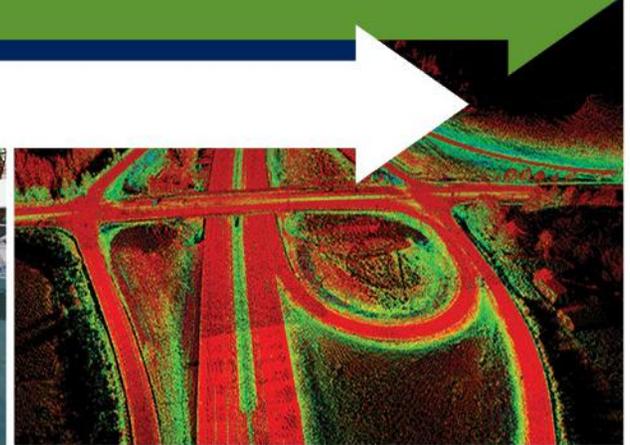


# Introduction to 3D, 4D, 5D, Schedule, Cost and Post-Construction



September 1, 2015

1:30 pm – 3:00 pm EST



---

## Why has FHWA selected 3D Modeling again for EDC3?

- 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>

U.S. Department of Transportation  
Federal Highway Administration

About Programs Resources Briefing Room Contact Search FHWA

## 3D Engineered Models

FHWA / Programs / Construction / Technologies and Innovations / 3D Engineered Models / 3D Engineered Models Webinar Series

**3D Engineered Models** Accelerated Construction e-Construction Intelligent Compaction Slide-in Bridge Construction SHRP2

Surveying 3D Design Construction Post-Construction Training Resources

### 3D Engineered Models Webinar Series

One of the technologies for the FHWA's Every Day Counts (EDC) initiative is 3D Engineered Models for Construction. A series of eight webinars have been developed to assist the FHWA's transportation partners in adopting this proven technology. The webinars are given in a "cradle to grave" sequence. Participants will hear how contractors incorporate 3D engineered models in their workflow of bidding and preparing to execute construction.

- [Webinar Series Summary](#)

**Who Should Attend** This webinar series is for local, state, and federal highway agencies, as well as consultants, surveyors, equipment manufacturers, software developers, and contractors who support these agencies in designing and constructing transportation facilities. Viewing previous webinars in the series will be beneficial.

#### Recorded Webinars

- [Overview of 3D Engineered Models for Construction](#)  
November 20, 2013 1:00 p.m. - 2:30 p.m. Eastern  
[Presentation](#) (.pdf, 2.2 mb)
- [Creating 3D Engineered Models](#)  
January 8, 2014 1:00 p.m. - 2:30 p.m. Eastern  
[Presentation](#) (.pdf, 4.9 mb)
- [Applications of 3D Models in the Construction Office](#)  
February 19, 2014 1:00 p.m. - 2:30 p.m. Eastern  
[Presentation](#) (.pdf, 3.5 mb)

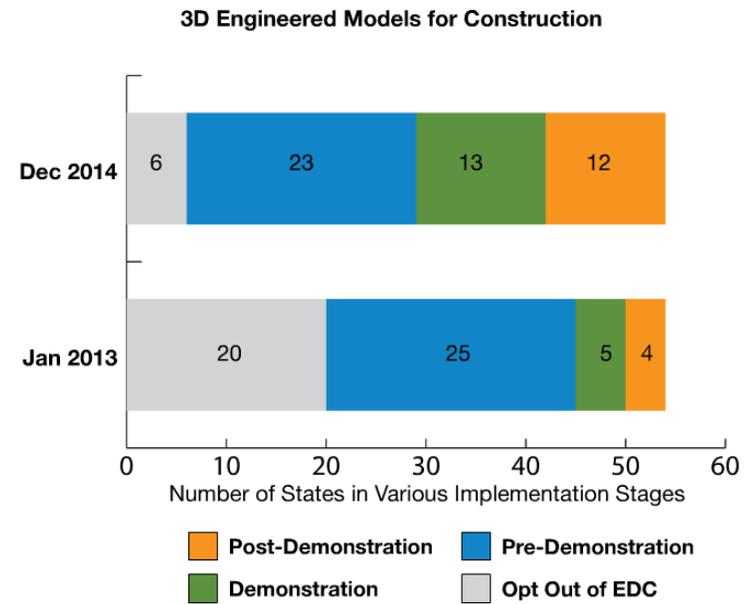
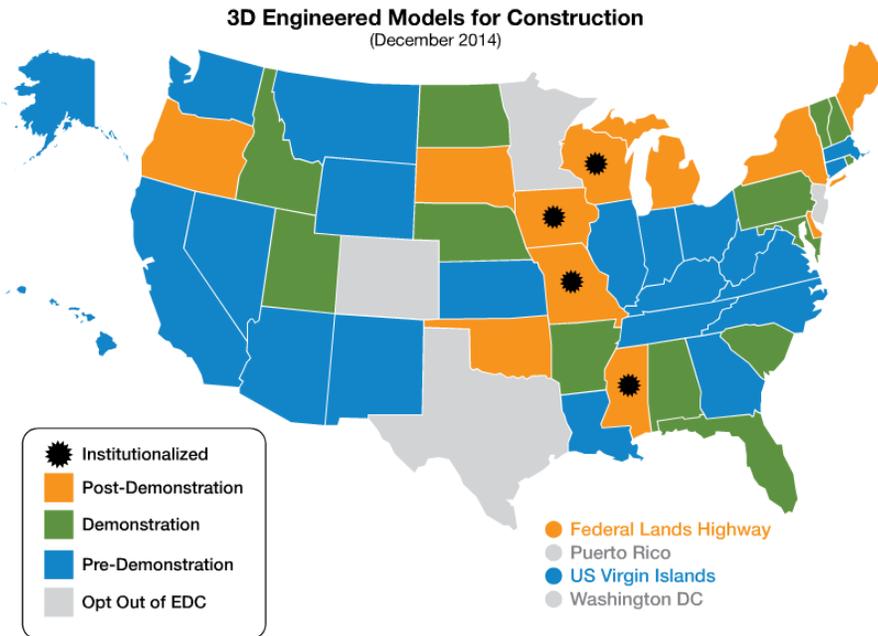
#### Every Day Counts

- This is among the Every Day Counts (EDC) initiatives. [Learn more about EDC](#)

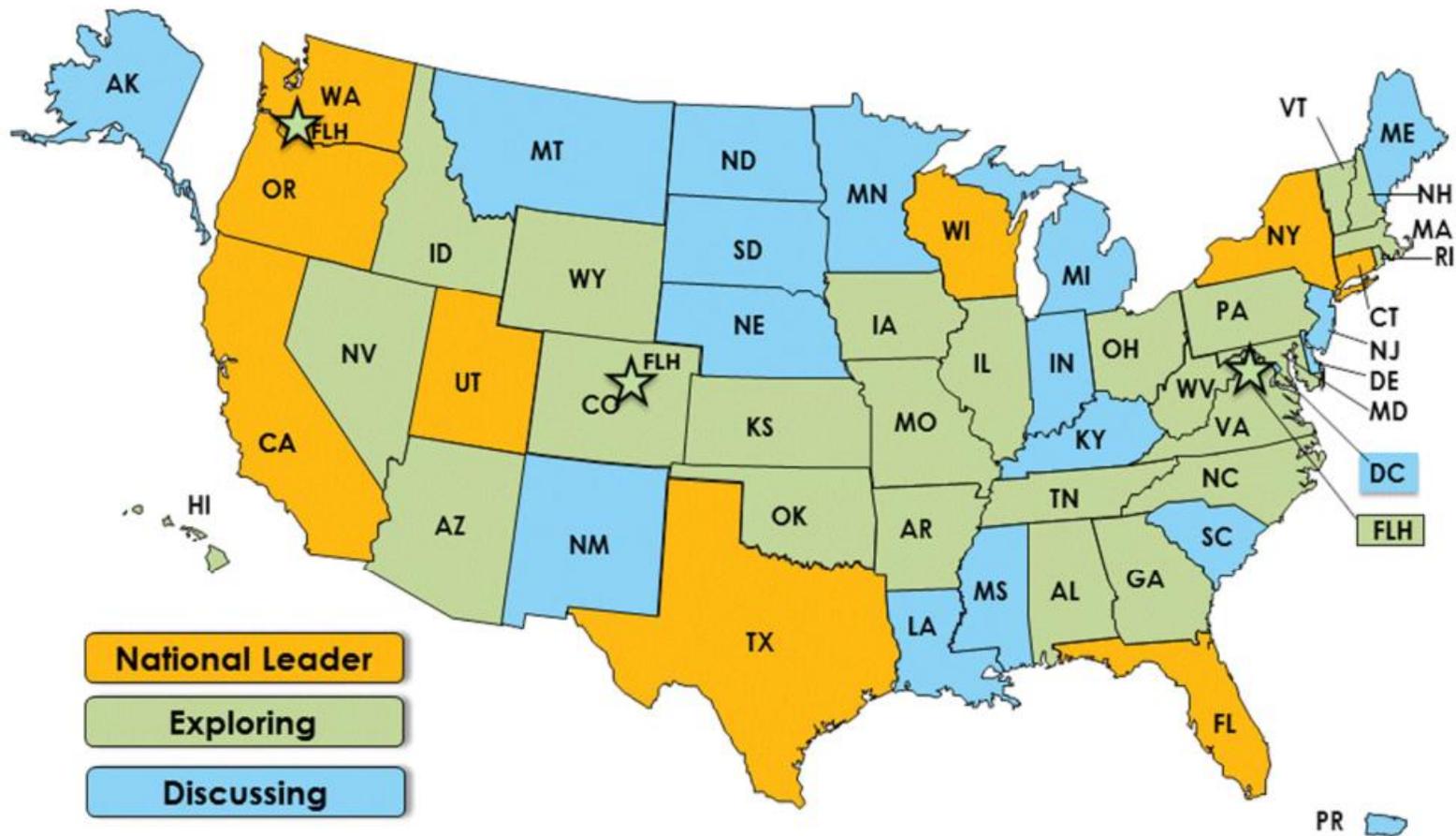
#### Contact

- Douglas Townes**  
[Resource Center \(Atlanta\)](#)  
404-562-3914  
[E-mail Douglas](#)

# State Implementation During EDC2



# EDC3 Baseline Implementation



National State of the Practice March 2015 based on States' self-reporting

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## 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

Today	Introduction to 3D, 4D, 5D Schedule, Cost and Post-Construction
Oct 2015	Using 3D Digital Data for Construction Engineering & Inspection
Nov 2015	Creating and Using 3D Models of Highway Structures
Jan 2016	Uses of 4D and 5D Models in Highways
Feb 2016	Getting Started with 4D and 5D Modeling
Mar 2016	Collection and Use of 3D Digital As-built Records
Apr 2016	Use of 3D Digital Data for Asset Management

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# Audience Demographics Polls

Please respond to the polls on screen.



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Douglas Townes, PE (FHWA Resource Center)

# Welcome and Introductions



Every Day Counts

# Today's Speakers

Speaker	Topic
Douglas Townes, PE <i>FHWA-Resource Center</i>	Welcome, Introductions & Webinar Series Information
Francesca Maier, PE <i>Parsons Brinckerhoff</i>	New Technology Focus Areas
Evan Rothblatt, EIT <i>AASHTO</i>	AASHTO Support for EDC and Innovation
Nelson Aguilar, PLS <i>Caltrans District 4</i>	Lessons Learned with the Technologies
Francesca Maier, PE <i>Parsons Brinckerhoff</i>	Moderated Question & Answer Session
Douglas Townes, PE <i>FHWA-Resource Center</i>	Next Webinar Information & Close

---

Francesca Maier, PE (Parsons Brinckerhoff)

# Technology Focus Areas

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# 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

