4D Modeling: Building Better by Building Virtually First

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The 4D Concept
4D Models link components in 3D CAD models with activities from the design, procurement, and construction schedules. The resulting 4D production model of a project allows project stakeholders to view the planned construction of a facility over time on the screen and to review the planned or actual status of a project in the context of a 3D CAD model for any day, week, or month of the project.

4D CAD Benefits
4D models enable a diverse team of project participants to understand and comment on the project scope and corresponding schedules in a proactive and timely manner. They enable the exploration and improvement of the project executing strategy, facilitate improvements in constructibility with corresponding gains in on-site productivity, and make possible the rapid identification and resolution of time-space conflicts. 4D CAD models have proven particularly helpful in projects that involve many stakeholders, in projects undergoing renovation during operation, and in projects with tight, urban site conditions.

For example, Walt Disney Imagineering used 4D models to plan the construction of the Paradise Pier portion of Disney’s recently opened California Adventure in Anaheim, CA. Tight site conditions, a must-meet completion deadline, and many non-construction stakeholders made the project ideal for the application of 4D project management. The 4D model enabled the project team to produce a better set of specifications and design drawings for the construction of the project, resulting in fewer unplanned change orders, a smaller construction team, and a comfortable completion of the project ahead of schedule. Figure 1 shows several snapshots from the 4D model built for this project.

Figure 1. 4D model snapshots

4D Modeling at Stanford University
Martin Fischer’s research group has been helping public and private owners and contractors build 4D models on their projects since 1993. Projects include hospital renovations, concert halls, commercial buildings, theme parks, museums, and industrial facilities. See http://www.stanford.edu/group/4D for details on the group’s research activities. By improving project communications, the 4D models have reduced unplanned change orders by 40% to 90%, reduced rework, increased productivity, and improved the credibility of the schedule and the project management teams. The application of 4D modeling also demonstrated that an easy to learn and use 4D interface that allows the project team to maintain an up-to-date 4D model.
with little effort and that makes it possible to explore schedule alternatives easily is essential for the widespread deployment of 4D models.

The Project Manager’s Desktop: 4D Interface

An interactive, easy-to-learn and use, and flexible 4D modeling software was developed over the last 3 ½ years in collaboration between Walt Disney Imagineering Research and Development and Martin Fischer’s research group at the Center for Integrated Facility Engineering (http://cife.stanford.edu) at Stanford University. Figure 2 shows the interface to the 4D software, which runs on the Windows platform. This interface allows the 4D modeler (typically the project scheduler) to organize, link, and view all scope and schedule information necessary for 4D modeling. The hierarchical organization of the project information makes it easy for the user to maintain the 4D model over the life of a project as more 3D and schedule detail become available. The drag and drop functionality makes it easy to link 3D model components and activities. The resulting 4D model enables everyone interested in a project to grasp and review schedules quickly.

Figure 2. 4D Model Interface.

The top part of the interface contains the time and space controls to orient and position the 3D model in the central window and to move through time in various ways (selecting a date, moving the time slider, or using the video-like controls). Users can also select the speed (intervals) for displaying the model. Here, the speed is set to 1 day, meaning that the 4D View window will show the activities that will take place on the various 3D components day by day. The CAD Components window shows the hierarchical organization of the 3D components that make up the building. This 3D model organization is imported from a Virtual Reality Markup Language (VRML) file produced by any 3D modeling software. The Schedule window shows the activities that are needed to build the project. The colored boxes next to the activity names
indicate the color in which a particular type of activity will be displayed in the 4D View window. The activities and corresponding fields are imported from scheduling software like Microsoft Project or Primavera’s Project Planner. The 4D Components window shows the 4D components organized hierarchically. A 4D component is one or several CAD components (copied from the CAD components window) that is linked to one or several activities from the schedule. The 3D model can be reorganized in any way necessary for schedule visualization. For example, the 4D modeler grouped several of the footings from the CAD Components window into a 4D component called sw_int_footing (highlighted in the 4D Components window). In the Schedule window, the activities needed to build the collection of footings called sw_int_footing are highlighted (rebar, form, pour). The 4D View window shows the pouring of the concrete for these footings on Aug. 17, 1999 in red as well as other activities scheduled for that day in their respective colors.

**How to get started?**

On every project, project managers, superintendents, and schedulers run mental 4D movies in their heads to think about the construction of the project. These professionals find it easy to relate to 4D models and to understand and use them. However, to get started with 4D modeling, one needs a 3D CAD model, which is typically missing on today’s projects. However, in the last year, we have found that 3D CAD software has become much more user-friendly for the modeling of projects in 3D and much more powerful in exchanging 3D project data with other software. Hence, for focused questions about the constructibility of a design and related schedule (e.g., in what sequence should the roller coaster for the Disney project be built?), owners and contractors have been able to build 3D and 4D models that help address such questions within a few hundred hours, which makes it economical and beneficial to support a project team’s decision making with 4D models.