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AN INTEGRATED PROCESS-BASED SIMULATION PLATFORM FOR CONSTRUCTION PROJECT PLANNING

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Overview

- Motivation, objectives and approach
- Process-based simulation method
- Multi-Model data exchange approach
- Construction Simulation Toolkit- CST
- Collaborative Simulation Portal- ProSIM
- Validation simulation projects
- Conclusion

Problem

- Creating reliable and reusable simulation models is very complex, time consuming task
- simulation software need very experienced simulation experts
- Set up and validation of a simulation model for a construction project need 2-3 months

Consequence:

- Simulation is not very often applied
- It cannot sufficiently handle the complexity of modern construction projects
- The benefits are not immediately obvious

Motivation

- Support planning of construction projects through rapid set-up of simulation models and fast variation of them

Consequences:

- Developing a set of convenient tools for setting-up of simulation models based on standard data interfaces
- Developing a collaboration platform to integrate the huge and complex projects data with low-cost entry for construction industry and enable communication between design, planning and simulation experts.

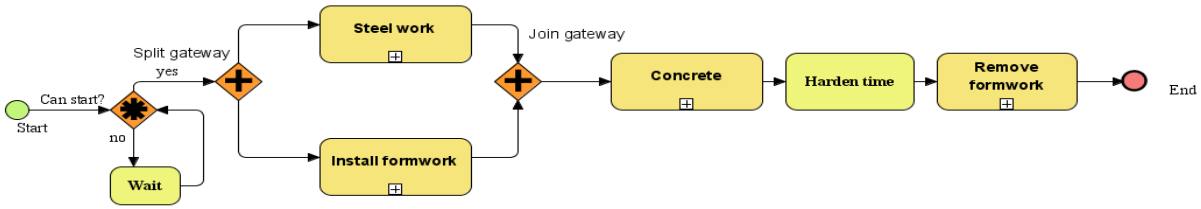
Approach

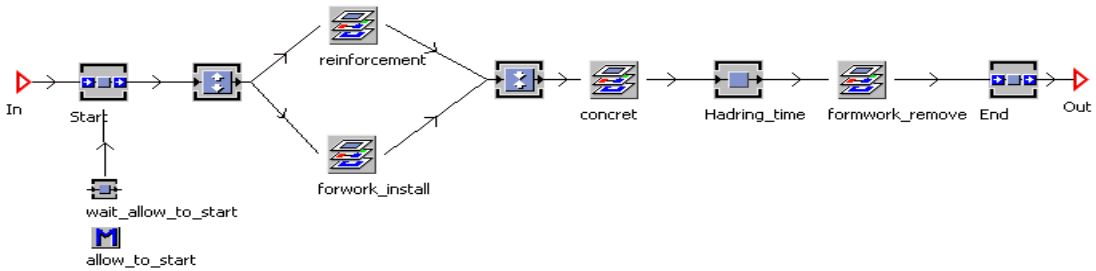
- **Process-based simulation approach**
  Using formal business process models BPMN notation, extend by resource modelling and providing the ability to transform them into simulation process
- **Reference Process Model method** to capture and organize the construction knowledge
- **Dynamic filter tool box (BIMfit)**
  for task based specification in BPMN via MVD and filtering of information views from different models
- **Multi Model method for data integration**
  and interoperability of design and planning information
- **Reusable simulation components (CST Toolkit)**
- **Collaborative simulation portal (ProSIM)**

Reference process models, RPM

RPM are generic conceptual models based on BPMN that formalize recommended practice for a certain domain. They can be combined to complex ones.

We have adopted and extended BPMN in order to capture and transform construction processes into simulation models.





BPMN

XML

Simulation

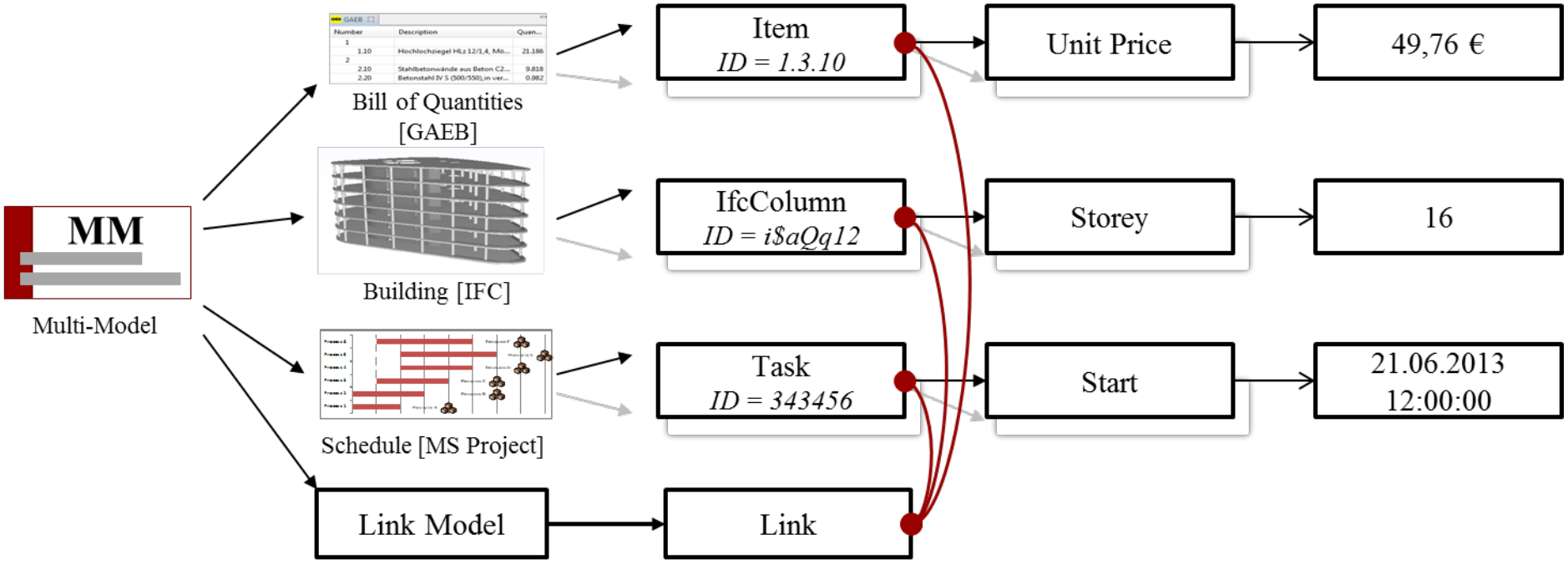
Multi Model Approach

Multi Model project planning is a paradigm shift from the building centric approach toward an equivalent interlinked data models using explicit and separated link models.

A multi-model container comprises several domain models and one or more link models. It includes meta information on container, domain and link level.

Multi Model approach is integrated with CST through providing import and export facilities.

