Buildings as Component Systems: a planning initiative for conflict-free buildings.

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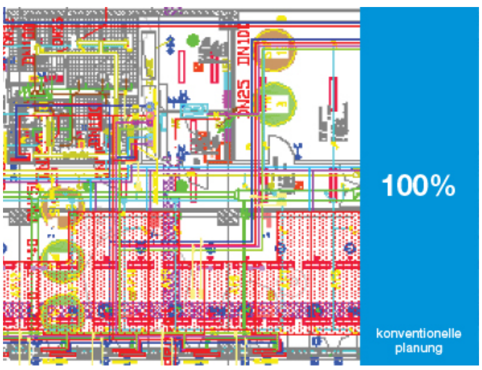
Building component systems have always been associated with construction, particularly when concerned with getting a project built quickly, efficiently and economically as well as the possibility to make changes or disassemble them. The roots to component systems have evolved from nomadic tents and conclude with the beginnings of industrialization with the intention of translating into industrialised processes (Figure 1 and 2).

Advantages and identification of these systems as opposed to conventional building provide an oversight in a range of highly qualified components, a higher degree in pre-fabrication inclusive of a significant acceleration in the building period. As a result they offer repetitive assembly processes, as well as a clear definitive transition in the capability of calculating quantities, costs, producing schedules, quality, and reducing risks. The disadvantages rest especially with claims of a highly uniform architecture and a crude adaptation potential to individual client and user expectations.

Figure 1 and 2:
Component System MIDI, Training center of swiss federal railways (SBB) in Löwenburg Murten Switzerland, 1980-82, Fritz Haller

Is there a possibility to engage the qualities and advantages of building component systems into free-flowing one-off building designs without compromising its variability in form and function? Could it not be said that in fact, **every building is a component system?**



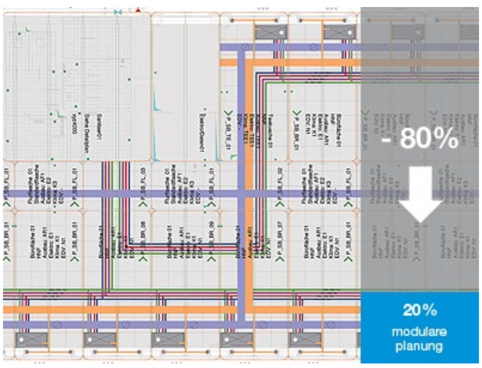


Figure 3 and 4:
An example of complexity reduction within the building services.

Presented here are three steps towards a unique methodological beginning which could transform every building project into one of modular planning design. Such is assisted by modern methods of database planning tools as well as CAD/CAM supported pre-fabrication methods, transforming projects with difficult geometries and diversified contexts into those of a systematic and assured format. The planning, results in greater repetition in construction and its processes, as well as a more comprehensive oversight of these. Complexity in design is typically reduced by 80% (Figure 3 and 4). The design becomes more conflict free and it is more consistently resolved. The assembly processes are clearly accelerated and improved throughout this 'learning-effect'. The pre-fabrication and logistics are sytematically supported. In conclusion of this process the building is delivered with a coherent, and in relation to traditional practice, a simplified building database (BIM) model.

I. Programming of the Form

Resolved geometries are the basic pre-requisite for building component systems. They are the pre-requesite for pre-fabrication of components, for a coordinated assembly process on the building site and for the inter-changeability of the building during its lifetime. Component systems, therefore, require a precise geometrical description. Advanced software methods, specifically for complex forms, are in this case, a tremendous aid.

