U.S. Department of Transportation
Federal Highway Administration

Applications of Enterprise GIS-T (AEGIST)
FHWAs Enterprise approach to a National GIS/LRS
Workshop 7, GIS-T 2021

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U.S. Department of Transportation
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Workshop Objectives and About AEGIST

About AEGIST

Pooled Fund Study (PFS): FHWA and 18 States Enhancing Enterprise Data Management and Governance Practices

Spatial Data Modeling

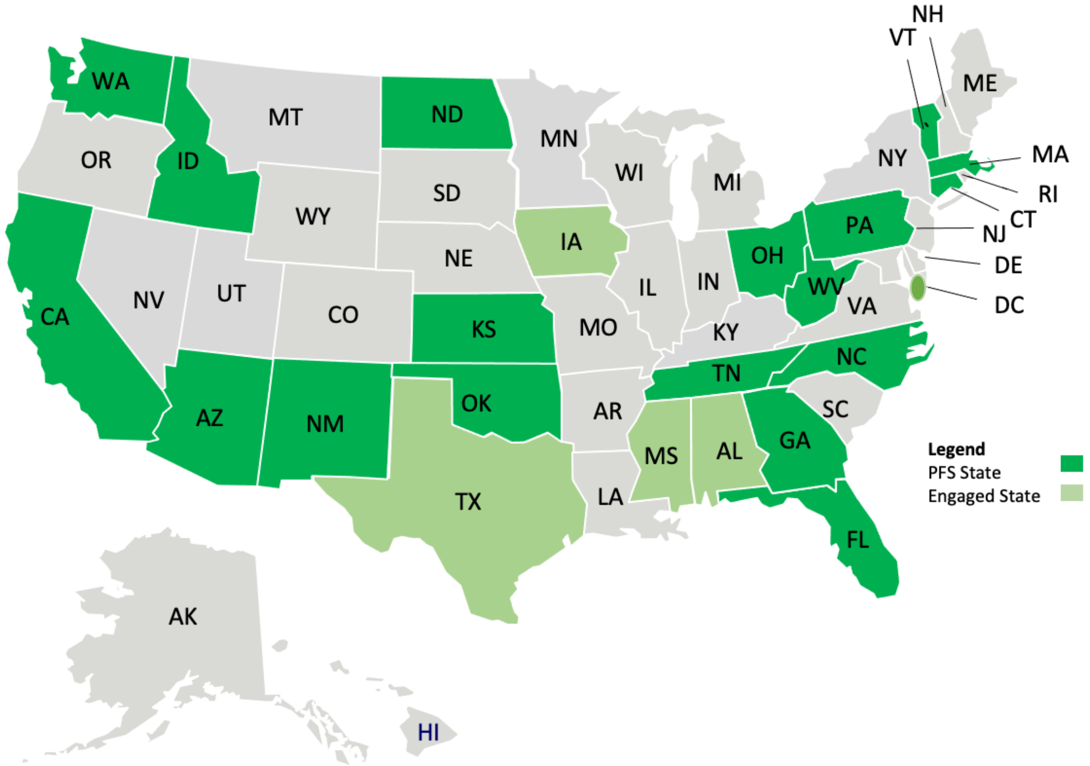
- Linear Referencing System, Routable Network, Events, Topology
- Linear/Spatial Referencing Data Models and Data Structures
- Data Quality, Availability, Readiness (FAIR), Authoritative Sources

Spatial Data Integration and Engineering

- Integrating and Engineering Business Data using LRS.GIS
- Data Conflation, Integration using LRS.GIS
- Data Hubs and Data Engineering Platforms for Preparing Data

Spatial Data Analytics

- Spatial Statistics, Econometrics, AI/ML, System of Engagement
- Federal, State Reporting: HPMS 9.0 (with MIRE and Intersections)
- Open Data Portals, Data Sharing and Use

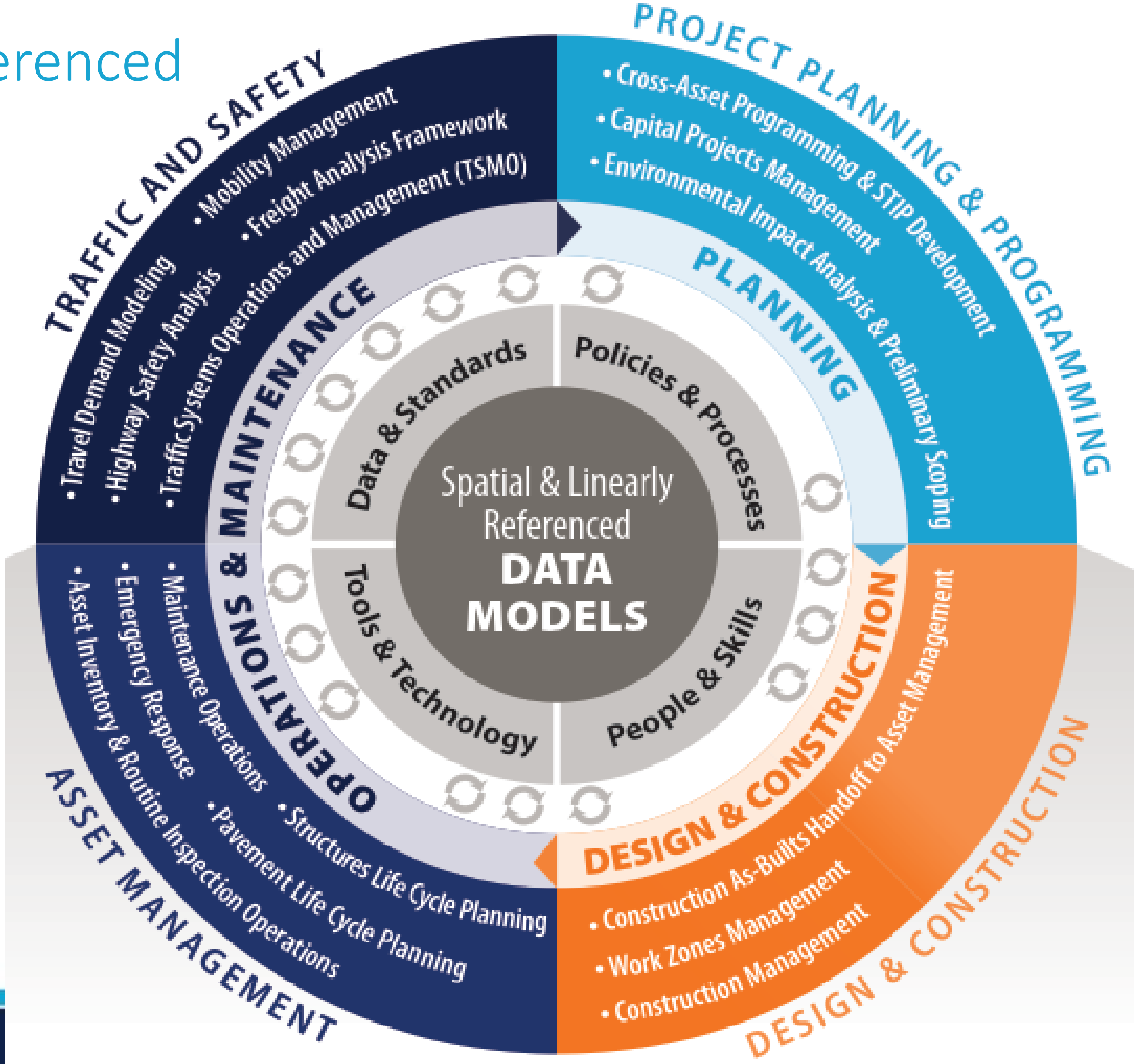


Governing Spatial & Linearly Referenced Data Models at Enterprise Level

Spatial Data Modeling for Transactional Systems of Record and for Enterprise Data Warehouses, Databases, Reporting and Publication (i.e., for Systems of Engagement)

1. **Routes and Concurrencies Publication Data Model:** Route ID, Name, Single/Dual-carriageway geometry and concurrent routes based on business user requirements: Safety, Travel Demand Modeling, Asset and Project Management

2. **Road Segments, Junctions and Intersection Data Model** with connectivity and topology for building a routable network with temporality using LRS Routes.
    1. Road Segments (Links)
    2. Junctions as Nodes (OGC GDF) & Junction Measures
    3. Intersection Points and Legs; Intersection Routes



© Source: Bhargava et.al. (2021). Identifying Data Frameworks and Governance for Civil Integrated Management. FHWA Research. WSP

Workshop Outline

Topic	Presentation	Breakouts
Workshop Objectives, About AEGIST and Demographics Poll	10 Minutes	
Publishing Routes Data Model with Topology & Connectivity for Business Users **Requirements:** Z-Values, Single/Dual-Carriageway, Concurrent Routes, Frontage Roads **Business Use Cases:** Calibrating Measure Values, At-Grade vs. Grade Separated Intersections, Flood Impact and Asset Resiliency Analysis, Geometric Safety (Curves, Grades) Analysis. Etc.	20 Minutes	30 Minutes* (3 Breakout Groups)
Break	10 Minutes	
Publishing Road Segments, Intersection, Junction, Legs, Topological Features for Users **Requirements:** Segments, Junctions & Intersection Connectivity; Topological Connectors (Turn Segments/Lanes, Median Crossovers), Turns, Turn Penalty and Restrictions **Business Use Cases:** Travel Demand Modeling, Routing, Highway Safety Analysis & MIRE	30 Minutes	45 Minutes* (2 Breakout Groups)
Summary, Wrap-Up and Next Steps	5 Minutes	

***Including Debrief and Polling**

Workshop Objectives

- **Build on the Road Network Data Modeling Principles Presented in Guidebook v1.0 that was released in Dec 2019.**
- **Provide Information about Guidebook v2.0 - Implementation of AEGIST at Pooled Fund Study States.**
  - **Publication Model for LRS and GIS Data** for Data Engineers and Data Scientists to Provision Data to Business Units/Systems
  - **Publish Named Routes and Inventory Routes** with Topology - Concurrency, Single/Dual Geometry, Route Relationships
  - **Publish Intersection Model with MIRE Attributes:** Junctions*, Intersection, Intersection Approach, Road Segments & Junction Route Measures
  - **Road Segments (LRS events)** exported to Create "Links" in Travel Demand Modeling systems, Establish Routability and Connectivity
  - **Road Segments connect at Junctions.** Not Intersections. But can be associated with Intersections using Junctions per OGC GDF
  - **Topological Connectors** for Building Routable Network, Modeling Divided/Undivided Highway Intersections
    - Internal Intersection Connectors
    - Turn Segments/Lanes (HPMS Items 12, 13 for Sample Panels)
    - Median Crossovers
    - Reverse Segments

Configuring Topological Connectors: LRS Centerline (Datum) and Routes; or, GIS Features for Spatial Conflation with LRS Objects: Routes, Events

**Terminology change in AEGIST Guidebook v1.0. Navigation Points will be referred to as Junctions (as per OGC GDF)*

Named Routes (All Roads)

Route_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	NetworkID	Type
FK	StateCode	Type
PK	**RouteID**	String(100)
UI	RoadName	String(500)
	BeginMeasure	Dec(22,3)*
	EndMeasure	Dec(22,3)*
	DateCreated	Date
	RecordDate	Date
FK	RecStatusID	Integer
	RecStatusBeginDate	Date
	RecStatusEndDate	Date
	SourceCheckSum	LongInteger
	<Metadata Fields>	Type
	Geom	Geometry

InventoryRoute_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	NetworkID	Integer
FK	RouteID	String(100)
PK	**InventoryRouteID**	String(100)
FK	OverlapObjectID	String(100)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
	BeginMeasure	Dec(22,3)*
	EndMeasure	Dec(22,3)*
	DateCreated	Date
	RecordDate	Date
	RecStatusID	Integer
	RecStatusBeginDate	Date
	RecStatusEndDate	Date
	SourceCheckSum	LongInteger
	<Metadata Fields>	Type
	Geom	Geometry

HPMSSampleSections_Active

PK	ObjectID	Type
Key	GlobalID	Type
FK	ObjectTypeID	Type
FK	RouteID	Type
	BeginMeasure	Type
	EndMeasure	Type
FK	RecStatusID	Type
	RecordDate	Type
	AffectedRecordDate	Type
	RecStatusBeginDate	Type
	SourceCheckSum	Type
	Geom	Type

IntersectionApproach_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
PK	**IntersectionApproachID (MIRE-129*)**	Integer
FK	IntersectionID	Integer
UI	IntersectionApproachName	String(100)
	<MIRE Intersection Leg Fields>	...
	<TemporalityFieldsActiveTable>	...
	SourceCheckSum	Type
	Geom	Geometry

Named Routes broken down into Inventory Routes at Ownership Boundaries and divided/undivided transition points

IntersectionRoute_Active

PK	ObjectID	Integer
FK	IntersectionRouteID	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
	<TemporalityFields>	Type
	SourceCheckSum	Type
	Geom	Type

Intersection_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
PK	**IntersectionID (M-110)**	Integer
FK	IntersectionTypeID (M-111)	Type
FK	IntersectionGeometryTypeID (MIRE-126)	Type
FK	IntersectionTrafficControlID (MIRE-121)	Type
FK	SignalizationPresenceTypeID (MIRE-122)	Type
	NumberOfLegs (MIRE-125)	Integer
	IntersectionAngle (MIRE-119)	Type
	<TemporalityFieldsActiveTable>	Type
	<MetadataFields>	Type
	Geom (MIRE-126)	Geometry

RoadSegment_Active (LNKS)

PK	ObjectID	Integer
PK	GlobalID	Integer
PK	**RoadSegmentID**	Integer
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
	DateCreated	Type
	RecordDate	Type
	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	Type
	<MetadataFields>	Type
	Geom	Geometry

Junction_Active (NODE)

PK	ObjectID	Type
PK	**JunctiionID**	Type
FK, Null	InteresectionID	Type
FK	JunctionTypeID	Type
	<TemporalityFields>	Type
	<MetadataFields>	Type
	Geom	Geometry

JunctionRouteMeasure_Active

FK	JunctionID	Integer
FK	RouteID	String(100)
	Measure	Dec(22,3)
	<TemporalityFields>	

Publishing Turn Lanes/Segments (HPMS-12, 13) Median Crossovers (MIRE 62) and Turns

TurnSegment_Active (H12, H13)

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**TurnSegmentID**	Integer
	TurnSegmentName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
FK	TurnSegmentTypeID	Integer
FK	Date Created	Integer
	RecordDate	Type
FK	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	Type
	<MetadataFields>	Type
	Geom	Geometry

MedianCrossover_Active (M62)

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**MedianCrossoverID**	Integer
	MedianCrossoverName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
FK	MedianCrossoverTypeID	Integer
FK	Date Created	Integer
	RecordDate	Type
	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	Type
Key	*<MetadataFields>*	Type
	Geom	Geometry