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

# Applications of 3D Data

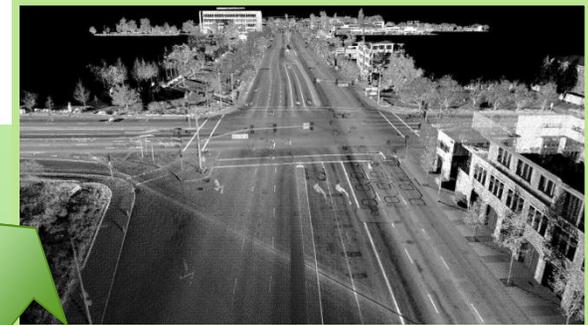


Image credits: Caltrans, Cold Spring Construction, Parsons Brinckerhoff

# Construction Engineering & Inspection



Microsoft Excel - SCS Report Utility

File Edit View Insert Format Tools Data Window Help

15

SCS Report Utility v2.10

NYSDOT  
Route 219

WorkOrder: BERM 8 CO  
First access: 7/12/07 7:5  
Last access: 12/2/07 11:1

Client: -

Record Type Data

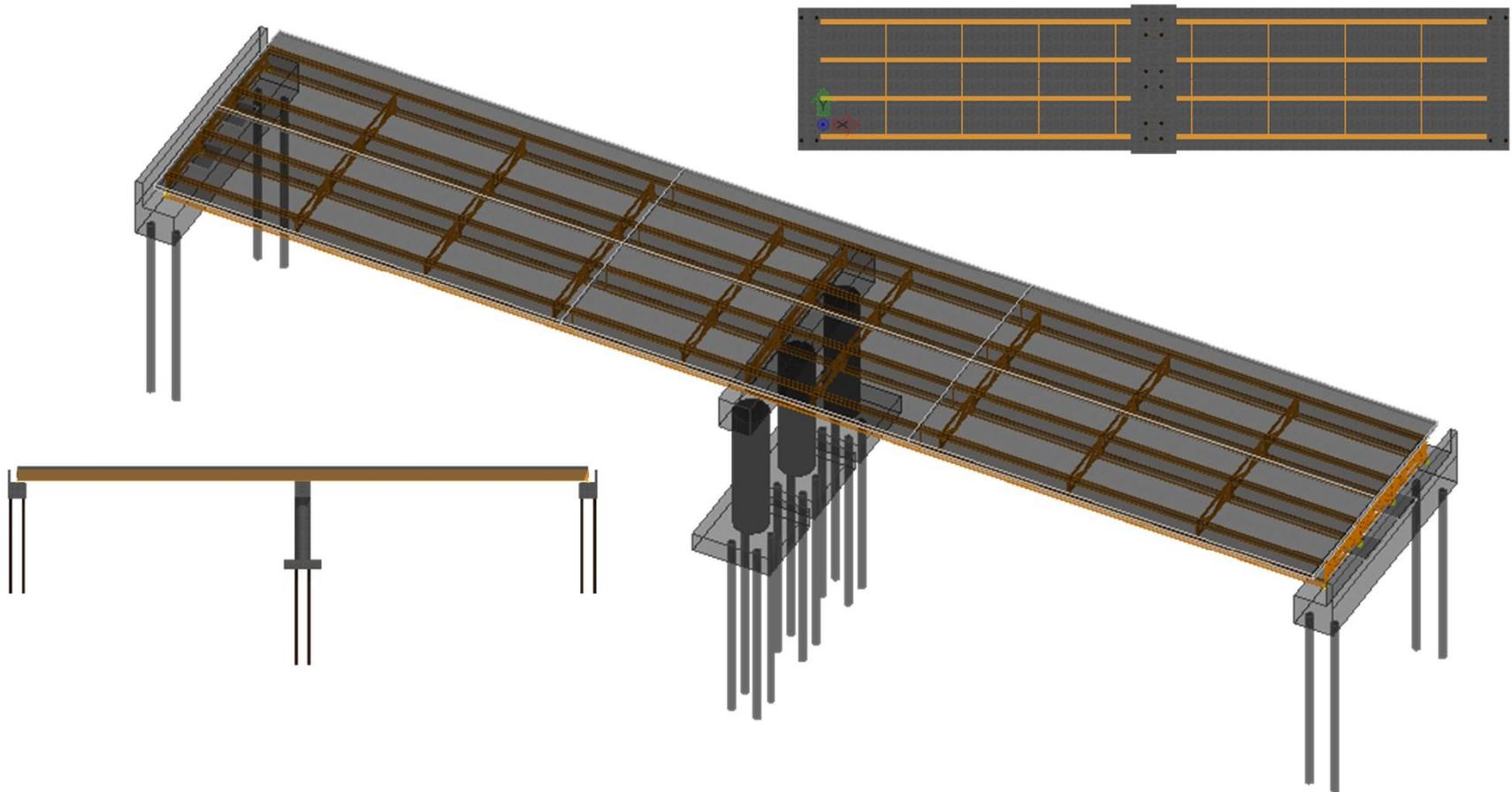
Record type	Sub type	Point Name	Line Name	Point Code	Measured N	Measured E	Measured Elev	HA / Lat	VA / Long	SD / WGS84	Precision	F
9	Topo	Breakline	LineP11	CORE1	CORE8	258132.272	342434.522	513.595			0.006	
10	Topo	Breakline	LineP12	CORE1	CORE8	258138.159	342438.971	513.125			0.004	
11	Topo	Breakline	LineP13	CORE1	CORE8	258131.971	342434.111	513.116			0.006	
12	Topo	Breakline	LineP14	CORE1	CORE8	258127.229	342431.638	513.088			0.005	
13	Topo	Breakline	LineP15	CORE1	CORE8	258121.072	342430.390	512.928			0.007	
14	Topo	Breakline	LineP16	CORE1	CORE8	258135.990	342430.236	512.795			0.005	
15	Topo	Breakline	LineP17	CORE1	CORE8	258111.614	342473.772	512.719			0.004	
16	Topo	Breakline	LineP18	CORE2	CORE8	258137.554	342434.228	512.696			0.006	
17	Topo	Breakline	LineP19	CORE2	CORE8	258136.276	342430.839	512.566			0.006	
18	Topo	Breakline	LineP10	CORE2	CORE8	258133.057	342436.615	512.488			0.006	
19	Topo	Breakline	LineP11	CORE2	CORE8	258129.229	342433.832	512.373			0.005	

Image credits: Parsons Brinckerhoff

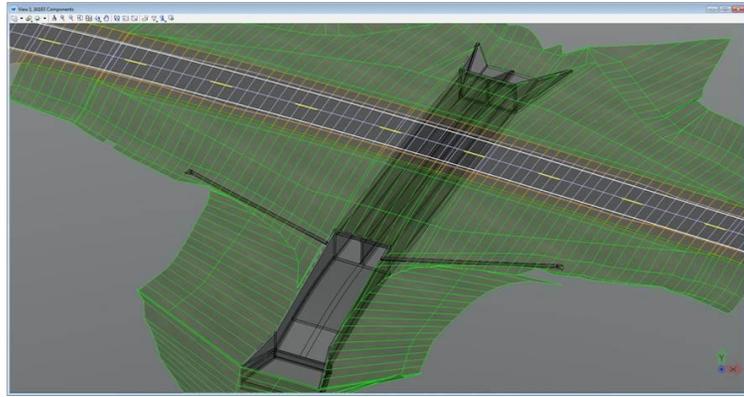
# Structure Models: Design Coordination



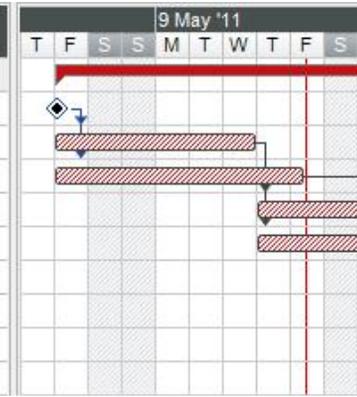
# Structure Models: Analysis & Plans



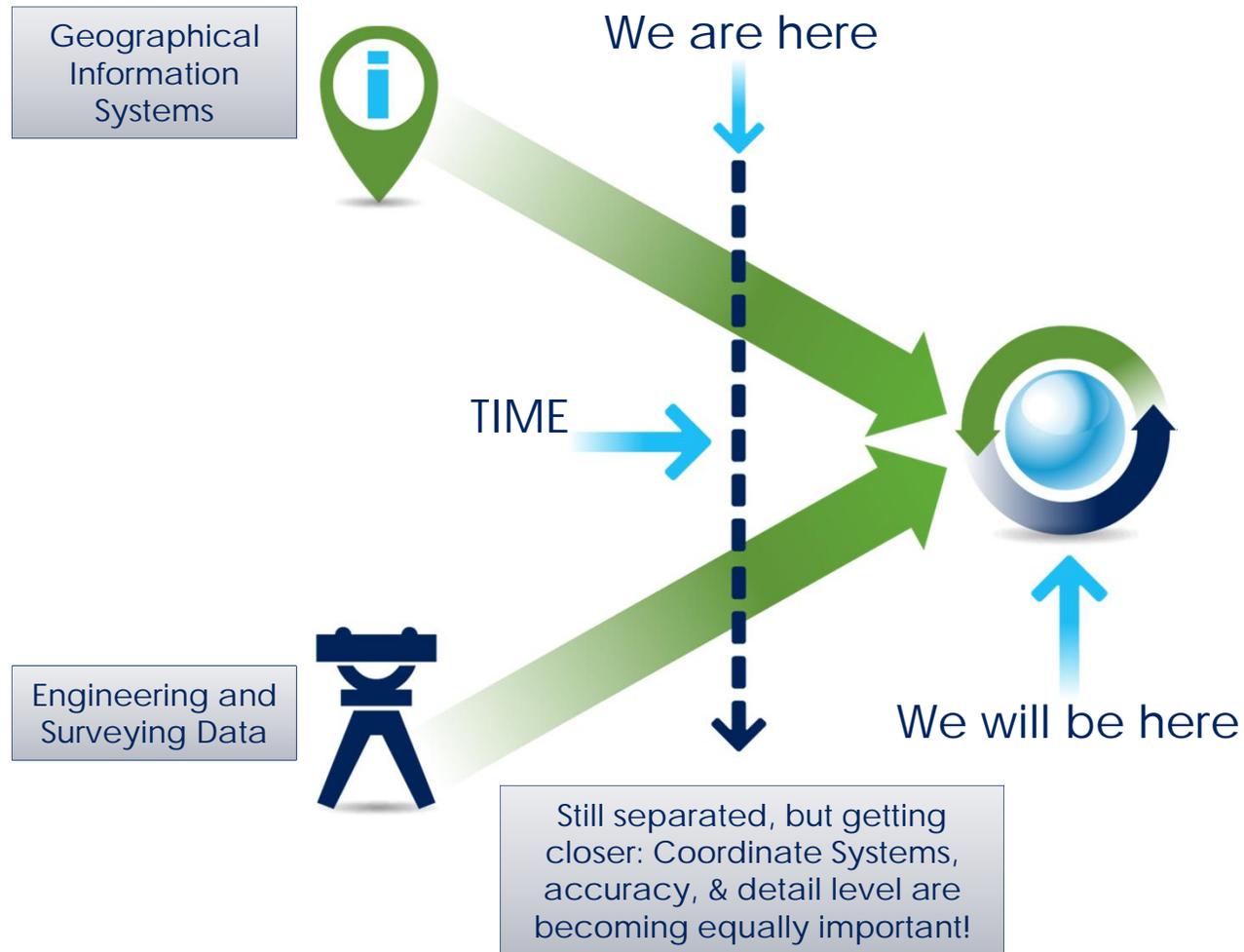
# 4D and 5D Modeling



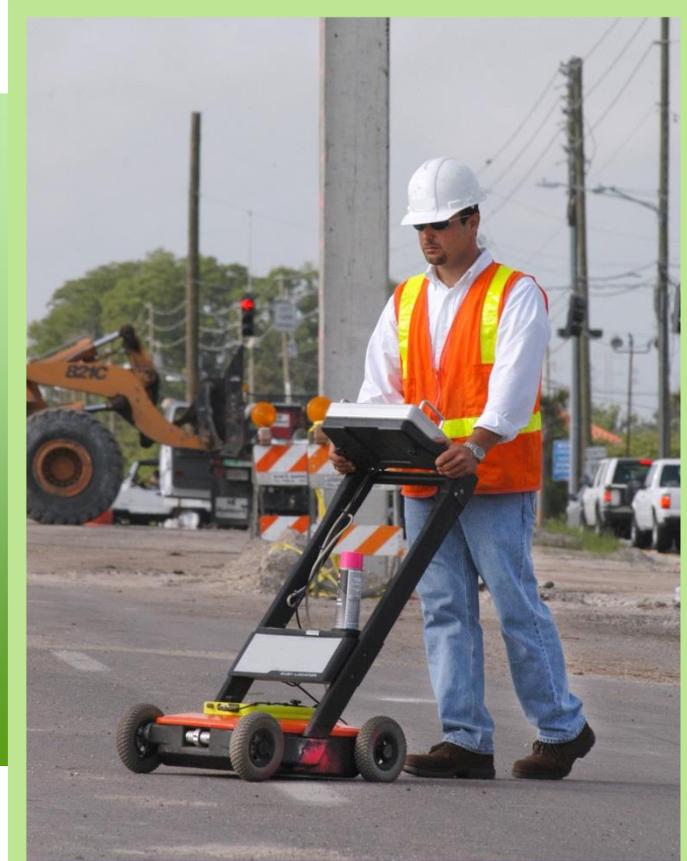
Task Name	Duration	Start
Project	19.47 days	5/6/2011
Start	0 day	5/6/2011
Task A	4 days	5/6/2011
Task B	5.3 days	5/6/2011
Task C	5.15 days	5/12/2011
Task D	6.32 days	5/12/2011
Task E	5.15 days	5/19/2011
Task F	4.5 days	5/20/2011
Task G	5.15 days	5/26/2011
Finish	0 day	6/2/2011