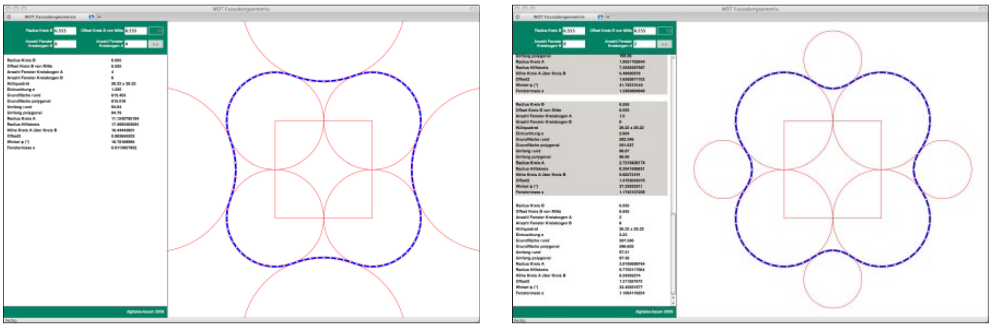


Figure 5 and 6: Parametric modeling example for the facade variations of a project.

The form of an architectural design gets programmed and is no longer 'just' drawn. It is through its programming that the form becomes a mathematical precision and reproducible entity. Parametrically, within a set of structural specifics, variable geometries can be generated. Through this method the programmed results can obtain the desired form in a stepwise process. An example is illustrated here with the apartment towers shown in Figure 5 and 6.
The programming provides within a set of geometric points and axes an equal separation between the structure and the facade, yielding an equal division of the facade elements as well as the correct angle between the mullions. The form can be varied within the set-point conditions without any loss of precision to these changes

The geometric points and axes are coined the 'project coordinate system'. All the elements of the design, building components and spaces are related to these geometrical points. As an *object*, they obtain a location coordinate through a building database model, valid across all the project stages.
Finally, the location points are established via on-site (electronically) measured devices and become the link between the virtual planning and physical worlds (Figure 7 and 8).

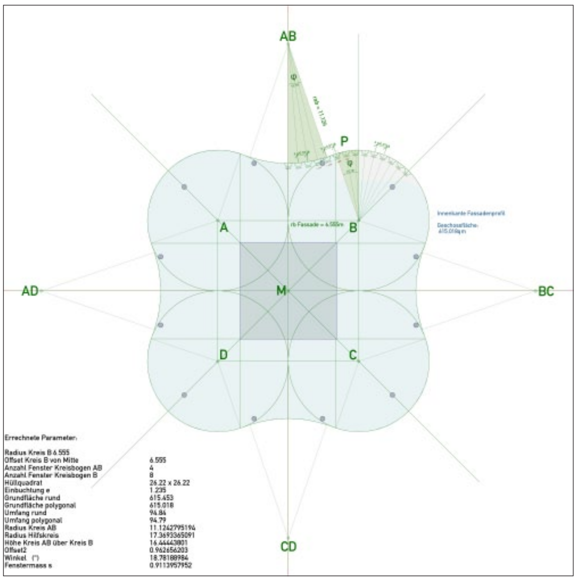


Figure 7 and 8:
Transfer of the chosen geometry in a project coordinate system and by a geometer on the construction site.

II. The Programmed Area

The complexity of a building design is characterized through its variety of elements and materials. The more precise this variety is described, the more controlled are all its process stages. The less variety, the greater the repetition rate, the sooner the application for industrialized processes.

Repetitive construction types permit industrialized pre-fabricated processes. Repetitive assembly processes likewise lead to a particular learning effect that will accelerate and qualitatively improve the building process.

The clarity of geometrical variations of an architectural design become evident when they are reduced into *'unit areas'*. Questions arise: Are there repetitions and symmetries? How are corners resolved? How and where do 'interruptions' such as shafts, central cores, services, structural walls etc. lie and occur? Quite often, simple corrections made to the entire geometry will have a significant effect on the area variation without influencing the overall function or individuality of the building design.

