Guide for

Selecting Projects Suitable for 4D Modeling

Summer 2016

U.S. Department of Transportation
Federal Highway Administration

3D Engineered Models:
Schedule, Cost, and Post-Construction

*An **Every Day Counts** Innovation*

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Selecting Projects Suitable for 4D Modeling

Introduction

State transportation agencies (STAs) continue to face the challenge of limited funding to build, improve, and operate their aging transportation infrastructure. At the same time, STAs are coming under increasing pressure from the public to be more transparent in how they use their resources, especially as they have to advocate for increased funding at both the federal and local level. Thus, STAs need to find new ways to manage risk, optimize resources, communicate with the public, and account transparently for construction expenditures. Four-dimensional (4D) models can help address each of these concerns.

A 4D model combines a three-dimensional (3D) model with a project schedule to create a simulation of construction activities. As an inherently visual tool that necessarily aggregates project information from many sources, a 4D model is more accessible to the public and fosters collaboration between stakeholders and engineering professionals in a variety of ways.

Figure 1 illustrates the four primary ways that 4D models can aid STAs in delivering projects. This document provides general guidance for selecting projects that are best suited for 4D modeling.

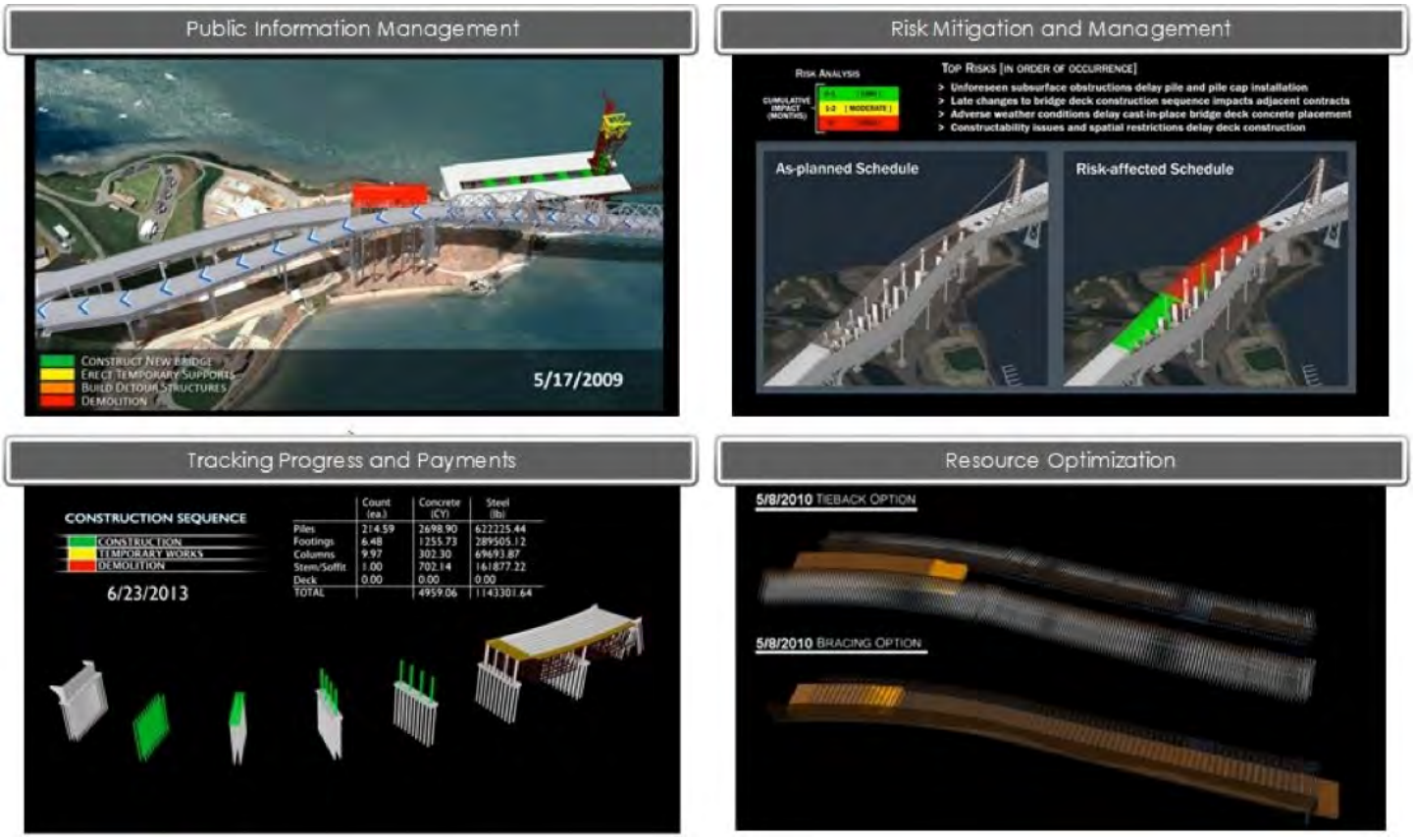


Figure 1: The Four Primary Ways in which 4D Models Can Aid in Transportation Project Delivery[1]

Relevance to Pre-Construction

Having control over the construction phase is critical for keeping a project on schedule and within budget. A 4D model can aid in risk identification, quantification, and mitigation as well as in response to risk events that do occur. Unexpected risk events increase the possibility of scope changes and schedule delays and can negatively affect work zone safety. This ultimately leads to unnecessary costs for the agency and the public.

While 4D models simulate construction, it can be worthwhile to initiate a 4D model during design. Communicating design intent through traditional contract documents is a difficult task because it relies on two-dimensional (2D) drawings, written descriptions of work, and static schedules, among other things. 3D models help communicate the overall design intent but fall short of effectively communicating details such as staging, traffic switches, and constraints on the contractor's means and methods (which 3D models and 2D drawings leave to interpretation).

1 Image courtesy of WSP | Parsons Brinckerhoff

One way that 4D models help with risk identification and mitigation is by fostering more detailed planning that identifies possible issues and allows them to be resolved preemptively. The visual accessibility of construction simulations provides more clarity and consistent understanding, aiding collaboration and communication.

Many STAs have established practices for producing 3D designs and critical path method (CPM) schedules. This creates an opportunity to incorporate 4D modeling into the processes of public and stakeholder engagement, applying for permits, and developing bid documents.

Contractors prepare bid responses, including means and methods, cost estimates, and project schedules, based on their risk perception. Less uncertainty will lead to less contingency in the bid prices and less float in the schedule. The timing of reducing this uncertainty determines whether contingency and float are removed in the response to the proposal or after the agency has let the project.

A project may be a good candidate for 4D modeling if there is a potential for significant risks that can be identified, managed, or mitigated using construction simulation, or if the simulation can provide enhanced visualizations that meet other objectives such as transparency or stakeholder engagement. Figure 2 provides a workflow for implementing 4D modeling on a project.

