3D Model-based Planning-Design-Construction-O&M for Transportation Project Delivery: Structures Perspective

CIM at Wisconsin DOT SE Freeways

Lance Parve, MSEng, PG, CIM SEF Coordinator

SE Freeways Design-Construction
Bio:

Lance Parve, MSEng, P.G.

Mr. Parve works as a Sr. Project Engineer/CIM Coordinator for the WisDOT in SE Freeways. His work involves planning, design, and construction of transportation projects greater than $500 million and also provides CIM-CAD-GIS, 3D technologies, and LiDAR survey coordination and support. Working for WisDOT since 2007 involving public sector work, with 15 years previous involvement in private sector civil and environmental infrastructure work, he has been involved in numerous successful planning, design, and construction mega-major transportation projects at WisDOT. He has a MS Engineering degree, MS Certificate Urban Planning GIS degree, and a BS Geological Sciences degree from the UW-Milwaukee. Additionally, he serves as Co-chairperson of the CIM-VDC Subcommittee of the National Academy of Sciences Transportation Research Board (TRB) ABJ95 Visualization in Transportation Committee.

Contact: lance.parve@dot.wi.gov
Phone: 414-750-1330 / 414-731-5375
WisDOT Transportation Infrastructure Design

Moving from 2D to Robust 3D Models
Design & Construction Best Practice Workflows: WisDOT SE Freeways

Where we are going

Where we are

2D CAD Models
- Object Features
- Objects Not Intelligent
- No 3D TIN-DTM Surfaces
- Geospatial
- Multi Disciplinary 2D
- Project-based

3D CAD Models
- Object Features
- Objects Not Intelligent
- 3D TIN-DTM Surfaces
- Geospatial
- Multi Disciplinary 3D
- Project-based

3D CIM Collaboration Models
- Intelligent Subassembly Features
- Collaborative 3D CIM Databases
- 3D TIN-DTM-3D Face Surfaces
- Geospatial
- Collaborative Multi Disciplinary 3D
- Project-based

3D CIM Integrated Collaboration Models
- Intelligent Subassembly Features
- Integrated 2D-3D-4D-5D-xD CIM Databases
- 3D TIN-DTM-3D Face Surfaces
- Geospatial
- Integrated Collaboration Multi Disciplinary 3D
- Life-cycle-based

ISOLATED

COLLABORATIVE

INTEGRATED

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Strategic Planning for WisDOT SE Freeways

“plans are useless but planning is essential”

- Strategic Goals: Organizational Clarity, Common Shared Vision, Model the Way, Align Objectives, Pull Together, Build Trust, Inspire Passion, Challenge the Process, Enable Others to Act
- Core Goals: Mobility, Accountability, Preservation, Safety, & Service
Road & Bridge Design Best Practice Workflows: WisDOT SE Freeways

- Key findings/Best practices for Transportation Infrastructure
  - People/Workforce + Organization/Process + Tools/Technologies = Success
  - Cost Benefits Analysis/Return on Investment Focus = $, Time, & Quality
  - PS&E 3D Model-based Digital Project Delivery = New Workflows
Road & Bridge Design Best Practice Workflows: WisDOT SE Freeways

- Key findings/Best practices for Transportation Infrastructure
  - Have Organizational Strategic Plan for 3D Technologies Implementation
  - Manage Change for Disruption to Current/Future Workflows/Dataflows
  - Use Best Available Tools & Technologies to Achieve Business Goals
Key findings/Best practices for Transportation Infrastructure

- Management Buy-in with Support for Innovation & Funding of 3T’s (ITEC, IT2, DM, BOS, S&M, 3D, Innovation Committees)
- Reduce Org “Silos of Excellence” Bottlenecks/Poor Workflows/Dataflows
- Encourage Collaboration Between Agencies/Bureaus/Regions/Bus Units
Road & Bridge Design Best Practice Workflows: WisDOT SE Freeways

**Where we are**

- **2D CAD Models**
  - Benefits/Advantages:
    - Automate drafting/standards
    - Draw efficiently/accurately
    - Layout scale model-paper space
    - Layout dimensions/text/notes
    - Visualize/view drawing
    - Layers/attributes/properties
    - Vector & raster/custom libraries
    - Modify/revise to reduce updates
    - Link CAE/CAD tools to CADD
    - E-construction stakeout
    - Organize/access project data

