AEGIST GIS-T Workshop

Integrating data from multiple sources for building an open-standards compliant, topologically connected, routable
Road Network Data Model

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Disclaimer: Information in this deck is subject to change during the AEGIST Project (2019 – 2024)

Workshop Agenda

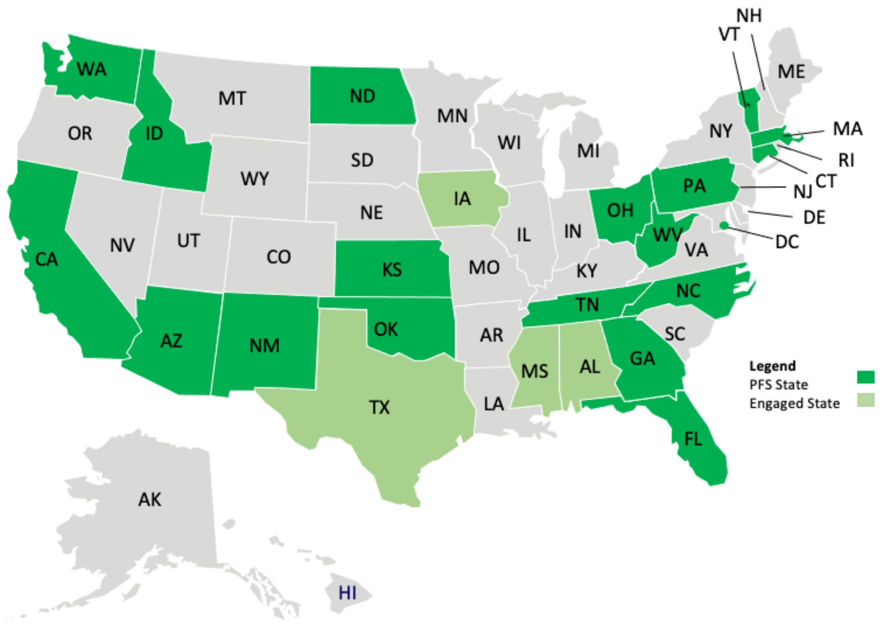
- **About AEGIST**
  - Objectives: Federal, State, Local Agencies, Private Sector
  - **Transportation Data and Business Use Cases:** Complete Streets (Safety), Design/CAD-GIS Integration, Freight, Asset Management, Travel Demand Modeling; ARNOLD, HPMS 9 and MIRE Reporting Requirements
  - Enterprise Data Life Cycle Management, Data Governance, Data Modeling, Data Engineering
- **About Workshop**
  - Workshop Objectives
  - Workshop Schedule: Presentations and Breakout Sessions (Open Discussion and Inputs)
- **Workshop Presentations (1.5 Hours) and Breakout Sessions (1.5 Hours)**
  - **Topic 1**: Routes, Centerlines, NG911 Roads, Road Names
  - **Topic 2:** Design-Construction to GIS Data Pipeline via Common Data Environment (~~BIM~~ and GIS Integration)
  - **Topic 3**: Modeling Standards, National & International Initiatives: Standard Organizations, S/w Vendors, Projects
- **Wrap-Up: Resources & Next Steps**

About AEGIST

- ❑ Objectives: Federal, State , Local Agencies
- ❑ Business Use Cases
- ❑ Systems, Applications and Tools
- ❑ Data Standards: Management & Governance
- ❑ Private Sector, Standard Development Organizations

About AEGIST

Pooled Fund Study (PFS):
FHWA and States
Enterprise Data Management and Governance
Standards, Processes, Tools and Technology



www.gisintransportation.com

SPATIAL DATA MODELING

- Linear Referencing System: Routes, Single/Dual Geometry, Concurrencies, Temporality
- Other Enterprise Systems: Asset Management, Traffic, Safety, Design, Construction, etc
- Linear/Spatial Referencing Data Models and Data Structures: Routes, Road Segments, Junctions, Intersections, Turn Segments, and Topological Connectors
- GIS Features and LRS Events Data Modeling across various Enterprise Systems: GIS-LRS, Asset Management, Design, Construction, Unmanned Aerial Systems (UAS), Project Management and Programming
- Publication Data for Users at DOTs, Local Agencies, FHWA, Private Sector Agencies
- Data Quality, Topology, Data Availability, Readiness (FAIR), Authoritative Sources

SPATIAL DATA INTEGRATION, ENGINEERING & DELIVERY

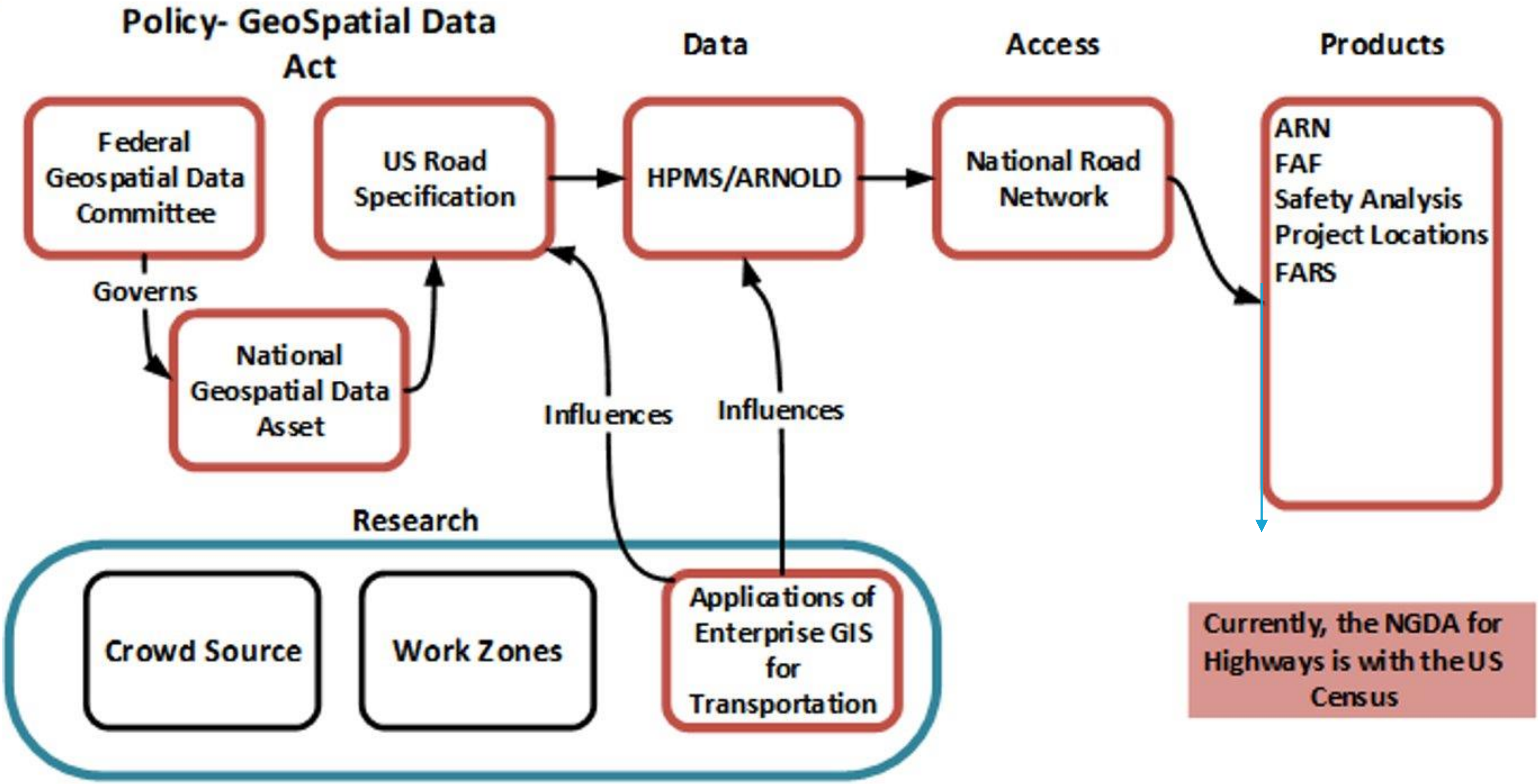
- Data Hubs and Data Engineering Platforms for Preparing Data
- Data Conflation, Integrating and Engineering Business Data using LRS.GIS
- **Governance** of (Spatial) Data Engineering Platform: Systems, Applications, Tools

SPATIAL DATA ANALYTICS

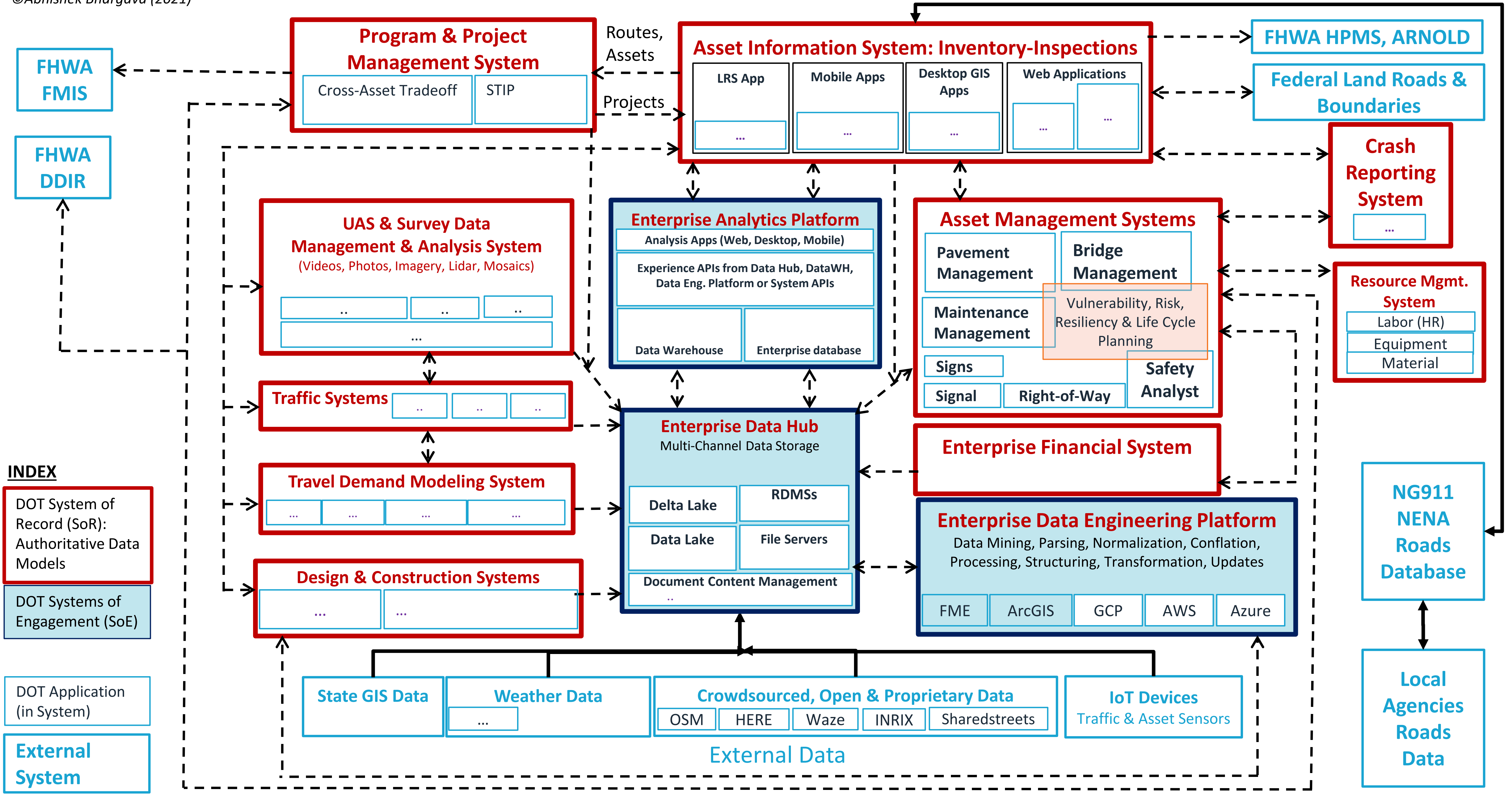
- Analytics Platforms: Open Data Portals, Data Warehouses, Enterprise Databases
- Spatial Statistics, Econometrics, AI/ML, Big Data Analytics
- **Governance** of (Spatial) Data Analytics Platform: Systems, Applications, Tools

About AEGIST

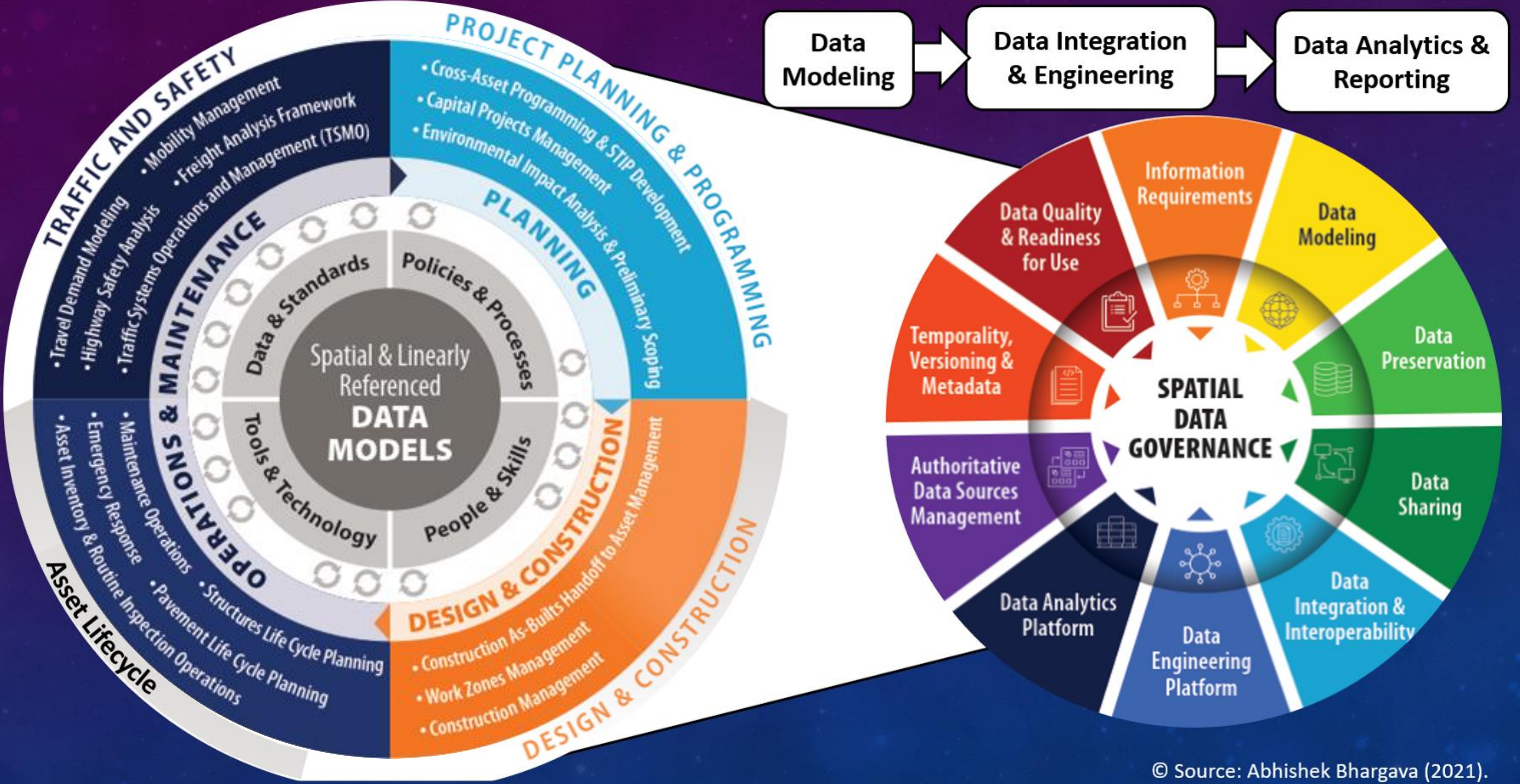
AEGIST, HPMS 9 and National Road Network



Building Information Modeling (BIM): Enterprise Systems, Applications, Tools and Processes Deployment Activities



Data Management and Governance



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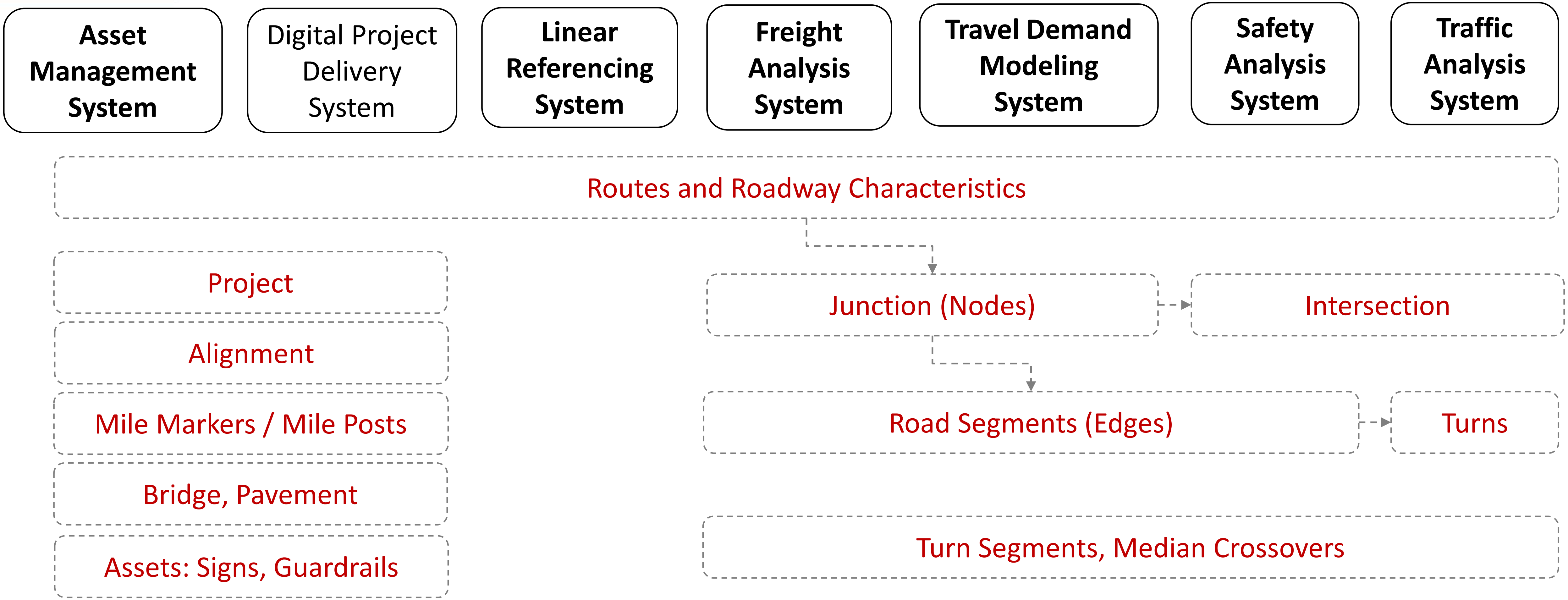
About Workshop

- ❑ Objective
- ❑ Schedule
  - ❖ Presentations
  - ❖ Open Discussion and Survey
  - ❖ Breakout Sessions and Roundtable Discussions
- ❑ Engagement Platform

Workshop Objective: Road Network Data Model Development for Enterprise Use

Data Assets



Workshop Objective: Road Network Data Model Development for Enterprise Use

Data Models

Asset Management System

Digital Project Delivery System

Linear Referencing System

Freight Analysis System

Travel Demand Modeling System

Safety Analysis System

Traffic Analysis System

FMIS *NBI, HPMS, ARNOLD* Routes and Roadway Characteristics *MIRE* *NPMRDS*

Project

Alignment

Mile Markers / Mile Posts

Bridge, Pavement

Assets: Signs, Guardrails, …

NG911 RCL & Nodes

USRS Road Profiles

Junction (Nodes)

Intersection

Open Street Maps Ways & Nodes

OGC Geographic Data Format, CityGML

Road Segments (Edges)

Turns

Industry Foundation Classes (IFC)

Generalized Modeling Network Specification (GMNS)

Turn Segments, Median Crossovers

Private Sector Data Vendors – Asset Data (including Roads), Traffic Data, Safety Data, Traveler Data, Lidar Data, Imagery Data

National and International Data Standard Development Organizations – ISO, OGC, W3C, AASHTO, FHWA, buildingSMART, etc

Workshop Objective

Road Network Data Model Management and Governance

USE CASES

- Freight Origin-Destination Routing Analysis
- Travel Demand Modeling
- Complete Streets: Safety Data Modeling and Analysis
- Traffic Analysis Systems
- Asset Performance Management & Life Cycle Analysis
- ARNOLD-HPMS-MIRE Reporting, National Bridge Inventory Reports
- Equity in Project Planning & Programming
- Design/CAD to GIS-Asset Management As-Builts asset data handoff

Data Assets in Road Network Data Model:

- Centerlines/Datum/ Anchor Sections (NCHRP-20-27)
- Routes: Vehicle, Bike Routes, Pedestrian Crosswalks and Sidewalks
- Intersections, Junctions (Nodes) or Network Links/Nodes (NCHRP 20-27), Intersection Legs
- Road Segments: NG911, Travel Demand Modeling (Links), Pavement, Traffic, Maintenance, Project Segments, HPMS Road Identification Segments
- Assets: Linear Bridges, Culverts, Guardrails, Medians, Signs (including Mile Markers), etc.

Data Standards: National & International Initiatives –

Standard Development Organizations   Private & Public Sector Agencies

Workshop Schedule

Presentations, Open Discussion, Survey and Breakout Sessions

- **About AEGIST, Workshop and Workshop Background (Business Use Cases)** — **20 Minutes**
- **Topic 1: Engineering Road Network Data Model using LRS, Open Street Maps, NG911, LiDAR, Imagery** — **60 Minutes**
  - » **Presentation 1:** Building Topologically Connected Road Network Model with Intersections, Links, Nodes *[30 Minutes]*
  - » **Breakout Session #1: Open Discussion and Survey** *[30 Minutes]*

BREAK: 10 Minutes

- **Topic 2: Acquiring and Integrating Road Network Data from Project, Design, Construction Systems** — **75 Minutes**
  - » **Presentation 2:** Existing Practices: Pennsylvania Turnpike Commission *[20 Minutes]*
  - » **Presentation 3:** Emerging Practice: Digital Twin, CDE & IFC Based Data Migration: Tennessee & Pennsylvania *[25 Minutes]*
  - » **Breakout Session #2: Open Discussion and Survey** *[30 Minutes]*

BREAK: 10 Minutes

- **Topic 3: Governing Road Network Data across Sources using Standards** — **50 Minutes**
  - » **Presentation 4:** National and International Agencies Collaboration and Initiatives for Standardizing Roads Modeling *[20 Minutes]*
  - » **Breakout Session #3: Open Discussion and Survey** *[30 Minutes]*
- **Wrap-Up: Resources and Next Steps** — **15 Minutes**

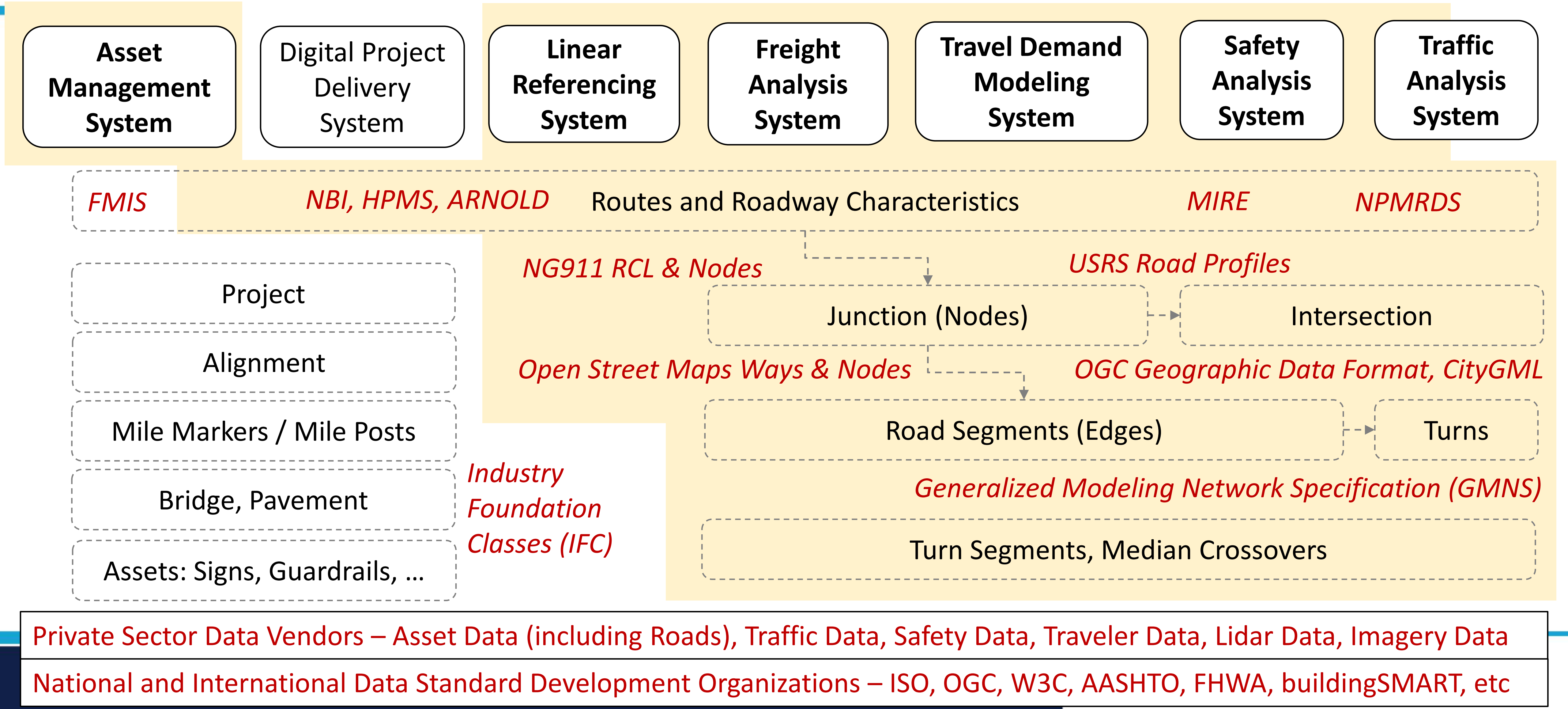
Topic 1: Integrate Multiple Data Sources

- Building Road Network Data Model

- Integrating Data from following Data Sources
  - LRS Data: Routes, Roadway Characteristics
  - Imagery
  - NG911 Road Centerlines, Local Agencies
  - Federal Lands (BLM, BOR, …)
  - Open Street Maps
  - LiDAR Data: MIRE FDEs

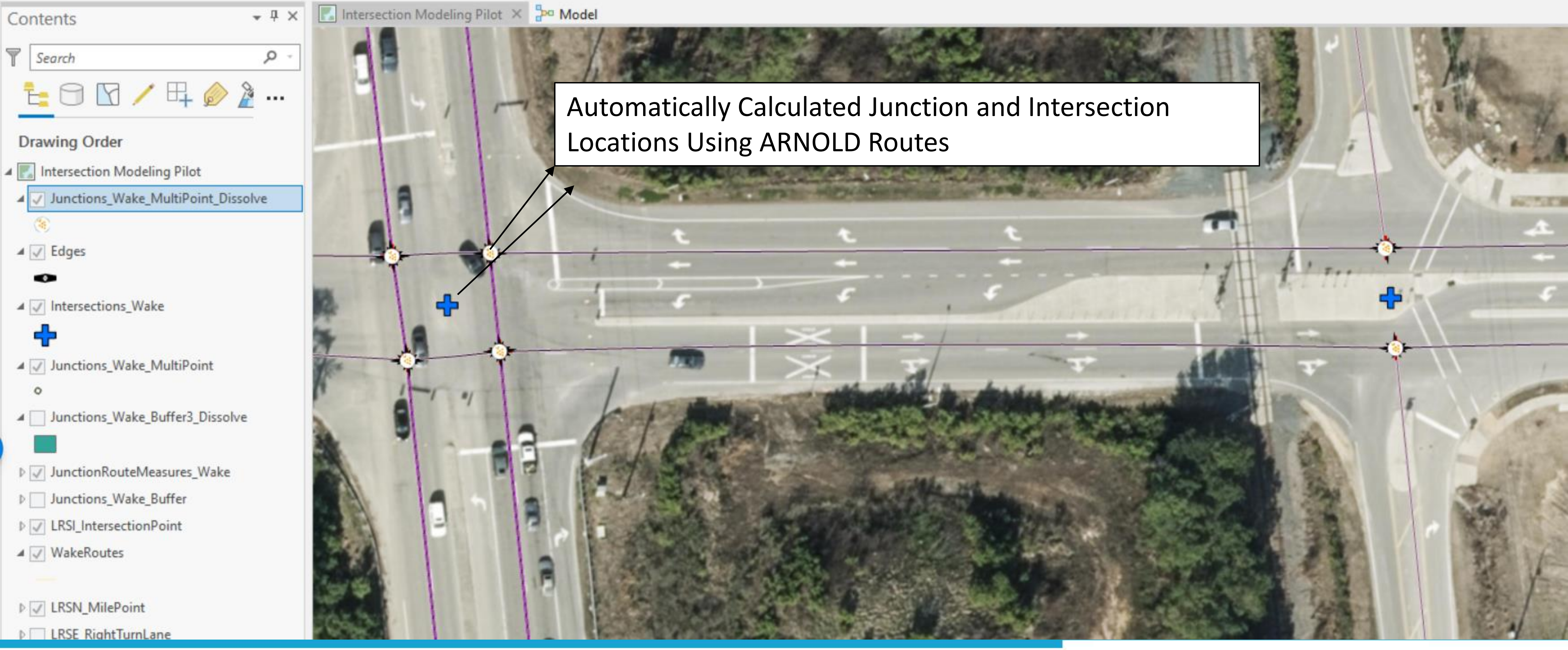
Topic 1 Objective: Road Network Data Model Development for Enterprise Use

Engineering Junction, Intersection and Roads Segments from LRS Routes, NG911 Roads, Lidar/Imagery, Open & Proprietary Roads Datasets



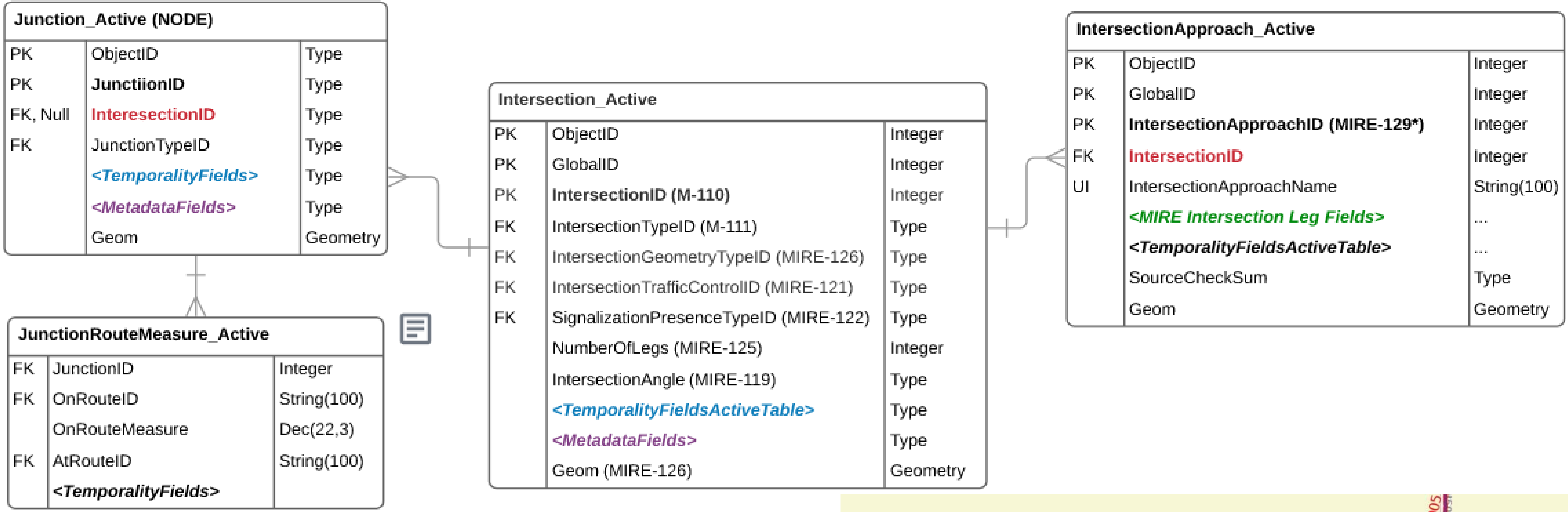
Road Network Data Model

LRS/ARNOLD Routes for Creating Junctions and Intersections



Road Network Data Model

LRS/ARNOLD Routes for Creating Junctions and “Associating” them with Intersections



OBJECTID *	JUNCTION_ID *	ON_ROUTE_ID	ON_ROUTE_MEASURE	AT_ROUTE_ID
59867	130966	03720040000	27.761996	03750067900
59868	130966	03720040000	27.761996	03750135900
59869	130966	03750067900	1.052282	03720040000
59870	130966	03750067900	1.052282	03750135900
59871	130966	03750135900	0	03720040000
59872	130966	03750135900	0	03750067900

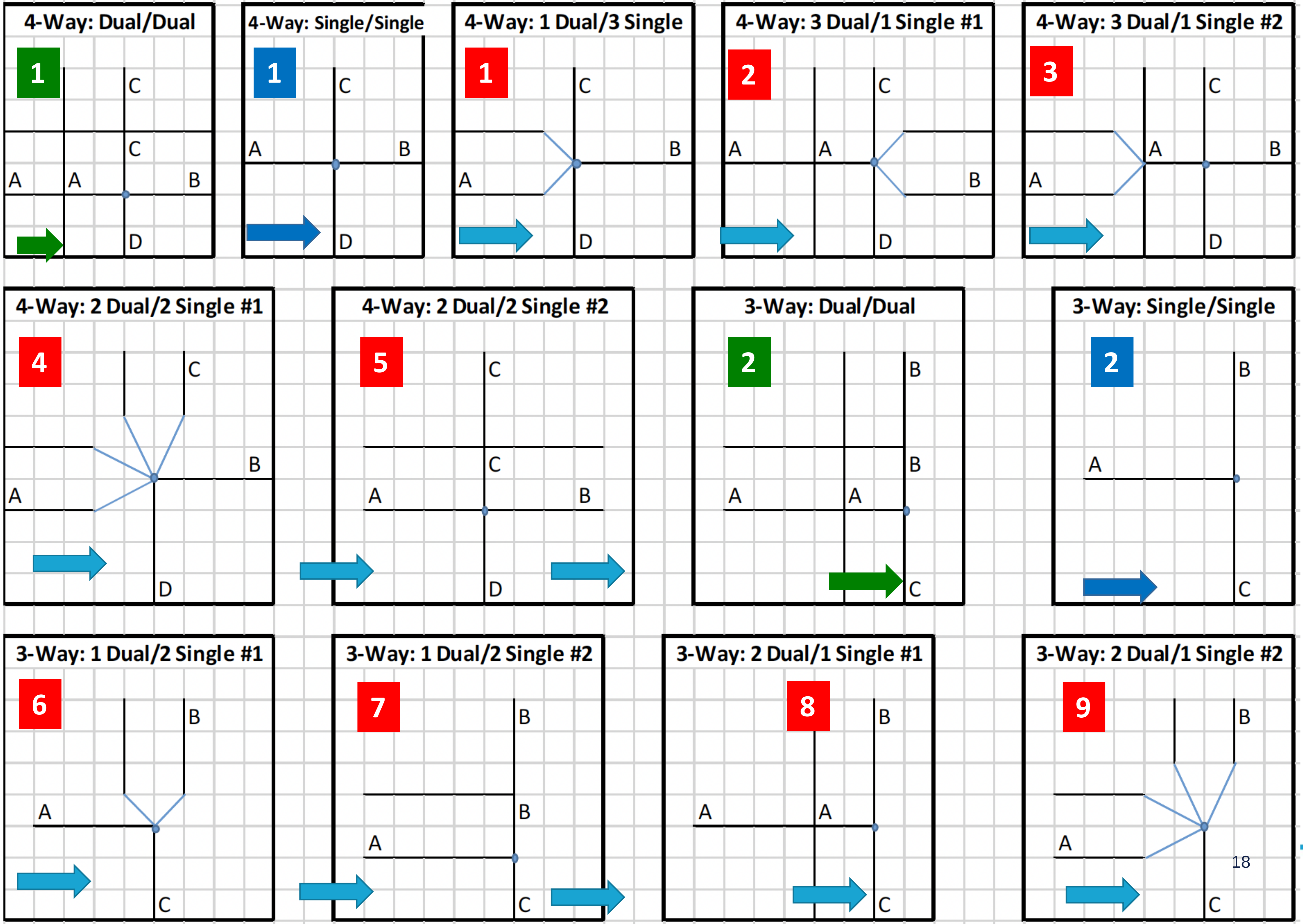
Scenario 1.1: Intersections with Non-State Highway System Route(s)

Undivided Highways (3/4 Way) **1.1.1**

Divided-Undivided Highways (3/4 Way) **1.1.2**

Divided Highways (3/4 Way) **1.1.3**

15

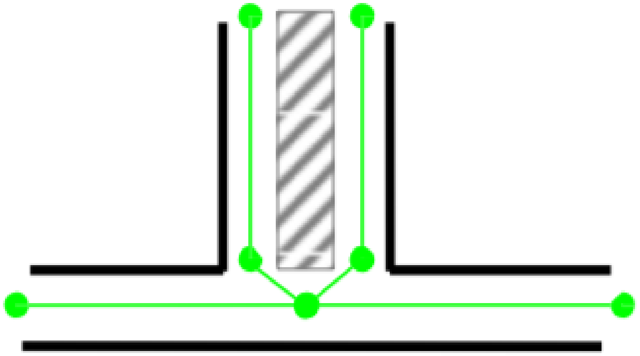


LRS Centerline (2D) Modeling Accuracy (LOA)

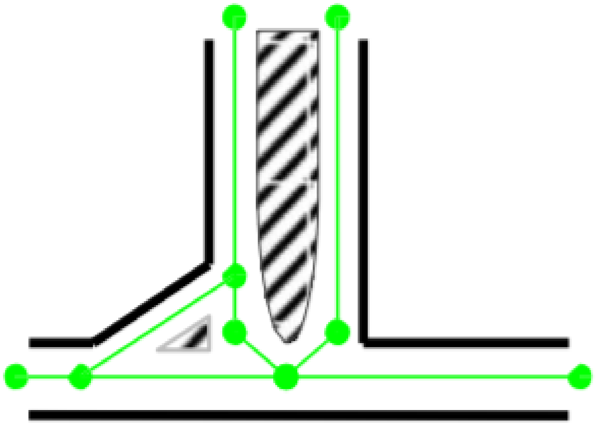
Kansas NG-911 Centerline Shape/Taper

- When the centerlines from a Dual Carriageway end to join a single centerline segment, a taper angle shall be used to connect the centerlines.

