

AEGIST: Applications of Enterprise GIS in Transportation

AASHTO GIS-T Update

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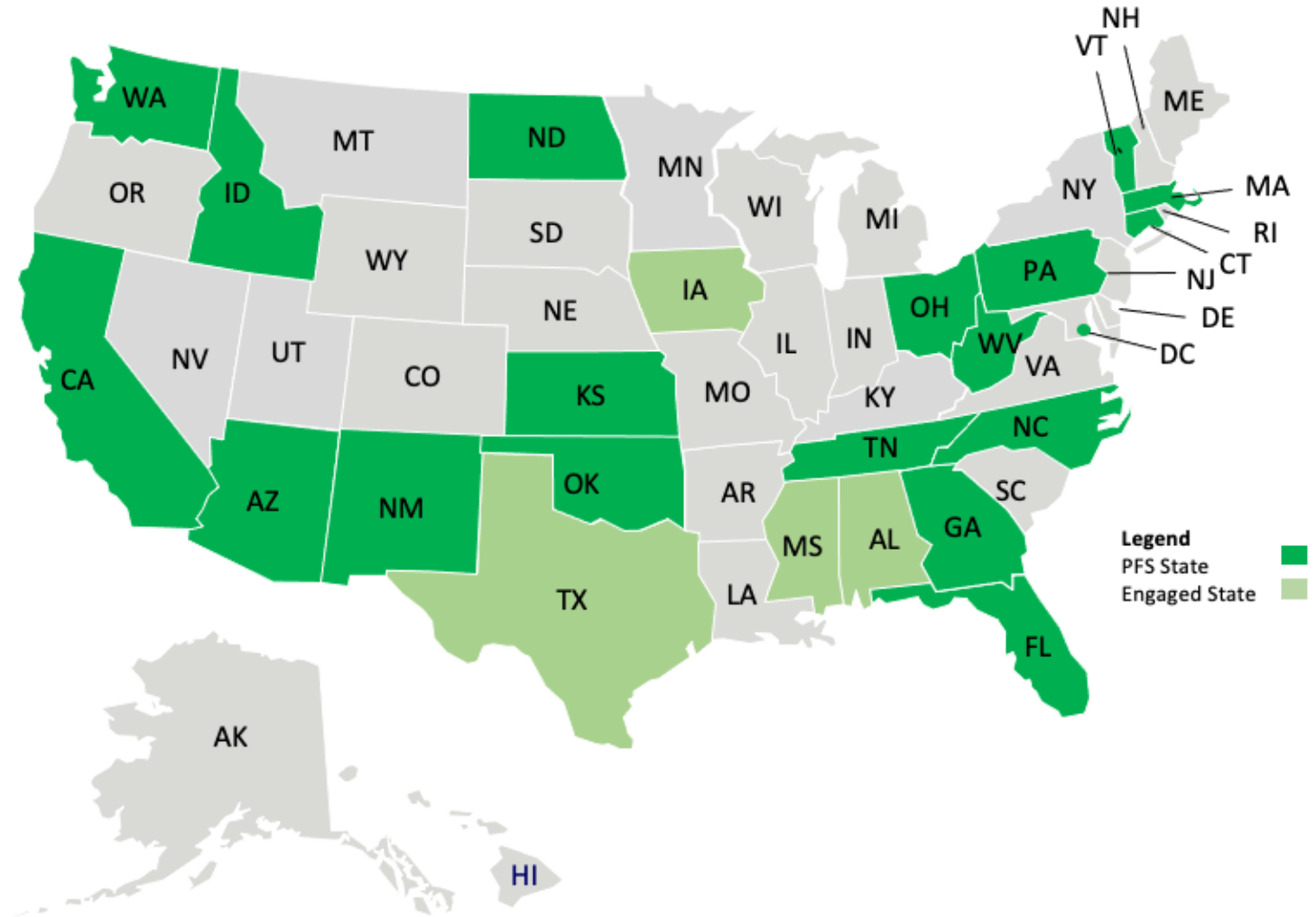
April 2022

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

AEGIST Activities Update

- FHWA Office of Planning and Safety
- States DOTs Participating: 18; Engaged 5
- Local Agencies and NG911 Stakeholders in California, Pennsylvania
- Federal Lands Management Agency
- Private Sector: Data and Software Vendors, Consultants working with Pooled Fund Study States



State DOT Technical Services Examples

- **Pennsylvania** Speed Limit Data Extraction Automation from PDFs; Integrating NG911 & DOT Roads
- **California** Roads Sharing (CaRS) Data and Application Architecture - Integrating NG911 & DOT Roads
- **Idaho** Data Governance Portal, Federal Lands Roads Data Conflation with DOT and Local Roads
- **Connecticut**: FME for Roads Data Quality Reporting
- **Ohio**: Strategic Plan for Road Network Data Management
- **Kansas, North Carolina, New Mexico & Florida**: Road Segments and Intersections Model for Model Inventory of Roadway Elements (MIRE), Safety Analysis, Freight Analysis, Travel Demand Modeling
- **Tennessee**: Design to GIS/Asset Management Data Migration

Pennsylvania

Speed Limit Data Extraction from Permits PDF using Python



Speed Limit Permits
(Authoritative Source)



County: Lancaster
SR: 0741 (Entire SR)
Speed Limit

As a result of an engineering and traffic study, a speed limit(s) on the following section(s) of the subject State-designated highway is hereby established:

From Segment	Offset	To Segment	Offset	MPH	Side	Posting Responsibility
0010	0000	0040	0000	Turnback		
0040	0000	0050	1247	35	Both	PennDOT
0050	1247	0090	0977	45	Both	PennDOT
0090	0977	0130	1938	35	Both	East Hempfield
0130	1938	0190	0000	35	Both	Manor Twp.
0190	0000	0210	0306	40	Both	PennDOT
0210	0306	0250	0150	45	Both	PennDOT
0250	0150	0250	2912	40	Both	PennDOT
0250	2912	0260	0000	Null With SR 0324		
0260	0000	0284	0000	45	Both	PennDOT
0285	0000	0285	1265	45	Descending	PennDOT
0284	0000	0284	1265	45	Ascending	PennDOT
0284	1265	0290	0000	Null With SR 0222		
0290	0000	0300	0345	40	Both	PennDOT
0300	0345	0320	0804	35	Both	West Lampeter Twp.
0320	0804	0350	2003	40	Both	PennDOT
0350	2003	0390	0000	25	Both	Strasburg Boro.
0390	0000	0400	2233	25	Both	Strasburg Twp.
0400	2233	0530	0870	50	Both	PennDOT
0530	0870	0540	3008	35	Both	PennDOT

(End SR)

Scripts and/or models to automate analysis

Process to extract data from PDF, Excel or other static documents

Create tools or processes to sync data among sources or notify when changes occur

```
def MRegDF(Page1DataSplit, year):
    DF = pd.DataFrame()
    for LineNo in range(3, len(Page1DataSplit)):
        #Regular expression being used to extract a list of tuples by including multiple () extraction brackets
        #Look for A-Z 0 or more times
        #IF you encounter one space, keep looking for A-Z 0 or more times
        #Stop extracting if you encounter space one or more times - But this should only happen after you have ignored
        #space one time. Extract all of these spaces as second value in the tuple
        #Third value in the tuple should include 0-9, encountered 0 or more times AFTER having encountered a series of spaces
        LineContentList = re.findall('[A-Z]*\s[A-Z]*\s+(\s+)([0-9,]*)', Page1DataSplit[LineNo])
        for item in LineContentList:
            if item[0] != ' ':
                s1 = item[0].strip()
                s2 = item[2].strip()
                s3 = ''
                for i in s2.split(","):
                    s3 = s3 + i
                DF = DF.append({'COUNTY':s1, 'MReg_'+str(year):s3}, ignore_index=True)
    DF = DF.set_index(['COUNTY'])
    return DF

MReg2013DF = MRegDF(MReg2013Page1DataSplit, 2013)
MReg2014DF = MRegDF(MReg2014Page1DataSplit, 2014)
```


California Road Sharing (CaRS)



California Road Sharing (CaRS)

Road to Governed California Centerlines

California's road system is managed by various authoritative roads data management government agencies. These include the Caltrans State Department of Transportation (DOT), 58 counties and 482 municipalities using multiple data systems.