# Convergence of Geospatial Data Systems



# Subsurface Utility Locating



# Creating Digital As-Built Records



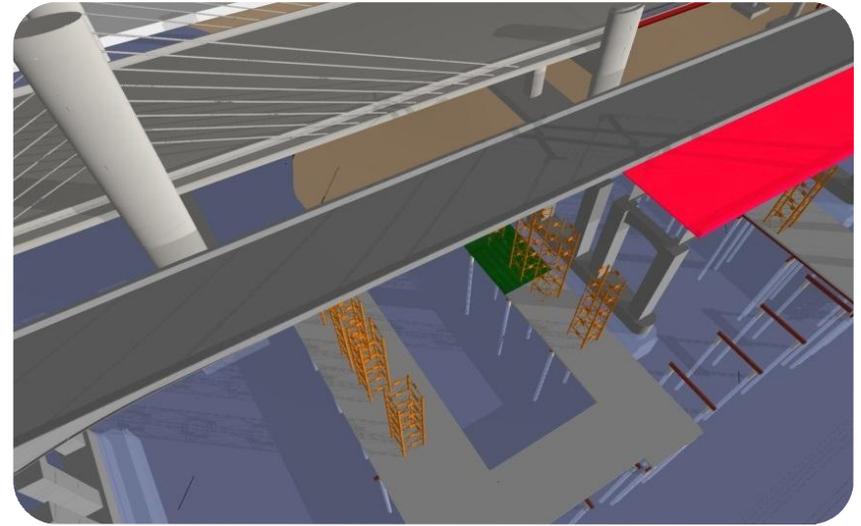
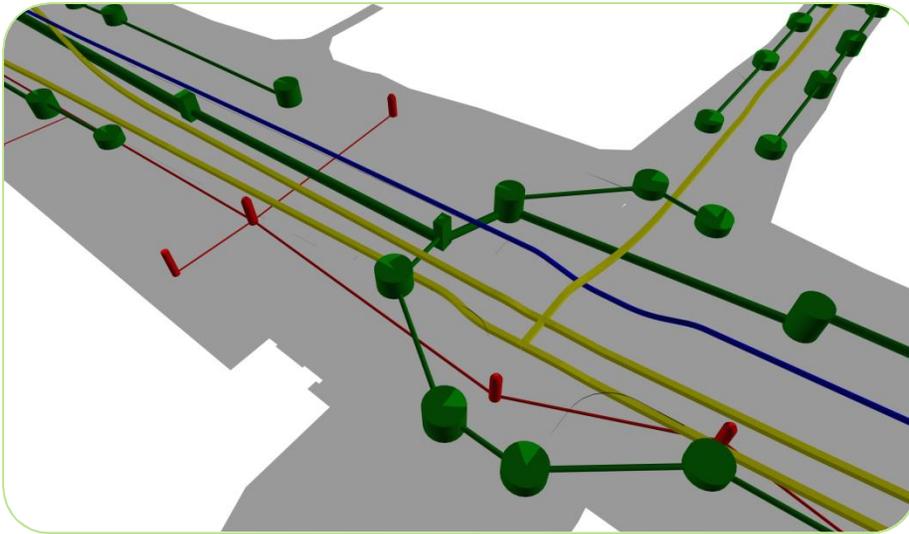
Construction is the safest, most cost-effective time to capture position information

# 3D Data for Asset Inventory and Condition

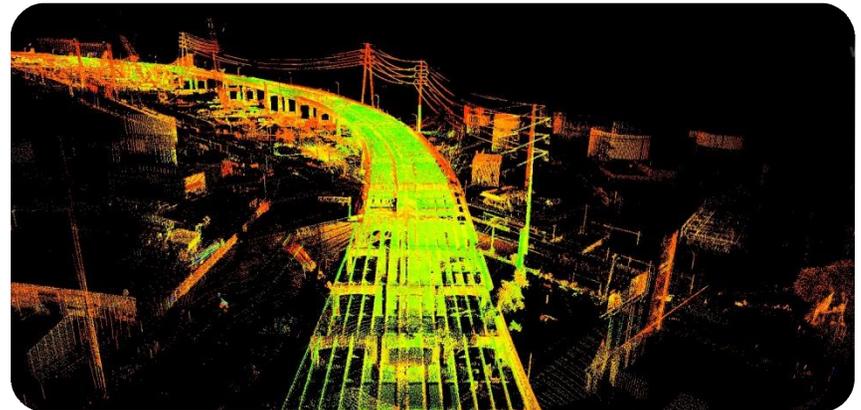


- Multi-disciplinary collaboration
- Preconstruction uses still being explored
- 12 roadway assets inventoried
- 6,000+ center lane miles mapped in 1 year

# Summary of EDC-3 Technologies



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



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# Poll Group 1

Please respond to the polls on screen.

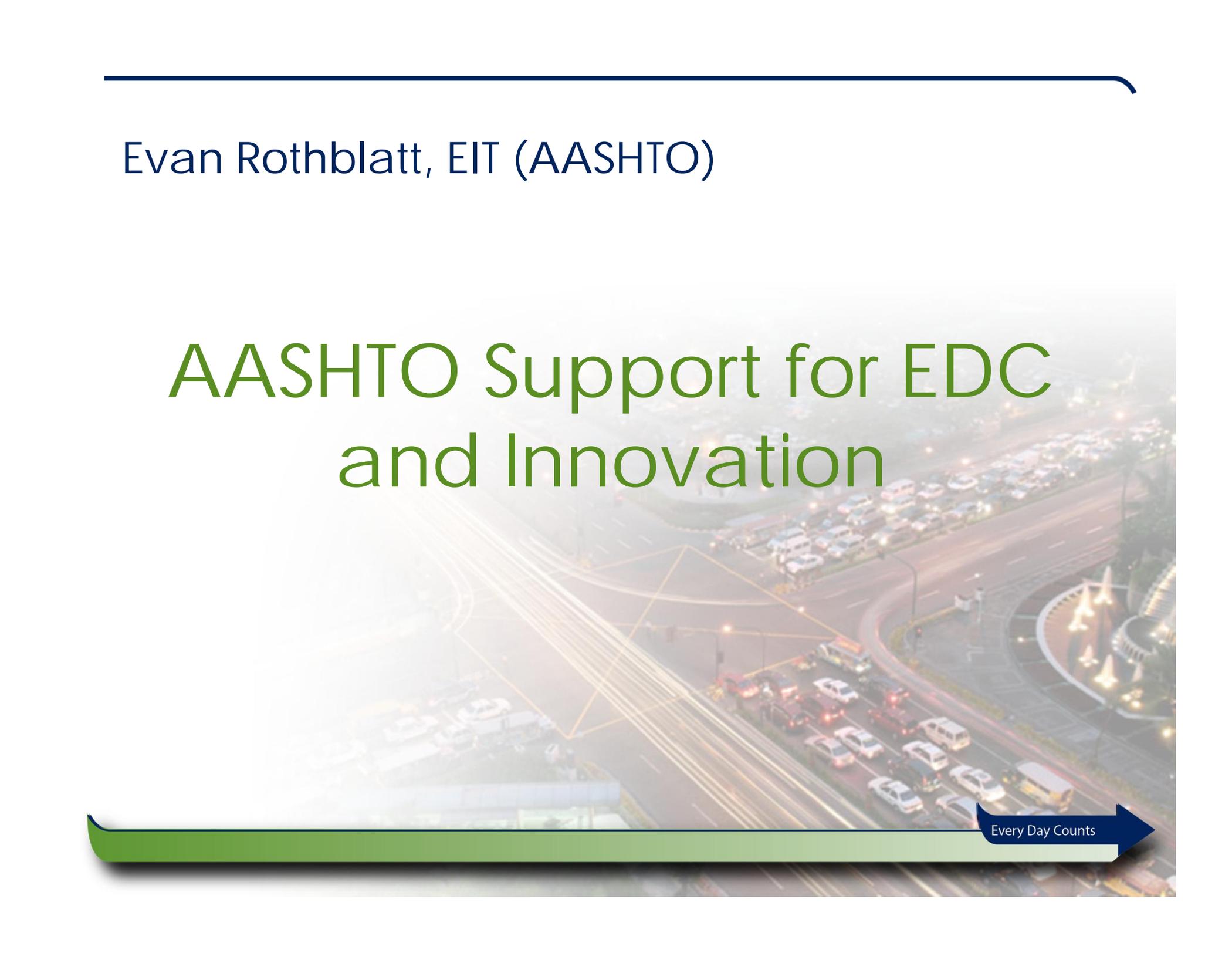


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Evan Rothblatt, EIT (AASHTO)

# AASHTO Support for EDC and Innovation

Every Day Counts



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# 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



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## Poll Group 2

Please respond to the polls on screen.



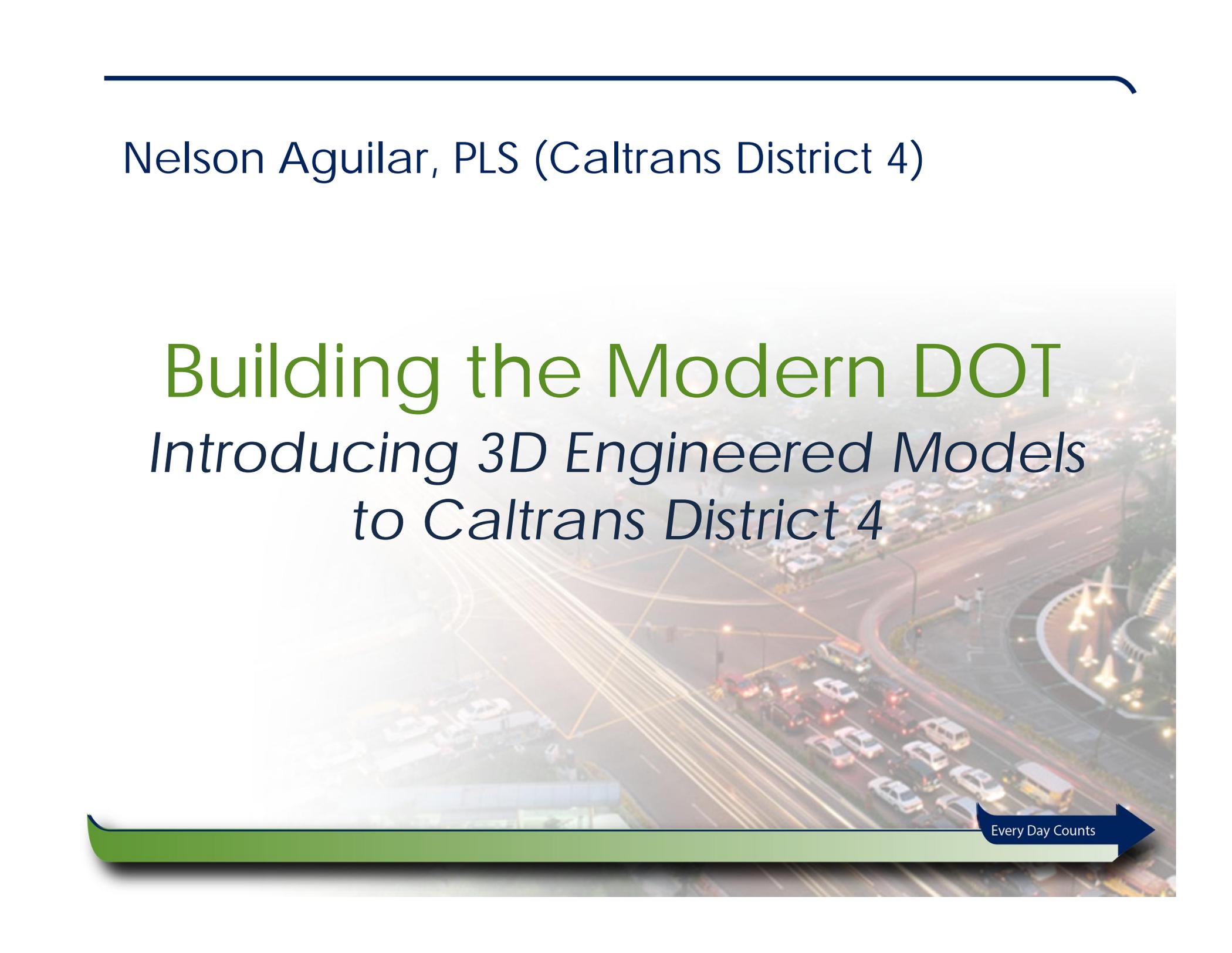
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Nelson Aguilar, PLS (Caltrans District 4)

# Building the Modern DOT

## *Introducing 3D Engineered Models to Caltrans District 4*

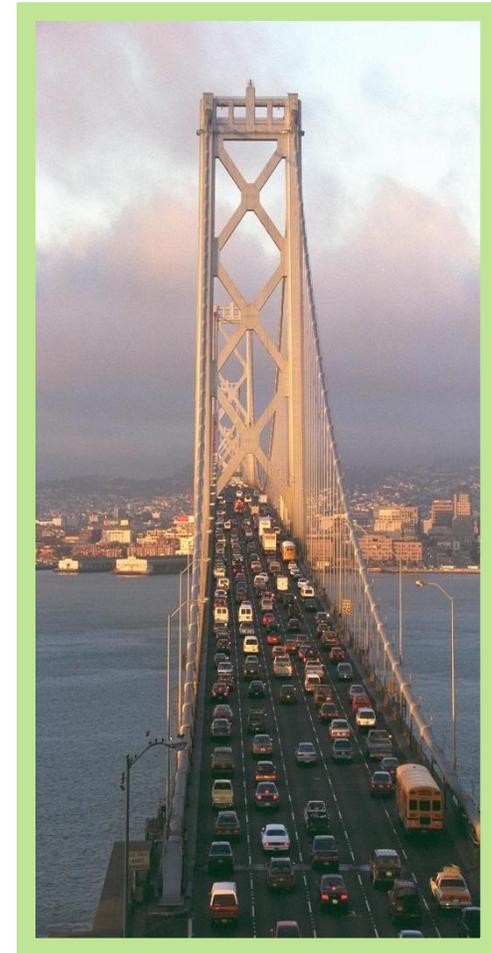
Every Day Counts

An aerial photograph of a complex highway interchange with multiple lanes and overpasses. A semi-transparent 3D wireframe model is overlaid on the scene, showing the structural layout of the interchange. The background is slightly blurred, emphasizing the 3D model. A blue arrow-shaped graphic at the bottom right contains the text 'Every Day Counts'. A green decorative bar is at the bottom left.

