Overview of 3D Engineered Models for Highway Construction

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Every Day Counts

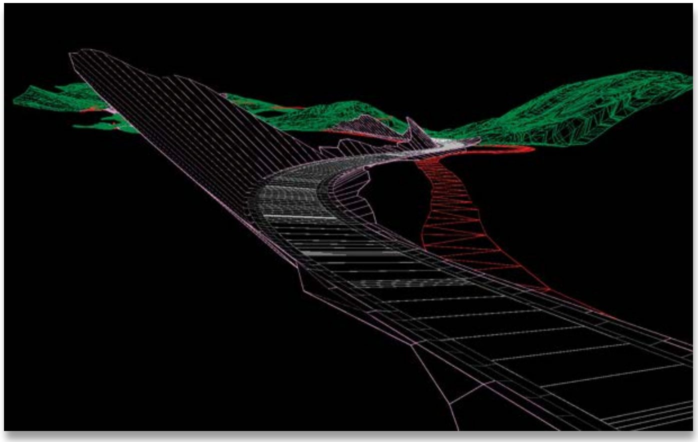
- FHWA initiative to:
  - Accelerate Project Delivery
  - Enhance Safety & Quality
  - Protect the Environment
- Every Day Counts 2 included 3D Engineered Models for Construction
  - Break down barriers for Implementation

What Is a 3D Engineered Model?

3D Engineered Model

- 3D Engineered Model: A digital graphical representation of proposed facility/site data consisting of x, y, and z coordinates for producing objects in three-dimensions to communicate design intent useful for visualization, analysis, animation, simulation, plans, specifications, estimates production, and life-cycle asset management.

3D Engineered Model in Wireframe View



3D Engineered Models

- 3D engineered models differ from 3D visualization models
  - 3D engineered models communicate design intent of the engineer
  - 3D visualization models convey aesthetics by illustrating how the roadway and bridge design will look for a non-technical audience, and generally lack the accuracy needed to properly construct the project

3D Visualization Model

Modern Surveying Equipment

- Total Stations
- Digital Levels
- Aerial Photogrammetry
- 3D Oblique Photogrammetry
- Global Positioning Systems (GPS)
- 3D Laser Scanning
- LiDAR
- Unmanned Aerial System (UAS)

3D Engineered Models for Highway Construction

Modern Surveying Equip

- Total Stations
- Digital Levels
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- Unmanned Aerial System

3D Laser Scanning

Terrestrial Laser Scanners

3D Engineered Models for Highway Construction

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- **LiDAR**
- Unmanned Aerial System

LiDAR

Mobile
LiDAR
Vehicles

3D Engineered Models for Highway Construction

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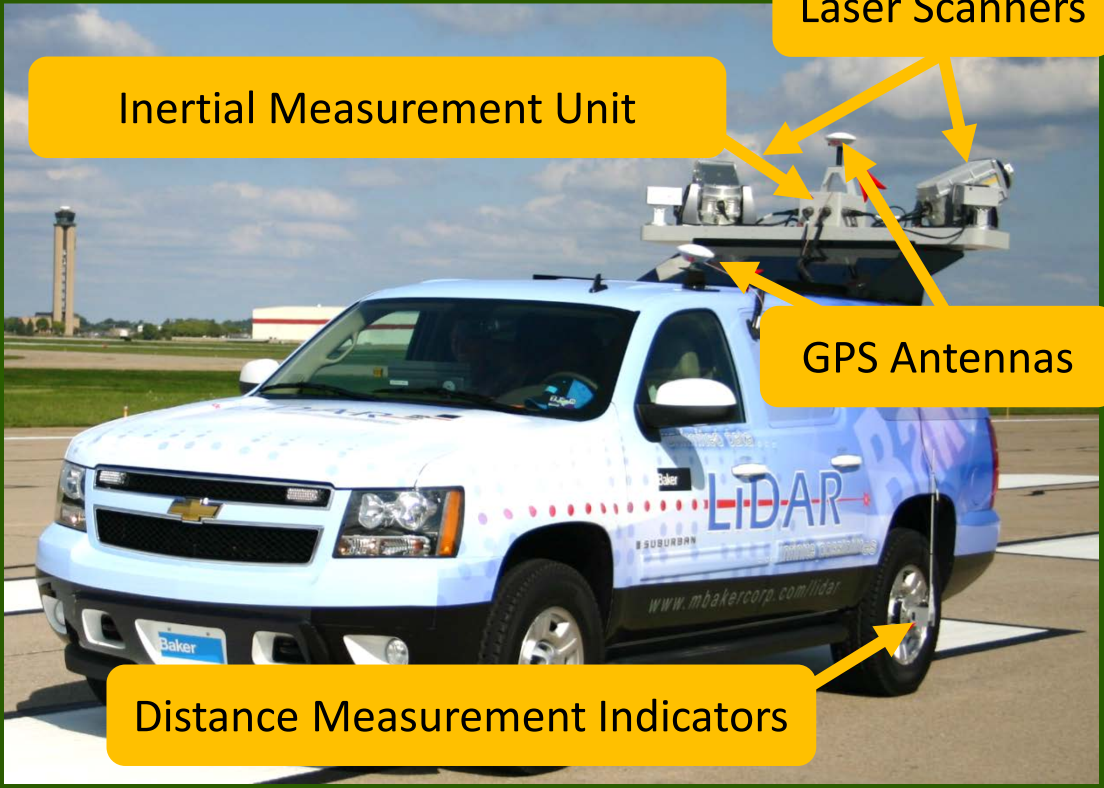
LiDAR



3D Engineered Models for Highway Construction

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Unmanned Aerial System (UAS)