Dual Carriage way terminations



Single termination without ramp

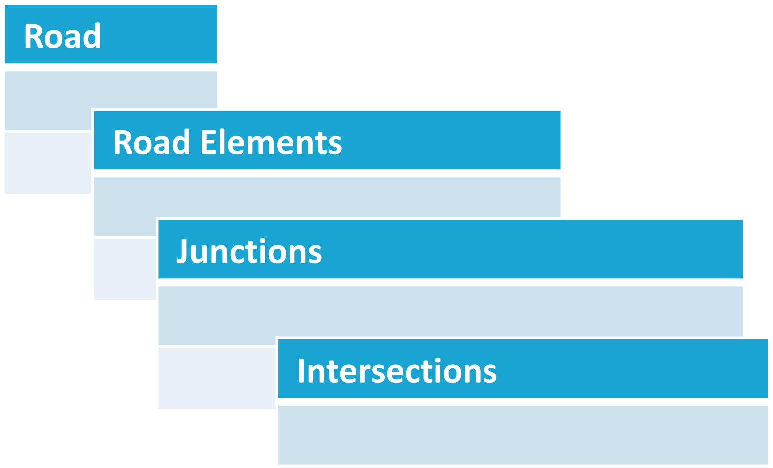


Termination with ramp

Source[1]: Kansas NG-911 GIS Data Model

OGC Topology: Geographic Data Format (GDF)

Intersection and Junctions



Linear and Spatial Referencing

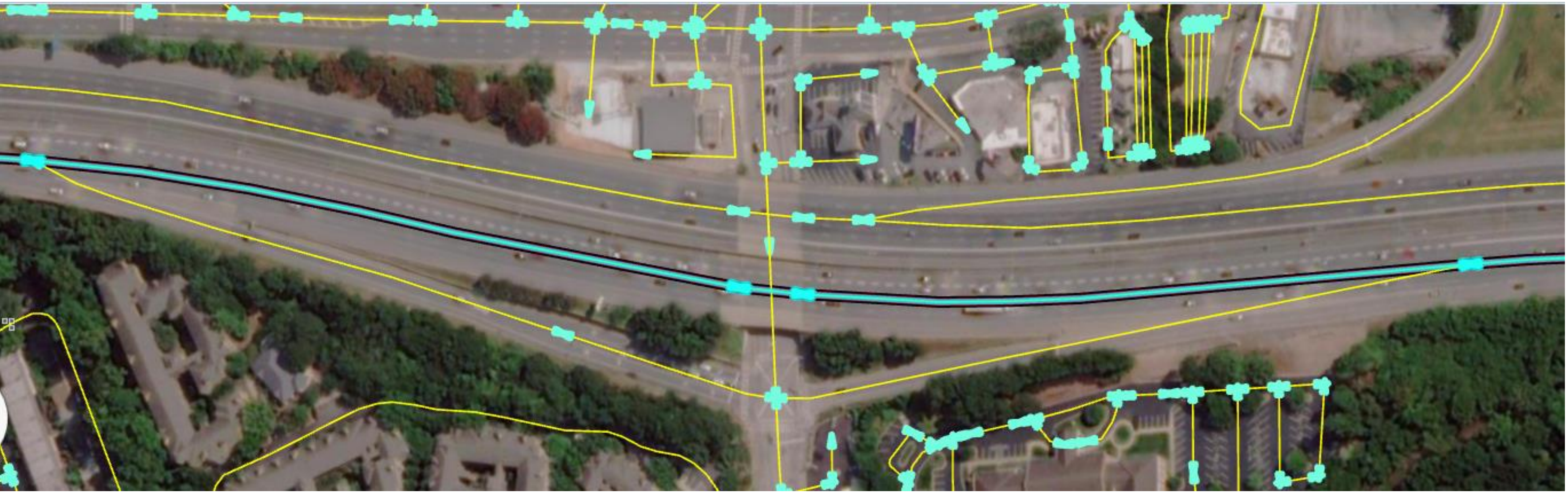
- ❑ LRS Route, Centerline (Datum), Route-Centerline (M:N)
- ❑ LRS Events
  - » **Junctions (Nodes):** At Intersections, TAZ Centroid*, Bridge, Access Points, Median Cuts, Intersection Median Ends, Intersection Leg Begin/End, State/County/Town/Parish Boundaries (Snap Points)
  - » **Intersection Point** at Centroid, at a perpendicular offset from LRS Route *(e.g.: Median Cut Intersection, MIRE-126)*
  - » **Road Segment:** Junction to Junction

- ❑ Topological Segments
  - » Intersection Connectors
  - » Turn Segments/Lanes (HPMS 12, 13)
  - » Median Crossovers (MIRE-62)

Connectivity:

- ❑ Road Segments and Intersection Parent-Child Data Relationship
- ❑ Junctions (Nodes) with Road Segments, Connectors, Turn Segments/Lanes, Median Crossovers, Reverse Route Segments, Inventory Routes, Continuity Intersection Points

Road Segment Use Case: Freight Origin-Destination Routing



Freight Route	Segment ID	Begin Junction ID	End Junction ID	Road Name	Speed Limit
100	73325903	69431853	69431880	..	65
100	358758343	69148880	69431863	..	70
100	73325904	69431863	69431865	..	65
100	73325905	69431865	69148897	..	60
100	73325905	69148897	69431891	..	70

84.4273949°W 33.8415490°N

Selected Features: 5

MENT | OUT_Pull11a - ToTerminal | Counties121_127n

Calculate | Selection: Select By Attributes | Zoom To | Switch | Clear | Delete | Copy

EdgeSequen	RoadNames	Origin_Des	NumberOfJo	Destinat_4	AvgDistanc
-1692820378713516190,6427226923243275847,7872297807254062231,...	Eugene Talmadge Memorial Bridge,Atlantic Coastal Hig...	South Carolina	374	b12	46.02858918582971
6428011016329063887,2709643821801372940		Fulton	135	b15	10.31696706028589
-3772566523323006118		Fulton	90	b15	12.63517712865134
3883060916671609923	Sullivan Road	Fulton	82	b15	5.724052206339342
2196668876445222640,-1163535265906310948,-1332252725276495092,...	Perimeter	Fulton	78	b15	19.03045369794904
-2356212690051327139,1945594236381943576,8153266790188650595,-...	N Coastal Highway,North Coastal Highway,South Coast...	South Carolina	52	b12	53.62336855189559
1879890688678032704,-4104625364390564628,-2816437862694231411,...	Augusta Road,Bonnybridge Road,North Coastal Highwa...	Effingham	37	b12	22.97700435052828
1879890688678032704,-4104625364390564628,-2816437862694231411,...	Augusta Road,Grange Road	Effingham	36	b12	19.89434431323804
9994526977984655524,-2352306268603014173,-2484389090956856686,-...	Perimeter,I 85	Cobb	28	b15	23.08887507768801

Illustration of TransCAD Network Link IDs, Topological and Flow Directionality

Classon Ave & Atlantic Ave

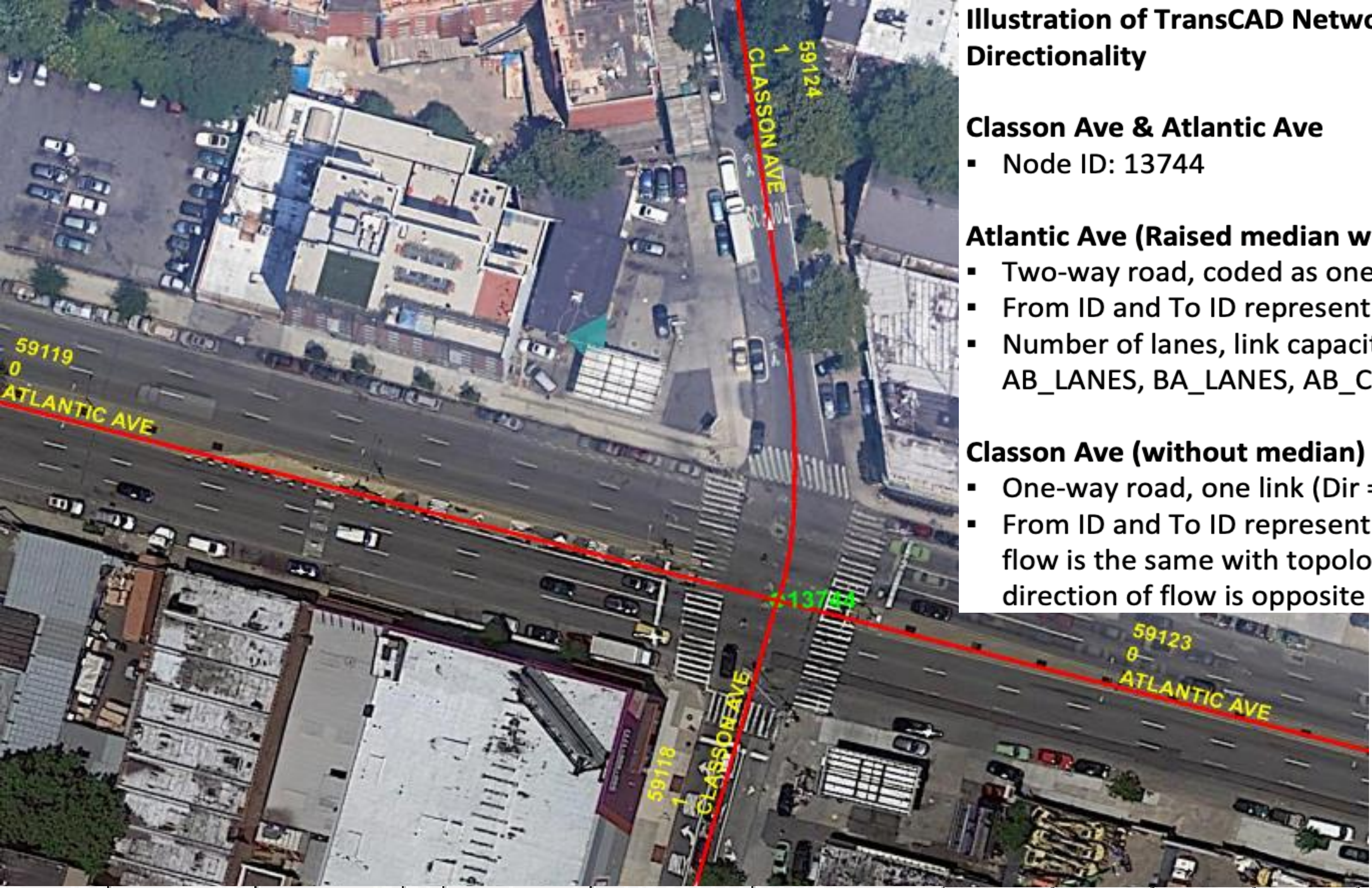
- Node ID: 13744

Atlantic Ave (Raised median with curb)

- Two-way road, coded as one bidirectional link (Dir = 0)
- From ID and To ID represent topological direction.
- Number of lanes, link capacity, ect. are coded in the format AB_LANES, BA_LANES, AB_Capacity, BA_Capacity

Classon Ave (without median)

- One-way road, one link (Dir =1)
- From ID and To ID represent topological direction. If the direction of flow is the same with topological direction, then Dir =1, if the direction of flow is opposite to the topological direction, then Dir=-1.



[From ID]	[To ID]	ID	Dir	Length	LID991111	NAME1	COUNTY	FCLASS	DESIGN	MEDIAN	ACCESS	SIGNAL	DRIVEWAY	TURN	TOT_LANE
13619	13744	59119	0	0.17	59119	ATLANTIC AVE	4	14	0	A	N	H	NS	NS	6
13744	13732	59124	1	0.07	59124	CLASSON AVE	4	16	0	N	N	H	NS	NS	2
13744	13873	59123	0	0.16	59123	ATLANTIC AVE	4	14	0	A	N	H	NS	NS	6
13688	13744	59118	1	0.29	59118	CLASSON AVE	4	16	0	N	N	H	NS	NS	1

Use Case: Travel Demand Modeling

Links, Nodes & Roadway Characteristics

Linear Referencing System → **Travel Demand Modeling System**

[1] Road Segments (Links)
[2] Junctions (Nodes)
[3] Intersection

Link Attributes
ID
From Node ID
To Node ID
Direction
Length
Functional Class
Facility Type/Link Type
Area Type
Auto/Truck tolls
Number of Lanes
Parking Restriction
Truck/HOV Usage
Median
Access Control
Signal Density
Turn Lane
Ramp Type
Bridge, Tunnel,…

Software default fields

Important general classification, used to calculate link speed and capacity

Components of generalized cost used for model path-building

Time of day characteristics used to build period networks

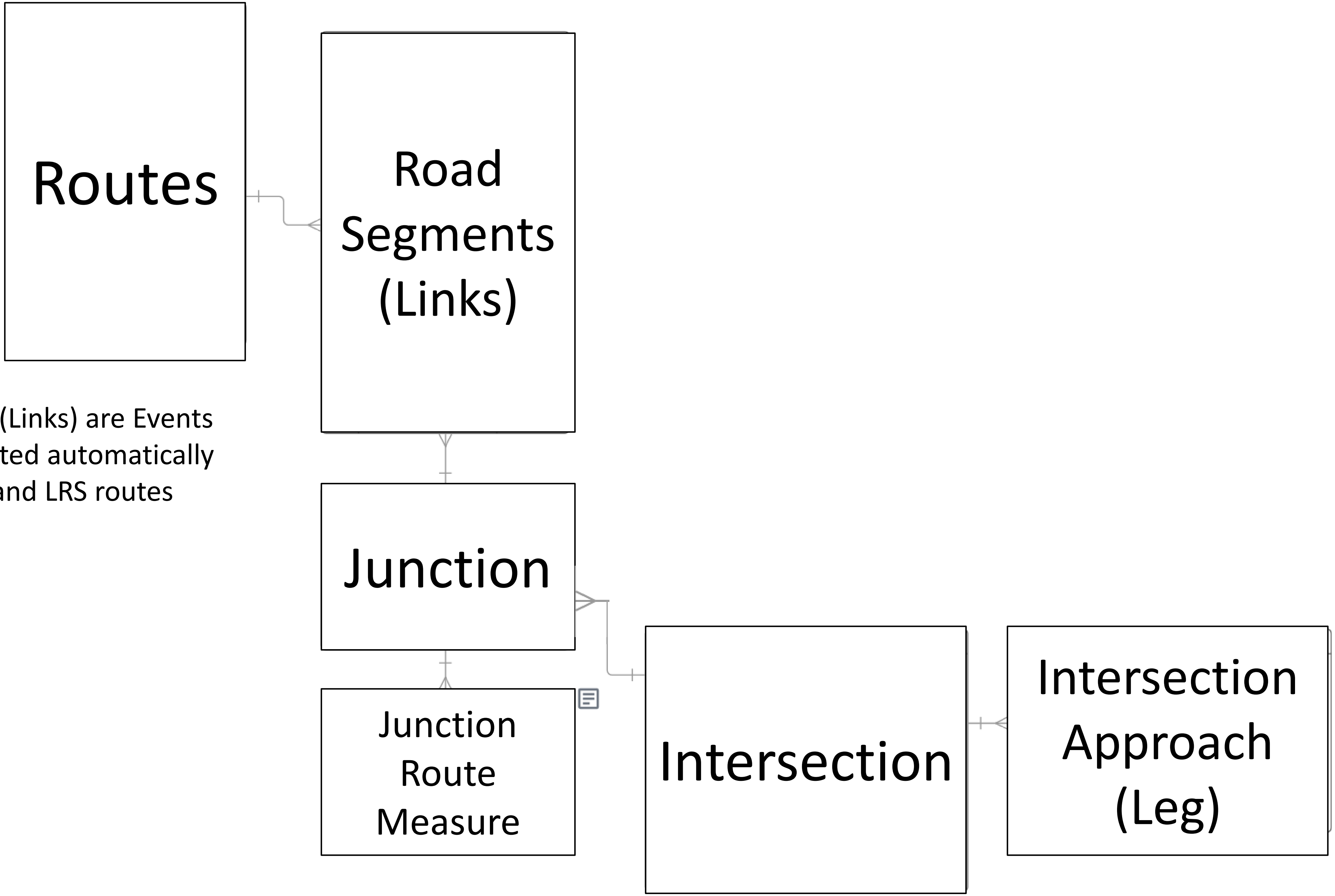
Model specific attributes used to compute the appropriate physical link types together with attribute listed above

Link Attributes
Road Segment ID
Begin Junction ID
End Junction ID
Direction
Length
HPMS-01 - Functional Class
HPMS-03 - Facility Type/Link Type
HPMS-02 – Urban Code
Auto/Truck tolls
HPMS-07 – Through Lanes
Parking Restriction
HPMS 08-11 – HOV/HOT/Toll
Median
Access Control
Signal Density
HPMS 12/13 – Turn Lane
Ramp Type
Bridge, Tunnel,…

MIRE Road Segments Attributes for Safety

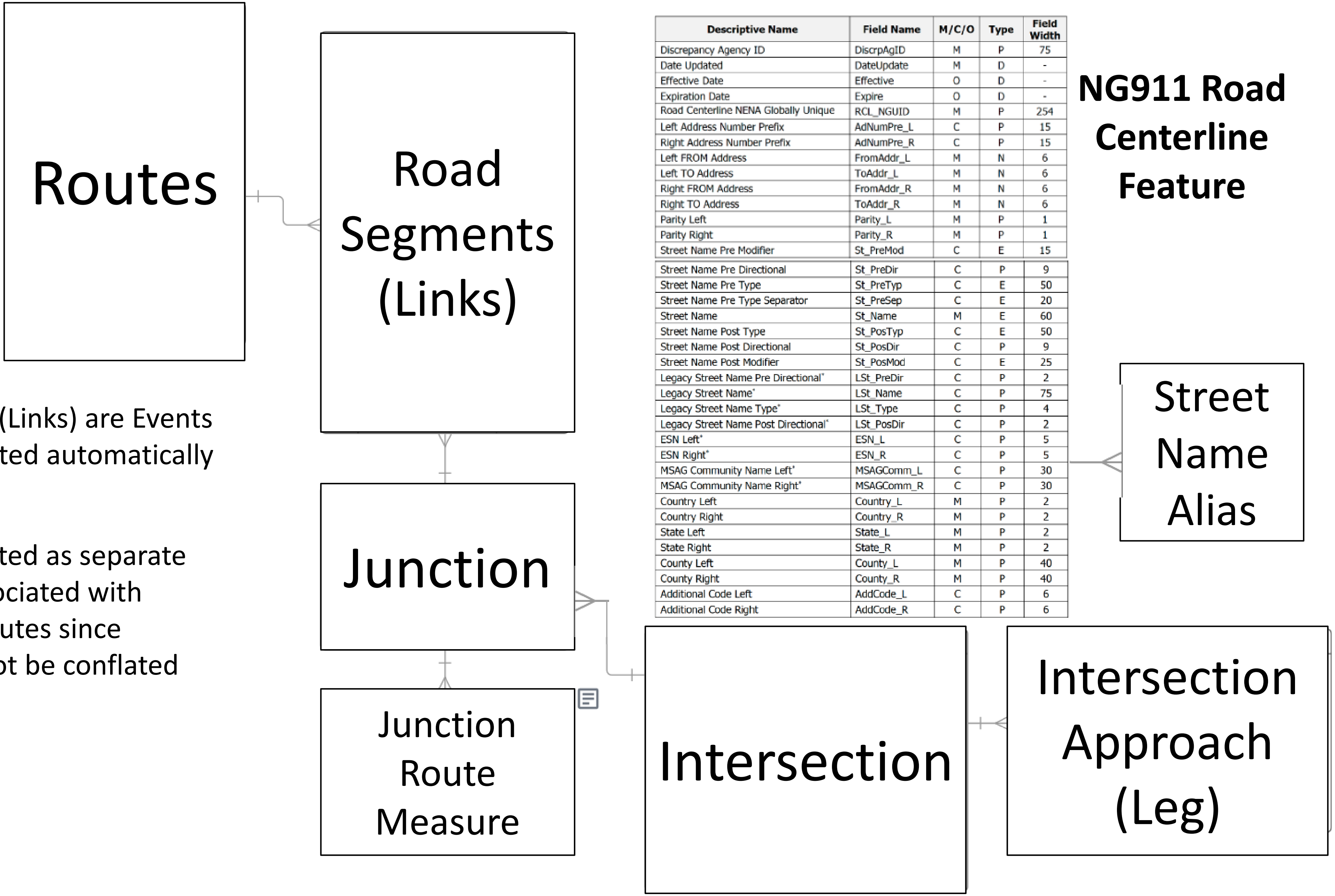
13. Segment Length [FDE]
14. Route Signing
15. Route Signing Qualifier
16. Coinciding Route Indicator
17. Coinciding Route – Minor Route Information
18. Direction of Inventory [FDE]
19. Functional Class [FDE]
20. Rural/Urban Designation [FDE]
21. Federal Aid [FDE]
22. Route Type [FDE]
23. Access Control [FDE]
24. Surface Type [FDE]
25. Total Paved Surface Width
26. Surface Friction
27. Surface Friction Date
28. International Roughness Index (IRI)
29. International Roughness Index (IRI) Date
30. Pavement Condition (Present Serviceability Rating [PSR])
31. Pavement Condition (PSR) Date
32. Number of Through Lanes [FDE]
33. Outside Through Lane Width
34. Inside Through Lane Width
35. Cross Slope
36. Auxiliary Lane Presence/Type
37. Auxiliary Lane Length
38. High-occupancy Vehicle (HOV) Lane Presence/Type

[Option 1] Create Road Segments from LRS Routes



- Road Segments (Links) are Events on the LRS, created automatically from Junctions and LRS routes

[Option 2] Create Road Segments from LRS Routes. Add NG911 RCL



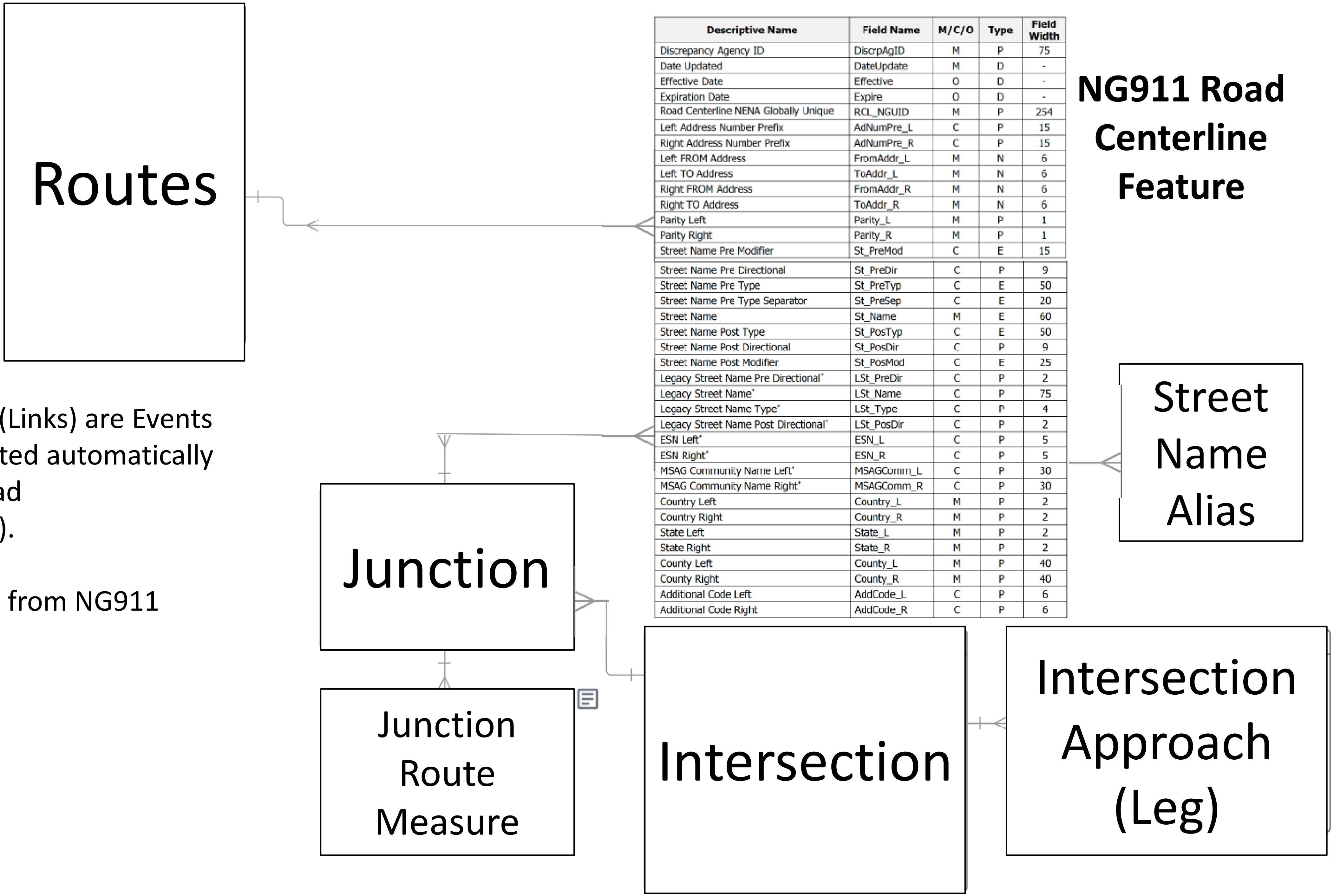
Descriptive Name	Field Name	M/C/O	Type	Field Width
Discrepancy Agency ID	DiscrpAgID	M	P	75
Date Updated	DateUpdate	M	D	-
Effective Date	Effective	O	D	-
Expiration Date	Expire	O	D	-
Road Centerline NENA Globally Unique	RCL_NGUID	M	P	254
Left Address Number Prefix	AdNumPre_L	C	P	15
Right Address Number Prefix	AdNumPre_R	C	P	15
Left FROM Address	FromAddr_L	M	N	6
Left TO Address	ToAddr_L	M	N	6
Right FROM Address	FromAddr_R	M	N	6
Right TO Address	ToAddr_R	M	N	6
Parity Left	Parity_L	M	P	1
Parity Right	Parity_R	M	P	1
Street Name Pre Modifier	St_PreMod	C	E	15
Street Name Pre Directional	St_PreDir	C	P	9
Street Name Pre Type	St_PreTyp	C	E	50
Street Name Pre Type Separator	St_PreSep	C	E	20
Street Name	St_Name	M	E	60
Street Name Post Type	St_PosTyp	C	E	50
Street Name Post Directional	St_PosDir	C	P	9
Street Name Post Modifier	St_PosMod	C	E	25
Legacy Street Name Pre Directional[*]	LSt_PreDir	C	P	2
Legacy Street Name[*]	LSt_Name	C	P	75
Legacy Street Name Type[*]	LSt_Type	C	P	4
Legacy Street Name Post Directional[*]	LSt_PosDir	C	P	2
ESN Left[*]	ESN_L	C	P	5
ESN Right[*]	ESN_R	C	P	5
MSAG Community Name Left[*]	MSAGComm_L	C	P	30
MSAG Community Name Right[*]	MSAGComm_R	C	P	30
Country Left	Country_L	M	P	2
Country Right	Country_R	M	P	2
State Left	State_L	M	P	2
State Right	State_R	M	P	2
County Left	County_L	M	P	40
County Right	County_R	M	P	40
Additional Code Left	AddCode_L	C	P	6
Additional Code Right	AddCode_R	C	P	6

- Road Segments (Links) are Events on the LRS, created automatically form Junctions
- NG911 RCL created as separate feature and associated with LRS/ARNOLD Routes since Geometry cannot be conflated

[Option 3] Create Road Segments from NG911 RCL: Road Centerlines

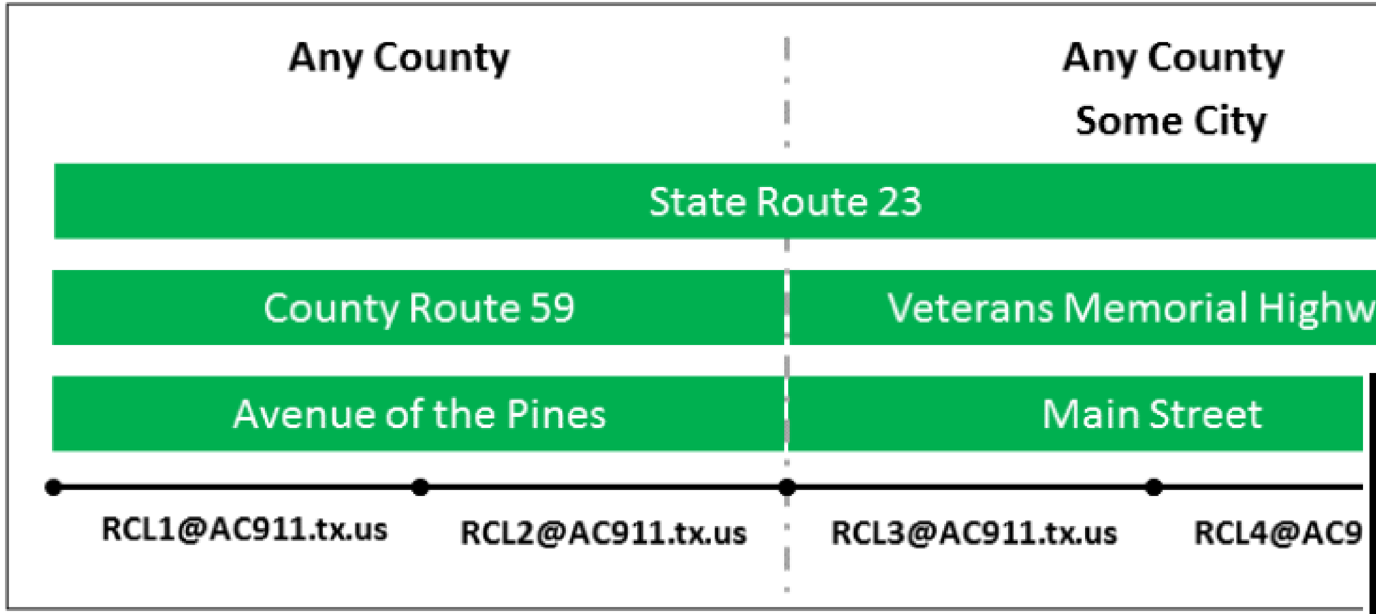
- Road Segments (Links) are Events on the LRS, created automatically from NG911 Road Centerlines (RCL).

