4D Animation for Project Delivery

4D = time + 3D

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Goals for 4D Animation and Session

• Learn how 4D modeling supports the communication of dynamic time-space information about critical aspects of a project’s lifecycle.
Personal History of 4D Modeling

- 1984: first work with 3D models
- 1987: saw first 4D model at Bechtel
- 1988: built 3D building information modeler
- 1993: built first 4D model
- 1996: prototyped VR interface for 4D modeling
- 1996: started research on automating 4D modeling
- 1998: developed easy-to-learn 4D modeling tool (now Common Point Project 4D)
- 1998: started research on computer-based analysis of schedules with 4D models
- 1999: started research on multi-screen group interaction with 4D models
- 2005: started research to extend 4D modeling beyond construction
- To date: helped deploy 4D models in many project phases on 40+ small and large projects totaling $5B+
Visualize the construction of this schedule

How much of the steel structure is erected when the air handler unit (AHU) arrives? Who else is working near the mechanical contractor when the AHU is installed?

Where should the AHU be unloaded and how should it be moved to its final position? Where will the steel contractor have the cranes when the AHU is installed?
AHU cannot be installed at this time
Creating a 4D Model

Schedule (MSP) from construction planner Amsterdam
3D model (Revit) from 3D modeler Neumarkt
Transfer 3D CAD elements and their organization

Transfer activity data

4D Model (Common Point Project 4D, GSim) from 4D modeler Amsterdam

Example from Max Bögl, Neumarkt, and Nick Liao and Peggy Ho, CIFE, Stanford University
Leverage information you already have and make it work for you.
Using a 4D Model for Construction Planning

Provide construction input to conceptual project planning

Coordinate construction with other project concerns

Conceptual project planning & design
Design
Procurement
Construction
Start-up
Operations

Develop construction strategy
Allocate Crews
Provide construction input to conceptual project planning

Need knowledge about:

- Major construction strategies, risks, cost implications, temporary and permanent access and utilities
- Issues and constraints for the project designers and public agencies
- Overall economics of the project
Coordinate construction with other project concerns

Need knowledge about:
• Systems and materials for the major project elements (foundations, structural system, exterior skin, interiors, etc.) and construction methods
• Ripple effects of construction method decisions and the timing of these decisions on the project goals
Develop construction strategy

Need knowledge about:
• Activity sequencing for a design, materials, construction methods, site conditions
• Safety, quality, cost, other risks
• Capabilities of labor and equipment
• Decision sequence for a productive and effective construction planning phase
• Possible adjustments to the facility design to improve its constructability
Allocate Crews

Need knowledge about:
• Details of the construction methods
• Site conditions and project-specific goals and circumstances
• Capabilities of the specific crews working on site
• The project’s master schedule and related flexibilities
• Performance of other subcontractors

Courtesy Accu-Crete, Alexandria, VA
Use of 4D models with multiple screens to compare schedules

Work with DPR Construction, Inc. and with Calvin Kam and Kathleen Liston
Other 4D Model Examples

• Safety analysis
• Prefab studies and analysis
  – Project level (how do prefab elements fit together)
  – Work level (how does a prefab element get built)
• Work method analysis and communication
  – Walls
  – Piles
Issues with 4D modeling

• Availability of a schedule
• Organization and level of detail of schedules and 3D models
• Software compatibility
• Use of 4D models in construction management workflows
• Clear plan for the development and review of 4D models
  – Stakeholders
  – Issues, purpose
  – Level of detail, accuracy, scope needed
• Other model uses
What’s next?

• Parametric 4D modeling
• Linking 4D models to other project information (e.g., specifications)
• Adding temporary structures to a 4D model automatically
• Increasing the level of detail of 4D models to support daily work planning
• Adding schedules other than construction to 4D models, e.g., maintenance schedules
• Including time-based information other than schedules, e.g., conditions of a structure, energy performance
• Calculating performance of a facility or cluster of facilities over time from a 4D model
Parametric 4D modeling

- Starting point
- Direction/flow of work
- Production rate
- Production rate parameters

Videoclip Courtesy Max Bögl, Germany, with Peggy Ho, Stanford University
Linking 3D models and specifications for detailed work planning and inspection support

**Condition Feature Ontology**

**Feature**
- 3D components or their parts that have important engineering meaning (e.g., wall, surface)

**Relative positions**
- Spatial relationships between components and context (e.g., exposed, concealed)

**Attributes**
- Permanent properties (e.g., material info.)

**Status**
- Changeable properties (e.g., schedule at a given time)

**3D CAD**
- Paint exposed surfaces, except where a surface is indicated not to be painted.
- Painting is not required on pre-finished metal surfaces.
- ...
Add temporary structures automatically to 4D models

4D model without temporary structures

• Representation of the geometric and action conditions of the project situation
• Feature Analysis
• Selection of appropriate temporary structures
• 3D model and installation schedule of the selected temporary structures

Available temporary structures

TSP Generator

4D model with the selected temporary structures
Managing and Learning about Construction Play by Play
Facility Lifecycle Modeling in 4D

With Zixiao Zhang, Stanford
4D model plus metrics

- **Environmental metrics**
  - CO2 Emissions
  - Electric Use
  - Water Use
  - Gas Use

- **Social metrics**
  - Growth and Job creation
  - Construction Labor Demand

- **Economic metrics**
  - Contribution To GDP
  - Investment
  - Construction Material Demand

Legend:
- Environmental metrics
- Social metrics
- Economic metrics

**4D simulation**
In Summary, 4D Models Support

• Strategic project planning
• Coordination of construction with other lifecycle phases
• Testing of construction methods
• Planning and control of projects
• Studies of prefabrication opportunities
• Understanding safety and other risks
• Many lifecycle considerations (structural performance, energy performance, …)
• Etc.