Multi Model Concept



Principle bundling of heterogeneous application models and explicit, ID-based links between their elements

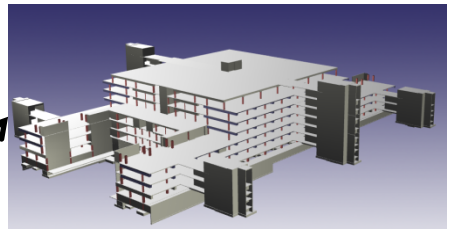
Multi Model Container Example

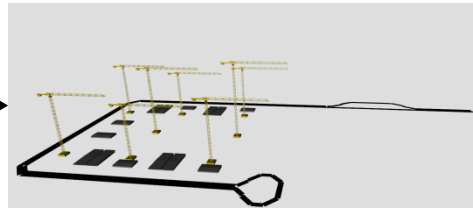
MMC for the Mefisto Airport project – Tender phase

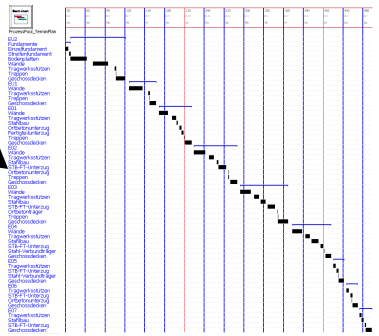
Mefisto Airport Terminal: Tender phase- Structural work

	ID	Format	Schema	Files
M1-Bill of Quantity	1	XML	GEAB 3.1	BoQ1:: gaebLV MEFISTO.X81 BoQ2:: gaebBGK-LV 1.X81
M2-Quantity Take-off	1	XML	1.0	QTO1:: MEFISTO LV VA.xml QTO2:: 1 LV VA.xml
M3-BIM	1	SPF	IFC2X3	a_td_mod_gcat_cad_rvt_cm_arc_2011_s1-7.ifc mf-1001-be-001.ifc
M4-Schedules	1	XML	CPIxml 1.0	Activity1:: Vorgangsmodell 1.xml
M5-Equipment	1	XML	1.0	Geraete.xml
M6-Cost Estimate	1	XML	1.0	Angebotskalkulation.xml

LM L1 QuantitySplit:(M1 M2 M4 M6 M3)

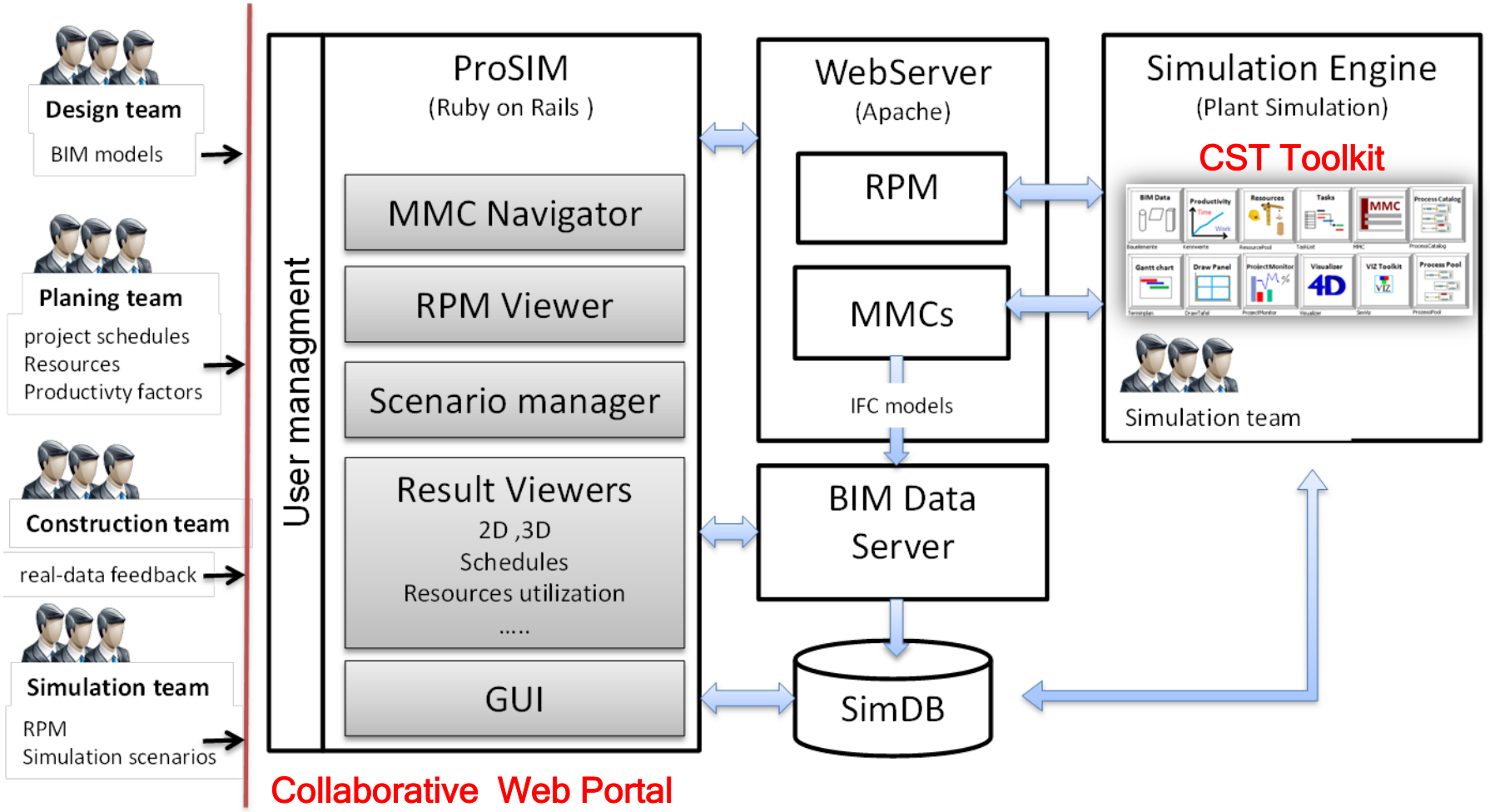






Download link: http://bci52.cib.bau.tu-dresden.de:3000/multi_model_containers/1

Simulation platform components



CST: Simulation Components

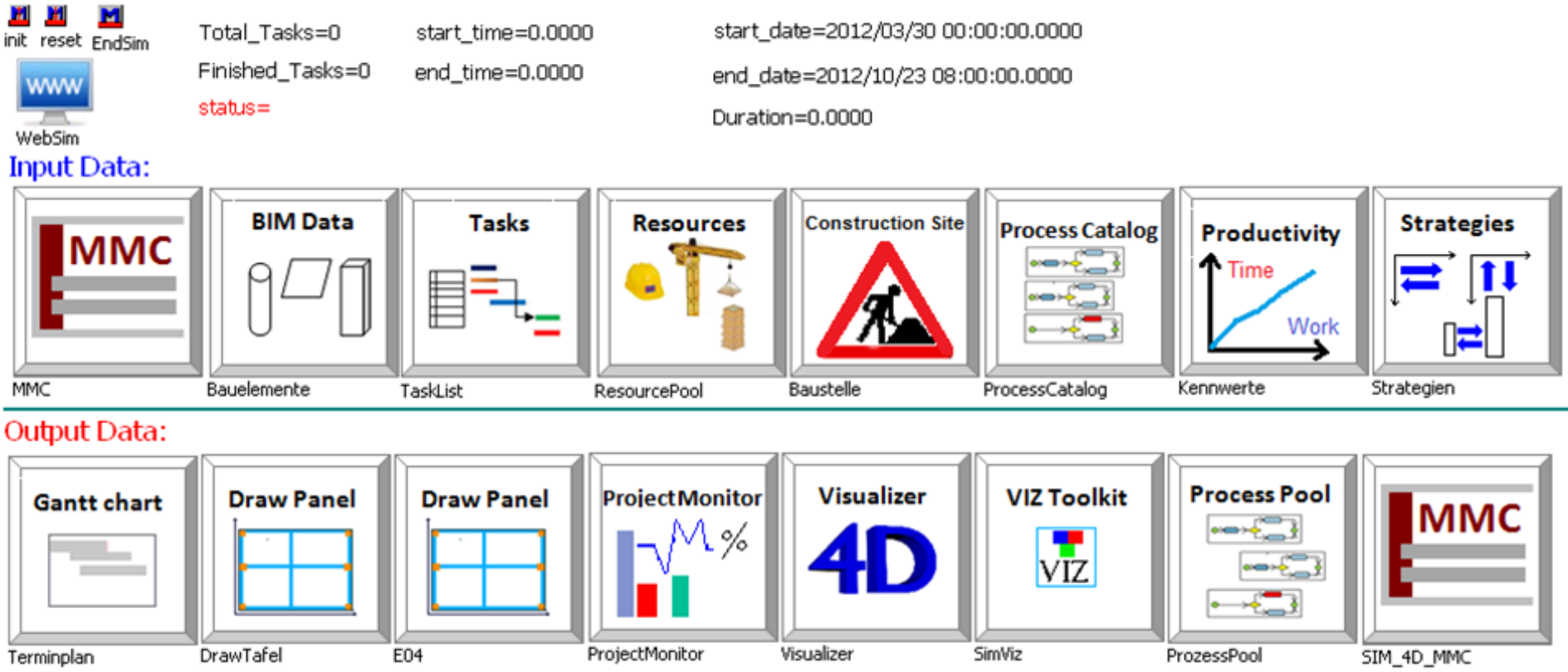
CST toolkit is implemented on top of the simulation software Plant Simulation (Siemens PLM).