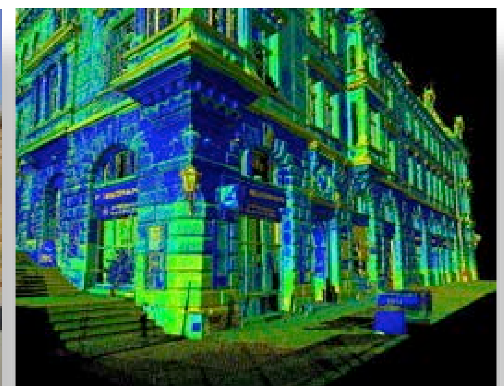
Trimble UX5 UAS

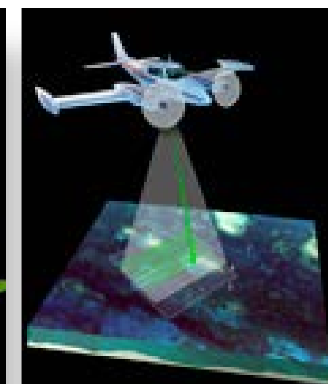
Benefits of Advanced Surveying Technology

- Increased density of survey shots by utilizing laser scanning
- Reduced number of personnel to perform survey
- Improved efficiency


Robotic Total Station


Mobile Scanning Truck


Point Cloud


Aerial LiDAR

Subsurface Utility Engineering (SUE)

- New ASCE Standard
  - Formal Definition
  - Definition of quality levels for existing utility information

When to Use SUE?

- Congested corridors
- Utilities that are expensive to relocate
- Critical infrastructure
- Abandoned utilities
- Unknown utilities
- Utility mapping

Subsurface Utility Engineering Tools

Geophysical Tools

Ground Penetrating Radar Unit

Electromagnetic Array Behind ATV

Pipe and Cable Locator

- Ground penetrating radar
- Pipe and cable locators

- Cameras/Sondes
- Electromagnetic equipment

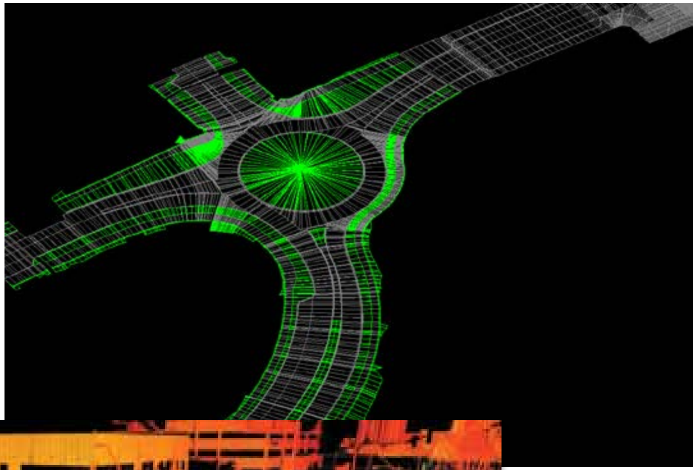
- Thermal detection
- Acoustic tools

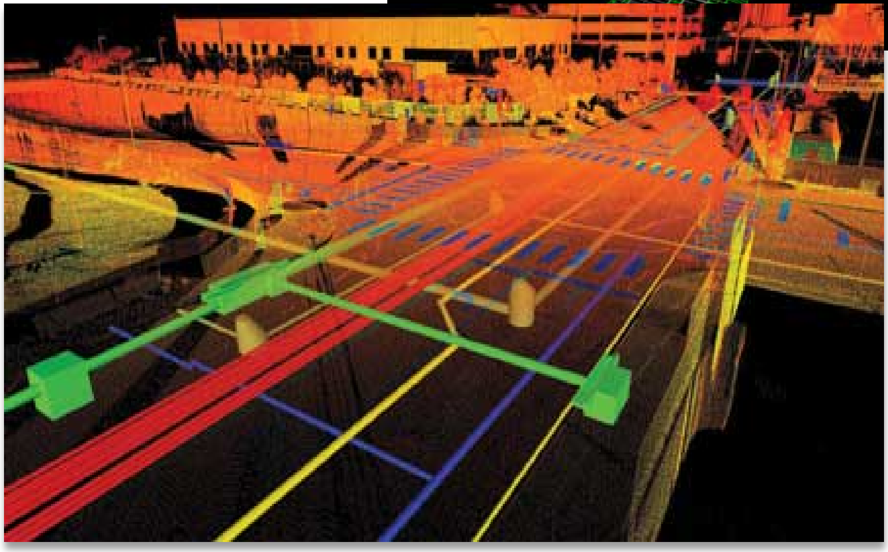
Subsurface Utility Engineering Tools

- General Tools
  - Surveying equipment: TPS, GPS, scanners, etc.
  - Computer software
  - Air- and hydro-excavation equipment for test holes