Turns_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**TurnID**	Integer
	TurnName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	ThroughJunctionID	Type
FK	EndJunctionID	Integer
FK	Date Created	Integer
	RecordDate	Type
FK	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
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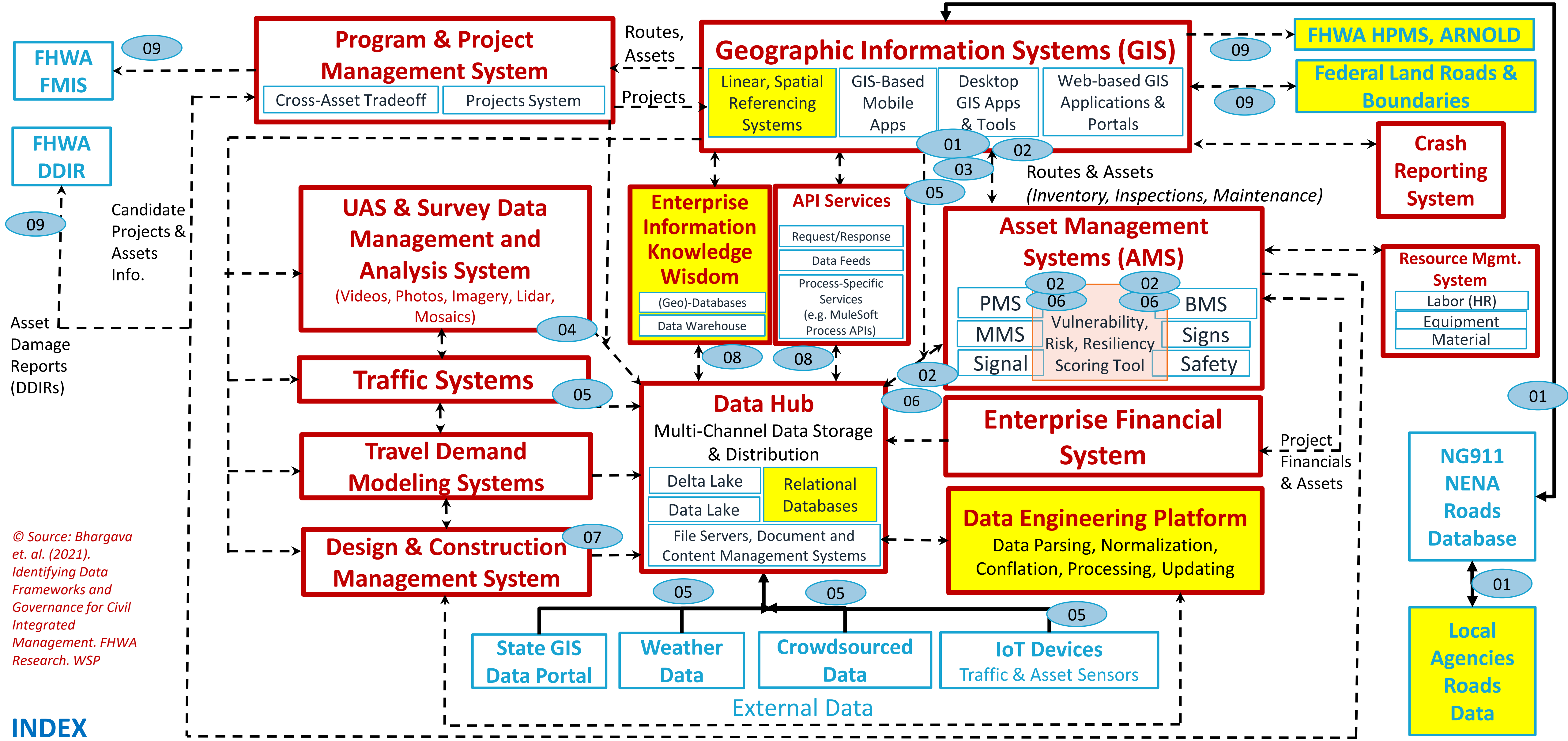
Key	*<MetadataFields>*	Type
	Geom	Geometry

ReverseSegment_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**ReverseSegmentID**	Integer
	ReverseSegmentName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
FK	Date Created	Integer
	RecordDate	Date
FK	RecStatusID	Type
	RecStatusBeginDate	Date
	RecStatusEndDate	Date
	SourceCheckSum	LongInteger
	<MetadataFields>	Type
	Geom	Geometry

Segment and Nodes for Connectivity & Routability

Spatial Data Modeling in Enterprise Systems, Data Model Integrations and Engineering and Spatial Analytics



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01: [Routes and Assets Data] from Linear, Spatial Referencing Systems **To** Asset & Project Systems, Data Hub, Warehouse
02: [Asset Inventory, Condition and Work History, Plans Data] from AMS **To** Data Hub & Vulnerability Analysis Systems
03: [Asset Damages Data] from Asset Inspection & Damage Assessment Apps **To** Asset Management System, GIS
04: [Survey, Inspection Data] from UAS & Survey Systems **To** AMS, GIS, Design, Construction, Data Hub Systems
05: [Incident, Traffic & Asset Data] from Weather, Traffic and Asset Systems **To** Data Hub, Warehouse, GIS, BI
06: [Repair Projects and Work Plan/Requests Data] from Vulnerability Analysis & DDIR Apps **To** PPMS & AMS
07: [As-Built Asset Data] Design, Construction **To** LRS-GIS Systems and Asset Management Systems
08: [Processed and Integrated Data for Analytics] from Data Hub **To** Data Warehouse & BI Systems
09: [Roads and Assets, Projects, Damages] from DOT Enterprise Systems **To** FHWA HPMS, FMIS, DDIR Systems

Demographics Poll

- Name and Agency
- Routes Management Approach
  - All Roads in State vs. Agency Administered Roads Only
  - Coordination between DOT and Local Agencies in your State
- Intersection and Road Segments Management Approach
  - Intersection as a referent in Intersection-Offset LRM
  - Intersection Points
  - Road Segments (Intersection to Intersection)

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Objective 1:

Routes Publication Data Model

Routes Model

Goal:

- Review specific use cases
- Shed light on LRS management styles

Requirement 1: Publish Routes with Z-Values

Requirement 2: Publish Dual Geometry for Divided Highways

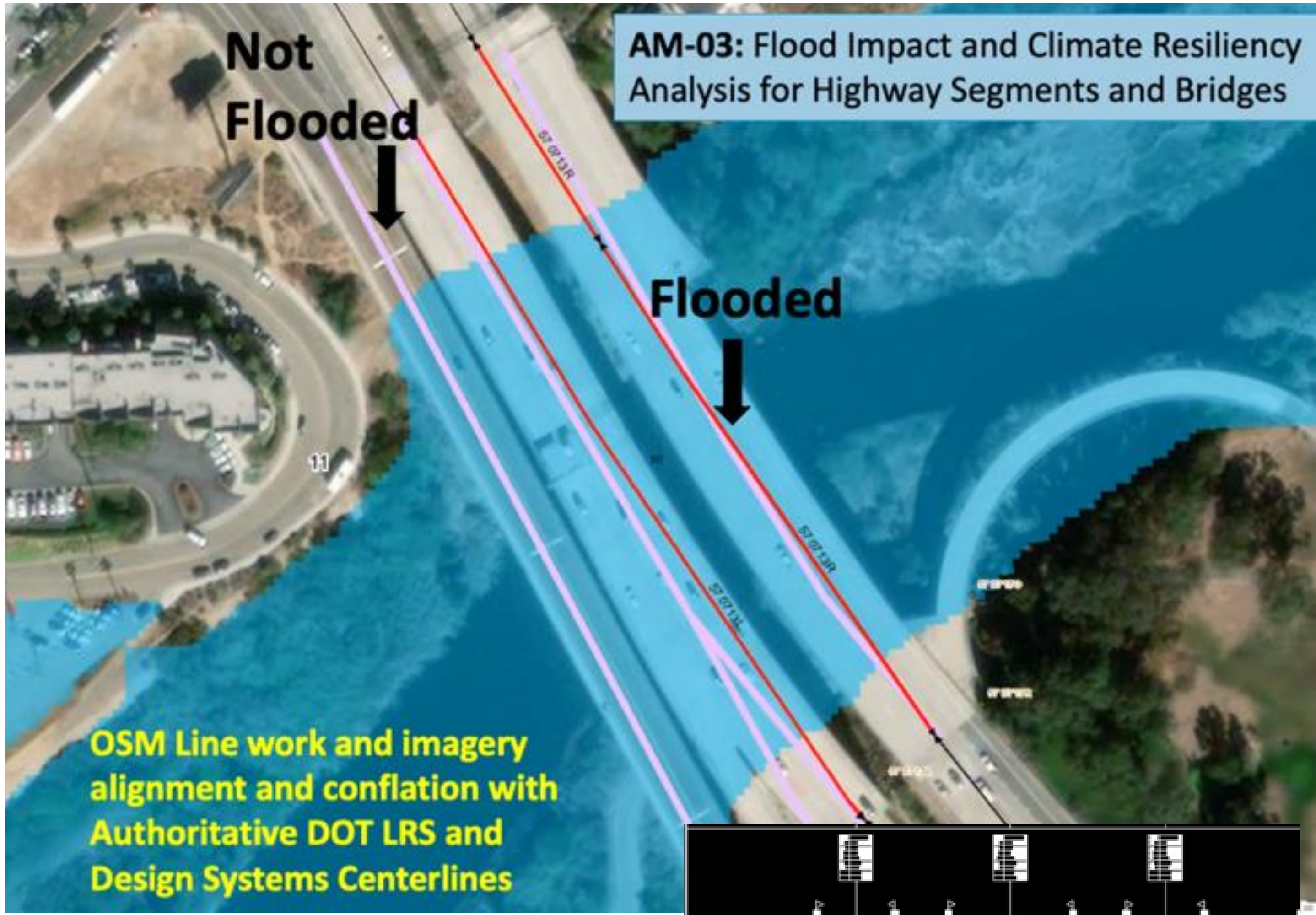
Requirement 3: Publish Route Topology

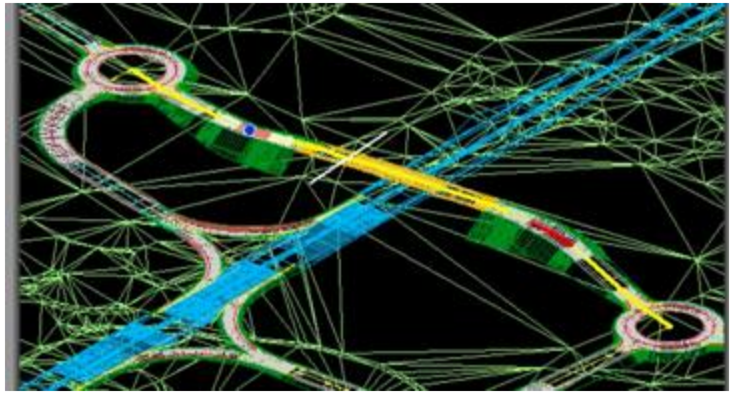
Routes Model

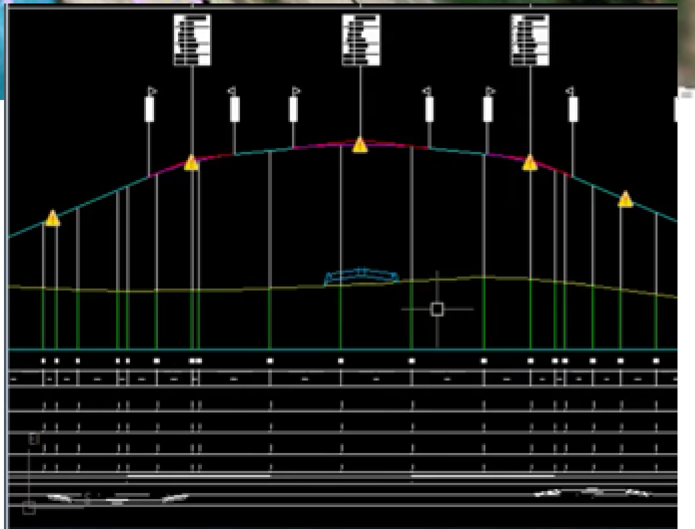
Requirement 1: Publish Routes with Z-Values

Topic 1.1: Business Use Cases

1) Calibrating Measure values for Routes
2) Distinguishing at-grade intersections vs. Under/Overpasses for Routing, Analysis
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?







Routes Model

Requirement 1: Publish Routes with Z-Values

Topic 1.2: Authoritative Data Sources for Z-Values

- GPS Trace: Pavement Data Collection Vans ⍰ North Carolina, New Mexico
- Lidar Point Clouds ⍰ Georgia, North Carolina, Oklahoma, Tennessee, Vermont, West Virginia
- As-let Plans or As-builts from Design/Construction

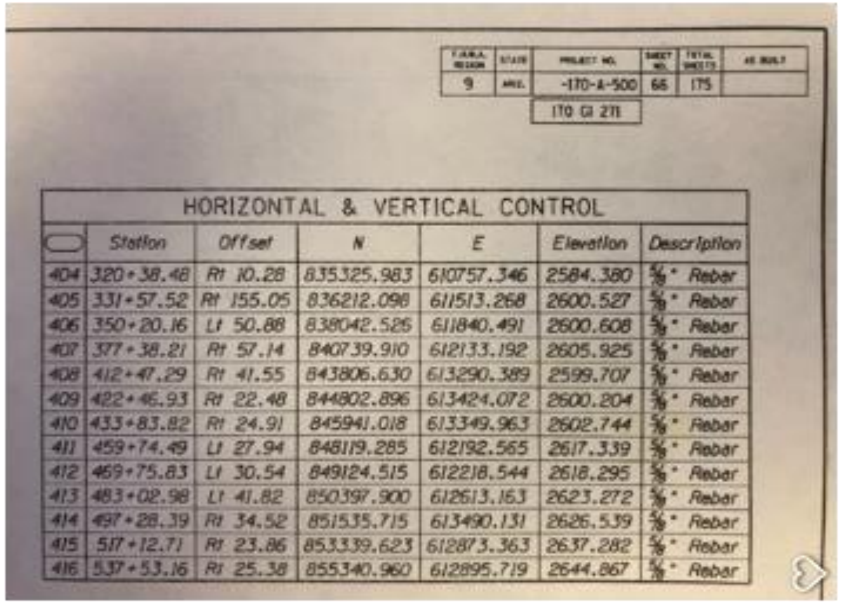
Topic 1.3: Density of Vertices with Z-Values

- Overlay GPS Trace, LiDAR data with z-elevation values on LRS Routes to Integrate, Engineer and Publish a 3D Routes Model for Business Users at varying scales depending on use.
- Typically, less density is better. More dense at locations of vertical and horizontal curvature to maintain alignments
- LRS does not need to hold z-elevations. But it can be one of the consumers of z-value data processing. Factor in LRS Precision (~0.001 Miles - 5 ft) if configuring Z-values in LRS. Utilize Z-value processing tools to determine values at specific vertex points along LRS

Routes Model: Requirement 1: Publish Routes with Z-Values

Z-coordinate attributes methods:

