllauftore /		white

FM - figure 3.02

Layer-Structure Building Services (HVAC/R), Example

Location

Building

Function / Process

CAD - Construction: Example Layers Industry Project — **Building Services**

Building Services (HVAC/R)					
	61	Sprinkler	sprinkler	c (contr.centr.)	green
	62	Ventilation	ventilators,	t (traces)	green
			supply air,	n (networks)	red
			extracted air,	o (outlets)	yellow
			outer air,	d (documents)	green
			exhaust air		yellow
	63	Heating	flow,		red
			return,		blue
			radiators		red
	64	Waste Water	foul water		blue
	65	Sanitary Installation	supply pipe,		40
			hot water,		red
			cold water,		green
			installations		white
	66	Compressed Air	compressed air		red
	67	Roof Drainage	rain water		160
	68	Gas	gas pipe		yellow
	69	Symbols			
	70	n.n.			

FM - figure 3.03

Data Classification, Example

[according to Heß]

- Data Format

- alphanumeric data
  - documents, tables
- vector graphic data
  - 2D, 3D
- pixel graphic data bitmaps
  - graphics, photos, videos

- Frequency of Change

- on short notice
  - notices of malfunction
- daily
  - operating hours
- weekly
  - consumption data
- monthly
  - personnel data
- regular
  - CAD drawing data

FM - figure 3.04

Planning Data comprised in Room Specifications, Example

		Use / Geometry					Finishings Room / Cost Group					Finishings Building Services				
Element	Sub-Elem		Fl. Area	Height	Wa. Surf	Win. Surf	Type Opening	Floor	Wall	Ceiling	Equipment	Requir. Room	Floor	Wall	Ceiling	Equipment
118.01	118.01.1	Production	4605,0	6,85			T 1.1	Epoxidharzbs.	St.B.Sockel	Stahlfachwerk		Temp:		Bel. Tableau	Sprinkler	Zu-und
				3,50			T3.1	Gabelst. 1,5 to	Metallsandw.	Trapezblech		> 19 ° C		8x 230V / 10 A	Hallenreflekt.	Abluftanlage
							Tor1.2	Ehubws. 1,5 to	glatte, abwas.	nachträgl.		Lufte:		6x 400V / 16 A	leuchten300lx	Normalbetrieb
							Tor1.3	desinfizierbar	Oberflächen	Einbau		V90.000m3/h		6x 400V / 32 A	Kabelbühnen	mit 100%AUL
							F1.1	Nasswischger.	Fenst.bänder	raumabschl.				2x 400V / 63 A	Notbeleuchtg	Wochenendb.
								R10, ch.Res.		Unterh.decke					Rettgs.zeichen	mit 100%UML
								Sockel 3 cm		möglich						E-Zuleitung f.
								Perimeterfom								Fertigungslin.
								optional R.B.								
								Feinsteinzeug								
118.02		Disp.Departm.	458,7	6,85			T 1.1	Epoxidharzbs.	St.B.Sockel	Stahlträger	4 Thermo-	Temp:		Lichtschalter aP	Sprinkler	Deckenluft-
							Tor1.1	Gabelst. 1,5 to	Metallsandw.	Trapezblech	schleusen	> 19 ° C		Zul. Torantriebe	Hallenreflekt.	erhitzer
							Tor1.3	Ehubws. 1,5 to	glatte, abwas.		2 Thermo-	Lufte: 2-fach		Bel.über Tore	leuchten300lx	100%UML
							F1.1	desinfizierbar	Oberflächen		schleusen	durch freie		4x Netzwerkans	Kabelbühnen	1xDruckluftans.
								Nasswischger.	Fenst.bänder		Jumbo	Lüftung		4x 400V / 16A	Notbeleuchtg	1/2"
								R10, ch.Res.				(Tore)		14x 230V / 10 A	Rettgsz.eichen	
								Sockel 3 cm						8x 230V/V 10 A		
								optional R.B.						Ans. Torabsich.		
								Feinsteinzeug						2x 400V / 32 A		
118.03		Store	90,0	6,85			T3.1	Epoxidharzbs.	St.B.Sockel	Stahlfachwerk	Beh.vol. 1000 l	Temp:		Lichtschalter aP	Sprinkler	Zu-und
							Tor1.3	Prüfz. WHG	Metallsandw.	Trapezblech		> 19 ° C		Steckdosen	Hallenreflekt.	Abluftanlage
								Gabelst. 1,5 to	glatte, abwas.	nachträgl.		Lufte:			leuchten300lx	Normalbetrieb
								Ehubws. 1,5 to	Oberflächen	Einbau					Kabelbühnen	mit 100%AUL
								desinfizierbar	Fenst.bänder	raumabschl.					Notbeleuchtg	Wochenendb.
								Nasswischger.		Unterh.decke					Rettgsz.eichen	mit 100%UML
								R10, ch.Res.		möglich						E-Zuleitung f.
								Sockel 3 cm								Fertigungslin.
								Perimeterfom								
								optional R.B.								
118.04		Adaptor 1	322,8	6,85			T 1.1	Stahlbeton	St.B.Sockel	Stahlträger		Temp:		2x 230V/V 10 A	Sprinkler	Deckenluft-
							Tor1.2	Flügelglättung	Metallsandw.	Trapezblech		15 ° C		2x 400V / 10 A		erhitzer
							Tor 1.4	Hartstoffschicht	glatte, abwas.			Lufte: 0,5-fach		1x 400V / 10 A	Lichtband	100%UML
							F1.1		Oberflächen			durch freie			Notbeleuchtung	
									Fenst.bänder			Lüftung				
												(Tore)				
118.05		Adaptor 2	280,5	4,00			Tor1.4	Stahlbeton	St.B.Sockel	Stahlträger		Temp:		2x 230V/V 10 A	Sprinkler	Deckenluft-
							Komplettelem.	Flügelglättung	Metallsandw.	Trapezblech		15 ° C		2x 400V / 10 A		erhitzer
							T 90	Hartstoffschicht	glatte, abwas.			Lufte: 0,5-fach		1x 400V / 10 A	Lichtband	100%UML
									Oberflächen			durch freie			Notbeleuchtung	(wird von
									Fenst.bänder			Lüftung				Hochregallager

FM - figure 3.05

Contents of Building Documentation

Documentations Structur

- Directories
- Identification Systems
- Formats

Plans, Building Model

- Location
  - land register
  - supply, disposal
  - open spaces
- Building
  - floor plans
  - sections
  - evaluations
  - details
- Building Services
  - media
  - control centres
  - traces
  - networks
  - outlets
- Equipment
  - furniture
  - process

Catalogues

- Room Specification
- Calculations
- Systems/ Equipment
- Documentation
- Product Datasheets

Job Describtions

- Building Site Diary
- Inspection

Dokumentation of Procedures

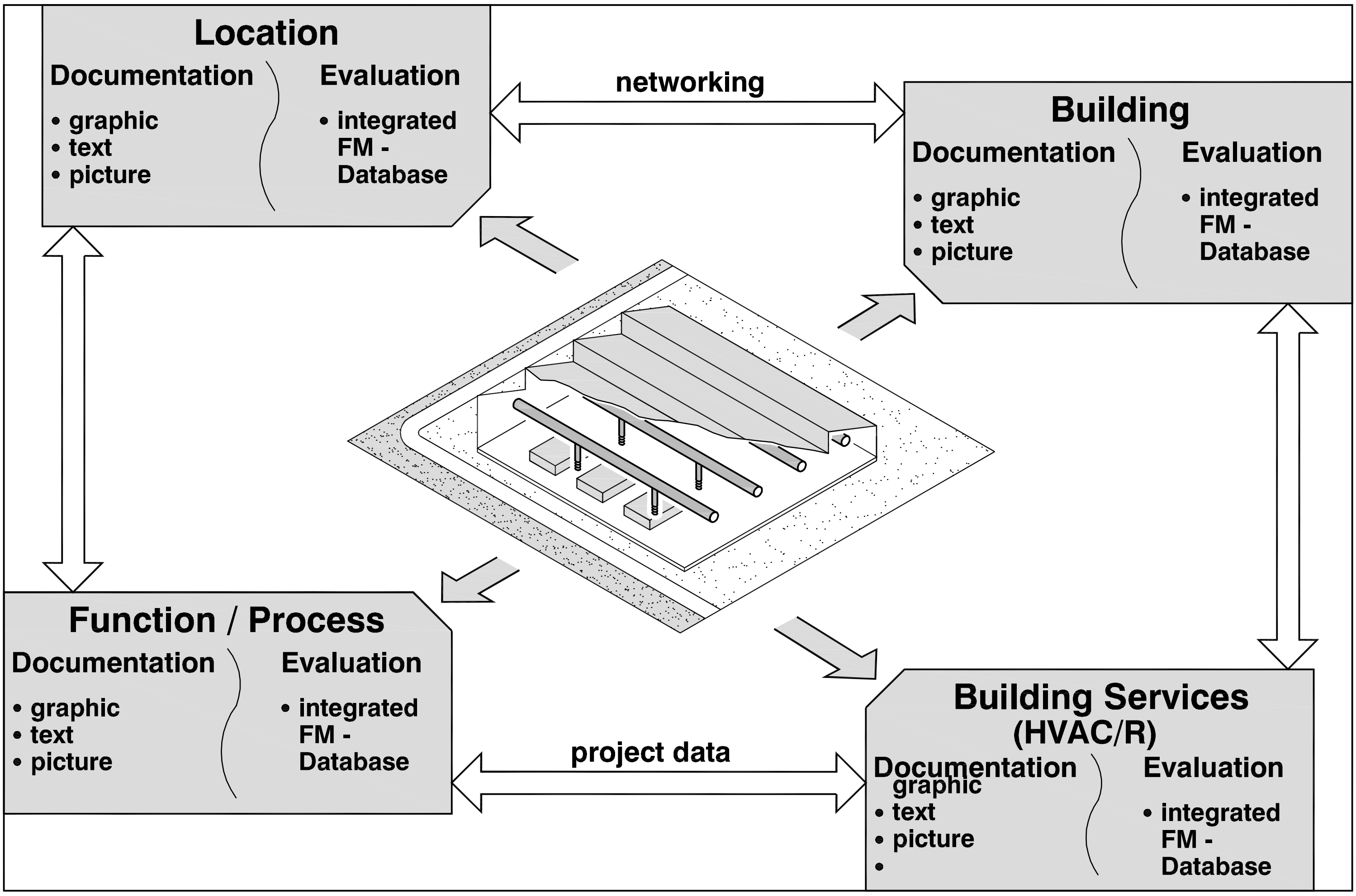
- Building Application
- Tender
- Quotes/ Offers
- Audit Reports
- Final Acceptance of Construction Work