Information in 3D Engineered Models

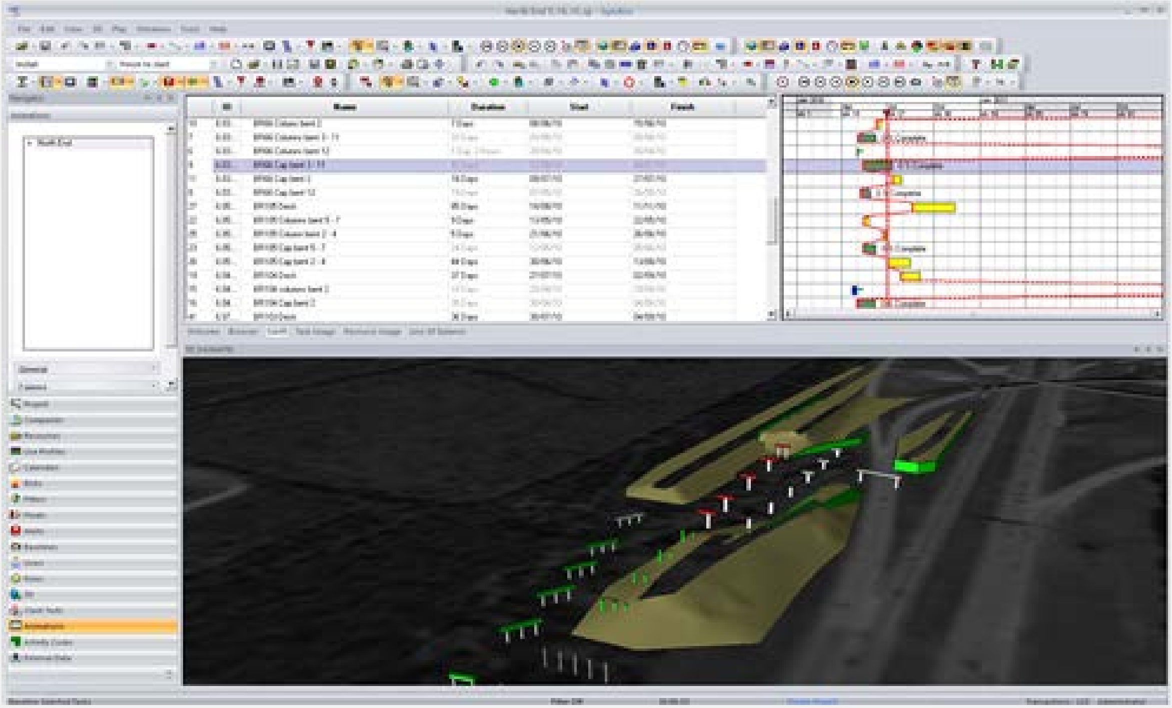
- Surfaces – Existing/Proposed
- Utilities
- Structures
- Time
- Cost





Incorporating Cost and Schedule Information

Adding Project Schedules (4D)

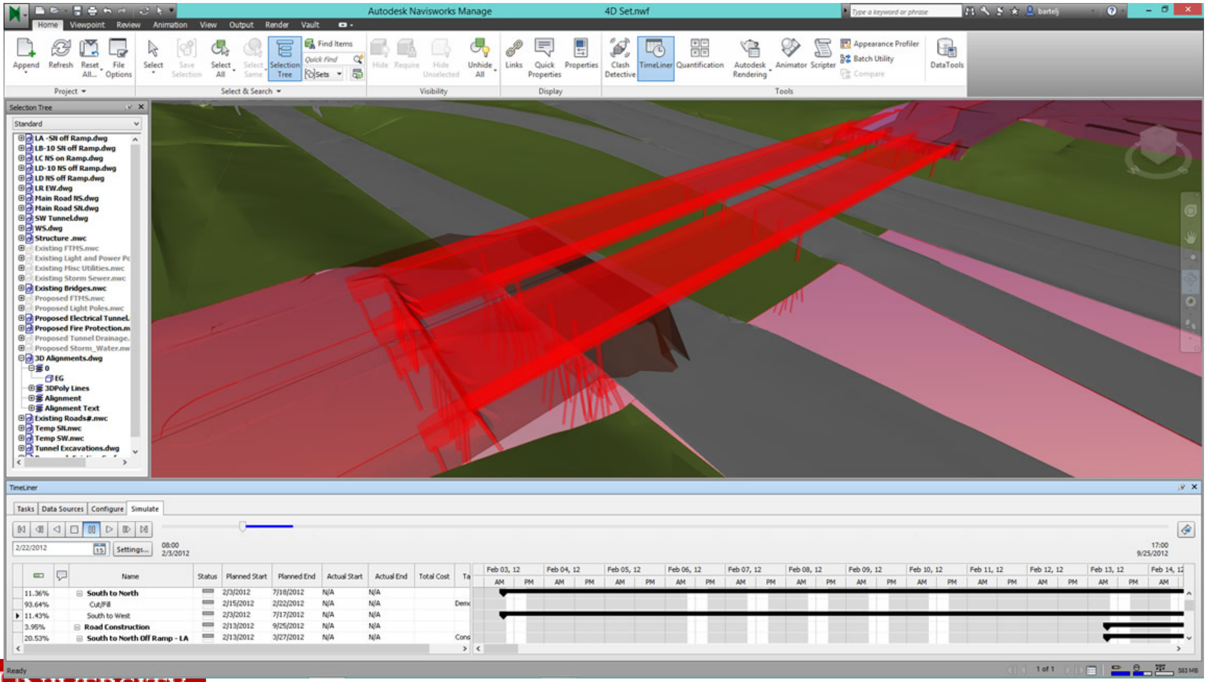


Screenshot of 4D Model

Incorporating Cost and Schedule Information

- Adding Project Cost Information (5D)
  - FHWA defines 5D modeling as:

    "A 4D model intelligently linked with cost information for a project"



5D Model Screenshot

Capabilities of 3D Engineered Models - CIM

- Civil Integrated Management (CIM)

