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## Multi-models: New potentials for the combined use of planning and controlling information

Mefisto is a lead project in the research program "IKT 2020 – software systems and knowledge technologies" of the German Federal Ministry of Education and Research (BMBF). The goal of the project is the development of a Management Information System for partnering-based, process-driven and risk-controlled construction planning and management. The project presents software solutions to combine current planning and controlling information in so-called multi-models. These multi-models allow for the transparent representation of the necessary construction tasks, for more holistic analyses of the project performance and risks as well as for a better management of the collaboration processes on a construction project.



**Mefisto: Combining design, engineering and management models across boundaries of corporations, AEC/FM disciplines and organisational hierarchies.**

■ Starting point for the developments in Mefisto are the design, engineering and management models used in construction planning and management today. Combining these models across the boundaries of corporations, AEC/FM disciplines and organisational hierarchies allows for the flexible integration of project information to better evaluate the current project plans

as well as to simulate and analyse the consequences of design and management decisions.

By contrast with the building-centric integration approaches of "Building Information Modeling," in Mefisto the different application models such as 3D building models, bills of quantities, time schedules



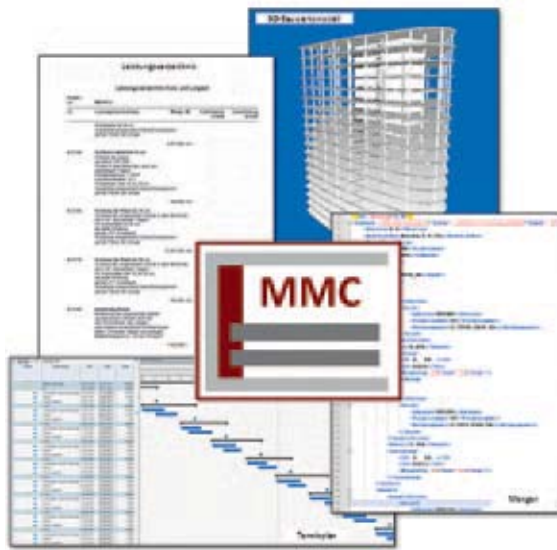
Utilisation of application models in hierarchic organisations of owners and contractors.

and quantity models are regarded as equivalent. Furthermore, it is assumed that for a long time these application models will be created separately with specialised software applications and stored locally with the different project partners. Consequently, the developments of the Mefisto project concentrate on mediating technologies in three areas:

- Multi-models and multi-model containers: multi-models consist of multiple interlinked application models that can be compiled and evaluated with specialised nD-software applications and that can be exchanged using multi-model containers.
- Mefisto platform: on the Mefisto platform the software applications of the project participants are connected via Web Service interfaces and the coordinated exchange of the multi-model containers is supported by central platform services.
- Information logistics: the Mefisto platform defines a standard business logic for the use of multi-models to manage the collaboration processes for creating and utilising application models as well as the corresponding access rights.

#### Combining engineering and management models

The basic idea of a multi-model is to combine selected engineering and management models in a single information resource. Within the resource the application models are bound together by link-models that explicitly specify the interdependencies among the models interlinking associated model elements. The result is a consistent multi-model that reflects a certain project status and view on the overall project information. It provides a sound basis to evaluate the current project situation as well as to further elaborate, simulate and analyse new design and construction alternatives.



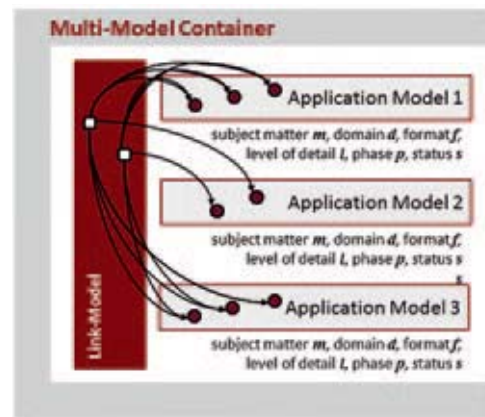
Bidding documents in a multi-model container.

