Introduction to 3D, 4D, 5D, Schedule, Cost and Post-Construction

September 1, 2015
1:30 pm – 3:00 pm EST
Why has FHWA selected 3D Modeling again for EDC 3?

- FHWA launched Every Day Counts with its partner AASHTO in 2009
- Second series of ECD technologies launched in 2012.
- 3D Modeling was included
  - 8 webinars
  - 12 workshops
  - 4 on-line training courses
  - Website https://www.fhwa.dot.gov/construction/3d/
  - Field demonstrations
Recordings of Previous Webinars

http://www.fhwa.dot.gov/construction/3d/webinars.cfm
State Implementation During EDC2

3D Engineered Models for Construction
(December 2014)

3D Engineered Models for Construction

Dec 2014

Jan 2013

Every Day Counts 4
EDC3 Baseline Implementation

National State of the Practice March 2015 based on States’ self-reporting
3D Modeling is Dynamic

New innovations are coming on the market every day

- More accurate LiDAR
- Software advances accommodating collaboration between partners
- New specifications for owner quality control
- More uses of initial survey data
- Better utility location data management
## 3D Engineered Models Webinar Series

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Audience Demographics Polls

Please respond to the polls on screen.
Welcome and Introductions
## Today’s Speakers

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Technology Focus Areas
Learning Objectives

- Introduce and use terminology that describes 3D, 4D, and 5D Engineered Models
- Distinguish between the three main focus areas for EDC-3 and identify the link to EDC-2 focus areas
- Describe the purpose, need and benefits for the three new focus areas
Terminology

- Asset Management
- 4D Model
- Roadway Inventory
- Remote Sensing
- Point Cloud
- Acceptance
- GIS
- Mobile LiDAR
- Terrestrial LiDAR
- Subsurface Utility Engineering
- Real-time Verification
- Post-Construction Surveying
- RTK GNSS Rover
- 3D Geospatial Data
- 5D Model
Applications of 3D Data

Image credits: Caltrans, Cold Spring Construction, Parsons Brinckerhoff
Construction Engineering & Inspection

Image credits: Parsons Brinckerhoff
Structure Models: Design Coordination

Image credits: Parsons Brinckerhoff/Port Authority of New York & New Jersey
Structure Models: Analysis & Plans
4D and 5D Modeling

Image Sources: Iowa DOT, Wikimedia Commons, Caltrans
Convergence of Geospatial Data Systems

Geographical Information Systems

Image Source: Oregon DOT

We are here

TIME

Still separated, but getting closer: Coordinate Systems, accuracy, & detail level are becoming equally important!

We will be here
Subsurface Utility Locating
Creating Digital As-Built Records

Construction is the safest, most cost-effective time to capture position information.
3D Data for Asset Inventory and Condition

- Multi-disciplinary collaboration
- Preconstruction uses still being explored
- 12 roadway assets inventoried
- 6,000+ center lane miles mapped in 1 year

Image Source: Utah DOT
Summary of EDC-3 Technologies

- CE&I workflows
- Structural models
- 4D/5D Modeling
- Post-construction survey data
- As-found survey data
Poll Group 1

Please respond to the polls on screen.
Evan Rothblatt, EIT (AASHTO)

AASHTO Support for EDC and Innovation
Current AASHTO Innovation Initiatives

Active Lead States Teams Focus Technologies

- Carbon Fiber Reinforced Polymer Strands
- e-Construction
- Plans on Demand
- Automated Traffic Signal Performance Measures
- Intelligent Roadway Information System
- UPlan Phase II
- Watershed Resources Registry
- Embedded Data Collector
- Sequential Flashing Warning Lights for Work Zones
- Towing and Recovery Service Partnership

Access earlier Lead States Team Focus Technologies

Additionally Selected Technologies (ASTs)

- Bridge Expansion Joint System
- Prep-ME Software
- Sandwich Plate System Bridge Decks
- Double Crossover Diamond Interchange
Poll Group 2

Please respond to the polls on screen.
Nelson Aguilar, PLS (Caltrans District 4)

Building the Modern DOT
Introducing 3D Engineered Models to Caltrans District 4
Caltrans Mission Statement

Provide a safe, sustainable, integrated and efficient transportation system to enhance California’s economy and livability.
About Caltrans - District 4