CST is the construction specific interface to general simulation engines.

CST aims to reduce the total duration and cost of construction projects through improving the planning quality and utilization rates of resources and avoid conflicts during the construction phase.

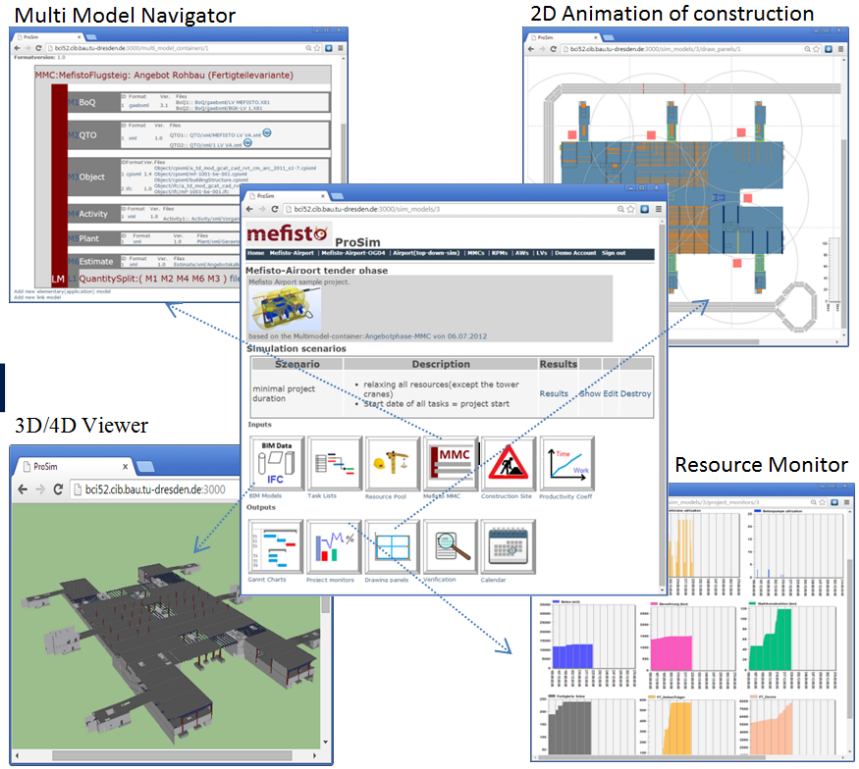
CST offers a set of simulation modelling components, which can be used in a modular way to create simulation models rapidly.

Simulation modelling components



ProSIM: Collaboration Platform

ProSIM platform is designed as an online web-based portal to support the communication and collaboration among all project planning members and to publish simulation model results and all related input data.



ProSIM can be accessed at
http://bci52.cib.bau.tu-dresden.de:3000/

Validation and Study Cases

- **Mefisto Office project**
  - 18 storey office building
  - Planning and simulation of constrcution work
  - Reduce the total duration of construction
- **Mefisto Airport Terminal Project**
  - Planning and simulation of logistic and construction work
  - Optimize the number of key resources
  - Optimize the construction site layout

Access to Simulation models and resutls at:

http://bci52.cib.bau.tu-dresden.de:3001/simweb/

http://bci52.cib.bau.tu-dresden.de:3000/

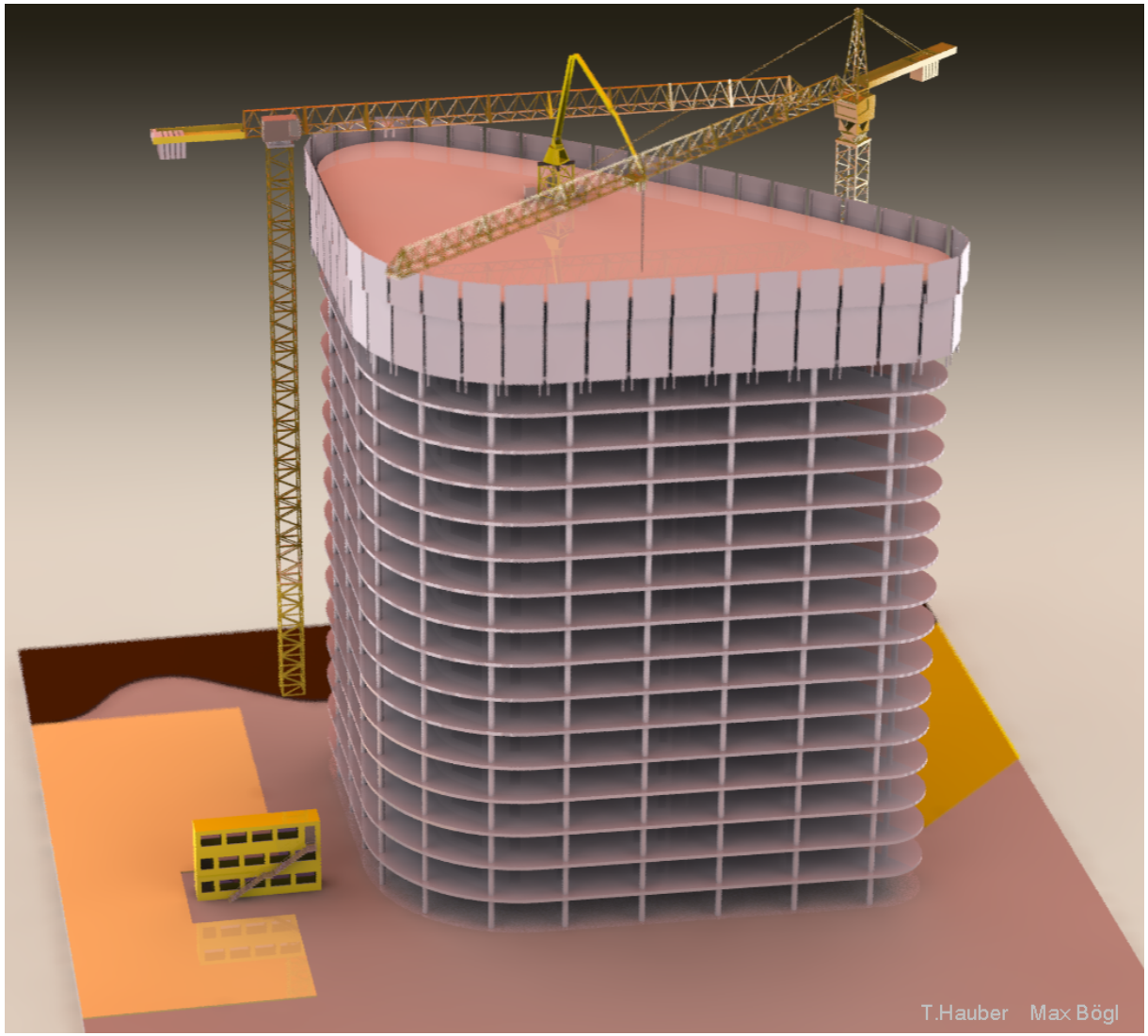
Conclusions and future work

- Using formal process modelling and reference models in order to capture and manage knowledge in construction domain and transfer them into simulation models
- Using Multi Model approach for project data exchange
- Construction specific simulation toolkit and a collaborative platform