Vision: The California Road Sharing (CaRS) Program will establish the Road to Governed California Centerlines. Road data modeling, management and exchange practices will be coordinated across Caltrans, Cal OES and Local agencies. A Statewide Roads Data, Applications and Technology Architecture will be created for management of road centerline geometry and road information. Pilot projects will be done with stakeholders in California and workshops will be held as part of the ongoing FHWA-led AEGIST program involving 18 States, in the U.S. to gather information for successful deployment of an integrated and federated data management system with data modeling, governance, sharing and QA/QC rules..

Benefits to Stakeholders

- Public safety enhancement through data-driven emergency management, preparedness and incident response
- Transportation planning, traffic studies, safety assessments and geo-locating address information (geocoding)
- Linear referencing of infrastructure asset inventory and condition assessment data in Asset Management Systems
- Capital and Maintenance project work data management (linear/spatial referencing)
- Topologically connected routable network development for map-based vehicle routing and analysis of driving directions, distances, roadway mileage.
- Deployment of Statewide Roads Data Governance Framework through establishment of National standards-based roads data modeling and QA/QC rules across government agencies
- Development of Digital Twin and AI/ML Applications for Infrastructure Management, CV/AV & Unmanned Aerial Systems

Roads Data Modeling & QA/QC Rules

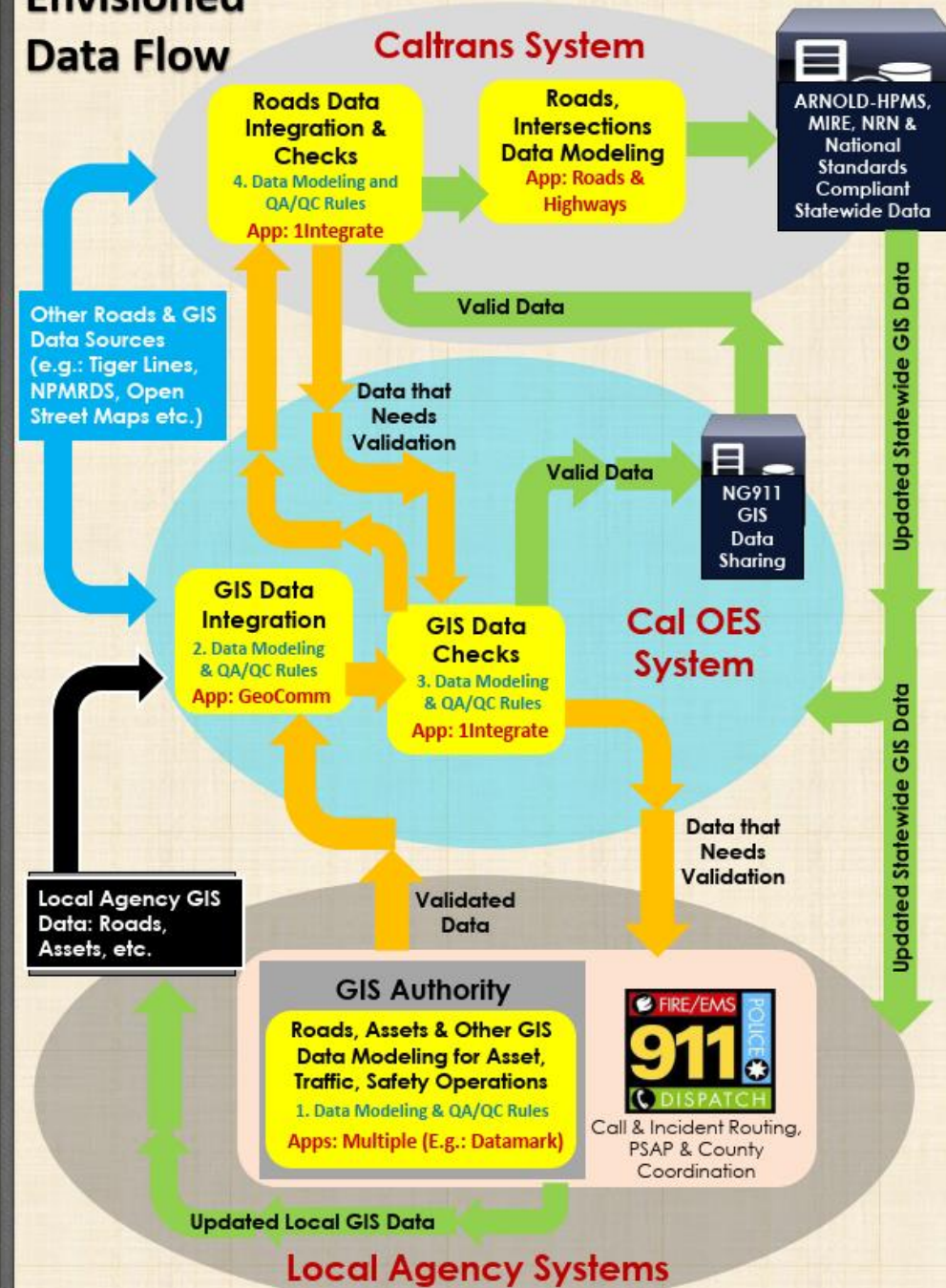
- Null and Multi-Part Geometry
- Duplicate Vertices
- Centerline Alignment
- Digitization Direction
- Centerline Accuracy, Source
- Self-Intersecting Geometry
- Start/End Nodes Alignment
- Overshoots/Undershoots
- Kickbacks
- Bifurcations
- Turn Lanes & Ramps Centerlines
- Emergency Crossovers
- Railroad Crossings
- Administrative Boundary Junctions
- Overlap/Concurrent Roads
- Dual-Geometry (Divided/Undivided)
- Roundabouts & Traffic Circles
- Road Identification Information (ID, Name, Class etc.)



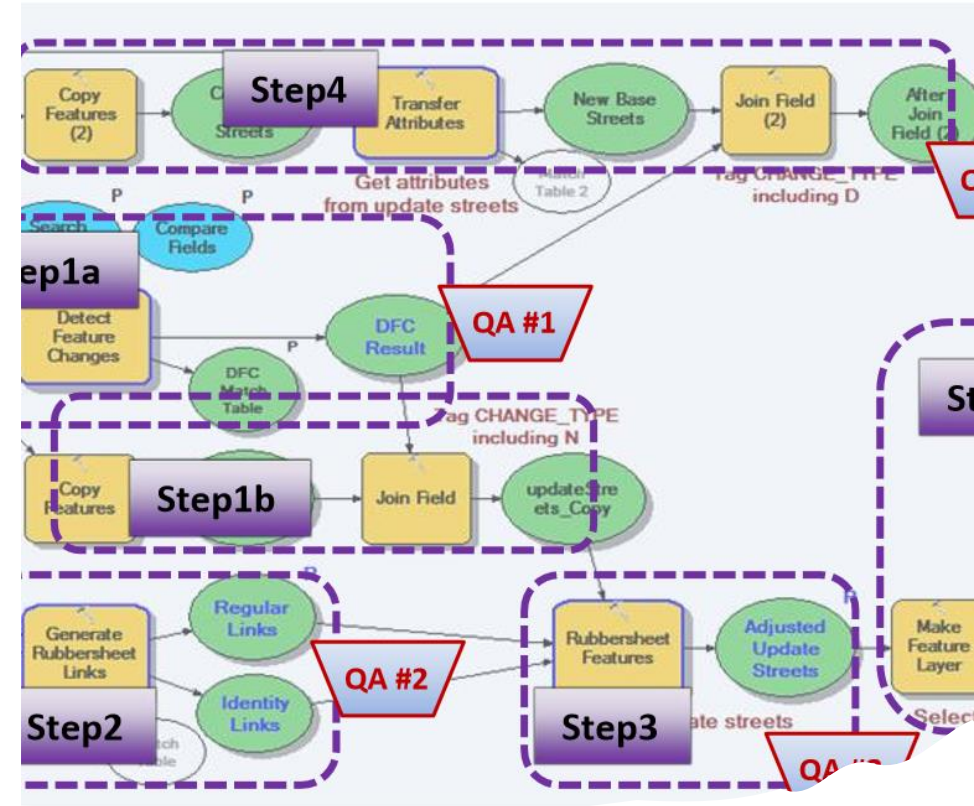
PROGRAM GOALS

- ✓ Create a governed state-wide road centerline dataset to meet ARNOLD and NG911 roads data requirements
- ✓ Provide mutual benefits to State and Local jurisdictions, especially the business users involved in highway project planning, survey, design, construction, safety, traffic and asset management operations
- ✓ Coordinate roadway cartographic and data model recommendations
- ✓ Support Transportation for the Nation (TFTN), which promotes a publically available, high quality road centerline that is coordinated across all levels of government
- ✓ Building Information Modeling (BIM) for Roads and Assets using Standards for supporting AI/ML Applications, CV/AV and UAS.