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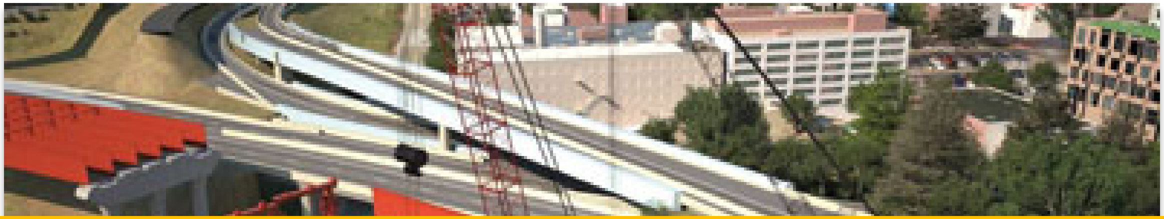
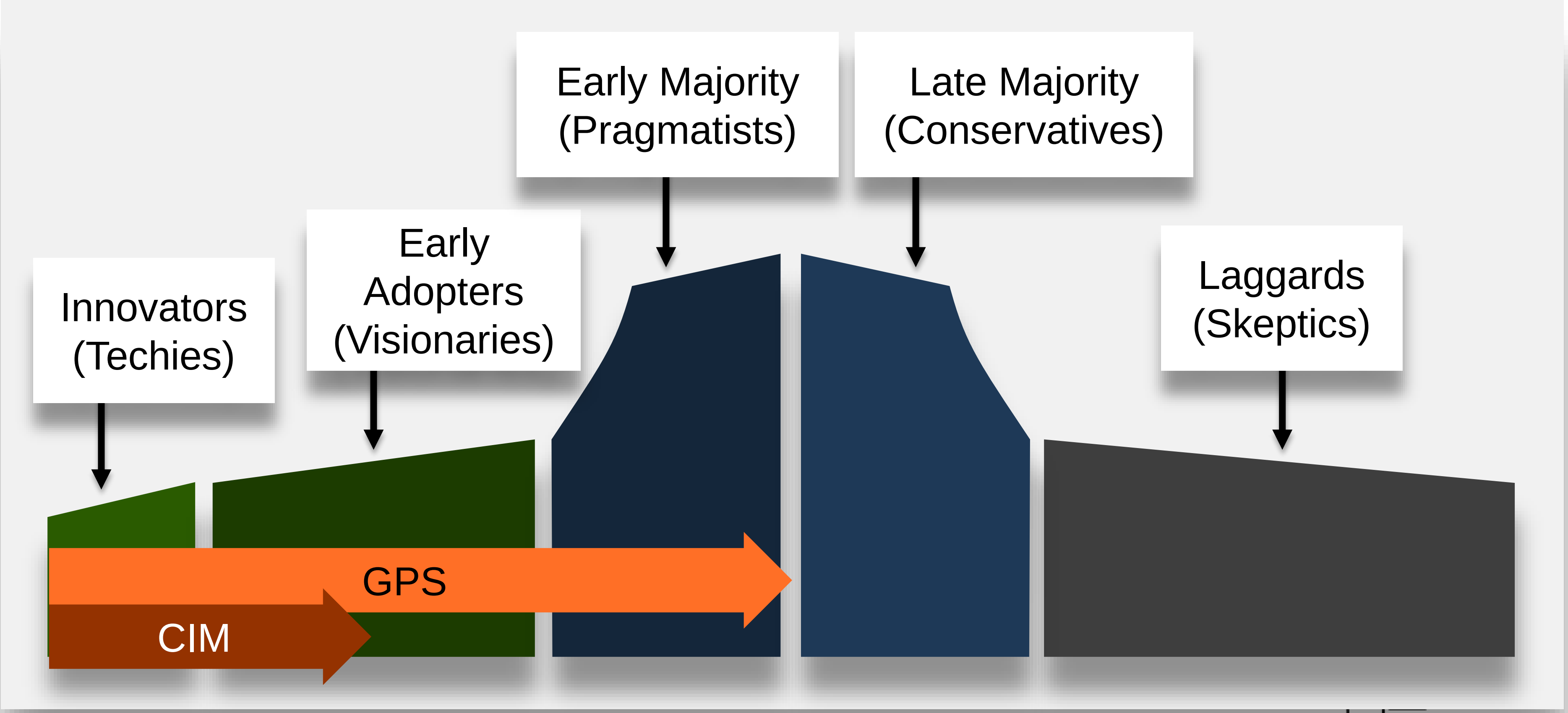


Civil Integrated Management (CIM)

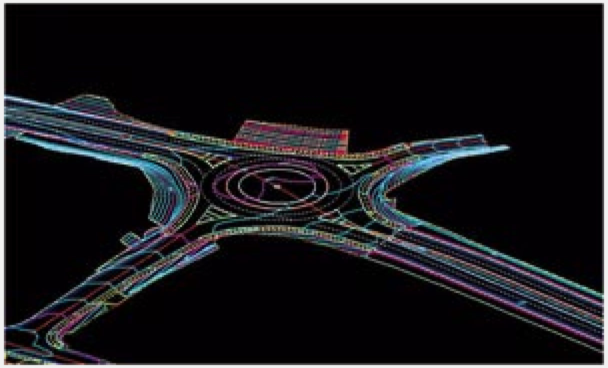
The collection, organization, and managed accessibility to accurate data and information related to a highway facility including planning, environmental, surveying, design, construction, maintenance, asset management, and risk assessment. (FHWA, AASHTO, ARTBA, & AGC)

Capabilities of 3D Engineered Models - CIM



Benefits of 3D Engineered Models in the Design Phase

- Optimize construction schedule
- Increased efficiency
- Early detection of issues
- Facilitates stakeholder buy-in
- Improves communication
- Models for presentation



Benefits of 3D

- Increased effic
- Early detection
- Facilitates stak
- Improves com
- Models for pre

Increased Efficiency

- Increase the efficiency of making design changes and dynamically updating the design thereby eliminating re-work.
- 3D engineered models allow accurate calculation of quantities before construction, ultimately reducing the potential for quantity overruns on construction projects, benefitting both the contractor and the owner.