  Create Junctions from NG911 From/To Nodes



Descriptive Name	Field Name	M/C/O	Type	Field Width
Discrepancy Agency ID	DiscrpAgID	M	P	75
Date Updated	DateUpdate	M	D	-
Effective Date	Effective	O	D	-
Expiration Date	Expire	O	D	-
Road Centerline NENA Globally Unique	RCL_NGUID	M	P	254
Left Address Number Prefix	AdNumPre_L	C	P	15
Right Address Number Prefix	AdNumPre_R	C	P	15
Left FROM Address	FromAddr_L	M	N	6
Left TO Address	ToAddr_L	M	N	6
Right FROM Address	FromAddr_R	M	N	6
Right TO Address	ToAddr_R	M	N	6
Parity Left	Parity_L	M	P	1
Parity Right	Parity_R	M	P	1
Street Name Pre Modifier	St_PreMod	C	E	15
Street Name Pre Directional	St_PreDir	C	P	9
Street Name Pre Type	St_PreTyp	C	E	50
Street Name Pre Type Separator	St_PreSep	C	E	20
Street Name	St_Name	M	E	60
Street Name Post Type	St_PosTyp	C	E	50
Street Name Post Directional	St_PosDir	C	P	9
Street Name Post Modifier	St_PosMod	C	E	25
Legacy Street Name Pre Directional*	LSt_PreDir	C	P	2
Legacy Street Name*	LSt_Name	C	P	75
Legacy Street Name Type*	LSt_Type	C	P	4
Legacy Street Name Post Directional*	LSt_PosDir	C	P	2
ESN Left*	ESN_L	C	P	5
ESN Right*	ESN_R	C	P	5
MSAG Community Name Left*	MSAGComm_L	C	P	30
MSAG Community Name Right*	MSAGComm_R	C	P	30
Country Left	Country_L	M	P	2
Country Right	Country_R	M	P	2
State Left	State_L	M	P	2
State Right	State_R	M	P	2
County Left	County_L	M	P	40
County Right	County_R	M	P	40
Additional Code Left	AddCode_L	C	P	6
Additional Code Right	AddCode_R	C	P	6

NG911 RCL and Street Name Alias



Road Centerline NGUID	Street Name Pre Modifier	Street Name Pre Directional	Street Name Pre Type	Street Name Pre Type Separator	Street Name	Street Name Post Type
RCL1@AC911.tx.us			Avenue	of the	Pines	
RCL2@AC911.tx.us			Avenue	of the	Pines	
RCL3@AC911.tx.us					Main	Street
RCL4@AC911.tx.us					Main	Street

Alias Street Name NGUID	Road Centerline NGUID	Alias Street Name Pre Type	Alias Street Name Pre Type Separator	Alias Street Name	Alias Street Name Post Type
AST1@AC911.tx.us	RCL1@AC911.tx.us	State Route		23	
AST2@AC911.tx.us	RCL2@AC911.tx.us	State Route		23	
AST3@AC911.tx.us	RCL3@AC911.tx.us	State Route		23	
AST4@AC911.tx.us	RCL4@AC911.tx.us	State Route		23	
AST5@AC911.tx.us	RCL1@AC911.tx.us	County Route		59	
AST6@AC911.tx.us	RCL2@AC911.tx.us	County Route		59	
AST7@AC911.tx.us	RCL3@AC911.tx.us			Veterans Memorial	Highway
AST8@AC911.tx.us	RCL4@AC911.tx.us			Veterans Memorial	Highway

Source: https://cdn.ymaws.com/www.nena.org/resource/resmgr/standards/nena-sta-006.1.1-2020_ng9-1-.pdf

Roads Modeling

HPMS 9 Road Identification Table similar to NG911 Road Centerline and Street Name Alias

Information about Road Name and Route Concurrencies

Complex Modifications

Route Identifications Table:

Route Number,

Alt Route Name, Qualifier, and Signing are consolidated

with a separate table structure. (**2023**)

Expanded to cover all public roads.

Field Name	Data Type (characters)	Description	Valid Values
BeginDate*	Date	Date at which the data becomes active.	MM/DD/YYYY
StateID*	Numeric (2)	State FIPS code	Up to two digits for the FIPS code**
RouteID*	VarChar (120)	Location reference ID for the linear feature	Up to 120 alpha-numeric digits that identify the route; this ID must be consistent with the Route ID in the State's LRS
BeginPoint*	Decimal (8,3)	Beginning milepoint	Identifies the point of origin for a given segment, using a decimal value in thousandths of a mile
EndPoint*	Decimal (8,3)	Ending milepoint	Identifies the terminus point for a given segment, using a decimal value in thousandths of a mile
RouteNumber	Numeric	The appropriate route number	Code only the appropriate route number (leading zeroes shall not be used). For example, Interstate 35W shall be coded as 35.
RouteName	Text	A familiar, non-numeric designation for a route	
IsPrimary	Numeric	Is this the highest order and lowest number route designation	Code 0 for no, or 1 for yes
RouteQualifier	Numeric	The route signing descriptive qualifier.	See Look-Up Table below. Code the value which best represents the manner in which the roadway segment is signed on the route markers.
RouteSigning	Numeric	The type of route signing	See Look-Up Table below. Code the value that best represents the manner in which the roadway segment is signed with route markers.
Comments (Optional)	VarChar (100)	Comment for State use	Variable text up to 100 characters; this field is optional

U.S. Department of Transportation
Federal Highway Administration

Complete Street Features

- Sidewalks
- Bike lanes (or wide paved shoulders)
- Special bus lanes
- Comfortable and accessible Public transportation stops
- Frequent and safe crossing opportunities
- Median islands
- Accessible pedestrian signals
- Curb extensions
- Narrower Travel Lanes
- Roundabouts

and more.

Complete Streets & Transportation Safety

Georgia Tech — CREATING THE NEXT

UC PRC — UNIVERSITY of CALIFORNIA | PAVEMENT RESEARCH CENTER — Davis • Berkeley

Research Roadmap: Inventorying Complete Streets for Asset Management

Vision: Incorporate Complete Streets into asset management systems to cost-effectively take advantage of the societal, economic, and environmental benefits of active transportation

Concept

Scope: Management of assets for long-term performance of active transportation assets as part of a complete streets network

- C1. Technology Review for Inventorying Complete Streets Assets
- C2. Current Practices and Needs Review for Complete Streets
- C3. County/City Review of Practices and Needs

Research

- R1. Inventorying Bike and Pedestrian (and ADA) Facilities ✓
- R2. Condition Evaluation Rating System of Bike and Ped Facilities
- R3. Long Term Performance and Forecasting for CS Assets
- R4. AV/CV for CS data collection
- R5. Crowdsourcing for CS data collection ✓
- R6. Network Level Measurement of Bike/Ped Counts
- R7. LCCA & Value of Complete Streets Improvements
- R8. Safety Impacts of Complete Streets Implementation ✓
- R9. Pilot Testing/ Feasibility of Technologies for Inventorying Complete Streets Assets ✓

Development

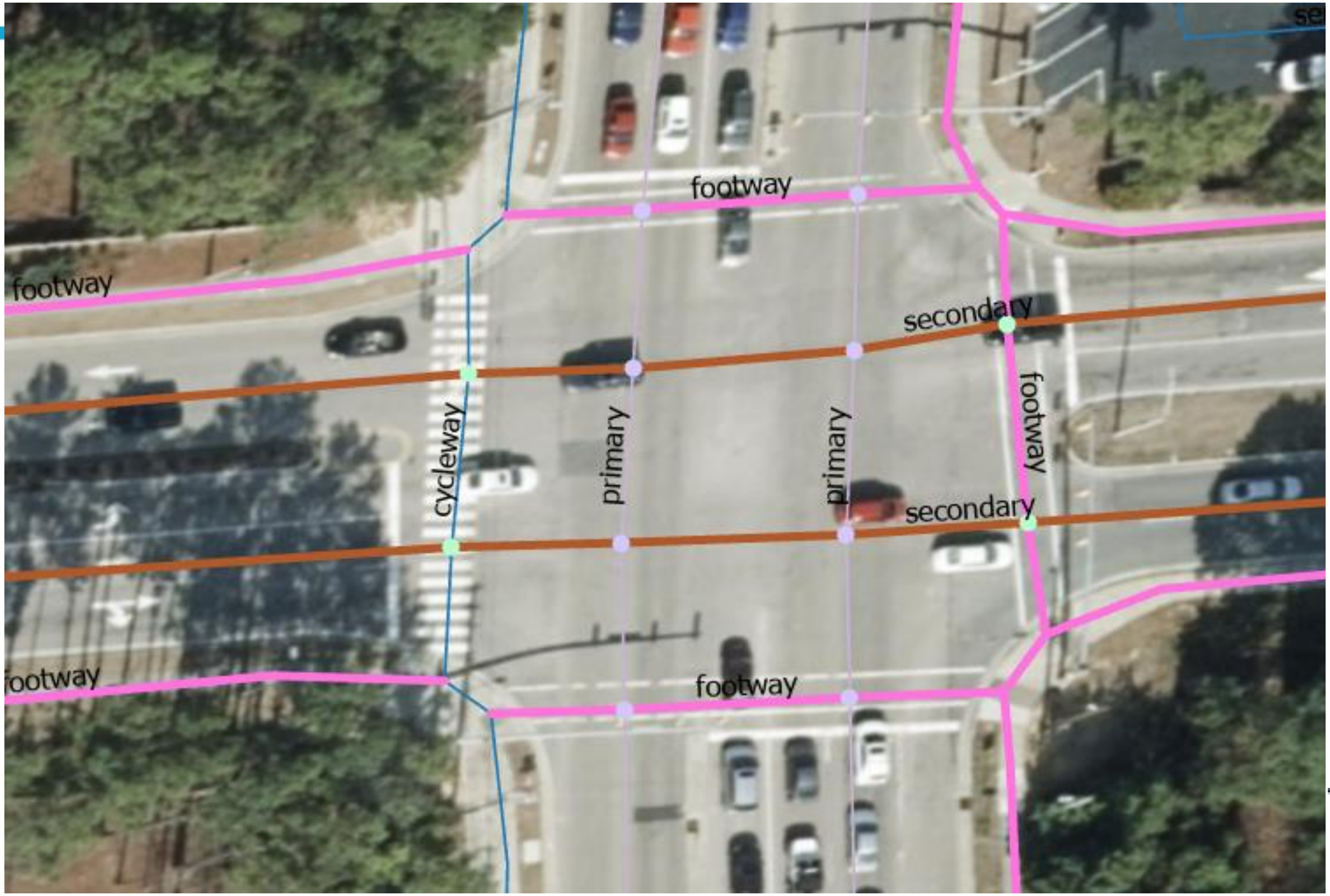
- D1. Guidance for Complete Streets Performance Measures, Targets, and Prioritization
- D2. Database Guidance for Complete Streets Assets ✓
- D3. User Interface for Data Input, Analysis, and Presentation
- D4. Optimized Data Collection Methods for Inventorying Complete Streets ✓

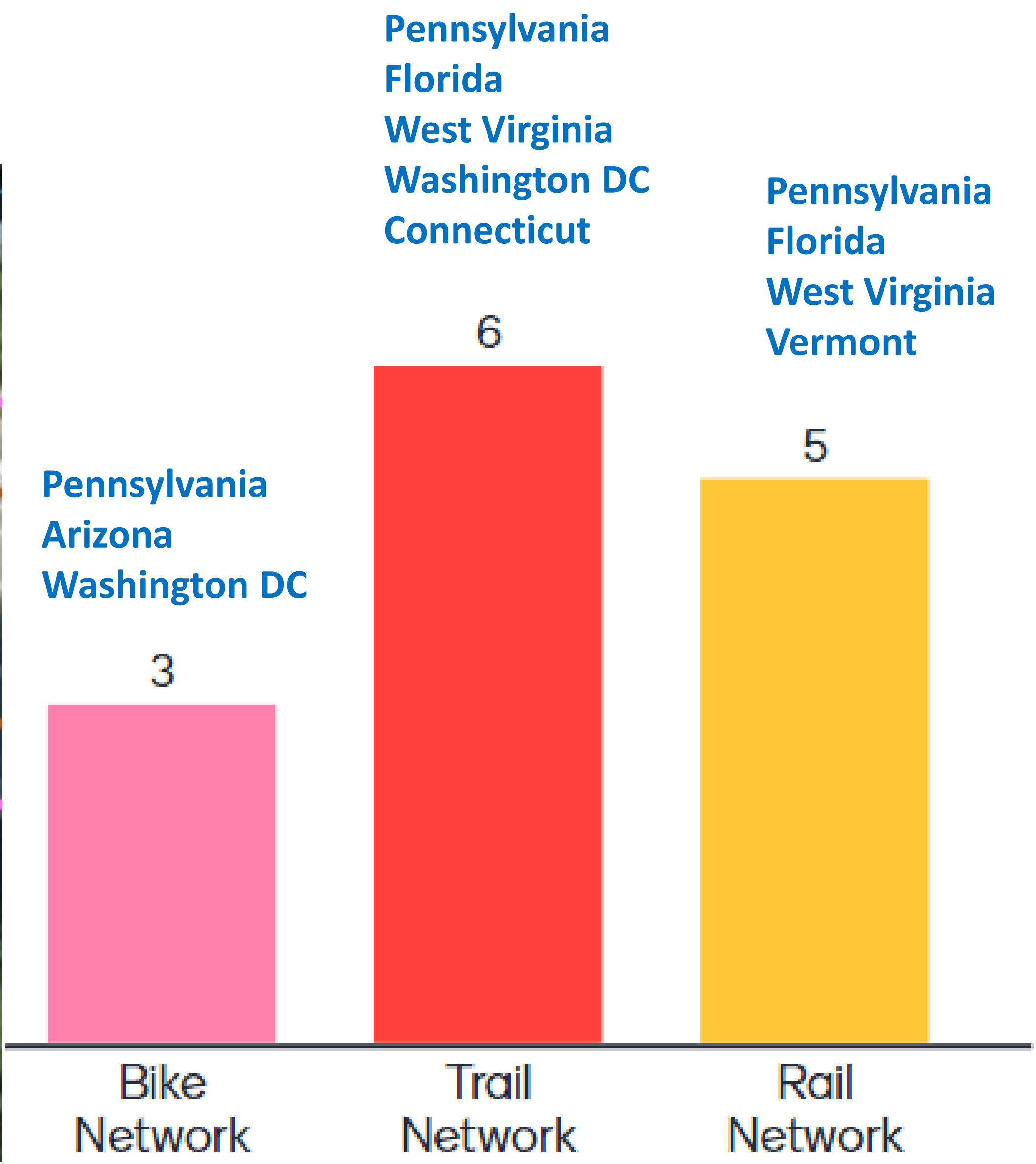
Implementation

- I1. Best Practices for Organizational Structures to Support CS
- I2. Best Practices to Encourage Interagency Collaboration for CS ✓
- I3. Training for Complete Streets Condition Evaluation and Prioritization
- I4. National Standards for Complete Streets Targets and Data Collection ✓

Current Project

States with Routes for Bike, Ped/Trail, Rail Networks

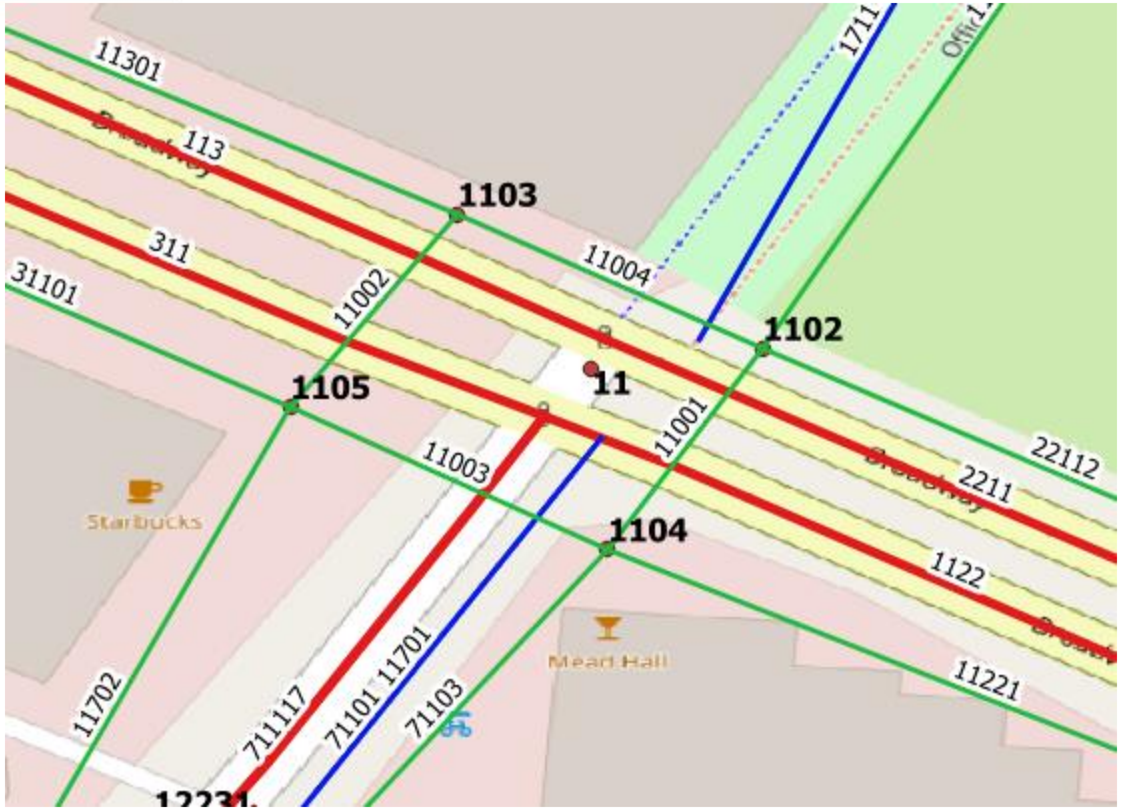




Number of Responses: 9

Generalized Modeling Network Specification (GMNS)

Modeling Multimodal, MIRE-Compliant Signalized Intersection from ARNOLD and NG911 Roads

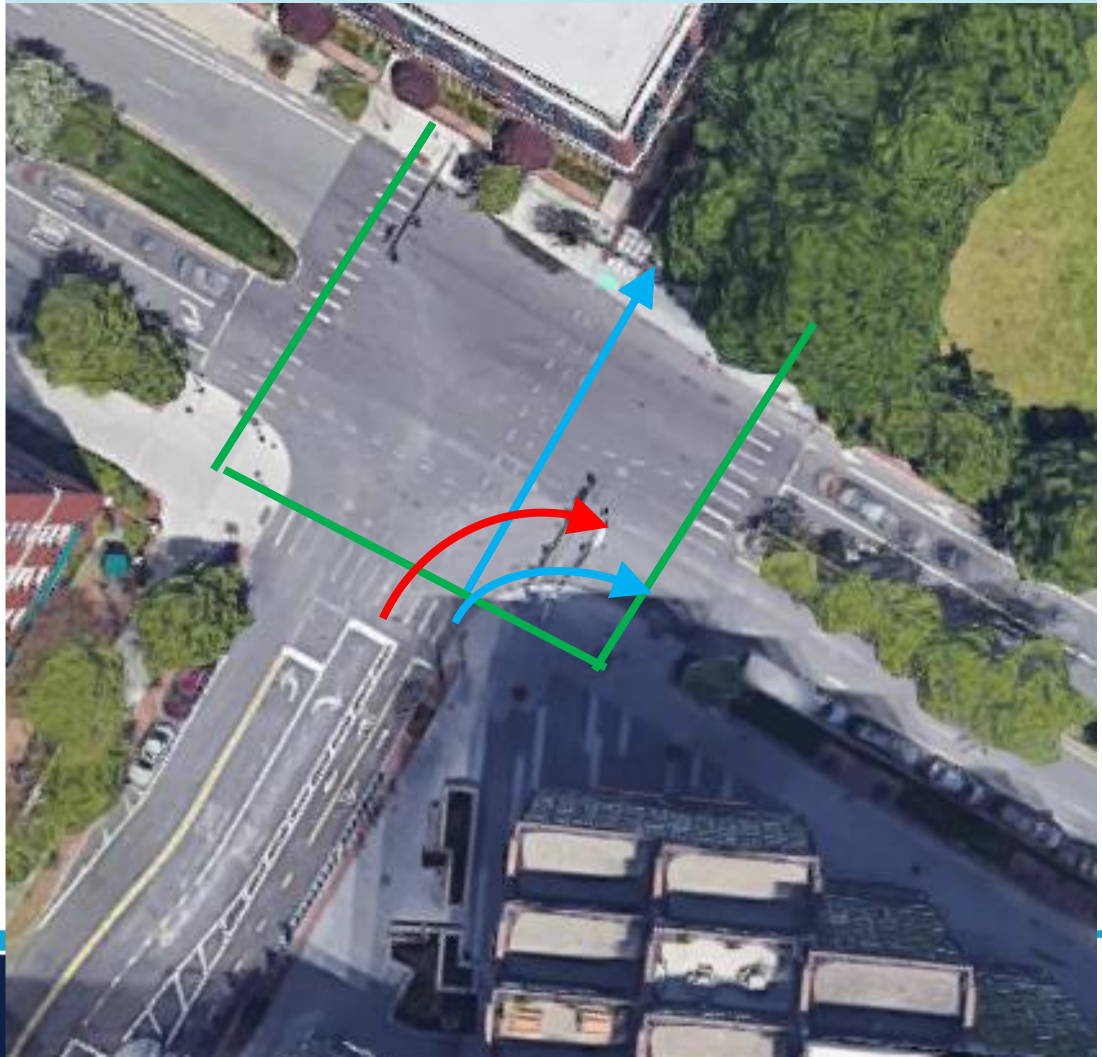


Red: Vehicle links and movements

Blue: Cycle track links and movements

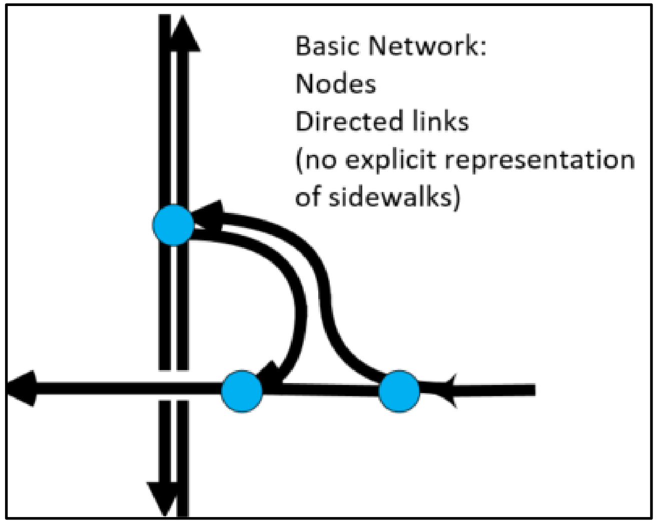
Green: Pedestrian links and crosswalks

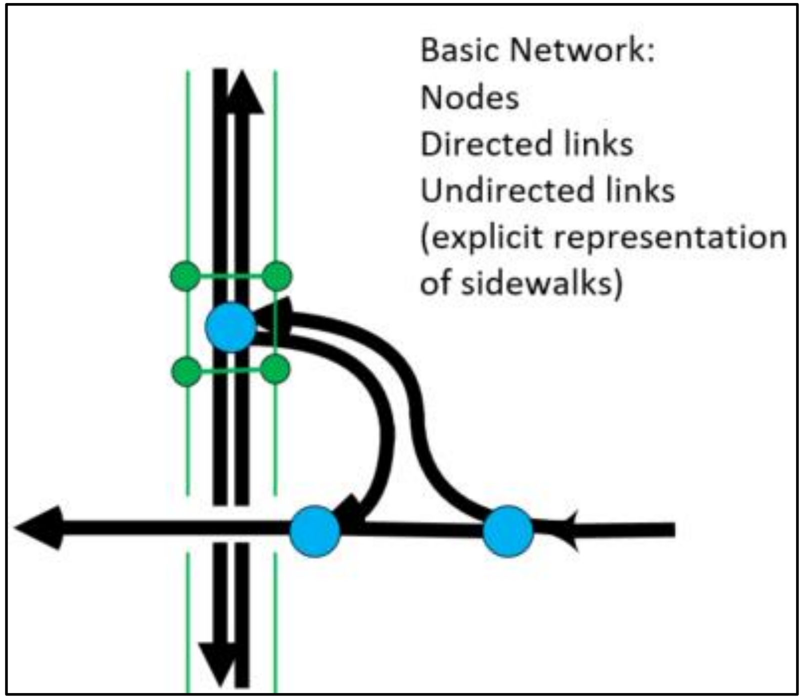
Selected Movements from Ames St.

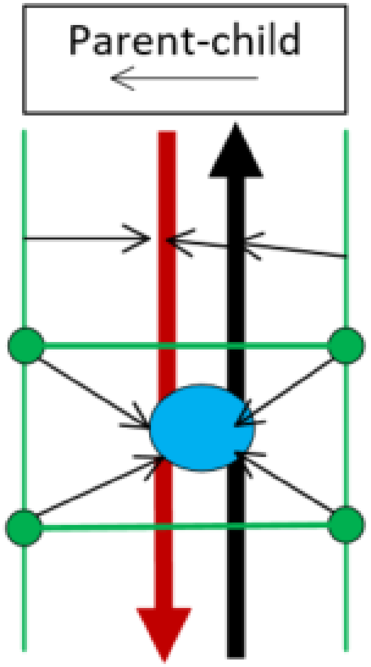


AEGIST Data Model with GMNS Multiresolution Representation

- Link level
- Lane level

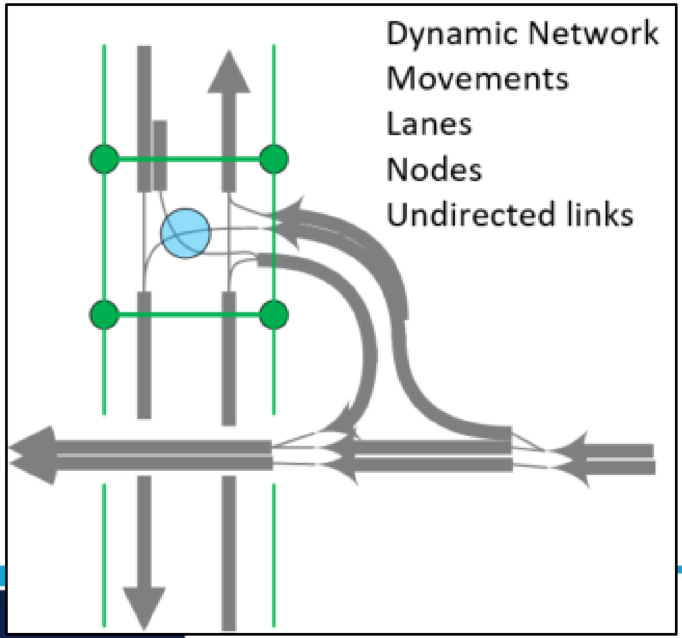


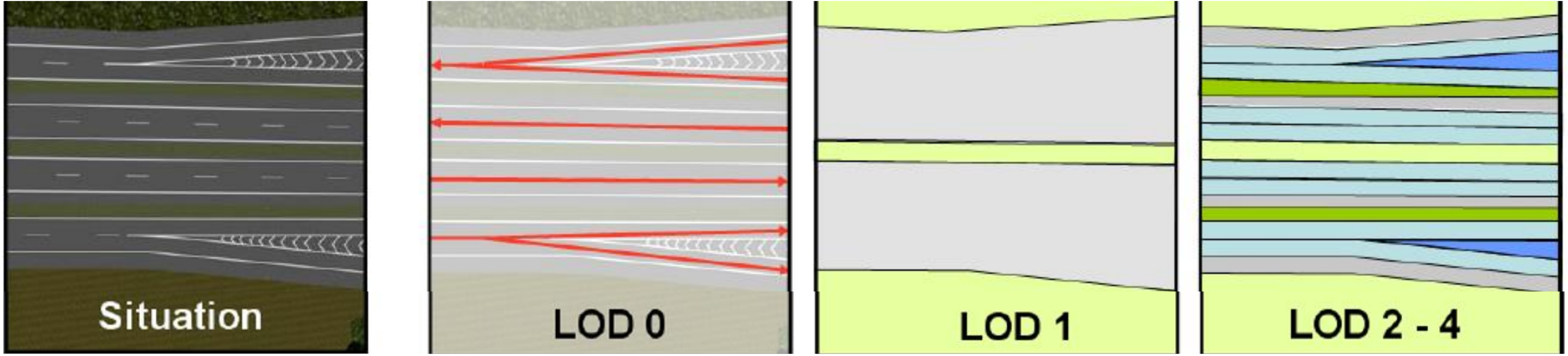




Links may have parent links
- Sidewalks to adjacent roads
- One side of a road to the other
(consider the case where the only link with shapepoints is the red link)

Nodes may have parent nodes
-Associate crosswalk entrances with signals





Level-of-Detail (LOD) (Geometry)

Source: CityGML

TransportationComplex provides linear network with line objects

→ line objects

TransportationComplex provides surface geometry describing the actual shape of the object

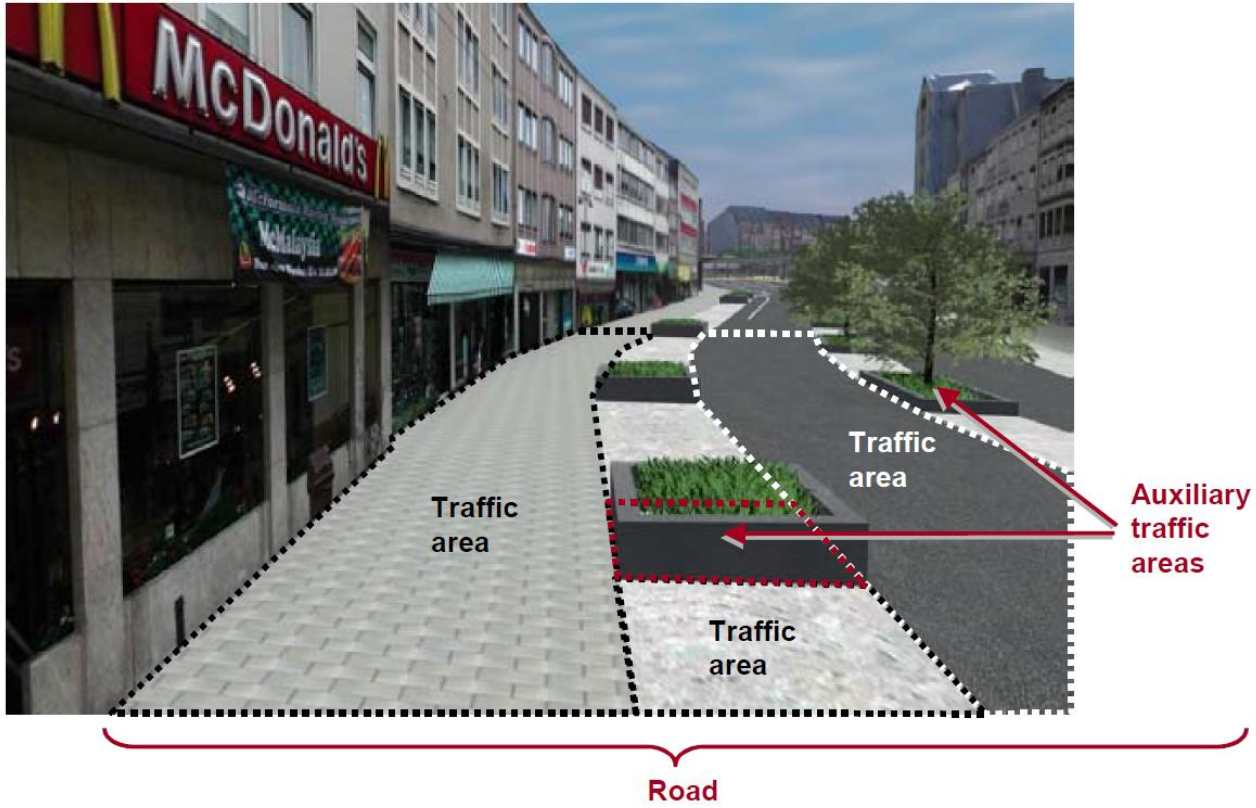
- TransportationComplex (Surface geometry)
- Terrain surface

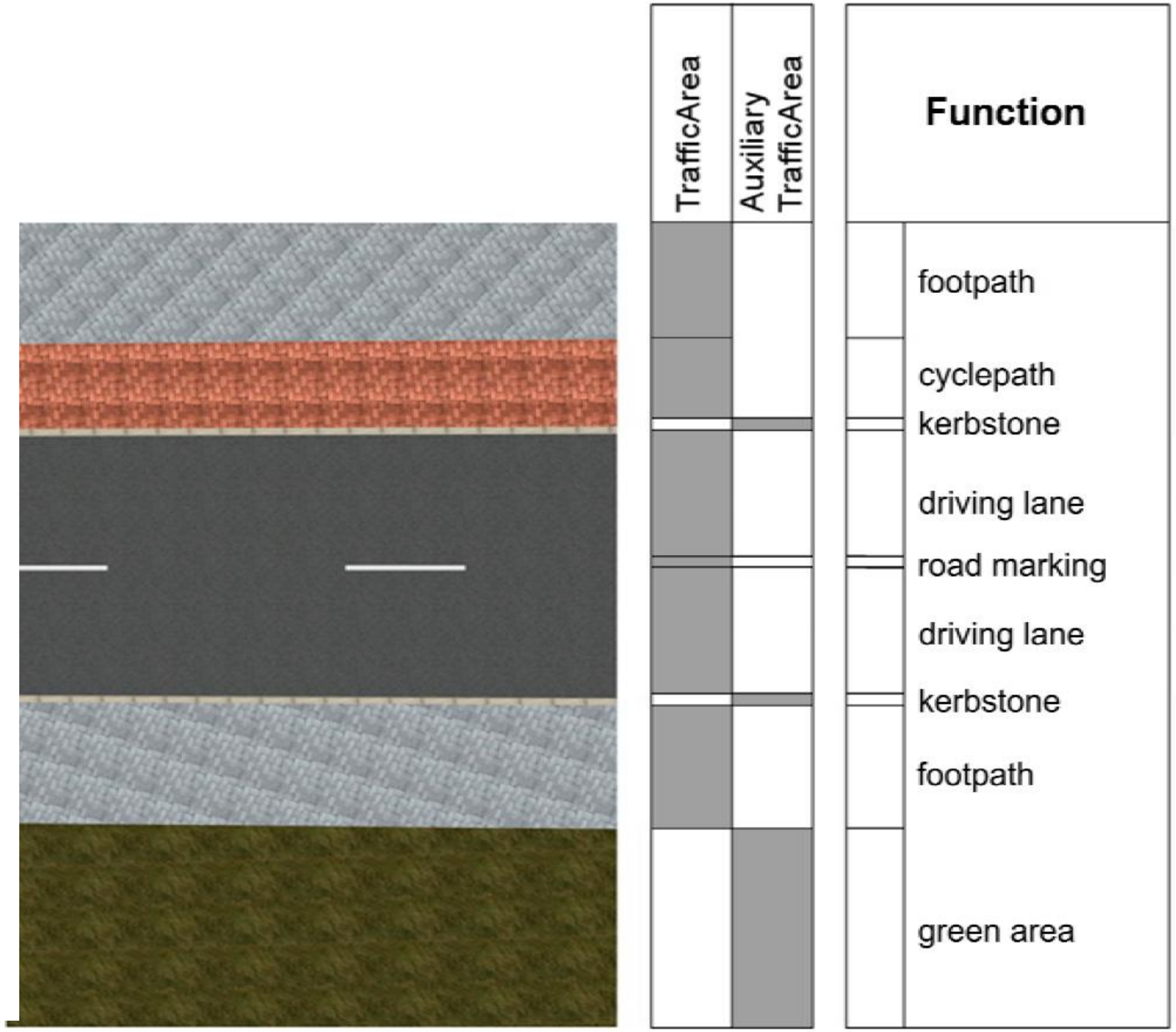
Surface geometry is devided thematically into TrafficAreas, like:

- Traffic – cars
- Traffic – emergency lane
- Traffic – restricted area
- Auxiliary - grass