Costs and Accounting

- Final Payments for Construction
- Payments to suppliers and Disposal Contractors

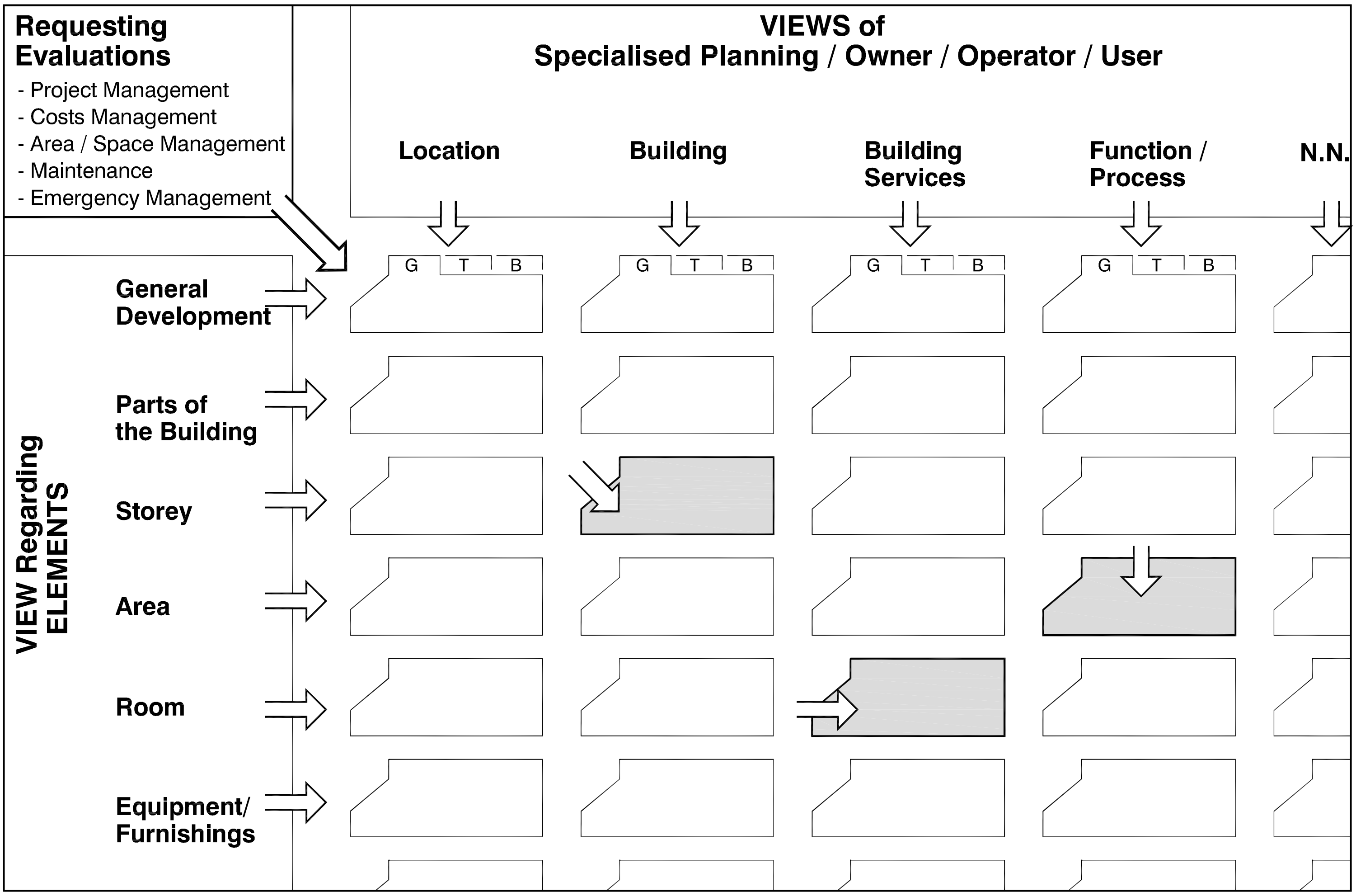
FM - figure 3.06

FM Location, Building, Building Services (HVAC/R), Equipment, Specialised Views



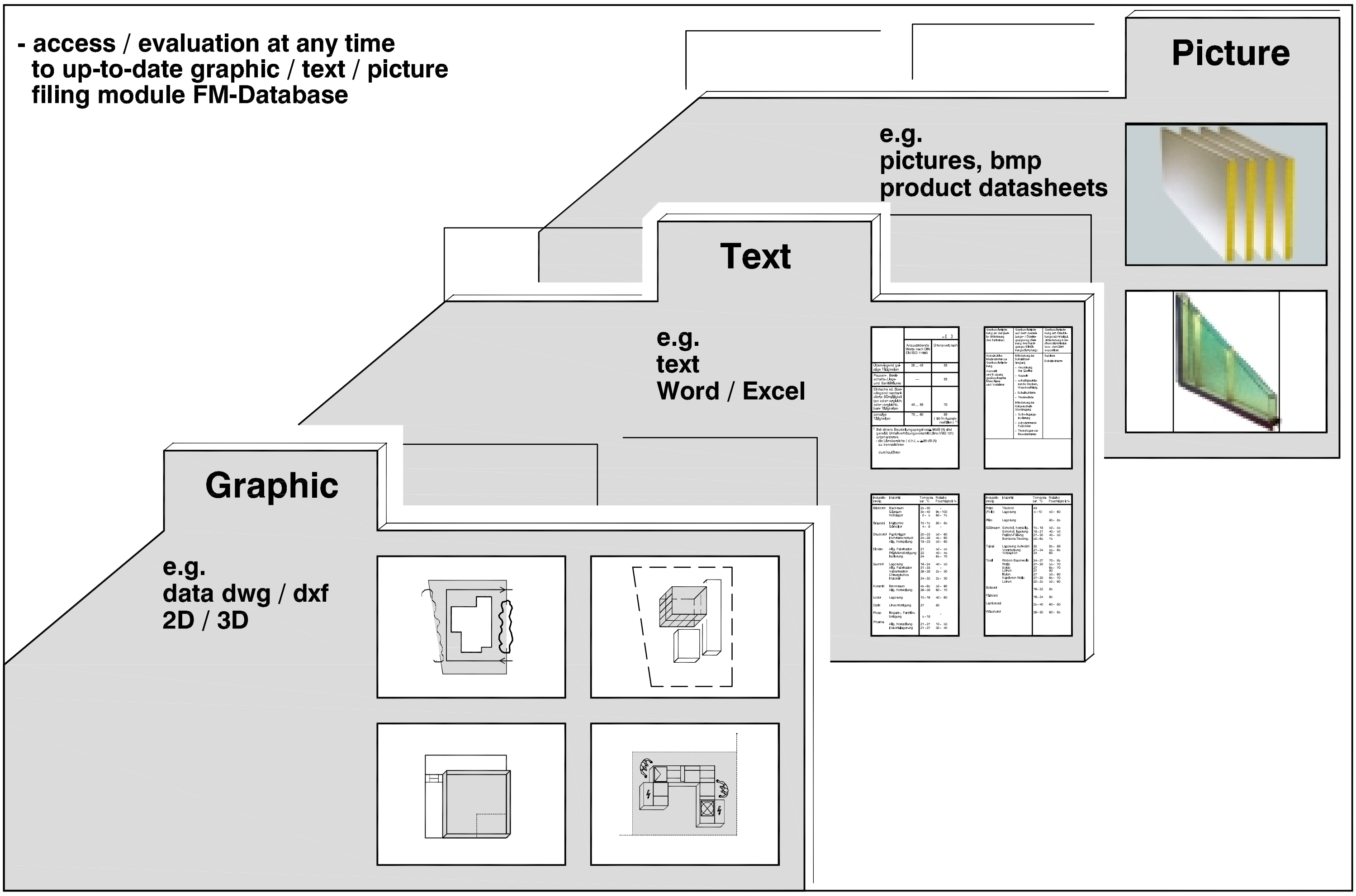
FM - figure 3.07 © J. Reichardt

Integrated FM-Data Model, Filing and Evaluation according to Views