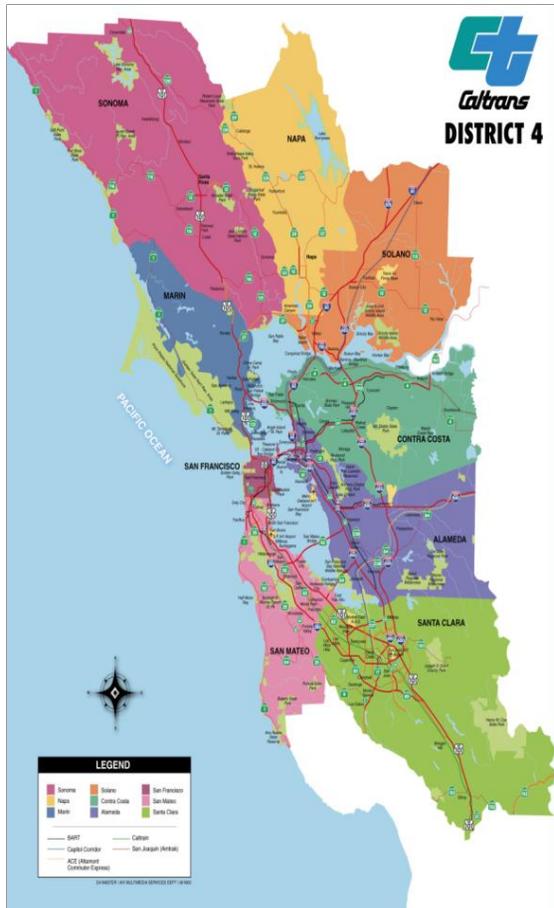
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# Caltrans Mission Statement

*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

---

# 3D Engineered Models: Caltrans Progress Report January – June 2015

## 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:

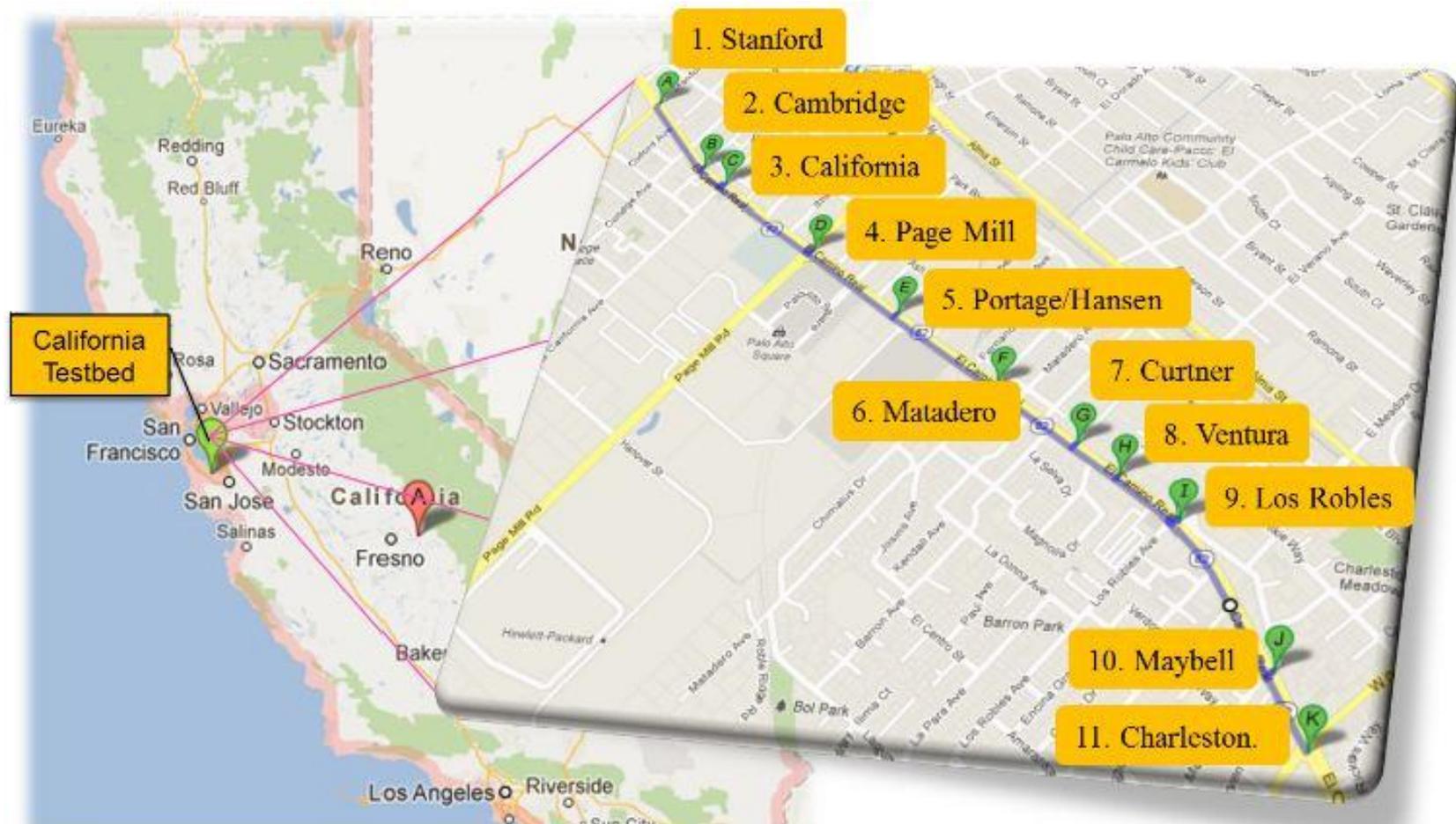
- *Development Stage-* For the practice of creating accurate as-built record drawings, the State is interested in pursuing 3D post-construction applications for continuing maintenance, management and future planning of highway facilities. Need to establish 3D engineered model for Design projects first.

---

## As-found Survey Data for Inventory & Asset Management

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

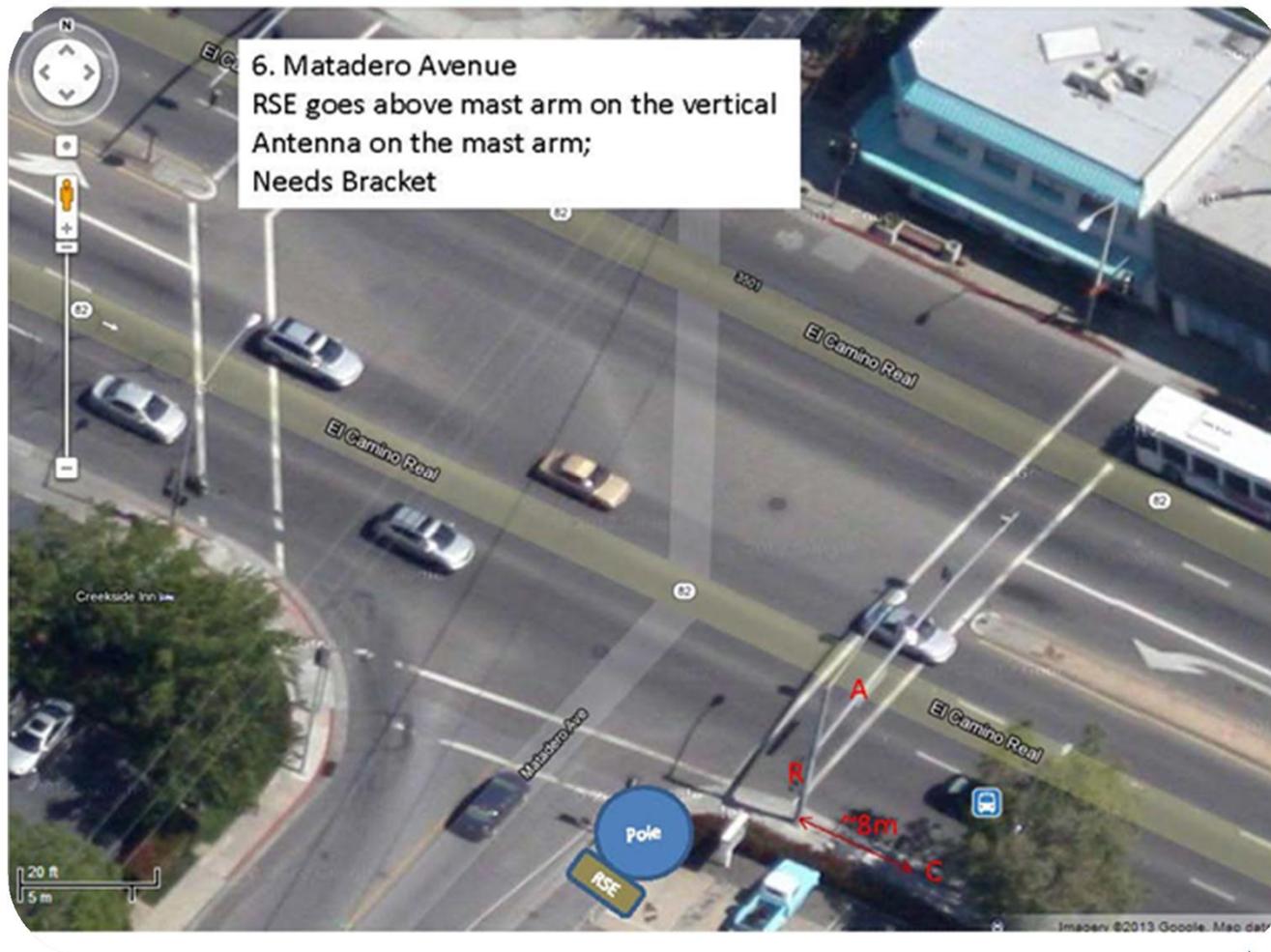
# California Connected Vehicle Test Bed



# Project Requirements



# Example Installation

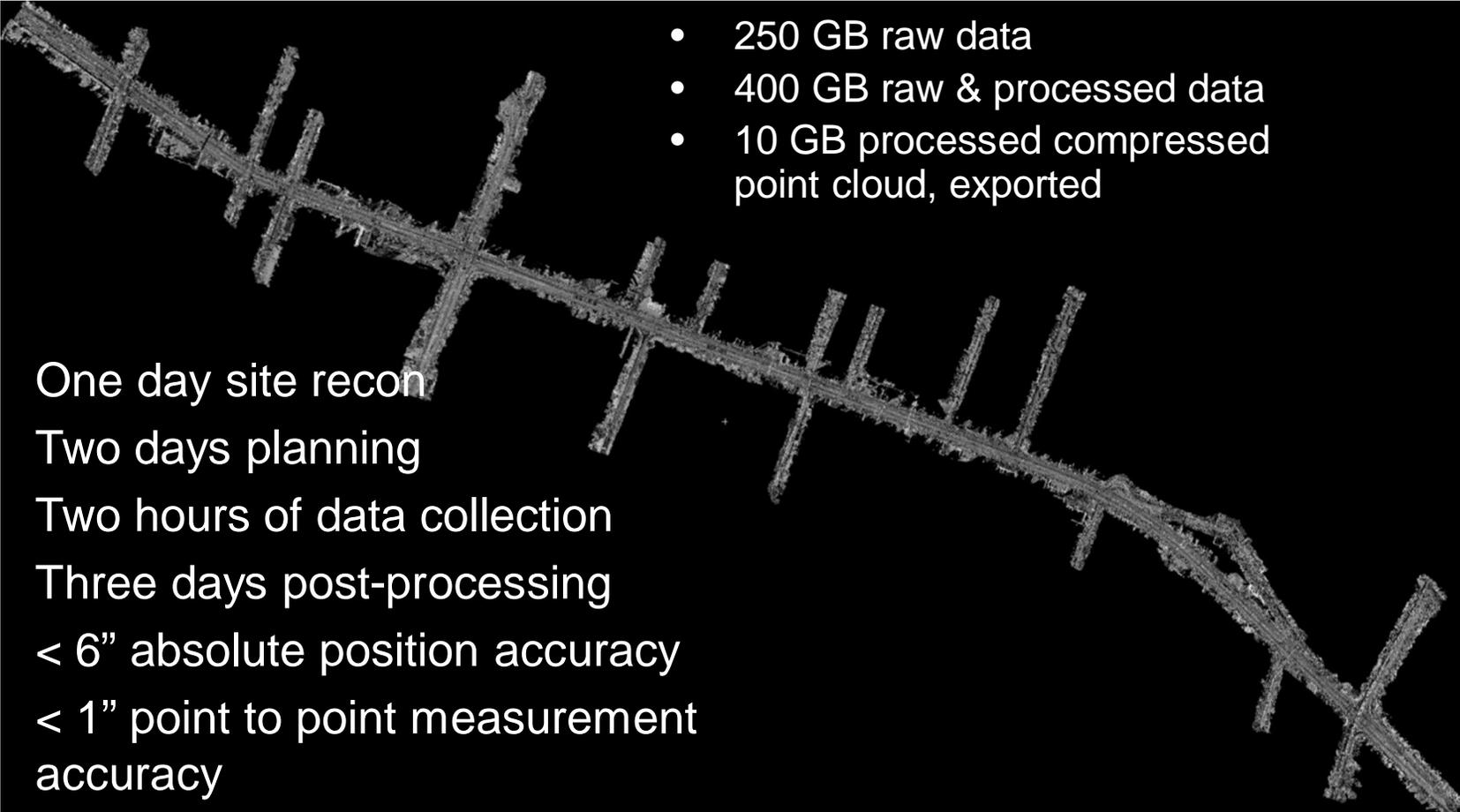


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## Actual Installation (Page Mill Road and El Camino Real)