- GPS breadcrumbs (i.e. GPS traces) collected by mobile data collection efforts
- LiDaR clouds
- Digital terrain models
- Engineering plan/profile tables



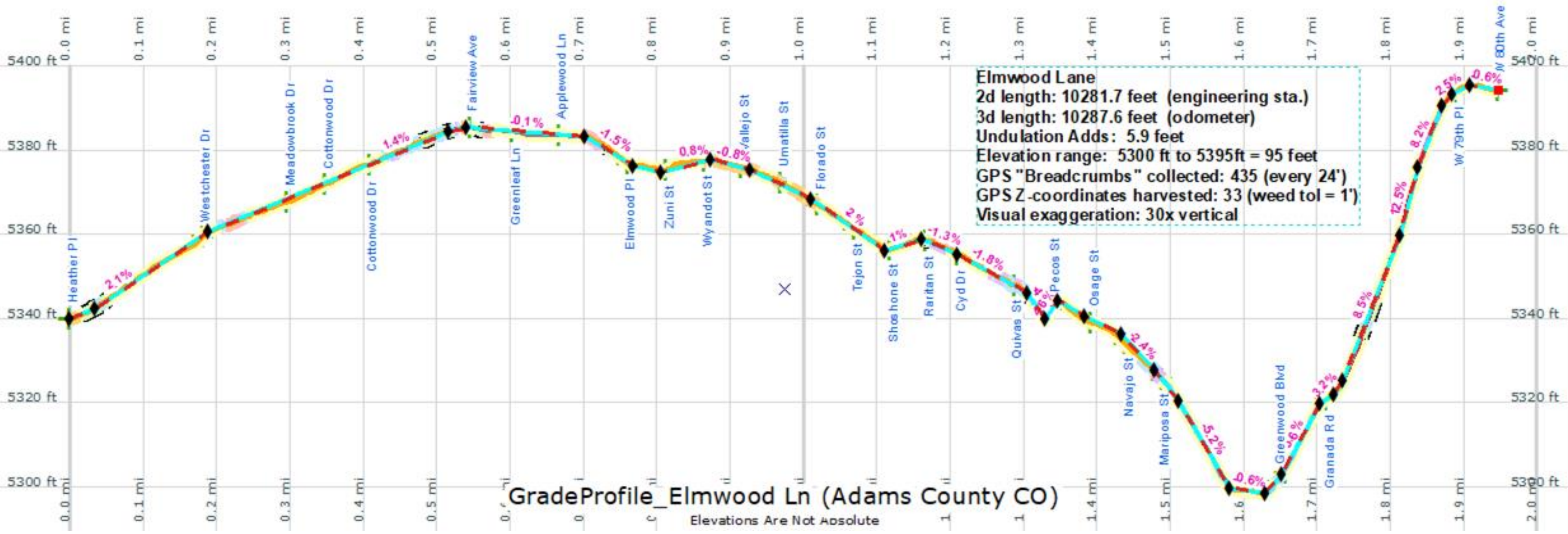
HORIZONTAL & VERTICAL CONTROL						
	Station	Offset	N	E	Elevation	Description
404	320+38.48	Rt 10.28	835325.983	610757.346	2584.380	5/8" Rebar
405	331+57.52	Rt 155.05	836212.098	611513.268	2600.527	5/8" Rebar
406	350+20.16	Lt 50.88	838042.526	611840.491	2600.608	5/8" Rebar
407	377+38.21	Rt 57.14	840739.910	612133.192	2605.925	5/8" Rebar
408	412+47.29	Rt 41.55	843806.630	613290.389	2599.707	5/8" Rebar
409	422+46.93	Rt 22.48	844802.896	613424.072	2600.204	5/8" Rebar
410	433+83.82	Rt 24.91	845941.018	613349.963	2602.744	5/8" Rebar
411	459+74.49	Lt 27.94	848119.285	612192.565	2617.339	5/8" Rebar
412	469+75.83	Lt 30.54	849124.515	612218.544	2618.295	5/8" Rebar
413	483+02.98	Lt 41.82	850397.900	612613.163	2623.272	5/8" Rebar
414	497+28.39	Rt 34.52	851535.715	613490.131	2626.539	5/8" Rebar
415	517+12.71	Rt 23.86	853339.623	612873.363	2637.282	5/8" Rebar
416	537+53.16	Rt 25.38	855340.960	612895.719	2644.867	5/8" Rebar

Pros and Cons:

- HPMS/MIRE support
- Vehicle routing
- Polyline complexity

Solution:

- Consider business needs for accuracy
- Manage as a feature outside of LRS
- Need for a standard
- Generalize vertices



Routes Model

Requirement 2: Publish Dual Geometry for Divided Highways

Topic 2.1: Business Use Cases

1) **Travel Demand Modeling**
2) **Highway Safety Analysis**
   a) Vertical Alignment/Curves by Direction (z-values of vertices in each direction)
   b) Safety Performance Functions, Level of Service Score (LOSS) & Diagnostic Analysis
   c) Highway Safety Improvement Program Projects
3) **Asset Management**
   a) Pavement Construction History
   b) Pavement Condition: Spatial Analysis
   c) Slope & Superelevation from Centerline
   d) Project Planning & Programming
   e) Asset Resiliency and Flood Impact Analysis

Topic 2.2: Criteria for creating dual geometry

- **Existing HPMS Criteria:** Median Type, Median Width
- **Median** Height, Shape, Size, Design Type?
- **Road Function:** Full Access vs. Limited Access.; If no Turning Movements allowed then divide. If curb has cutouts, then road should be modeled as undivided. Basically, local regulation – allowed to cross or not
- **Speed Differential**
- **Passing Sight Distance**
- **Number of Lanes**

Approach 1

One Route to model for both Directions – One Route Record (route is two-way facility)

Approach 2

One Route per Direction - Two Route Records with <u>“same” geometry</u> (each route is one-way facility)

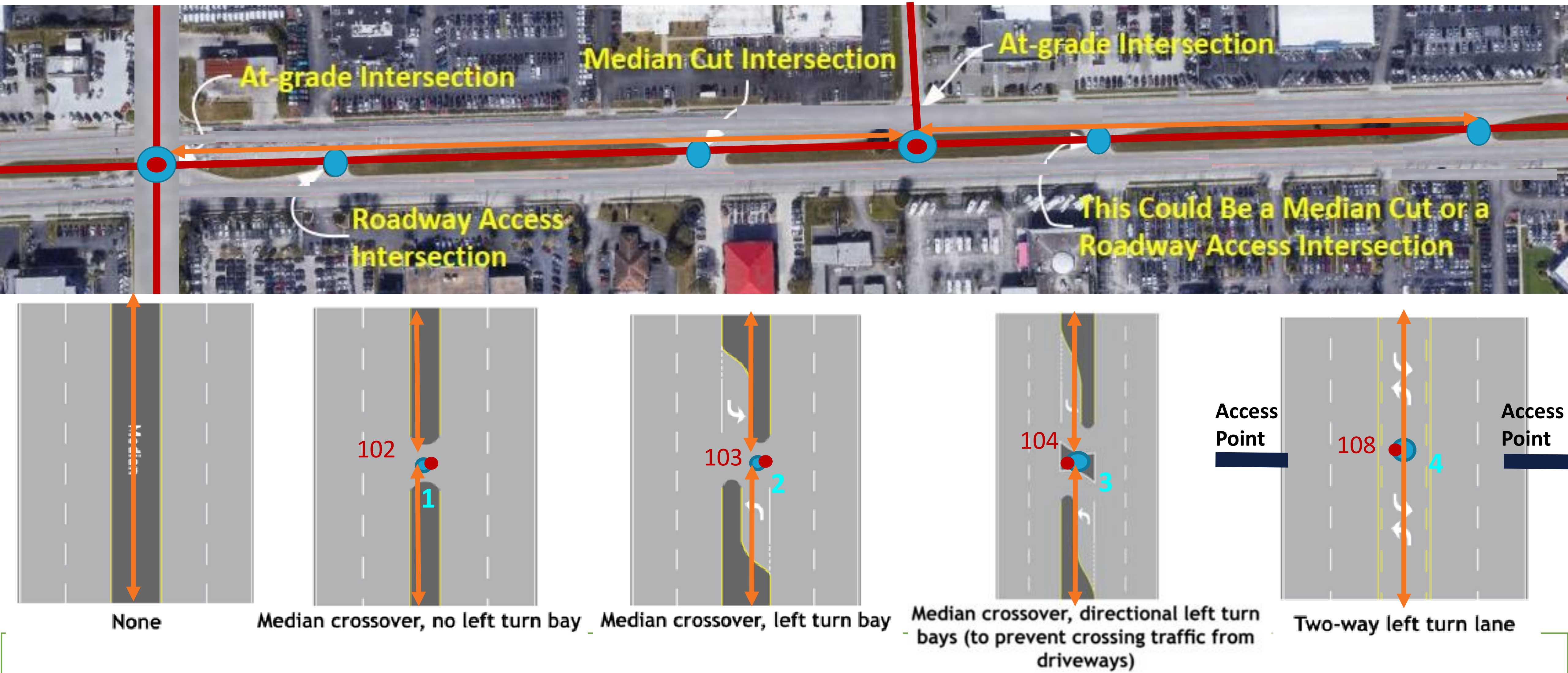
Approach 3

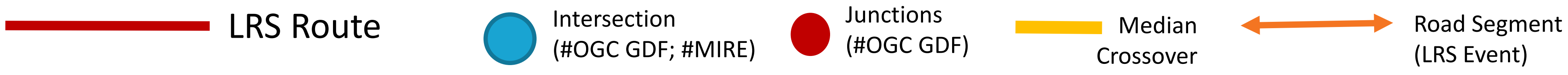
One Route per Direction - Two Route Records with <u>“different” geometry</u> (each route is one-way facility)

Routes Model

Scenario: Single Geometry

Requirement 2: Publish Dual Geometry for Divided Highways

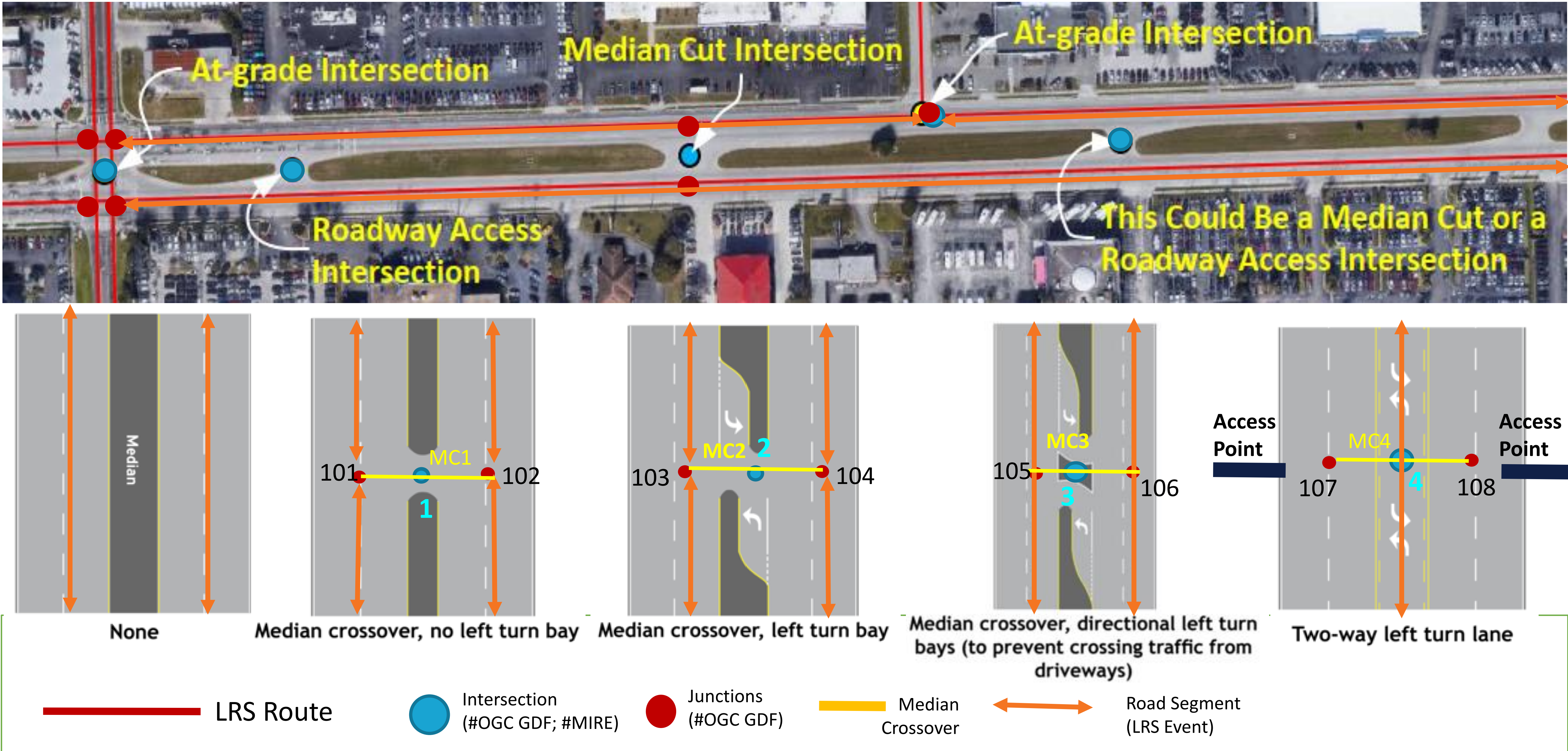




Routes Model

Scenario: Dual Geometry

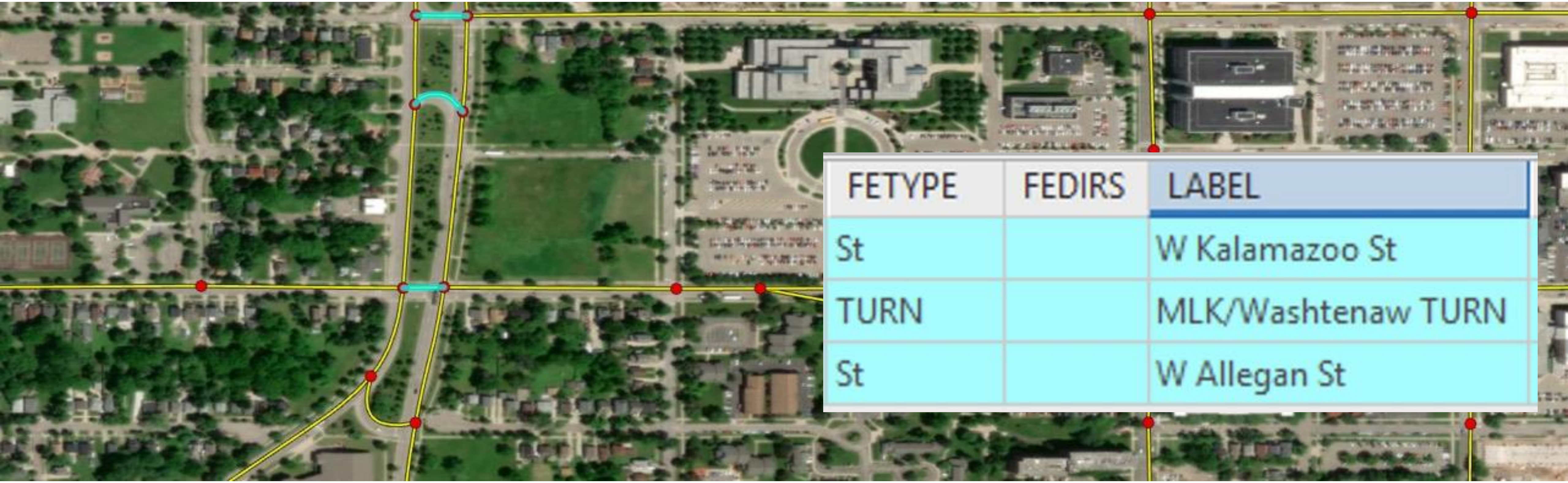
Requirement 2: Publish Dual Geometry for Divided Highways



