3D VISUALIZATION, SIMULATION AND VIRTUAL REALITY IN ACCELERATOR DEVELOPMENT

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Abstract

Visualizing complex beamline designs, animating installation procedures and virtually walking through planned facilities - 3D modelling is a powerful tool with a broad range of applications in accelerator development. The poster gives examples for established and emerging 3D modelling applications at the European XFEL and their benefits: 3D visualization enables inspection and compliance analysis of interfacing systems and components. Simulations enable early verification of e.g. safety and transportation concepts. Digital humans can be inserted into accelerator models to perform e.g. reachability and field-of-sight studies for installation works. Movies of transport and installation procedures can be created for staff training. And ultimately, stereo projection can be used to inspect and simulate designs and processes in virtual environments. 3D modelling helps discovering and resolving design issues earlier and leads to large savings in time and cost.

INTRODUCTION

Promoting the benefits of 3D modelling, DESY has successfully developed and established a collaborative design process, which enables global collaborations to jointly develop 3D models of current and next-generation projects, such as the European XFEL and the planned International Linear Collider, ILC [1]. At XFEL the resulting 3D models quickly developed into a ubiquitous and generally accepted tool for communication 0. This paper provides examples for some of the established and emerging applications of visual modelling and illustrates their benefits.

ONE SIZE DOES NOT FIT ALL

One of the key principles of the collaborative engineering process is to “model for a purpose”. Different purposes put different requirements on a model regarding e. g. its level of detail or its content. We recommend creating dedicated models for each purpose. Typical models for specific purposes include:

- **Placeholder** models that enable integration, collisions checks and interface analysis. They contain e.g. reserved space and interface details.
- **Detailed Design** models that provide the basis for fabrication. They define how to assemble a component from parts and provide their exact geometry and material properties.
- **Physics Simulation** models that enable MC simulation and detector optimization. They describe segmentation, shape and physics behavior of components.

Obviously the models cannot be automatically derived one from another, but have to be created and maintained manually as they have to represent the same objects differently. For example, placeholder models are usually bigger than the component’s envelope, as they may need to reserve additional space for tools, tolerances and moving parts. A design model of a calorimeter may contain the readout boards and their fixtures, while the physics simulation model would contain the board’s sensitive areas, but not necessarily the fixtures.

Project teams initially accept creating and maintaining more than one model only reluctantly, as this seems to pose additional effort on the modeling especially in the beginning, but in the long run it returns large benefits in usability and model performance. The following sections illustrate some types and applications of models.

CONCEPTUAL PLANNING

Assignment of space is one of the major concerns in every complex design effort. While initial approaches start often with 2D layouts, the geometries of the involved systems and components soon become so complex that

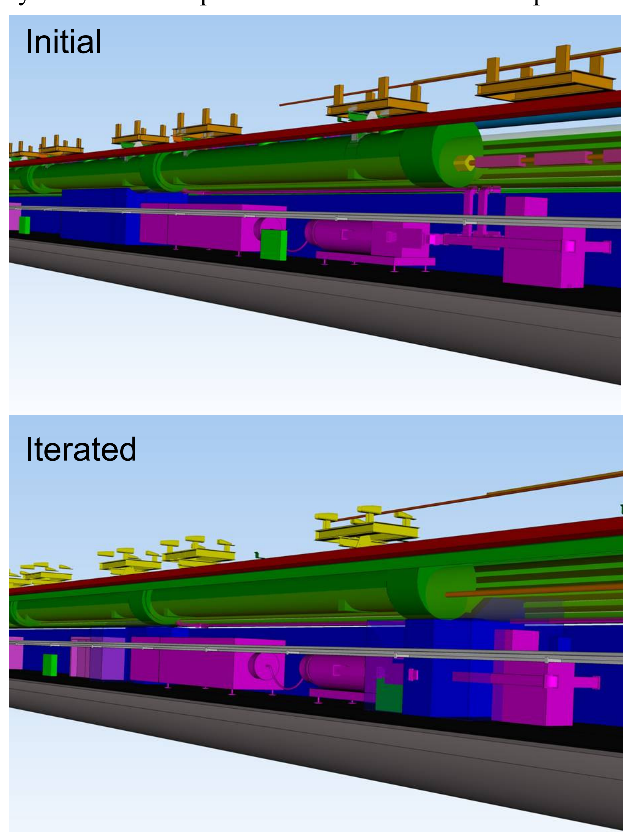

Figure 1: Conceptual planning with 3D placeholder models.

3D layouts are required. Placeholder models are well-suited for quick investigations of different scenarios as they are easy to handle and have only light “footprints”. While detailed models would contain huge amounts of internal geometries and constraints which would need to be kept consistent, placeholders can disentangle facility planning from detailed engineering. Maintaining separate placeholder and detailed models throughout the project enables the teams also in late stages to investigate upcoming new ideas or scenarios for necessary changes with minimum impact on the detailed engineering.

Figure 1 shows an example for evolving facility planning in an accelerator tunnel using placeholders.