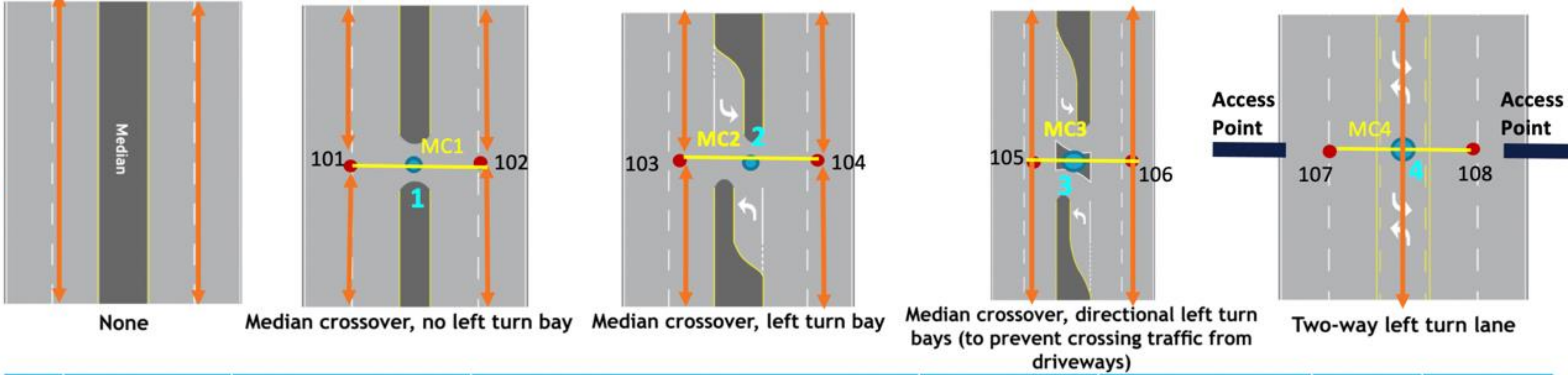
Use Case	Project Planning	Project Delivery	Operations & Maintenance
Project Information Modeling in FMIS & DOT PPMS	LOD 0, LOD 1	LOD 0, LOD 1	
Complete Streets for Highway Safety Analysis	LOD-0, 1, 2-4		LOD 0, LOD 1, LOD 2-4
Asset Inventory & Performance, ARNOLD Reporting			LOD 0
Travel Demand Modeling, Freight OD-Routes Analysis			LOD 0
Traffic Design Model Simulation		LOD 2-4	
Roadway Geometry (Alignment, Pavement Cross-section, Profile)		LOD 1, LOD 2-4	
Point Cloud Classification and Asset Data Extraction from Lidar			LOD 2-4

CityGML Road Network Model Elements






23:CAR_COLLISION
Detecting Pedestrian and Vehicle Conflicts, Crashes in an Intersection



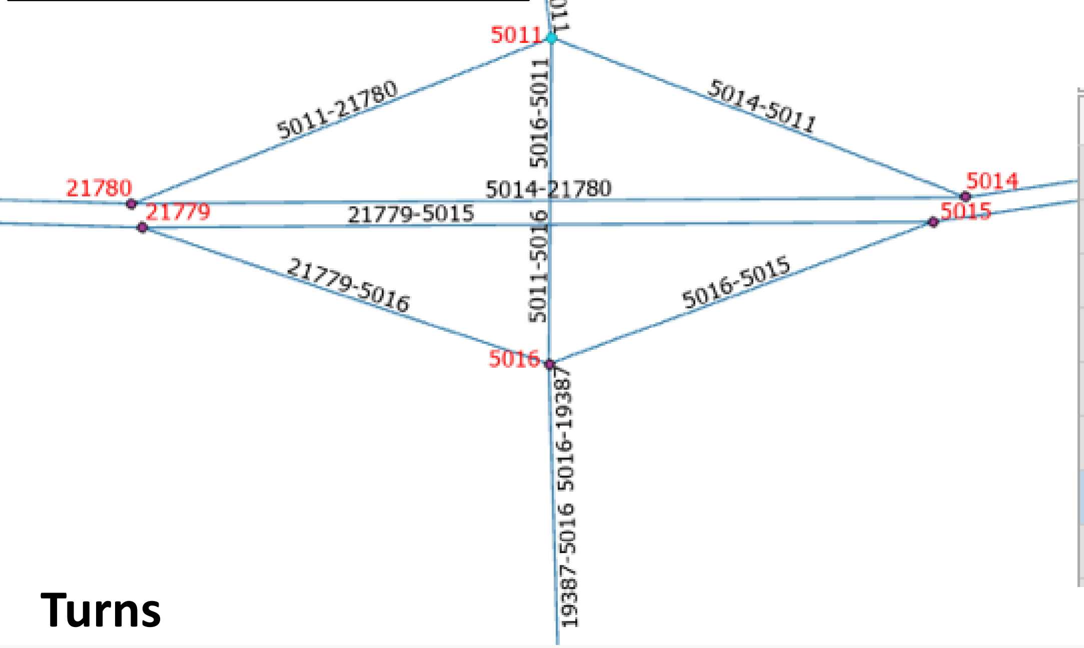
INT ID	Intersection Name	Intersection Type (MIRE-111)	Geometry Type (MIRE-126)	Traffic Control Type (MIRE-121)	Signalization Presence Type (MIRE-122)	No. of Legs (MIRE-125)	Geometry (XYZm)
1	Median Cut Int 1	1 - Roadway/Roadway	7- Non-Conventional Intersection - Median U-Turn	1 - Uncontrolled	5 - Unsignalized	0	X_1,Y_1,Z_1,m_1
2	Median Cut Int 2	1 - Roadway/Roadway	7 - Non-Conventional Intersection - Median U-Turn	1 - Uncontrolled	5 - Unsignalized	0	X_2,Y_2,Z_2,m_2
3	Median Cut Int 3	1 - Roadway/Roadway	7 - Non-Conventional Intersection - Median U-Turn	1 - Uncontrolled	5 - Unsignalized	0	X_3,Y_3,Z_3,m_3
4	Median Cut Int 4	1 - Roadway/Roadway	7 - Non-Conventional Intersection - Median U-Turn	1 - Uncontrolled	5 - Unsignalized	0	X_4,Y_4,Z_4,m_4

Junc.ID	INT ID	Geom.
101	1	X_1,Y_1,Z_1
102	1	X_2,Y_2,Z_2
103	2	X_3,Y_3,Z_3
104	2	X_4,Y_4,Z_4
105	3	X_3,Y_3,Z_3
106	3	X_4,Y_4,Z_4
107	4	X_3,Y_3,Z_3
108	5	X_4,Y_4,Z_4

Median Crossover ID	Median Crossover Name	Begin Junction ID	End Junction ID	Route ID	Begin, End Measure	Median Crossover Type (MIRE-62)	....	Geometry
1	MC 1	101	102			No Left Turn Bay		$[X_1,Y_1,Z_1]$
2	MC 2	103	104			Left Turn Bay		$[X_2,Y_2,Z_2]$
3	MC 3	105	106			Directional Left Turn Bay		$[X_3,Y_3,Z_3]$
4	MC 4	107	108			Two-way left Turn Lane		$[X_4,Y_4,Z_4]$

[9] Modeling Turns

Michigan Travel Demand Modeling Network (Emme)



Nodes: A Node does not have to be at an Intersection, e.g.: CT Tie Points

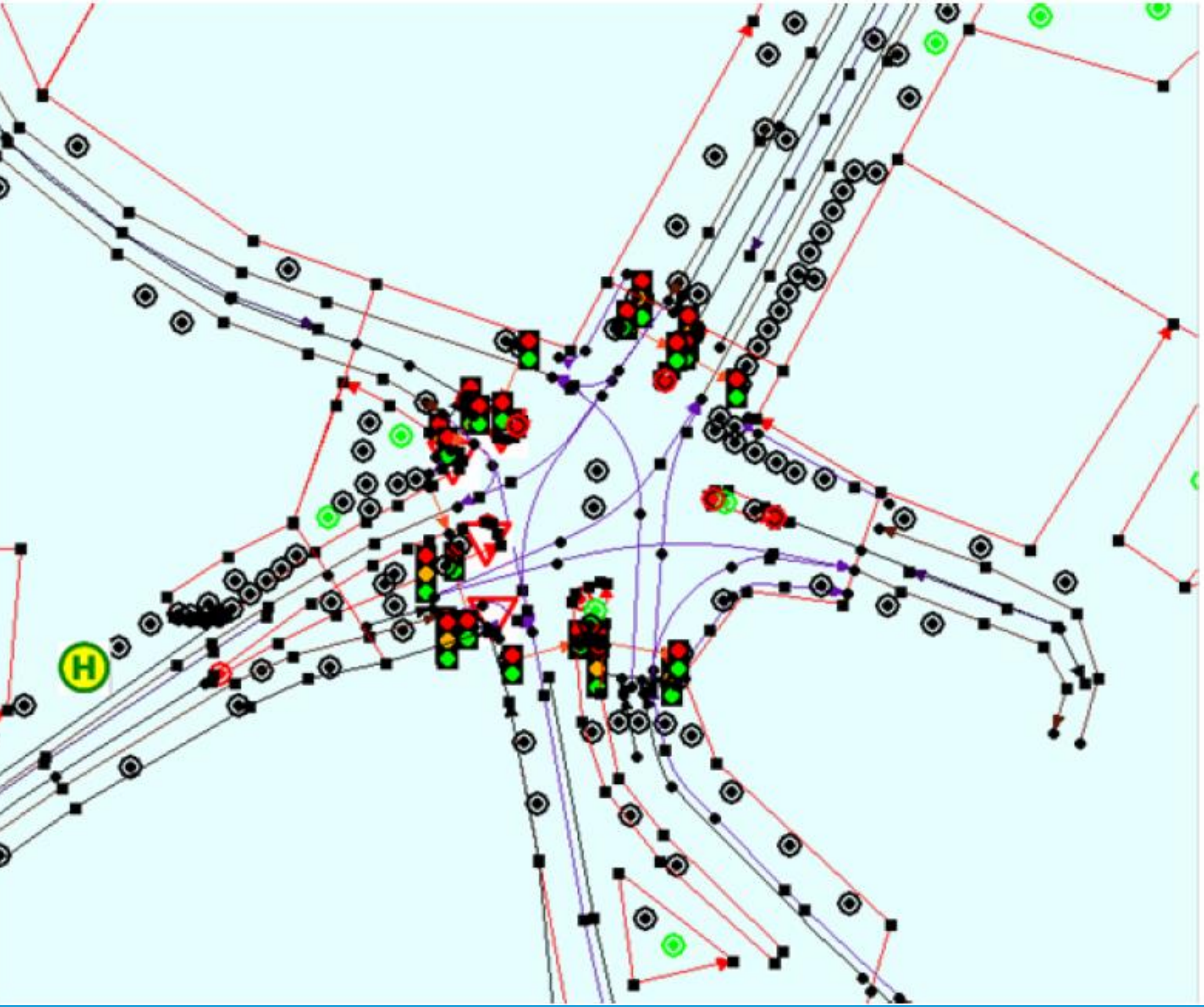
FID	Shape	ID	X	Y	DATA1	DATA2	DATA3	ISZONE	ISINTERSEC
1971	Point	5011	302824.18757	1750232.1251	0	0	0	0	1
1972	Point	5012	303237.28123	1713073.9999	0	0	0	0	0
1973	Point	5013	302948.28115	1713000.625	0	0	0	0	0
1974	Point	5014	303619.90612	1752033.0001	0	0	0	0	0
1975	Point	5015	303722.56241	1751880.125	0	0	0	0	0
1976	Point	5016	304274.68762	1750151.9999	0	0	0	0	1
1977	Point	5017	308747.37487	1833742.375	0	0	0	0	1
1978	Point	5018	310742.31248	1834809.9999	0	0	0	0	0

Turns

OID	ID	JNODE	INODE	KNODE	TPF	DATA1	DATA2	DATA3	@avaut	@avbqt	@avh2t	@avh3t	@avhqt	@avlqt
0	5014-5011-5016	5011	5014	5016	-1	0	0	0	33.200001	9.200001	1.43534	0.302932	133.20001	3
1	5014-5011-21780	5011	5014	21780	0	0	0	0	0	0	0	0	0	0
2	5014-5011-23853	5011	5014	23853	-1	0	0	0	95.089836	42.199997	16.715115	4.339508	3313.8748	14.8
3	5016-5011-5016	5011	5016	5016	0	0	0	0	0	0	0	0	0	0
4	5016-5011-21780	5011	5016	21780	-1	0	0	0	2.4	0	0.032135	0.007318	1.6	0
5	5016-5011-23853	5011	5016	23853	-1	0	0	0	310.98734	195.79999	44.966614	12.196842	7051.7607	44.600002
6	23853-5011-5016	5011	23853	5016	-1	0	0	0	135.8	34.400002	7.572992	1.774333	2145.1406	9.6
7	23853-5011-21780	5011	23853	21780	-1	0	0	0	610.44226	308.18484	86.436714	23.787447	10592.301	37.374294

Complex Urban Intersection Modeling, Complete Streets

Source: CityGML

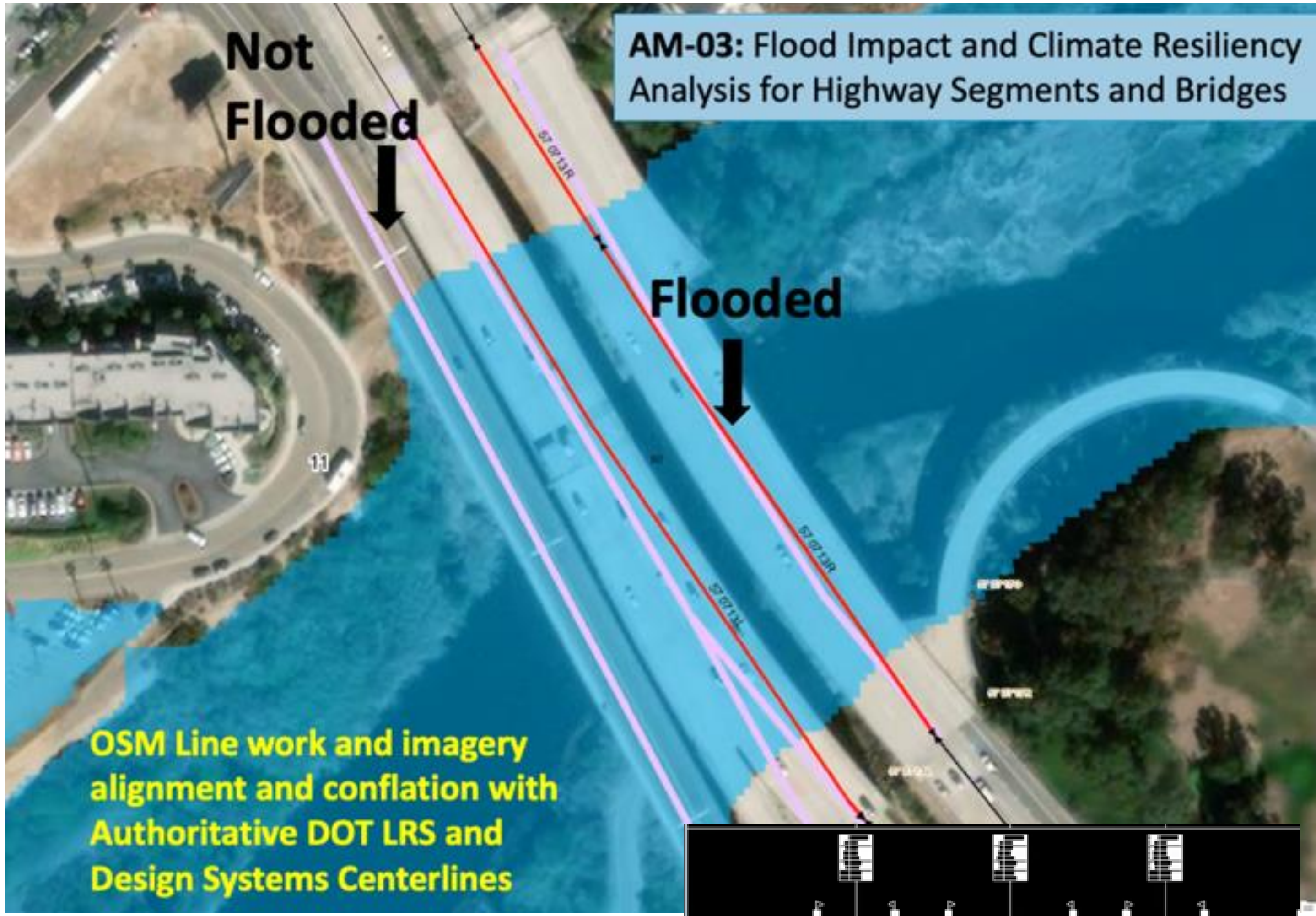


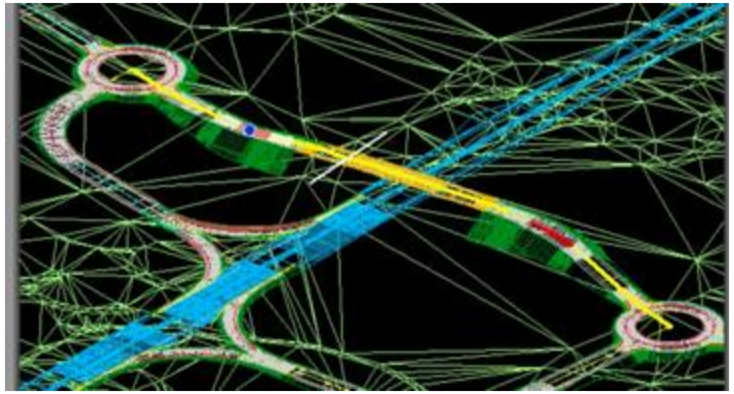
Routes Model

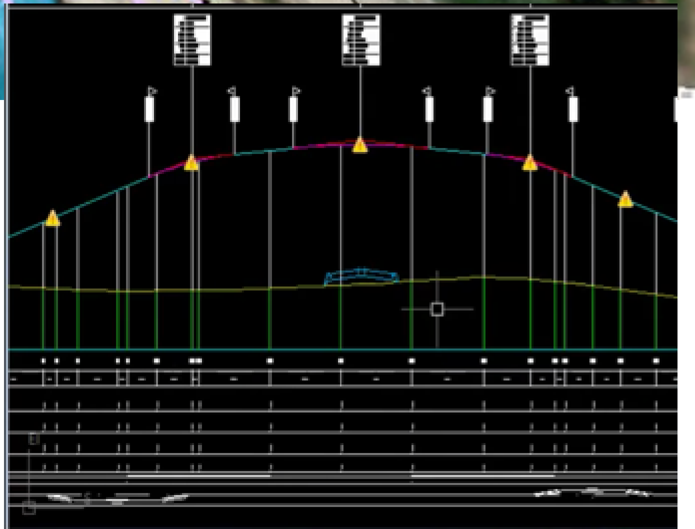
Publish Routes with Z-Values

Business Use Cases

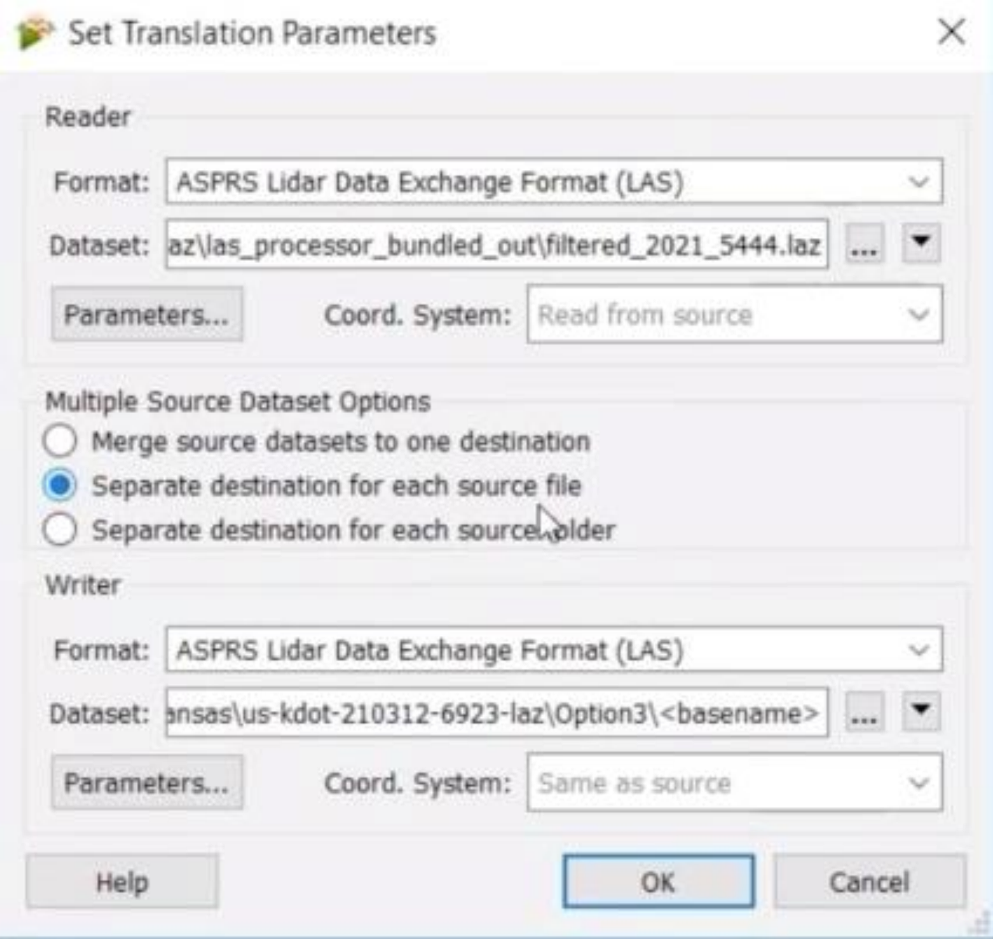
1) Calibrating Measure values for Routes
2) Distinguishing at-grade intersections vs. Under/Overpasses for Routing, Analysis
    a) Freight Routing based on vertical clearance, bridges
    b) Oversized/Overweight Vehicle Routing
3) Geometric Safety Analysis (Curve, Grade)
    a) Vertical Curves for Safety
    b) Spatial Econometric Models for Safety Performance Functions
4) Asset Management: Risk & Resiliency Analysis
    a) Flood Impact Analysis
    b) Rockfall Analysis
    c) Snow Removal (Identifying Steep Hills)
    d) Estimating Resurfacing Volumes
    e) Slope & Superelevation Calculations
    f) Vertical Bridge Clearance
5) Other?

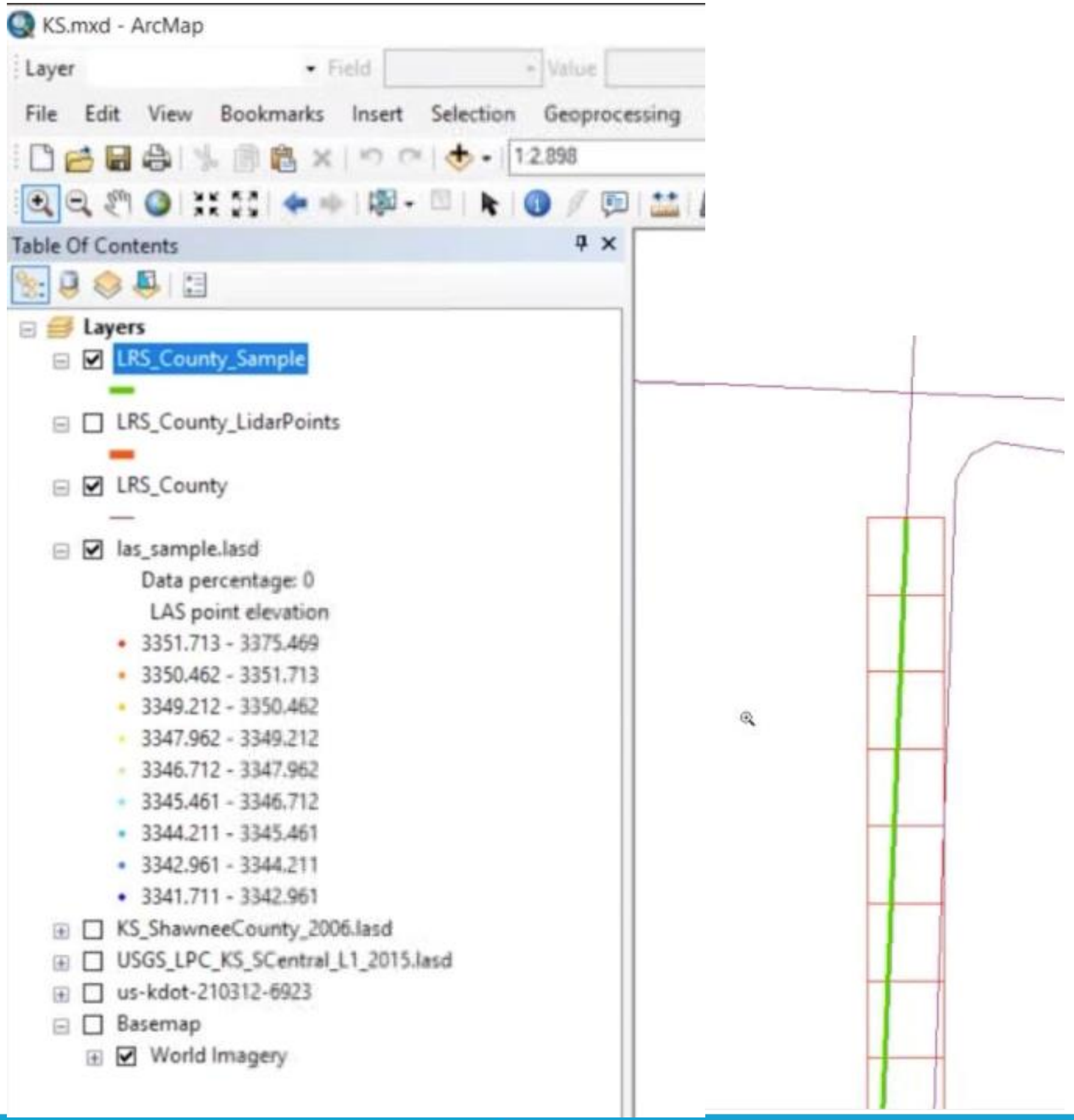




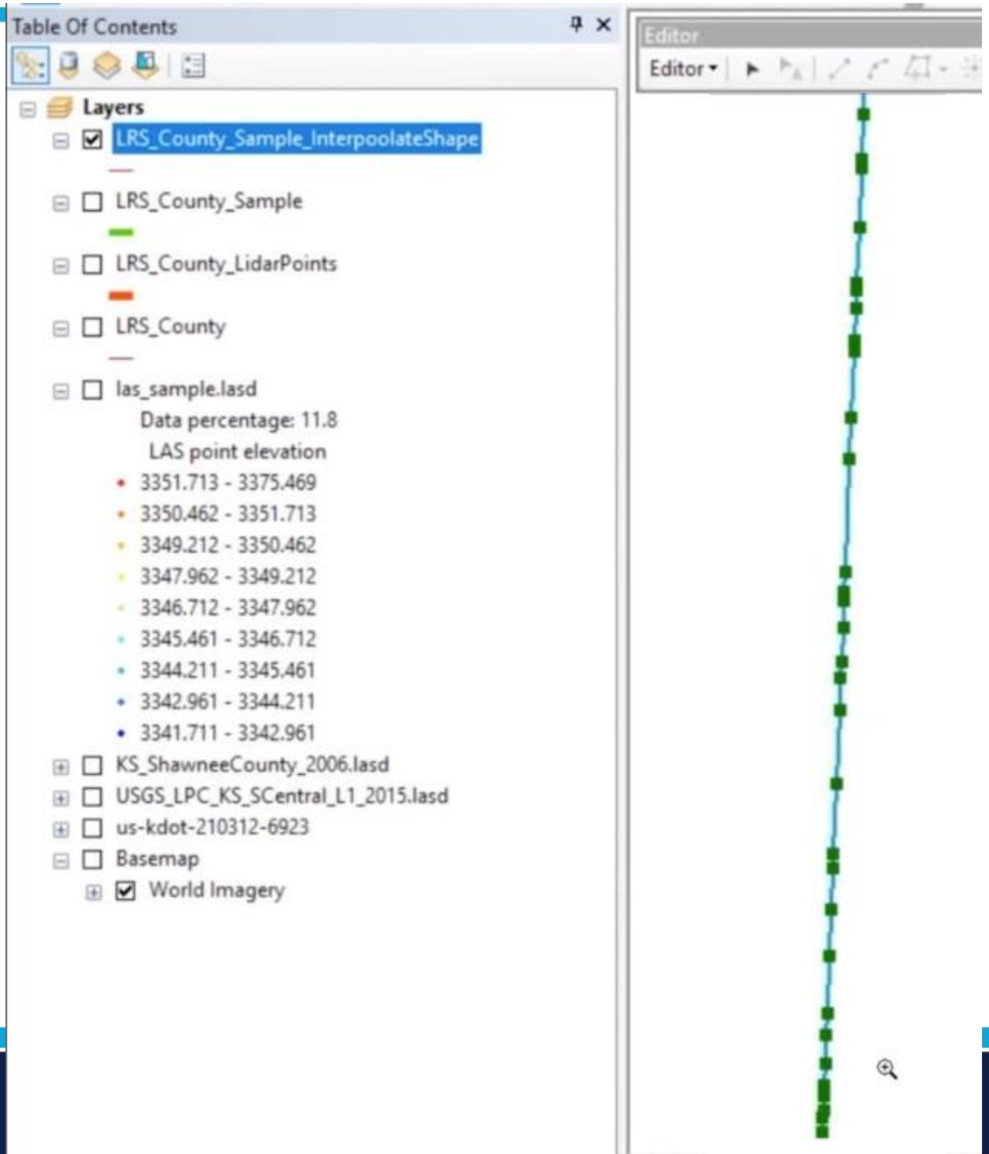


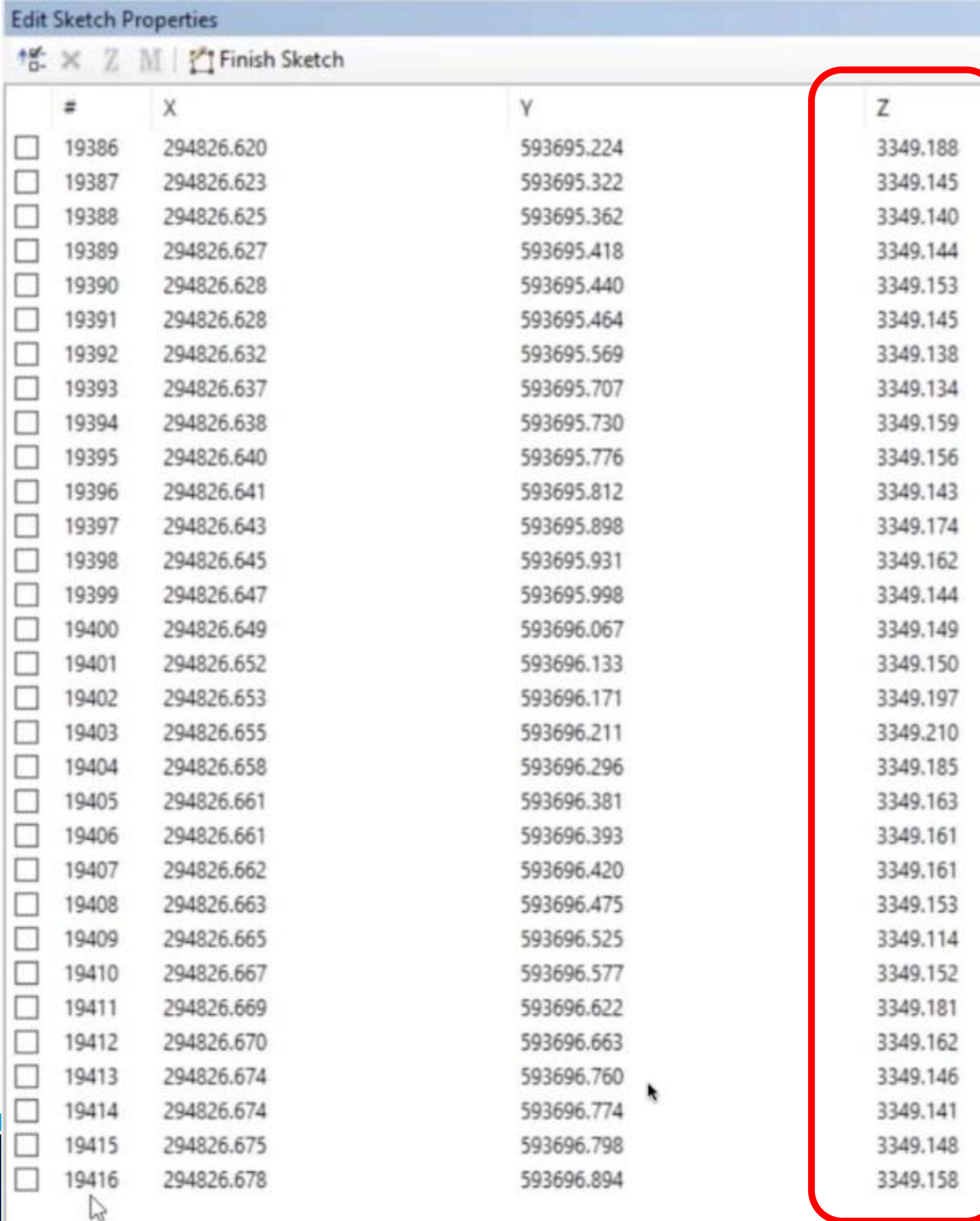
Develop and publish 3D Roads Data Model





Develop and publish 3D Roads Data Model





#	X	Y	Z
19386	294826.620	593695.224	3349.188
19387	294826.623	593695.322	3349.145
19388	294826.625	593695.362	3349.140
19389	294826.627	593695.418	3349.144
19390	294826.628	593695.440	3349.153
19391	294826.628	593695.464	3349.145
19392	294826.632	593695.569	3349.138
19393	294826.637	593695.707	3349.134
19394	294826.638	593695.730	3349.159
19395	294826.640	593695.776	3349.156
19396	294826.641	593695.812	3349.143
19397	294826.643	593695.898	3349.174
19398	294826.645	593695.931	3349.162
19399	294826.647	593695.998	3349.144
19400	294826.649	593696.067	3349.149
19401	294826.652	593696.133	3349.150
19402	294826.653	593696.171	3349.197
19403	294826.655	593696.211	3349.210
19404	294826.658	593696.296	3349.185
19405	294826.661	593696.381	3349.163
19406	294826.661	593696.393	3349.161
19407	294826.662	593696.420	3349.161
19408	294826.663	593696.475	3349.153
19409	294826.665	593696.525	3349.114
19410	294826.667	593696.577	3349.152
19411	294826.669	593696.622	3349.181
19412	294826.670	593696.663	3349.162
19413	294826.674	593696.760	3349.146
19414	294826.674	593696.774	3349.141
19415	294826.675	593696.798	3349.148
19416	294826.678	593696.894	3349.158

LRS Centerline Management & Governance

- **Administration Level 1: Multiple Centerline Geometries**
  - DOTs manage all DOT Roads. Local roads managed by DOTs and/or Local agencies, who provide data to DOTs for updating All Roads dataset
  - Multiple Road Centerline geometry sources used to add data to DOT LRS. These sources include: DOT CAD/BIM, NG911, HERE, INRIX XD Segments, Traffic Message Channel (TMC) Sections, Open Street Maps (OSM) Ways
  - Different geometries allowed to co-exist (for the same road). Each geometry is managed by individual agencies. They are used by agencies for supporting mutually exclusive business processes.
- **Administration Level 2: Integrated Centerline Geometries Based on Ownership**
  - DOT manages DOT Roads only. Established rules for integrating data from local agencies and/or NG911 into DOT LRS.
  - DOT integrates roads data from local agencies using edge matching and administrative boundary points
  - Roadway alignment data integrated automatically from DOT Design System to create new centerlines and/or process realignments
- **Administration Level 3: Conflated Centerline Geometries**
  - Road Centerlines from Public and Private sector agencies are conflated using a set of centerline conflation rules. Goal is to create one road centerline for referencing transportation data & modeling 1.5D/2D/3D Geometry Roads
  - Changes are detected automatically and change proposals created to reconcile differences in centerline across agencies
  - Road data conflated from external community and/or proprietary roads data sources (e.g.: OSM, HERE, INRIX, Geotab) to support business