- **3D CAD Models**
  - Benefits/Advantages:
    - Modify, reuse, & revise in 3D to reduce updates
    - 3D geospatial & rapid prototyping shop drawings
    - 3D visualizations using walk/drive-through simulations/animations
    - GPS stakeout/3D QA-QC
    - Subgrade grading/string-less paving using AMG up to 30% savings

- **3D CIM Collaboration Models**
  - Benefits/Advantages:
    - Multi-disciplinary collaboration
    - Identify/reduce issues earlier by clash detection/resolution
    - Reduce redesign, rework, DINs, & CCOs cost savings/avoidance opportunities up to 25%
    - Staged-temporary construction
    - Constructability analysis
    - Optimize/visualize design-construction with VDC-CIM
    - Link 3D to 4D & 5D/BOM

- **3D CIM Integrated Collaboration Models**
  - Benefits/Advantages:
    - Multi-disciplinary collaboration
    - Clash detection/resolution to eliminate issues to reduce redesign, DINs & CCOs
    - Database lifecycle mgmt for O & M with data warehousing
    - PLM link to PDM/CRM/BPM/ERP
    - Process/workflows management
    - Enterprise LAN + WAN & cloud
    - E-design/e-construction use of 3D models/tools with mobile devices

**Where we are going**

**ISOLATED**

**COLLABORATIVE**

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AB95-VISUALIZATION IN TRANSPORTATION COMMITTEE
TRB 94TH ANNUAL MEETING, JANUARY 2015, WASHINGTON, DC
Road & Bridge Design Best Practice Workflows: WisDOT SE Freeways

3D Technologies Implementation Plan-2014 Roadmap

- PS&E + 3D Model Production
- Design Review
- Multi-disciplinary Collaboration
- Visualization/Augmented Reality
- Simulation & Analysis
- Constructability Analysis
- 4D Schedules/Staging
- 5D Costs
- E-Specifications
- Virtual Clash Detection
- Design LiDAR-Integrated Surveys
- 3D CAD SDDs
- Geotech & Soil Borings
- Public Information
- Cloud DPD/DDE

- 3D Models - AMG/AMC Earthworks & Stringless Asphalt/Concrete Paving
- Construction Review
- Design-Construction-Contractor Collaboration
- Field Image Capture/Visualization
- Utility Inspection
- SPAR/GPR
- Field Clash Detection
- Construction LiDAR-Integrated Surveys
- Bluebeam vs Adobe Pro As-builts
- O & M Lifecycle
- Asset Management
- Cloud DPD/DDE
- Mobile Devices-Tablet PCs
- E-Construction
CIM 3D Modeling: Zoo Interchange
Construction: 2012-2018

- 9 miles of freeway + RRs
- 6 service interchanges
  - North Avenue
  - Watertown Plank Road
  - Bluemound Road
  - 84th Street
  - Greenfield Avenue
  - STH 100
- Major Arterial Roadways
  - STH 100/Mayfair Road
  - Watertown Plank Road
  - Swan Boulevard
  - Glenview Avenue
  - Greenfield Avenue
CIM 3D Modeling: Zoo Interchange
Construction: 2012-2018

- $1.7 b reconstruction of Zoo IC-Corridor
- Handles almost 350,000 avg. vehicles per day in traffic
- Over 15 miles of construction including arterials
- Construction involves 68 bridges including 6 RR structures, 1 system/7 service interchanges, 108 retaining walls, 15 noise walls, 2 box culverts, 115 sign structures & numerous utilities
- Temp. roads/structures to accommodate 2 lanes of traffic during construction
- 3D CIM for all disciplines is deployed throughout Zoo IC Design-Construction
CIM 3D Modeling: Zoo Interchange Construction: 2012-2018

CBA/ROI involving Contract Change Order Issues (to date):

Zoo IC Construction Project- $446.5 m of 1.7 b total (Complete in 2018 as of 03/31/15)
STH 100, Glenview Ave, WTP Rd, Swan Blvd, STH 100/UP RR Bridges, Greenfield Ave, 76th St Bridge, 84th St, Temp Salt Shed, Traffic Mitigation, Advanced Signing, & Int Corridors, Core 1
Field Issues - $12.6 m or 3.0% (1141 DINs/CCOs – avg $7,400) with $4.2m Balancing/Equalizing Mods
Plan Inadequacy Issues - $3.10 m (146 DINs/CCOs – avg $21,200)