A multi-model for preparing a bid proposal may for example comprise: (1) a 3D building model and (2) calculated quantities deduced from its elements. These can be interlinked with the items in (3) a bill of quantities and (4) a corresponding cost calculation as well as with (5) the activities of a time schedule. With such a multi-model different aspects of the required construction tasks and supporting measures can be represented more transparently. Particularly, the interactive visualisation of information from different application models in combination with the 3D building model allows for the user to more intuitively access, understand and evaluate the contained project information.

To support the combination and interlinking of application models in consistent multi-models, the software applications on the Mefisto platform are supplemented with newly developed modeling, visualisation and analyses technologies. The developed components first allow the user to systematically inspect the interdependent applications models within a multi-model from different discipline perspectives and on different levels of detail. Second, they provide for the navigation of the overall information space of interdependent application models within the multi-models on a construction project. Furthermore, rule-based methods are applied: on the one hand to automatically interlink and complement application models and on the other hand to filter interrelated project information from a multi-model to be translated, aggregated or otherwise transformed for further use in adjacent areas of construction planning and management.

### Data exchange using Multi-Model Containers

For the exchange of multi-models among different project participants and software applications a new exchange format named the multi-model container was developed. The container only defines a superstructure to encapsulate different kinds of application models and corresponding link models. Within the container the application models are treated as independent information resources with their own application domain, data schema and data formalisation. This way, the multi-model container allows for the flexible utilisation of established file formats, such as the IFC\* standard for 3D building models and GAEB\*\* DA XML for specification models using bills of quantities. In addition, in Mefisto a series of supplements to existing data standards and several new data schemas were specified to allow for the exchange of e.g. construction site models, cost models, organisation models and risk models.



Principle structure of a multi-model container.

On the Mefisto platform the multi-model container is realised by a collection of data files that are exchanged within a compressed archive file. In addition to the application models and link models, the container comprises a XML-based description of the container content. It provides metadata on the subjects, detailing and data format as well as the contributors for each of the contained models. On the one hand, this metadata supports the administration, retrieval and utilisation of the application models throughout the project. On the other hand, they can also be used to define multi-model templates that prescribe the requirements regarding content and formalisations of application and link models yet to be produced.

### Project collaboration with multi-models

In their entirety the multi-models on a construction project open up a multi-dimensional information space of interdependent application models that can be



independently processed by the project participants. Each participant has the opportunity to produce new application models on his/her own responsibility and interlink them with existing models. Depending on the situation these newly created multi-models can be maintained locally or published project-wide as a basis for further planning and controlling tasks. In comparison to the often pursued integration of project information in central project databases or product model servers, this approach distributed model-based collaboration represents a paradigm shift.

In the Mefisto project various software components (MM plug-ins) have been developed for the local creation and analysis of the multi-models: on the one hand for existing specialised software applications such as iTWO (RIB Software AG), GRANID (gibGreiner GmbH) and SolidWorks (SolidWorks GmbH) and on the other hand for new analytical tools like the SiteSimEditor (Ruhr-Universität Bochum) and the M2A2 Multi-Model Assembly and Analysing Platform (Technische Universität Dresden).



Software systems on the Mefisto-Platform.

For the project-wide use of multi-models the Mefisto platform provides central platform services for the coordination of collaboration processes (information logistics) as well as for the filtering and transformation the multi-models (multi-model management).

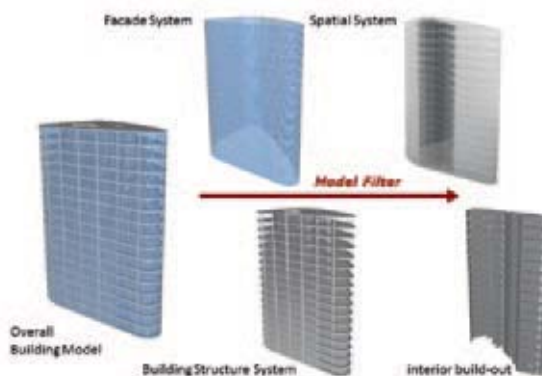
The information logistics of the Mefisto-Platform is realised by a set of platform services for managing platform users and multi-models. Via these services, project participants can publish and retrieve multi-model containers from their local software applications. Moreover, a central workflow service allows for assigning planning and controlling tasks to the different project participants as well as for delivering the respective results.