LRS Centerline Data Integration from Authoritative Sources

- **Administration Level 1:** Multiple Road Centerlines co-exist. At best, locals provide PDF/Paper maps to DOT, who digitizes manually
- **Administration Level 2:** **Integration** of roads data from DOT CAD. NG911/Local roads appended. Automated processes for Data Integration
- **Administration Level 3:** **Conflation** of roads data from received from NG911/Local agencies and/or proprietary, community data sources

		Administration Level 1		Administration Level 2		Administration Level 3	
**Data Sharing Agreement State		DOT Manages All Roads, No Locals Coordination	Local Roads Data Imported and Digitized from PDF/Paper	Importing Roadway Alignment from Design using Automated Tool	Local/NG911 Roads Data Authoritative & Appended to DOT Roads	DOT Conflating Local/NG911 Centerlines Geometry	DOT Conflating Proprietary, Community Roads
1	Arizona				Local to DOT, Append given owner		
2	Caltrans	DOT, No Locals Coordination					
3	Connecticut		Local, Digitize PDF/Paper				
4	Colorado						
5	Florida	DOT, No Locals Coordination					
6	Georgia					Local, Conflate GIS Files?	
7	Idaho		Local, Digitize PDF/Paper				
8	New Mexico				Local to DOT, Append given owner	Local, Conflate GIS Files	
9	North Carolina					Local, Conflate GIS Files	
10	North Dakota	DOT, No Locals Coordination	Local, Digitize PDF/Paper				
11	Ohio**		Local, Digitize PDF/Paper*		Local to DOT, Append given owner*	Local, Conflate GIS Files	
12	Oklahoma		Local, Digitize PDF/Paper				
13	Pennsylvania	DOT, No Locals Coordination					
14	Tennessee	DOT, No Locals Coordination					
15	Texas**					Local, Conflate GIS Files	
16	Vermont				Local to DOT, Append given owner		
17	Washington**		Local, Digitize PDF/Paper			Local, Conflate GIS Files	
18	Washington DC						
19	West Virginia	DOT, No Locals Coordination	DOT/Local?, Digitize PDF/Paper				

Mentimeter

Breakout Session 1:

Open Discussion & Survey

Discuss modeling approach and use cases for:

- **Road Segments and Road Names**:
  - Option 1: Create Road Segments from LRS Routes
  - Option 2: Mange both NG911 RCL and Road Segments created from LRS Routes.
  - Option 3: Integrate NG911 RCL and Street Name Alias Table with ARNOLD Routes. Conflate NG911 RCL Geometry with DOT LRS Geometry
- **Use cases for Integrating Roads** from other sources: NG911, Open Street Maps, HERE, INRIX etc.
  - Freight Routing Analysis
  - Travel Demand Modeling
  - Safety Analysis (including Pedestrian, Bike, Safety)
  - MIRE Reporting
- **Intersection Leg**: Where to begin and end?:
  - Begin where crosswalk intersects route
  - Begin where stop bar intersects route
  - Begin where median end intersects route
  - Other?
- **Turns should be modeled:** Using Links, Nodes

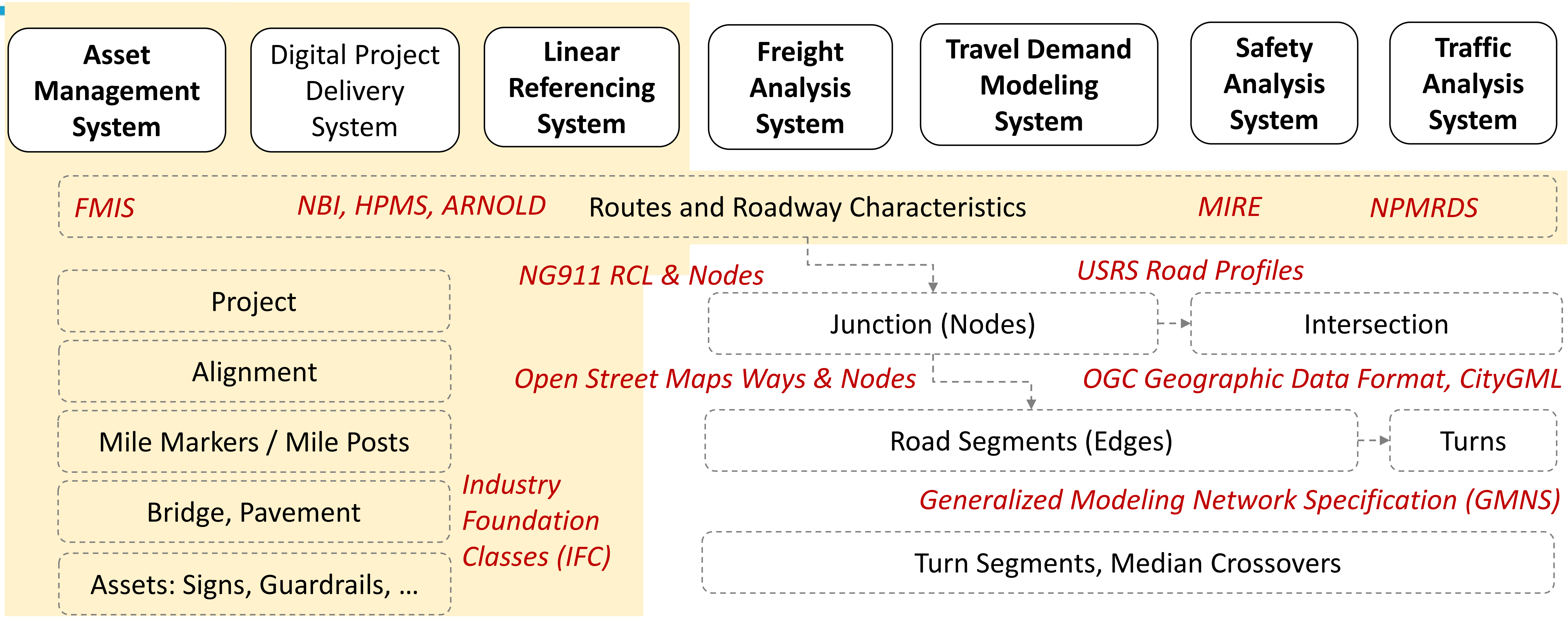
Topic 2: Design/CAD Data Integration

- National BIM-GIS Integration: Design/CAD to GIS Asset Information Model

- Integrating Data from following Design/CAD
  - Existing Practices, Tools & Techniques
    - Pennsylvania Turnpike Commission
    - Connecticut DOT
    - Utah DOT
  - Envisioned IFC Based Process

Topic 2 Objective: Road Network Data Model Development for Enterprise Use

Integrating Asset, Roadway and Project Data from Digital Project Delivery Systems into

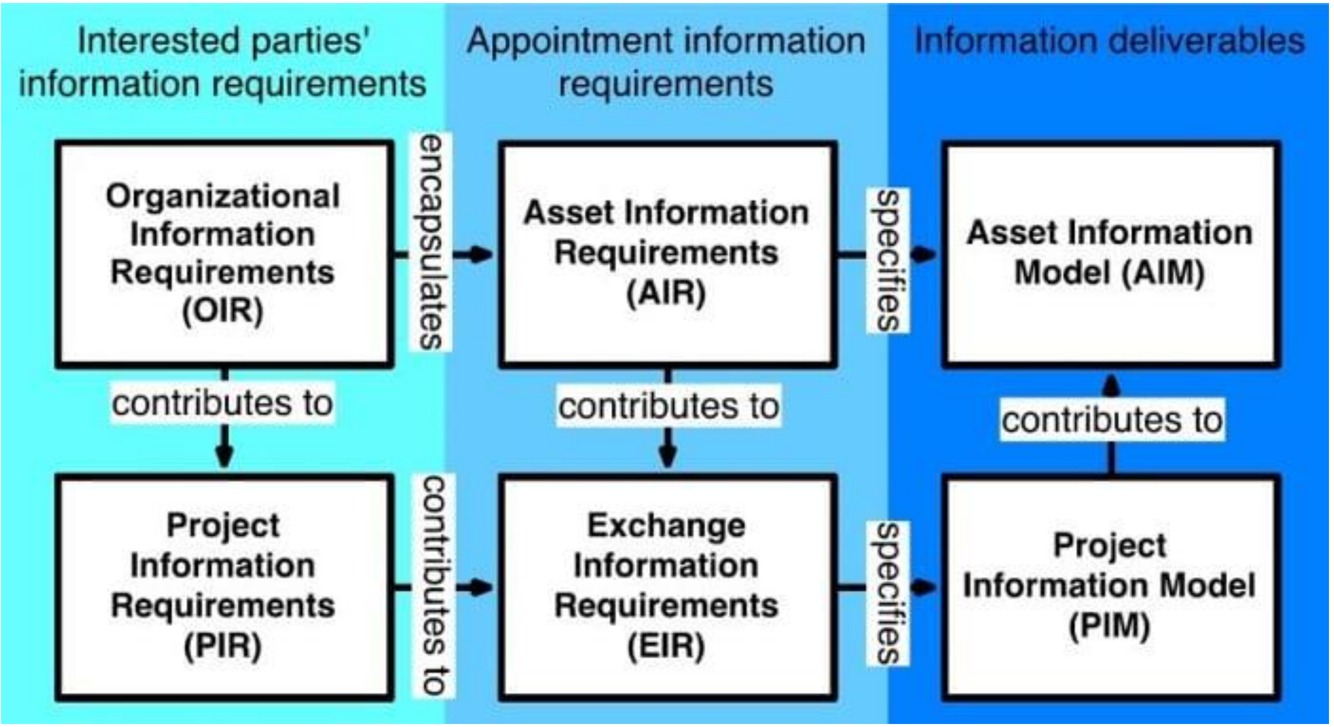


Private Sector Data Vendors – Asset Data (including Roads), Traffic Data, Safety Data, Traveler Data, Lidar Data, Imagery Data

National and International Data Standard Development Organizations – ISO, OGC, W3C, AASHTO, FHWA, buildingSMART, etc

Why Design to GIS/AM Data Exchange?

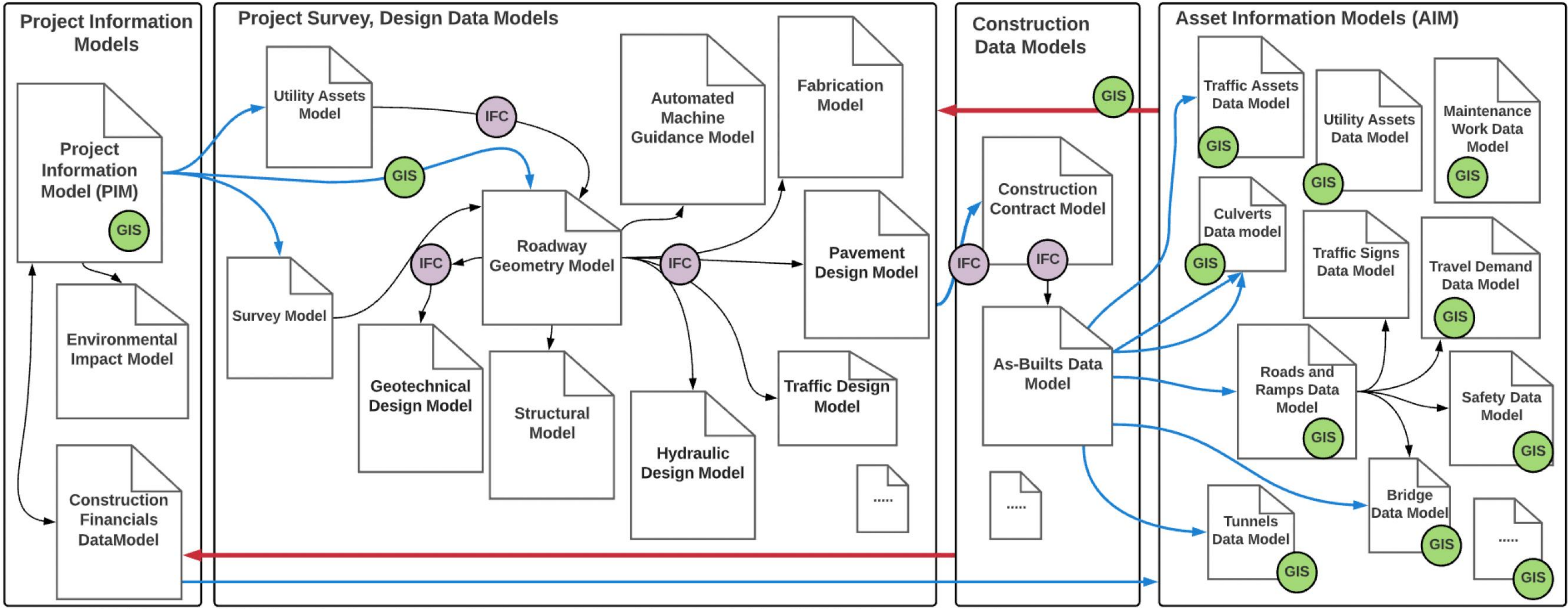
- Road Network Data Stewards need to specify "Asset Information Requirements" for Digital Project delivery Teams (#ISO-19650)
- Most State DOTs working on Digital Delivery Roadmaps for Building Information Modeling. GIS-LRS Personnel will be requested for AIRs.
- Design-Construction Systems now allow for Road Network Data Modeling similar to how Roads Data Model is Setup in GIS-LRS Systems



Road Network Data Modeling at Enterprise Level

Machine Readable Data Models Based on Open Standards

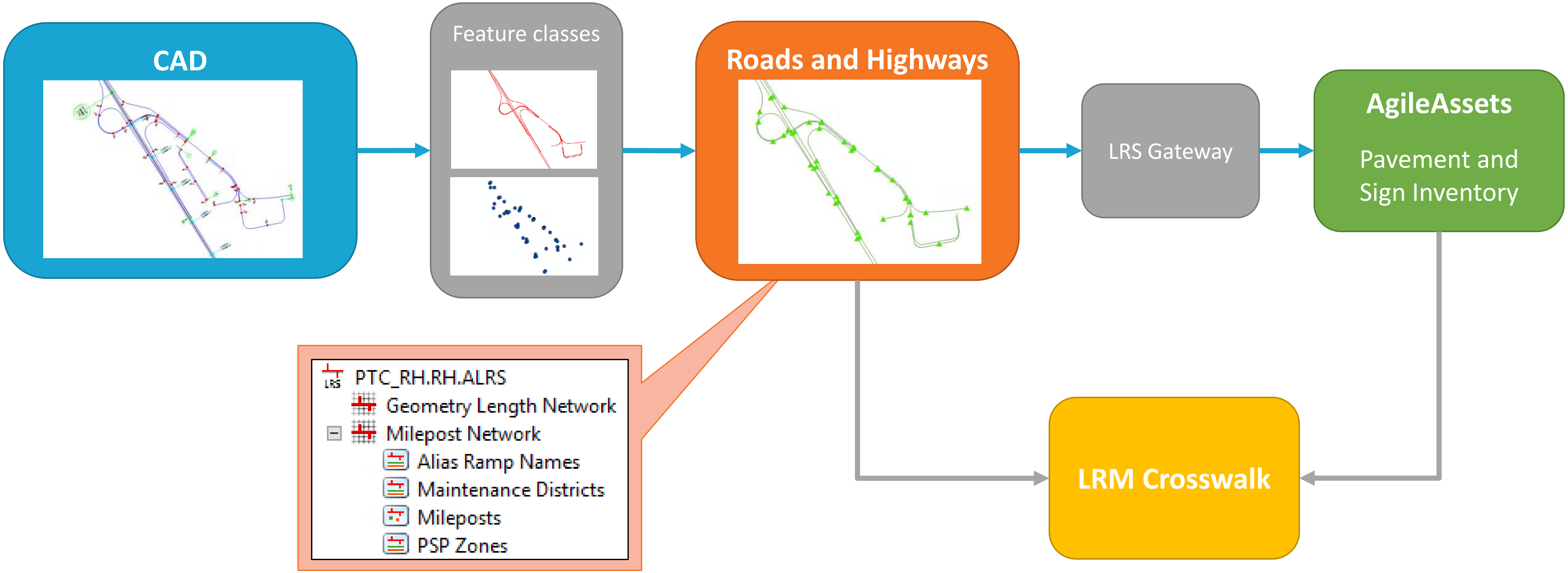
Digital As-Builts Handoff to Asset Management – Data Life Cycle for Roads & Asset Data



Source: Abhishek Bhargava (2021). Governing Data Models and Exchanges in Building Information Modeling (BIM) for Infrastructure. IHEEP.

Pennsylvania Turnpike Commission: Design/CAD to GIS

Route centerlines, mileposts, and stationing



PTC: Design/CAD

Route centerlines, mileposts, and stationing

PTC: Milepost LRM Events and Use Cases

CAD TravelLaneMilePosts
CAD TravelLane
R&H Mileposts events
R&H Milepost Network

CAD TravelLaneMilePosts

ROUTEID	MILEPOSTNUMBER	STATION
ANB	036.1	330+69

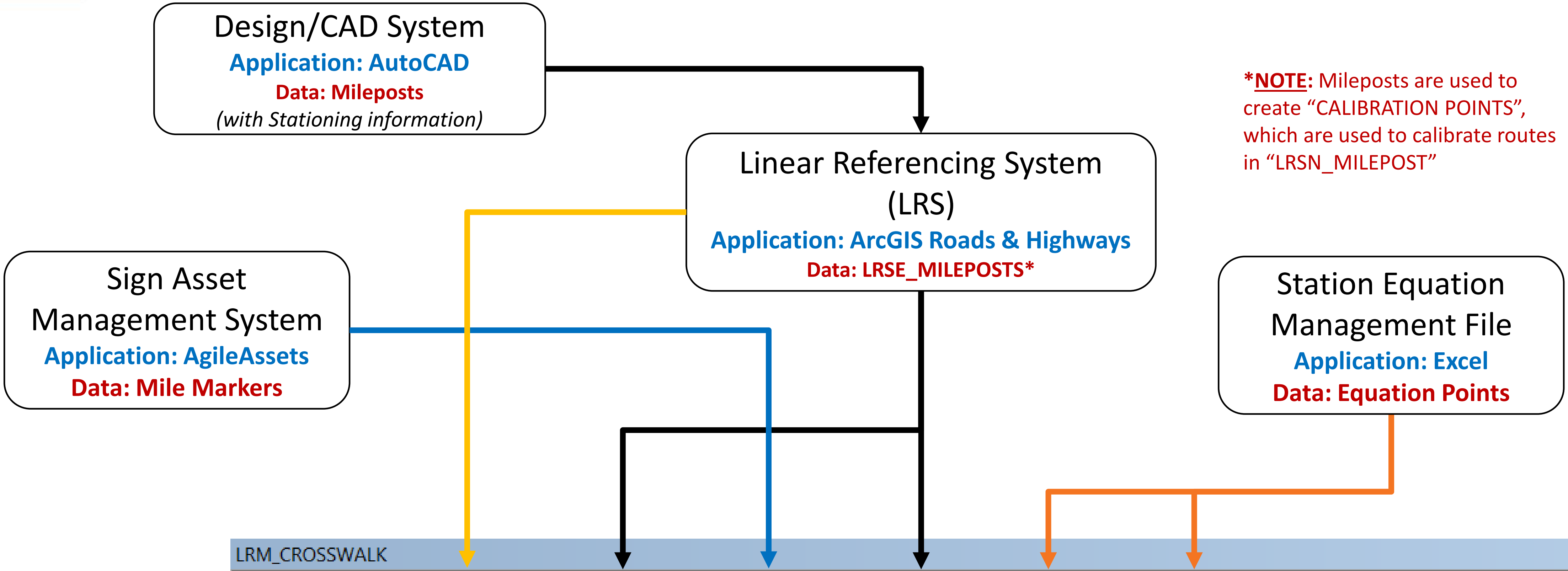
0 (1 out of 16124 Selected)

CAD TravelLaneMilePosts

R&H Mileposts events

Route ID	Measure	Milepost Number TEXT	Station
ANB	36.1	036.10	870+09

PTC LRM Crosswalk

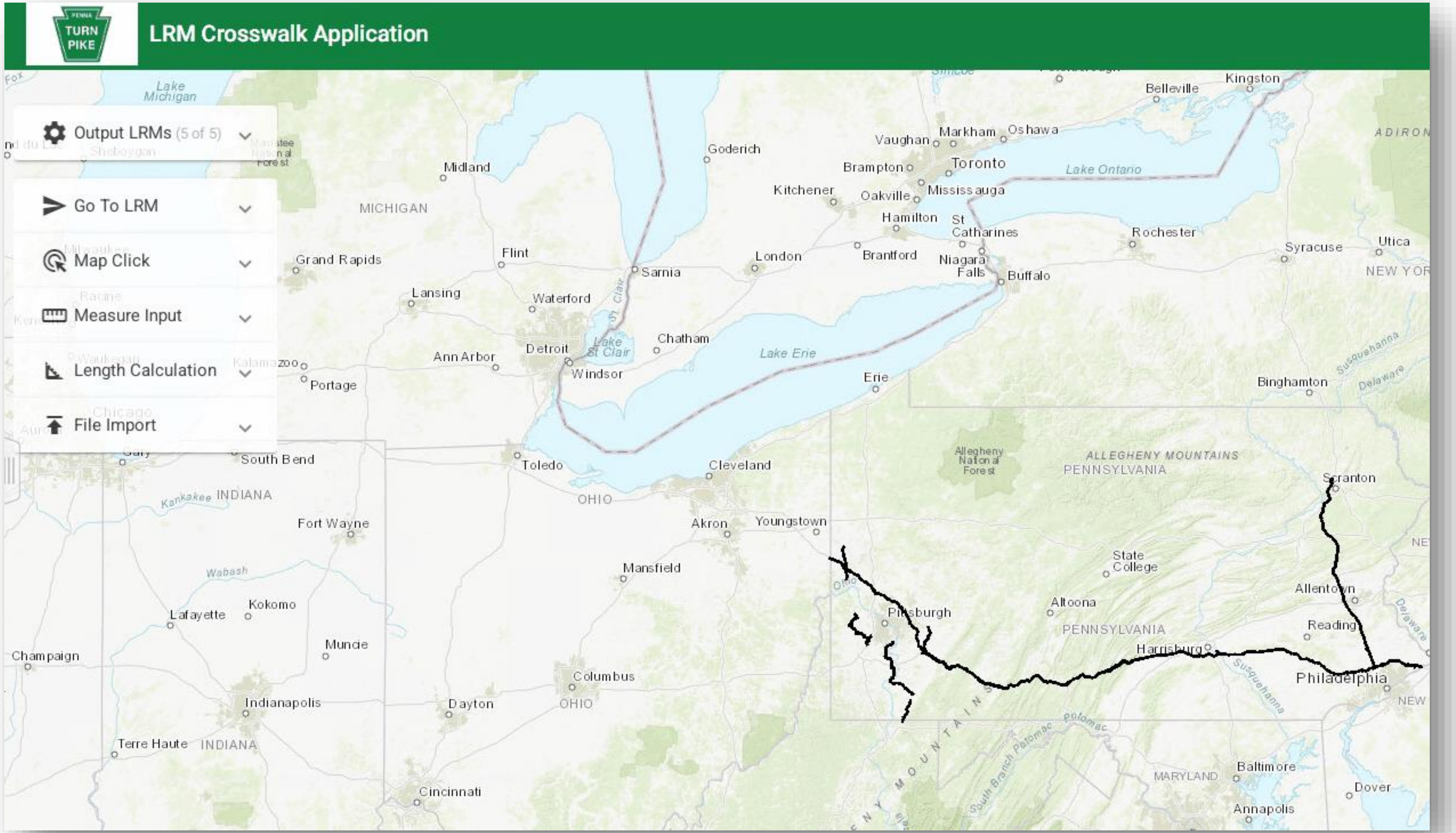


***NOTE:** Mileposts are used to create "CALIBRATION POINTS", which are used to calibrate routes in "LRSN_MILEPOST"

LRM_CROSSWALK

ROUTEID *	GEOMETRY_LENGTH *	MILEPOST *	MILE_MARKER *	STATION *	STATION_AH *	STATION_BK *	LATITUDE *	LONGITUDE *	FEATURE_TYPE *
ANB	19.551073	38.8	38.7965	1012+65.00	<Null>	<Null>	40.367657	-75.399999	Milepost
ANB	19.554704	38.803632	38.8	1012+85.11	<Null>	<Null>	40.367706	-75.400026	Mile Marker
ANB	19.628073	38.877	38.876644	<Null>	10+00.00	1016+72.50	40.368687	-75.400562	Equation Point
ANB	19.650431	38.899358	38.9	11+17.61	<Null>	<Null>	40.368986	-75.400726	Mile Marker
ANB	19.651073	38.9	38.9006	11+21.00	<Null>	<Null>	40.368995	-75.400731	Milepost

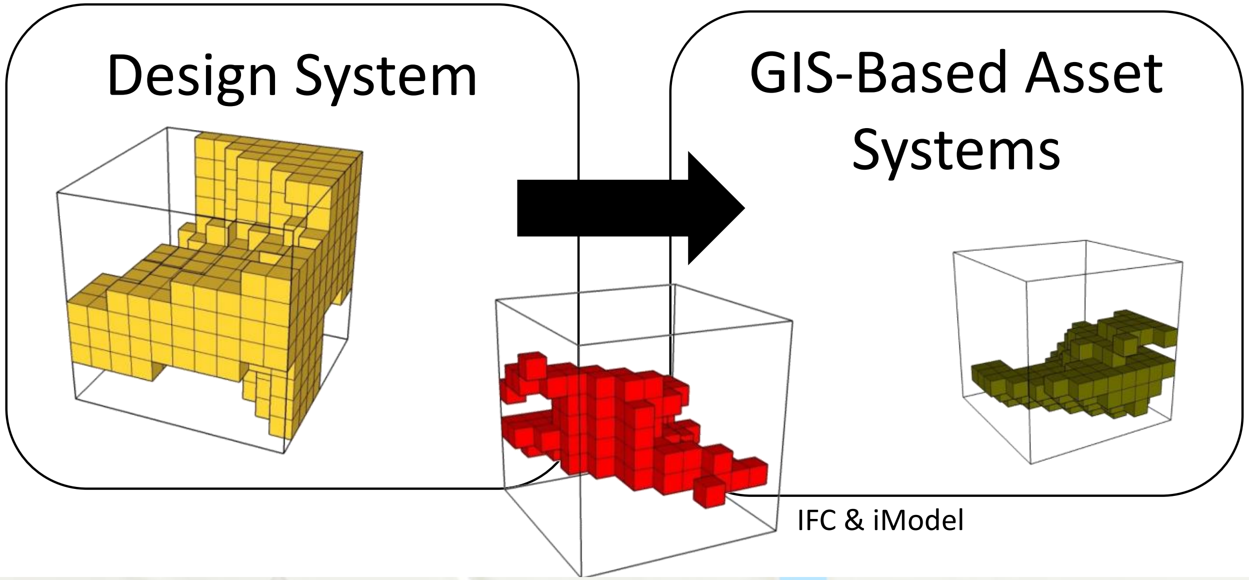
PTC LRM Crosswalk Application Screens

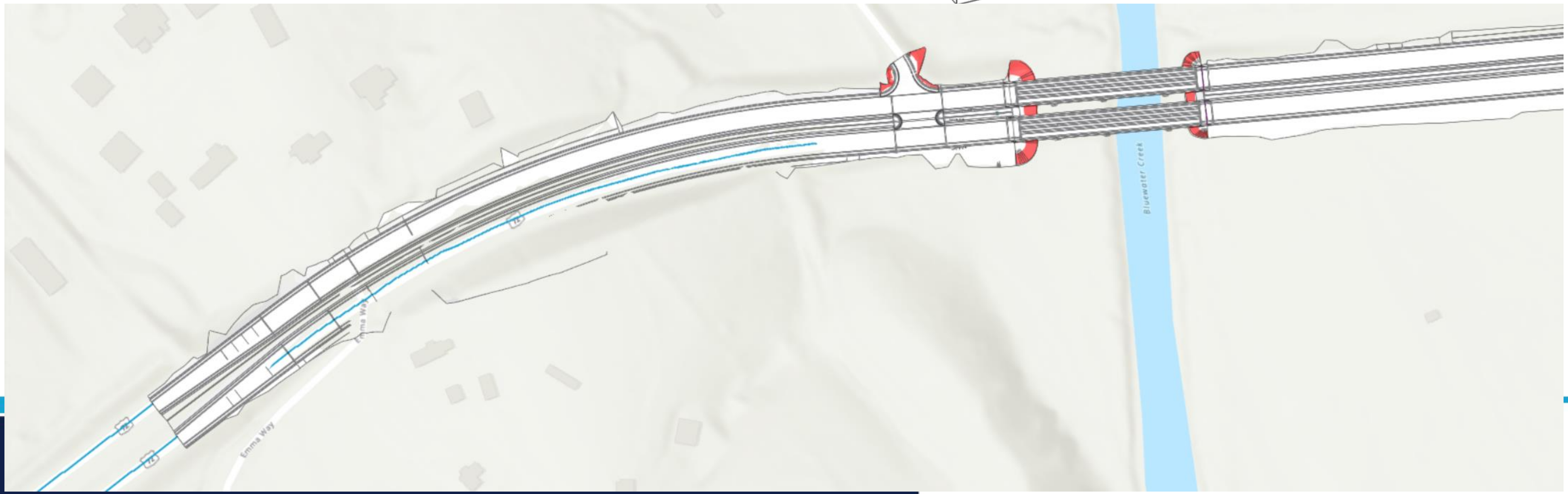


LRM to LRM Transformation: Where am I?
Thursday 3:30-4pm
Ballroom C1

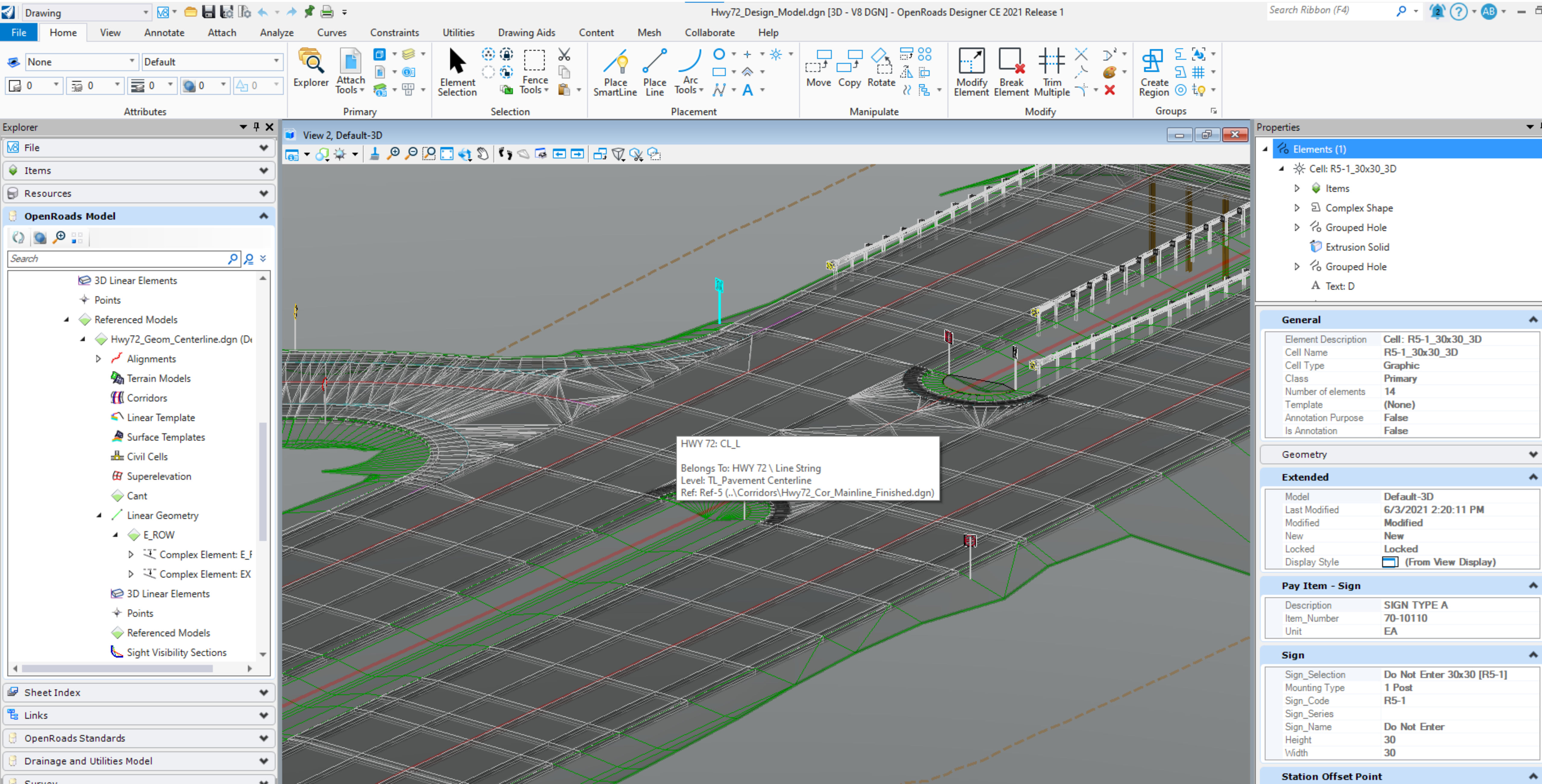
Road Network Data Modeling using data from Design-Construction

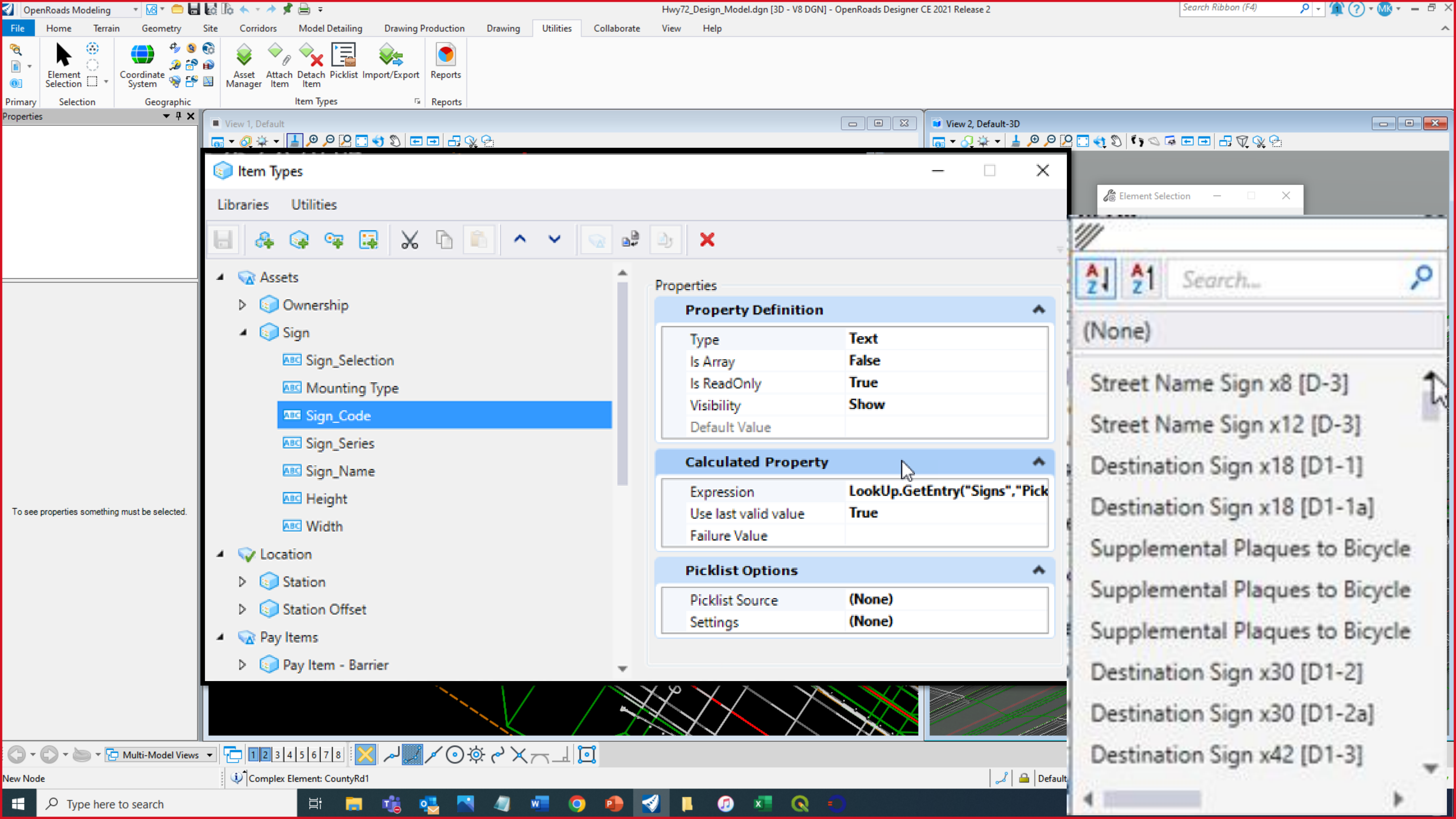
- Asset Information Model
  - » Road Centerlines
  - » Stations
  - » Pavement Construction History
  - » Assets
    - Signs
    - Guardrails
    - Bridge
    - ..