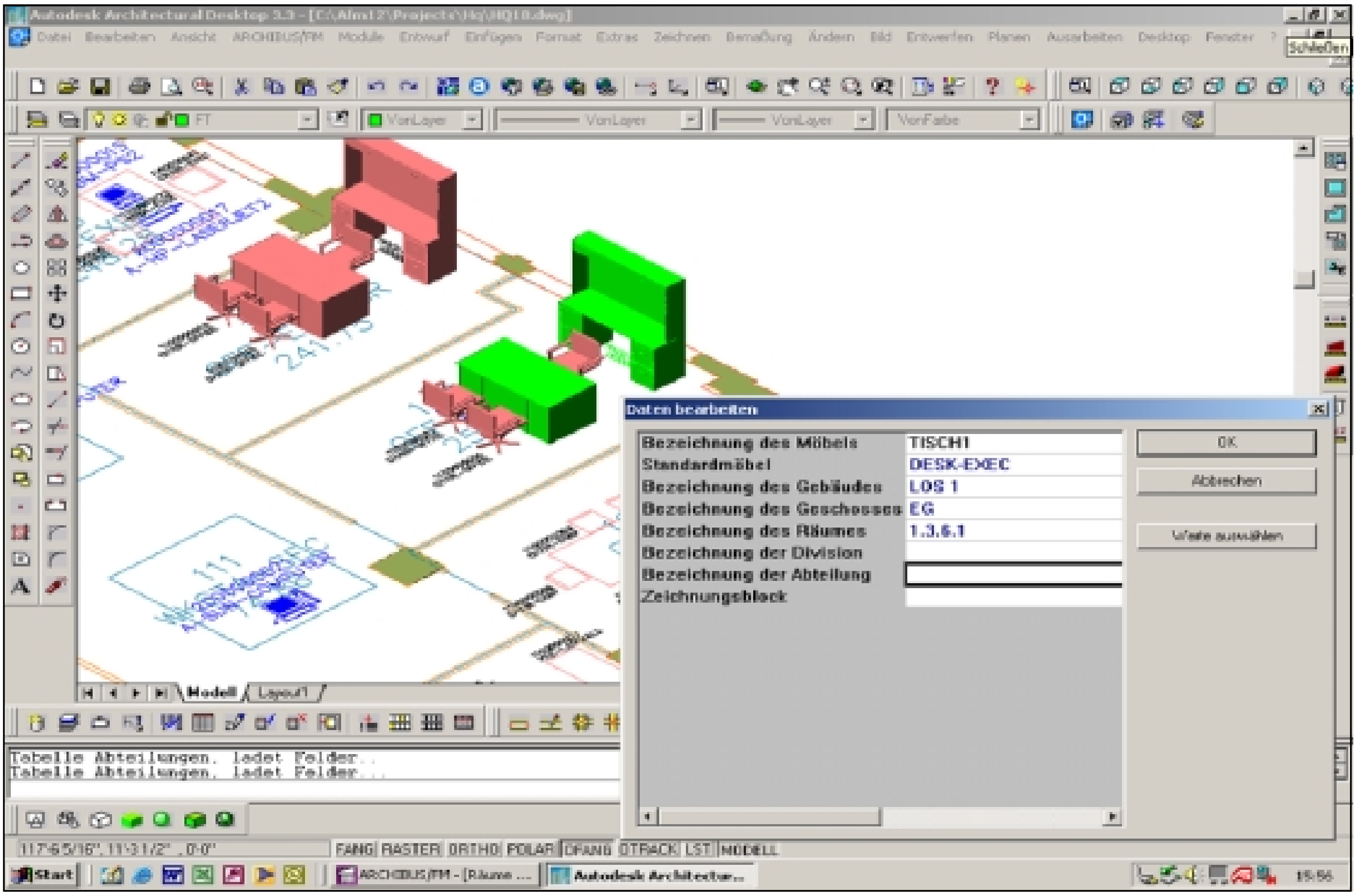
FM - figure 3.08 © J. Reichardt

Integrated FM-Data Model, Example of File Module, Graphic, Text, Picture



FM - figure 3.09

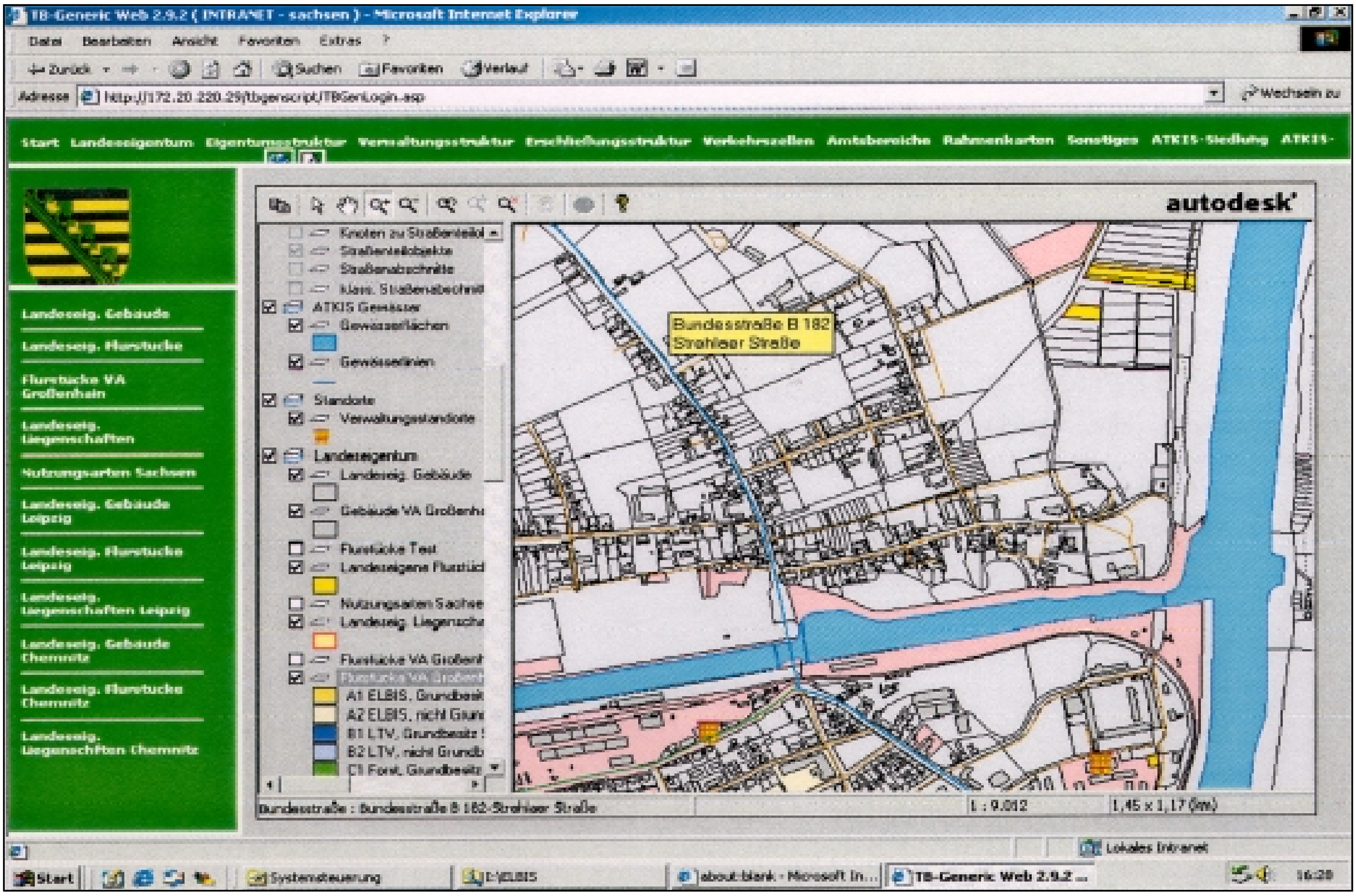
Archibus/FM, Integration of AutoCAD via Overlay Function



FM - figure 3.10

Municipal Real Estate Administration, Example - Location

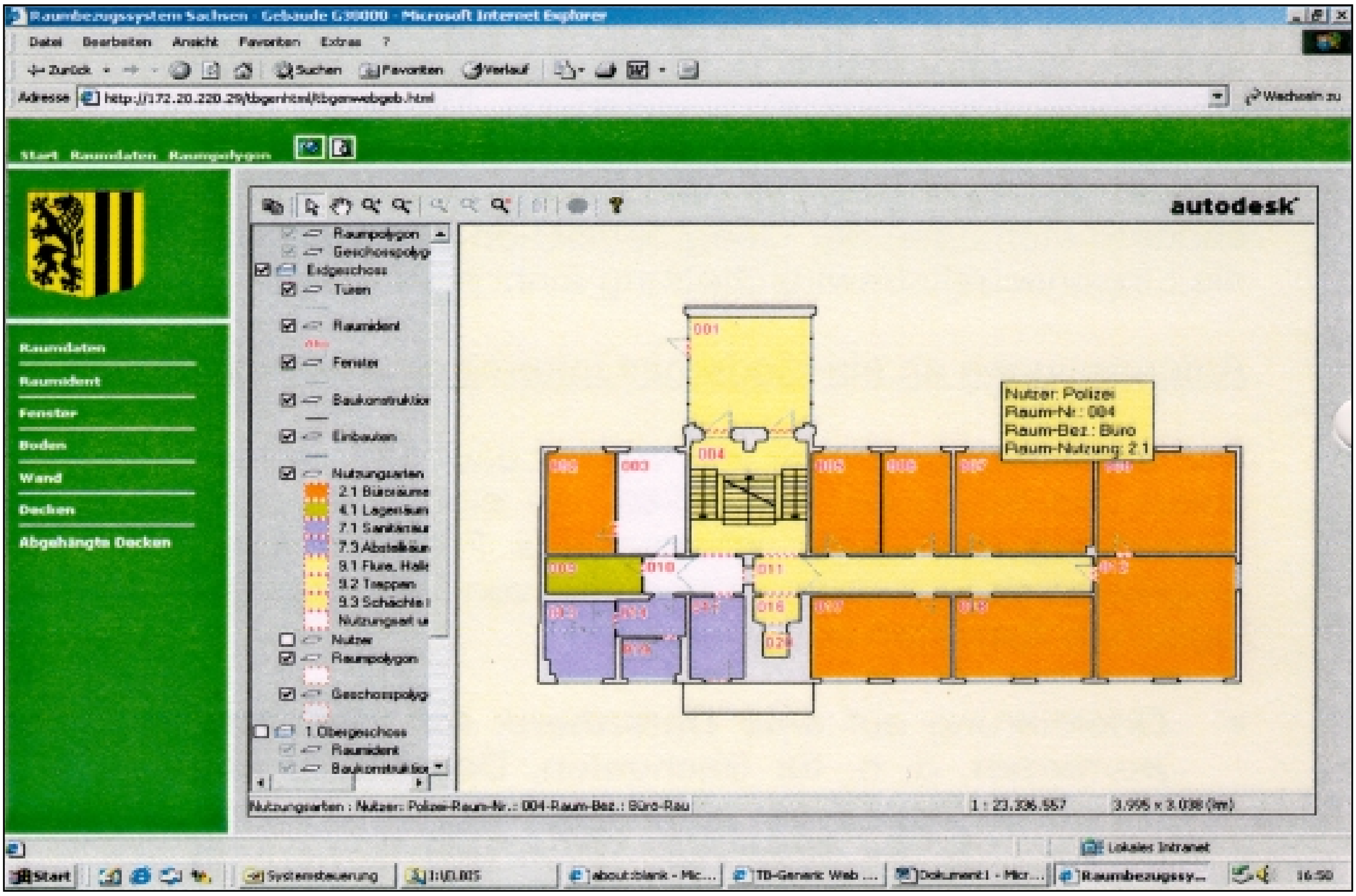
[according to KMS]