3D Engineered Models for Highway Construction

Benefits of 3D

- Increased effic
- Early detection
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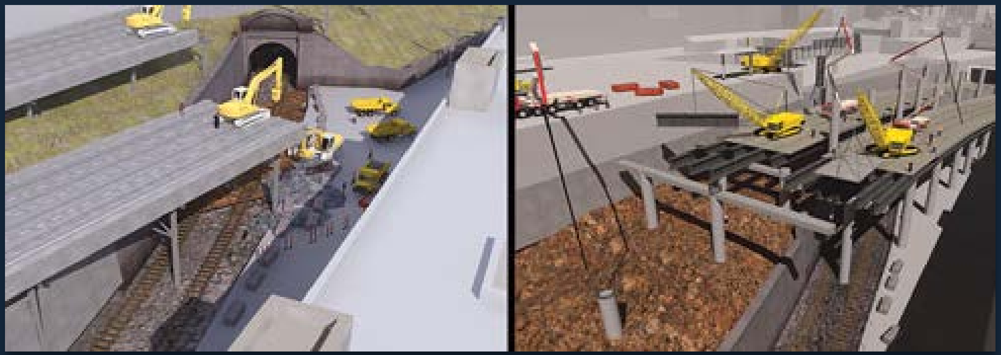
Early Detection of Issues

- Architects and engineers also benefit from the use of 3D engineered models. The designer has the ability to identify utility conflicts, site grading challenges, and many other constructability issues earlier in the design process. By identifying these potential issues, the design can be modified to avoid costly contract changes during construction.
- 3D engineered models also provide quality control (QC) throughout the design process, which creates a more accurate 3D engineered model.



3D Engineered Models for Highway Construction

Benefits of 3D

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Select each benefit fo

Facilitates Stakeholder Buy-In

- Providing a visual representation of what the finished project will look like.
- Used during public information meetings and/or posted to a website to allow the public to provide comments and concerns prior to the final design phase.
- Allows the owner to see a virtual "drive through" or "fly over" of the project to understand what the end product will look like and how it will function.

3D Engineered Models for Highway Construction

Benefits of 3D

- Increased effic
- Early detection
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Improves Communication

- Use of 3D engineered models improves communication during the design and construction phases of projects.
- Showing the 3D model to the owner allows everyone to see exactly where problem areas lie and to easily identify owner requests.

3D Engineered Models for Highway Construction

Benefits of 3D

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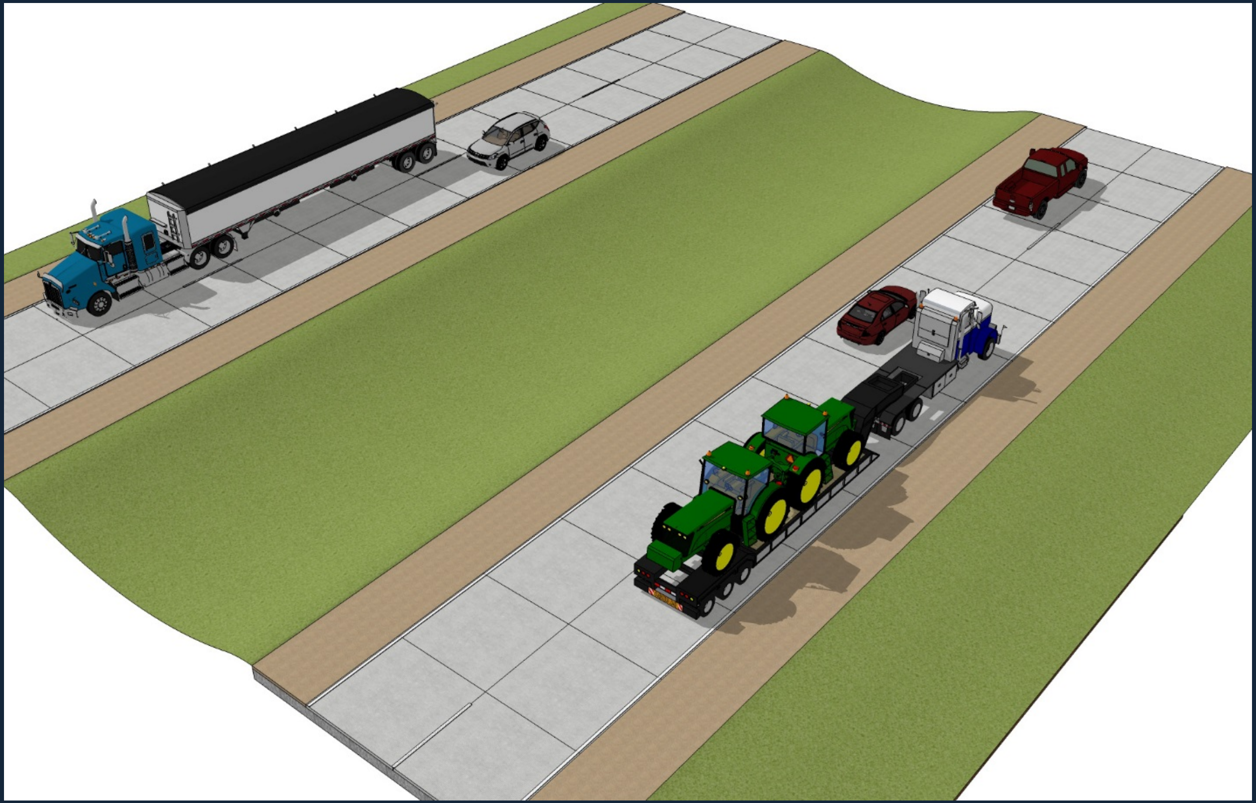
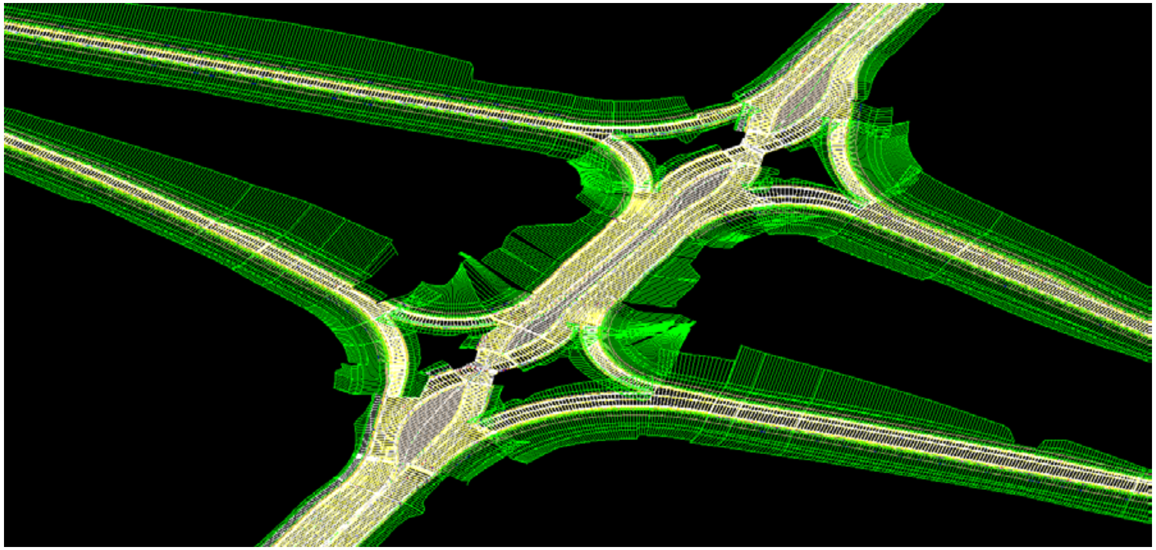
Models for Presentation