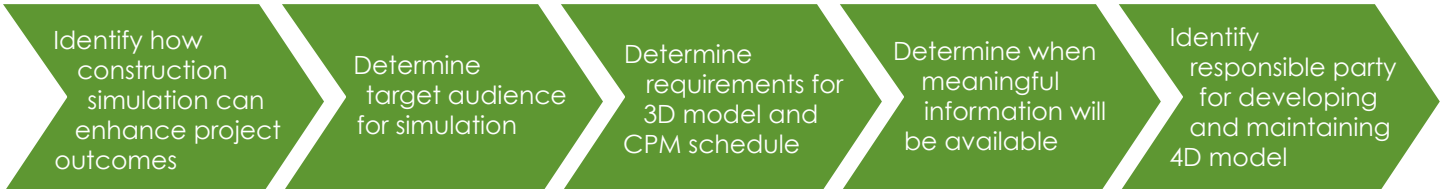


Figure 2: Approach to Initiating a 4D Model

Defining 4D Modeling Objectives

Planning the Development of a 4D Model

The first step is to identify the purpose and need for the model, and this will reveal the target audience. The level of effort to create a 4D model is highly dependent on the intended purpose. A 4D model developed for public involvement may be based on an overview of construction activities, such as project staging and traffic detours, but may need high visual quality and contextual content outside the project limits. A 4D model intended for technical review may use more rudimentary visual quality but needs specific design details for analyzing options and constructability constraints and optimizing resources.

The primary categories of intended uses for 4D models as a communication tool are enhanced visualization, risk mitigation, resource optimization, and tracking progress and payments. Examples of uses within these categories are shown in Figure 3.