Envisioned Data Flow



Source: Abhishek Bhargava. Data Engineering and Architectures for Building Information Modeling in GIS (BIM-I-GIS)



Idaho Geoprocessing Tool for DOT and Federal Lands Roads Data Conflation

Idaho Data Governance Tools

Data Catalog

Object Type
Library

**Data
Dictionary**

Data Models
Catalog

**Applications
Catalog**

**Applications
Communication
Diagram**

Interface
Catalog

Authoritative
Data
Management
Models

Data Quality
Governance
System

Data Integration
& Engineering
Governance
System

Data
Provisioning
Governance
System

Data Analytics
Governance
System

C1: BIM Data Management Strategy Governance

- E1: Organizational Priorities, Goals and Objectives
- E2: Data Management Program and Charter
- E3: Roadmap of BIM Programs, Projects & Deliverables

C2: BIM Data Governance Council: Roles & Responsibilities

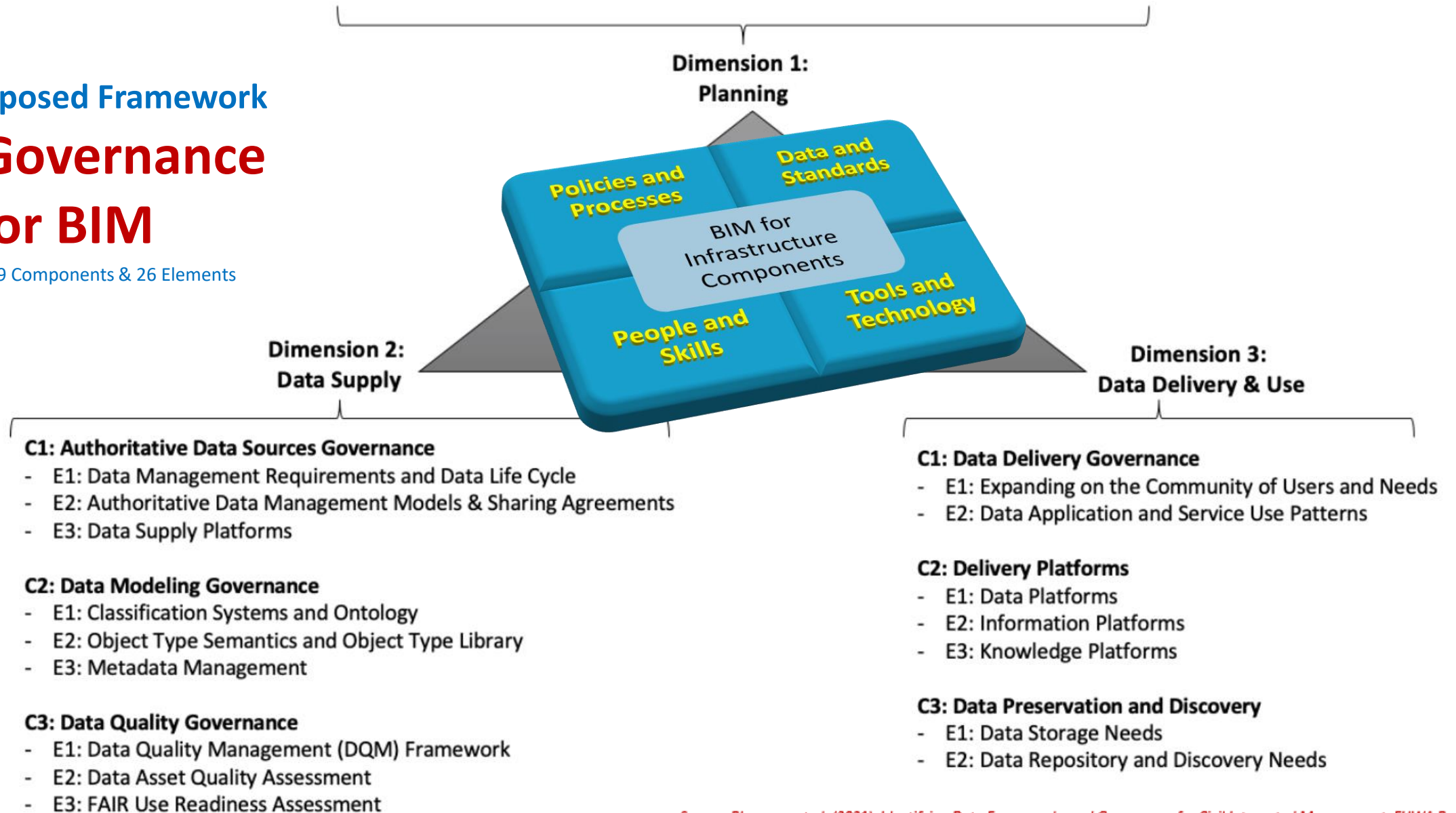
- E1: Data Governance Organizing Bodies
- E2: Data Governance Policy & Functions
- E3: Data Governance Roles with Governance Bodies

C3: BIM Data Portfolio

- E1: Data Assets Inventory
- E2: Data Applications Inventory
- E3: Data Framework (Taxonomy)

FHWA Proposed Framework Data Governance For BIM

3 Dimensions, 9 Components & 26 Elements



Data Assets Inventory and Applications

TOGAF 9.2 Standard Compliant

Data Assets | Object Type Library (OTL) | Data Dictionary | Data Applications

Grid view | 1 hidden field | Filter | Grouped by 1 field | Sort | Color | Share view