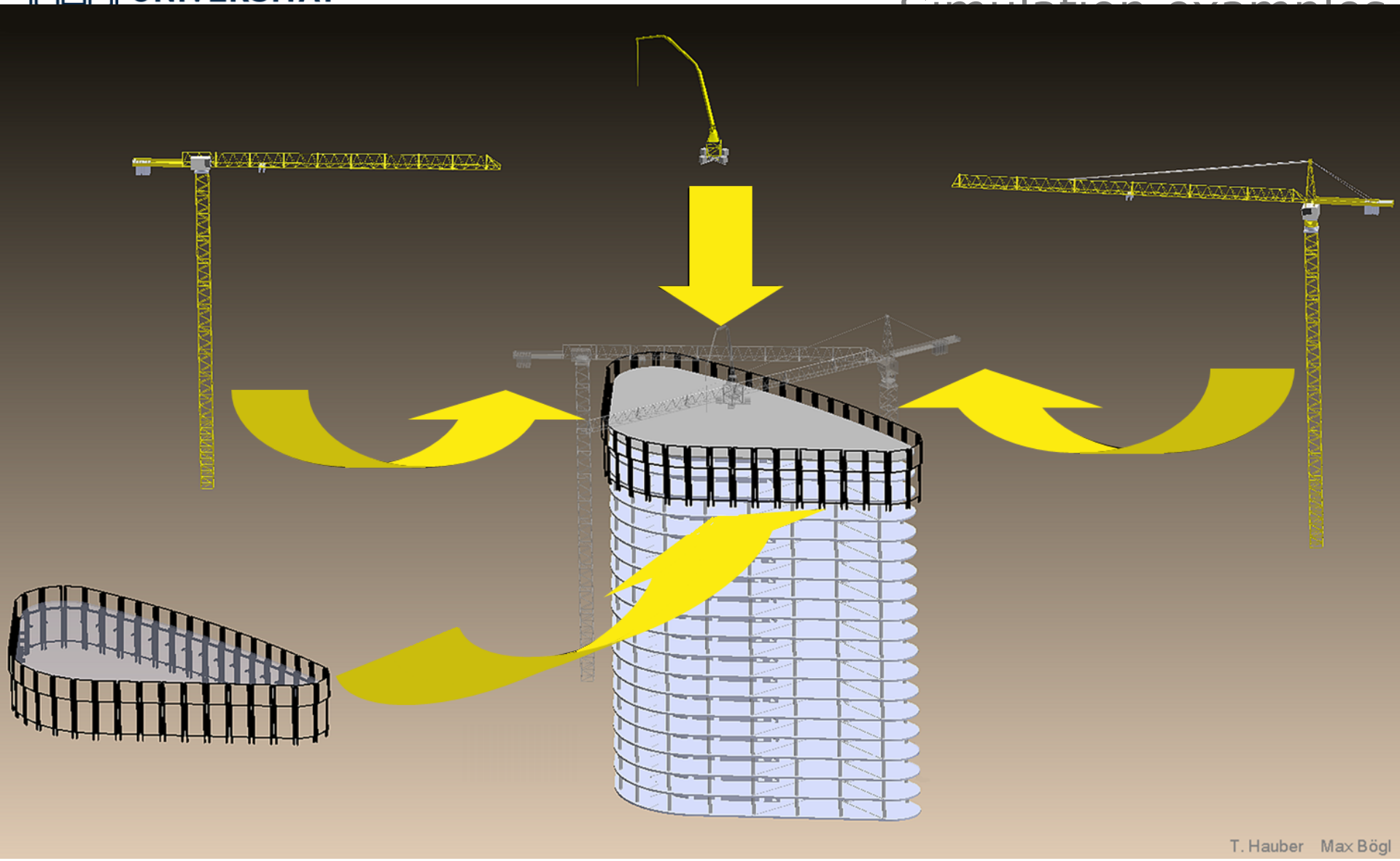
Future work:

- Integrating the simulation platform with project real data collected on construction site
- Extending reference process models for other project types or disciplines like bridges and interior work