3D Techniques Used in Modern Highway Construction

- Grading
- Excavation
- Milling
- Intelligent Compaction
- Paving



3D Engineered Models for Highway Construction

3D Techniques Use

- Grading
- Excavation
- Milling
- Intelligent Compact
- Paving

AMG for Grading

AMG Motor Grader 1

AMG Motor Grader 2

AMG Dozer

U.S. Department of Transportation
Federal Highway Administration

3D Engineered Models for Highway Construction

innovation ingenuity Every Day Counts imagination invention

3D Techniques Use

- Grading
- Excavation
- Milling
- Intelligent Compact
- Paving

AMG Excavation

AMG Excavator

Monitor Found Inside Excavator Cab

IOWA STATE UNIVERSITY
Institute for Transportation

U.S. Department of Transportation
Federal Highway Administration

3D Engineered Models for Highway Construction

3D Techniques Use

- Grading
- Excavation
- Milling
- Intelligent Compact
- Paving

Stringless Milling

Stringless Milling Machine

Milling Operation

IOWA STATE UNIVERSITY
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3D Engineered Models for Highway Construction

3D Techniques Use

- Grading
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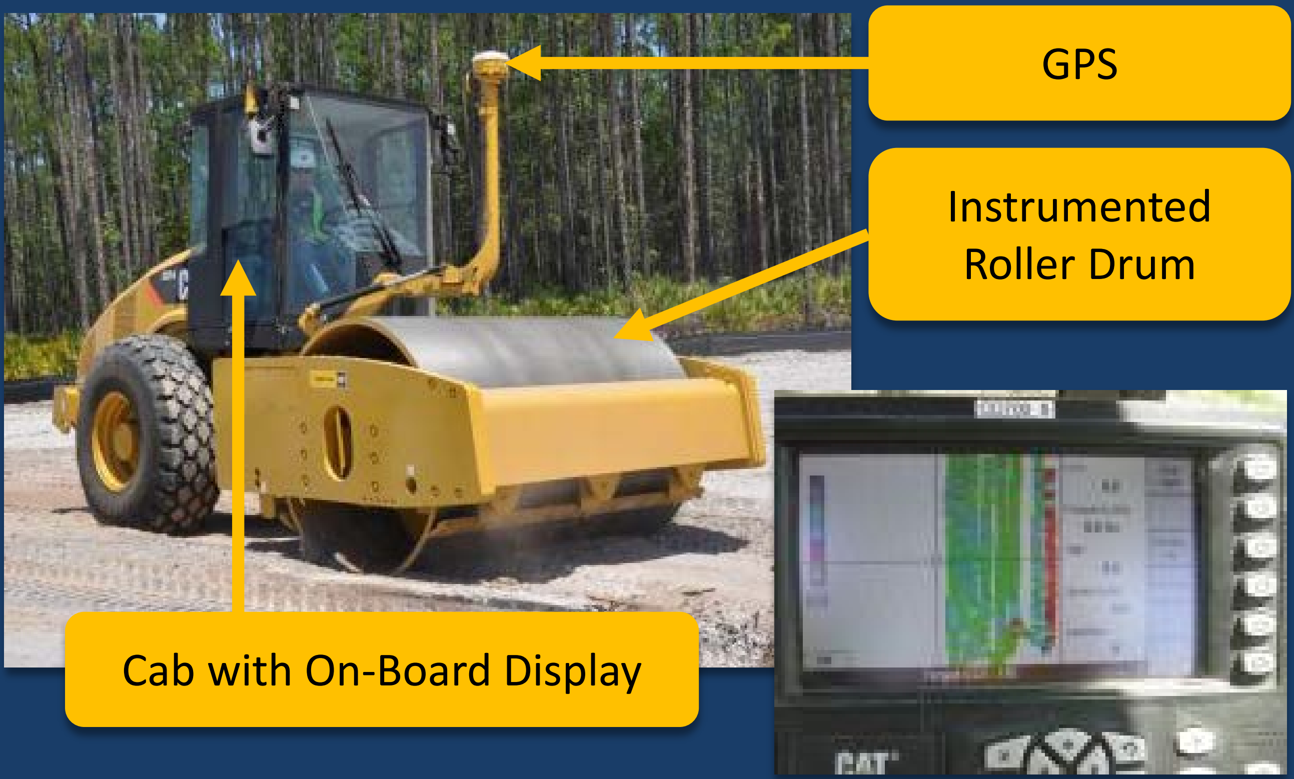
Intelligent Compaction



3D Engineered Models for Highway Construction

3D Techniques Use

- Grading
- Excavation
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- Intelligent Compact
- Paving

Stringless Paving

Stringless HMA Paving

Stringless PCC Paving

Why Change?