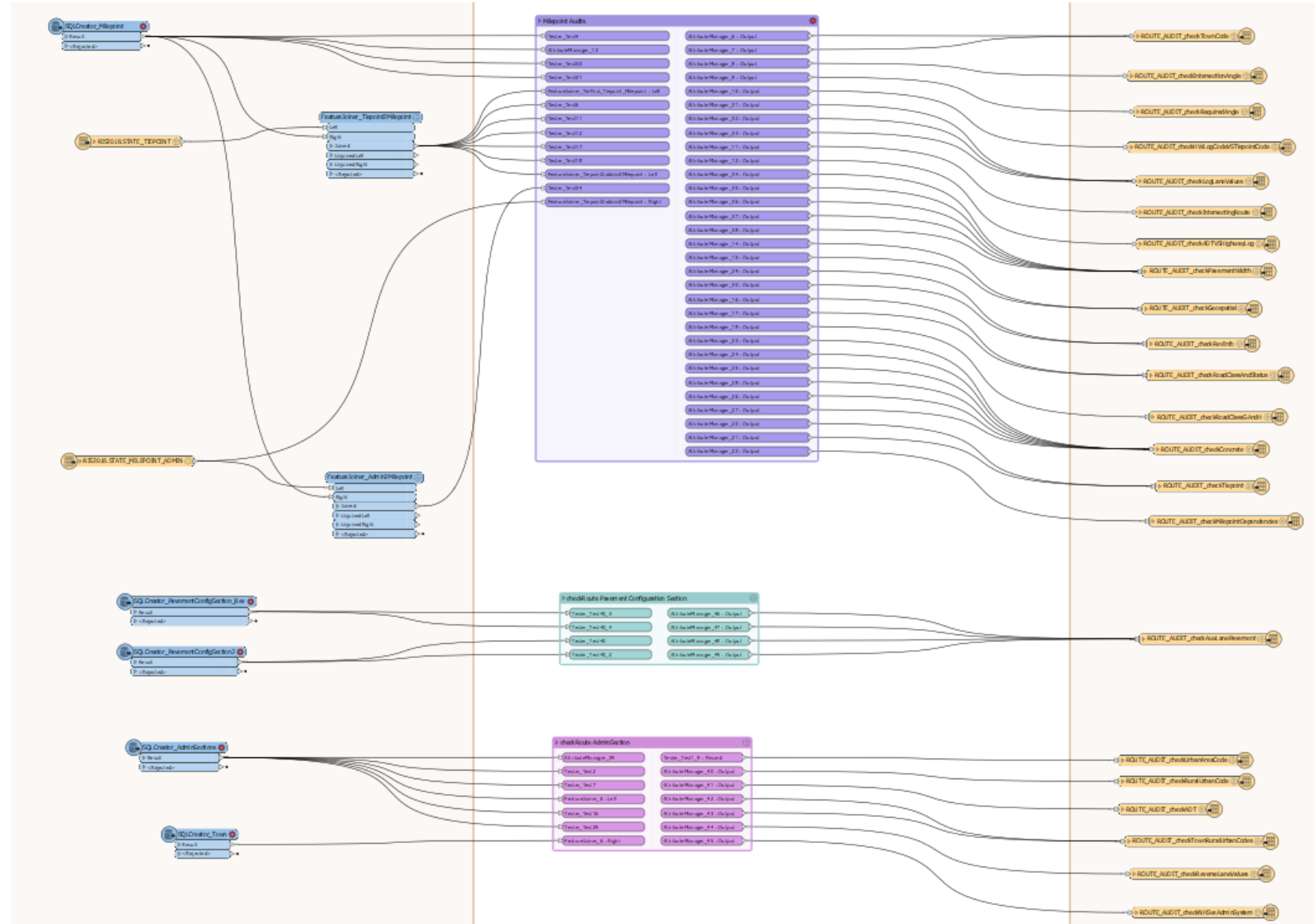
Asset ID	Description	Owners	Stewards	Performance Goal	Business Domain	Priority	
PERFORMANCE GOAL							
Infrastructure Health Count 11							
28	1 Bridge	As part of national requirements for our bridge inve...	DOT Bridge Department	Program Info Coordinato...	Infrastructure Health	Asset Management	High
29	Culvert		DOT Asset Management	ITD Districts	Infrastructure Health		
30	Horizontal Curve (Alignment)		HPMS Coordinator Doro...	HPMS Coordinator Doro...	Infrastructure Health		
31	HPMS 0.1 Mile Segments		HPMS Coordinator Doro...	HPMS Coordinator Doro...	Infrastructure Health		
32	HPMS Sample Sections		HPMS Coordinator Doro...	HPMS Coordinator Doro...	Infrastructure Health		
33	Maintenance Work Orders		DOT Asset Management	Maintenance Manager S...	Infrastructure Health	Asset Management	Medium
34	Pavement (Road) Surface	Road Surface is maintained on state routes by ITD a...	DOT Asset Management	HPMS Coordinator Doro...	Infrastructure Health	Asset Management	High
35	Pavement Distress				Infrastructure Health	Asset Management	High
36	Pavement Roughness (IRI)	Pavement ratings gathered from longitudinal road p...	DOT Roadway	Pavement Data Manager...	Infrastructure Health	Asset Management	High
37	Pavement Structure				Infrastructure Health	Asset Management	High
38	Snow Plow Data	Data generated from snowplow pings process as pa...	DOT Maintenance Supp...	Maintenance Manager S...	Infrastructure Health	Fleet & Equipment	High
PERFORMANCE GOAL							
Infrastructure Health Traffic Safety Mobility Count 3							
PERFORMANCE GOAL							
Infrastructure Health Mobility Count 3							
PERFORMANCE GOAL							
Traffic Safety Count 4							
45	Crash Data	Records of crashes with vehicle and severity inform...	Office of Highway Safet...	Office of Highway Safet...	Traffic Safety	Management	High
46	Intersection Influence Area	A spatial polygon feature that represents the shape ...	DOT Asset Management	Not Currently Managed	Traffic Safety	Management	Low
47	Intersection Routes		Not Currently Managed	Not Currently Managed	Traffic Safety	Management	Low
48	Traffic Counts	Raw Traffic data from counters	DOT Traffic Data	Traffic Data Manager Ma...	Traffic Safety	Travel Demand Modeling	High

Connecticut DOT

Data Quality Automation using FME

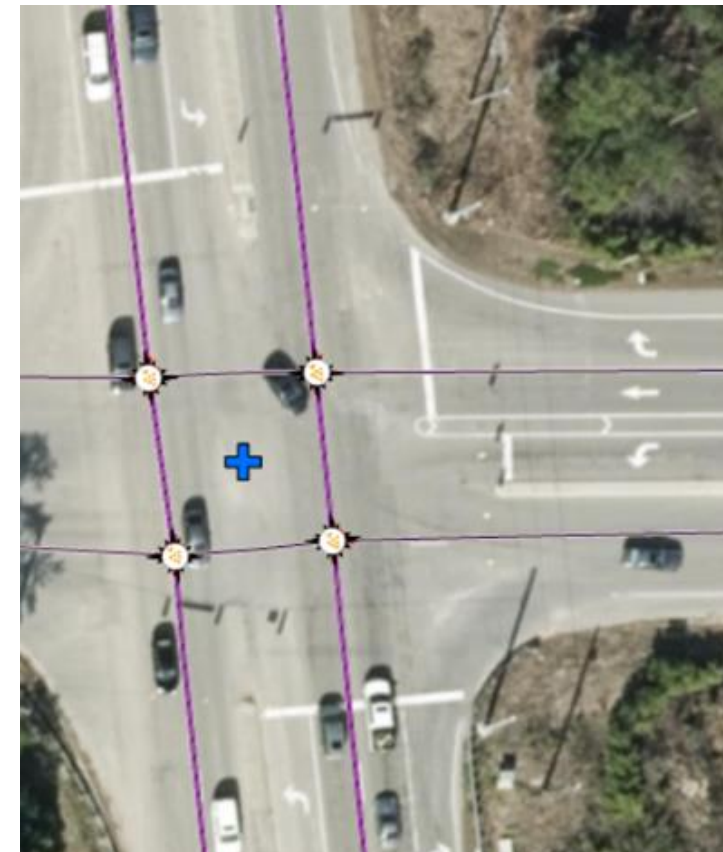
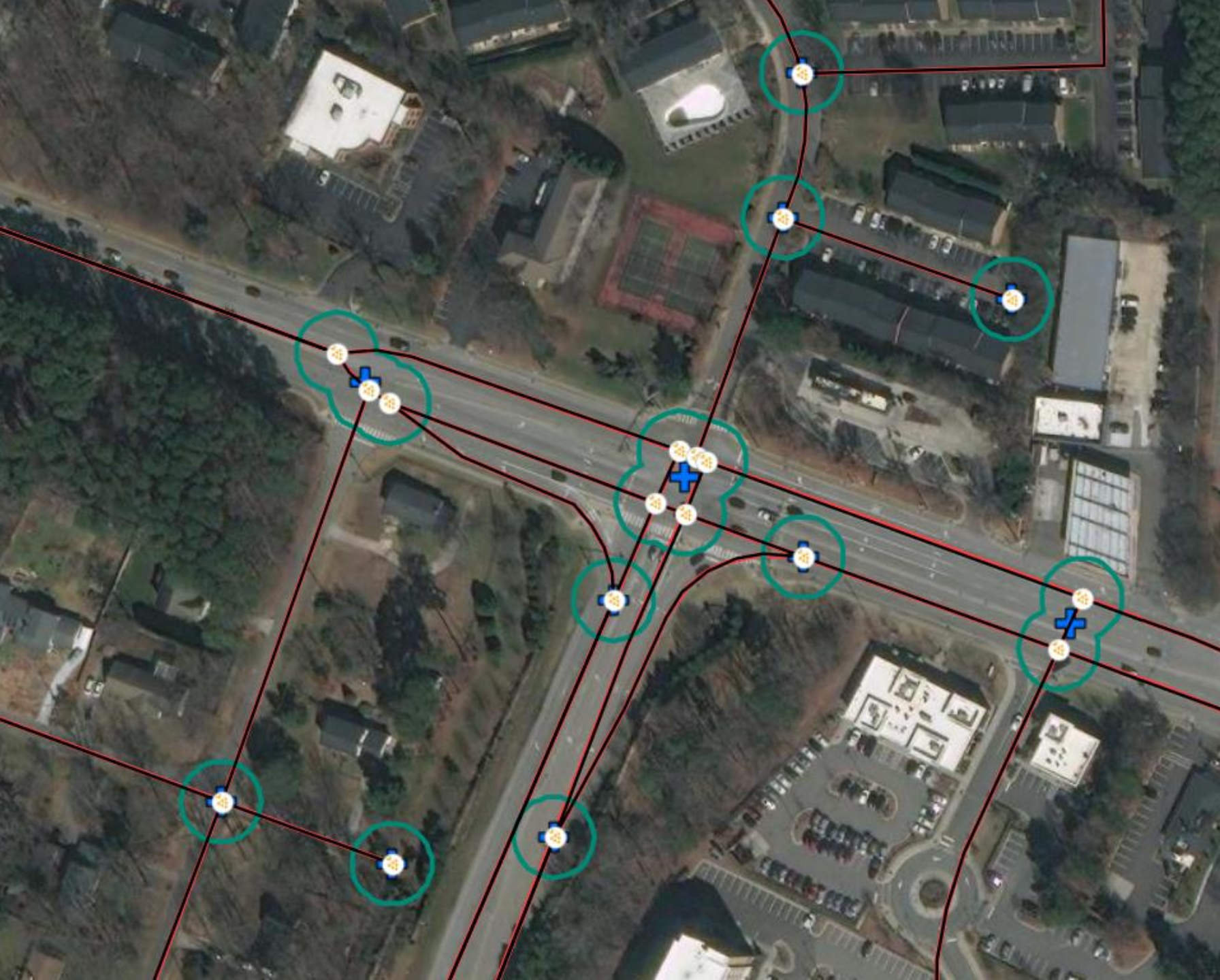
Road Network Data Quality Checks