- RD-Roadway/Drainage: 34.0% (196-$4.40 m) ($22,300 per issue)
- GN-General: 24.0% (224-$3.10 m) ($13,600 per issue)
- EW-Earthwork: 10.8% (57-$1.40 m) ($24,500 per issue)
- BR-Bridges: 10.8% (89-$1.40 m) ($15,700 per issue)
- WU-Wet Utilities/Drainage: 8.5% (182-$1.10 m) ($5,900 per issue)
- EL-Electrical/ITS/FTMS: 4.8% (131-$0.624 m) ($4,800 per issue)
- TR-Traffic: 4.2% (93-$0.543 m) ($5,800 per issue)
- RW-Retaining Wall: 1.2% (28-$0.152 m) ($5,400 per issue)
- NW-Noise Wall: 0.8% (5-$0.105 m) ($21,000 per issue)
- SS-Sign Structures: 0.6% (16-$0.077 m) ($4,800 per issue)
- SA-Safety: 0.6% (6-$0.073 m) ($12,200 per issue)
- LD-Landscaping: 0.2% (7-$0.026 m) ($3,800 per issue)
- O-Other/Demo: 0.1% (4-$0.017 m) ($4,300 per issue)
- Overrun-Underuns/Balancing-Equalizing Mods: 33.3% (108-$4.20 m) ($39,300 per issue)
C3D Technologies/3D Modeling Costs involving Zoo IC (to date):

Zoo IC Construction Project- $1.7 b total (% - Complete in 2018)

- LiDAR and Integrated Survey – Pre-Design Data Collection:
- CIM PXP:
- 3D Modeling - Roads:
- 3D Modeling - Structures:
- 3D Modeling - Utilities:
- 3D Modeling - Traffic:
- 3D Modeling - PI:
- 3D Modeling - Other:
- 3D Modeling QA/QC:
- 3D Modeling e-Construction/3D Rovers (CEC):
- LiDAR and Integrated Survey – Post-Design Data Collection:
- As-built 3D Modeling:
- 3D Modeling Tools
- O-Other:
CIM 3D Modeling: I-94 Mitchell Interchange
Construction: 2011-2012

- $294.4m reconstruction of Mitchell IC – part of the 39-mile $1.9 b I-94 N-S construction
- Handles over 195,000 avg. vehicles per day
- Mitchell IC is over 10 miles of construction
- Construction involves 3 tunnels, 13 bridges, 1 system/4 service interchanges (including Airport Spur), 29 retaining walls, 7 noise walls, 4 box culverts, 54 sign structures & numerous utilities
- Temp. roads/structures to accommodate 2 lanes of traffic during construction
CIM 3D Modeling: I-94 Mitchell Interchange
Construction: 2011-2012

CBA/ROI involving Contract Change Order Issues:

I-94 Mitchell IC Construction Project-$294.4 m
Mitchell IC, CD Road, 27th St, Airport Spur, College/Grange Aves
Field Issues - $22.2 m or 7.5% (651 of 669 DINs/CCOs) (avg - $33,180)
• GN-General: 30.5% (148-$6.8 m) ($45,674 per issue)
• RD-Roadway/Drainage: 25.5% (66-$5.7 m) ($85,631 per issue)
• WU-Wet Utilities/Drainage: 11.1% (90-$2.4 m) ($27,120 per issue)
• BR-Bridges: 8.0% (114-$1.8 m) ($15,557 per issue)
• NW-Noise Wall: 8.0% (14-$1.8 m) ($125,909 per issue)
• RW-Retaining Wall: 7.7% (78-$1.7 m) ($21,818 per issue)
• EW-Earthwork: 4.5% (17-$1.0 m) ($59,220 per issue)
• EL-Electrical/ITS/FTMS: 2.6% (93-$0.6 m) ($15,557 per issue)
• TR-Traffic: 2.1% (26-$0.5 m) ($18,174 per issue)
• SS-Sign Structures: 0.1% (23-$0.02 m) ($738 per issue)
CIM 3D Modeling: I-94 Mitchell Interchange
Construction: 2011-2012

CBA/ROI involving Contract Change Order Issues:

I-94 Mitchell IC Construction Project-$294.4 m
Field Issues - $22.2 m or 7.5% (651 of 669 DINs/CCOs)
• Plan Requests RFIs (Plan Submittals, Plan Omissions, Plan Conflicts, Shop Drawings, Calculation Sheets, Additional Info): 42.1% (274 issues)
• Construction Changes (CRI Submittals, Non-conforming Items, Facilitation): 32.4% (211 issues)
• Design Issues (Plan Inadequacies, Quantity Calculations, Premium Costs): 16.1% (105 issues)
• Differing Site Conditions (Soil Conditions, Utility Mislocations, etc.): 9.4% (61 issues)
• Withdrawn: 2.7% (18 Issues)
• Interdisciplinary Conflicts VDC-BIM-CIM Opportunities: 6.9% (45 issues)
CIM Applications:
- 3D Structures Modeling (WisDOT BOS) for SE Freeways

Tool(s) Used/Workflows:
- Bentley LEAP Enterprise Suite–Standard Bridge Structures
- In-house Program–Standard Bridge Structures
- Other–Specialty Bridge Structures
- Bentley Microstation with In-roads–Retaining Walls
- Bentley Microstation with In-roads–Sign Structures
- Bentley Microstation with In-roads–Other

Benefits:
- Structures Design

Challenges:
- Interoperability
Infrastructure Workflows & Tools: SE Freeways Zoo IC Structures (F45)

CIM Applications:
- 3D Structures Modeling (F45-HNTB, CH2MHiLL, K&A, etc.) for SE Freeways

Tool(s) Used/Workflows:
- Bentley LEAP Enterprise Suite—Standard Bridge Structures
- Bentley LEAP Enterprise Suite with Microstation—Specialty Bridge Structures
- Bentley Microstation with In-roads—Retaining Walls
- Bentley Microstation with In-roads—Sign Structures
- Bentley Microstation with In-roads—Other

Benefits:
- Structures Design

Challenges:
- Interoperability
CIM Applications:
- 3D Structures (F45-HNTB, CH2M Hill, K&A, etc.) for SE Freeways
- Standard Bridge Structures

Tool(s) Used/Workflows:
- Majority are pre-stressed girder, <20° skew, on multi-column piers
- LEAP-Conspan (Superstructure)
- LEAP-RC Pier (Substructure)

Benefits:
- Structures Design (Standard Bridges)
- Structural Analysis

Challenges:
- Interoperability
CIM Applications:
- 3D Structures (F45-HNTB, CH2MILL, K&A, etc.) for SE Freeways
- Specialty Bridge Structures

Tool(s) Used/Workflows:
- Curved Steel Box Girders—(Superstructure)
- MDX + Excel with Macros—Preliminary Design, Load Rating
- LARSA—Final Analysis
  Secondary Member Design, Constructability Review, Deflections during Construction
- Excel with Macros—Final Design (Code Check)
  Secondary Members, Splices, Cambers, Screeds

Benefits:
- Structures Design (Specialty Bridges)
- Structural Analysis

Challenges:
- Interoperability
Infrastructure Workflows & Tools: SE Freeways Zoo IC Structures (F45)

CIM Applications:
- 3D Structures (F45-HNTB, CH2M Hill, K&A, etc.) for SE Freeways
- Specialty Bridge Structures

Tool(s) Used/Workflows:
- Curved Steel Box Girders–Substructure
- Hammerhead Piers on Drilled Shafts (Pile Footing Option)
- LARSA–Global Stiffness Analysis
- FB Multiplier + Excel + In-house Program–Pier Drilled Shaft Design
- Excel–Pier Pile Footing Design
- Mathcad + Excel + In-house Program–Hammerhead Pier Cap & Column

Benefits:
- Structures Design (Specialty Bridges)
- Structural Analysis

Challenges:
- Interoperability
Infrastructure Workflows & Tools: SE Freeways Zoo IC Structures (F45)

CIM Applications:
- 3D Structures (F45-HNTB, CH2MHill, K&A, etc.) for SE Freeways
- Specialty Bridge Structures

Tool(s) Used/Workflows:
- Railroad Bridge Structures, Deck Girder, Through-plate Girder
- Mathcad + Excel–Superstructure
- FB Multiplier–Substructure (Coordination between Structures/Geotech)

Benefits:
- Structures Design (Specialty Bridges)
- Structural Analysis

Challenges:
- Interoperability
Infrastructure Workflows & Tools: SE Freeways Zoo IC Structures (F45)

CIM Applications:
- 3D Structures (F45-HNTB, CH2MHiLL, K&A, etc.) for SE Freeways
- Specialty Retaining Wall Structures (Geotech Design)