# MTLS Results



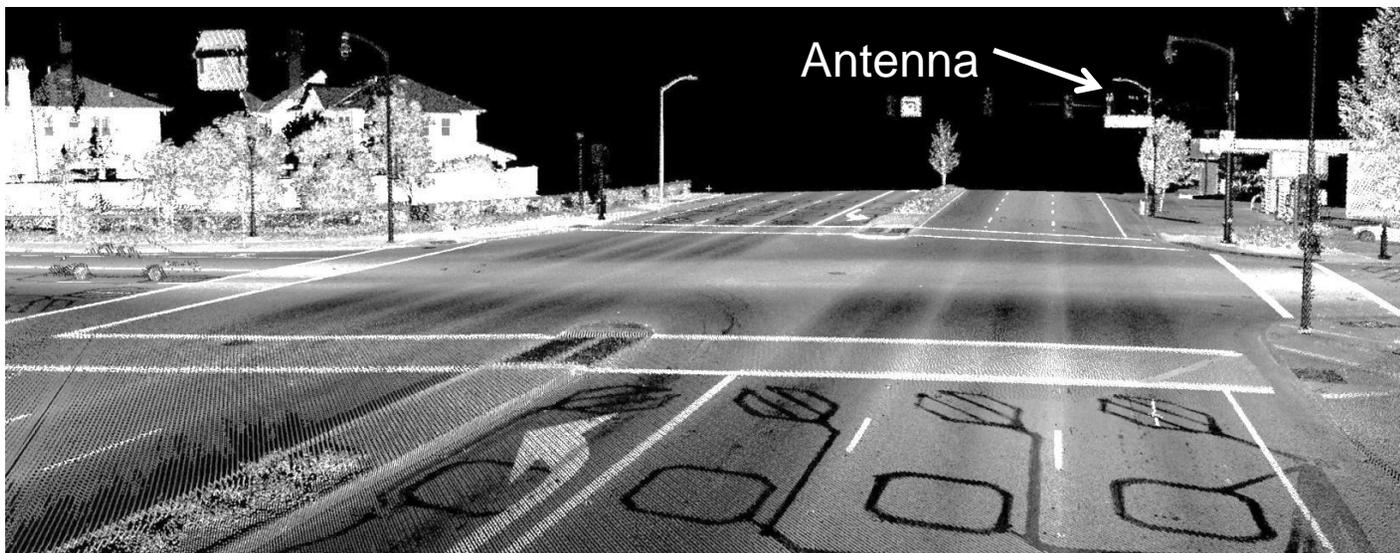
- 250 GB raw data
- 400 GB raw & processed data
- 10 GB processed compressed point cloud, exported

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.



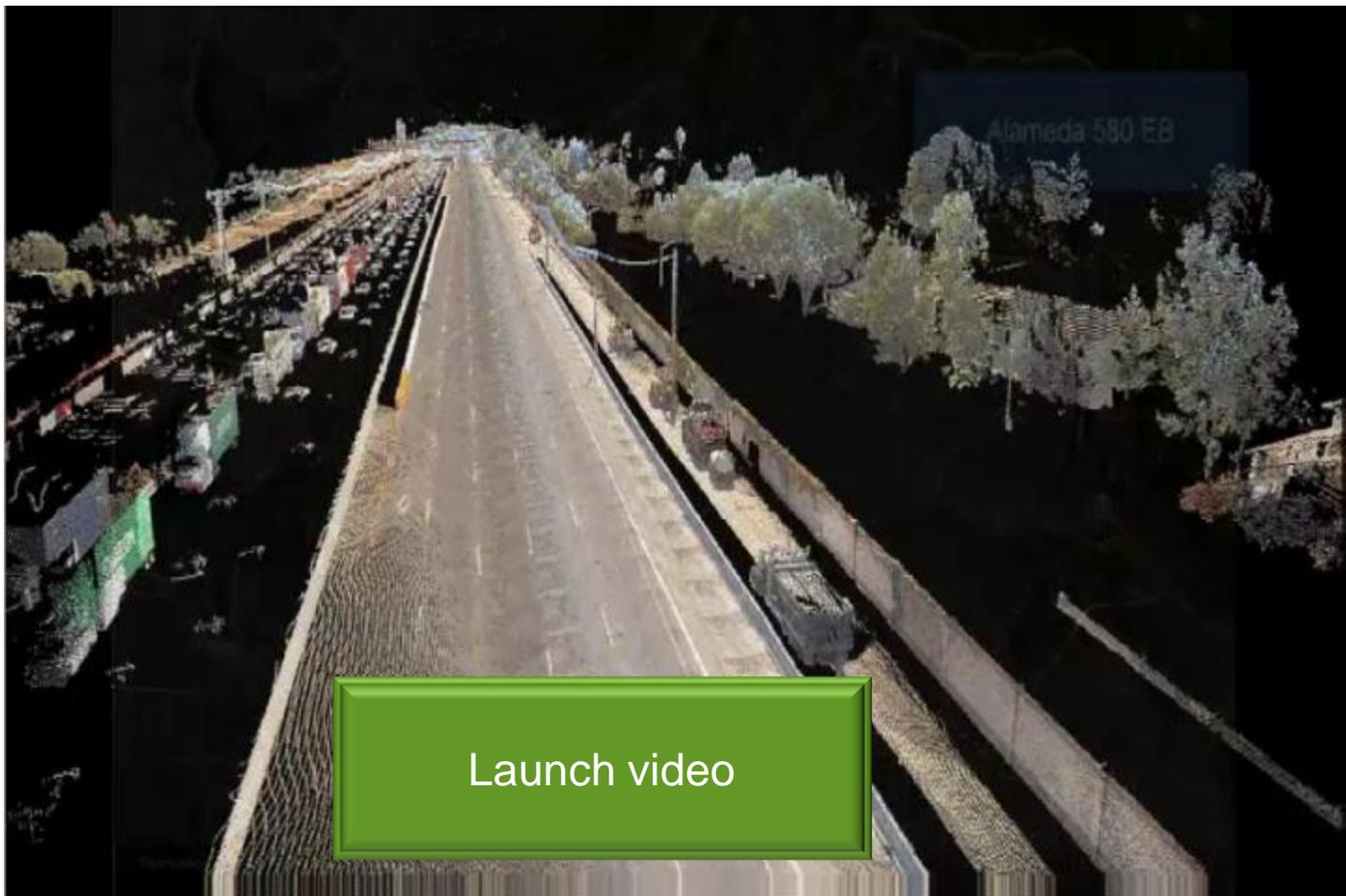
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## Mobile Scanning Freeways for Roadway Sign Project

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

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# Overhead Sign Project Demo



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## 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



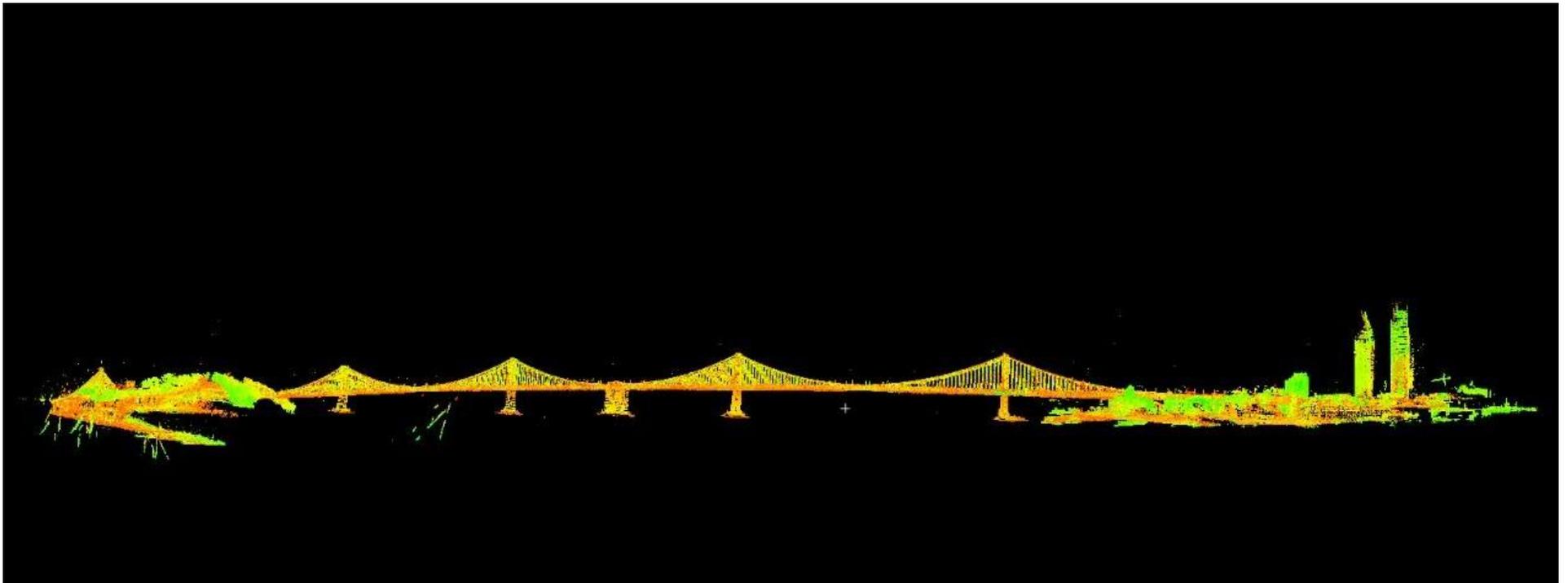
---

## 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 SFOBB



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# 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

Original Concept	New Concept
STLS Scan of the SAS Tower and Deck	Complete Digital As-Built of the SFOBB
<ul style="list-style-type: none"><li>• Post-load transfer condition</li><li>• Deck deformation analysis</li><li>• Whatever else the engineers wanted</li></ul>	<ul style="list-style-type: none"><li>• Stationary scanning from pier caps, decks, and towers</li><li>• Mobile scanning from decks</li><li>• Airborne lidar and digital orthophotos</li></ul>

# Main Cable



---

# Inside the SAS



Image credit: Randy Wigton

# Checking the data



Image credit: Randy Wigton

# NCHRP Report 748: Guidelines for the Use of Mobile LiDAR in Transportation Applications



# Surveyor at Work



Image credit: Randy Wigton

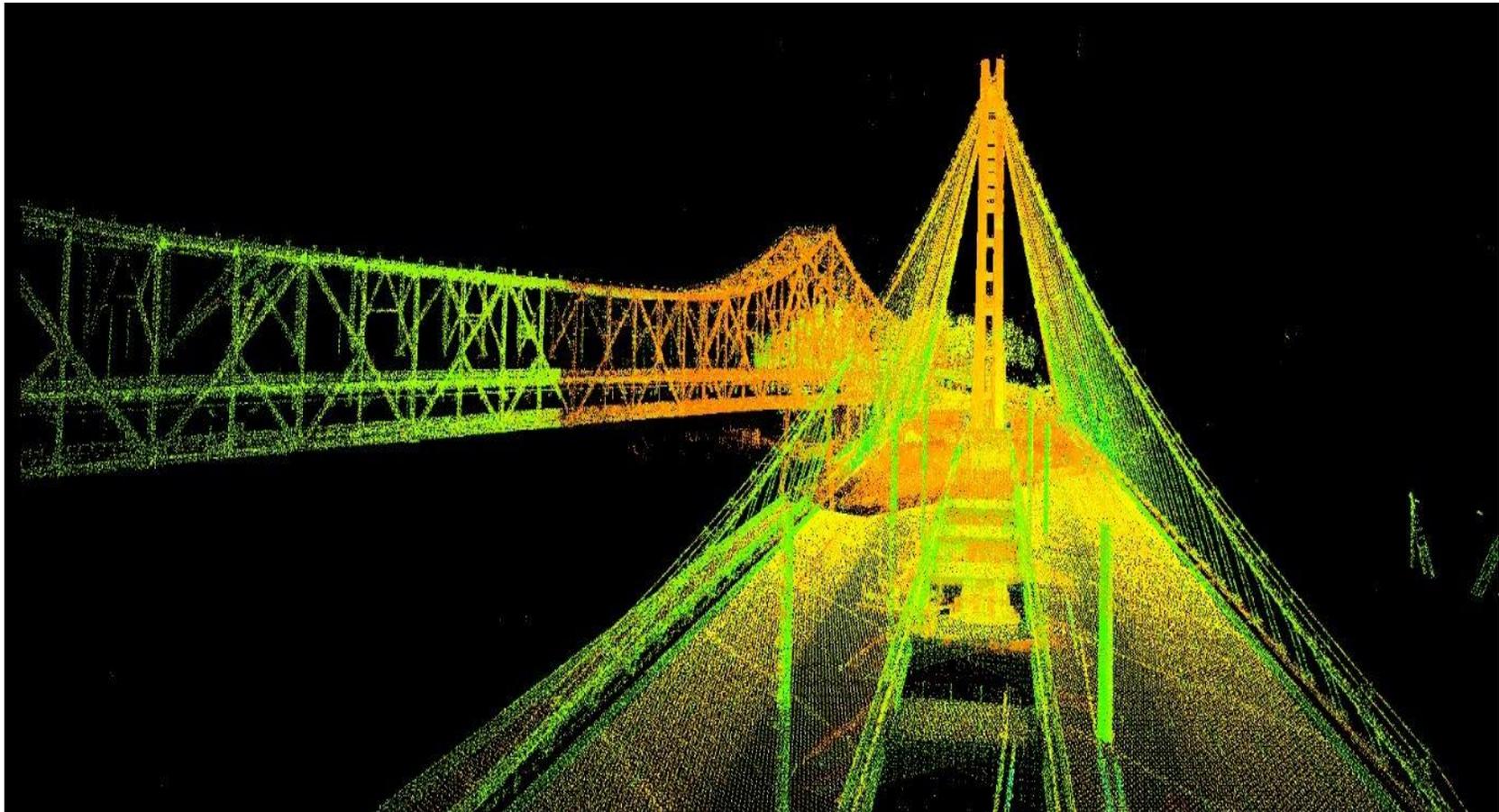
# Staff Accessing a Pier Cap



Image credit: Randy Wigton

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# What does the Data Look Like?