- Routes
- Tiepoints/Nodes
- Intersection
- Pavement
- Traffic



Road Network Data Model for MIRE, Routing & Travel Demand Modeling

North Carolina, Kansas, New Mexico, Florida



Ohio GIS Strategic Roadmap

Draft, Work in Progress

Geospatial Roadway Inventory Data Models for Supporting Equity in Transportation Planning

Building Road Asset Information Models to support USDOTs' Transportation Equity Action Plan



Bike and Pedestrian Routes Modeling for Complete Streets

Models for Bike Routes, Trail Network. Classification System for Bike Lanes. Adopt Standards like Generalized Modelling Network Specification (GMNS)



Road Network Data Governance for Enterprise Business Users

Data Catalog, Applications Communication Diagram, Data Models, Roadway Characteristics & Road Sections Data Engineering and Provisioning to Enterprise Users



Road Segments, Junctions and Intersections Model

Topological Road Network Model with Road Segments, Intersections, Junctions **for MIRE, Safety Analysis and Travel Demand Modeling, Freight Analysis**



Asset Data Extraction from Design for Integrating into Roadway Inventory System

Building Information Modeling (BIM) for Infrastructure using Geospatial Data and Information Systems. Creating Asset Information Models from Digital As-Builts (DABs).



Data Quality Framework: Rules

Additional Rules for FME-Based Data Quality Workspaces. Data Quality Assessment Dashboards



LRS Road Network Administration

LRS Centerline Modeling for All Roads using data from Local Agencies, DOTs Design Alignments,



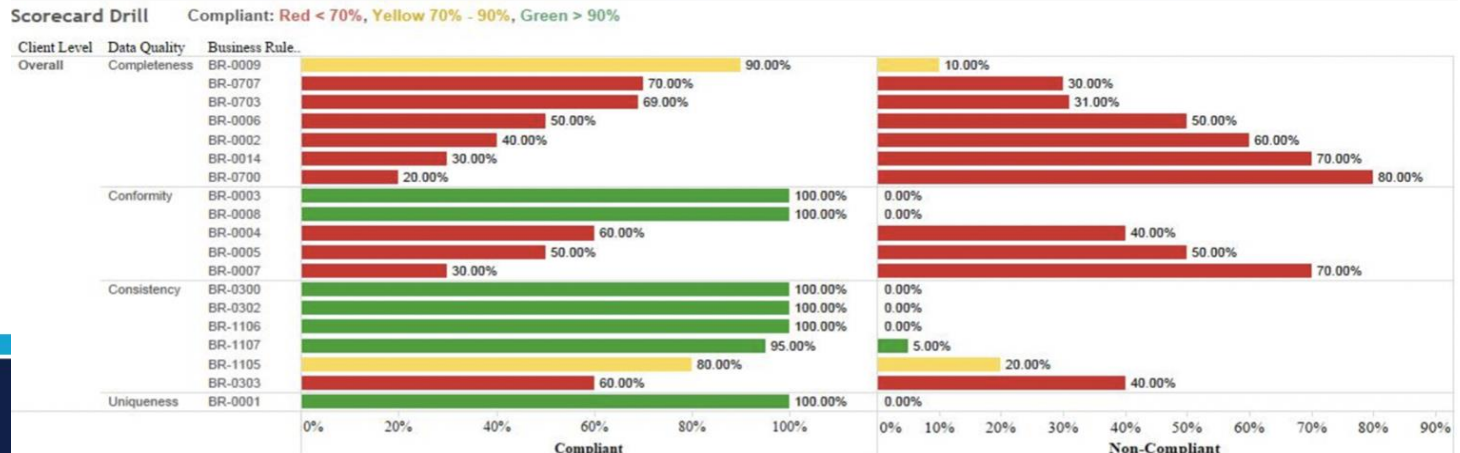
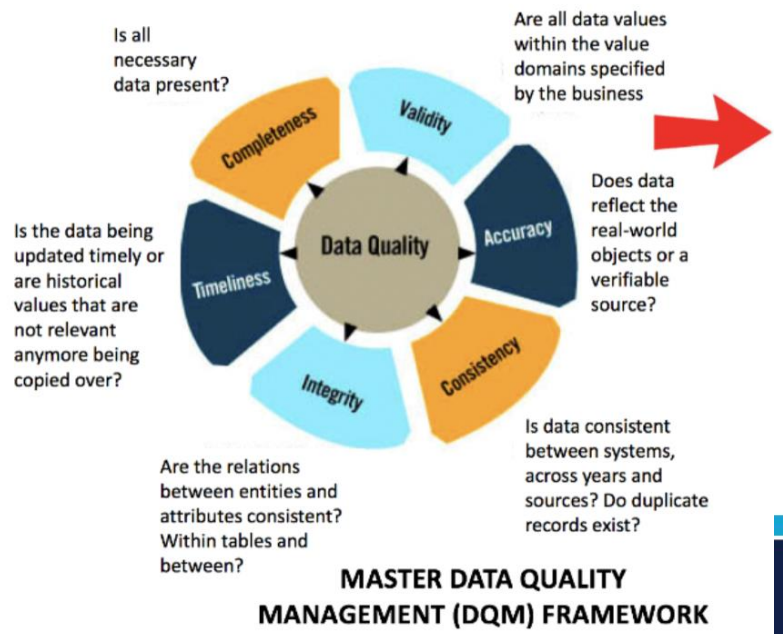
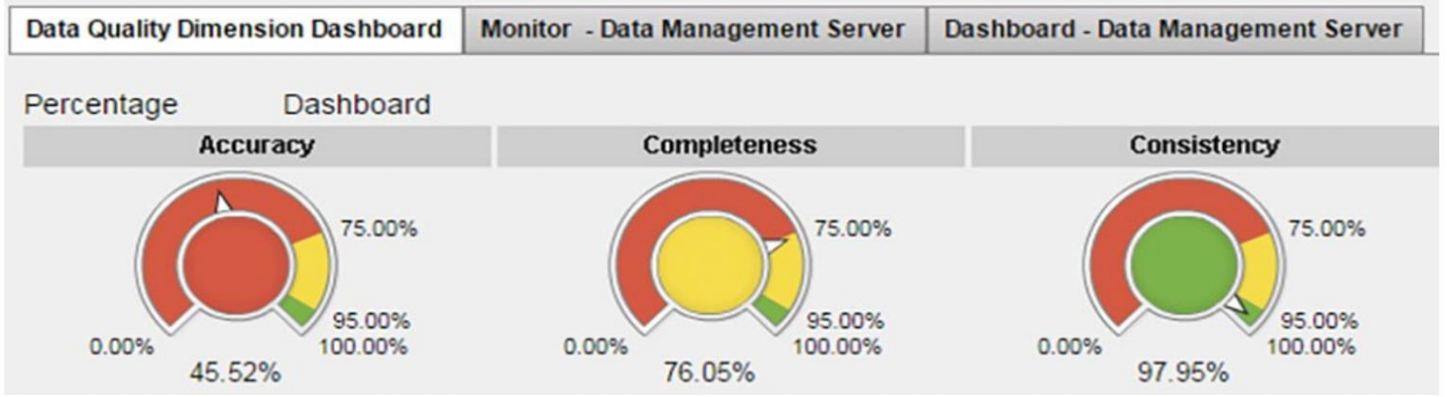
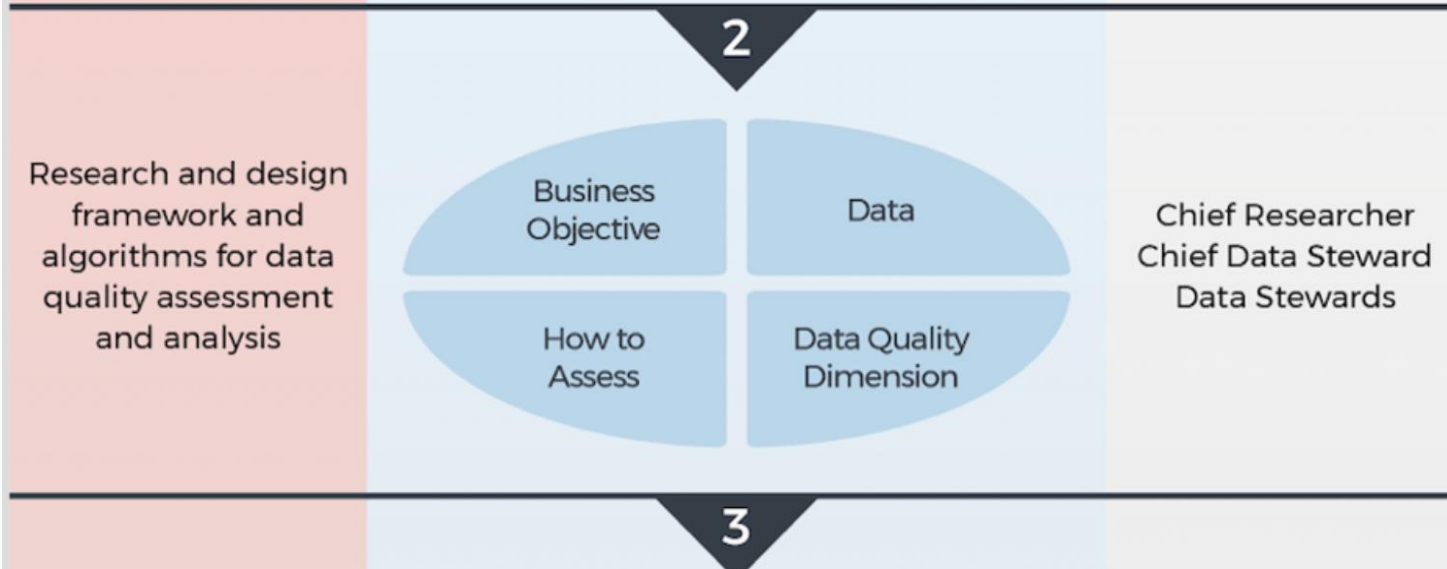
HPMS 9.0 Data Model Updates