Various process management technologies are applied to support the planning and coordination of the

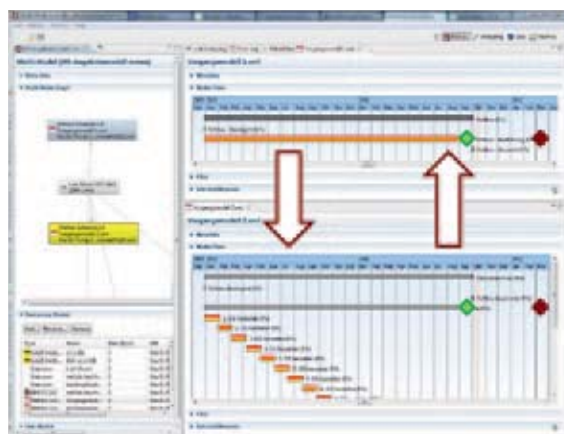
multi-model-based collaboration processes. The business logic of the Mefisto-Platform is first of all defined by general business process models, called Reference Process Modules. Integrating multi-model templates, these process models formally specify the requirements for the different planning and controlling models to be produced. On a particular construction project these reference processes can be customised and interlinked with project schedules as well as reused for the instantiation of respective workflows. Furthermore, the multi-model container is also used for workflow coordination: on the one hand planning and controlling tasks can be assigned to the participants using multi-model templates and on the other hand the tasks results can be delivered in a corresponding result container.

**Potentials for the application of multi-models**

Overall the research project Mefisto elaborates a variety of collaboration methods and technical solutions for multi-model-based construction planning and management. Their potential applications and benefits are investigated in several demonstrations scenarios by the contractors and the project management company on the project.



Filtering model views and systems from a building model.

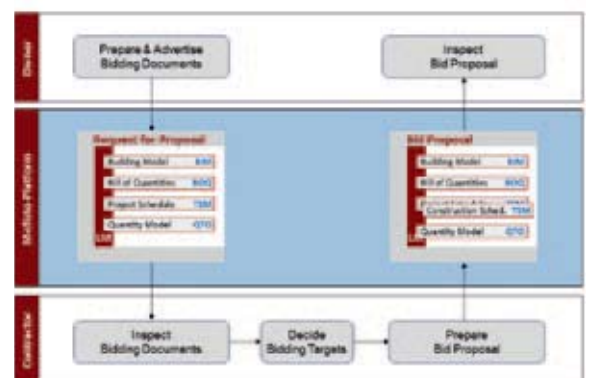


Interlinking coarse-grained and fine-grained project schedules, M2A2 Multi-Model Assembly and Analysing Platform. (TU Dresden)



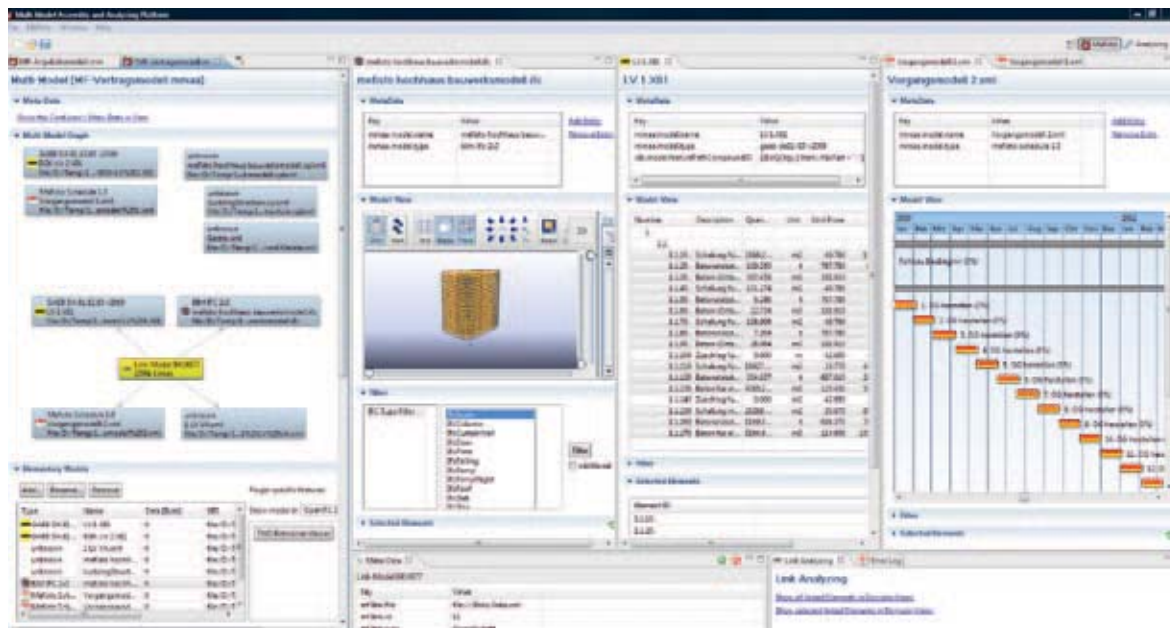
The methods and tools developed for the interlinking and the combined processing of application models first of all provide for managing the interdependencies among disparate application models. Of particular significance for the identification and maintenance of these interdependencies are filtering methods to extract discipline- or tasks-specific sub-models as well as visualisation methods to interactively inspect and navigate the combined application models.