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# Mobile LiDAR Point Cloud



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## LiDAR Data Collected

### Data Volume, Storage, and Backup

- 340 STLS 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

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# Initial Use of the SFOBB Data

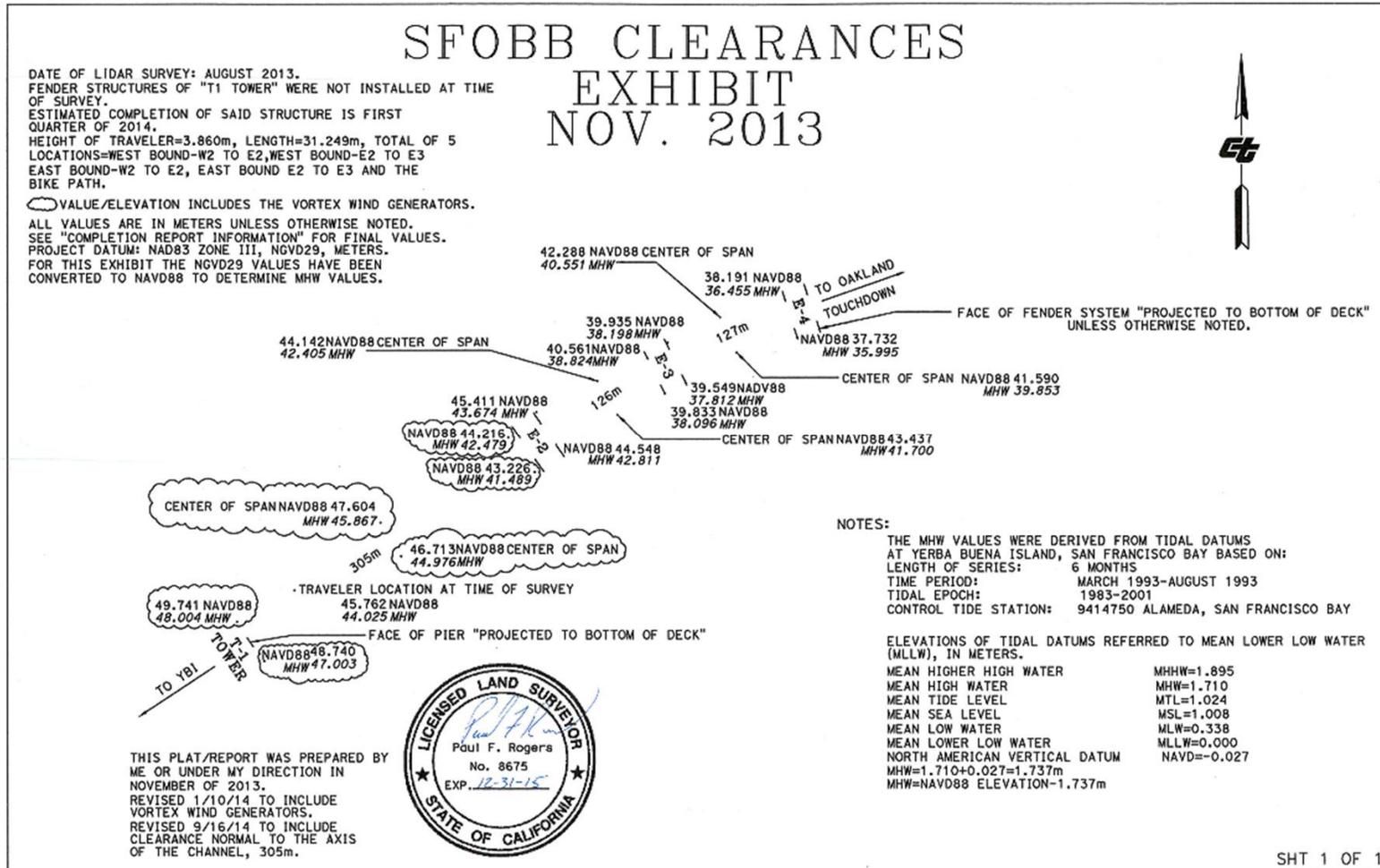
- East Span Shipping Clearances - USCG
- SAS Tower deformation Diagrams
- Vehicle Clearance Envelope Analysis
- Suspender Cable Verticality
- Main Cable Location vs. Plan
- West Span Tower Locations – USCG
- West Span Mid-Span Anchorage data for another project

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# SFOBB East Span Profile

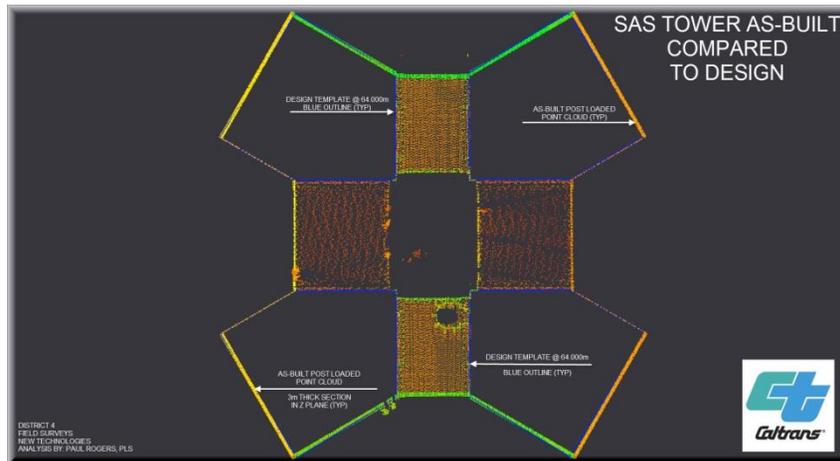


# Final SFOBB East Span Clearance Report

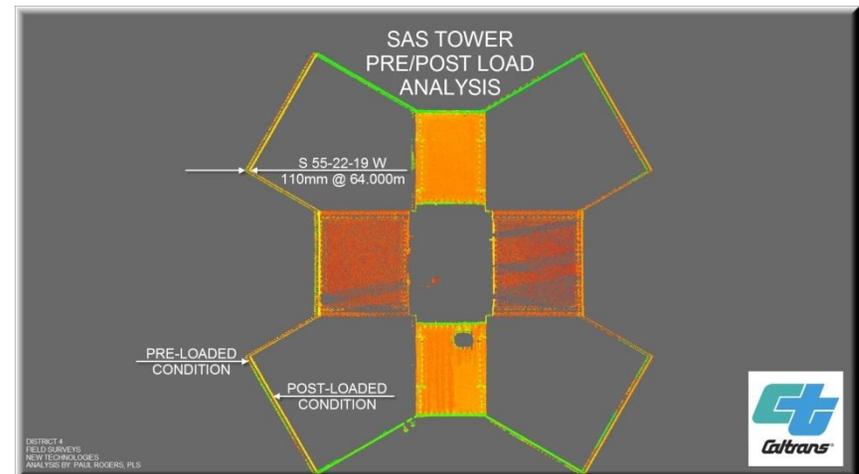


# SFOBB East Span Tower Cross Section Comparisons

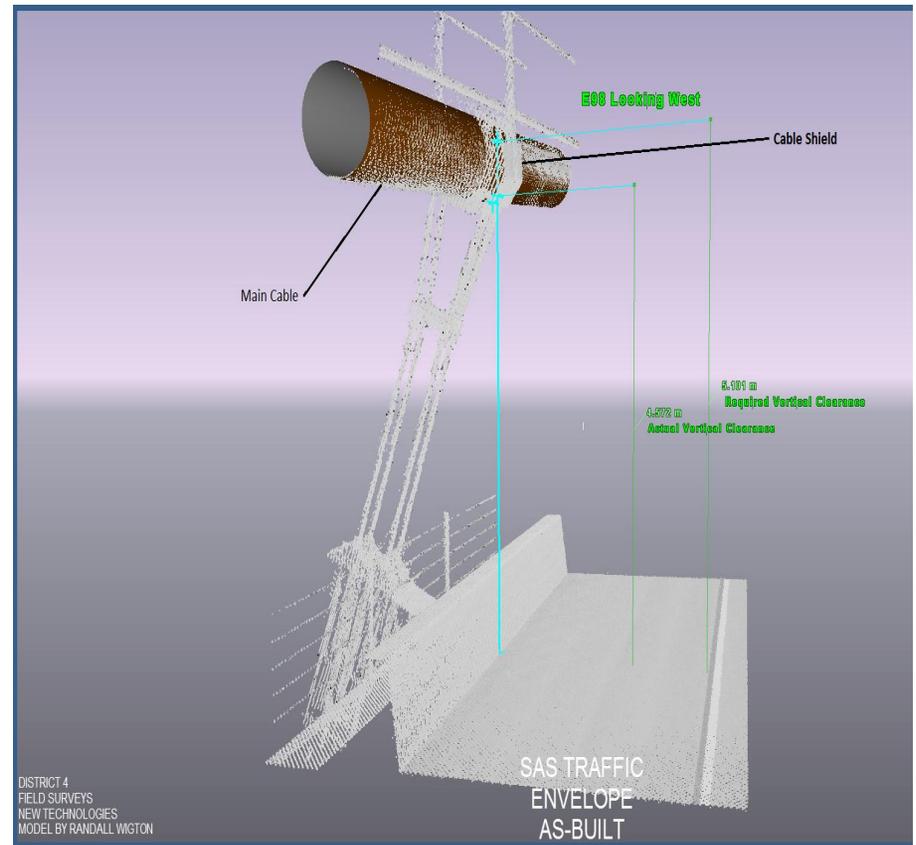
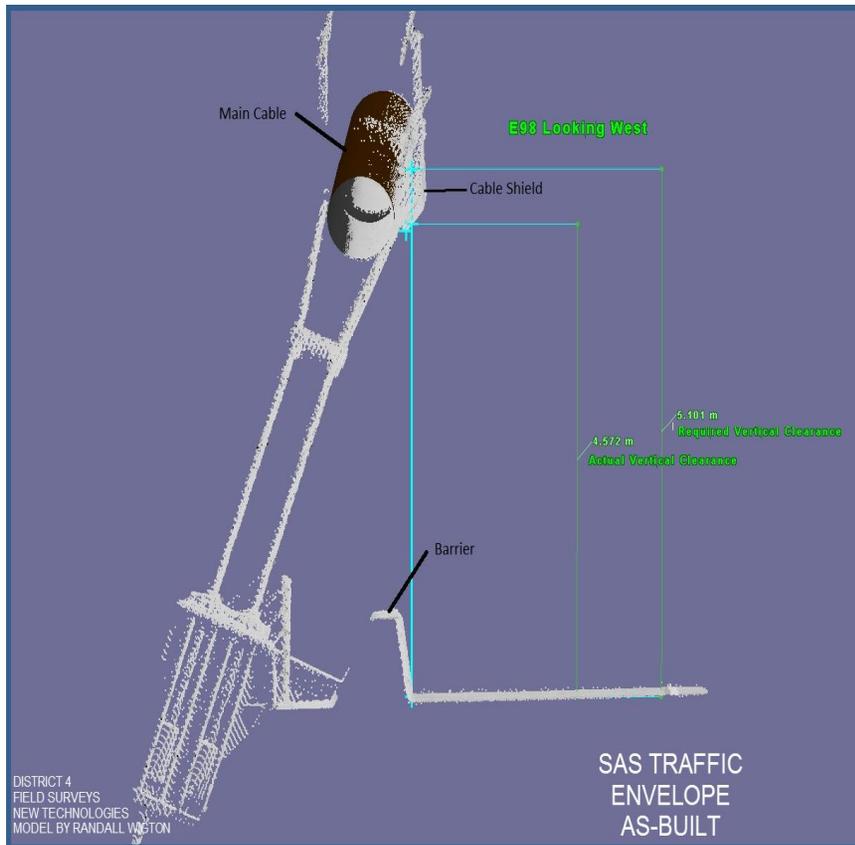
## As-built to Design Comparison