FM - figure 4.01

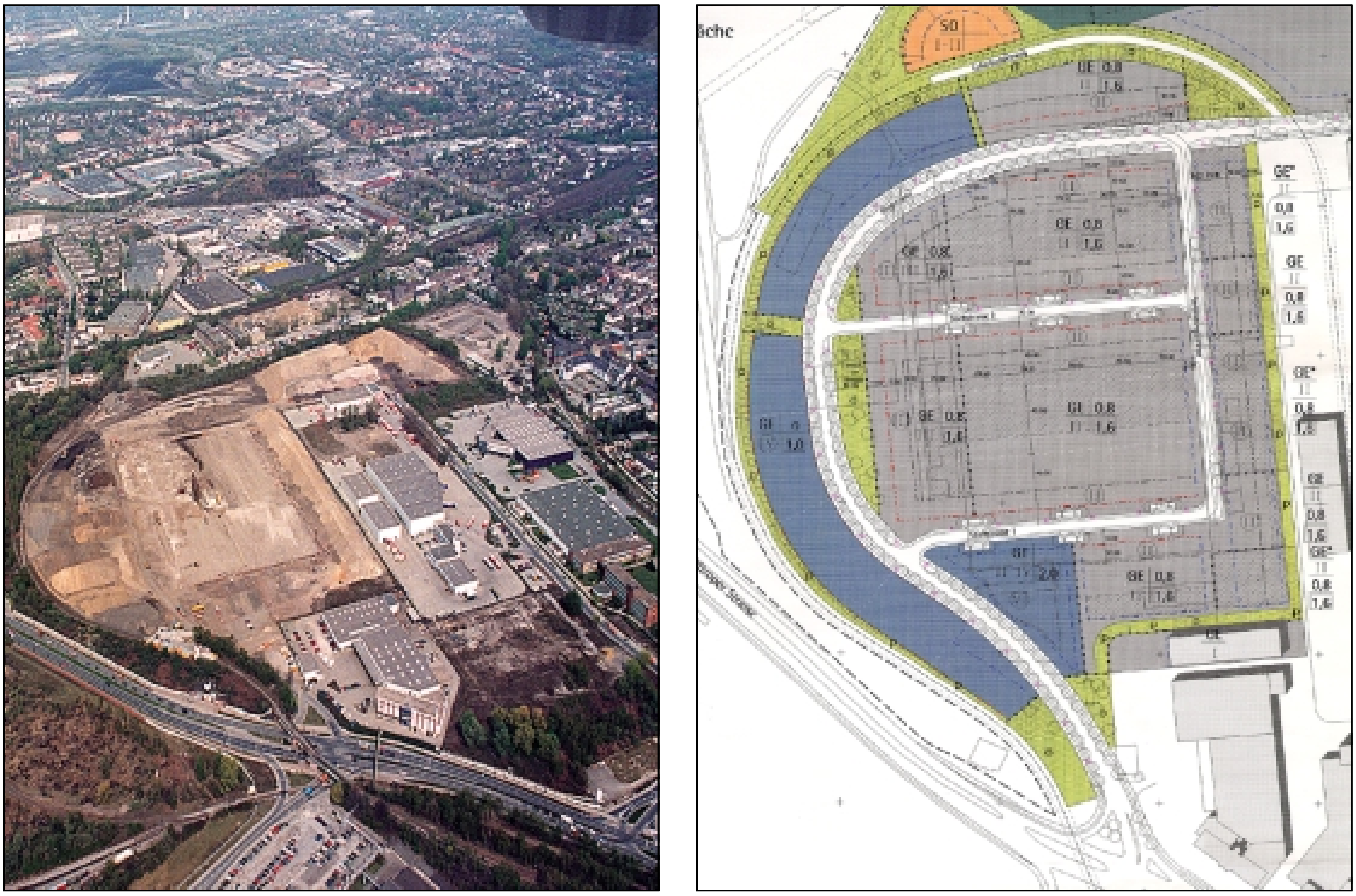
Municipal Real Estate Administration, Example - Floor Plan

[according to KMS]