New potentials for the effective utilisation of model-based project information are also offered by the procedures and tools to build supplementary simulation and analyses models. Based on the interlinked application models simulation models of the construction processes and the project risks can be generated much more efficiently. Furthermore, the multi-models can also be used to conduct geometrical and kinematic analyses of the production processes on the construction site as demonstrated in the following article by Thomas Hauber.

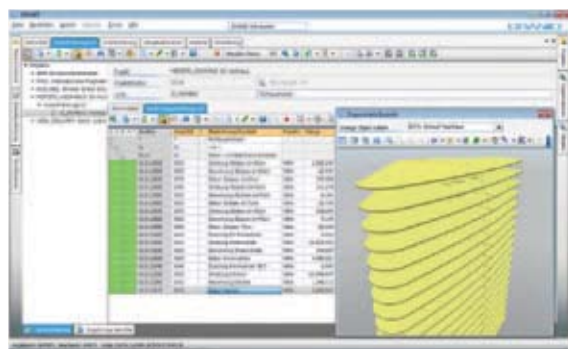


**Business Process Model: Construction bidding with multi-model containers.**

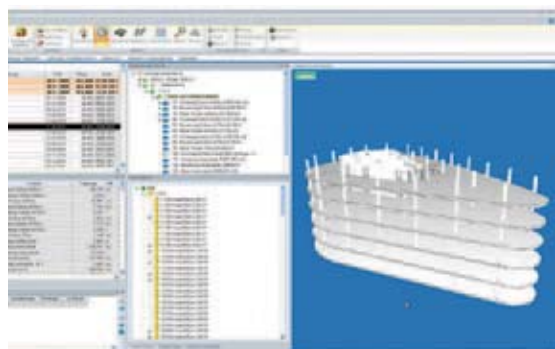
Finally, the procedures and tools for process management offer the basis for realising (multi-)model based collaboration in construction practice. Prerequisite for the effective application of multi-models are harmonised collaboration processes and detailed agreements on their content and form. In Mefisto detailed multi-model templates and reference process



Multi-model container of Mefisto-High-Rise, M2A2 Multi-Model Assembly and Analysing Platform. (TU Dresden)



Multi-model container of Mefisto-High-Rise, GRANID (gibGreiner GmbH)



Multi-model container of Mefisto-High-Rise, iTWO (RIB Software AG)

modules are first of all developed for the collaboration processes between owners and contractors, e.g. for construction bidding and construction progress reporting as well as for change management. The elaborated demonstration scenarios have shown that these reference processes provide a good basis to plan and coordinate the technical and organisational interfaces of a project as well as for realising the corresponding software systems.

**Acknowledgement**

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\*IFC (Industry Foundation Classes) is a standard conceived and certified by buildingSMART e.V. for the exchange of building information models (BIM). Further information can be found at: [www.buildingsmart.de](http://www.buildingsmart.de).

\*\*GAEB stands for Joint Committee for Electronics in Construction. The GAEB promotes the application of electronic data processing in construction based on a common language of all stakeholders involved.

GAEB DA XML is intended to establish a common standard for construction information exchanged during construction bidding, contracting and invoicing as well as during construction execution. Further information can be found at: [www.gaeb.de](http://www.gaeb.de).