National Highway Freight Network (NHFN) Roadway Segments, Restricted Public Roads, Widening Potential, AADT, Route Identifications (Primary/Secondary Routes)



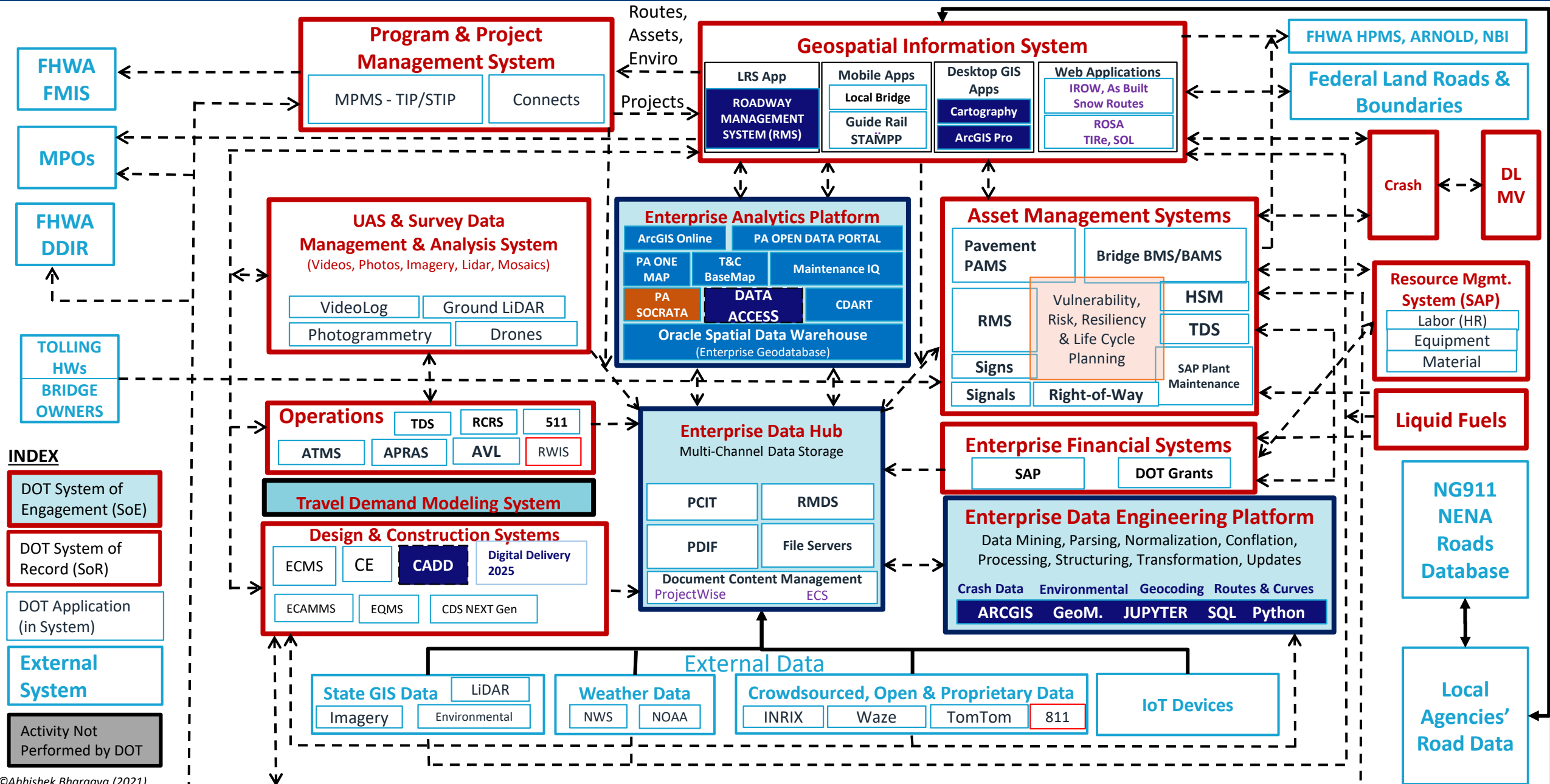
Idaho: HPMS Data Quality Rules Automation & Dashboards

1. Portfolio: Inventoried “data assets”
2. Data Models & their objective. Enterprise Data Dictionary, Data Quality Dimensions and rules
3. Automating data processing, integration & quality using Data Science Workbench
4. Data Governance Dashboards