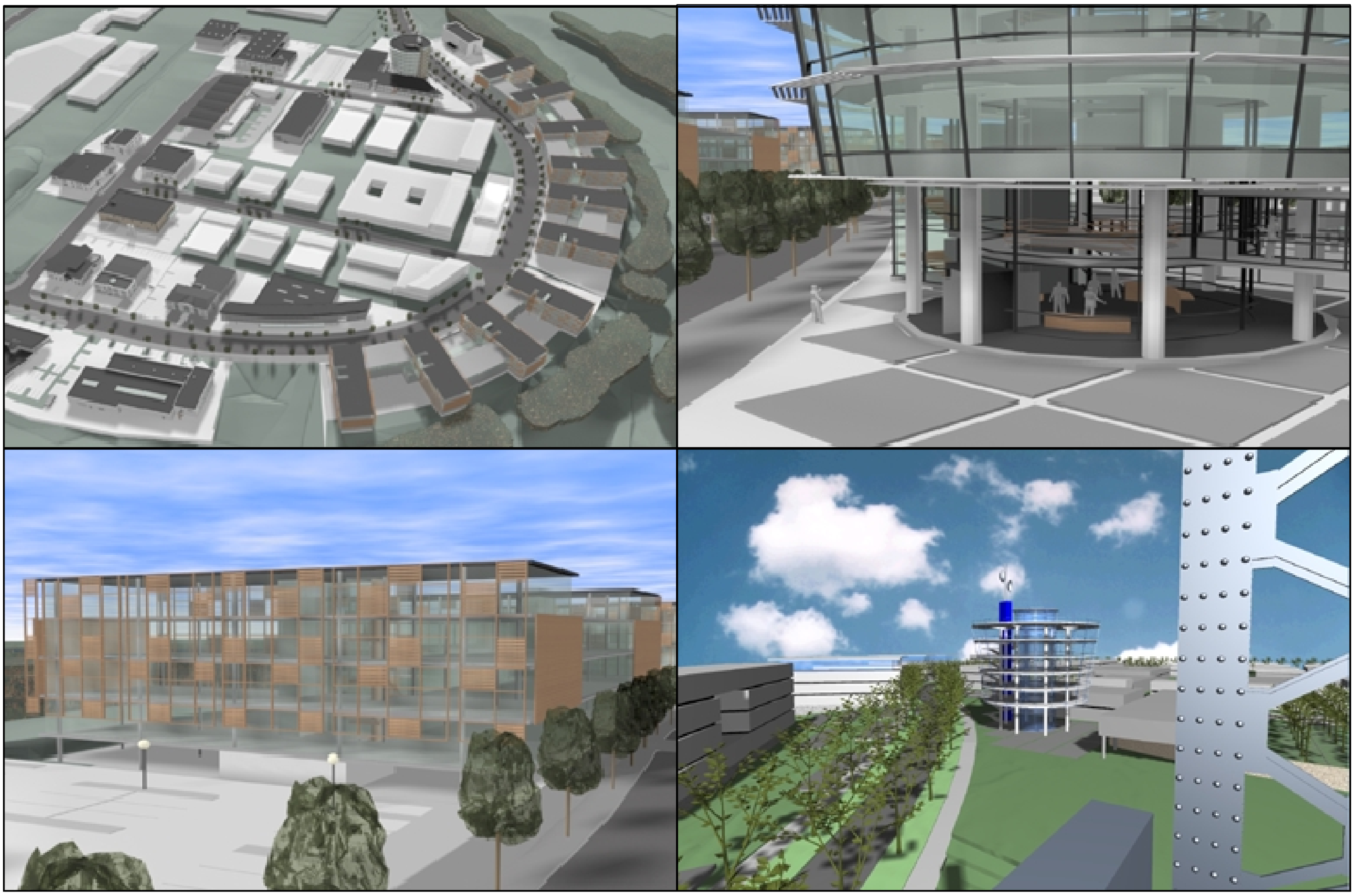
FM - figure 4.02

Urban Development, Building Law Regulations - Example



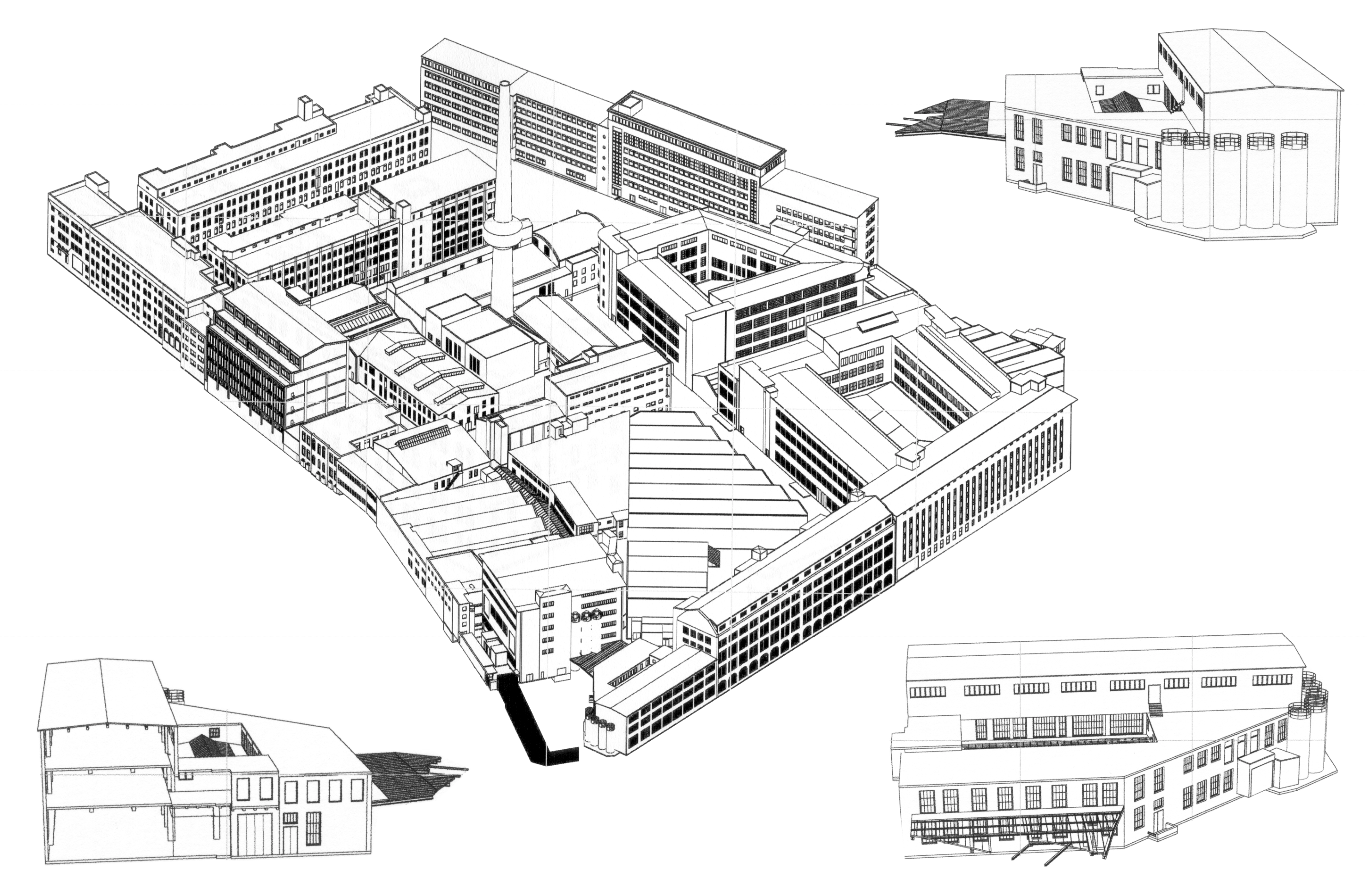
FM - figure 4.03 © J. Reichardt

Urban Development, Virtual Urban Model - Example



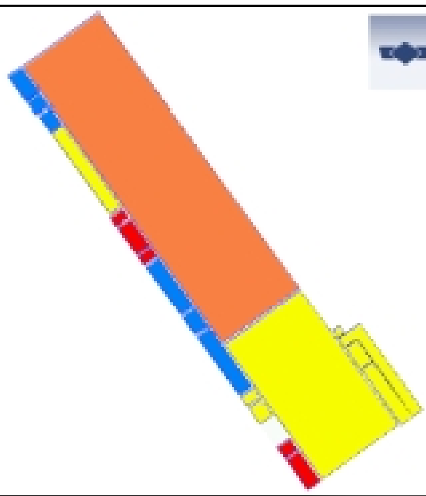
FM - figure 4.04 © J. Reichardt

Survey, 3D-Building Documentation - Example



FM - figure 4.05

Survey, Area Differentiation - Example



PHOENIX

Mustermarkierung	Standard-beschreibung	Gesamtzahl	Gesamtfläche	Durch-schnittsfläche
	Büroraum	6	115,16	19,19
	Lagerraum	8	706,25	88,28
	Produktion	1	1.124,88	1.124,88
	Sanitärraum	5	55,76	11,15
		20	**2.002,05**	**Summe**
		20	**2.002,05**	**Gesamtsumme**

Abteilungsname
CONSEO

Bezeichnung des Gebäudes	Bezeichnung des Geschosses	Standardraum	Raumfläche: Manueller Eintrag
58	1	Buero1	160,00
63	1	Lager1	195,00
45	2	Buero3	870,00
45	3	Sanitaer	525,00
25	1	Lager1	296,00
25	5	Lager1	210,00
160	3	Lager1	51,00
58	5	Buero1	17,00
59	4	Buero1	272,00
157	3	Buero1	534,00
60	2	Buero1	12,00
58	3	Buero1	172,00
50	5	Lager3	164,00
157	1	Prod5	1.043,00
64	1	Lager1	47,00
59	1	Lager4	270,00
60	7	Prod6	181,00
60	ZW	Prod1	49,00
160a	2	Prod1	88,00
58	1	Prod5	102,00
60	6	Prod1	261,00
			5.519,00

Abteilungsname
DAS

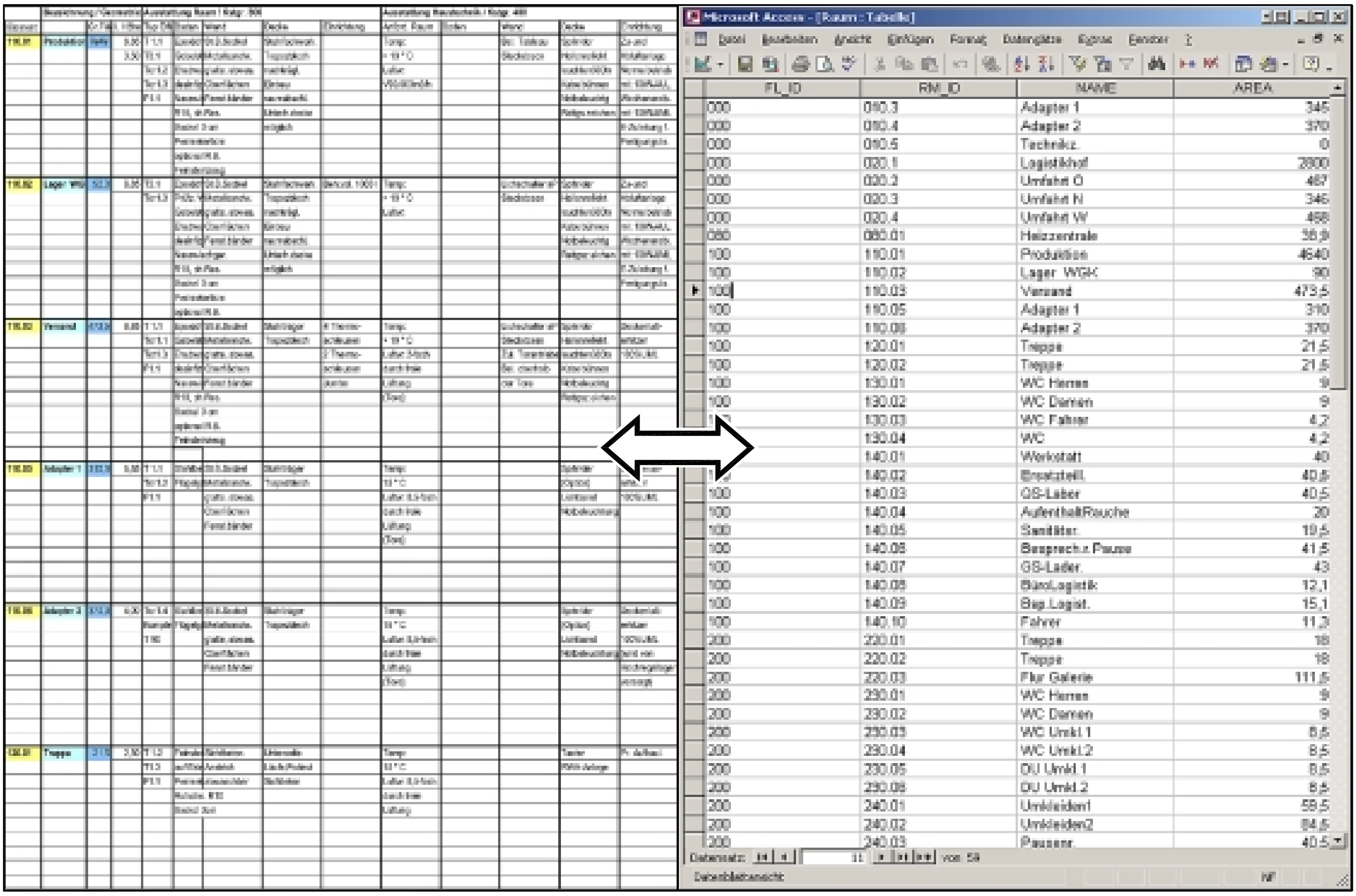
Bezeichnung des Gebäudes	Bezeichnung des Geschosses	Standardraum	Raumfläche: Manueller Eintrag
117	1	Lager1	516,00
			516,00

Abteilungsname
EX

Bezeichnung des Gebäudes	Bezeichnung des Geschosses	Standardraum	Raumfläche: Manueller Eintrag
158	ZW	Buero1	26,00
157	2	Lager2	1.453,00
77	2	Prod1	529,00
77	1	Prod1	678,00
159	ZW	Prod1	449,00
41	1	Prod1	258,00
41	2	Prod1	92,00
158	2	Prod1	258,00
158	1	Prod1	422,00
159	1	Prod1	1.221,00
			5.386,00

FM - figure 4.06

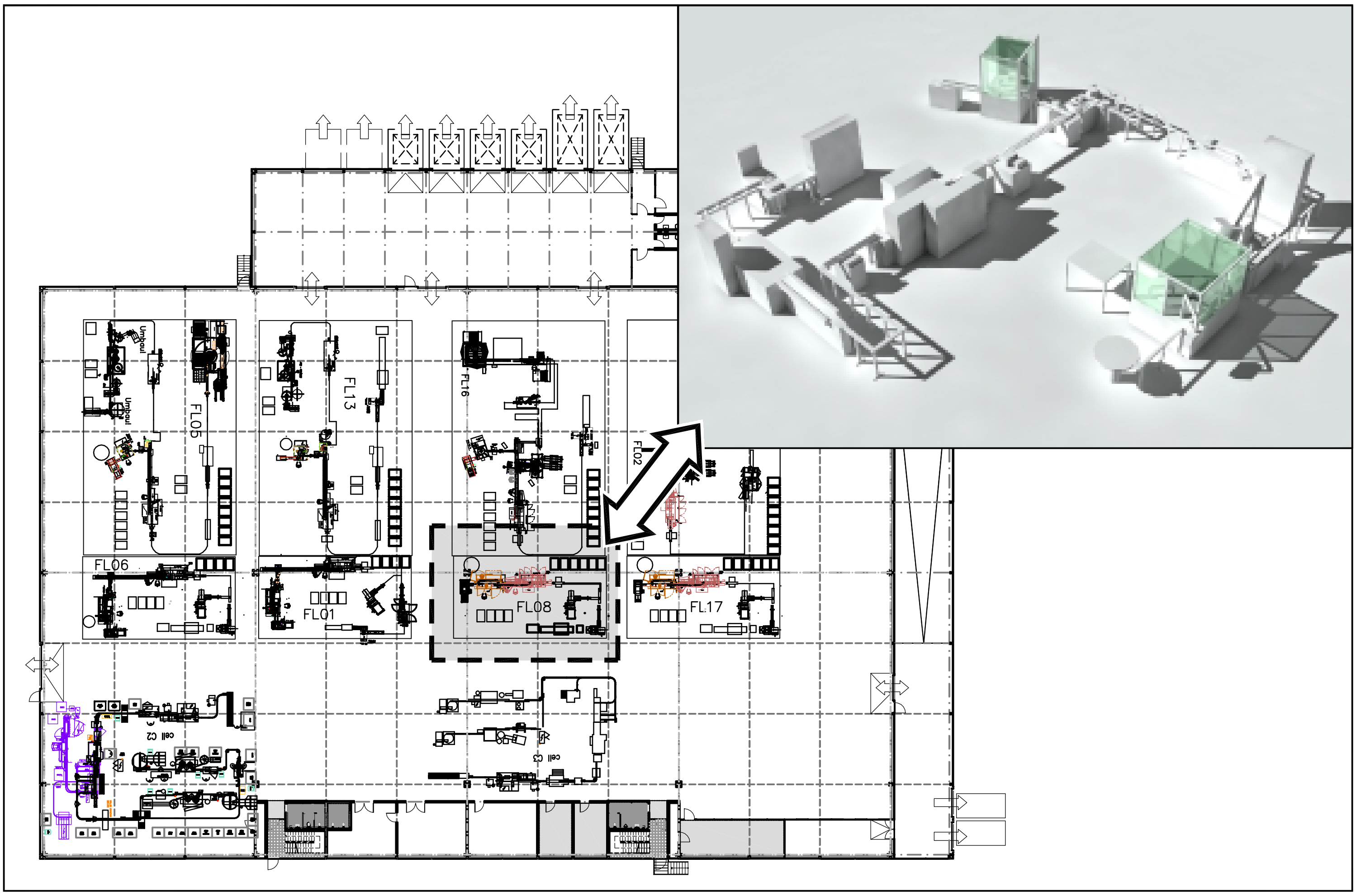
Transfer of Excel Room Specifications to Oracle Database Example