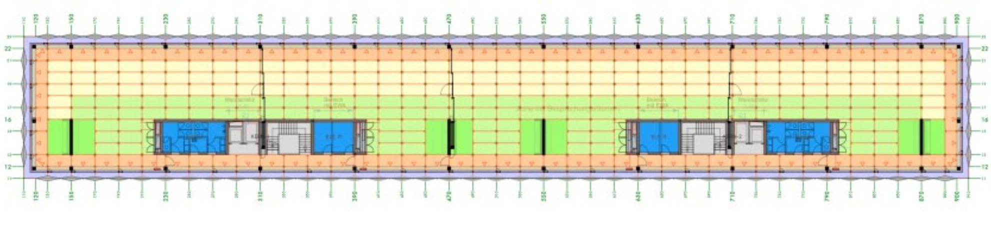


Figure 9:
Complexity is measured through the various 'unit areas'. Facade, corners, and interior zones become equal through small corrections made to the entire geometry.

Complexity is measured through the various *unit areas* (Figure 9 and 10). Facade, corners, and interior zones become equal through small corrections made to the entire geometry. The various unit areas of the design are ultimately the foundation for a structured building model (BIM-model). They are an additional modeling stage providing the traditional BIM with a reduced and therefore leaner and more comprehensive design model. All *unit-areas* are placed into an *object-oriented* catalogue. Their occurrences are anchored into a project coordinate system and receive a clear identification and location marker.

Figure 10:
New ORM office building Roche Diagnostics, Mannheim, 2009, Florian Nagler architects

III. The Unit-Area Related Component System (Figure 11)
In the controlled planning process all *unit-area* functions, uses, fit-outs and assemblies are assigned. The design is linked together through similar planning features, construction types, logisitic characteristics, assembly units and maintenance features. Through this method the team is engaged into the planning of a trade-integrated resolution of the individual *unit-areas*, per building level, from that of a conventional separate trade solution. Through the high repetition rates it is possible to consider relatively detailed and resolved *unit-areas* especially in regards to aspects of logistics, their assembly and management of construction.

Obviously, throughout the design progression, there is a constant reevaluation and refinement of the modeling. This is a clear indication that building designs, in the first instance, are in fact logistical assignments. Planning implies the reworking of a multitude, in fact, similar circumstances, as well as the modelling of similarity and diversity. Therefore the assignment of design planning is very strongly related to that of a programming task. Software terminology such as *object* (type), *relationships*, *attributes*, and *inherent*, can all be incorporated into architectural design. For these tasks, it is appropriate to consider that the procurement of building is more associated with programming terminology and database tools than a CAD software package itself.

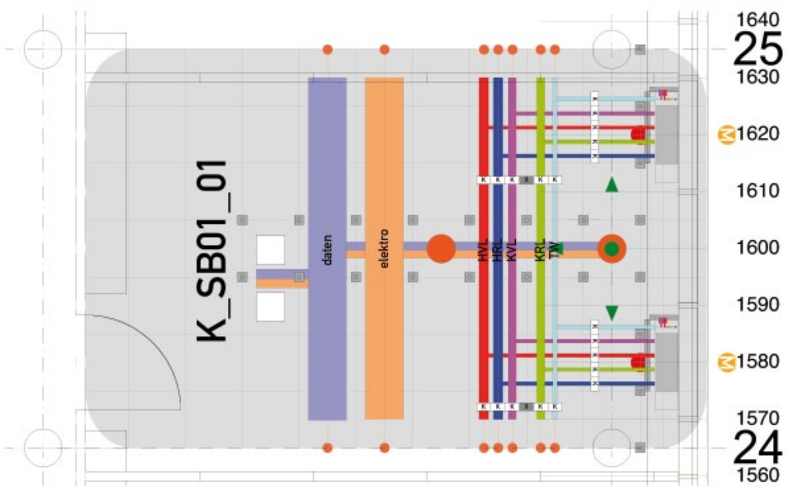


Figure 11:
This figure shows a typical reworking of a unit-area for an office building. The aspects of facade, partitions, raised floor cavity, electrical, communication cabling with hook-up locations, distribution channels for heating and cooling as well as the connection points to other unit-areas are all zone based in regards to an integral planning. Consequentially, an approved and checked off building component system is developed with individual fixed points and tolerance zones. The variation of modules, for example, in relation to pipe diameters and fit-out are controlled through parametric methods.