INTERFACE DEFINITION

Interface definition is a major area of concern when delegating and distributing work over several project teams. 3D models can be used to define and monitor the compliance of interfacing components in complex environments. The approach is to enrich simple placeholders with interface details, as interfaces do not need to know details beyond the immediate connection. Figure 2 illustrates the approach for an accelerator module and its connection to the rf system

CLASH DETECTION

Architectural, structural and physics systems are often developed by different groups and in different environments. Assembling the components into a so-called master model of the facility enables project teams to detect and remove clashes before the systems reach the construction site, thus avoiding unbudgeted changes and schedule delays 0. Figure 3 shows an example for combined architectural and structural models which illustrates the necessity and complexity of coordinating the various disciplines.

ANIMATION & SIMULATION

Visual models can be used to create animations and movies for illustrating and analysis specific processes. For example, component shapes can be extruded to check whether they fit through gaps, alleys or shafts for transportation. The safety concept can be checked by analyzing potential clashes of escape routes. Digital humans can be inserted into the scene to investigate whether they have enough room for movements, and to check their field of sight. And sequences of work actions can be captured in a movie to serve as an instruction for e. g. installation tasks.

VIRTUAL REALITY

The visual models can be enhanced with textures, lights and shadows to provide more realistic impressions, and they can be projected in scale 1:1 using a stereo beamer to create virtual reality (VR). Complementing technical design documents, the virtual accelerator offers realistic perceptions of dimension and space. Figure 4 shows an

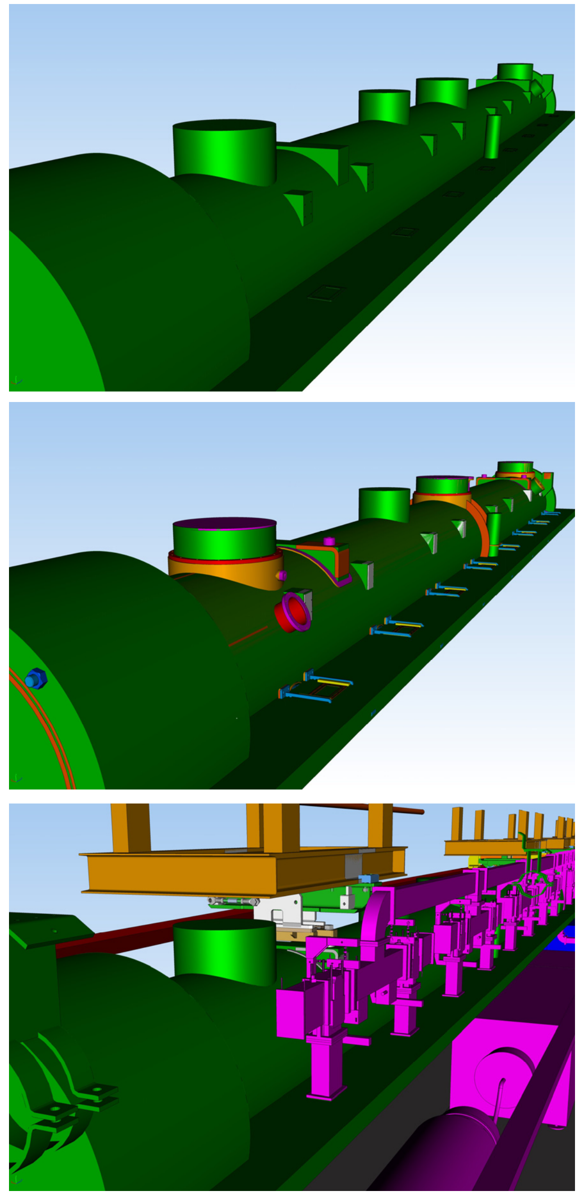

Figure 2: Accelerator module placeholder (top) with rf interface details (middle) and connected waveguides (bottom).

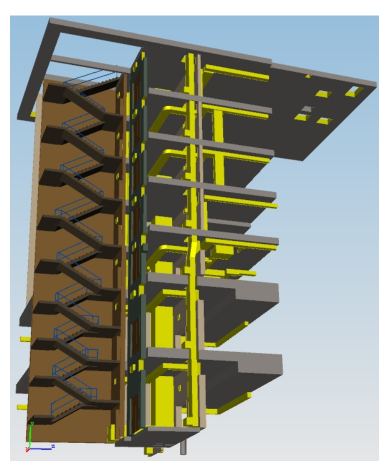

Figure 3: Architectural and structural models combined.

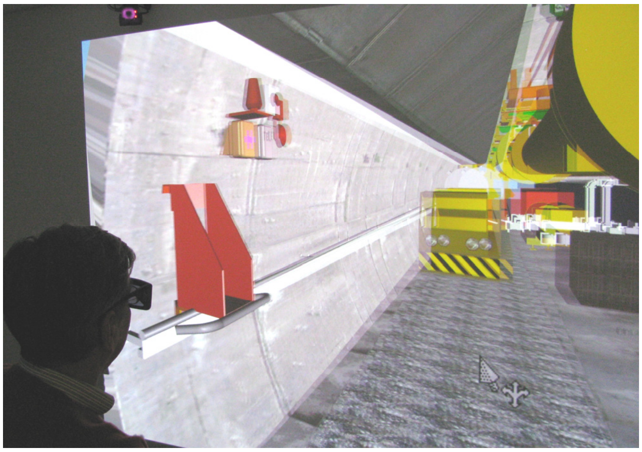

Figure 4: Accelerator model in VR showroom.

example of an accelerator model shown in an VR environment.

ACKNOWLEDGEMENT

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REFERENCES

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