Routes Model

Requirement 2: Publish Dual Geometry for Divided Highways

Travel Demand Modeling - Median Crossover Ramps



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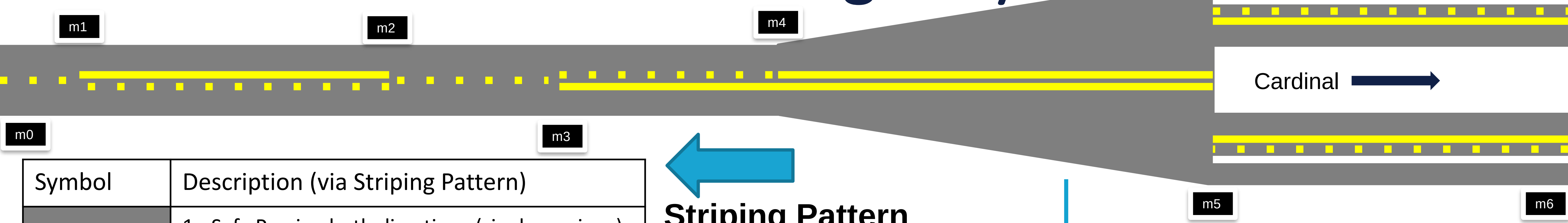
1498	Polyline	360774	0	0.02	14	2	30	12	0	0	7	16a	3500164	335505	0.678	0.698	W	Kalamazoo	St		W Kalamazoo St
1501	Polyline	40828	-1	0.03	6	3	30	12	0	0	3	16a	3105960	3331248	0	0.032		MLK/Washtenaw	TURN		MLK/Washtenaw TURN
1502	Polyline	40909	1	0.03	5	3	30	12	0	0	3	16a	3935973	339807	0.4	0.425	W	Allegan	St		W Allegan St

Click to add new row.

If Dual Geometry Routes used in Travel Demand Modeling Systems, do we also need median crossovers & turn lanes?

- No Median Crossovers and Turn Segments Necessary for Travel Demand Modeling. Single Carriageway Geometry Preferred, but OSM being used

Business Case: full dual carriageways



Symbol	Description (via Striping Pattern)
	1 - Safe Passing both directions (single carriage)
	2 - No Passing Cardinal (single carriage)
	3 - No Passing noncardinal (single carriage)
	4 - No Passing Either (single carriage)
	5 - Not Applicable (dual carriages)

Route	Beg	End	Pattern
Hwy X	m0	m1	1
Hwy X	m1	m2	3
Hwy X	m2	m3	1
Hwy X	m3	m4	2
Hwy X	m4	m5	4
Hwy X	m5	m6	5

Striping Pattern

- Works on single centerline (even when dual exists)
- Schematic (5+ options) (must pre-process to analyze)
- Fewer rows/records overall (but **not** if lots of continuity intersections)
- Good for tracking bid quantities

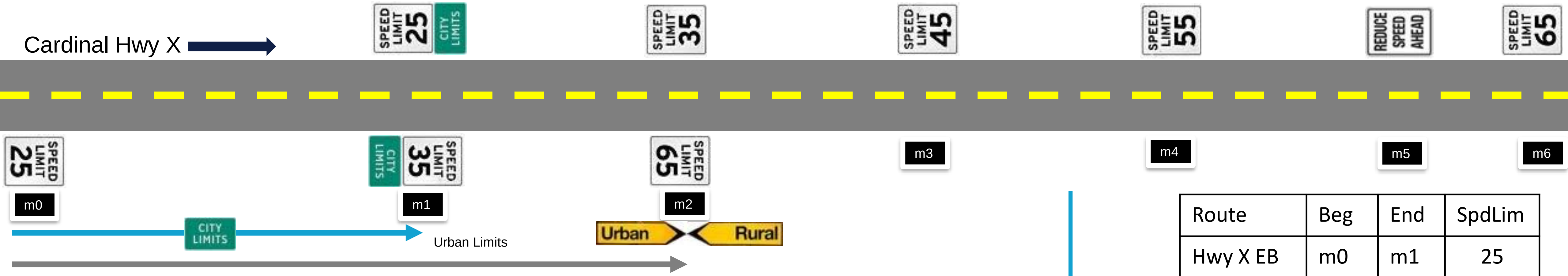
Safely Pass? Or Not?

- Prefers/Requires prefers directional routes (does **not** require 2 centerline arcs – unless you prefer)
- Realistic – only 2 options (collect one option – auto-populate other)
- Immediately available for overlay
- Good for safety analytics
- Easy to convert to HPMS %Passing

Code	Description (binary)
0	0 – No Passing
1	1 – Safe Passing Allowed

Route	Beg	End	Code
Hwy X EB	m0	m3	1-Pass
Hwy X EB	m3	m5	0-No
Hwy X EB	m5	m6	1-Pass
…..	…..	…..	…..
Hwy X WB	m0	m1	1-Pass
Hwy X WB	m1	m2	0-No
Hwy X WB	m2	m4	1-Pass
Hwy X WB	m4	m5	0-No
Hwy X WB	m5	m6	1-Pass

Business Case: full dual carriageways



Route	Beg	End	SpdLim
Hwy X EB	m0	m1	25
Hwy X EB	m1	m2	35
Hwy X EB	m2	m6	65
…..	…..	…..	…..
Hwy X WB	m0	m1	25
Hwy X WB	m1	m2	35
Hwy X WB	m2	m3	45
Hwy X WB	m3	m4	55
Hwy X WB	m4	m6	65

No “Need” for Dual Carriages in order to benefit from them…

- Speed Limits progressively decrease approaching an urbanized area (right to left)
- Speed Limits abruptly restored as leaving urbanized area entering rural (left to right)
- Directional carriageways can occupy the same geometry.
- Fewer rows/records overall – stack both directional speeds onto same row
- Requires some pre-process to assign/overlay onto crashes

Route	Beg	End	SpdLim Card	SpdLim nCard
Hwy X	m0	m1	25	25
Hwy X	m1	m2	35	35
Hwy X	m2	m3	65	45
Hwy X	m3	m4	65	55
Hwy X	m4	m5	65	65

… Dual Inventory Routes simplify directional attributes

- Immediately available for overlay
- Cartographically symbolize with event offset
- Easy to convert to HPMS Item 14 Speed Limit
- More useful for safety analytics and travel demand modeling
- Data collection and verification is easier without looking over your shoulder for what’s happening in other direction

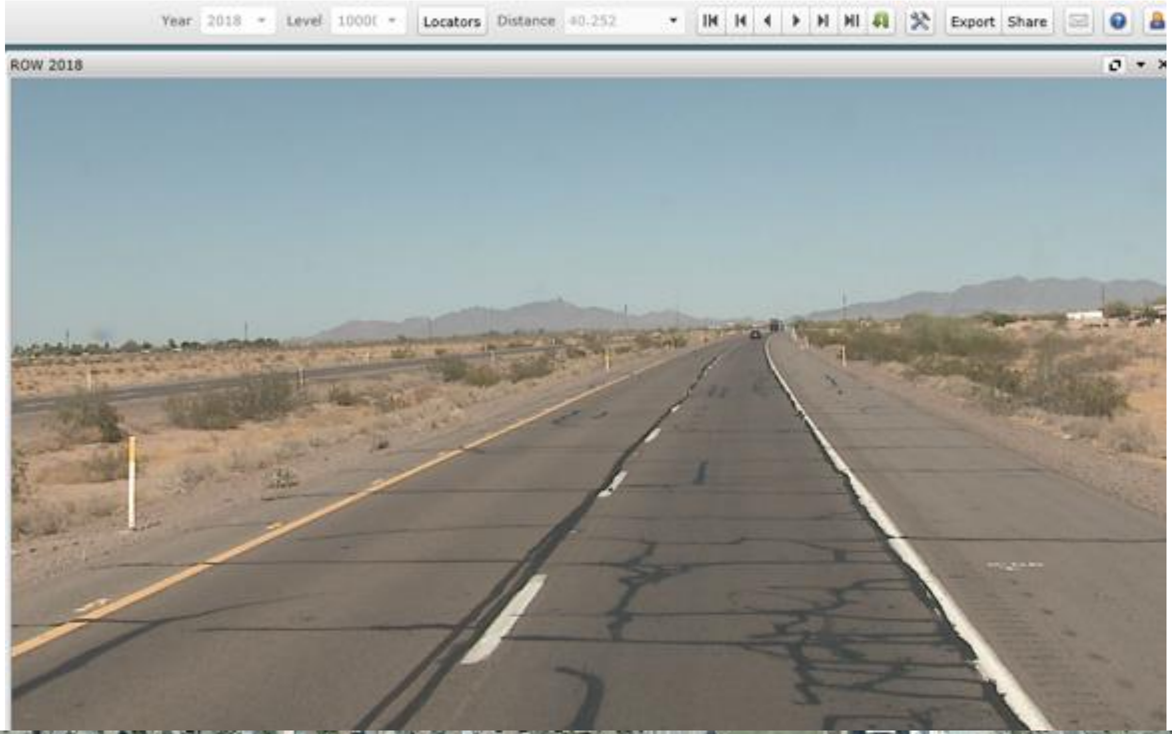
Use Case 2: Spatial Safety Analysis

Intersection Analysis

- Junction and Junction Leg
- Crash rate analysis
- Ease of analysis
- Simple is better

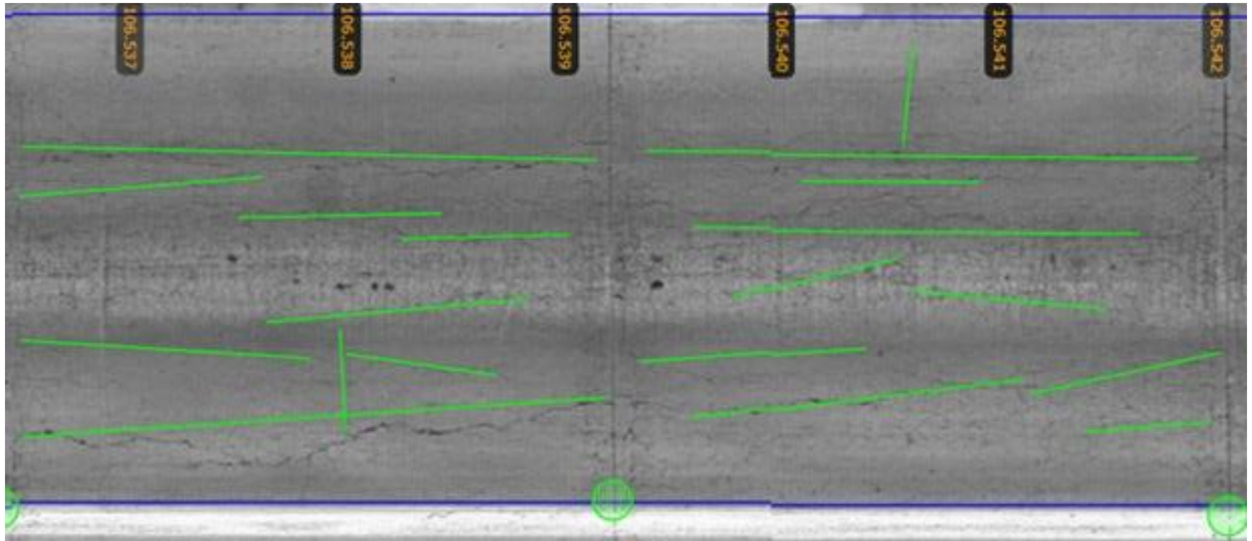
Use Case 3: Asset Management

Pavement Inspection Image (unstructured Data) Analysis and Integration with HPMS-Pavement Management Sections



Modern Pavement Management Systems

- Georeferenced Image Frames Created from Videos for spatial analysis by Computer Vision Algorithms
- Integrated with Structured Pavement Management Sections and HPMS Sections for IRI, Distress, Cracking
- Machine Learning Algorithm Run along each Route (by direction) to identify pothole locations and flag those locations as events



Routes Model

Requirement 3: Publish Route Topology

Topic 3.1: Establish Route Topology using Inventory Routes

1) Single/Dual-Carriageway Relationship
2) Concurrent Named Routes Relationship
3) Mainline and Frontage Road Relationship
4) Mainline (Primary Route) & Managed Lanes (HOV, HOT) Relationship
5) Named Routes break at:
   - State/County/Town/Parish Boundaries;
   - Continuity Intersections: Transition points of divided/undivided geometry

   Create a "Junction" at the break point and Establish topological connectivity between the "Inventory Route" Segments & "Junctions"

Route_Active

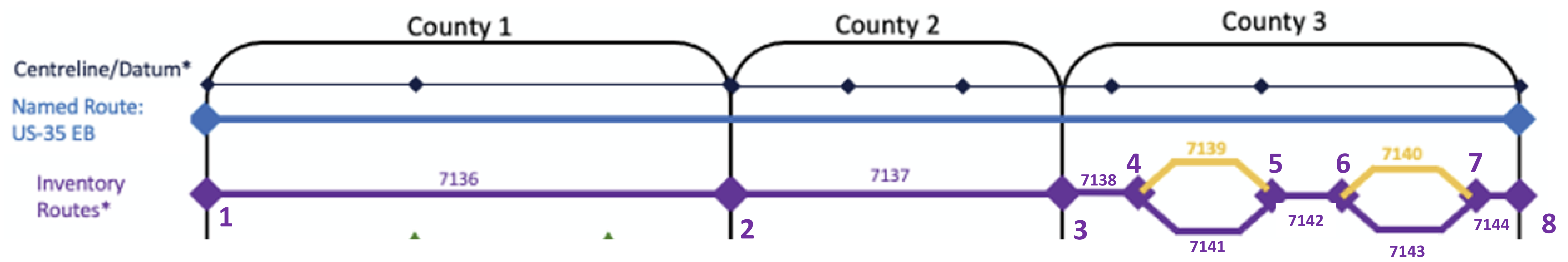
PK	ObjectID	Integer
PK	GlobalID	Integer
FK	NetworkID	Type
FK	StateCode	Type
PK	**RouteID**	String(100)
UI	RoadName	String(500)
	BeginMeasure	Dec(22,3)*
	EndMeasure	Dec(22,3)*
	DateCreated	Date
	RecordDate	Date
FK	RecStatusID	Integer
	RecStatusBeginDate	Date
	RecStatusEndDate	Date
	SourceCheckSum	Type
	<Metadata Fields>	Type
	Geom	Geometry