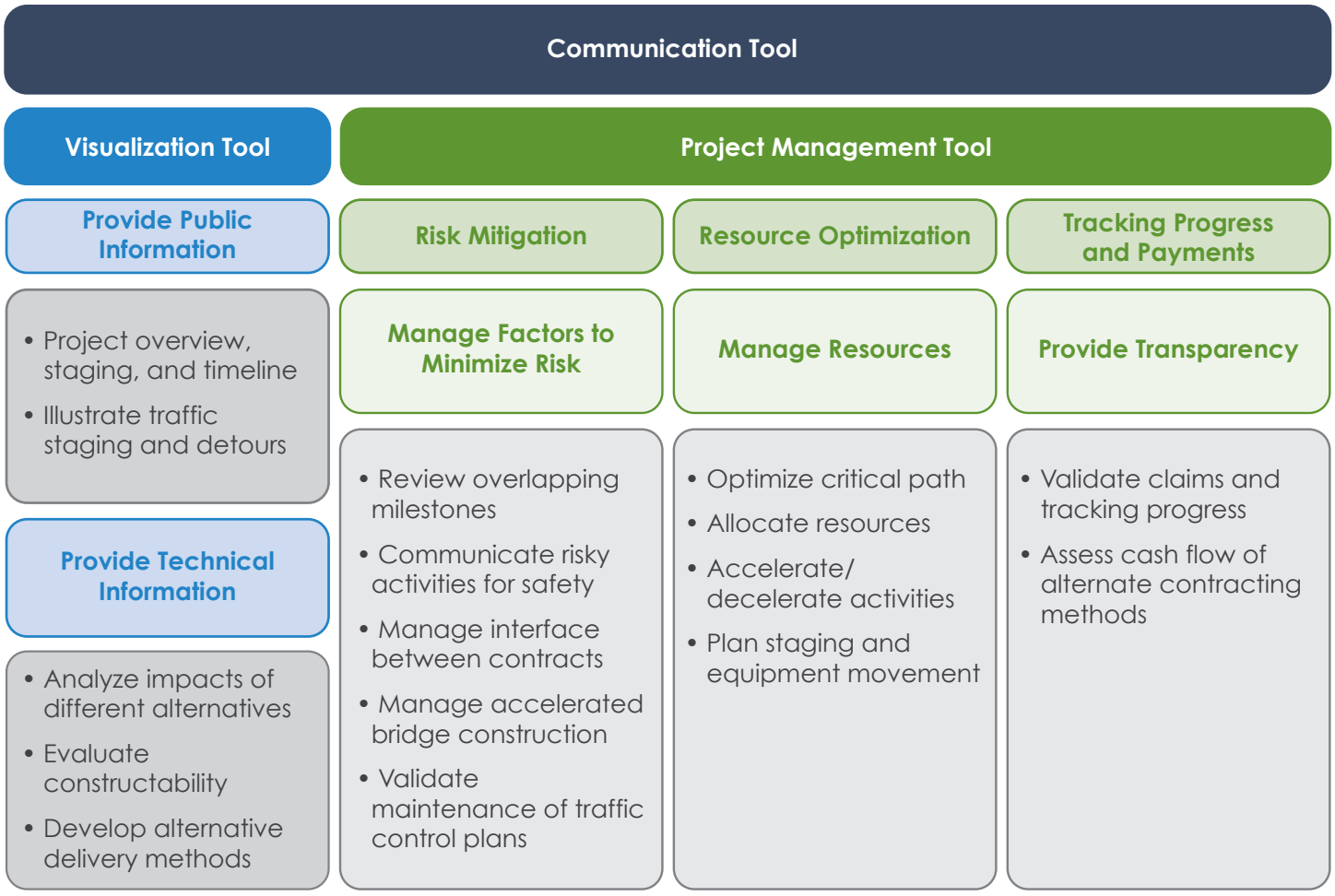


Figure 3: Categories and Example Uses of 4D Models

Defining 3D Model and CPM Schedule Requirements

The level of effort to develop a 4D model also depends on the level of detail required in either the 3D model or the CPM schedule, or both. Some projects may benefit from a detailed CPM progress schedule with a multi-level, hierarchal work breakdown structure (WBS), while some projects may only need to show significant milestones using a high-level staging construction sequence. The level of detail can be defined based on the purpose of the 4D model and can range in complexity to meet agency needs.

Table 1 illustrates key considerations for determining levels of detail. It is important to note that the level of detail in the 3D model should be developed closely in concert with the scheduling detail, which needs to be determined early in the process.

Table 1: Considerations for Determining Levels of Detail for 4D Models[2]

Levels of Detail	Modeling Considerations		
	Basis of Design	**Visualization Needs**	**Schedule Details**
Level 1	• 2D CADD Drawings + Aerial Photos	• Communication for Public Involvement (non-technical) • Communication for Contract Review	• Major Milestones + High Level WBS
Level 2	• Low Density/Low Detail 3D Corridor Model	• Communication for Public Involvement (non-technical) • Preliminary Technical Review (Project Delivery Team)	• Major Milestones + High Level WBS
Level 3	• High Density/High Detail 3D Corridor Model	• Communication for Public Involvement (non-technical) • Project Technical Review (Project Delivery Team)	• CPM Multi-level WBS for Specific Activities
Level 4	• High Density/High Detail 3D Corridor Model • Pre-fabrication and Shop Models • 3D Bridge Models	• Communication for Public Involvement (non-technical) • Constructability Technical Review (Construction Team)	• CPM Multi-level WBS for Entire Project