- Optimization of Construction Materials and Schedule
- Data Streamlining
- Field to Finish Time is Shortened
- Quality Control Improvements
- Safety Improvements

3D Engineered Models for Highway Construction

Optimization of Construction Materials and Schedule

Traditional 2D Method

- Contractor calls surveyor for grade stakes and paving hubs prior to grading and paving. Contractor’s schedule is dependent upon surveyor.

3D Engineered Models Method

- Contractor obtains 3D engineered model from the engineer and is able to begin grading and paving activities as soon as they are mobilized on site.

3D Engineered Models for Highway Construction

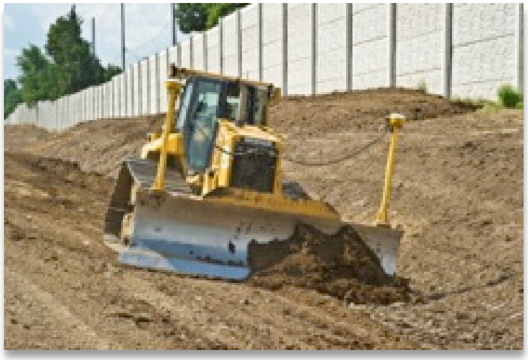
Optimization of Construction Materials and Schedule

Traditional 2D Method

- Contractor makes multiple passes with grading equipment to achieve finish grade. Grading relies upon operator's judgment between grade stakes by "connecting the dots."

3D Engineered Models Method

- The operator will be able to view the on-board AMG monitors to determine the amount of cut/fill at all locations within the 3D engineered model limits and reduce passes while delivering more accurate grades.



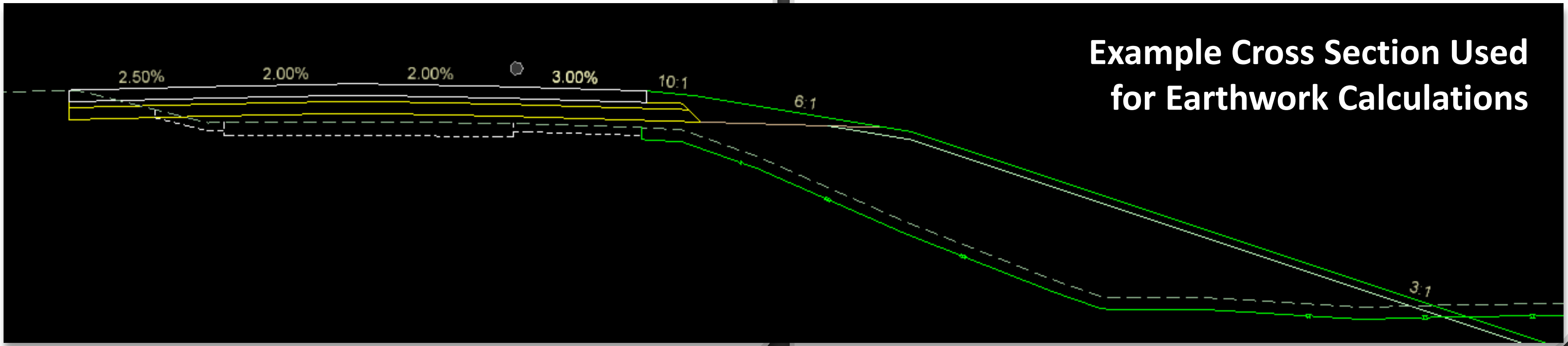
Optimization of Construction Materials and Schedule

Traditional 2D Method

- Earthwork quantities are determined using the average end area method (cut/fill volumes can be inaccurate, especially on highly irregular terrain).

3D Engineered Models Method

- Accurate earthwork quantities are determined by analyzing all areas of the 3D engineered model.



Example Cross Section Used for Earthwork Calculations

3D Engineered Models for Highway Construction

Optimization of Construction Materials and Schedule

Traditional 2D Method

- Contractor paves PCC overlay with additional thickness to avoid disincentive for overlay being too thin. Significant material overage.

3D Engineered Models Method

- Contractor utilizes 3D engineered model to accurately calculate amount of PCC needed to obtain specified thickness.

3D Engineered Models for Highway Construction

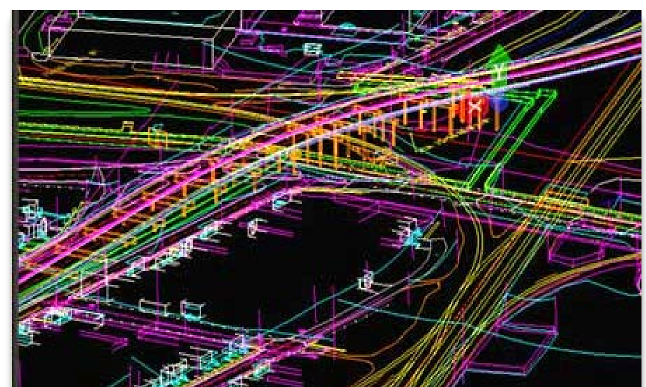
Data Streamlining

Traditional 2D Method

- Surveyor and contractor had to independently calculate grades based on plan view information.

3D Engineered Models Method

- 3D engineered models contain the information needed for layout purposes, nearly eliminating the need for independent calculations by the surveyor.



3D Engineered Models for Highway Construction

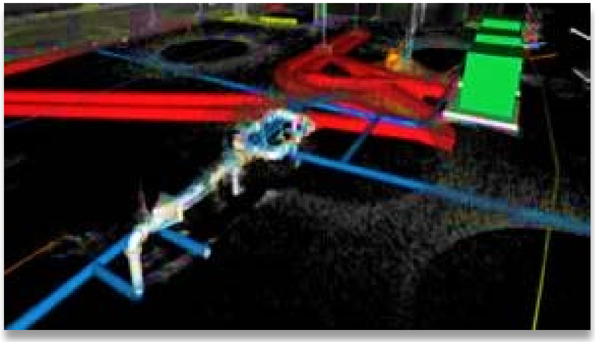
Field to Finish Time is Shortened

Traditional 2D Method

- Contractor potholes to locate existing utilities. This is a time-consuming process and is only a snapshot of the utility location at one point along the corridor.