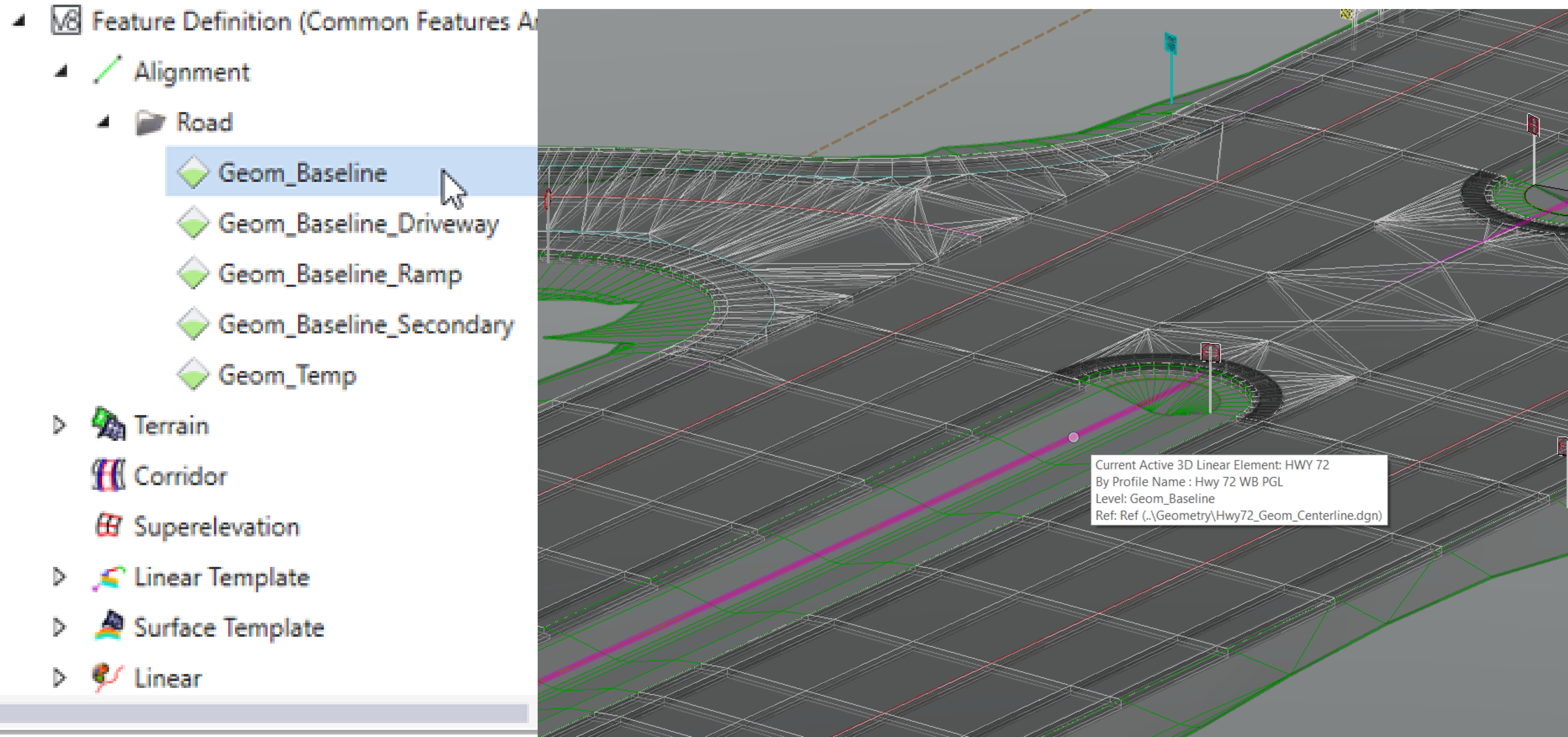


Open Design File and Inspect Model Elements, Item Types

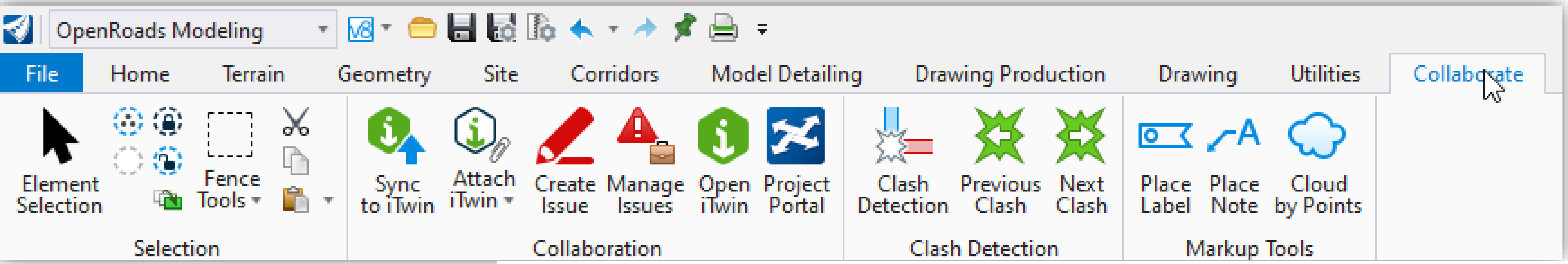


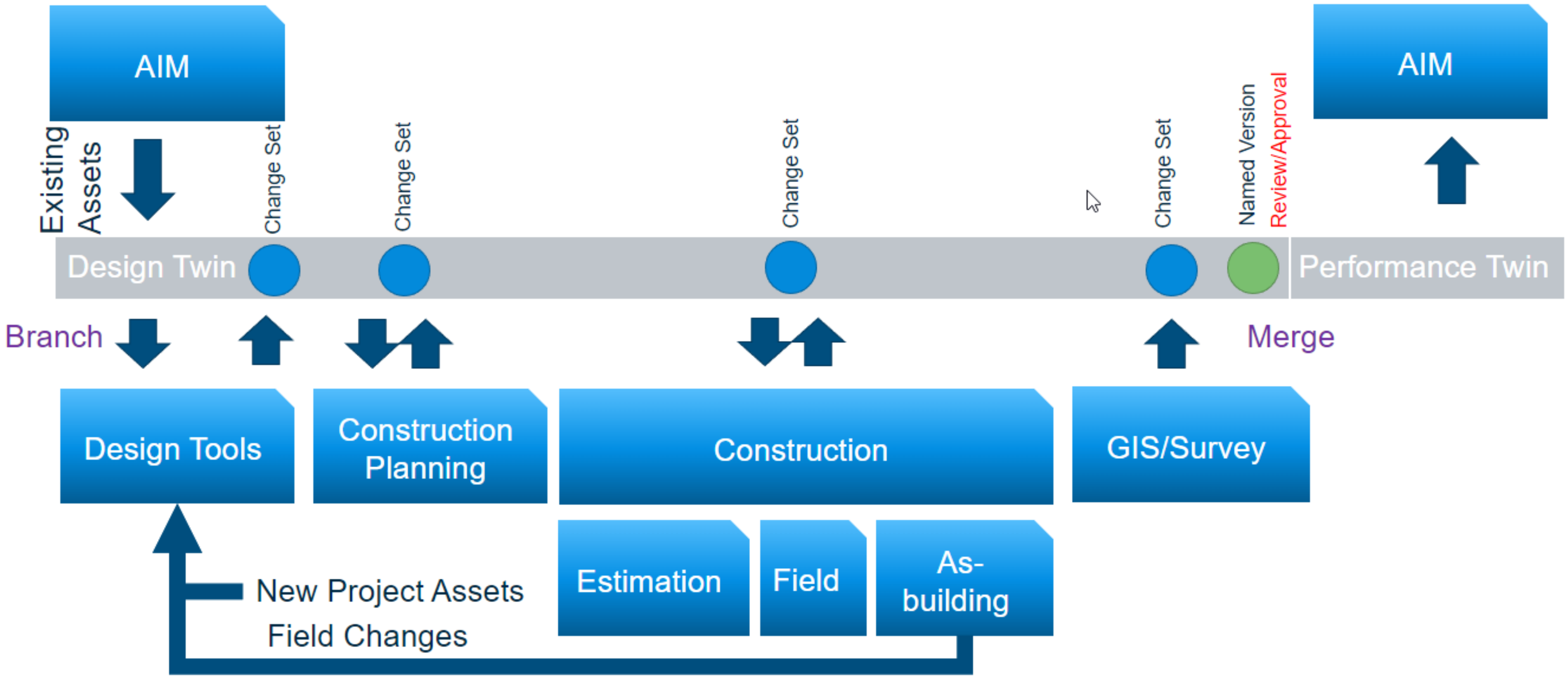

Hwy72_Design_Model.dgn [3D - V8 DGN] - OpenRoads Designer CE 2021 Release 2
File
Home
Terrain
Geometry
Site
Corridors
Model Detailing
Drawing Production
Drawing
Utilities
Collaborate
View
Help
Element Selection
Coordinate System
Asset Manager
Attach Item
Detach Item
Picklist
Import/Export
Reports
Primary
Selection
Geographic
Item Types
Properties
To see properties something must be selected.
View 1, Default
View 2, Default-3D
Item Types
Libraries
Utilities
Assets
Ownership
Sign
Sign_Selection
Mounting Type
Sign_Code
Sign_Series
Sign_Name
Height
Width
Location
Station
Station Offset
Pay Items
Pay Item - Barrier
Properties
Property Definition
Type
Text
Is Array
False
Is ReadOnly
True
Visibility
Show
Default Value
Calculated Property
Expression
LookUp.GetEntry("Signs","Pick
Use last valid value
True
Failure Value
Picklist Options
Picklist Source
(None)
Settings
(None)
Element Selection
Search...
(None)
Street Name Sign x8 [D-3]
Street Name Sign x12 [D-3]
Destination Sign x18 [D1-1]
Destination Sign x18 [D1-1a]
Supplemental Plaques to Bicycle
Supplemental Plaques to Bicycle
Supplemental Plaques to Bicycle
Destination Sign x30 [D1-2]
Destination Sign x30 [D1-2a]
Destination Sign x42 [D1-3]
Multi-Model Views
New Node
Complex Element: CountyRd1
Default
Type here to search

Roads Data Model in Design, with Roadway Characteristics

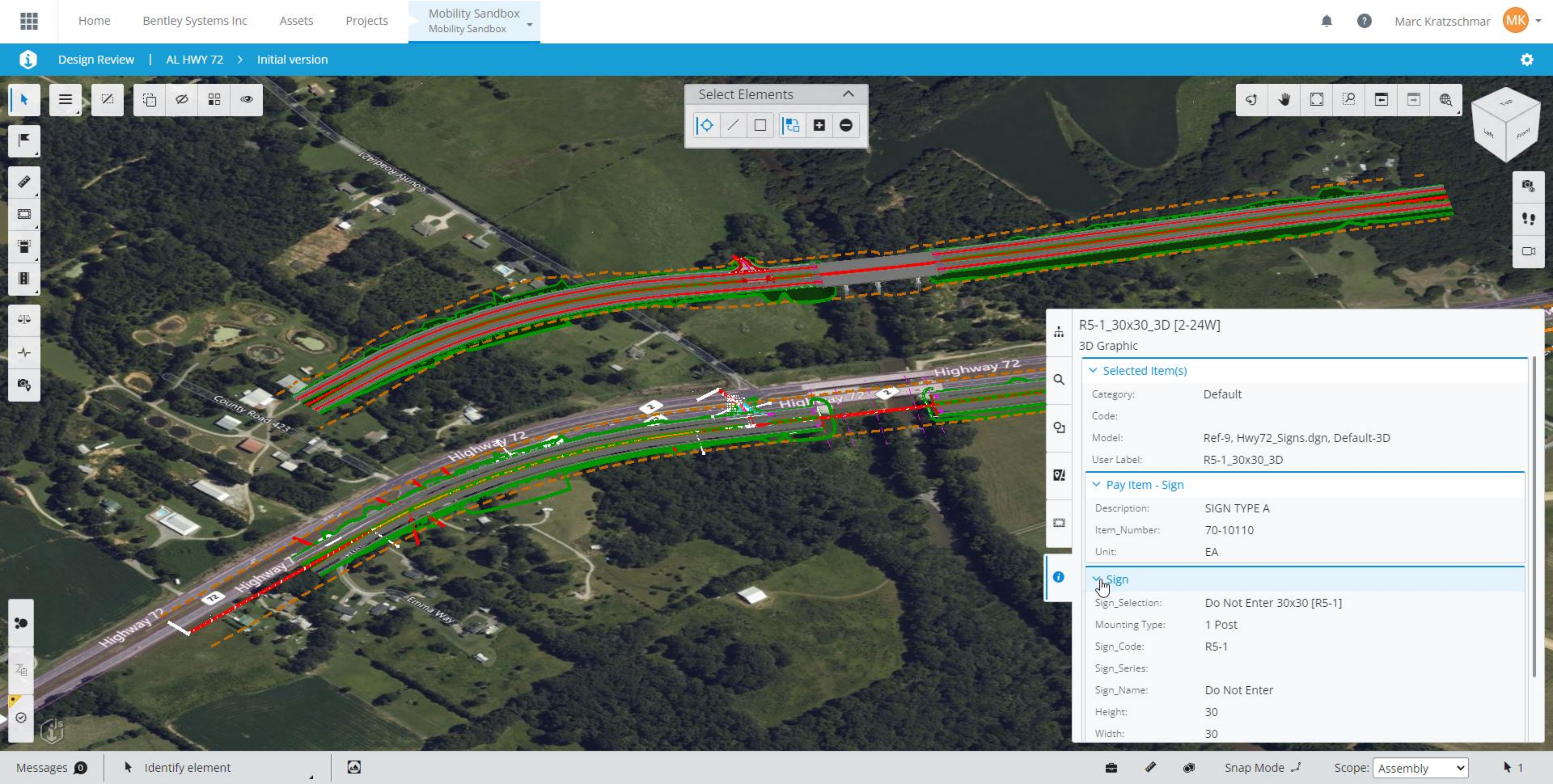


Publishing Roads Design Data Model to Common Data Environment (iTwin Hub)

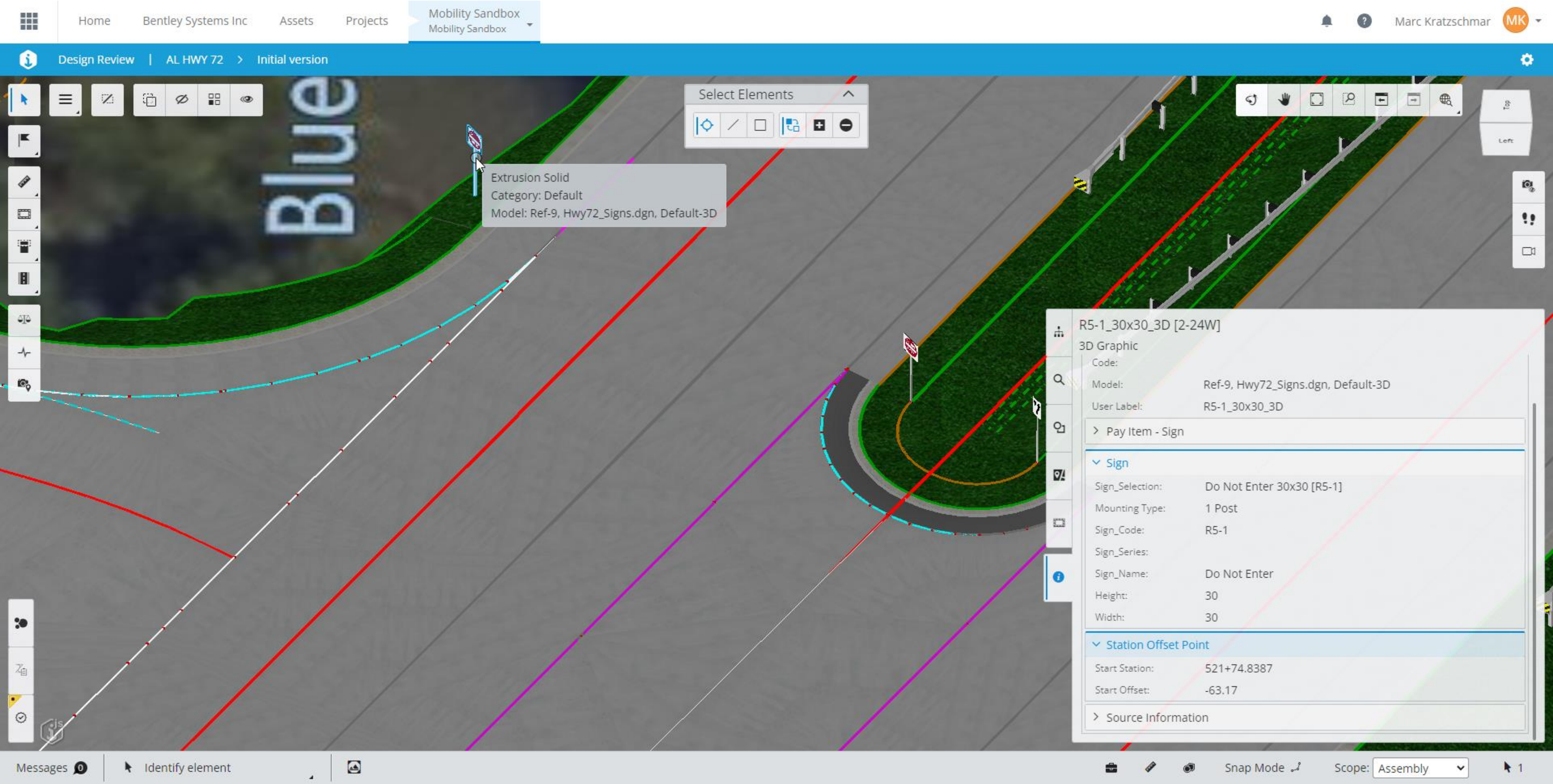




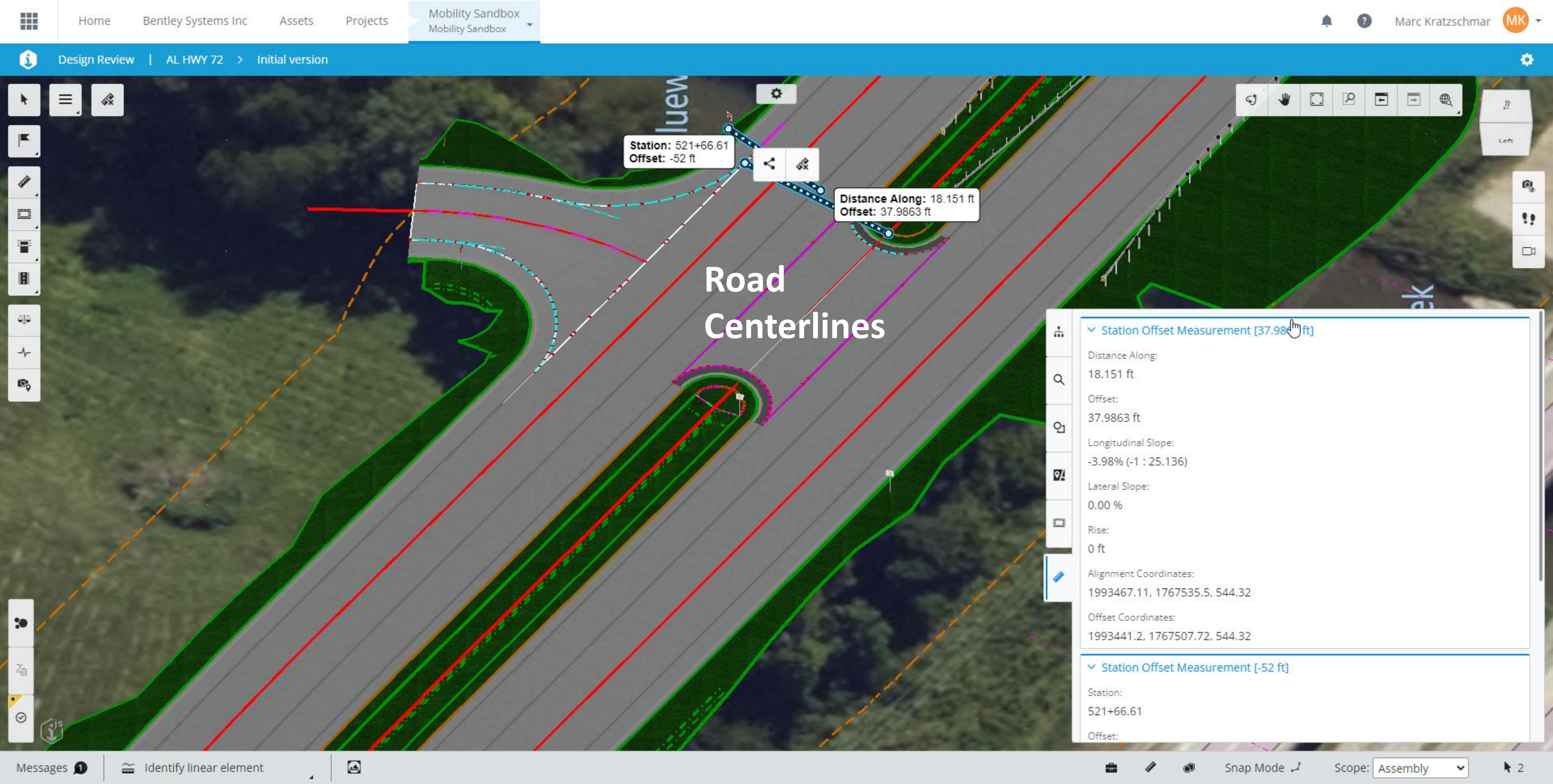
iTwin Platform – Common Data Environment: Roads and Assets iModel

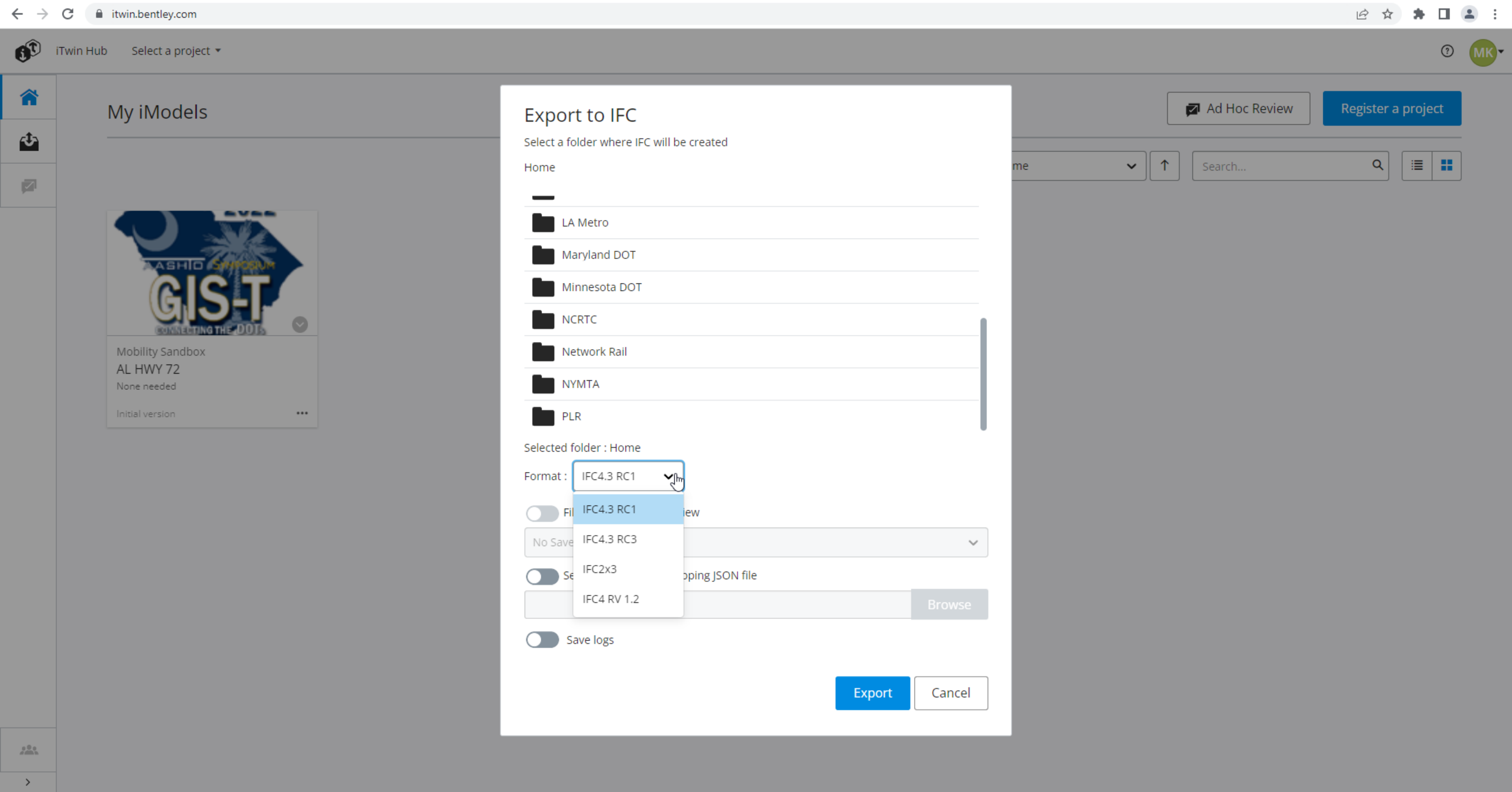


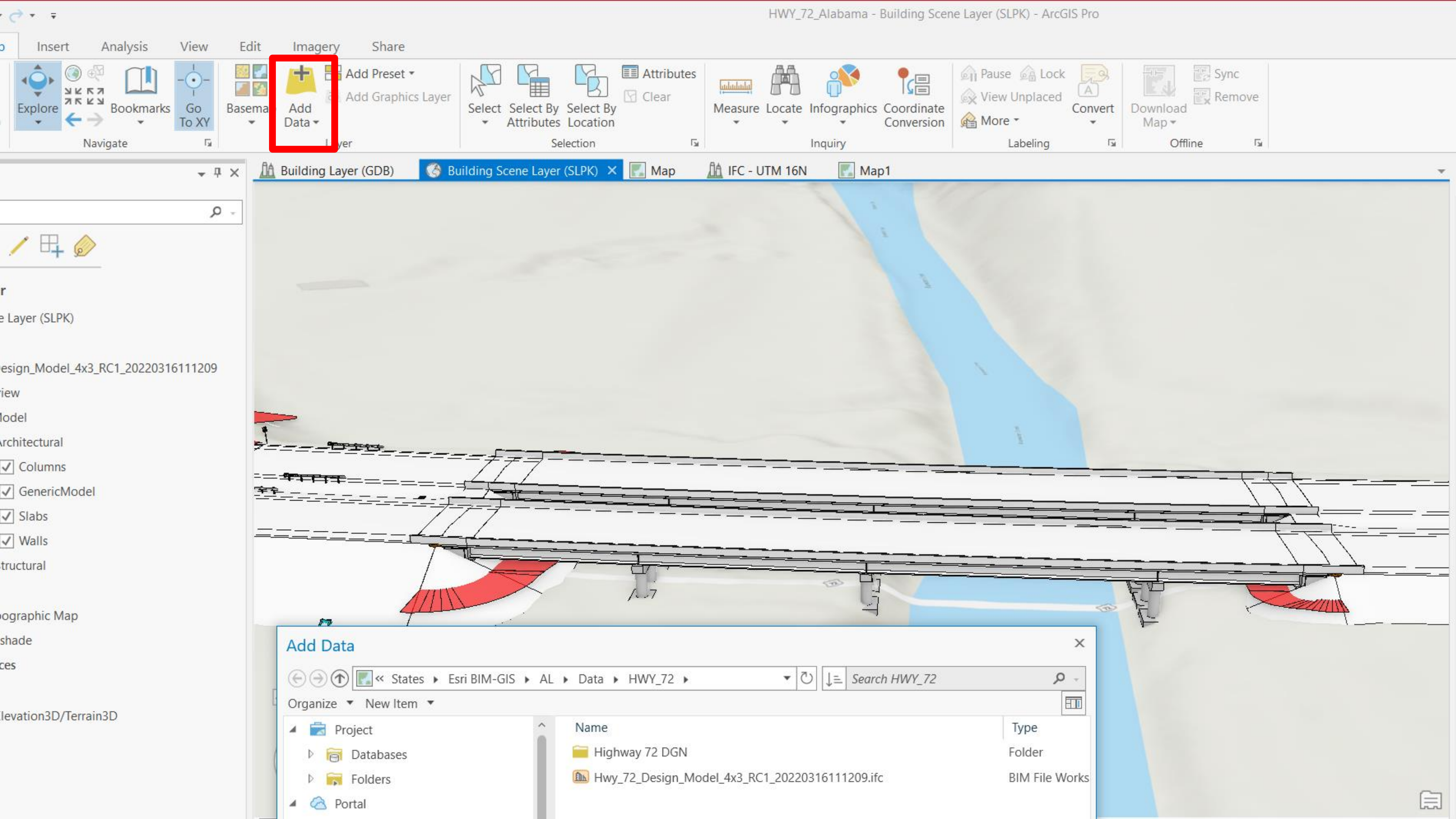
iTwin Platform – Common Data Environment: Roads and Assets iModel



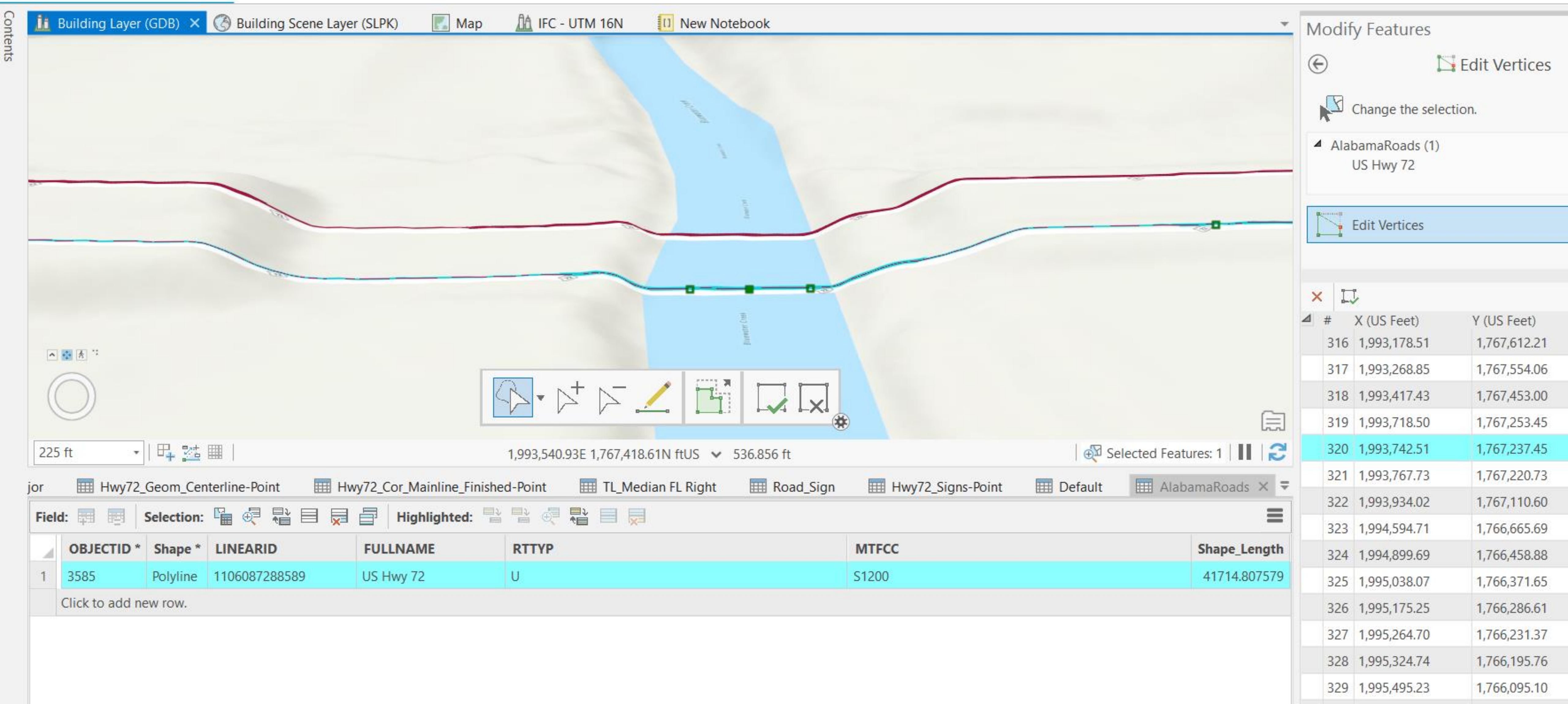
iTwin Platform – Common Data Environment: Roads and Assets iModel