FL_ID	RM_ID	NAME	AREA
000	010.3	Adapter 1	345
000	010.4	Adapter 2	370
000	010.5	Technikz.	0
000	020.1	Logistikhof	2800
000	020.2	Umfahrt O	487
000	020.3	Umfahrt N	346
000	020.4	Umfahrt W	468
080	080.01	Heizzentrale	38,9
100	110.01	Produktion	4640
100	110.02	Lager WGK	90
100	110.03	Versand	473,5
100	110.05	Adapter 1	310
100	110.06	Adapter 2	370
100	120.01	Treppe	21,5
100	120.02	Treppe	21,5
100	130.01	WC Herren	9
100	130.02	WC Damen	9
[illegible]	130.03	WC Fahrer	4,2
[illegible]	130.04	WC	4,2
[illegible]	140.01	Werkstatt	40
[illegible]	140.02	Ersatzteill.	40,8
100	140.03	QS-Labor	40,5
100	140.04	AufenthaltRauche	20
100	140.05	Sanitäter	19,5
100	140.06	Besprech.r.Pause	41,5
100	140.07	QS-Lader.	43
100	140.08	BüroLogistik	12,1
100	140.09	Bsp.Logist.	15,1
100	140.10	Fahrer	11,3
200	220.01	Treppe	18
200	220.02	Treppe	18
200	220.03	Flur Galerie	111,5
200	230.01	WC Herren	9
200	230.02	WC Damen	9
200	230.03	WC Umkl.1	8,5
200	230.04	WC Umkl.2	8,5
200	230.05	DU Umkl.1	8,5
200	230.06	DU Umkl.2	8,5
200	240.01	Umkleiden1	59,5
200	240.02	Umkleiden2	84,5
200	240.03	Pausenr.	40,5

FM - figure 4.07

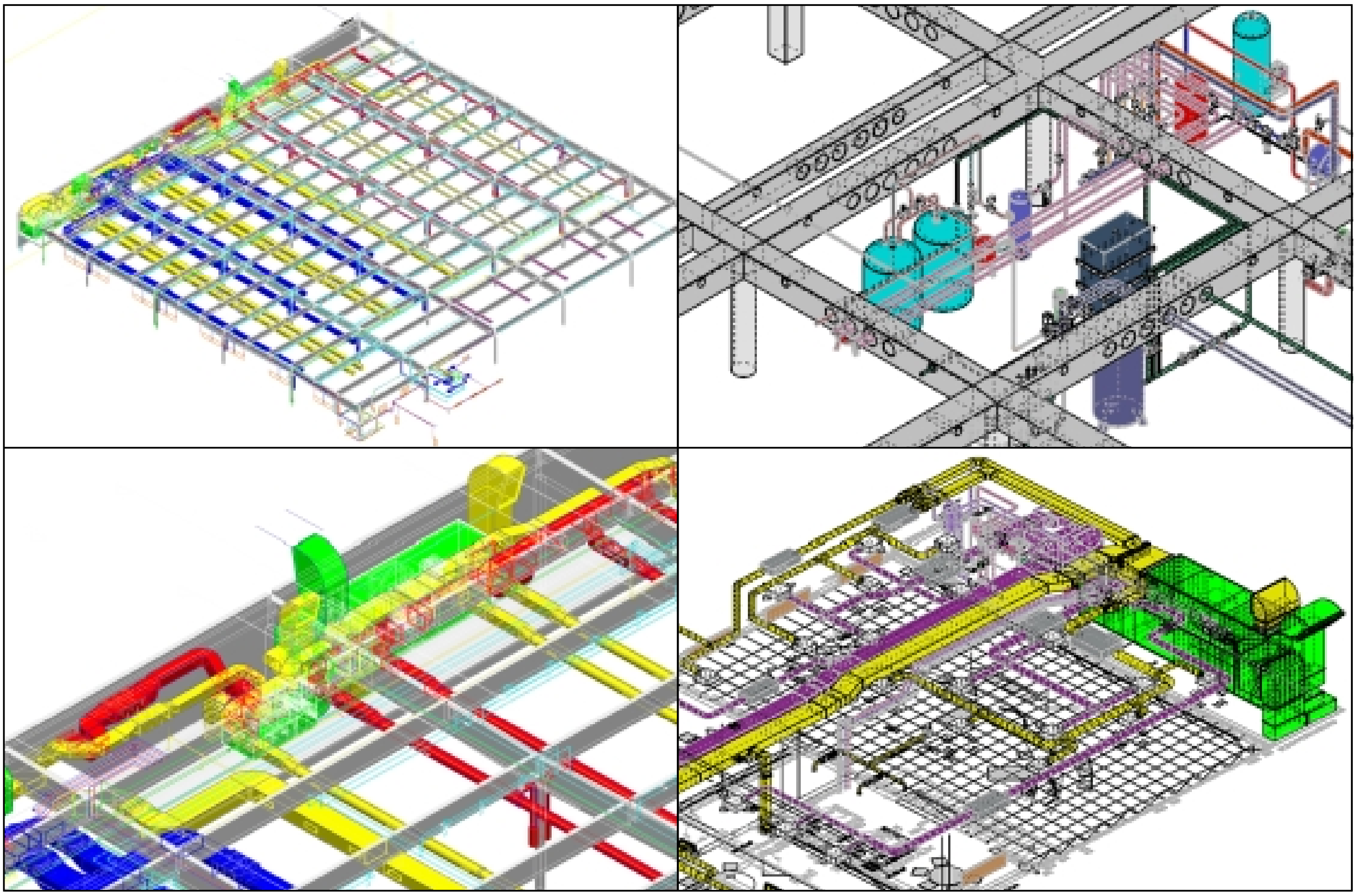
2D/3D-Connection of Building Data and Equipment



FM - figure 4.08

3D-Media Model, Industry Hall

[according to Schewior, Labus]



FM - figure 4.09

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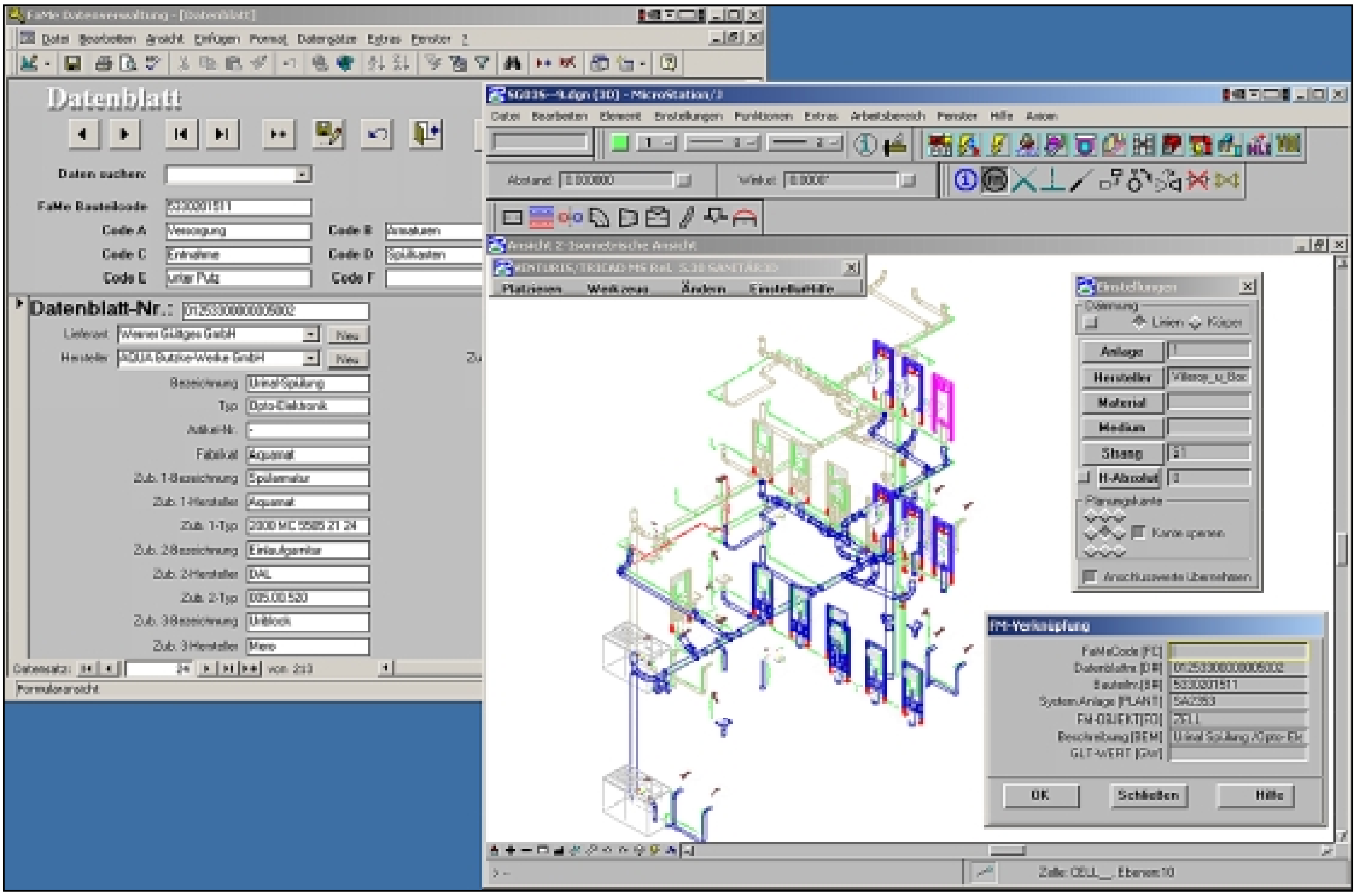
Connection of 3D-Model and Database - Example