InventoryRoute_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	NetworkID	Type
FK	RouteID	String(100)
PK	**InventoryRouteID**	String(100)
FK	OverlapObjectID	String(100)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
	BeginMeasure	Dec(22,3)*
	EndMeasure	Dec(22,3)*
	DateCreated	Type
	RecordDate	Type
	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	Type
	<Metadata Fields>	Type
	Geom	Geometry

Routes Model Topology: Named Routes and Inventory Route

Requirement 3: Publish Route Topology: Inventory Routes



Object ID	Route ID (Named Route)	Inventory Route ID	Begin Measure	End Measure	Begin Junction ID	End Junction ID	Overlap Object ID
1	US-40	7136	..	…	1	2	
2	US-40	7137	..	…	2	3	
3	US-40 EB	7138	..	…	3	4	
4	US-40 WB	7139	..	…	5	4	7141
5	US-40 WB	7140	..	…	7	6	7143
6	US-40 WB	7141	..	…	4	5	
7	US-40	7142	..	…	5	6	
8	US-40	7143	..	…	6	7	
9	US-40	7144	..	…	7	8	

Requirement 3: Publish Route Topology – Route Concurrencies

#	X (US Feet)	Y (US Feet)	M
1	813701.78	599871.32	0
2	813953.22	599933.07	0.049
3	814002.63	599950.68	0.059
4	814036.02	599959.88	0.066
5	814050.58	599962.33	0.069
6	814063.18	599964.04	0.071
7	814079.2	599965.75	0.074
8	814099.75	599967.46	0.078
9	814120.17	599968.56	0.082
10	814149.77	599968.69	0.088
11	814170.42	599967.55	0.091
12	814193.19	599965.05	0.096
13	814219.61	599961.38	0.101
14	814247.26	599955.51	0.106
15	814275.14	599947.93	0.112
3500	843718.59	942558.35	78.224
3501	843660.43	942948.11	78.302
3502	843640.48	943084.84	78.33

	OBJECTID	State_Code	Route_ID	Comments	Year_Recor	StateYearK	Shape	shape_Length
1	49341	9	A007	7-N	2019	919	Polyline M	1.238684
2	49342	9	A007R	7-S	2019	919	Polyline M	0.222202
3	49567	9	A202	202-N	2019	919	Polyline M	1.262498

Breakout #1 [20 Minutes] Debrief and Polling [10 Minutes]

Breakout Group 1: Patrick Whiteford & Joe Breyer	Breakout Group 2: Jim Meyer & Abhishek Bhargava	Breakout Group 3: Greg Ciparelli & Justin Brunetti
Topic 1.1, 1.2, 1.3	**Topic 2.1, 2.2**	**Topic 3.1**

Breakout Groups Debrief [2 Minutes each] and Polling Questions

» Topic 1.1: Business Use Cases for Publishing Routes Model with Z-Values

» Topic 1.2: Authoritative Data Sources for Z-Values

» Topic 1.3: Density of Vertices with Z-Values

» Topic 2.1: Business Use Cases for Publishing Dual Geometry

Use Case 1: Travel Demand Modeling   Use Case 2: Safety Analysis   Use Case 3: Asset Management

» Topic 2.2: Criteria for Dual Geometry for Roads with two directions

» Topic 3.1: Establish Route Topology Using Inventory Routes. Route Relations:
(a) Cardinal/Non-Cardinal route (b) Frontage Roads (c) HOV/HOT/Managed Lanes

Objective 2:
Road Segments Junctions and Intersection Data Model for Routable Network, Connectivity, Topology

Session 3 Objective: Breakout Discussion/Inputs on Listed Rules

Breakout Group 1: Justin Brunetti
Patrick Whiteford and Jim Meyer

Breakout Group 2: Greg Ciparelli
Abhishek Bhargava and Joe Breyer

Review Content Related to these Rules; Discuss During Breakouts; Follow-up with Debrief, Polling.

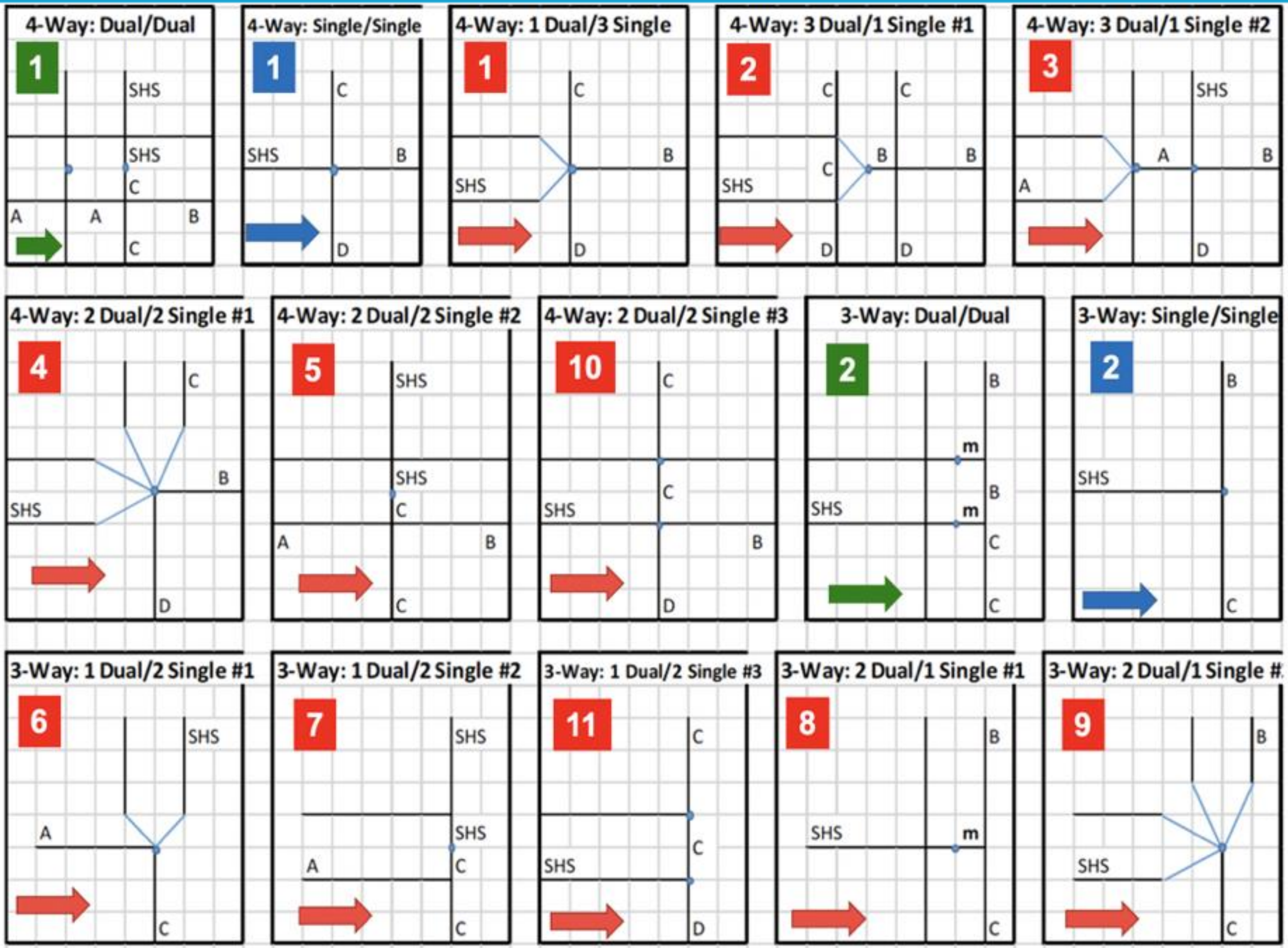
- Rule 4.1: Road Segments should begin and end at Junction Points. Setup as LRS Events and TDM Links.
- Rule 4.2: No tapering/bending of Road Segments at Hashtag Intersections (so that length can be used as true indicator of route length). But, at undivided-undivided intersections tapering happens and starts at junctions?
- Rule 4.3: Junctions created at: Intersection, TAZ Centroid, Bridge, Crosswalk, Intersection Leg (begin/end), etc.
- Rule 4.4: Junctions can coincide with Intersection Point (INTP) at intersections of undivided highways
- Rule 4.5: Topological Features begin/end at junctions: (a) Internal Intersection Connectors (b) Turn Segments (HPMS-12, 13) (c) Median Crossover (d) Reverse Segments
- Rule 4.6: Topological Features can be setup as (a) Spatial Features (b) Road Centerline/Routes (c) LRS Events
- Rule 4.7: Median Cut Intersections (MIRE-126) are stored along with other at-grade intersections
- Rule 4.8: Median Crossover (MIRE-62) serves as Topological Connector on Dual Geometry Roads.
- Rule 4.9: Median Crossover (MIRE-62) starts/ends at Junctions, passes through Median-Cut Intersection (MIRE-126)
- **Rule 4.10: Turns modeled with three nodes in GIS. Turn Restrictions & Penalty are Junction (Node) Attributes.**
- **Rule 4.11: Topological Connectivity is created between: (a) Road Segments & Junctions (b) Junctions and Turns (c) Median Crossovers and Junctions (d) Turn Lanes/Segments and Junctions (e) Intersection Routes, Junctions and Intersection Leg**

Scenario 1.1: 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

Caltrans

Rules: All

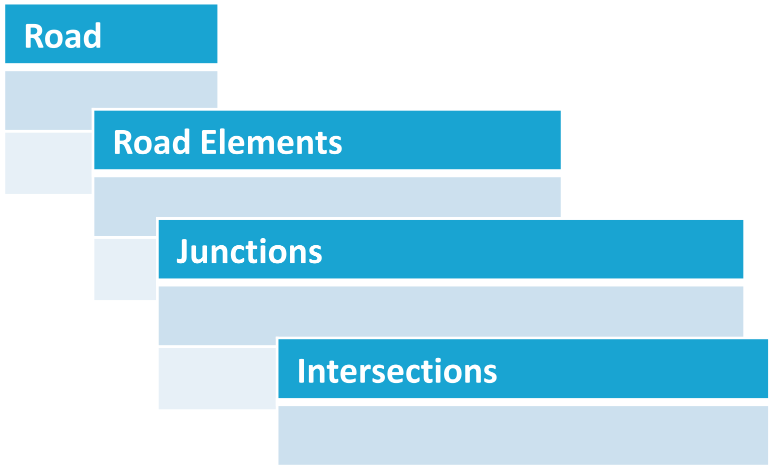
OGC Topology: Geographic Data Format (GDF)

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
- Spatial Features: Topological Features
  - Connectors
  - Turn Segments/Lanes (HPMS 12, 13)
  - Median Crossovers (MIRE-62)

Connectivity:

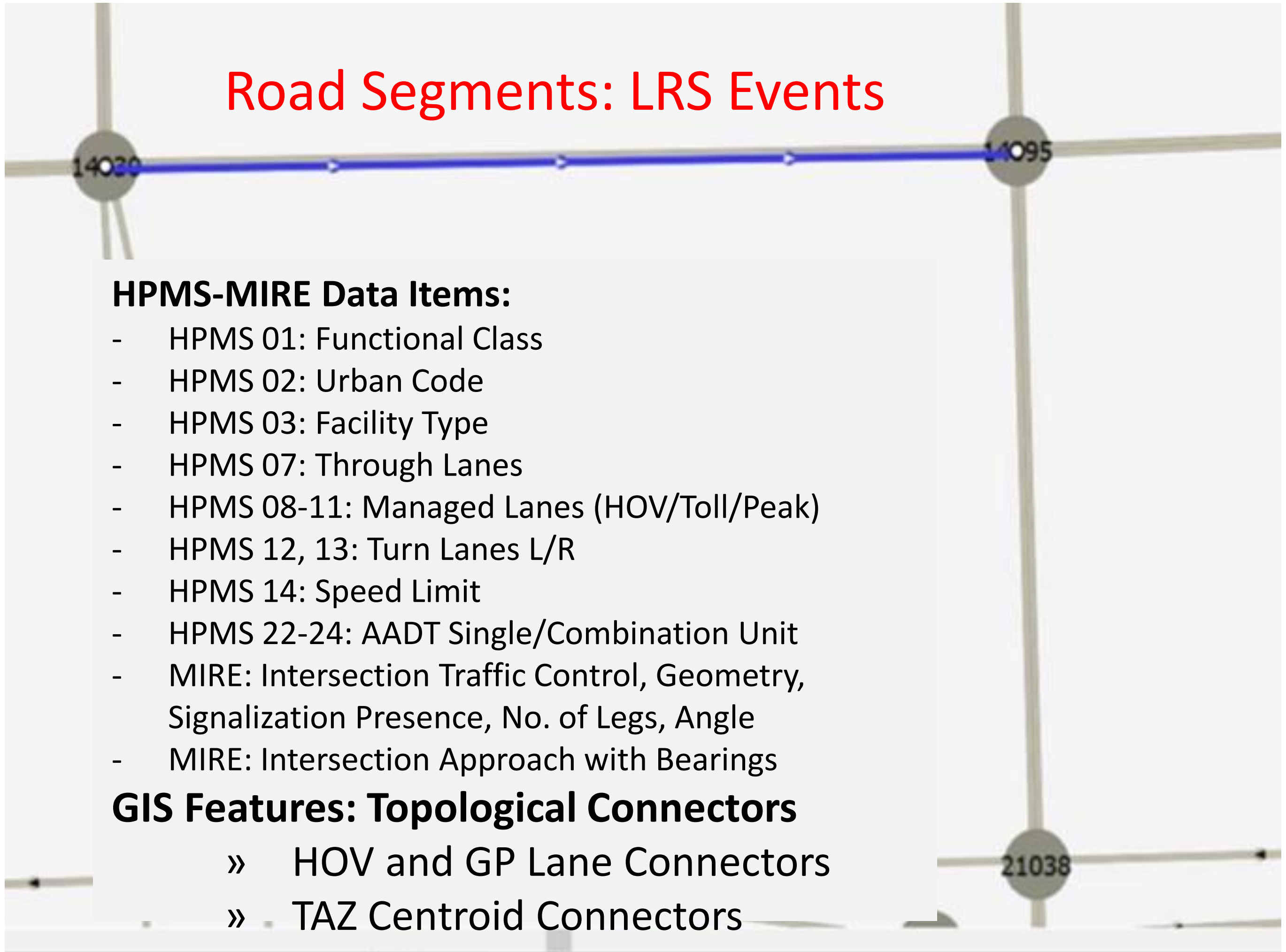
- Road Segments and Intersection Parent-Child Data Relationship
- Junctions (Nodes) with Road Segments, Connectors, Turn Segments/Lanes, Median Crossovers, Reverse Route Segments, Inventory Routes, Continuity Intersection Points