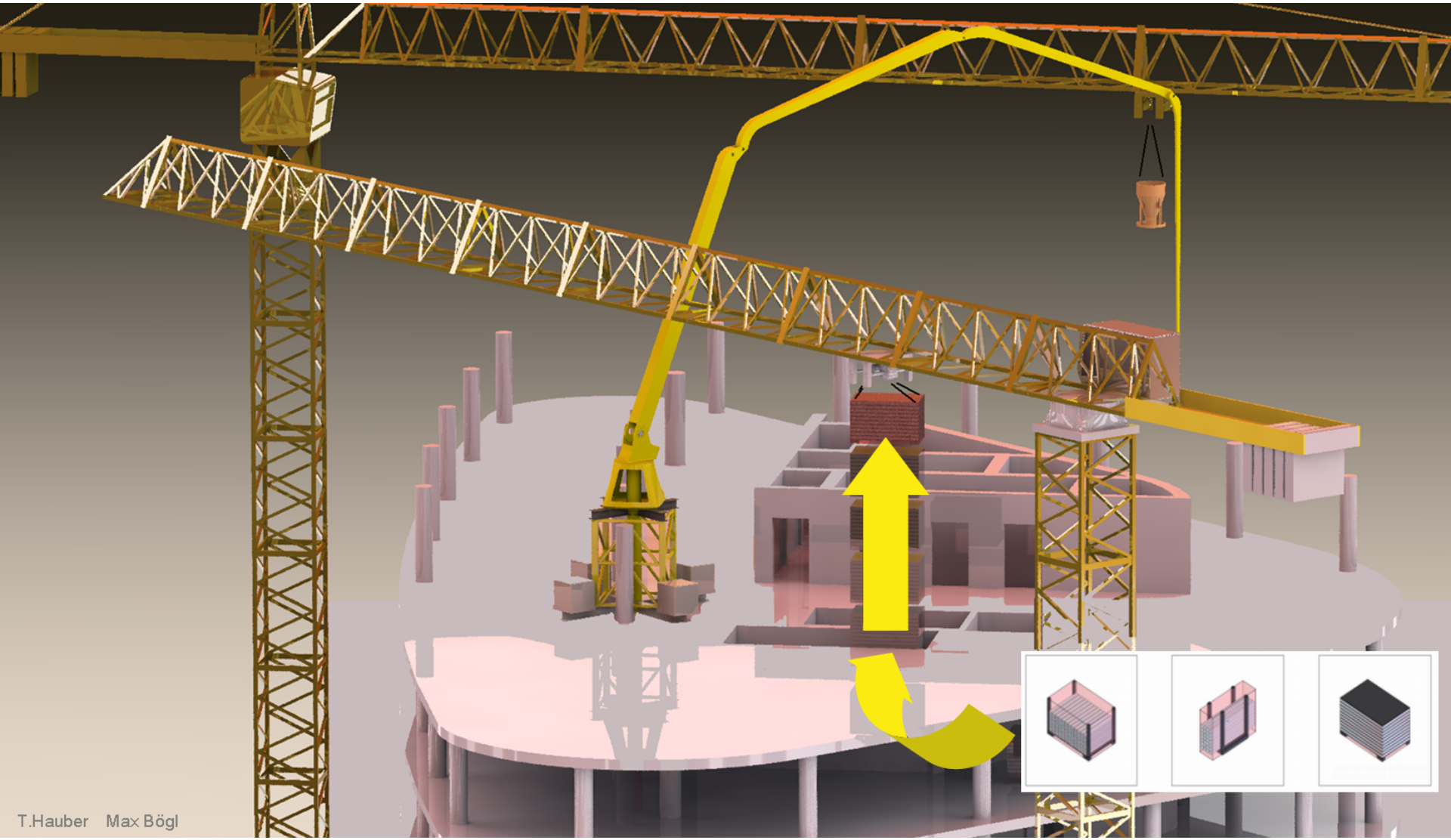
Simulation examples



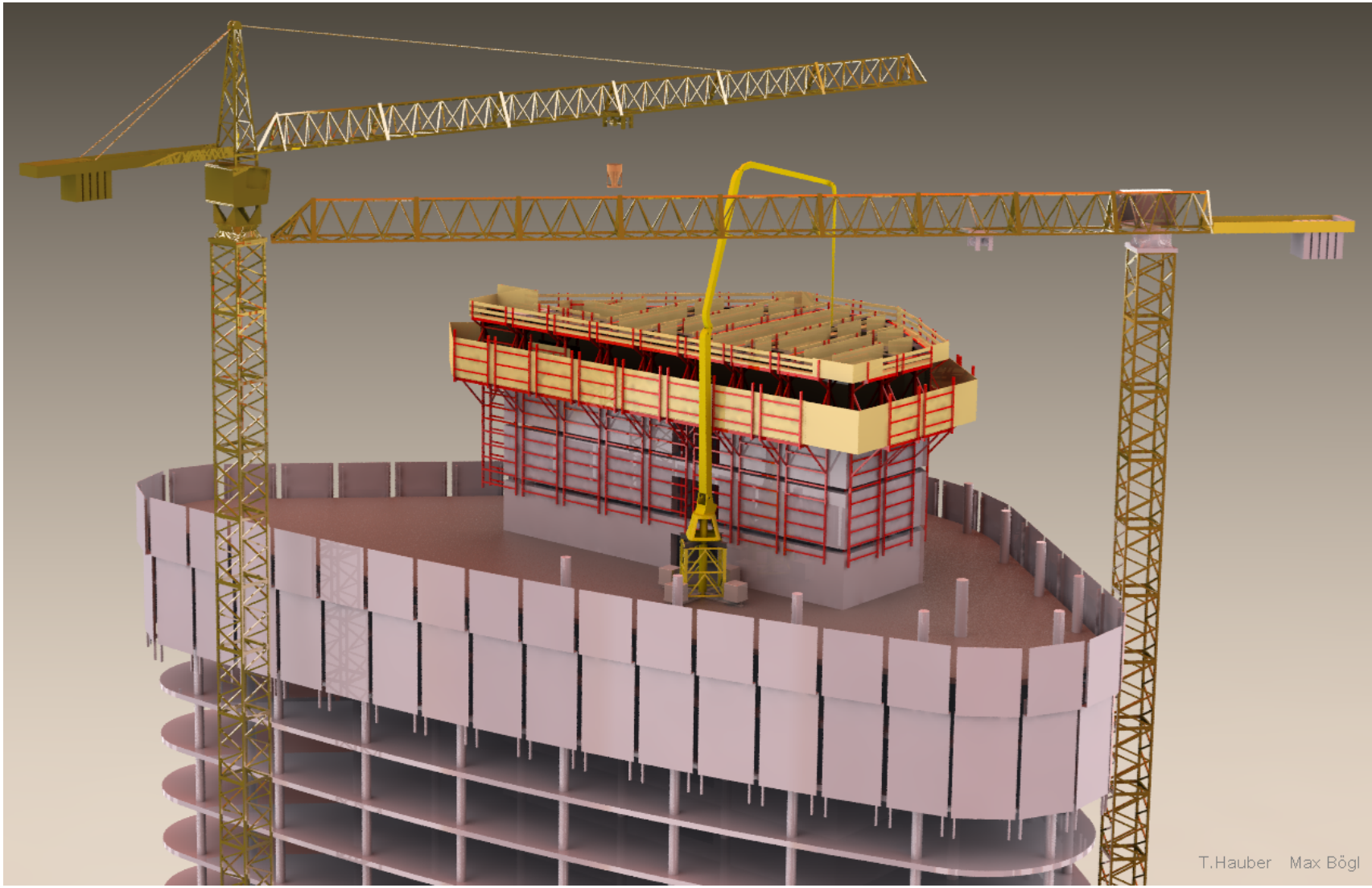
Simulation examples



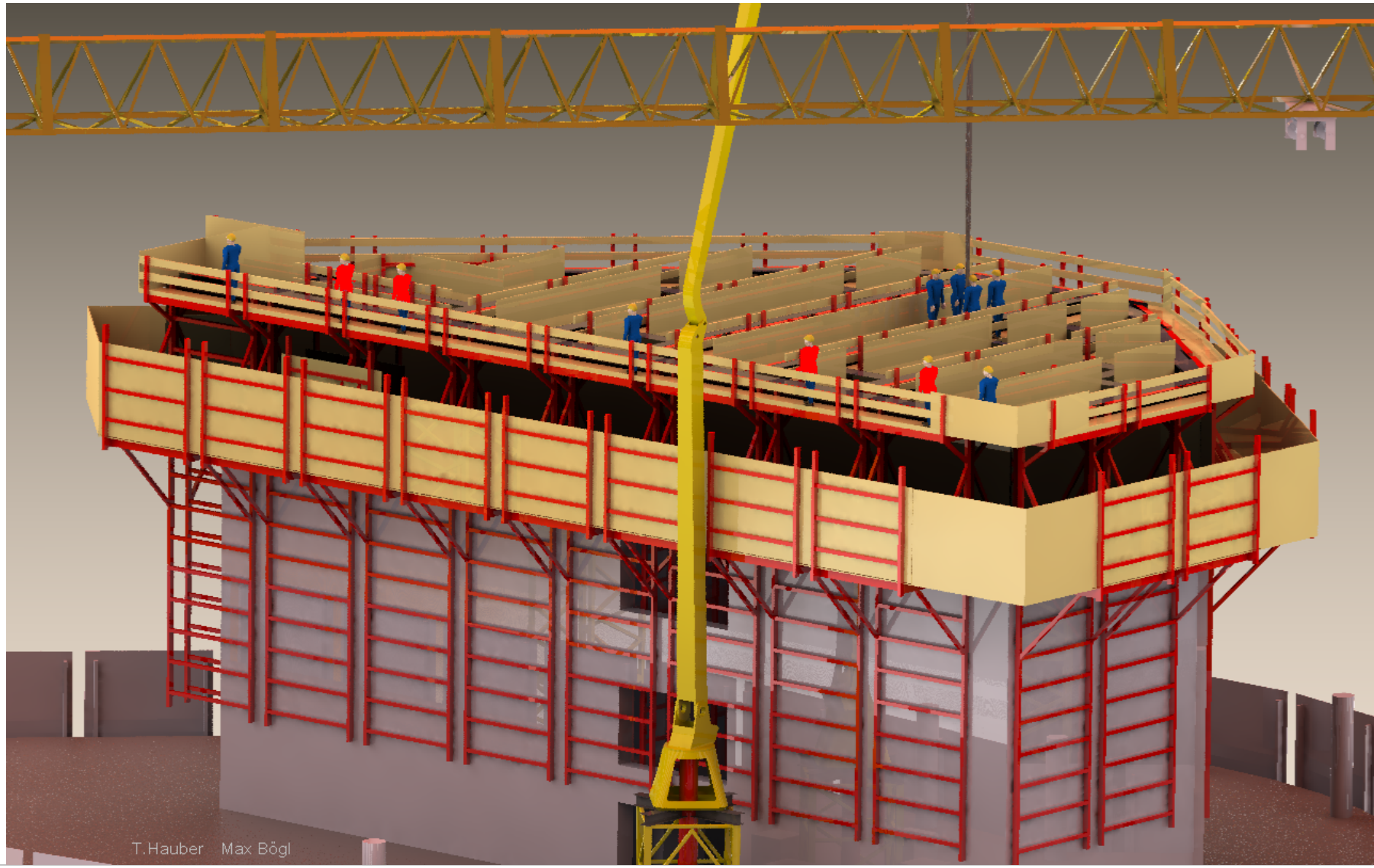
Simulation examples



Simulation examples



Simulation examples



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mefisto

Management – Führung – Information – Simulation im Bauwesen

Thank you !