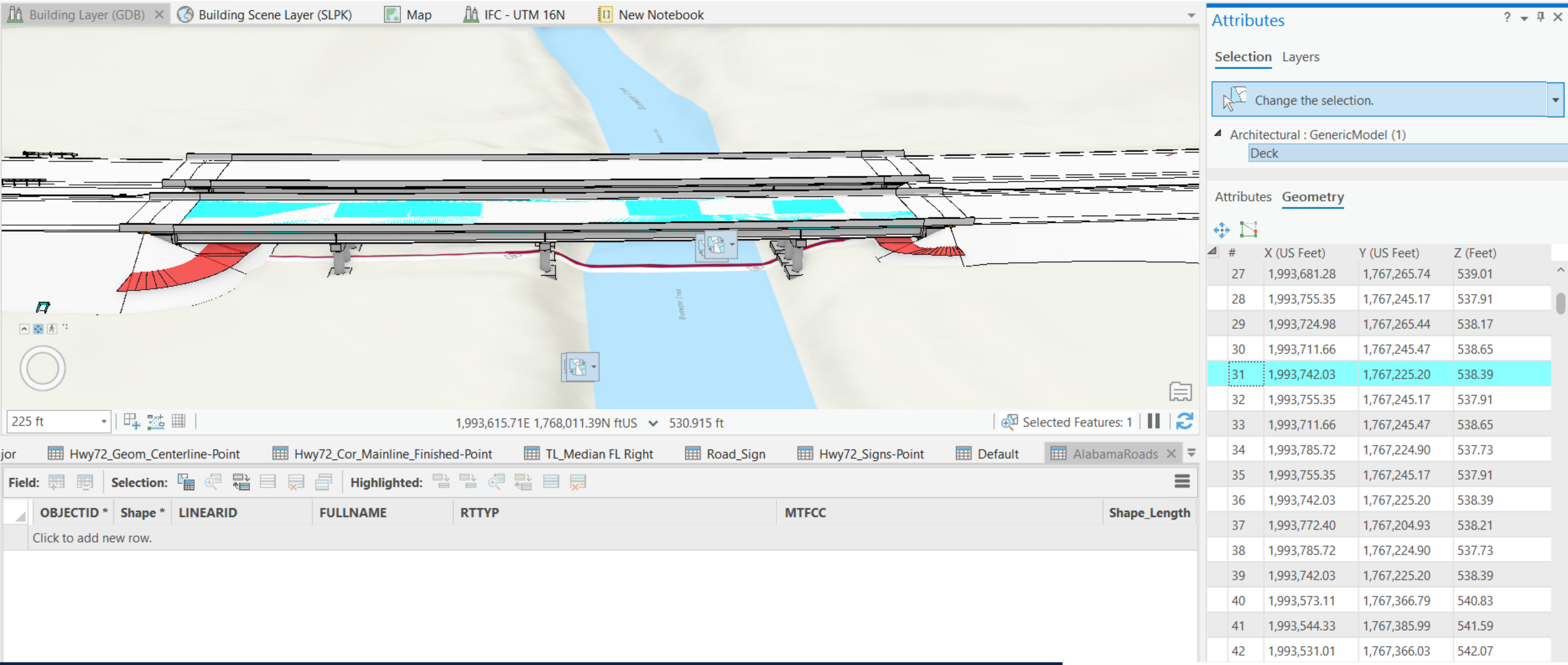

itwin.bentley.com
iTwin Hub
Select a project
My iModels
Ad Hoc Review
Register a project
Search...
Mobility Sandbox
AL HWY 72
None needed
Initial version
Export to IFC
Select a folder where IFC will be created
Home
LA Metro
Maryland DOT
Minnesota DOT
NCRTC
Network Rail
NYMTA
PLR
Selected folder : Home
Format :
IFC4.3 RC1
IFC4.3 RC1
IFC4.3 RC3
IFC2x3
IFC4 RV 1.2
Browse
Save logs
Export
Cancel


HWY_72_Alabama - Building Scene Layer (SLPK) - ArcGIS Pro
Insert
Analysis
View
Edit
Imagery
Share
Explore
Bookmarks
Go To XY
Navigate
Basema
Add Data
Add Preset
Add Graphics Layer
Select
Select By Attributes
Select By Location
Attributes
Clear
Selection
Measure
Locate
Infographics
Coordinate Conversion
Inquiry
Pause
Lock
View Unplaced
More
Labeling
Convert
Download Map
Sync
Remove
Offline
Building Layer (GDB)
Building Scene Layer (SLPK)
Map
IFC - UTM 16N
Map1
Columns
GenericModel
Slabs
Walls
Add Data
States
Esri BIM-GIS
AL
Data
HWY_72
Search HWY_72
Organize
New Item
Project
Databases
Folders
Portal
Name
Type
Highway 72 DGN
Folder
Hwy_72_Design_Model_4x3_RC1_20220316111209.ifc
BIM File Works

ARNOLD ALRS Routes-Centerlines: 2D Geometry



Receiving Realignments and/or New Alignments for Roads & Bridges: 2D/3D Geometry



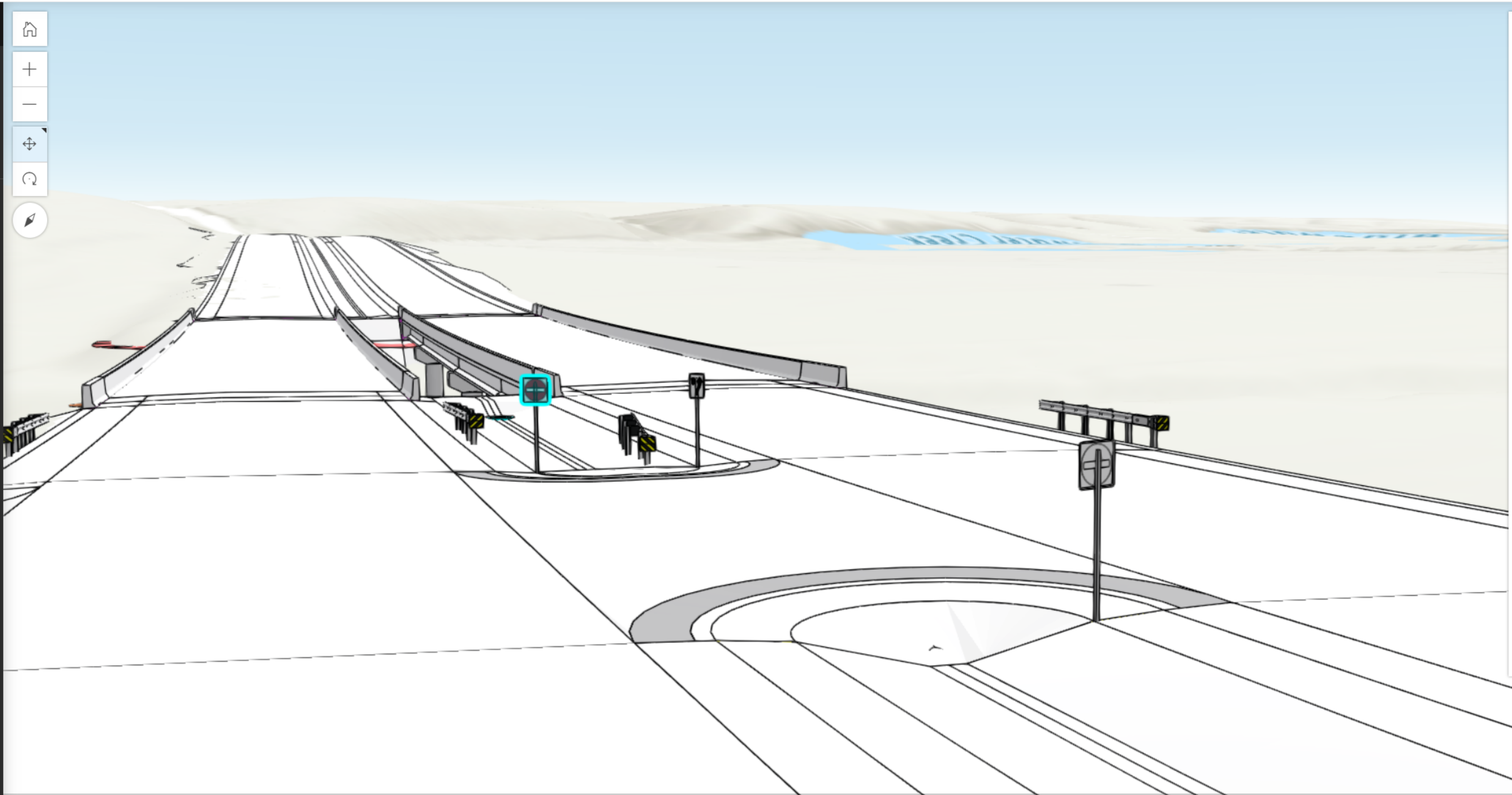
Importing Alignments and Stationing

dataanalytics.maps.arcgis.com/home/webscene/viewer.html?webscene=31b1b8b15c134b829cc2662574f83f93

Apps | Tools | Drives | References | Projects

Home ▾ Bridge_at_Hwy_72

New Scene ▾



Complex Shape

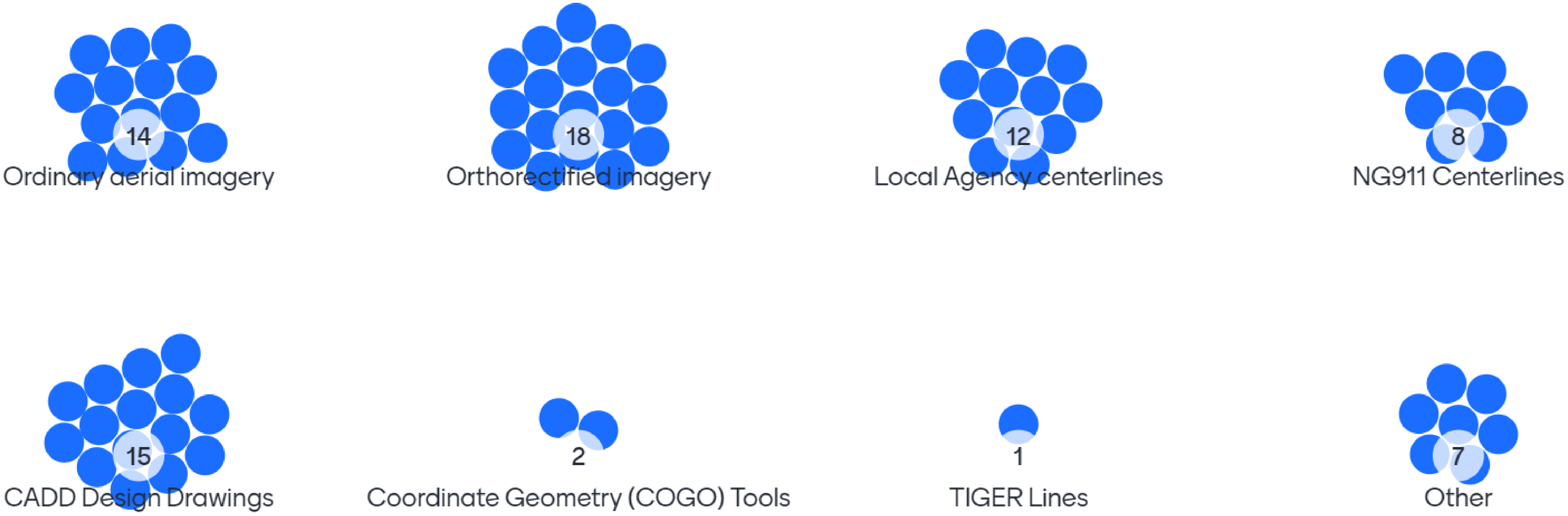
Wingwall_Build_Order	
Wingwall_Material	
Additional_Bottom_Vertical_Offset	
Bottom_Horizontal_Offset	
Bottom_Thickness	
Bottom_Vertical_Offset	
Footing_Offset	
Top_Horizontal_Offset	
Top_Thickness	
Top_Vertical_Offset	
Unit_Length	
Mounting_Type	
Sign_Code	
Sign_Name	
Sign_Selection	
Start_Offset	
Identifier	R9-14_30x
Skew	

ZOOM TO

LRS Centerline Modeling Approaches: Current State

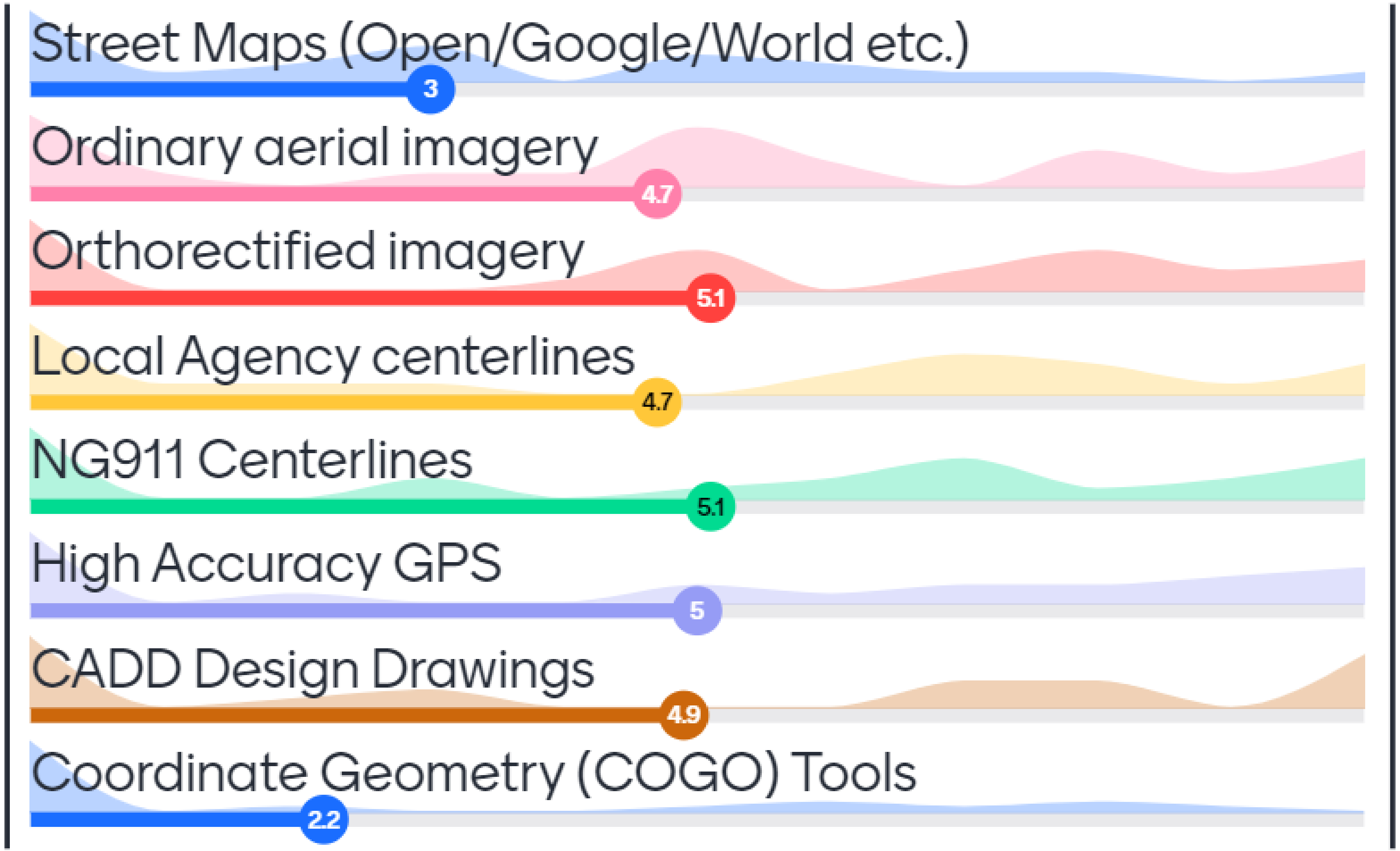
What do you use to digitize road centerlines?

Mentimeter



Which of these do you think is the most mature way of digitizing road centerlines?

- 0-10 Scale



LRS Centerline Modeling Source and Accuracy: Document Methodology

- **Effort Level 1:** Utilized National data sources[1] (e.g., Census TIGER, NATD) or ordinary Aerial/Satellite Data[2]
- **Effort Level 2:** Utilized Orthorectified Aerial imagery[3], COGO Tools[4], CAD/BIM Alignments[5] from Digital Delivery/As-Builts
- **Effort Level 3:** Utilized NG911, Local or other Authoritative Agency Data; and/or Private Sector Data Source

		Effort Level 1		Effort Level 2		Effort Level 3	
		Ordinary Aerial Imagery (2D Centerlines)	National Data Sources (TIGER, NATD)	Orthorectified Aerial Imagery (2D Centerlines)	Local Agency/NG911 Centerlines	CAD-BIM Drawings/Models (Digital Delivery)	Proprietary / Community Roads (OSM, HERE, INRIX..)
1	Arizona				Yes	Yes	
2	Caltrans	Yes		Yes			
3	Connecticut	Yes		Yes	Yes		
4	Colorado						
5	Florida		Yes	Yes		Yes	
6	Georgia			Yes		Yes	
7	Idaho	Yes		Yes	Yes	Yes	
8	New Mexico	Yes		Yes	Yes	Yes	
9	North Carolina			Yes	Yes	Yes	Yes
10	Oklahoma	Yes				Yes	
11	Pennsylvania	Yes		Yes		Yes	
12	Vermont			Yes		Yes	
13	Washington	Yes		Yes	Yes	Yes	
14	Washington DC	Yes		Yes		Yes	
15	West Virginia	Yes		Yes	Yes		

Linear Referencing Methods Management

- **Administration Level 1:** No Referent LRM, All Data Stored in one LRM which is mileage based
- **Administration Level 2:** Referent-offset LRMs created, but only used to ingest data all data stored in mileage LRM(s)
- **Administration Level 3:** Referent-offset LRMs created and used for data ingestion, reporting. Data can be reported in any LRM.

		County/Town/District Boundary Offset	Milepost/Mile-Marker Offset	Derived Measure-Based LRMs	Intersection-Offset	Other Referent-Offset
1	**Arizona**		Yes		Yes	Yes
2	**Caltrans**	Yes	Yes			Yes
3	**Connecticut**				Yes	
4	**Colorado**					
5	**Florida**		Yes			
6	**Georgia**	Yes	Yes			
7	**Georgia**					
8	**Idaho**				Yes	
9	**New Mexico**					
10	**North Carolina**		Yes		Yes	
11	**Oklahoma**		Yes			
12	**Pennsylvania**	Yes	Yes		Yes	Yes
13	**Vermont**	Yes	Yes			
14	**Washington**		Yes			
15	**Washington DC**					
16	**West Virginia**	Yes	Yes		Yes	

LRS Centerline Modeling Detail (LOD)

- **Administration Level 1:**
  - **Vertices**: No established rules for vertex density when editor digitizes centerlines
  - **Breaking centerlines**: Centerline length and break points not formally managed. No policy or procedure for defining centerline geometries
  - **Z-values**: Z-values are not modeled in the LRS
- **Administration Level 2:**
  - **Vertices**: Formal "internal" procedural document exists, that is used to determine vertex density when digitizing centerlines
  - **Breaking centerlines:** Formal "internal" procedural document exists to determine centerline geometry length and break points
  - **Z-values**: Z-values are not modeled in the LRS, but Z-values extracted from other data sources (e.g.: LiDAR) are integrated with LRS Routes to engineer a 3D linear routes data model. The engineered data model is published for use in specific business processes.
- **Administration Level 3:**
  - **Vertices:** Formal procedural document to (a) determine vertex density (b) bring external linework into LRS (c) Perform QA/QC checks on external linework to ensure it meets vertex density rules, and (d) perform geometry conflation, correction for external data in accordance with procedural document. *(Note: External data source could be NG911, DOT CADD, etc.)*
  - **Breaking centerlines:** Formal procedural document to (a) determine centerline geometry length and break points (b) ensure that external linework meets centerline geometry and break points related rules
  - **Z-values:** Z-values modeled in the LRS, and vertical curve is considered in determining centerline vertex density.

LRS Centerline Modeling Detail (LOD)

		Administration Level 1			Administration Level 2			Administration Level 3		
		No Vertex Density Rules	NO Centerline Break Points & Length Rules	Z-values Not Modeled in LRS	Vertex Density Rules (Internal)	Centerline Break Points & Length Rules (Internal)	Z-values Integrated outside of LRS	Vertex Density Rules, QA-QC for Internal-External Roads	Centerline Break Points & Length Rules for Internal-External Roads	Z-values Modeled. Vertical Curve considered in Vertex Density
1	Arizona			Not modeled. Would like to.						
2	Caltrans									
3	Connecticut			Don't include z-values in LRS						
4	Colorado									
5	Florida			**Don't include z-values in LRS**						
6	Georgia			Not modeled. Would like to.						
7	Idaho			Not modeled. Would like to.						
8	New Mexico			Not modeled. Would like to.						
9	North Carolina						Modeled			
10	North Dakota			Not modeled. Would like to.						
11	Oklahoma				Yes					
12	Pennsylvania			Not modeled. Would like to.						
13	Tennessee			Not modeled. Would like to.						
14	Texas			**Don't include z-values in LRS**						
15	Vermont			Not modeled. Would like to.	Yes					
16	Washington			Not modeled. Would like to.						
17	Washington DC									
18	West Virginia			Not modeled. Would like to.	Yes					

[Mentimeter]

Breakout Session 2:

Open Discussion & Survey

Discuss Modeling Approach and Use Cases for:

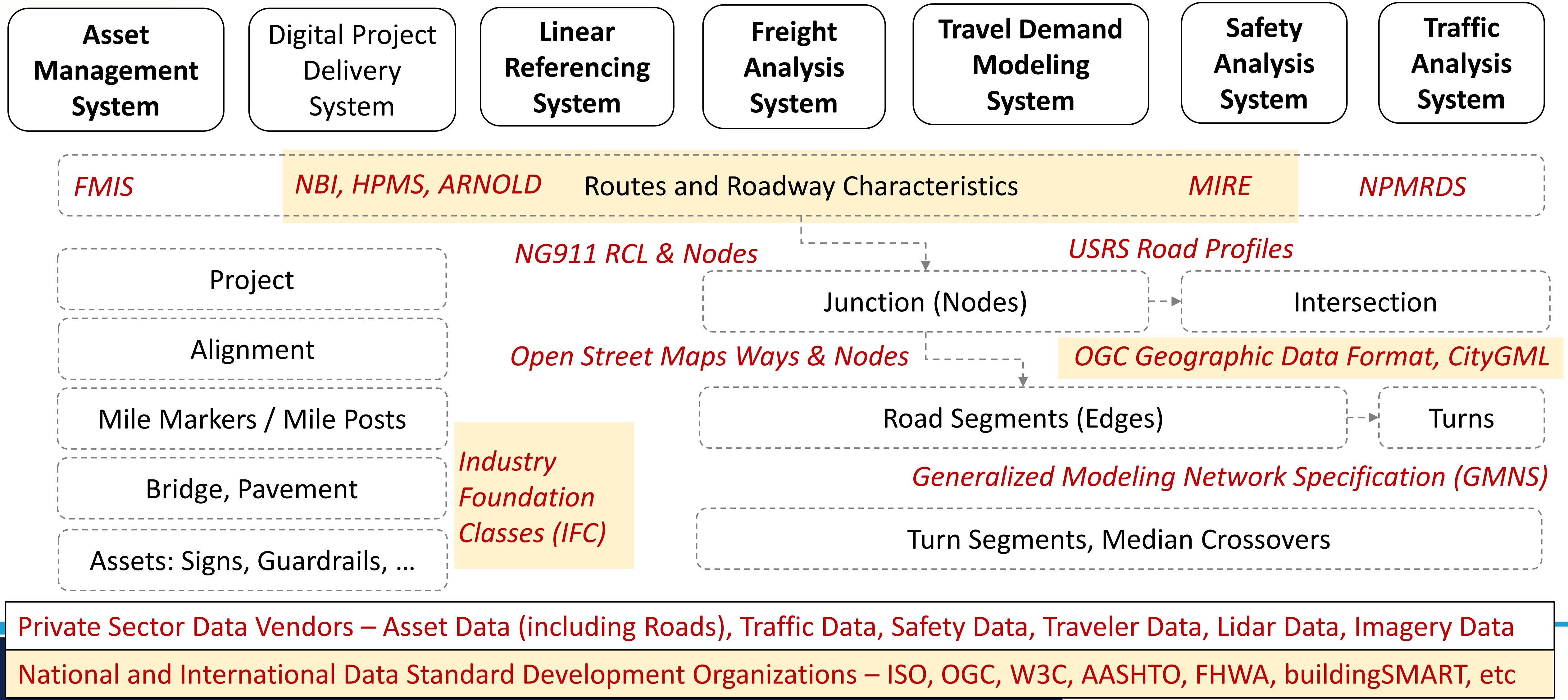
- **Centerlines/Datum Modeling and Data Governance**
  - Pull Linear Referencing Data from Design
  - Establish Geometry Modeling Standards and manuals at Enterprise level: Centerline Modeling Detail: Vertices, Horizontal and Vertical Curves/Grades, Z-Values
- **Asset Information Requirements for Design/CAD**; For example
  - Stations: Mileposts, Mile-markers
  - Centerlines: Dual/Single Carriageway? Median Crossovers, Turn Lanes, Vertical Alignment?
  - HPMS Data Items: Roadway Characteristics
  - MIRE Data Items: Intersection data
  - Assets and Attributes: Signs, Signals, Guardrails, etc.
- **Organizational Process for Engagement with Digital Delivery/Design-CAD** team – What? How? Who?
- **Tools-Techniques for facilitating Design to GIS/AM exchange**
  - What design data model?
  - What tool is used to extract?
  - What data is extracted?
  - What features in GIS are updated?

Topic 3: Modeling Standards: What? Why? How?

- ❑ National and International Initiatives
- ❑ Level of Information (LOI) Content Standards
  - ❖ USRS
  - ❖ HPMS-MIRE
  - ❖ FHWA NBI, AASHTO NBE-BME
  - ❖ buildingSMART Industry Foundation Classes (IFC)
  - ❖ MUTCD
- ❑ Level of Detail (LOD) Standards: Geometry
  - ❖ OGC Geographic Data Format
  - ❖ OGC CityGML
  - ❖ buildingSMART IFC
  - ❖ Generalized Modeling Network Specification (GMNS)

Topic 3 Objective: Road Network Data Model Development for Enterprise Use

National and International Organizations Collaboration to Facilitate Road Network Data Model Creation



National and International Initiatives

Standards Development and Adoption

- FHWA ARNOLD, HPMS 9 and MIRE
- AASHTO Resolution: buildingSMART IFC Adoption
- Open Geospatial Consortium (OGC) and buildingSMART Collaboration
- World Wide Web Consortium Collaboration (W3C) and Initiatives
- Software Vendors: Adoption and Use of Standards – Esri, Bentley, Autodesk, etc.
- National and International Transportation Agencies with Standards: Projects, Pilots and Best Practices

AEGIST Guidebook v2.0 Data Modeling Standards

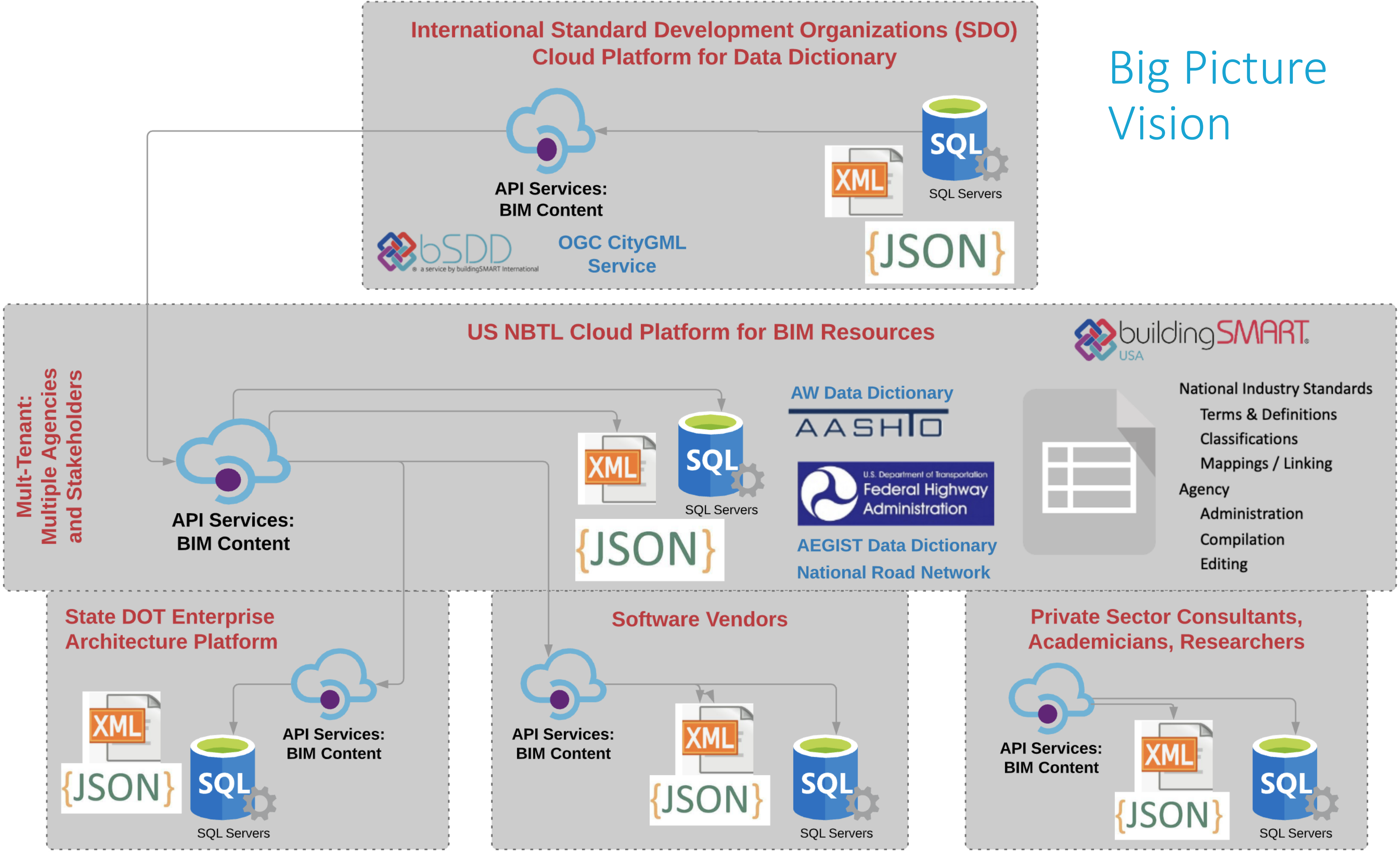
Content Standards

1. Highway Performance Monitoring System (HPMS 9), especially HPMS 9.0 Reassessment
2. National Bridge Inventory (NBI); Bridge Management Elements (BME); National Bridge Elements (NBE)
3. United States Road Specifications (USRS) and US Army Corp of Engineers (USACE) Road Lines
4. United States Census Bureau's Road TIGER/Line files
5. Model Inventory of Roadway Elements (MIRE)

Geometry Standards

1. All Roads Network of Linearly Referenced Roads (ARNOLD)
2. Geographic Data Format (GDF) from Open Geospatial Consortium (OGC)
3. CityGML from Open Geospatial Consortium (OGC)
4. General Modeling Network Specification (GMNS)
5. Industry Foundation Classes (IFC) from buildingSMART
6. Open Street Maps (OSM) and Shared Streets
7. Proprietary standards: Esri Roads & Highways ALRS, Bentley AssetWise LRS (AWLRS), GeoMedia, Rizing Intersection Manager, TransCAD, Cube, Emme, HERE, INRIX etc.

Big Picture Vision



Disclaimer: FHWA is facilitating the discussion around NBTL and currently there are no plans for FHWA to host the NBTL

IFC Implementation: Software Vendors & Business Use Cases

Asset Information Modeling (AIM) – Design, Construction, Operations & Maintenance (ISO 19650)

Project Information Modeling (PIM) – Project Site and Assets

Enterprise Data Life Cycle Management using Geospatial Applications

Geometry and Content Data Modeling in Geospatial Digital Twins

Vendor Support for Open Standards
Podcast Highlights – Jack Dangermond

Jack Dangermond
President and Founder
Esri

"One of the common intersections with the great work you guys are doing in building standards, so we can **interoperate** with the whole built environment to support the work of your listeners…

Do we support open standards? Any company is a damn fool if they don't support **open standards**. If you're going to work in a modern world, you must be open and interoperable with other companies…

Company's today have to be **open** and to **innovate** in highly competitive markets"

Episode link: https://www.buzzsprout.com/1609339/8329446

Vendor Support for Open Standards
Podcast Highlights - Keith Bentley

Keith Bentley
Founder
Bentley Systems

"The only real approach to making an **industry-wide transformation**, is for people to organize around things that are **open** – and obviously buildingSMART is big on things that are open...

A lot of people don't quite understand that 'open' can make the huge difference between whether your data is valuable **long-term**, or not. Do you own your own data? Are you able to get to your data without paying somebody...

Our entire mission on our digital twin journey has been around allowing users to have **choices** to own their own data".

Episode link: https://www.buzzsprout.com/1609339/8544390

Vendor Support for Open Standards
Podcast Highlights – Andrew Anagnost

Andrew Anagnost
Chief Executive Officer
Autodesk

"Customers need an **interoperable ecosystem**...interoperability is key to a successful digital future for AEC and quite frankly, we're proud that we have roots in the early discussions on this especially around **openBIM**"

The importance of having conversations like this, and having organizations like buildingSMART, can help drive some of the critical **process changes** that need to happen to drive an ecosystem that is more sustainable and efficient. It's not just about technology, it's about **changing the ecosystem** to work better".