Level 5	• Pre-fabrication and Shop Models • 3D Bridge Models	• Communication for Public Involvement (non-technical) • Constructability Technical Review (Construction Team)	• Cost Loaded CPM Multi-level WBS for Entire Project (5D)

Availability of Meaningful Information

A 4D model is a tool that helps communicate project information, and its value is limited by the quality of the engineering information it contains. Engineers routinely work with incomplete data and measure their judgments accordingly. However, with a highly visual tool such as a construction simulation, it is possible to miscommunicate or misrepresent the quality of the information. This is particularly relevant to 4D models that are prepared prior to bid letting.

Often, the detail necessary is only available once a contract has been let and the contractor begins planning in detail. Schedules and 3D models that include staging, interim works, falsework, and equipment may only be available at a six-week look-ahead and may continue to be refined by the contractor. If this level of detail is needed, the STA should approach 4D modeling by clearly defining the 3D model and CPM schedule requirements in the bid documents.

2 Levels of detail also depend on the complexity of the project and progress schedule details.

Responsibility for Developing and Maintaining the Model

The optimal party to develop and maintain the 4D model depends on the specific project. CPM schedules often contain intellectual property such as resource productivity rates and supplier cost information. When the STA only needs outputs from a 4D model, such as simulation videos or still images, it may be better to have the contractor develop and maintain the 4D model. In this case, the bid documents need to clearly define the requirements for the 4D model and the deliverables.