## Pre to Post Load Analysis



# SFOBB As-Built Traffic Envelope



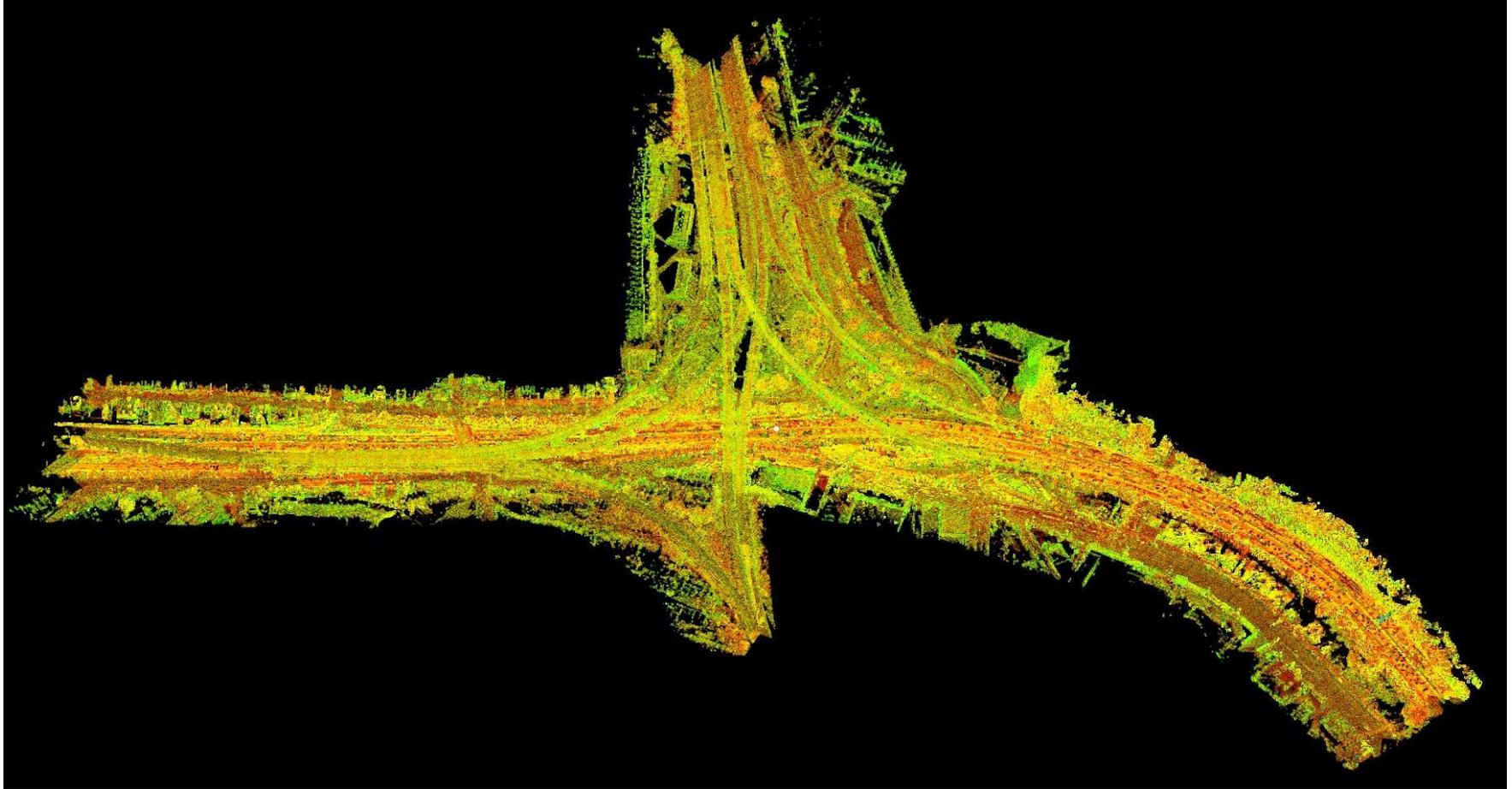
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## What are the possibilities?

- Mining Additional Data per Requests?
- Planning for New Improvements?
- Public Outreach?
- Emergency Response?
- Bridge Management Information System?

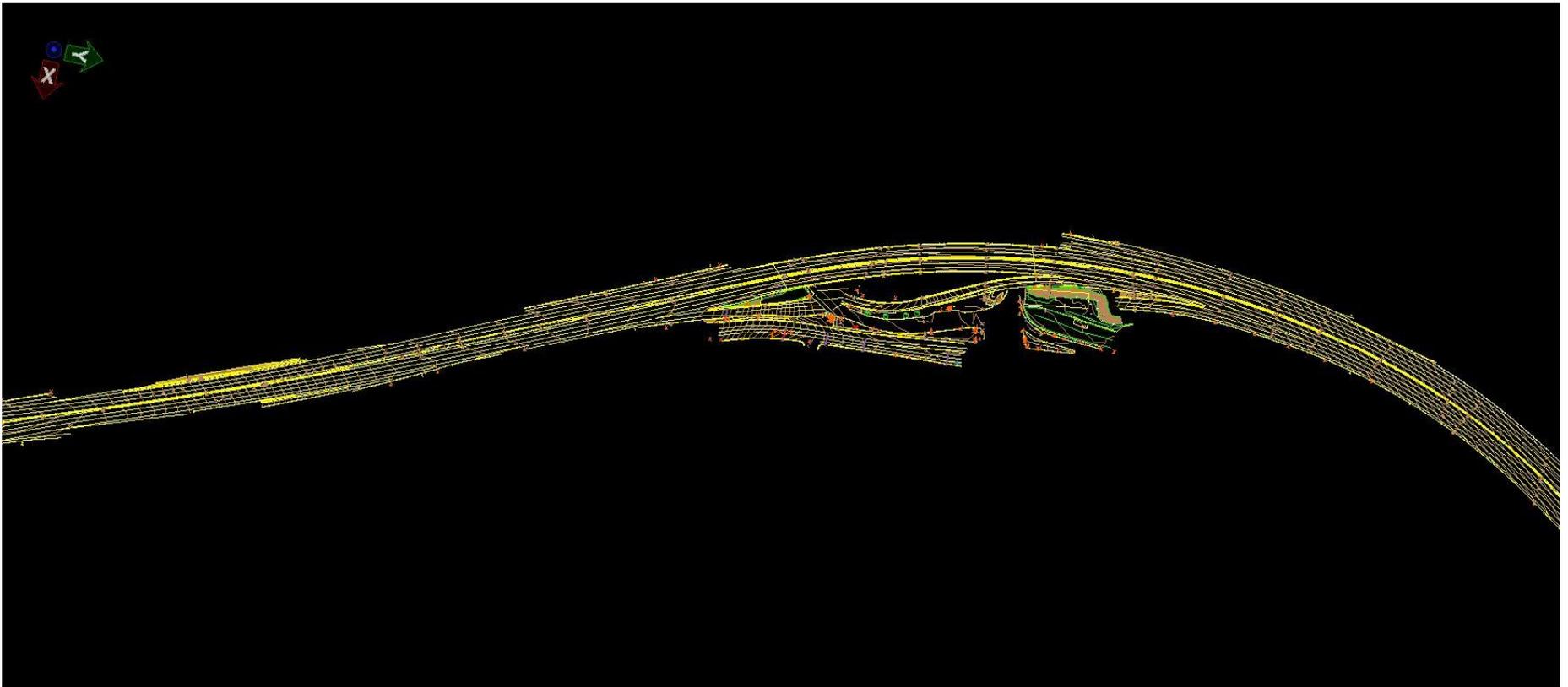
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# Laser Scan of the SF-101/280 IC



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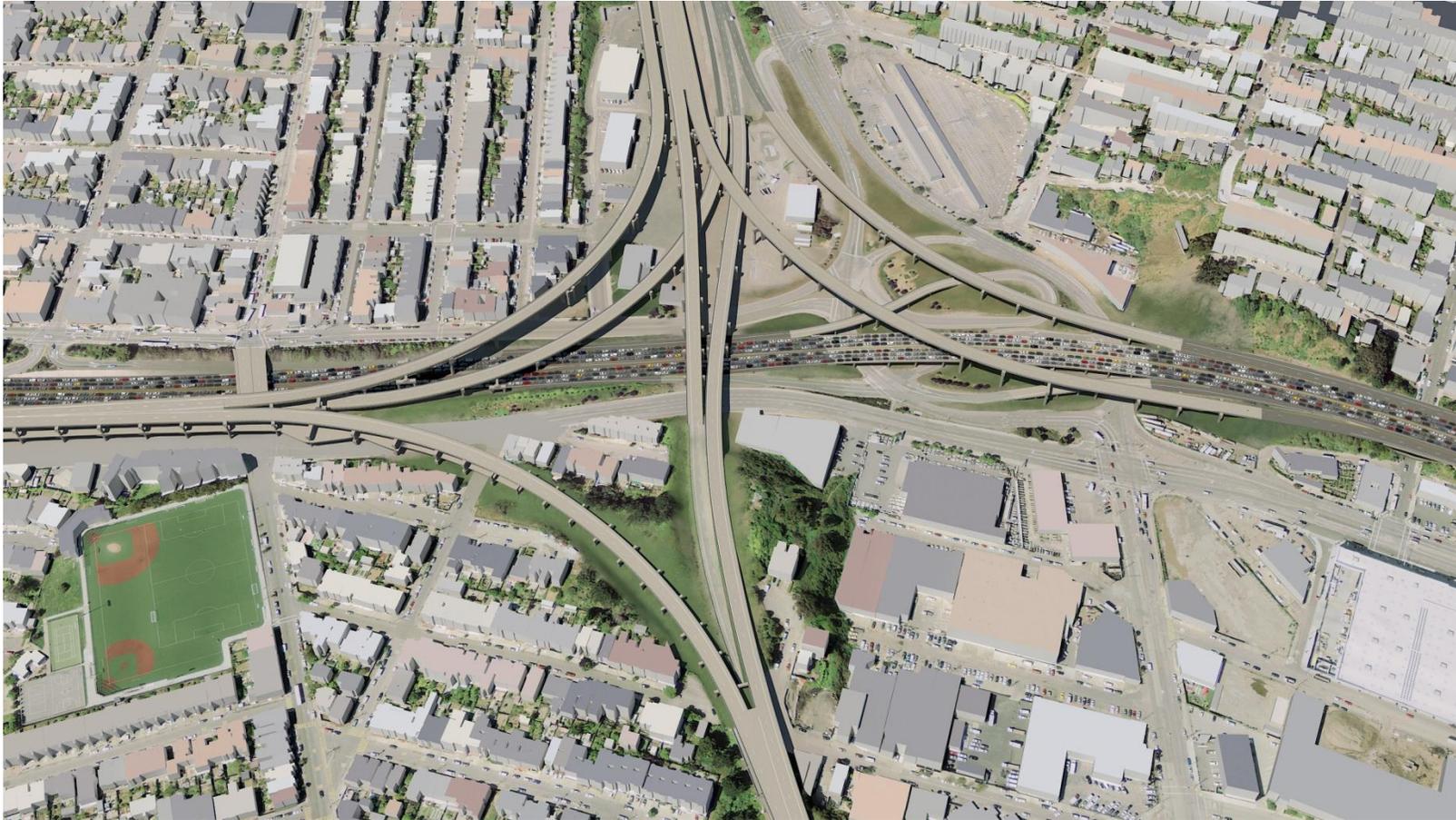
# Partial DTM, SF-101



# Rendered Visualization Model



# Visualization Model with Rendered Traffic



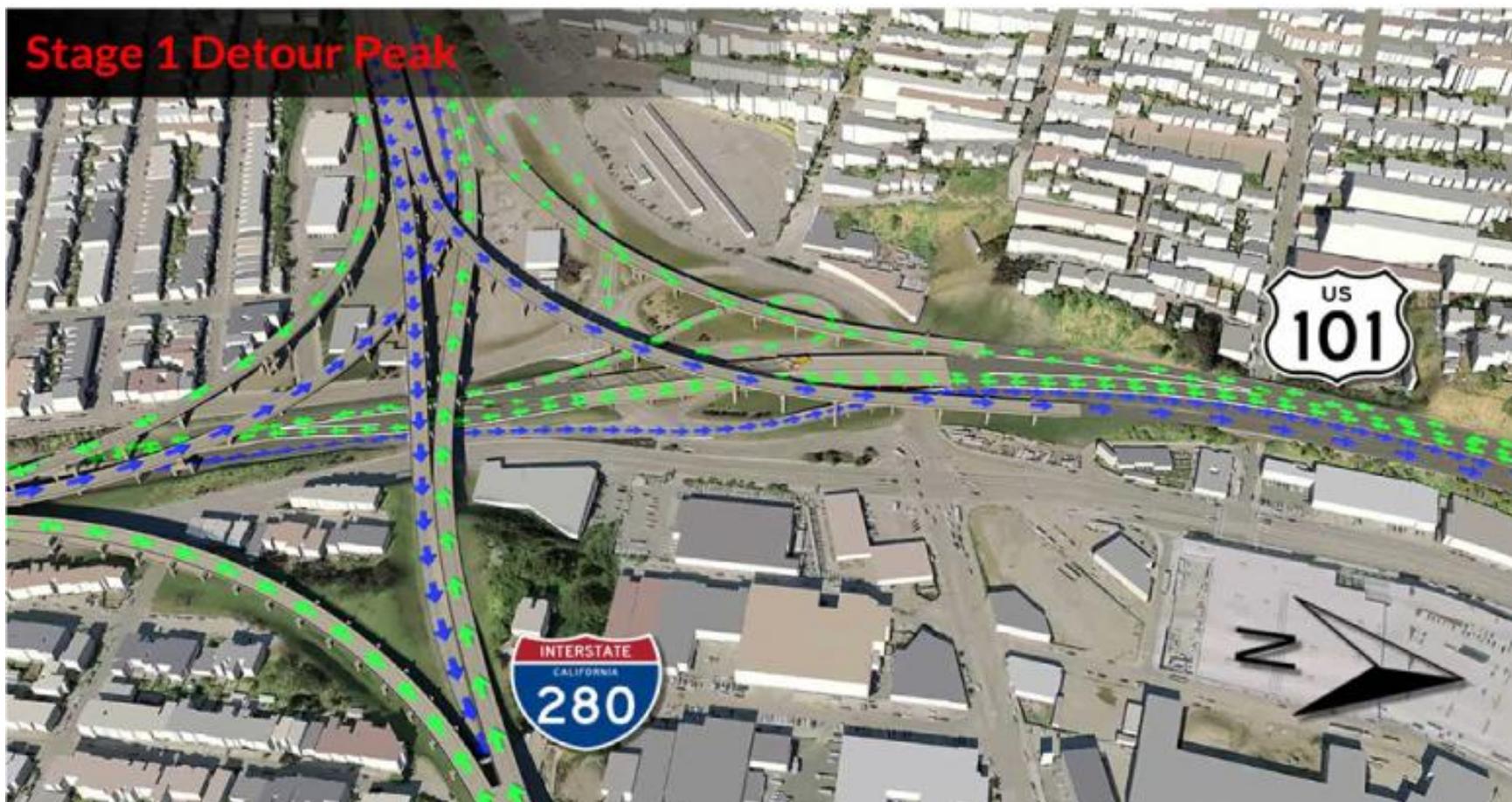
# Visualization Model with Rendered Traffic – Alternative Study