[according to Schewior, Labus]



FM - figure 4.10

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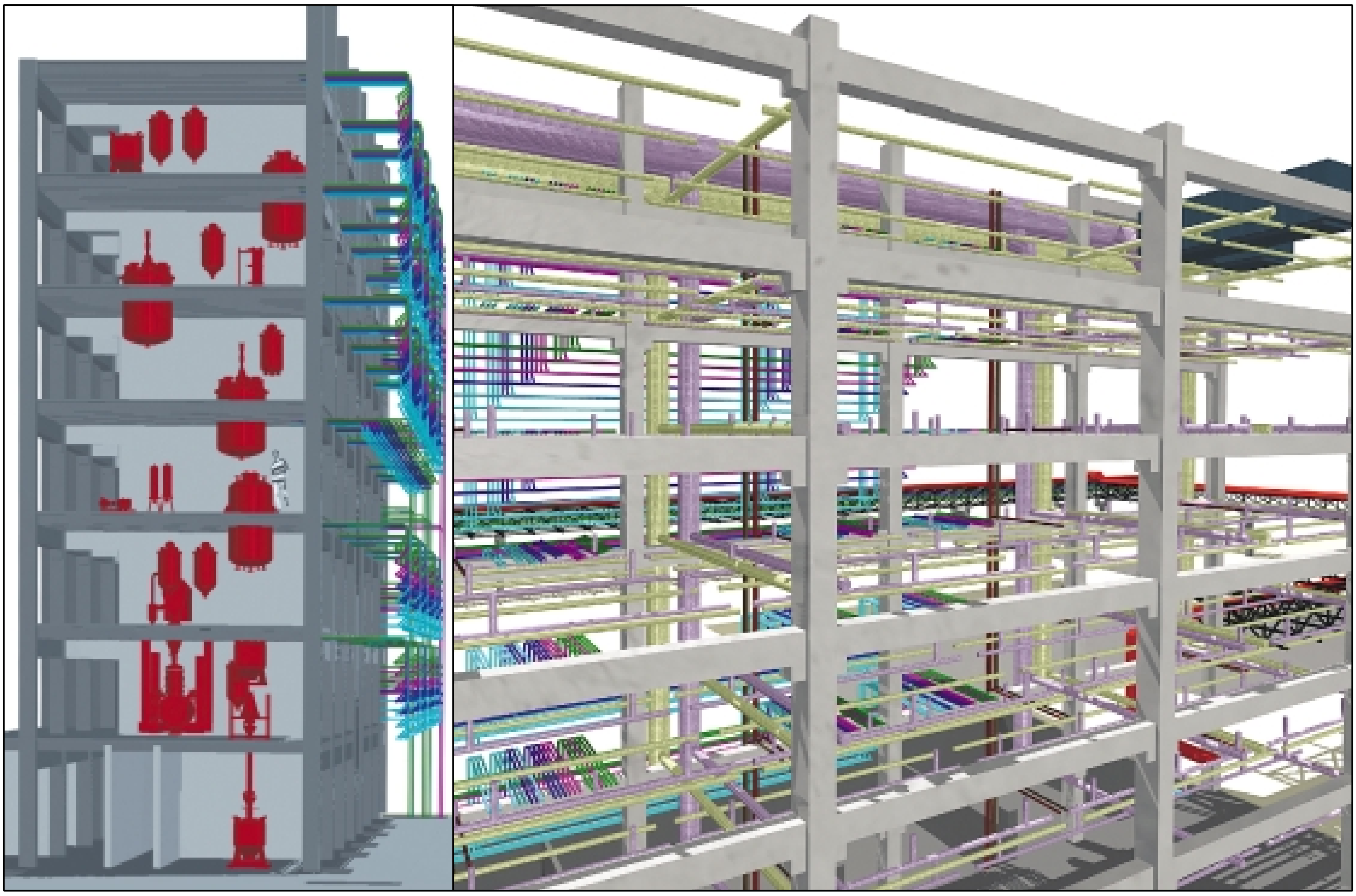
Example - Production Module, Production Media



FM - figure 4.11

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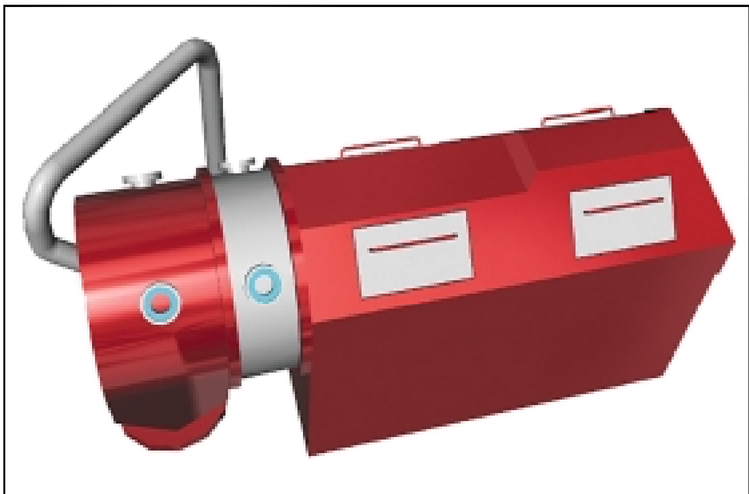
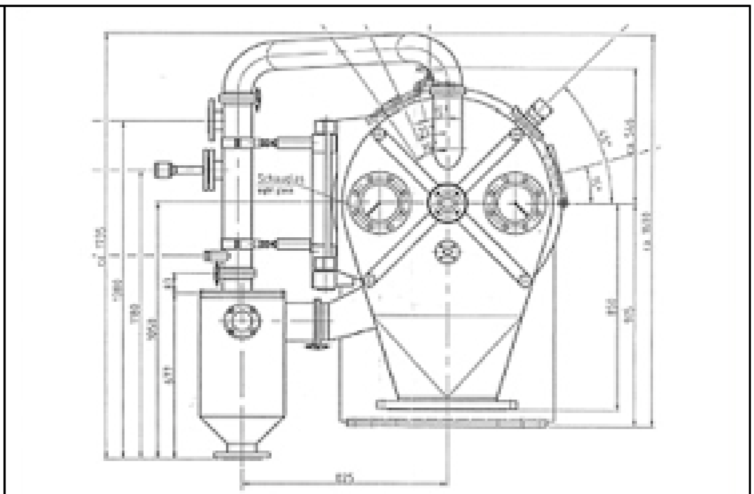
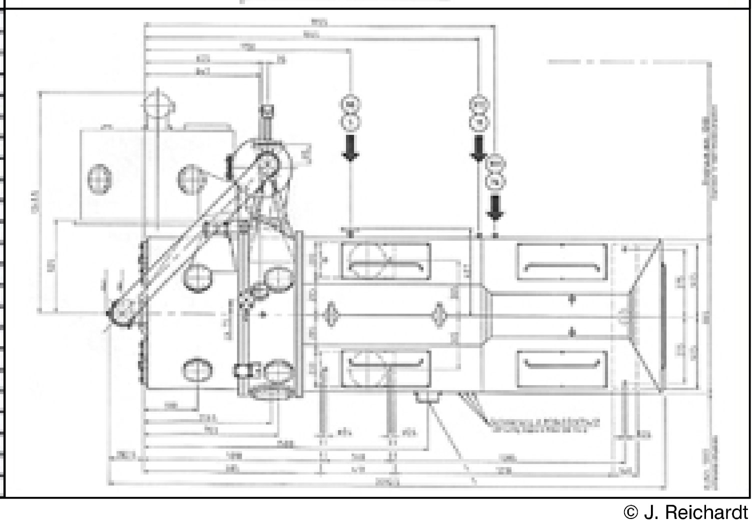
Example - ID-Card of an Inverting Filter Centrifuge





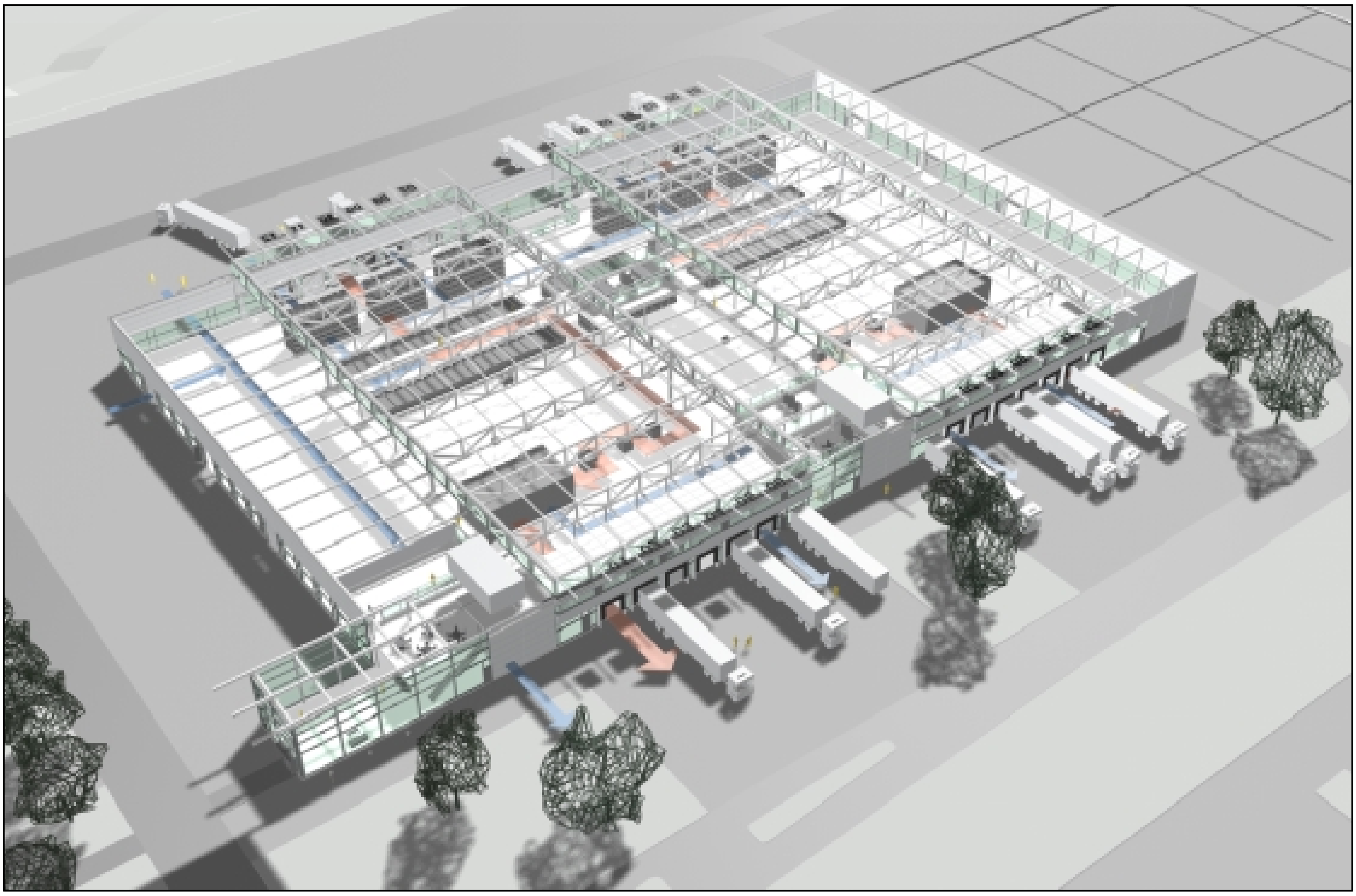
Bez	Pos	Benennung	DN	PN	DIN	ANSI	Anschlußart
	1						
N1	2	Füllanschluß	40	10	2576		
N4	3	Anschluß für Trolball	65	6	2576		verschlossen
	4	Inspektionsöffnung	125	6	2576		verschlossen
N6	5	Waschanschluß Trommelrückw and	15	10	2576		
	6	N2-Anschluß Filtratgehäuse	15	10	28117		
N7	7	N2-Anschluß Feststoffgehäuse	15	10	28117		
N3	8	Abluft Zyklon	50	10	28025		
N8	9	Filtratablauf	100	10	28025		
N2	10	Feststoffauslaß	400	10	2642		
N10	11	N2-Anschluß Lagerkörper	10	10			für Rohr AD12
	12	E-Motor 22KW 1500min					
	13	E-Motor 5,5KW 1500min					
N11	14	Anschluß Steuerluft	6	10			für Rohr AD8
	15						
	16	Drucktransmitter	50	10	28025		eingebaut
	17	Füllstandsgrenzschalteranschluß	G1				verschlossen
	S4	N2-Eingang	15	10			für Rohr AD18
	S5	N2-Ausgang	15	10			für Rohr AD19