When multiple construction contracts share staging areas or traffic, the owner or the owner's program manager is often the best party to develop and maintain the 4D model. In this case, the requirements, especially for schedule organization and WBS task naming, need to be clearly defined in the bid documents. This will streamline routine 4D model updates.

Developing Project Selection Criteria

Selecting 4D Modeling Projects

Traditionally, 4D models are used for complex transportation projects with significant risk, but other projects may also benefit from their use. Specific requirements may be developed using the following approaches.

Delivery Method: 4D modeling requirements may be requested for alternative delivery method projects. There are proven benefits in managing risk, optimizing resources, and tracking payments transparently for design-build projects, and 4D modeling could also benefit the design-bid-build delivery method based on scope complexity and contract amount.

Project Specific: 4D modeling requirements may be sought for high-profile projects with significant public involvement, cost-share projects (multiple owners), or projects with significant schedule-based risks that are high probability or high impact or that can be effectively managed through simulation. Cost-share projects are excellent candidates for using 4D models, as 4D modeling provides a way to track progress with transparency and accountability. For projects with large contract values spanning more than one fiscal year, five-dimensional (5D) models can help agencies budget across fiscal years.

Scope Specific: This approach may be used for any project regardless of delivery method or contract amount. The 4D modeling requirements may be developed for specific construction activities to mitigate risk on most construction projects, such as reviewing multiple contracts and overlapping activities; construction traffic maintenance, including staging and detours; construction staging; and bridge construction (traditional or accelerated).

Establishing a Selection Criteria Matrix

Specific types of transportation projects benefit from a 4D model. Selection should meet the needs of the organization while considering the benefits or the added value as well as the level of effort required to create the 4D model. Table 2 is provided as a general guide for evaluating agency needs in selecting projects that would benefit from 4D models.

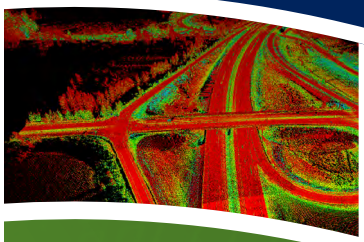
Table 2: Sample Selection Criteria Matrix

Selection Criteria Matrix			
Design-Build Project Delivery	**Design-Bid-Build Project Delivery**	**Multiple Contract Management**	**High Risk Project Impacts**
• Large and complex project scope • Need to develop means and methods during design • Track progress and payments (transparency)	• Large and complex project scope • High profile project with significant public involvement • Significant environmental impacts	• Manage interface between multiple contracts • Manage cost-share scope and expenses	• Projects with full traffic closures or long detours with high impact delays • Revenue impact of closures (e.g., toll facilities) • Schedule impacts (e.g., accelerated bridge construction)

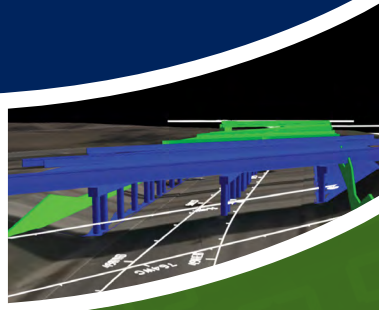
Conclusion

The use of 4D models offers STAs a better way to manage risk and resources, increase communication with all project stakeholders, and promote transparency and accountability. The benefits of 4D models not only add value to alternative delivery method projects, but can also add value to projects with traditional delivery methods. In fact, transportation projects incur a certain amount of risk regardless of scale and scope, thus making 4D models another valuable tool for both risk and project management. While 4D models for design-build and large-scale projects may require a significant amount of effort to develop, this may not be the case for models generated for simple and smaller projects. The process for selecting 4D modeling projects should consider both the potential risk and the level of effort to produce the delivery products.

***Every Day Counts**, a state-based initiative of the Federal Highway Administration's Center for Accelerating Innovation, works with state, local and private sector partners to encourage the adoption of proven technologies and innovations to shorten and enhance project delivery.*







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