Rules: 4.1, 4.2, 4.3, 4.3, 4.4

BUSINESS USE CASE 1: TRAVEL DEMAND MODELING

LRS-GIS TO TRAVEL DEMAND MODELING SYSTEMS. SEND ROAD SEGMENTS, NODES



HPMS-MIRE Data Items:

- HPMS 01: Functional Class
- HPMS 02: Urban Code
- HPMS 03: Facility Type
- HPMS 07: Through Lanes
- HPMS 08-11: Managed Lanes (HOV/Toll/Peak)
- HPMS 12, 13: Turn Lanes L/R
- HPMS 14: Speed Limit
- HPMS 22-24: AADT Single/Combination Unit
- MIRE: Intersection Traffic Control, Geometry, Signalization Presence, No. of Legs, Angle
- MIRE: Intersection Approach with Bearings

GIS Features: Topological Connectors

» HOV and GP Lane Connectors

» TAZ Centroid Connectors

[From ID]	[To ID]	ID	Dir	Length	LID991111	NAME1	NAME2	NAME3	COUNTY	FCLASS	DESIGN	MEDIAN	ACCESS	SIGNAL	DRIVEWAY	TURN	RAMPTYPE	SPECIAL	TOT_LANE
13619	13744	59119	0	0.17	59119	ATLANTIC AVE			4	14	0	A	N	H	NS	NS	NA	NA	6
13744	13732	59124	1	0.07	59124	CLASSON AVE			4	16	0	N	N	H	NS	NS	NA	NA	2
13744	13873	59123	0	0.16	59123	ATLANTIC AVE			4	14	0	A	N	H	NS	NS	NA	NA	6
13688	13744	59118	1	0.29	59118	CLASSON AVE			4	16	0	N	N	H	NS	NS	NA	NA	1

Rule: 4.1 and 4.2
TDM Link and Node Attributes

ERD of Road Network and Intersections in LRS and GIS-Based TDM Systems

GIS-Based TDM System (TransCAD, VISSUM, AIMSUM)

Link Attributes	
ID	Software default fields
From Node ID	
To Node ID	
Direction	
Length	
Functional Class	Important general classification, used to calculate link speed and capacity
Facility Type/Link Type	
Area Type	
Auto/Truck tolls	Components of generalized cost used for model path-building
Number of Lanes	Time of day characteristics used to build period networks
Parking Restriction	
Truck/HOV Usage	
Median	
Access Control	Model specific attributes used to compute the appropriate physical link types together with attribute listed above
Signal Density	
Turn Lane	
Ramp Type	
Bridge, Tunnel,…	

Node Attributes	
ID	Software default fields
Longitude	
Latitude	
Zone(TAZ)	
Cycle length	Intersection flags used to identify the nodes with turning restrictions and penalties.
Number of Intersection Approaches	
Intersection, …	

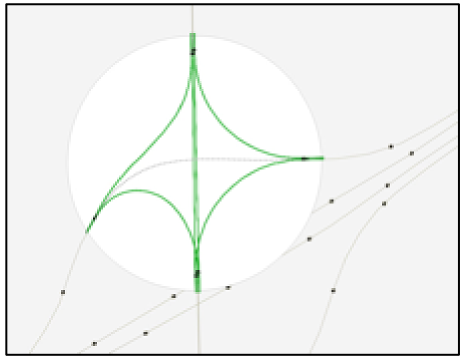


Illustration of Turning Movements at Intersections in Emme Network (Chicago Metropolitan Agency for Planning Model)

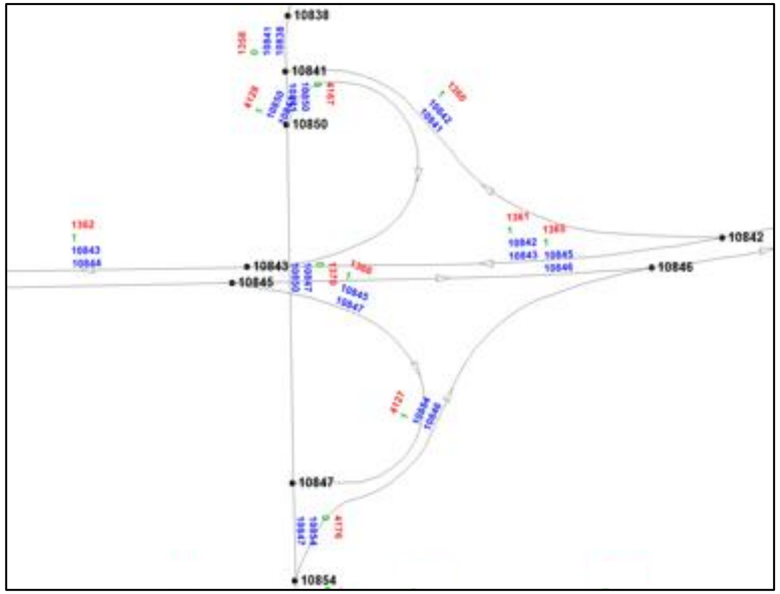
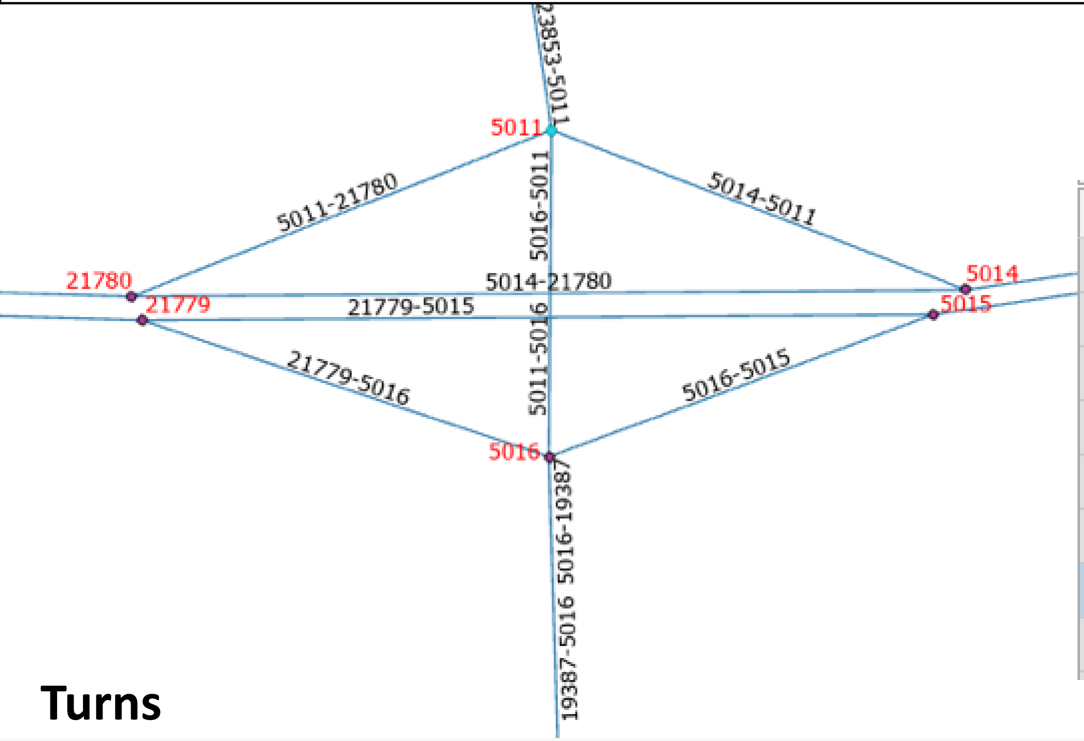


Illustration of TransCAD Network Link IDs, Topological and Flow Directionality (New York Best Practice Model)

Labels:

- Node ID (black)
- Link ID (red)
- Direction(green):
  0=two-way, 1=with topo, -1=opposite topology
- From Node ID (blue) : topological direction
- To Node ID (blue) : topological direction

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

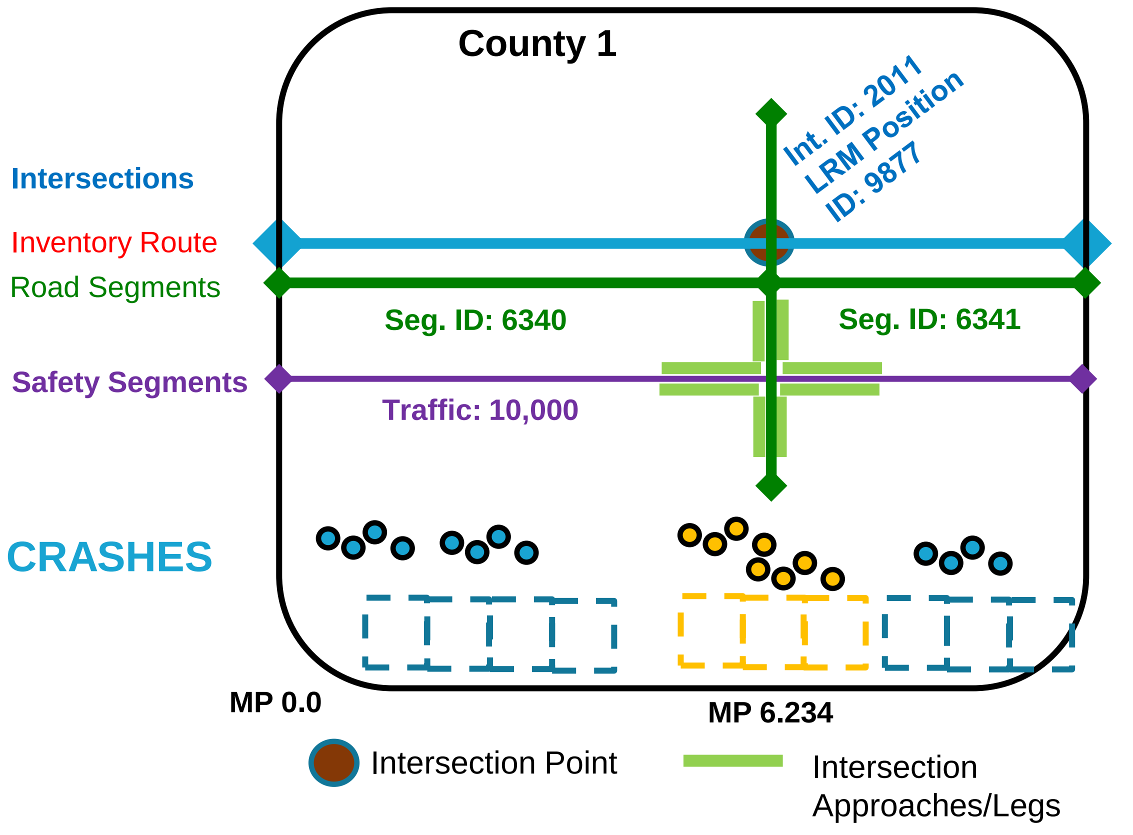
Turns

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

BUSINESS USE CASE 2: SAFETY SEGMENTS MODELING

#CTDOT. #ODOT

Business Use Case for:
Rule 4.1: Publish Road Segments for MIRE,
Different from Road Segments for Travel Demand.



I. Road Segments

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 Ra
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

III. INTERSECTION LEG (EACH APPROACH)

128. Intersection Identifier for this Approach
129. Unique Approach Identifier FDE
130. Approach AADT
131. Approach AADT Year
132. Approach Mode
133. Approach Directional Flow
134. Number of Approach Through Lanes
135. Left-Turn Lane Type
136. Number of Exclusive Left-Turn Lanes
137. Amount of Left-Turn Lane Offset
138. Right-Turn Channelization
139. Traffic Control of Exclusive Right-Turn Lanes
140. Number of Exclusive Right-Turn Lanes
141. Length of Exclusive Left-Turn Lanes
142. Length of Exclusive Right-Turn Lanes
143. Median Type at Intersection
144. Approach Traffic Control
145. Approach Left Turn Protection
146. Signal Progression
147. Crosswalk Presence/Type
148. Pedestrian Signal Activation Type
149. Pedestrian Signal Presence/Type
150. Crossing Pedestrian Count/Exposure
151. Left/Right Turn Prohibitions
152. Right Turn-On-Red Prohibitions
153. Left Turn Counts/Percent
154. Year of Left Turn Counts/Percent
155. Right Turn Counts/Percent
156. Year of Right Turn Counts/Percent

[Business Use Case: 4]
Oversized/Overweight Vehicle Routing

Rule 4.1: Road Segments with Attributes (Different from TDM)
Rule 4.10: Turns, Turn Restrictions and Turn Penalty as Junction (Node Attributes)

- Number of Left/Right Turning lanes/segments on road
- Turn Restrictions at Intersections (e.g. due to intersection angle, prohibited u-turn; although OS/OW vehicles may not be making any u-turns)
- Median crossovers (median cut intersections) are likely not needed. But point location of at-grade and access road intersections is needed as they are decision points in the road network.
- Information about both directions of a road, such as speed limit, lane width, shoulder width, passing/no-passing zones, presence/absence of HOV/Toll lanes. Basically, any information that allows a truck to be routed successfully from one origin to destination.
- Bridge locations and route carried, route under/over a bridge. Also, National Bridge Inventory attributes like vertical clearance, horizontal clearance, structure length, width. The bridges can be represented as points on the map. Linear bridge not necessary.