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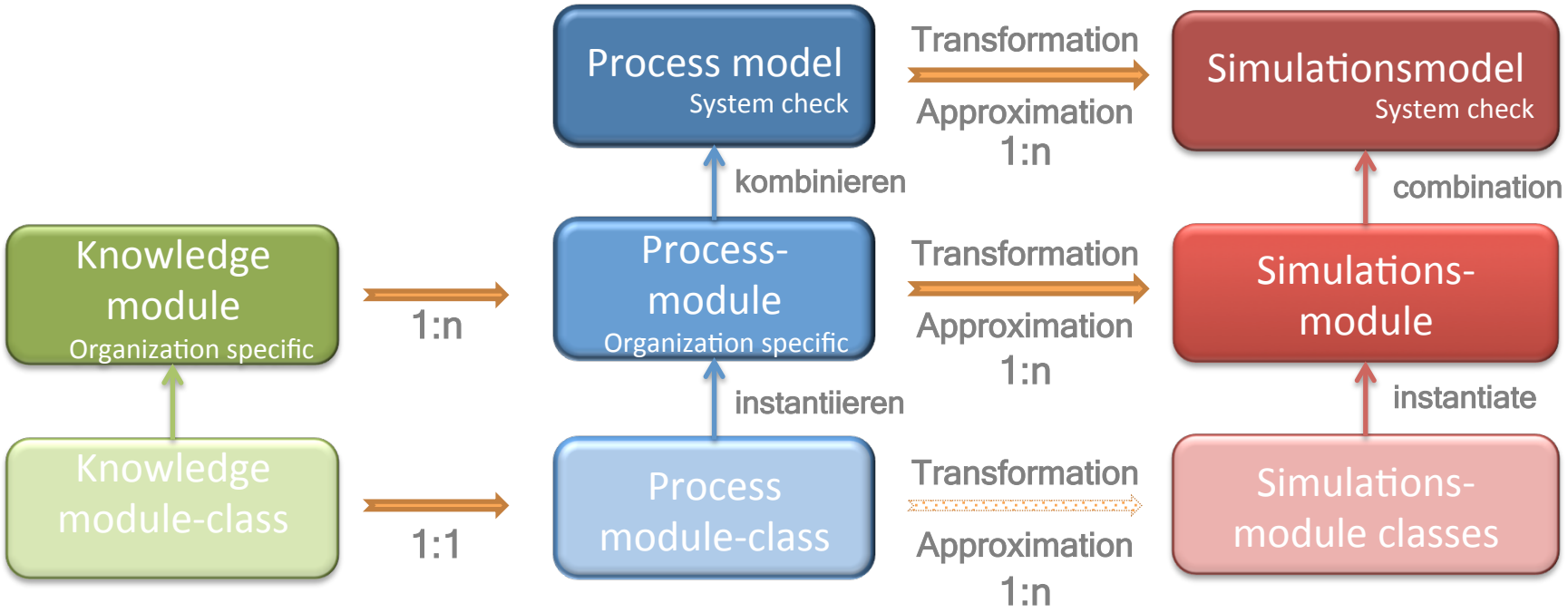
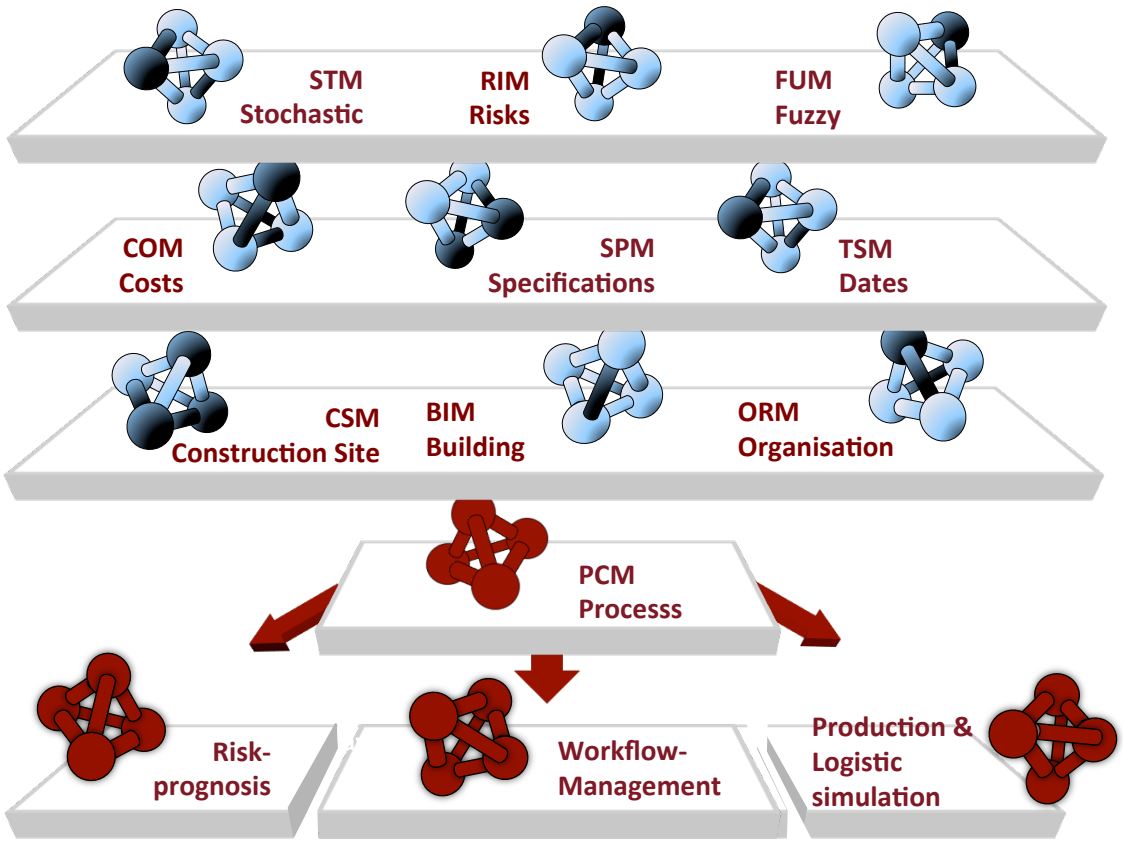
DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Transformation path of process models into simulation models