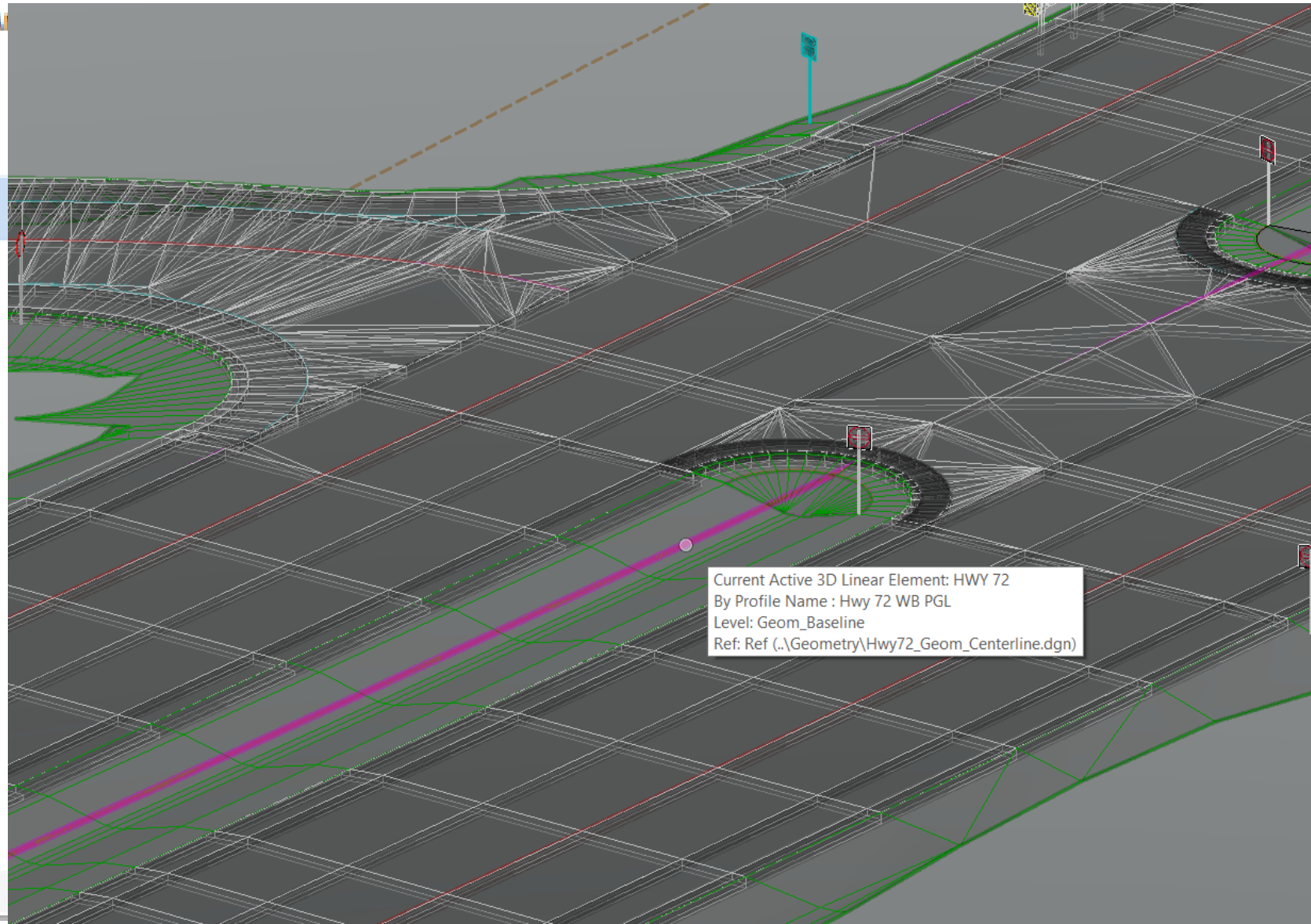
AEГИST: PENNDOT EDITION

APPLICATIONS FOR ENTERPRISE GIS IN TRANSPORTATION



Tennessee DOT: Design Data to GIS and Asset Management

- Feature Definition (Common Features A
 - Alignment
 - Road
 - Geom_Baseline
 - Geom_Baseline_Driveway
 - Geom_Baseline_Ramp
 - Geom_Baseline_Secondary
 - Geom_Temp
- Terrain
- Corridor
- Superelevation
- Linear Template
- Surface Template
- Linear



Current Active 3D Linear Element: HWY 72
By Profile Name : Hwy 72 WB PGL
Level: Geom_Baseline
Ref: Ref (..\Geometry\Hwy72_Geom_Centerline.dgn)

Tennessee DOT: Design Data to GIS and Asset Management

R&Hs Linear Referencing System – Route Redlines and Events

Contents

Building Layer (GDB) | Building Scene Layer (SLPK) | Map | IFC - UTM 16N | New Notebook

225 ft | 1,993,540.93E 1,767,418.61N ftUS | 536.856 ft | Selected Features: 1

Modify Features

- Edit Vertices
- Change the selection.
- AlabamaRoads (1)
 - US Hwy 72
- Edit Vertices

#	X (US Feet)	Y (US Feet)
316	1,993,178.51	1,767,612.21
317	1,993,268.85	1,767,554.06
318	1,993,417.43	1,767,453.00
319	1,993,718.50	1,767,253.45
320	1,993,742.51	1,767,237.45
321	1,993,767.73	1,767,220.73
322	1,993,934.02	1,767,110.60
323	1,994,594.71	1,766,665.69
324	1,994,899.69	1,766,458.88
325	1,995,038.07	1,766,371.65
326	1,995,175.25	1,766,286.61
327	1,995,264.70	1,766,231.37
328	1,995,324.74	1,766,195.76
329	1,995,495.23	1,766,095.10

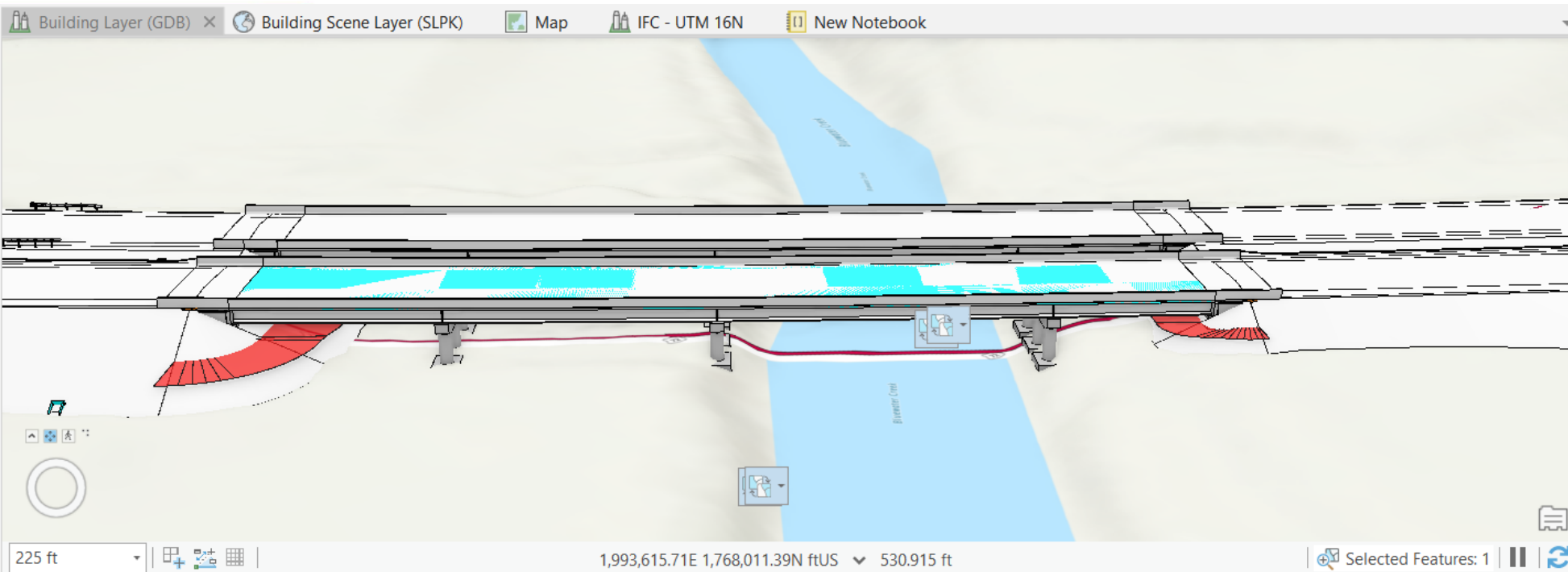
Field: Selection: Highlighted:

OBJECTID *	Shape *	LINEARID	FULLNAME	RTTYP	MTFCC	Shape_Length	
1	3585	Polyline	1106087288589	US Hwy 72	U	S1200	41714.807579

Click to add new row.

Tennessee DOT: Design Data to GIS and Asset Management

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



Attributes

Selection Layers

Change the selection.