The reworked unit-area becomes the delivery and assembly standard and is the basis for the quality checks and commissioning (see Figure 12).

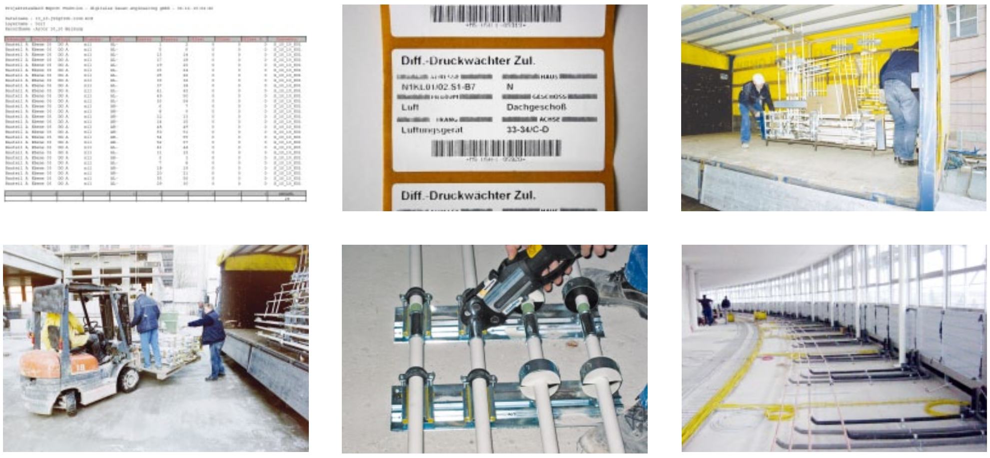


Figure 12:
The logistical, assembly, quality checking and commissioning process.

IV. Implementation

It is basically possible to conceive every building design into a modular programmable form through the method sketched out and presented here. In theory, such implementation should be considered early, before fixing the design with the investors or board of approval (Figure 13).

In practice, design and building is a team inter-disciplinary effort. A functional team and a unified mindset for the design are the true success factors. All the stakeholders must therefore accept a modular planning initiative, especially because conventional practice methods and roles will be abandoned. Consequently, as a result, the possibilities are great for all to participate as a unified team.

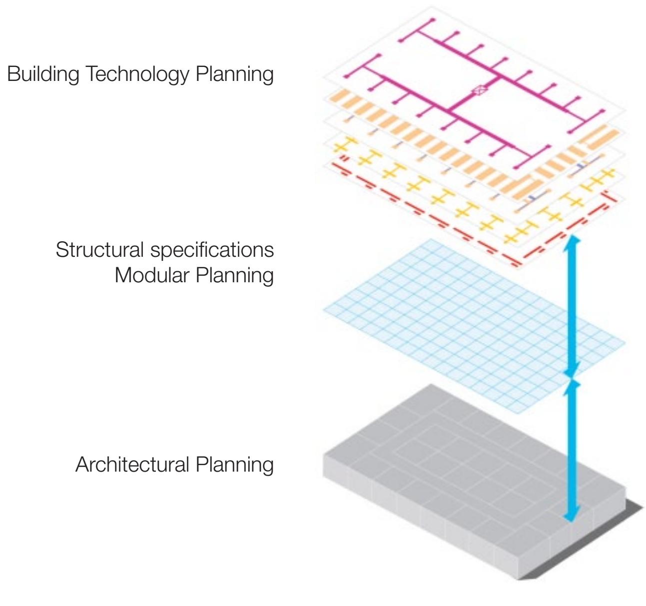


Figure 13:
The theme of modular building resides inbetween architecture and technical planning. The planning by the stakeholders becomes analysed through the project-coordinated system and is entered into the floor plans and building catalogues. The structured guidelines are distributed back to the planners for their input. Refinements to these guidelines are continuously undertaken throughout the design process.