The hierarchical structure of model domains



Additive models

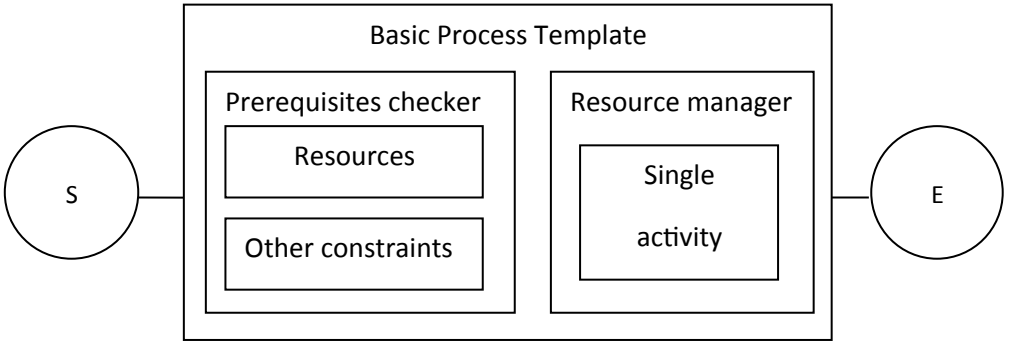
Additive models

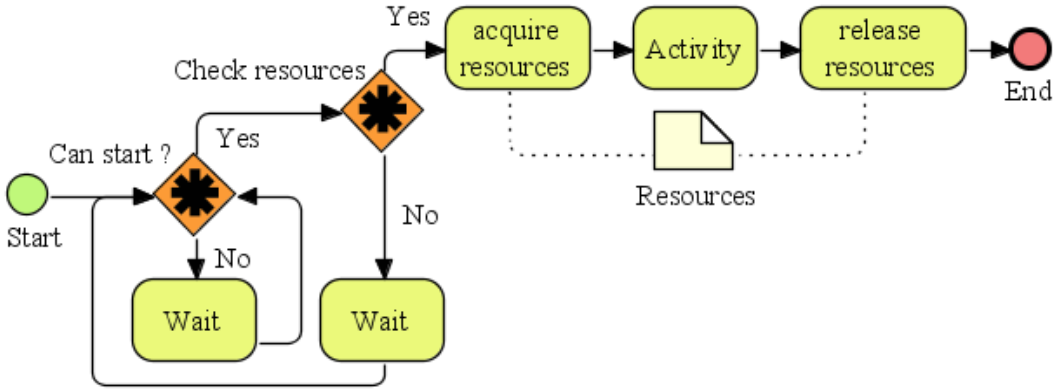
Self-standing models

Combining model

Analyses models

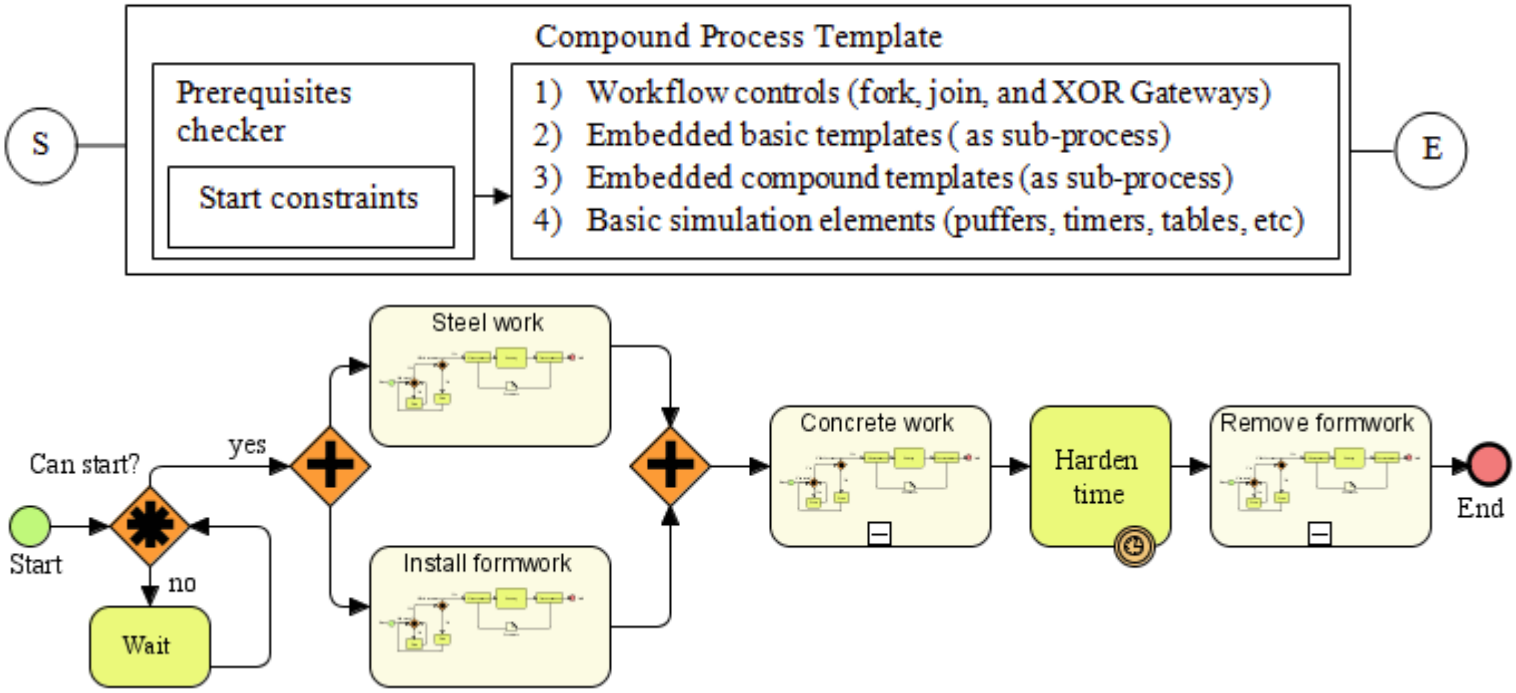
Basic process template for single activity





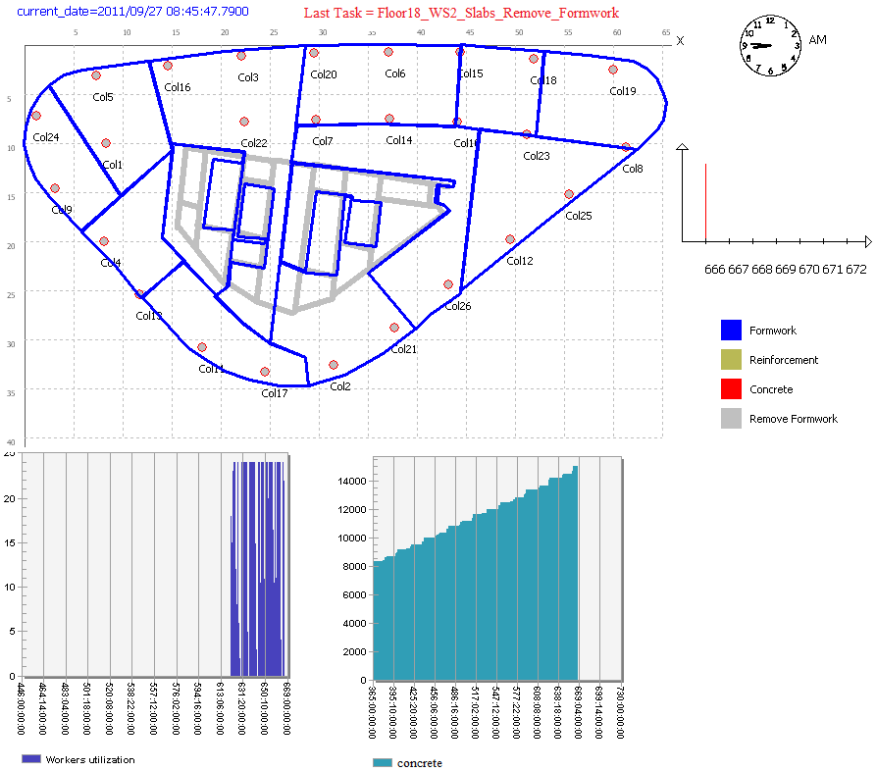
The basic process template will be used later to map the single tasks in BPMN into single tasks of the simulation models.

Compound process templates

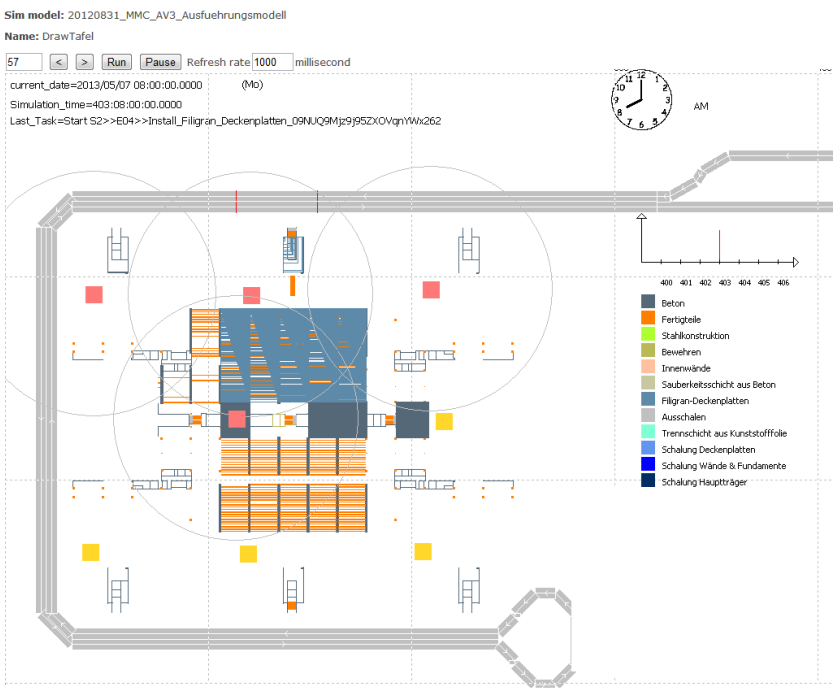


The compound process template is used to map compound process task of a generalized process task in a compound simulation task, detailed enough to run a simulation