Hashtag Intersections

Rule 4.1: Road Segments for Travel Demand Modeling from LRS Events with HPMS data
Rule 4.2: No Tapering/Bending of Road Segments at Hashtags.
Rule 4.3: Junctions created at Intersections. Store Route Measure Values

OGC GDF and IFC Intersection & Property Set (using HPMS-MIRE)

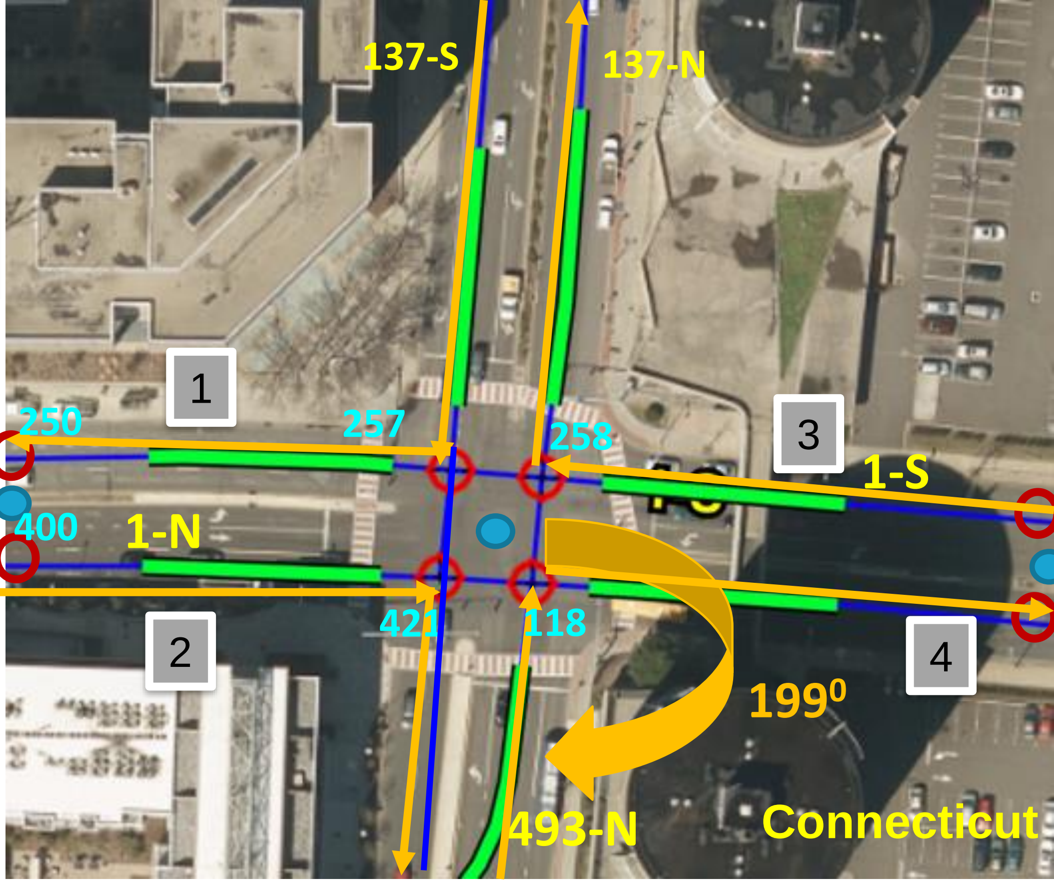
INT ID	Intersection Type (MIRE-111)	Geometry Type (MIRE-126)	Traffic Control Type (MIRE-121)	No. of Legs (MIRE-125)	Geom. (XYZ)
1000	…		…	8	X,Y,Z

Road Segments ⟷

ID	Begin Junc.ID	End Junc.ID	Begin INT ID	End INT ID	Route	Begin Measure	End Measure
1	257	250	1000	500	1-S	6.93	10.93
2	400	421	500	1000	1-N	2.93	6.93
3							

OGC GDF Junctions

Junc.ID	INT ID	Geom.
421	1000	X_1,Y_1,Z_1
257	1000	X_2,Y_2,Z_2
258	1000	X_3,Y_3,Z_3
118	1000	X_4,Y_4,Z_4



Junction Route Measures

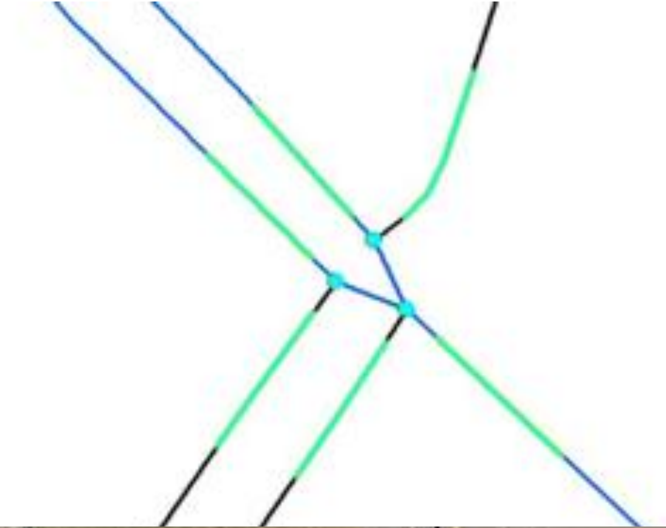
Junction ID	Route	Measure
421	137-S	0.00
421	1-N	6.93
257	137-S	0.01
257	1-S	6.93
258	1-S	0.0
258	137-N	0.01
118	137-N	0.01
118	1-N	6.94
118	493-N	0.34

INTA-INTERSECTIONAPPROACH

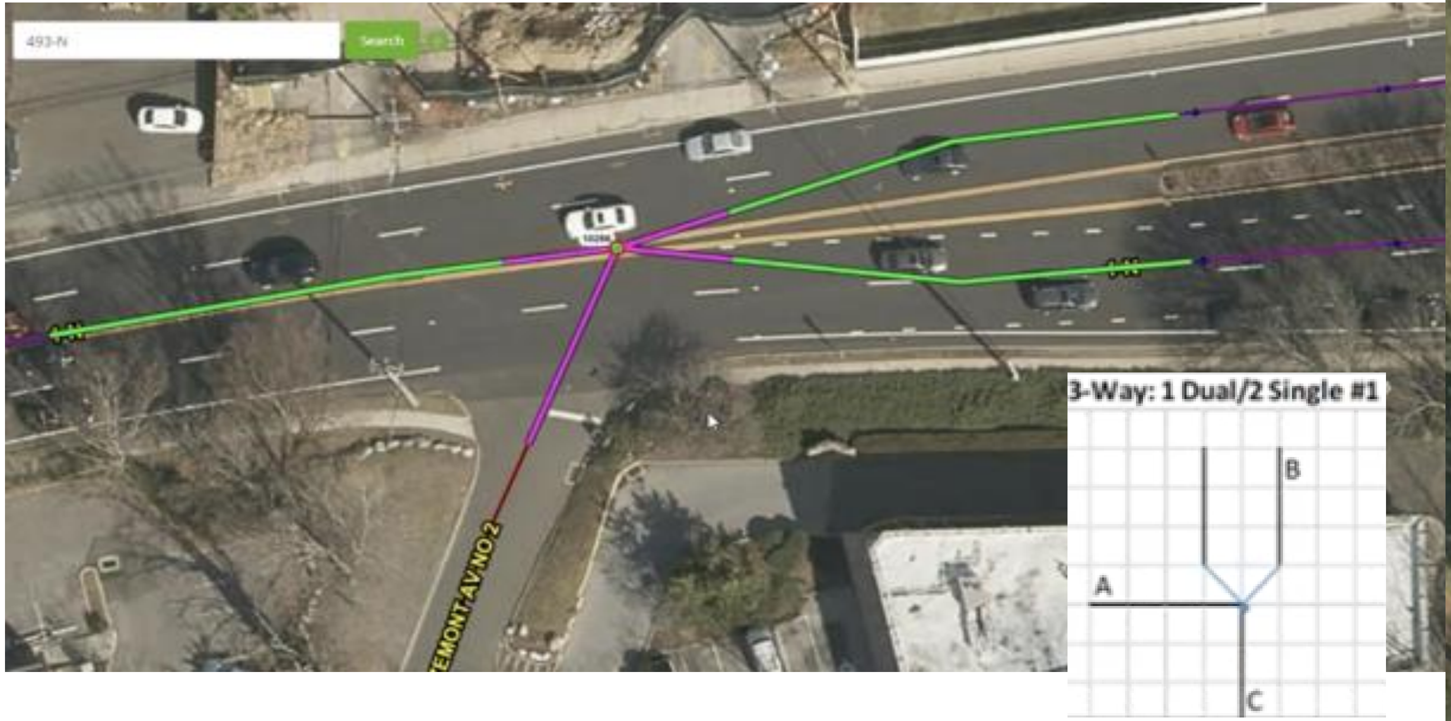
APPR_ID	ROUTE_ID	BEGIN_POIN	END_POINT	APPR_DIR_F	NUM_THRU_L	LT_LN_TYPE	APPR_SIDEW	APPR_PED_S
000001-135-094	1-N	6.945	6.965	2	6	2		
000001-135-272	1-N	6.905	6.925	2	6	2		
000001-135-271	1-S	6.905	6.925	2	6	2		
000001-135-094	1-S	6.945	6.965	2	6	2		
000001-135-003	137-N	0.015	0.035	2	4	2		
000001-135-004	137-S	0.015	0.035	2	4	2		
000001-135-199	493-N	0.315	0.335	2	4	2		

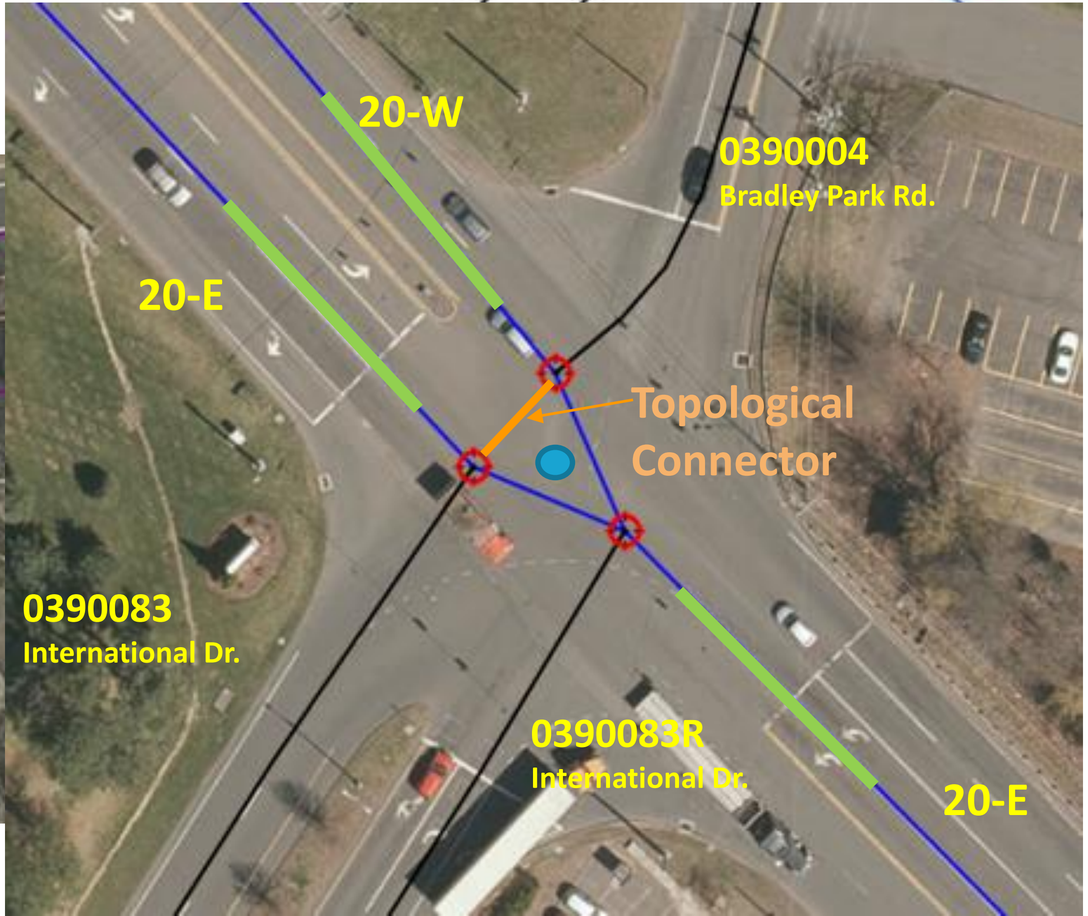
Other MIRE Attributes for Intersection Legs

Topics: 4.1, 4.2, 4.5: Location of Junctions and Start/End of Road Segments at Divided-Undivided Highway Intersections;
Intersection Approach not connected to Junctions
Topological Features (internal intersection connectors) begin/end at Junctions

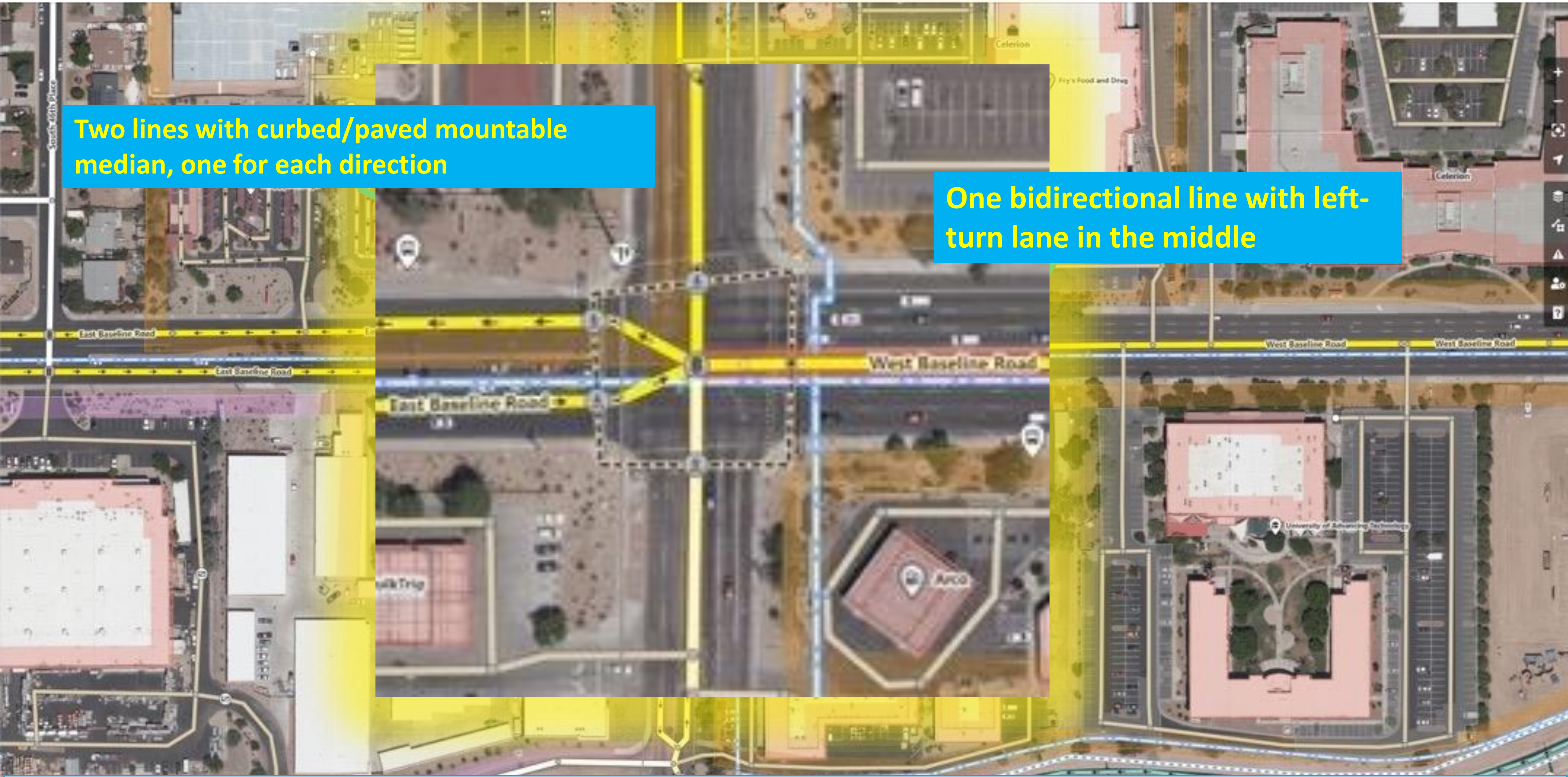


- Bending Divided Highway Routes. When to Start Tapering? At Junctions
- Where do Intersection Legs and Road Segments end?
- Bend Road Segments at Junctions
- Road Segments End at the Junction Points