Architectural : GenericModel (1)

Deck

Attributes Geometry

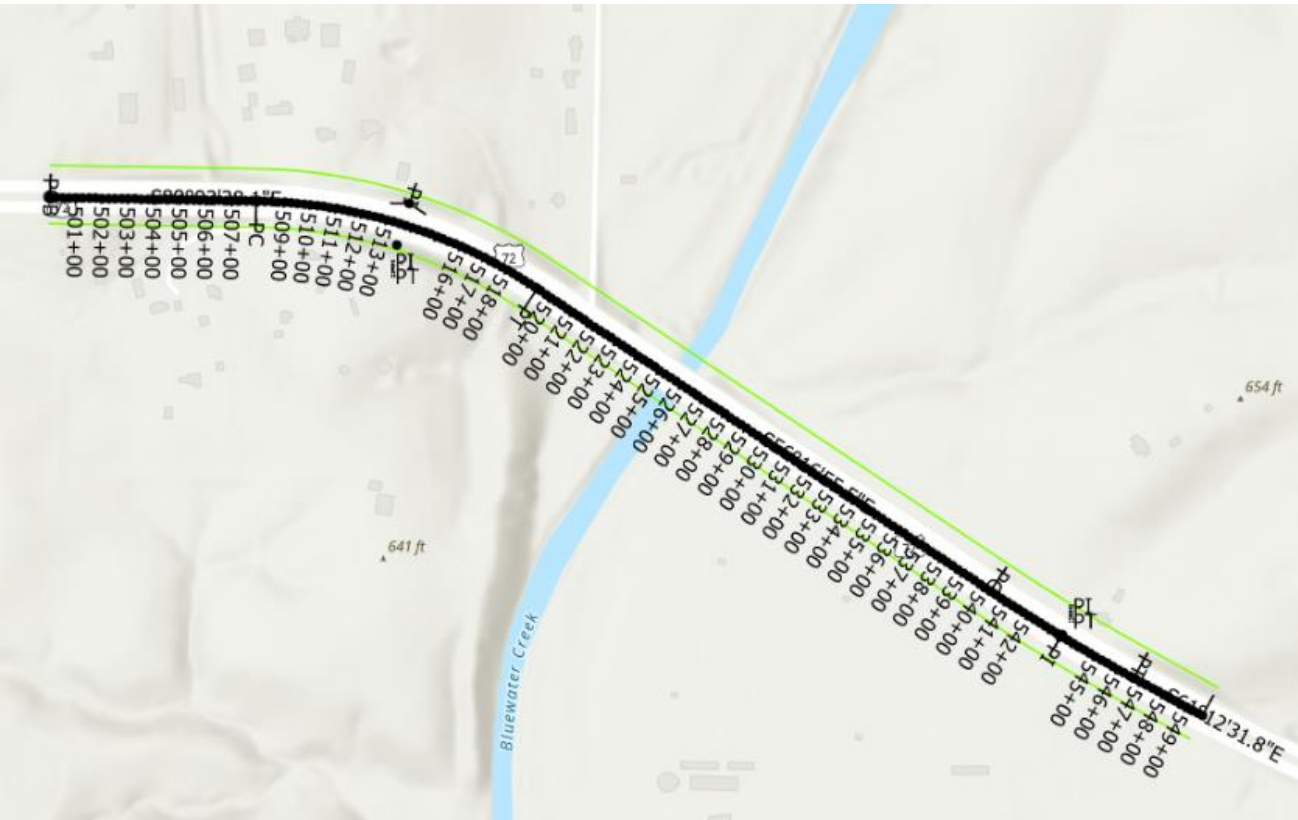
#	X (US Feet)	Y (US Feet)	Z (Feet)
27	1,993,681.28	1,767,265.74	539.01
28	1,993,755.35	1,767,245.17	537.91
29	1,993,724.98	1,767,265.44	538.17
30	1,993,711.66	1,767,245.47	538.65
31	1,993,742.03	1,767,225.20	538.39
32	1,993,755.35	1,767,245.17	537.91
33	1,993,711.66	1,767,245.47	538.65
34	1,993,785.72	1,767,224.90	537.73
35	1,993,755.35	1,767,245.17	537.91
36	1,993,742.03	1,767,225.20	538.39
37	1,993,772.40	1,767,204.93	538.21
38	1,993,785.72	1,767,224.90	537.73
39	1,993,742.03	1,767,225.20	538.39
40	1,993,573.11	1,767,366.79	540.83
41	1,993,544.33	1,767,385.99	541.59
42	1,993,531.01	1,767,366.03	542.07

for Hwy72_Geom_Centerline-Point Hwy72_Cor_Mainline_Finished-Point TL_Median FL Right Road_Sign Hwy72_Signs-Point Default AlabamaRoads

Field: Selection: Highlighted:

OBJECTID *	Shape *	LINEARID	FULLNAME	RTTYP	MTFCC	Shape_Length
Click to add new row.						

Importing Alignments and Stationing



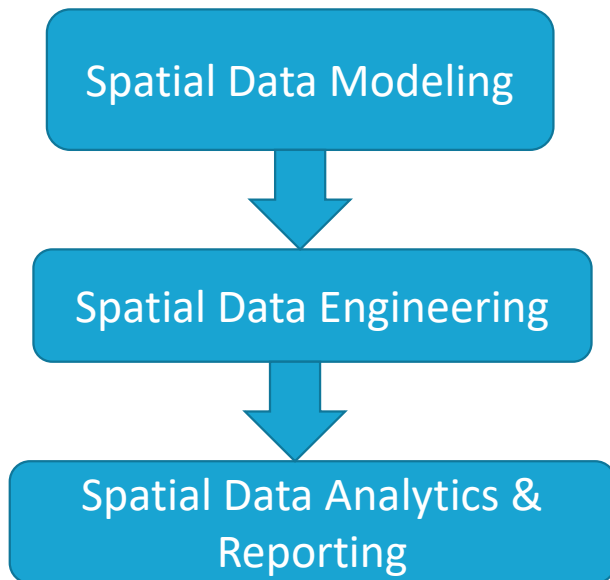
AEGIST Implementation Activities at PFS States

	CA	CT	FL	ID	TN	PA	OH	KS	NM	NC
Spatial Data Governance, Management <i>Strategy, Roadmap, Metadata, Data Portfolio & Library, Workshops</i>				✓	✓	✓	✓			✓
Spatial Data Modeling										
Roads Data Modeling & Business Rules <i>DOT, Federal, Local: HPMS, ARNOLD, NG911, MIRE, Intersection</i>	✓		✓			✓	✓	✓	✓	✓
Intersections Data Model <i>HPMS 9.0, MIRE, GDF, IFC Roads Based</i>			✓				✓	✓	✓	✓
Data Quality Automation <i>HPMS, MIRE & Assets</i>	✓	✓		✓						
Spatial Data Integration and Engineering										
Roads Data Integration, Authoritative Data Mgmt. <i>DOT, Federal, Local Roads Data Sharing & Federation</i>	✓		✓					✓	✓	
Road Network and Events Data Publication/Sharing <i>Data Model for Data Warehouses. Data Models & Engineering in Data Hubs</i>		✓		✓		✓	✓			
Spatial Data Analytics										
Spatial Statistics, Econometrics, AI/ML, Optimization <i>Descriptive, Diagnostics, Predictive and Prescriptive Analytics; Image Analysis</i>				✓		✓		✓	✓	✓

Governing Data Using Spatial & Linear Referencing Systems

Spatial Data Modeling in Transactional Systems of Records (SoRs) and **Spatial Data Engineering** for Publication to Enterprise Data Warehouses, Databases to support **Spatial Data Analytics and Reporting** Via the Systems of Engagement (SoE)

Ensuring Transportation Equity by Preparing Spatial Transportation Data for Decision Makers across All Asset Life Cycle Phases & Processes



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.

AEGIST Developing Roads and Assets Data Models using Data Standards

International Standard Development Organizations (SDO) Cloud Platform for Data Dictionary

API Services: BIM Content

bSDD a service by buildingSMART International

OGC CityGML Service

XML

SQL Servers

{JSON}

US NBTL Cloud Platform for BIM Resources

buildingSMART USA

AW Data Dictionary AASHTO

U.S. Department of Transportation Federal Highway Administration

AEGIST Data Dictionary National Road Network

National Industry Standards

- Terms & Definitions
- Classifications
- Mappings / Linking
- Agency Administration
- Compilation
- Editing

Multi-Tenant: Multiple Agencies and Stakeholders

API Services: BIM Content

XML

SQL Servers

{JSON}

State DOT Enterprise Architecture Platform

API Services: BIM Content

XML

{JSON}

SQL Servers

Software Vendors

API Services: BIM Content

XML

{JSON}

SQL Servers

Private Sector Consultants, Academicians, Researchers

API Services: BIM Content

XML

{JSON}

SQL Servers

Source: Abhishek Bhargava, Framework for National BIM Transportation Library

Questions