3D Engineered Models Method

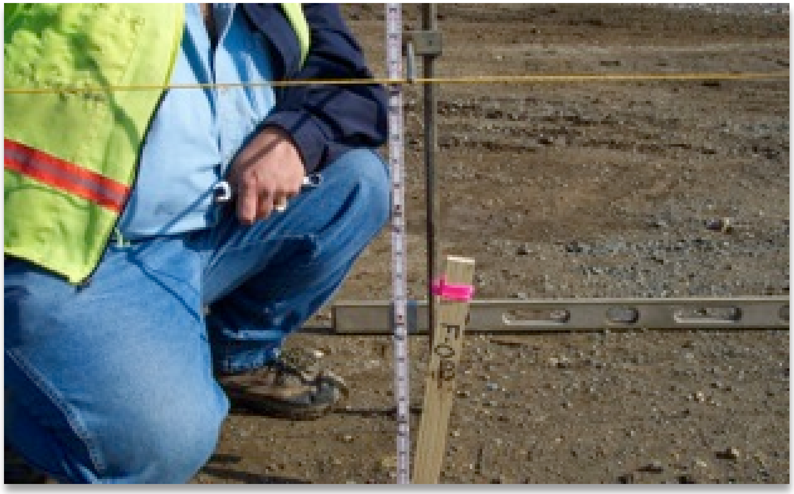
- The 3D engineered model with adequate information from a variety of sources allows better visualization and opportunities for clash/gap detection of subsurface utilities to help reduce overall project risk.



Field to Finish Time is Shortened

Traditional 2D Method

- String line crew waits for paving hubs and then sets up string line in advance of the paving train.



3D Engineered Models Method

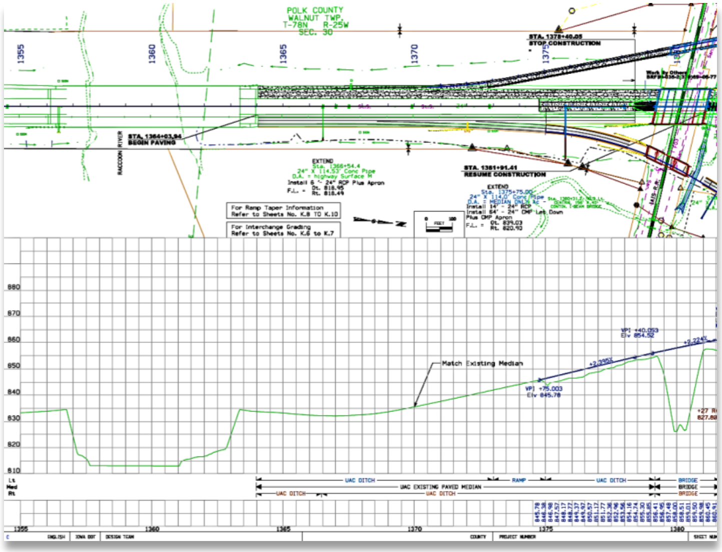
- Paving contractor can begin paving operations as soon as subgrade and sub base have been prepared.

3D Engineered Models for Highway Construction

Quality Assurance Improvements

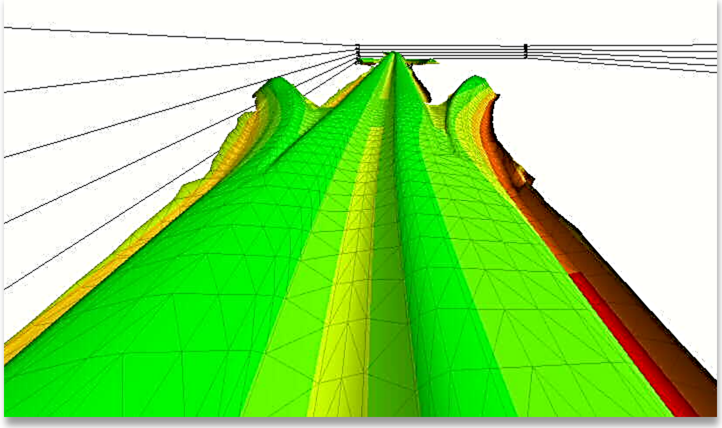
Traditional 2D Method

- Engineer relies on 2D plan views, profiles, and cross sections for QA.



3D Engineered Models Method

- Engineer can see isometric views, virtually drive-through the corridor, use drainage analysis tools, and identify utility conflicts for QA.



Quality Control Improvements

Traditional 2D Method

- Construction observer has to rely on grade stakes and grading contours in 2D to QC grading operations.

3D Engineered Models Method

- Construction observer can walk the site with a tablet and GPS rover to spot-check finished grade elevations.

Safety Improvements

Traditional 2D Method

- Surveyors and large equipment working simultaneously in close proximity to one another.

3D Engineered Models Method

- Grade stakes and paving hubs are not required, therefore surveyors would make fewer trips out to the site.

3D Engineered Models for Highway Construction

Safety Improvements

Traditional 2D Method

- String line crew will work ahead of paving train setting up string.

3D Engineered Models Method

- No string line is necessary when using stringless paving methods.

How to Get Started

- Define Your Goals
  - Design quality assurance
  - Grading AMG
  - Paving AMG
  - Utility conflicts
- Talk to Contractors – What do they want/need?
- CAD Standards/Design File Documentation
- Revise your specifications/standards if necessary

More Information?

www.fhwa.dot.gov/construction/3d/