- Encompasses the 9 counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Solano, Sonoma, and Santa Clara
- Over 3,300 positions with an annual operating budget of over $500 million
- Manages over 6,500 lane miles on over 770 centerline miles of conventional highways and 690 centerline miles of freeways, including 459 miles of carpool lanes
- Over $3.4 billion and 119 capital outlay projects currently under construction
- Operates seven toll bridges: Antioch, Benicia, Carquinez, Richmond-San Rafael, San Mateo-Hayward, San Francisco-Oakland and Dumbarton

For 3D Engineered Models for As-found Survey Data for Inventory and Asset Management:

– Demonstration Stage- Demonstration Stage- By using LiDAR to map six hundred miles of freeway assets in the San Francisco Bay Area, Caltrans was able to significantly improve sign data. This data will not only be used for sign data asset inventory, but for original ground data, DTM’s, for projects that are in the pipeline for roadway improvements.

For 3D Engineered Models for project Schedule and Cost (4D/5D):

– Development Stage- Collecting guidance and best practices, building support with partners and stakeholders, attending meetings with FHWA. The State is interested in pursuing 4D schedule and/or 5D cost estimating applications for improved project management or seeking additional information on how to implement them.

For 3D Engineered Models for Post-Construction:

– Development Stage- For the practice of creating accurate as-built record drawings, the State is interested in pursuing 3D post-construction applications for continuing maintenance, management and future planning of highway facilities. Need to establish 3D engineered model for Design projects first.
As-found Survey Data for Inventory & Asset Management

- California’s Connected Vehicle Test Bed
- Mobile Scanning Freeways for Roadway Sign Project
California Connected Vehicle Test Bed

1. Stanford
2. Cambridge
3. California
4. Page Mill
5. Portage/Hansen
6. Matadero
7. Curtner
8. Ventura
9. Los Robles
10. Maybell
11. Charleston
Project Requirements
Example Installation

6. Matadero Avenue
RSE goes above mast arm on the vertical
Antenna on the mast arm;
Needs Bracket
Actual Installation (Page Mill Road and El Camino Real)
MTLS Results

- 250 GB raw data
- 400 GB raw & processed data
- 10 GB processed compressed point cloud, exported

One day site recon
Two days planning
Two hours of data collection
Three days post-processing
< 6” absolute position accuracy
< 1” point to point measurement accuracy
El Camino Real / Page Mill Rd.
El Camino Real / Stanford.
Mobile Scanning Freeways for Roadway Sign Project

- Overhead sign project
- ~550 centerline miles
- Dimensioned over 1000 signs
- Delivery in GIS interface
- 18 TB of data collected, processed & stored
Overhead Sign Project Demo

Launch video
The Added Benefits from the Overhead Sign Project

- The collected data is being mined for three capital projects.
- However, decision was made not to target the scans due to the Sign Projects timetable. This decision had added costs and time to the capital projects.
Integrating Schedule (4D) & Cost (5D) Modeling

- San Francisco-101 Presidio Parkway
- San Francisco Oakland Bay Bridge (SFOBB)
SF-101 Presidio Parkway
San Francisco-Oakland Bay Bridge

4D/5D models support construction planning and logistics
Post-Construction Surveying for 3D As-Built Records

- Laser Scanning the San Francisco Oakland Bay Bridge
- Laser Scanning the San Francisco Route 101/280 Interchange
Laser Scan of the SFO BB
San Francisco-Oakland Bay Bridge

- System is well over 4 miles long
- West Span 9,620 feet long
- East Span 10,304 feet long
- West Approach Viaduct 3,707 feet long
- YBI Tunnel & West Transition 862 feet long
- East Span Transition Structures
# SFOBB Project Scope

<table>
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<th>Original Concept</th>
<th>New Concept</th>
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<td>STLS Scan of the SAS Tower and Deck</td>
<td>Complete Digital As-Built of the SFOBB</td>
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<td>• Post-load transfer condition</td>
<td>• Stationary scanning from pier caps, decks, and towers</td>
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<tr>
<td>• Deck deformation analysis</td>
<td>• Mobile scanning from decks</td>
</tr>
<tr>
<td>• Whatever else the engineers wanted</td>
<td>• Airborne lidar and digital orthophotos</td>
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Main Cable

Saddle

SAS Bridge = Self-Anchored Suspension

Main Cable

Suspender Ropes

Decks

Pier

Piers Caps

Photo by Caltrans

Every Day Counts 50
Inside the SAS

Image credit: Randy Wigton
Checking the data
NCHRP Report 748: Guidelines for the Use of Mobile LiDAR in Transportation Applications
Surveyor at Work