Tool(s) Used/Workflows:
- Cut (Soldier Pile & Lagging, Secant Pile) Walls
- PY wall, Deep Ex (at times with Site-specific P-Y Curves)
- Slide, Excel–External Stability Check

Benefits:
- Structures (Geotech) Design
- Structural/Geotech Analysis

Challenges:
- Interoperability
Infrastructure Workflows & Tools: SE Freeways Zoo IC Structures (F45)

CIM Applications:
- 3D Structures (F45-HNTB, CH2MHiIl, K&A, etc.) for SE Freeways
- Sign Structures

Tool(s) Used/Workflows:
- SAP, Excel, Mathcad–Superstructure
- Per WisDOT standards (Geotech verify)–Substructure

Benefits:
- Structures Design
- Structural Analysis

Challenges:
- Interoperability
Infrastructure Workflows & Tools: SE Freeways Zoo IC Structures (F45)

CIM Applications:
- 3D Structures (F45-HNTB, CH2MHiill, K&A, etc.) for SE Freeways
- Standard Retaining Wall Structures (Geotech Design)

Tool(s) Used/Workflows:
- Fill (MSE) Walls (Proprietary)
- Settle 3D, Plaxis–Settlement Check
- Slide, Excel–External Stability Check
- Bentley Microstation

Benefits:
- Structures (Geotech) Design
- Structural/Geotech Analysis

Challenges:
- Interoperability
CIM Applications:
   - 3D Geotech (WisDOT & F45-HNTB, CH2M Hill, K&A, etc.) for SE Freeways

Tool(s) Used/Workflows:
   - Bentley gINT for Soil Borings
   - Keynetix/Autodesk Geotech (Pilot)

Benefits:
   - Geotech

Challenges:
   - Interoperability
Automated Infrastructure Planning: SE Freeways Project Prioritization & Sequencing

55+ miles designed and/or constructed with 218 miles of 273 total miles to be prioritized and sequenced involving freeways in southeast Wisconsin.

SE Freeways Study Segments

[Map of SE Freeways study segments with various numbered segments depicted with red lines, indicating prioritization and sequencing.]
Automated Infrastructure Planning: SE Freeways Project Prioritization & Sequencing

CIM Applications:
- Decision Matrix for SE Freeways Planning, Prioritizing, & Sequencing Projects
- Web-based SE Freeways Intranet/Extranet GIS Data Warehouse

Tool(s) Used:
- ESRI ArcGIS (7-County 2D File GeoDB GIS Data Warehouse)
- Autodesk C3D (7-County Project Data 3D to 2D)
- Decision Lens (MS Excel Import-Export to-from GIS)

Benefits:
- Strategic Capital Finance Planning, Resource Allocating, & Asset Management Planning
- Customizable Analytical Hierarchical Decision Matrix Weighting of Criteria Fields

Challenges:
- Data Warehousing of Large 7 County Datasets
- Web-based Access of Collaborative SE Freeways GIS DB - Intranet and/or Extranet
CIM 3D Modeling: Zoo Interchange
Design-grade Survey

3D Survey Integrated Mapping using LiDAR-Static/Mobile/Aerial Scanning with Supplemental RTK GPS/Digital Leveling/TS/UAV Existing Conditions
CIM 3D Modeling: Zoo Interchange
Design-grade Survey
CIM 3D Modeling: Zoo Interchange
Design-grade/Post-construction Surveys

Georeferenced
Hi-res Digital Images
3D XYZ Return LAS Point Clouds
2D -3D Feature Lines 3D DTM-TINs X-Sections
3D CIM-BIM DSMs
CIM 3D Modeling: Zoo Interchange Design

3D Roads/Drainage/Surfaces
CIM 3D Modeling: Zoo Interchange Design

3D Structures: Bridges, Ret Walls, Noise Walls, Tunnels, Sign Bridges, Other
CIM 3D Modeling: Zoo Interchange
Design

3D Utilities-Gas, Steam, Electrical, Comm, Fiber Optic, Tel/Data, CATV/Data, Other
CIM 3D Modeling: Zoo Interchange Design

3D ITS/FTMS, Lighting, Signs, Signals, Landscaping, Water, San Sewer, Other
CIM 3D Modeling: Zoo Interchange Design

3D Staged Model with Temporary Surfaces, Roads, Drainage, Structures, Other
CIM – Multi-disciplinary Integrated 3D Design