# Temporary Bridge Study



# Arrows Instead of Vehicles



# Final Visualizations Animation



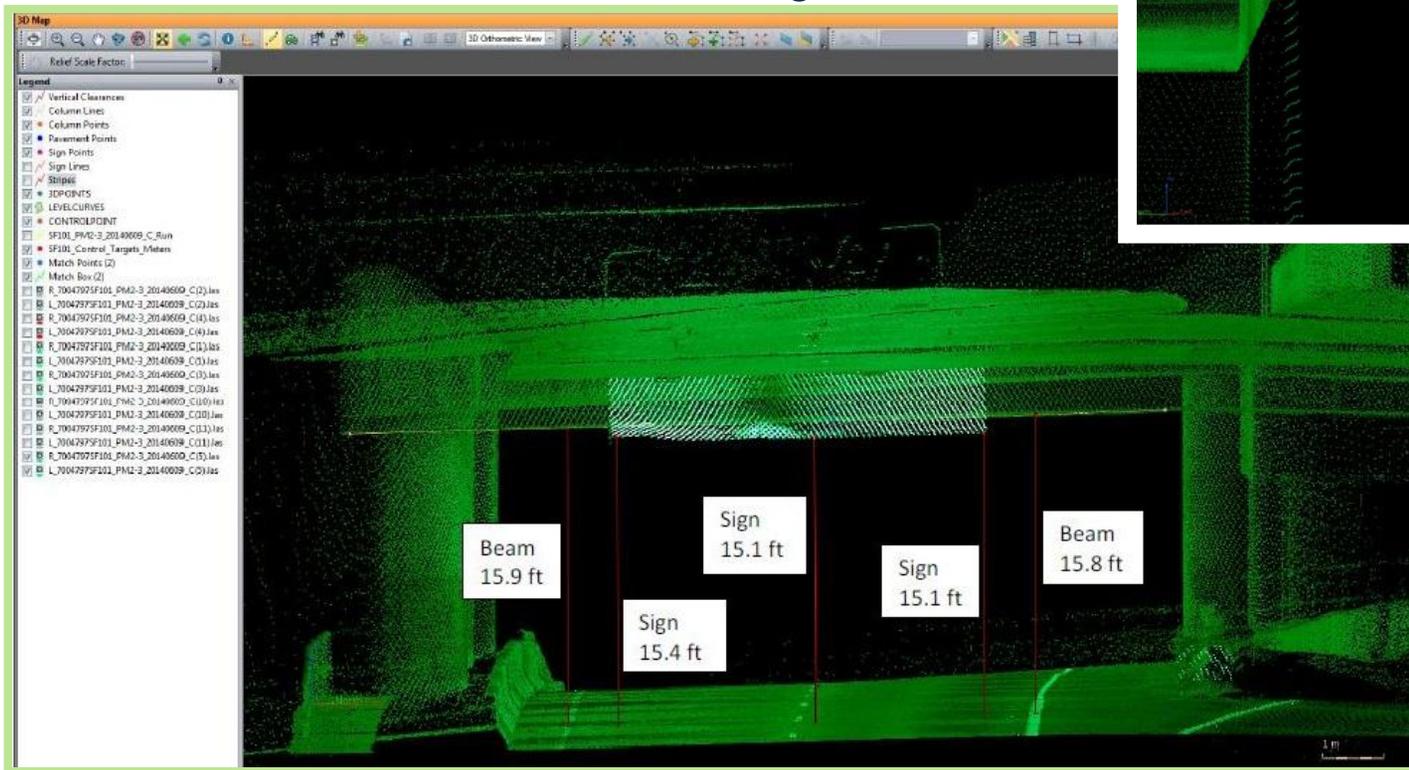
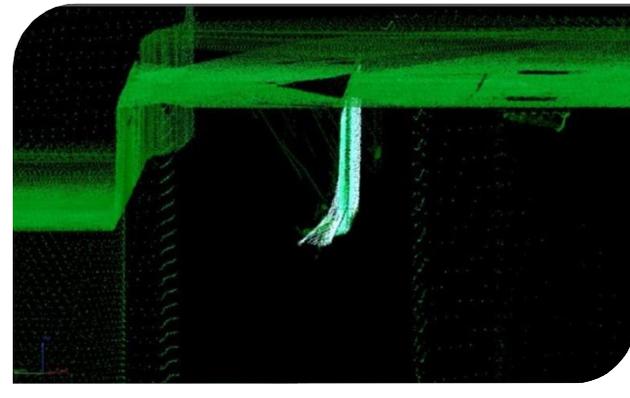
# Final Visualization Animations



# Mining Data for a Claim

Damaged Sign

## Vertical Clearances for Overhead Sign

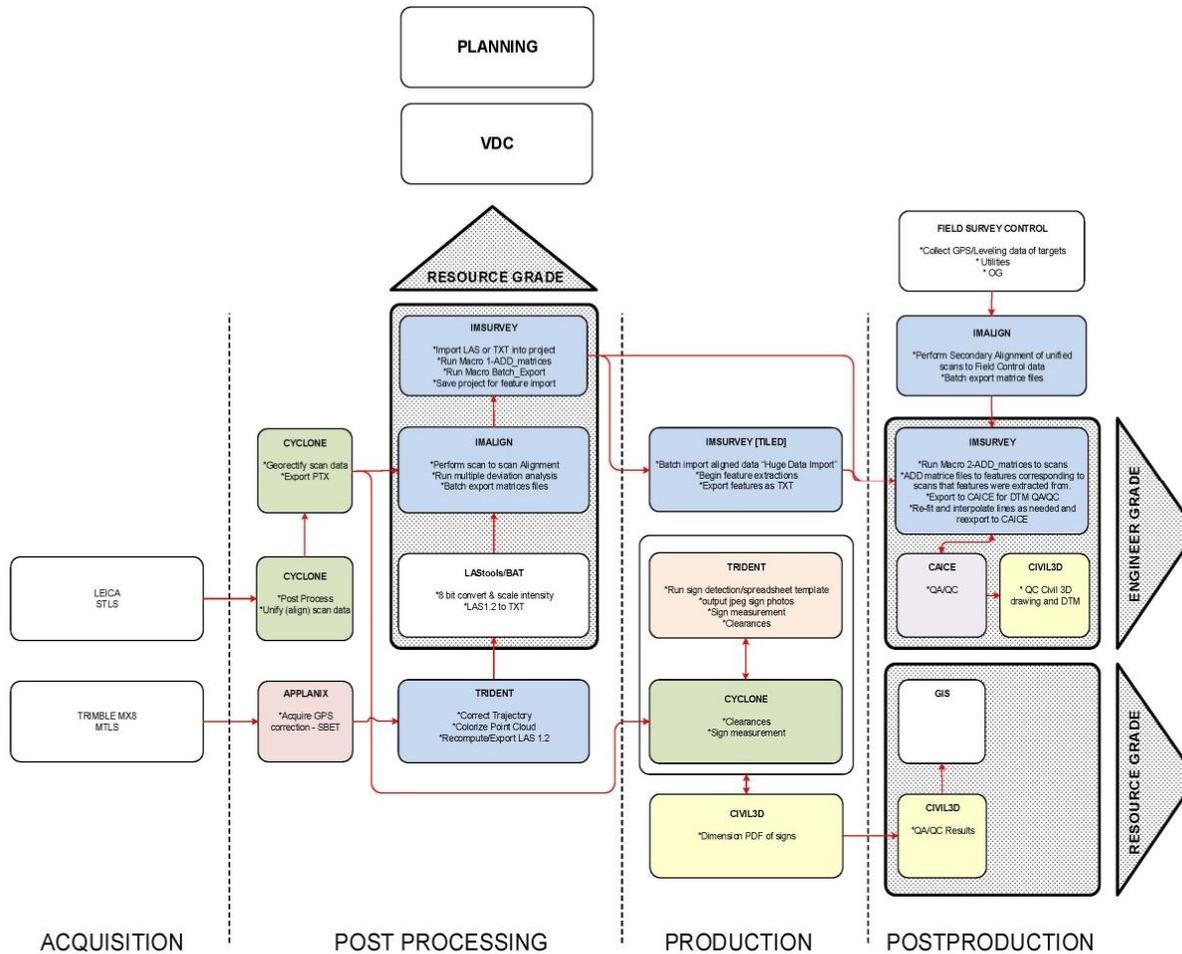


# Where are we going from here?

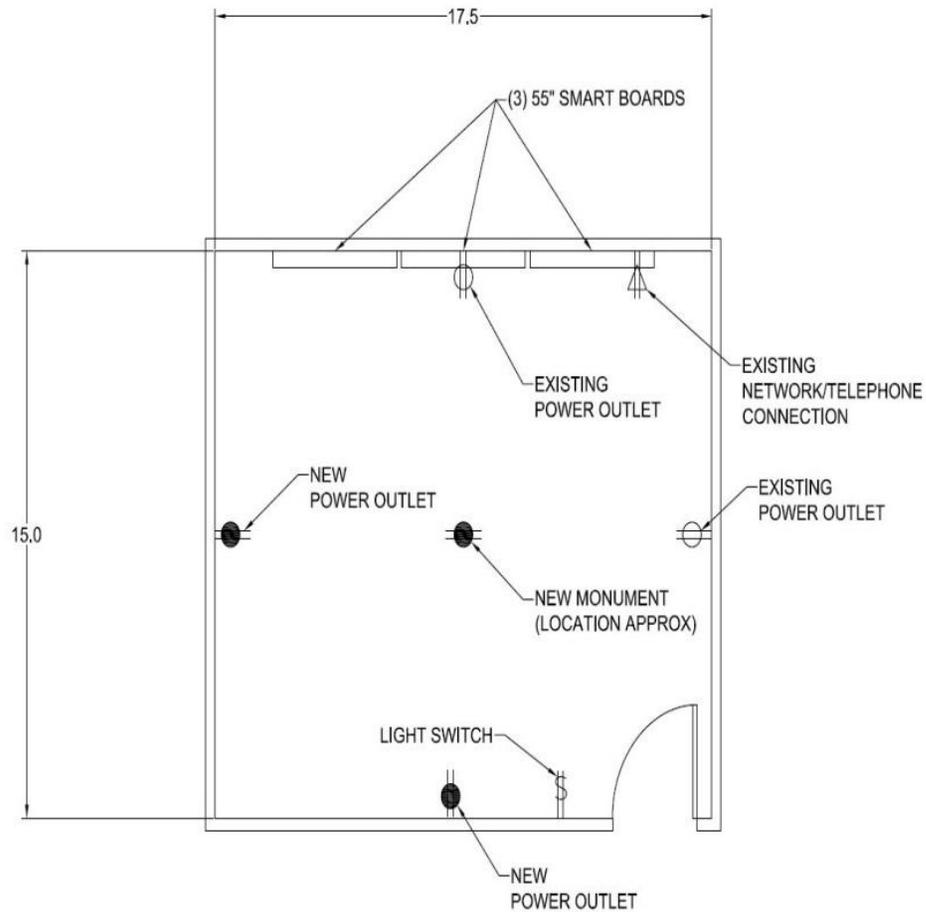
- Evolution of technology for transportation projects
- Moving into the future – Integrated corridor management, Connected or Autonomous vehicles, ...



# New Workflows



# Data Management



I Room Simulation



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## NCHRP Legal Research Digest 58 March 2013: The Legal Aspects of Digital Data

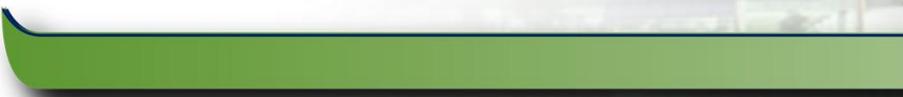
- Copyright Laws
- Ownership of Models
- Protection of Models and Collaborators
- Liability
- Securing Classified Data
- Sharing Digital Data
- 3D Model Issues that may Limit Copyright Protection

---

THANK YOU!



Every Day Counts



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## Poll Group 2

Please respond to the polls on screen.



---

## Learning Outcomes

- 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

---

# Learning Outcomes Polls

Please respond to the polls on screen.



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# Moderated Q&A



## Next Webinar

Registration opens next week

Today	Introduction to 3D, 4D, 5D Schedule, Cost and Post-Construction
Oct 6, 2015	Using 3D Digital Data for Construction Engineering & Inspection
Nov 2015	Creating and Using 3D Models of Highway Structures
Jan 2016	Uses of 4D and 5D Models in Highways
Feb 2016	Getting Started with 4D and 5D Modeling
Mar 2016	Collection and Use of 3D Digital As-built Records
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