FM - figure 4.12

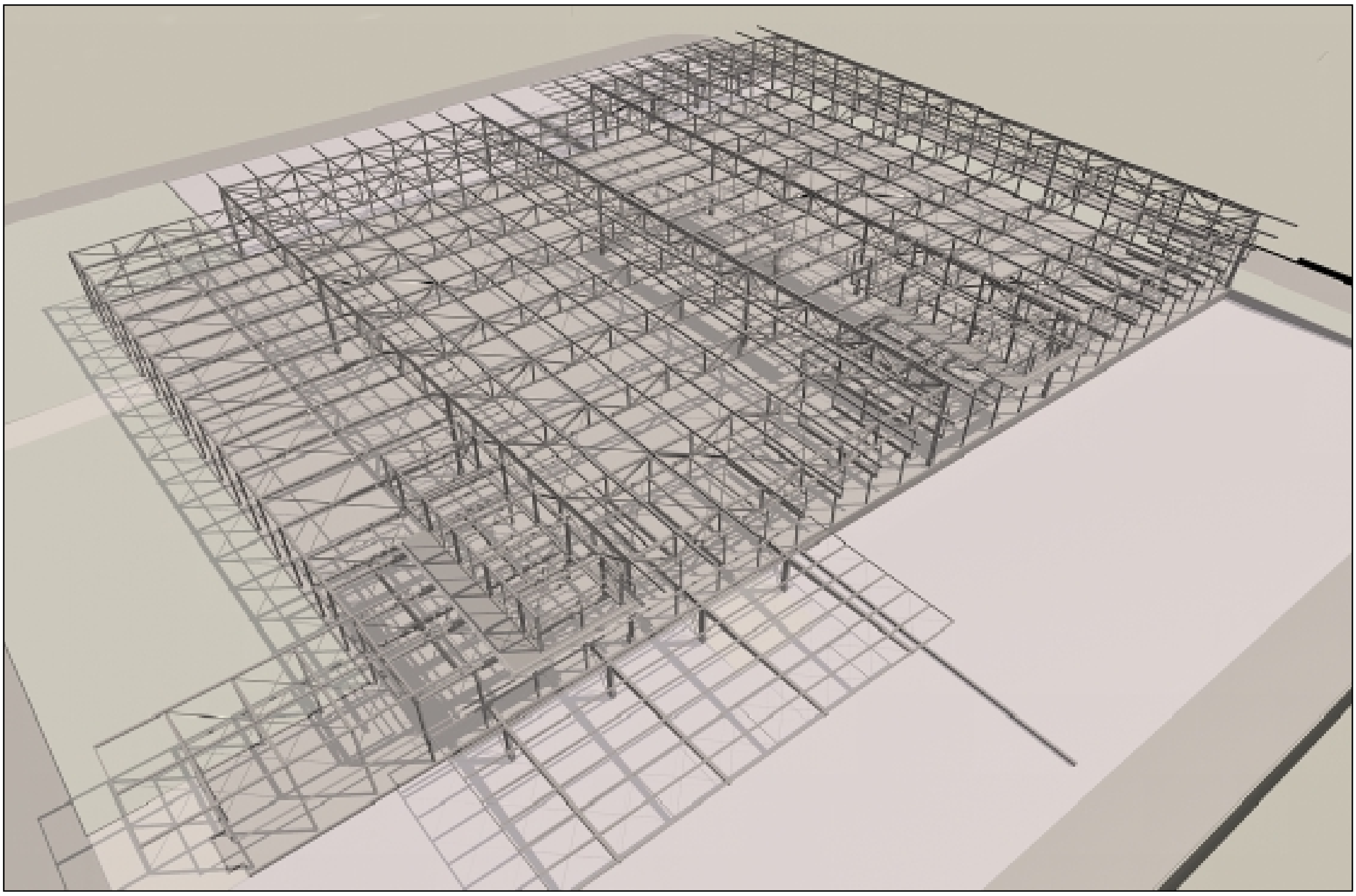
© J. Reichardt

Example - 3D-Building Model



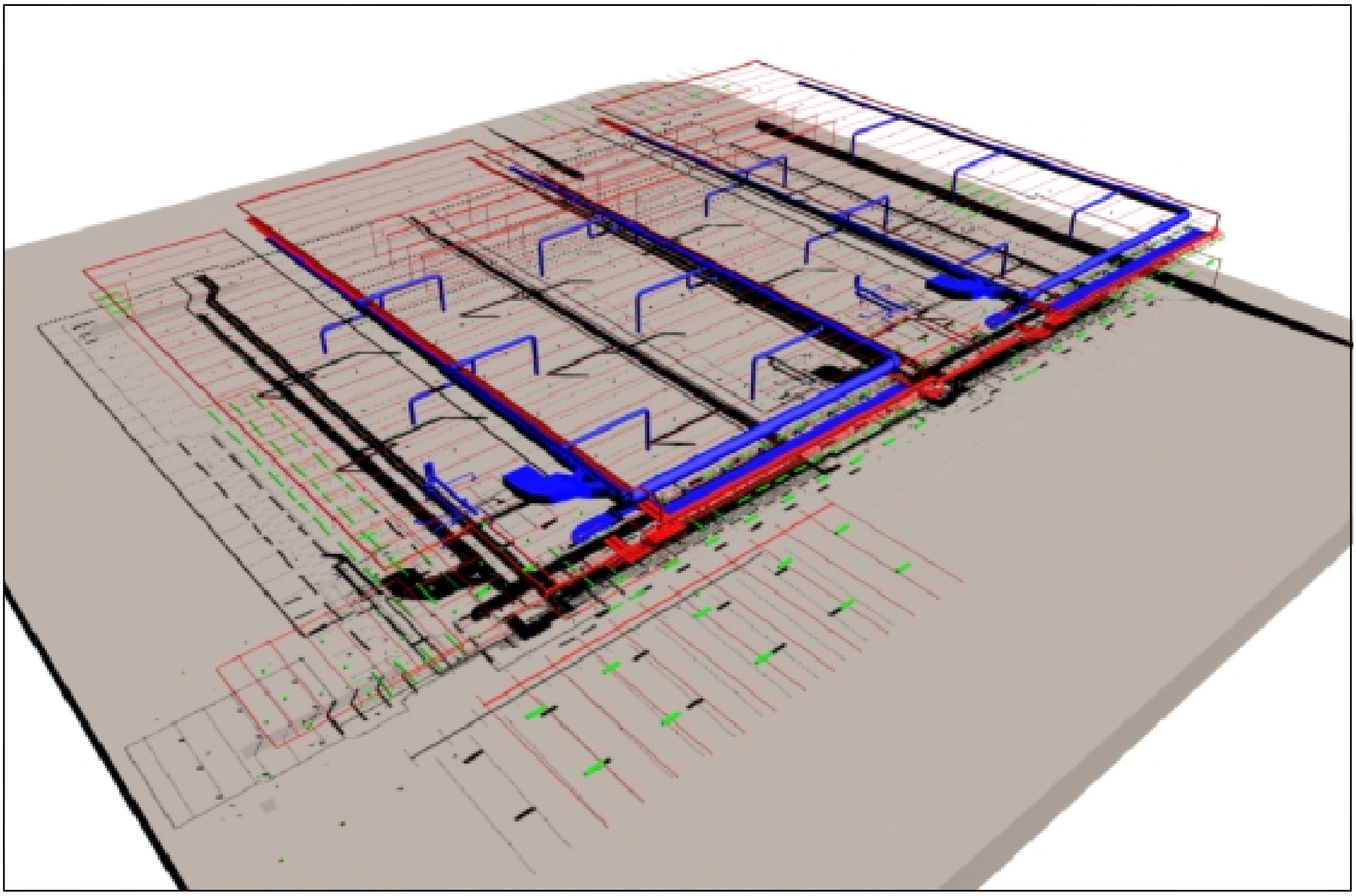
FM - figure 4.13 © J. Reichardt

Excerpt - 3D-Model of Load Bearing Structure



FM - figure 4.14 © J. Reichardt

Excerpt - 3D-Media Model



FM - figure 4.15

XXX

FM - Abb. XXX