**CIM Applications:**
- Multi-disciplinary Integrated 3D Design Workflows for Roadway, Structures, Geotech, Utilities, Traffic, S&S, Other
- Clash Detection between Disciplines in Design Reviews

**Tool(s) Used:**
- Bentley Microstation + In-roads (Design) SS2 / Autodesk C3D 2014
- Bentley Navigator (Clash Detection) / Autodesk Navisworks 2014

**Benefits:**
- Improved Design & Design-Construction Reviews
- Earlier Detailed Clash Detection-Resolution
- Improved PS&E Production Quality & 3D Model Delivery

**Challenges:**
- All Design Disciplines Designing in 3D
- Better 3D Modeling SW Tools Needed for Structures & Utilities
CIM Applications:
- Digital Project Delivery 3D Model-based PS&E Production + 3D Models (3DAMG Model @Prebid & 3D Ancillary Model @Precon)
- Clash Detection Preformed after 60% & Draft PS&E Reviews

Tool(s) Used:
- Bentley Microstation + In-roads (Design) SS2 / Autodesk C3D 2014
- Bentley Navigator (Clash Detection) / Autodesk Navisworks 2014

Benefits:
- Earlier Detailed Clash Detection-Resolution
- Improved PS&E Production & 3D Model Delivery Pre-bid/Pre-con

Challenges:
- “Rule-based” Clash Detection
- Pre-bid - AMG/Precon - Ancillary 3D Model Delivery Timeframes
CIM 3D Modeling: Zoo Interchange Design

Applications:
- Final design and staging plan development
- Public Involvement

Tool(s) Used:
- Autodesk Navisworks
- Bentley Navigator

Benefits:
- Evaluate staging options
- Evaluate utility relocations

Challenges:
- Requires 3d elements from design
- Requires detailed schedule and durations
- Accuracy of existing surface or utility data
- Design tool or visual aid??
CIM 3D Modeling: Zoo Interchange Design

3D Photorealistic/Augmented Reality/Rendered Model
CIM Applications:
- Exhibits & Maps from 3D Engineered Models & GIS for PI
- Renderings & Simulations from 3D Engineered Models for PI

Tool(s) Used:
- Bentley Microstation SS2 / Autodesk C3D 2014 / 3DS Max / RDV Systems / Forum8
- Autodesk 3DS Max

Benefits:
- Improved Renderings & Simulations Directly from 3D Models
- Improved Visualizations for Stakeholders

Challenges:
- Renderings & Simulations 3D Workflows Timeframes
- Better 3D Rapid Modeling Software Tools Needed
CIM 3D Modeling: Zoo Interchange Design

Post-Construction Initiatives:
As-built Record CEC Updating of 3D Model Pilot Project
CIM 3D Modeling: Zoo Interchange Construction

3D Engineered Models in Construction-SE Freeways/Region

CIM to Field Issues Tracking
CIM 3D Modeling: Zoo Interchange Construction

3D Engineered Models in Construction-SE Freeways/Region

Real-time Information Collaboration
CIM Applications:
- Collaboration Using Autodesk BIM Field 360, Glue, & Buzzsaw
- Construction Issues Management + Design-Construction Reviews

Tool(s) Used:
- Autodesk BIM Field 360, Glue, & Buzzsaw (Pilot)
- Office & Field Mobile Devices (Pilot)

Benefits:
- Improved Issues Notification
- Improved Design-Construction Reviews
- Improved Construction Collaboration & Coordination

Challenges:
- Mobile Devices Hardware (iOS Apple vs MS Win Office Tablets)
- Software Applications (Apple vs 32-bit MS Windows software)
3D Technologies/Modeling Trends

• Standards (CAD, BIM/CIM, LandXML, IFC, ISO, Other)
• Integrating Infrastructure Chain (Fabricators, etc.)
• Schedule-4D (Constructability/Staged Construction)
• Costs-5D
• Constructability Review with Schedule/Costs
• Reality Capture (Photo Point Cloud vs LiDAR Point Cloud)
• VR/AR
• As-builting (2D Blue Beam, 3D Markup, etc.)
• UAS/UAVs
• Life-cycle use of the 3D Model
Intelligent Vehicles + Sensor Technologies + Intelligent Roads with Automated 3D Design

Driverless Vehicles
Machine-Controlled UAV
Traffic Operations

UAV
Accident Monitoring
Lane, Distance, Time Compression