Simulation Output
2D Animation

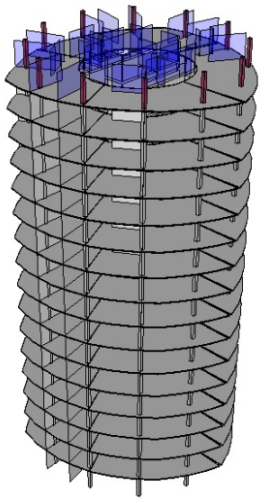


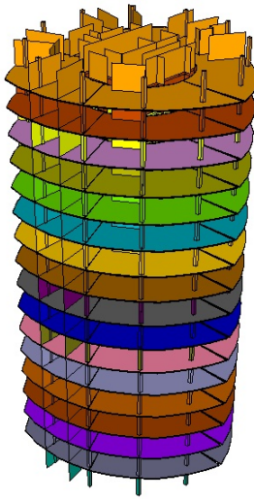
Mefisto-Office project



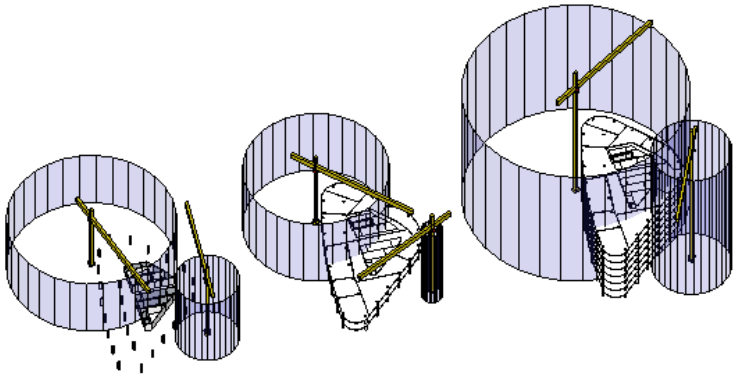
Mefisto- Airport project

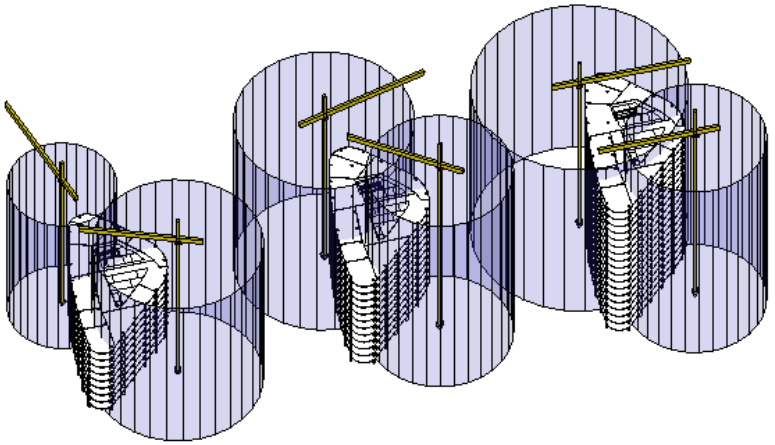
Simulation Output
4D Animation





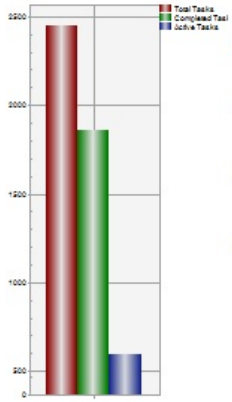
Building elements are colored according to activity types (steelwork, formwork, concrete work) or work finished within time intervals (days, weeks, months)



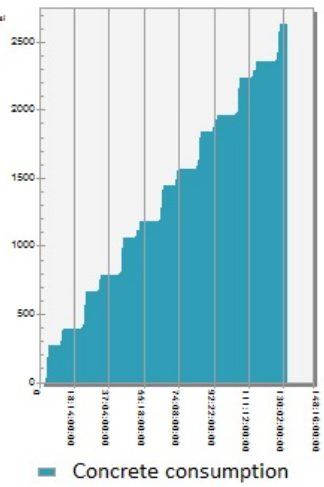


3D Visualizer

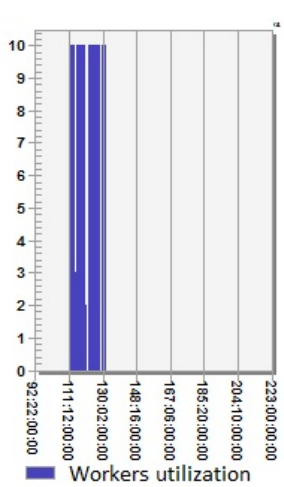
Simulation Output
Material usage/Resources utilization



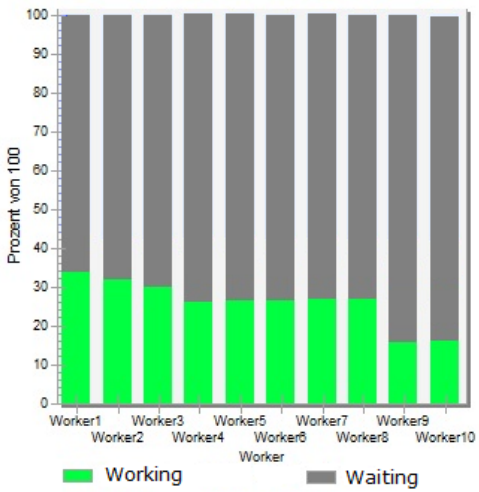
Active Tasks



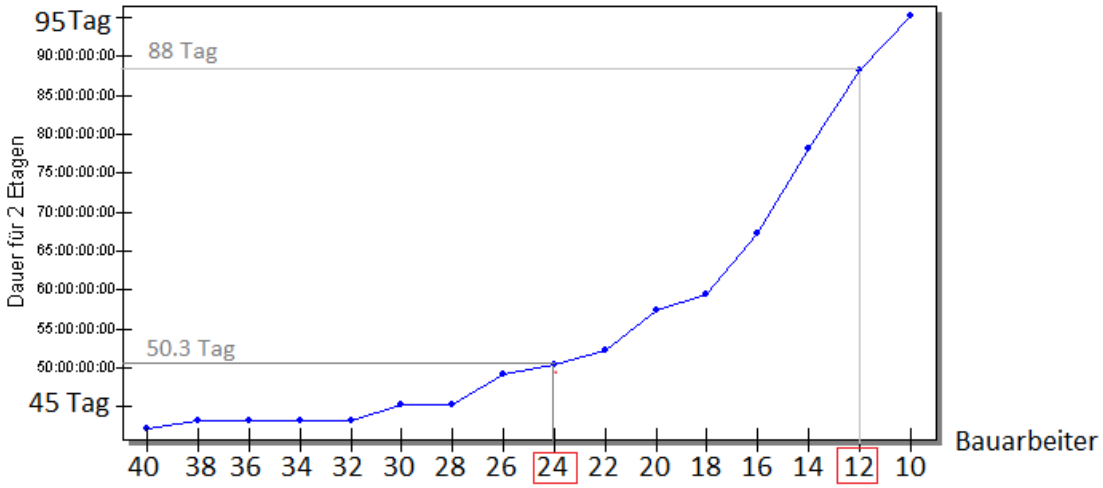
Concrete consumption



Workers utilization



Resources utilization and material usage with time



Effect of changing the number of workers on the construction work duration of 2 floors