Image credit: Randy Wigton
Staff Accessing a Pier Cap

Image credit: Randy Wigton
What does the Data Look Like?
Mobile LiDAR Point Cloud
LiDAR Data Collected

Data Volume, Storage, and Backup

- 340 STL Scans
  - 400 GB of data
- 3 Days of MTLS Scans
  - 1.1 TB of data
- Airborne LiDAR
  - 3 Longitudinal & 2 Cross Passes
  - 200 GB of data
Initial Use of the SFO BB Data

- East Span Shipping Clearances - USCG
- SAS Tower deformation Diagrams
- Vehicle Clearance Envelope Analysis
- Suspender Cable Verticality
- Main Cable Location vs. Plan
- West Span Tower Locations – USCG
- West Span Mid-Span Anchorage data for another project
SFOBB East Span Profile
Final SFOBB East Span Clearance Report

SFOBB CLEARANCES
EXHIBIT
NOV. 2013

DATE OF LIDAR SURVEY: AUGUST 2013.
FENDER STRUCTURES OF "TI TOWER" WERE NOT INSTALLED AT TIME
OF SURVEY.
ESTIMATED COMPLETION OF SAID STRUCTURE IS FIRST
QUARTER OF 2014.
HEIGHT OF TRAVELER=3.860m, LENGTH=31.249m, TOTAL OF 5
LOCATIONS=WEST BOUND=W2 TO E2, WEST BOUND=E2 TO E3
EAST BOUND=W2 TO E2, EAST BOUND E2 TO E3 AND THE
BIKE PATH.
VALUE/ELEVATION INCLUDES THE VORTEX WIND GENERATORS.
ALL VALUES ARE IN METERS UNLESS OTHERWISE NOTED.
SEE “COMPLETION REPORT INFORMATION” FOR FINAL VALUES.
PROJECT DATUM: NAD83 ZONE III, NAVD93, METERS.
FOR THIS EXHIBIT THE NAVD93 VALUES HAVE BEEN
CONVERTED TO NAVD88 TO DETERMINE MHW VALUES.

NOTES:
The MHW VALUES WERE DERIVED FROM TIDAL DATUMS
AT YERBA BUENA ISLAND, SAN FRANCISCO BAY BASED ON:
LENGTH OF SERIES: 6 MONTHS.
TIME PERIOD: MARCH 1993-AUGUST 1993
TIDAL EPOCH: 1983-2001
CONTROL TIDE STATION: 9414750 ALAMEDA, SAN FRANCISCO BAY
ELEVATIONS OF TIDAL DATUMS REFERRED TO MEAN LOWER LOW WATER
(MLLW), IN METERS.
MEAN HIGHER HIGH WATER
MEAN HIGH WATER
MEAN TIDE LEVEL
MEAN SEA LEVEL
MEAN LOW WATER
MEAN LOWER LOW WATER
NORTH AMERICAN VERTICAL DATUM

This plat/report was prepared by
Paul F. Rogers
No. 6075
EXP. 12/31/15
SHT 1 OF 1
SFOBB East Span Tower Cross Section Comparisons

As-built to Design Comparison

Pre to Post Load Analysis
SFOBB As-Built Traffic Envelope

SAS TRAFFIC ENVELOPE AS-BUILT

Every Day Counts 63
What are the possibilities?

- Mining Additional Data per Requests?
- Planning for New Improvements?
- Public Outreach?
- Emergency Response?
- Bridge Management Information System?
Laser Scan of the SF-101/280 IC
Partial DTM, SF-101
Rendered Visualization Model
Visualization Model with Rendered Traffic
Visualization Model with Rendered Traffic - Alternative Study
Temporary Bridge Study
Arrows Instead of Vehicles

Stage 1 Detour Peak
Final Visualizations Animation

Existing Condition Peak
Final Visualization Animations
Mining Data for a Claim

Vertical Clearances for Overhead Sign

Damaged Sign

Beam 15.9 ft

Sign 15.1 ft

Sign 15.4 ft

Beam 15.8 ft

Sign 15.1 ft
Where are we going from here?

- Evolution of technology for transportation projects
- Moving into the future – Integrated corridor management, Connected or Autonomous vehicles, …
Data Management

I Room Simulation
Upgrade IT Infrastructure
NCHRP Legal Research Digest 58 March 2013: The Legal Aspects of Digital Data

- Copyright Laws
- Ownership of Models
- Protection of Models and Collaborators
- Liability
- Securing Classified Data
- Sharing Digital Data
- 3D Model Issues that may Limit Copyright Protection
THANK YOU!
Poll Group 2

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