Episode link: https://www.buzzsprout.com/1609339/8383669

Vendor Support for Open Standards
Podcast Highlights – Rob Painter

Rob Painter
CEO, Trimble

“the view we have of **buildingSMART** is to make the whole greater than the sum of the parts…

We all need to be more **open** and to have less data loss. Our **commitment** is to have this philosophy of openness and the continual pursuit of being more open…

we continue to focus on **interoperability**”

Episode link: https://www.buzzsprout.com/1609339/8329446

buildingSMART International

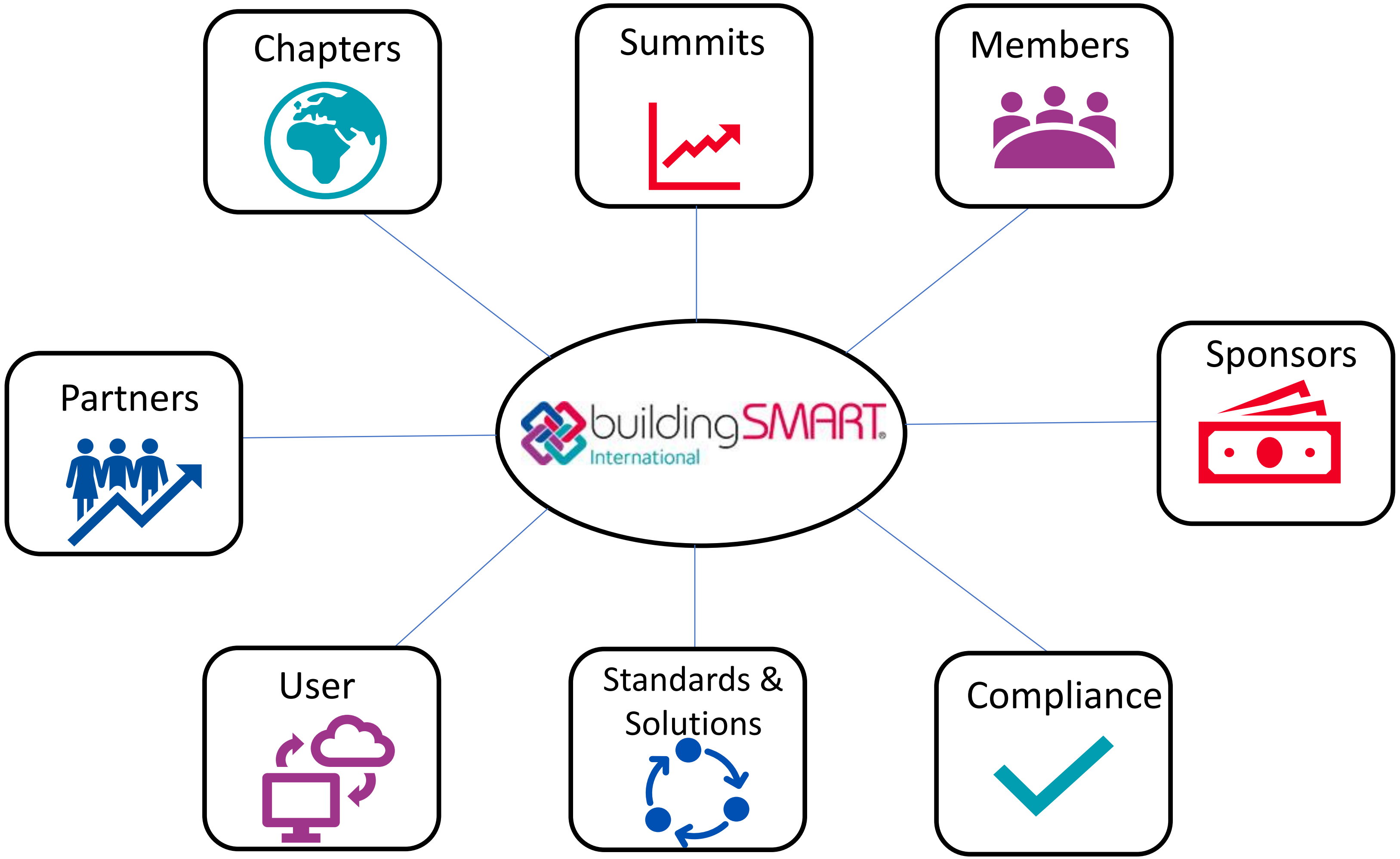
Open

Neutral

Non-Profit

International

buildingSMART International



Standards Adoption

IFC

AASHTO Board of Directors Administrative Resolution:

Adoption of IFC Schema as the national standard for AASHTO States

Administrative Resolution AR-1-19
Title: Adoption of Industry Foundation Classes (IFC) Schema as the Standard Data Schema for the Exchange of Electronic Engineering Data

Whereas, Several data schema exist for the exchange of electronic engineering data, among them Trans XML, Land XML, and various industry schemas; however, there is no single standard data schema recognized by the industry;

Whereas, Transportation agencies need to implement asset management more efficiently throughout the lifecycle of the asset, which requires the ability to exchange data seamlessly;

Whereas, Transportation agencies are progressing toward Building Information Models as the successor to the standard plan set for highway infrastructure projects;

Whereas, Transportation agencies are utilizing a variety of tools and equipment from multiple vendors and manufacturers to gather, display, and work with the data necessary for infrastructure project development, and interoperability of the models is a critical feature so that the agencies have the ability to transfer data seamlessly across these platforms;

Whereas, Seamless data transfer necessitates a single data schema that is recognized as the industry standard, otherwise there is a potential loss of data when translated from one device or one application to another; however, there has been a lack of consensus for adoption of a single schema;

Whereas, To date efforts to establish a national standard data schema have not been successful, in large part due to the inability to identify an agency or entity capable of providing ongoing development, support, and maintenance of the schema, so it would be advantageous to move toward a schema where that support mechanism already exists;

Whereas, There is an international effort underway, led by buildingSMART International, to extend their existing Industry Foundation Classes (IFC) standard data schema to incorporate infrastructure projects including IFC Bridge and IFC Road;

Whereas, Adoption of a single data schema by transportation agencies would give vendors and manufacturers the standard we need to facilitate collaboration on their adoption as well;

Whereas, The AASHTO Committee on Bridges and Structures already has several efforts underway to facilitate the adoption of IFC Bridge as the standard data schema for their discipline, and it would be essential in order to ensure and maintain interoperability between these two disciplines that we adopt IFC Road for highway infrastructure projects; and

Whereas, There are other AASHTO committees with interest in this effort, including but not limited to the Committee on Data Management and Analytics, the Committee on Bridges and Structures, and AASHTOWare; now, therefore, be it

Resolved, That the AASHTO Board of Directors recommends the adoption of IFC Schema as the national standard for AASHTO States;

Resolved, That an internal, cross-committee, multi-disciplined group within AASHTO should be formed to coordinate schema development, identify gaps, resolve any conflicts, and avoid duplication of efforts; and

Resolved, That possible AASHTO membership in buildingSMART International should be investigated to provide representation and participation for the state DOTs in schema development.

Approved by the AASHTO Board of Directors
October 9, 2019

IFC

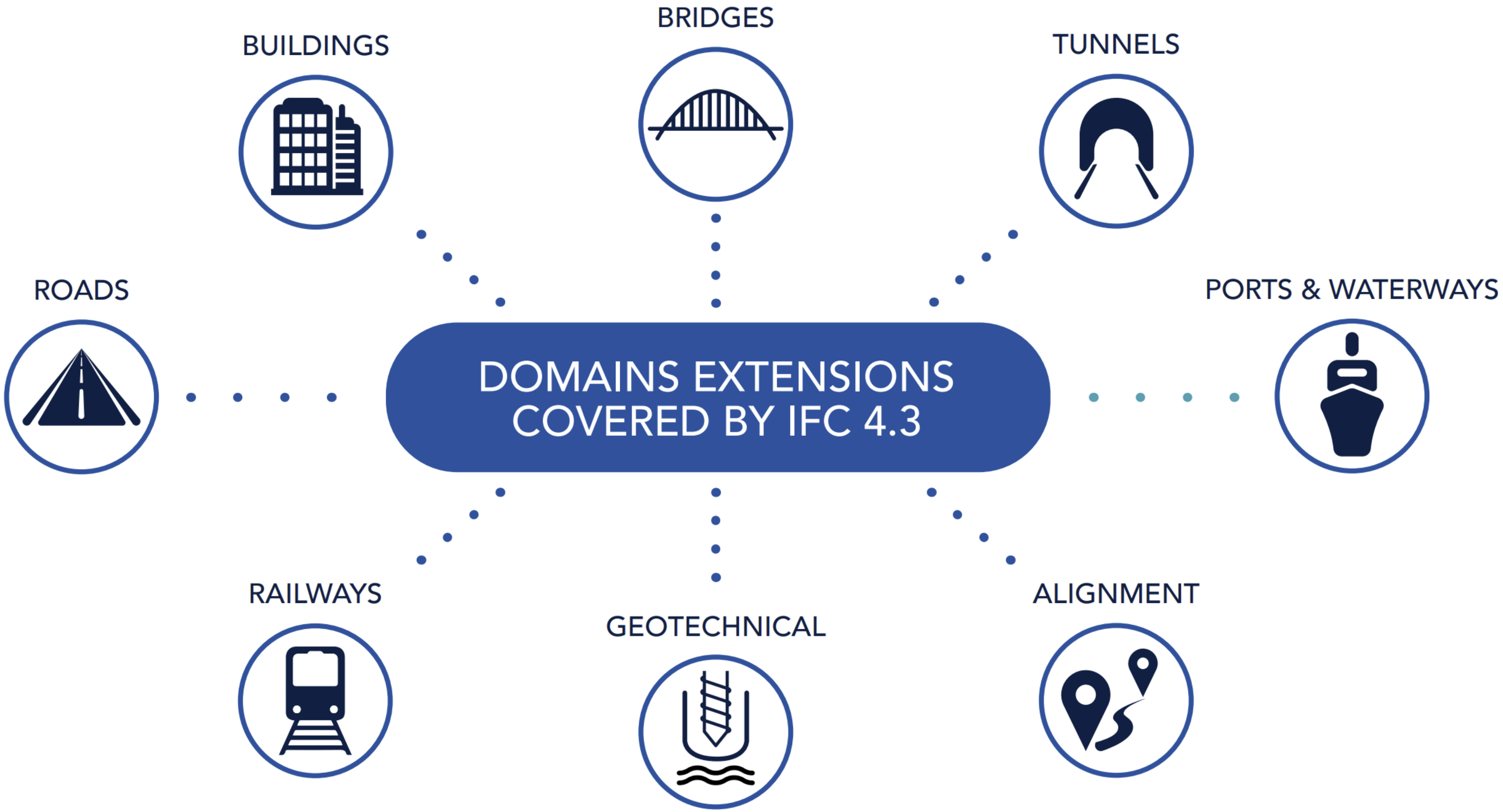
Industry Foundation Classes (IFC)

A domain specific open software standard for data exchange

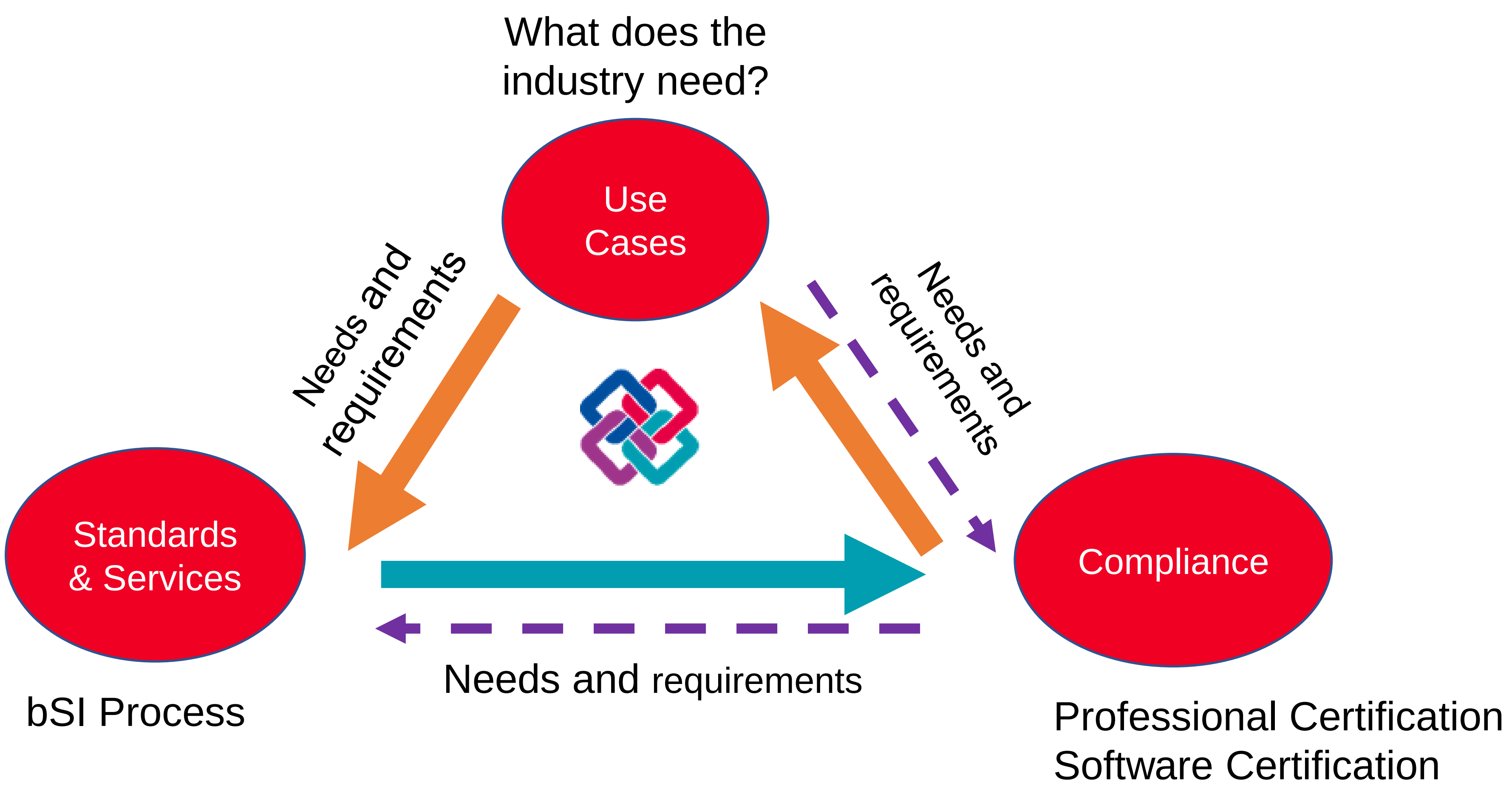
buildingSMART® International → ISO

ISO 16739

The New IFC 4.3 Standard

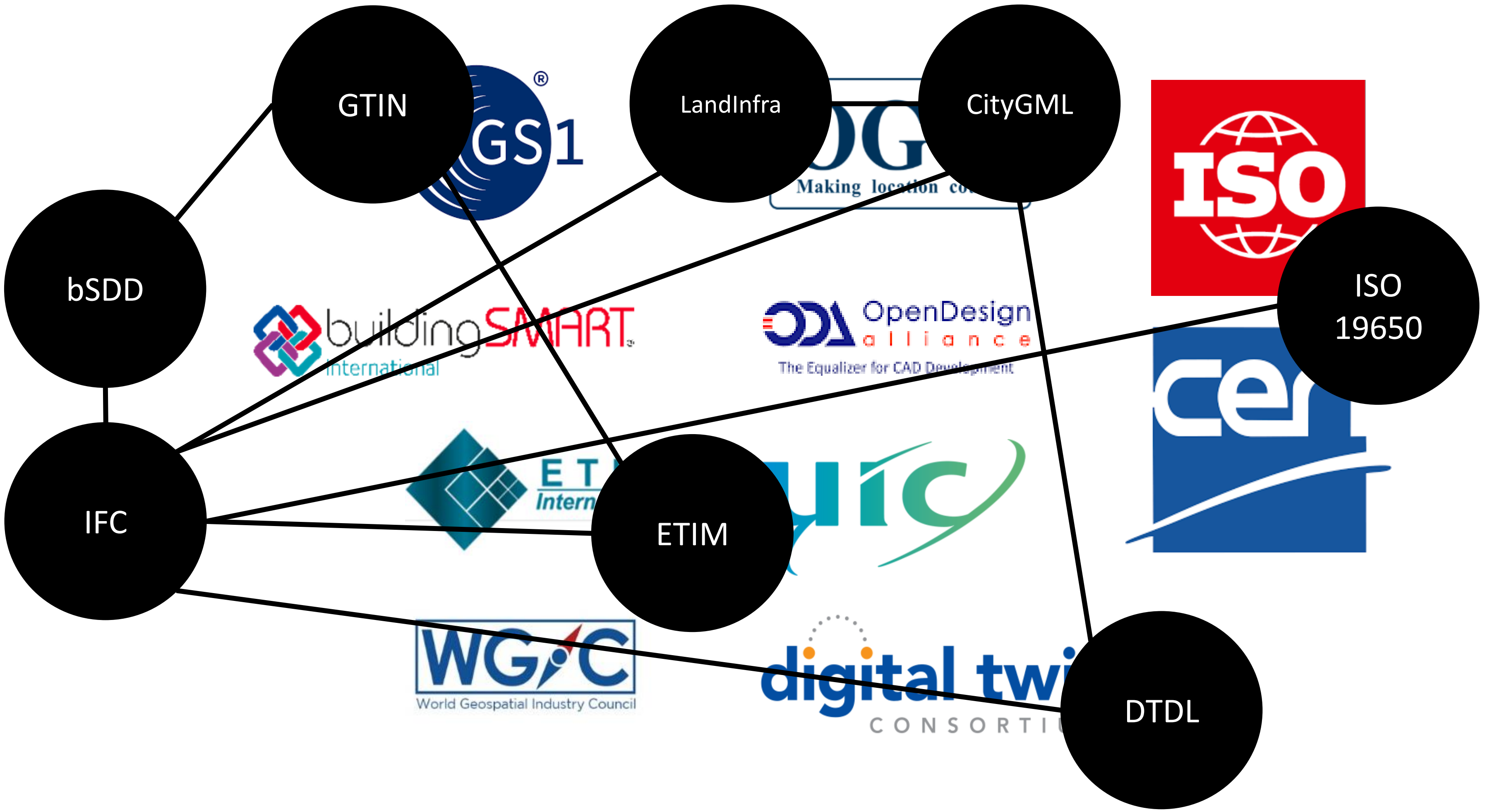


buildingSMART International



Open Standards Partnerships

Open Standards Integration



buildingSMART + OGC Collaboration

Demand for BIM – GIS interoperability

Key topics of common interest:

- Semantics
- Placement
- Geology
- Interfaces

Joint Initiatives:

- IDBE (bSI OGC) White paper published 2021
- IDBE Pilot Project (OGC call for participation)
- White paper for BIM and GIS in the geotechnics domain
- Airport Room

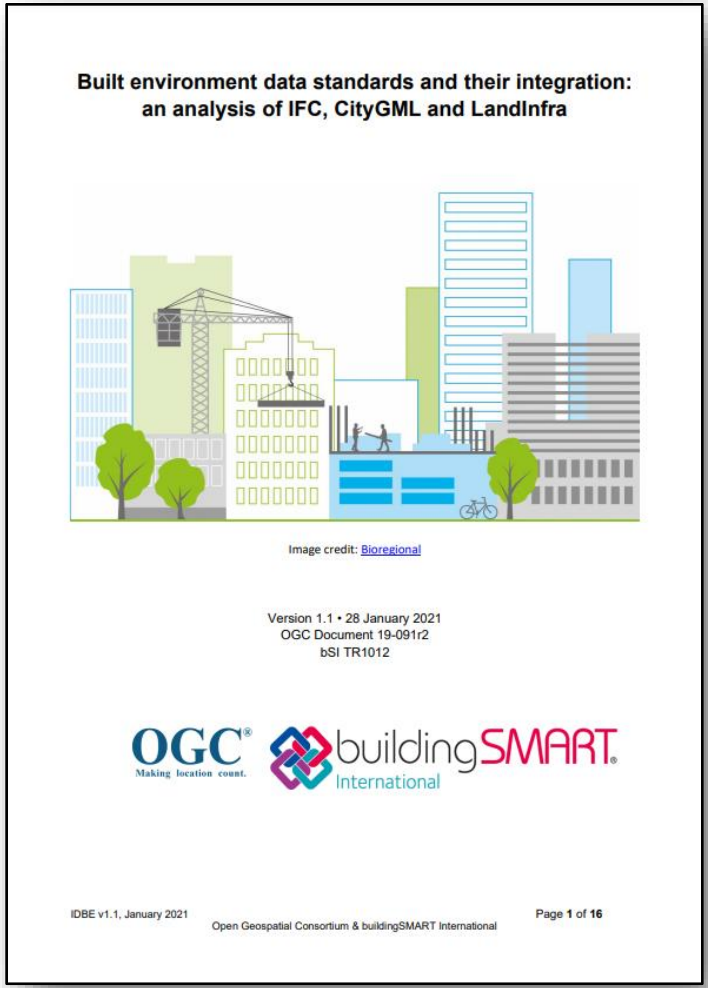

Built environment data standards and their integration: an analysis of IFC, CityGML and LandInfra

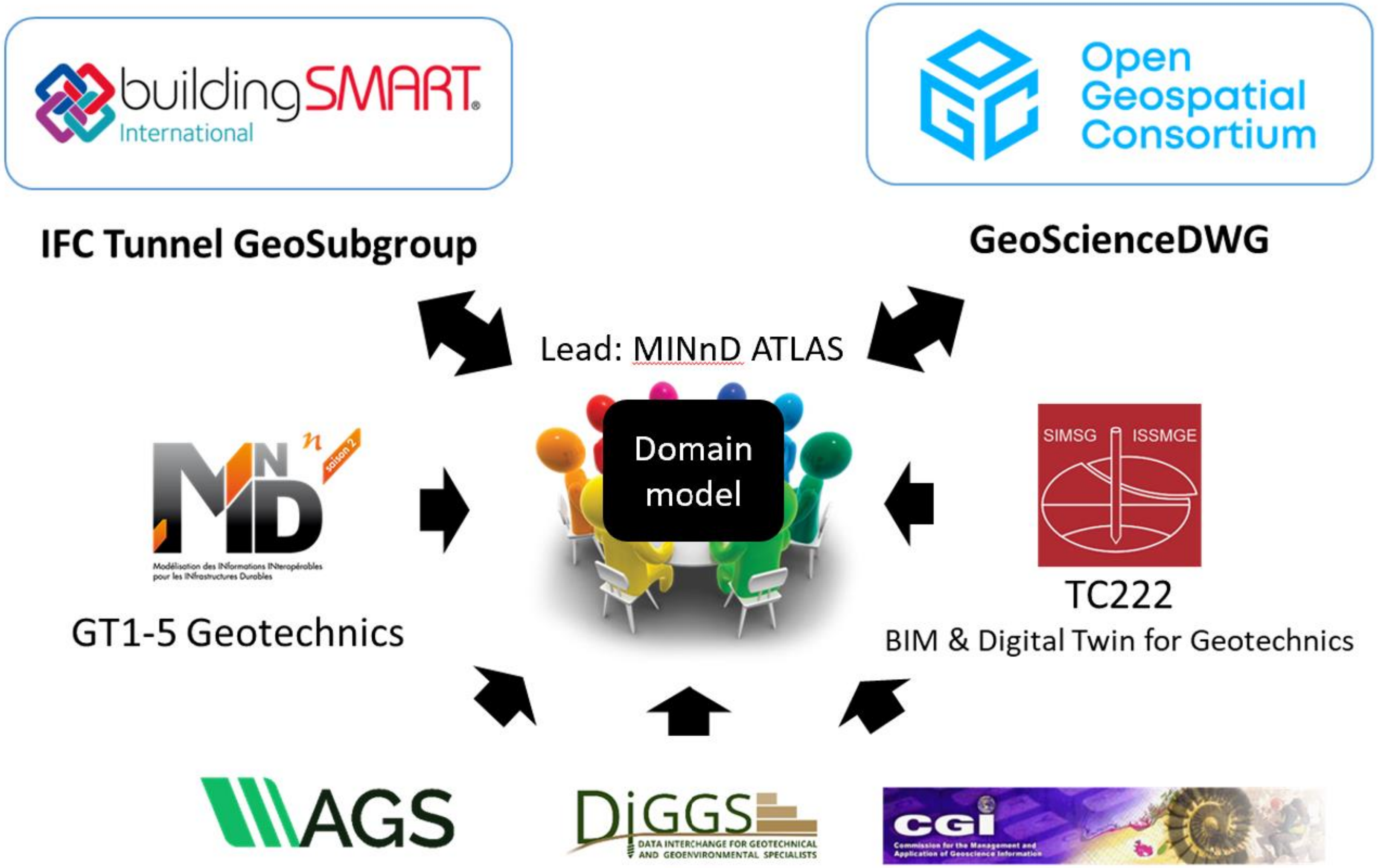
Image credit: Bioregional

Version 1.1 • 28 January 2021
OGC Document 19-091r2
bSI TR1012

OGC® Making location count.
buildingSMART International

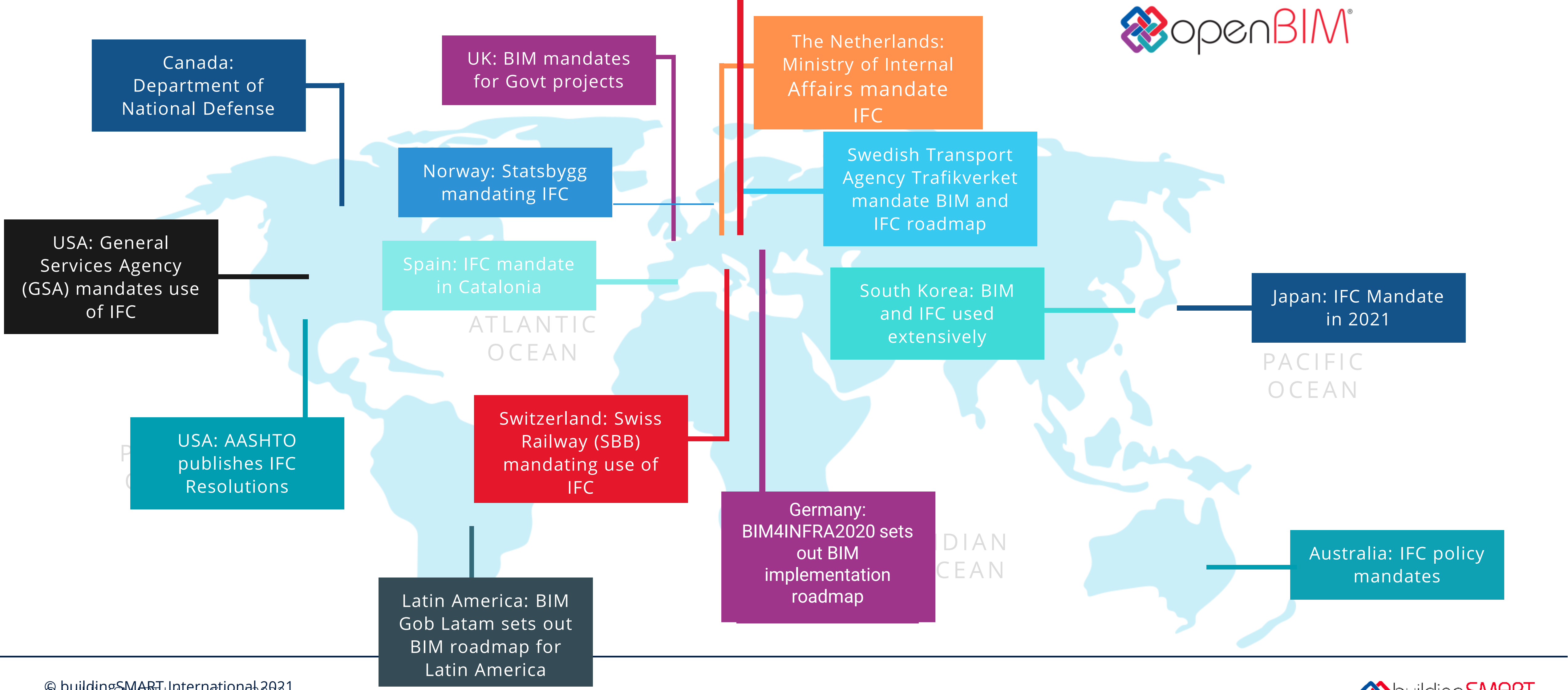
IDBE v1.1, January 2021
Open Geospatial Consortium & buildingSMART International
Page 1 of 16

buildingSMART + OGC Collaboration BIM ←→ GeoTech

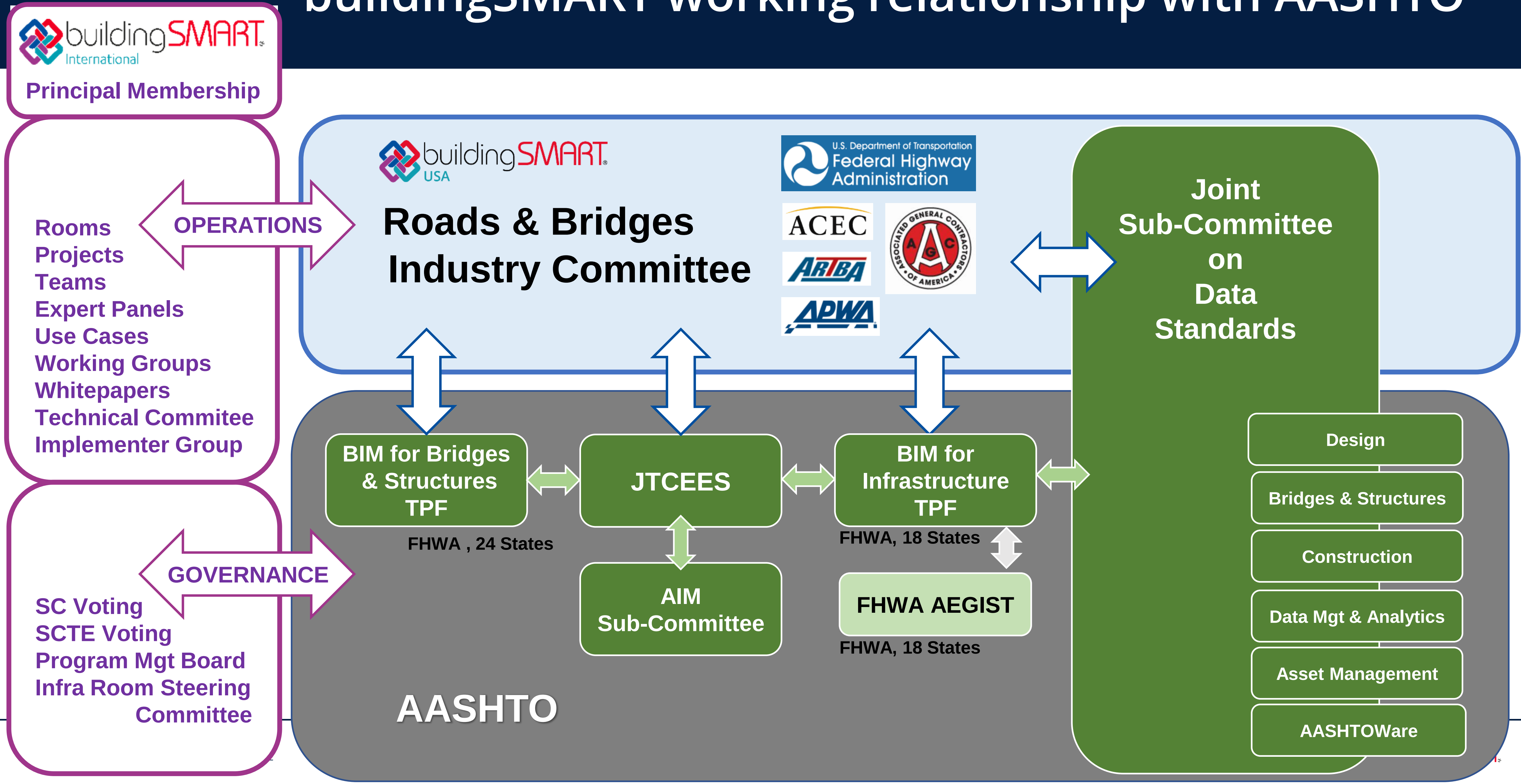


IFC Adoption

GLOBAL PERSPECTIVE



buildingSMART working relationship with AASHTO



Case Studies and Projects

- Interstate Bridge Replacement, Washington and Oregon
- AEGIST Pooled Fund Study Pilots with State DOTs
  - » Pennsylvania State DOT
  - » Tennessee State DOT
  - » Ohio State DOT
- New South Wales – Roads and Asset Data Modeling for Design-Asset Systems

2020 buildingSMART Award Winner

IFC for Design: Panama Canal 4th Bridge

Total length
7 KM

Constructed by
DESIGN-BUILD

VARIOUS DISCIPLINES
Such as the main bridge, approach bridges, and interchange areas

1 Cable-Stayed Bridge
17 Girder Bridge
5 Culvert
47 Road

Open standards enabled:

- ✓ Open machine-readable manual
- ✓ Bridge designers used IFC software
- ✓ Developed using Linked Data and semantic web
- ✓ Integrating ontologies was key
- ✓ ifcOWL, IFC 2x3, IFC4

Mentimeter

Breakout Session 3:

Open Discussion & Survey

Discussion Topics:

- Projects, Pilots and Best Practices in Standards-Based Road Network Data Modeling?
- Why Standards? What are the Business Use Cases?
  - **As-Built and Proposed Assets Modeling:** Design-Construction to Asset Management Handoff?
  - Road Network for Travel Demand Modeling
  - Road Network for Freight Analysis
  - Road Network for Connected Vehicles Environment
  - Other?
- How can AEGIST and FHWA help with adoption of Standards at State and Local Agencies?
  - **Collaboration and Role of Private Sector** – How Road Network Data Vendors and Software Vendors are adopting Road Network Standards
  - **Engagement with Standard Development Organizations** in Adoption and Deployment of Standards (e.g.: AEGIST Pooled Fund Program? BIM Pooled Fund Program? Standards deployment via Pilots)
  - Other Approaches?
- Are there policies and processes being formulated at State and/or Local agencies related to Data Standards development/adoption?

Wrap Up

Resources

AEGIST Presentations, Webinars

https://gisintransportation.com/presentations/
https://gisintransportation.com/webinars
https://gisintransportation.com/about/objectives-themes/

AEGIST

- ABOUT
- PEER EXCHANGES
- WEBINARS
- WORKSHOPS & MEETINGS
- PRESENTATIONS

Outreach for **Applications of Enterprise GIS In Transportation**

PRESENTATIONS

Presentations

- January 25, 2022: AEGIST TRB Update at AED40 Committee Meeting
- January 7, 2022: AEGIST Complete Streets Vision and Activities
- January 2020: TRB Annual Meeting Geographic Information Science and Applications Committee Meeting
- August 2020 Traffic Records Forum
- September 2020: National Roads Symposium, HPMS 9.0 Inputs
- October 2020: RHUG Presentation on AEGIST Vision and Goals

RESOURCES

- Applications of Enterprise GIS in Transportation (AEGIST) Guidebook v1.0. **Read the Guidebook**
- Guidebook v2.0 Under Development.

How do I get involved?

For more information and version 1.0 of the guidebook, please visit: https://www.gis.fhwa.dot.gov/AEGIST.a

Upcoming AEGIST Events: 2022

Peer Exchange 3: AEGIST Guidebook v2.0 Collaborative Development with Agency Practices

- Chapter 1: Geospatial Information Systems: Data & Applications
- Chapter 2: Centerlines (Datum) Information Modeling
- Chapter 3: Route Network Information Modeling
- Chapter 4: Intersection Information Modeling
- Chapter 5: Asset Information Modeling (AIM)
- Chapter 6: Project Information Modeling (PIM)

- Data Management & Applications
  - Data Architecture: Information Requirements
  - Data Modeling
  - Data Integration/Interoperability
  - Data Quality
  - Data Engineering & Analytics Platforms
- Data & Applications Governance

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Erin Lesh, NCDOT
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Ryan Koschatzky, NCDOT
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Vikki Hankus, Ohio DOT
Lavanya Sugumar, Ohio DOT
Sam Granato, Ohio DOT

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Nathan Easley, ESRI
Rahul Rakshit, ESRI
Chad Baker, Caltrans
Kathleen Mohla, Caltrans
Gerald Schumacher, Caltrans
Yueming Wu, WVDOT
Charles McNeel, WVDOT
Aaron Ferrari, WVDOT
Will Holmes, KYTC
James Graham, DCDOT
Will Thoman, ITD
Margaret Pridmore, ITD
Kevin Koester, KS DOT
Elsit Mandal, KS DOT
Chase Null, KS DOT
James Stewart, KSDOT

Frank Desendi, PennDOT
Patrick Kielty, PennDOT
Jesse Frankovich, MDOT
Karen Faussett, MDOT
Kevin Hunt, NYSDOT
Patrick Kemble, NYSDOT
Tom Neville, TXDOT
Jennifer Bierman, TXDOT
Gene Barrera, Merced County
Natasha Potter, CalOES
Sam Sedgwick, CalOES
Amanda Kabisch-Herzog, CalOES
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