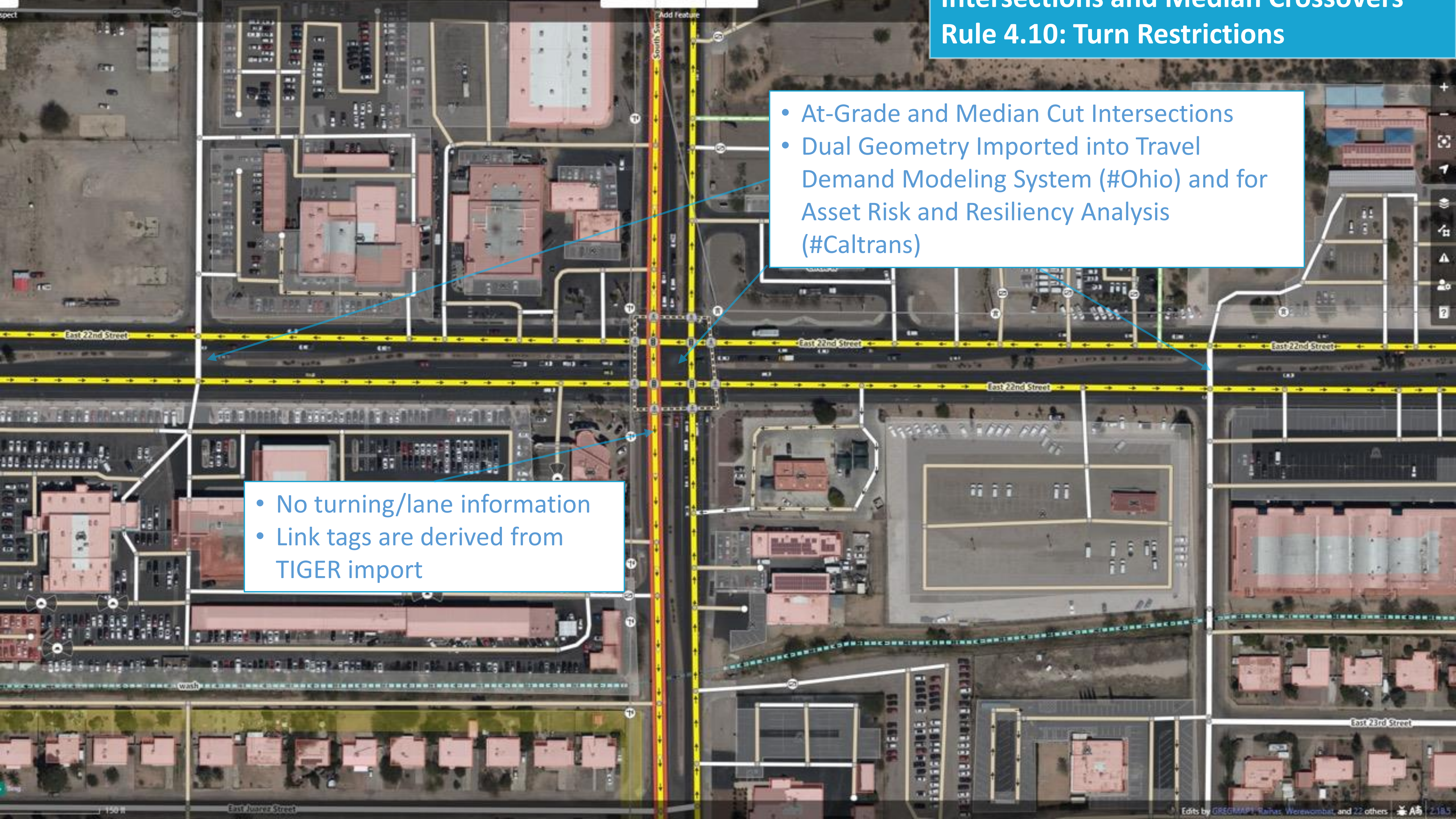


Topics: 4.1, 4.2: Location of Junctions and Start/End of Road Segments at Divided/Undivided Highway Intersections



Open Street Map intersection features: intersection points, legs, turn lanes and Road Segments that Taper into the Intersections

Intersections and Median Crossovers
Rule 4.10: Turn Restrictions



- At-Grade and Median Cut Intersections
- Dual Geometry Imported into Travel Demand Modeling System (#Ohio) and for Asset Risk and Resiliency Analysis (#Caltrans)

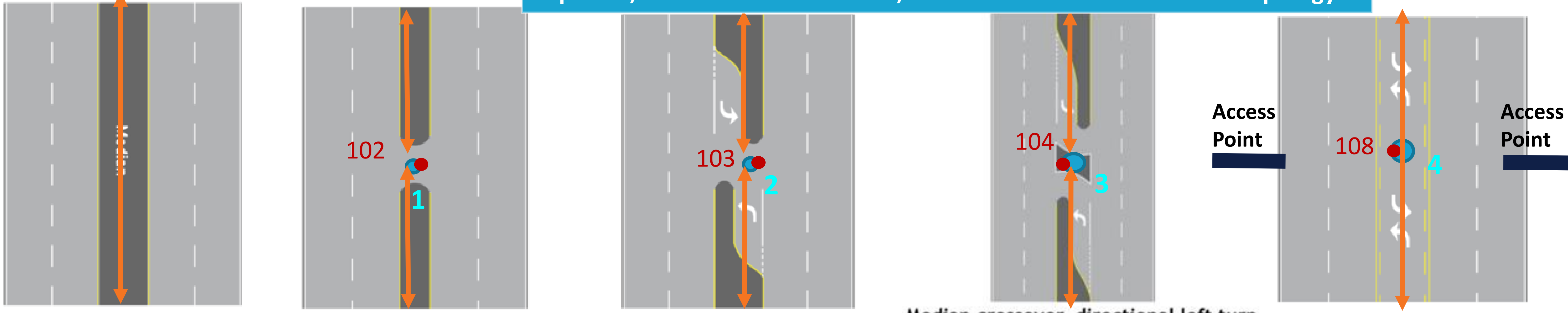
- No turning/lane information
- Link tags are derived from TIGER import

Routes Model

Scenario: Single Geometry

Topic: 4.10 (b)
Modeling Turn Restrictions at Junction (Node) Attributes)?

Topic 4.8, 4.9: Median Crossovers, Median Cut Intersections and Topology



None

Median crossover, no left turn bay

Median crossover, left turn bay

Median crossover, directional left turn bays (to prevent crossing traffic from driveways)

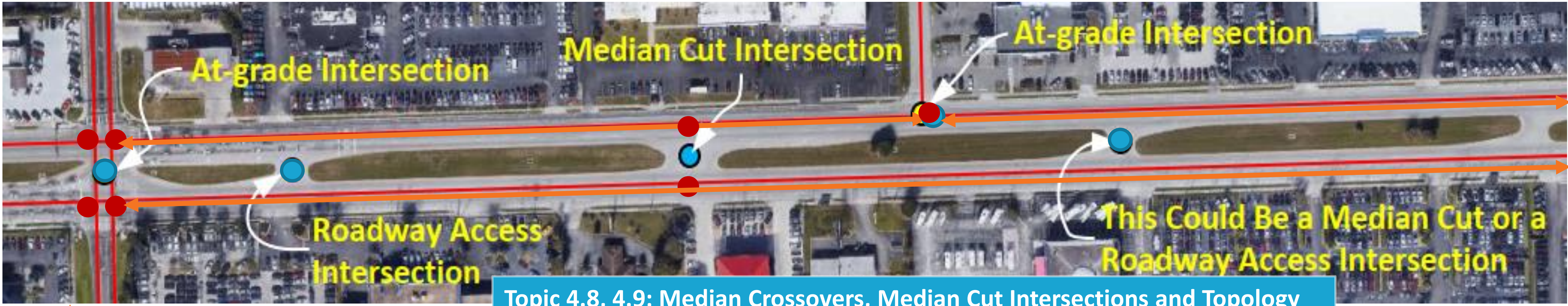
Two-way left turn lane

LRS Route | Intersection (#OGC GDF; #MIRE) | Junctions (#OGC GDF) | Median Crossover | Road Segment (LRS Event)

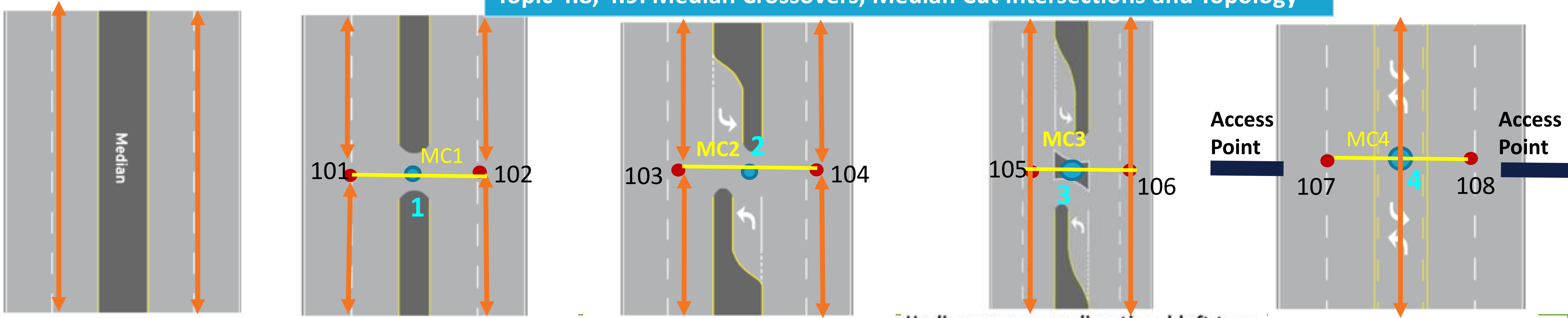
Routes Model

Scenario: Dual Geometry

Topic: 4.10 (b)
Modeling Turn Restrictions at Junction (Node) Attributes)?

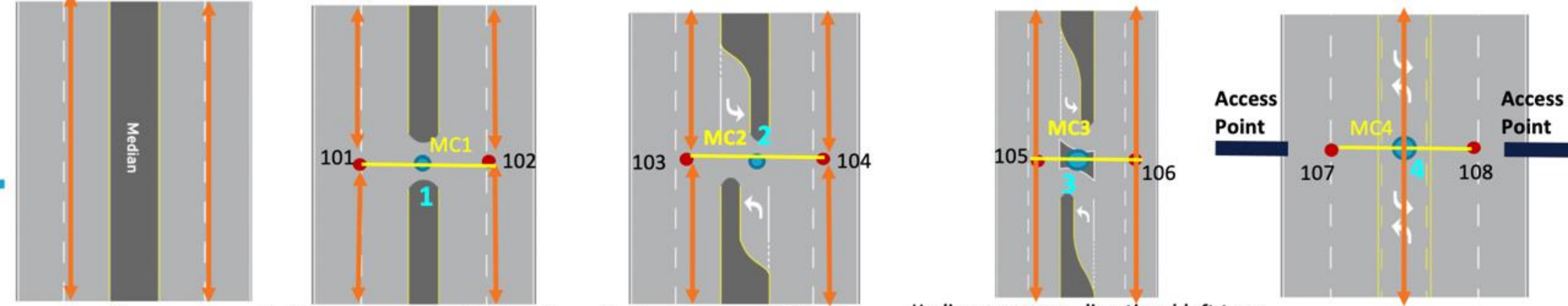


Topic 4.8, 4.9: Median Crossovers, Median Cut Intersections and Topology



None | Median crossover, no left turn bay | Median crossover, left turn bay | Median crossover, directional left turn bays (to prevent crossing traffic from driveways) | Two-way left turn lane

LRS Route — Intersection (#OGC GDF; #MIRE) — Junctions (#OGC GDF) — Median Crossover — Road Segment (LRS Event)



None | Median crossover, no left turn bay | Median crossover, left turn bay | Median crossover, directional left turn bays (to prevent crossing traffic from driveways) | Two-way left turn lane

Topic 4.8, 4.9: Median Crossovers, Median Cut Intersections and Topology

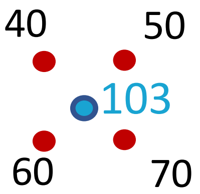
INT ID	Intersection Name	Intersection Type (MIRE-111)	Geometry Type (MIRE-126)	Traffic Control Type (MIRE-121)	Signalization Presence Type (MIRE-122)	No. of Legs (MIRE-125)	Geometry (XYZm)
1	Median Cut Int 1	1 - Roadway/Roadway	7- Non-Conventional Intersection - Median U-Turn	1 - Uncontrolled	5 - Unsignalized	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

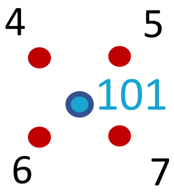
Junc.ID	INT ID	Geom.
101	1	X_1,Y_1,Z_1
102	1	X_2,Y_2,Z_2
103	2	X_3,Y_3,Z_3
104	2	X_4,Y_4,Z_4
105	3	X_3,Y_3,Z_3
106	3	X_4,Y_4,Z_4
107	4	X_3,Y_3,Z_3
108	5	X_4,Y_4,Z_4

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		$[X_4,Y_4,Z_4]$

Intersection (#OGC GDF; #MIRE) | Junctions (#OGC GDF) | Median Crossover | Road Segment (LRS Event)

Rules: 4.5 and 4.6:
Turn Segments/Lanes
(HPMS-12, 13)
Can be Setup as GIS Features, LRS Routes or Events





Turn Segments Start & End at Junctions

TurnSegment_Active (H12, H13)		
PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	TurnSegmentID	Integer
	TurnSegmentName	String(100)
FK, Null	RouteID	Type
Null	BeginMeasure	Type
Null	EndMeasure	Type
	TurnSegmentTypeID	Integer
FK, Null	BeginJunctionID	Type
FK, Null	EndJunctionID	Type
FK	RecStatusID	Type
	RecordDate	Type
	AffectedRecordDate	Type
	RecStatusBeginDate	Type
	SourceCheckSum	Type
Null	Geom	Geometry

Road Seg ID	Road Seg. Name	Begin Junction ID	End Junction ID	Begin INT ID	End INT ID	Route ID	Begin, End Measure	Geometry
1001	Link 1	70	13	103	102	I-70 EB		xyzm1
1002	Link 2	14	6	102	101	I-70 WB		xyzm2
1003	Link 3	4	10/**11 (along)**	101	102			xyzm3
1004	Link 4	12	50	102	103			xyzm4

Turn Seg. ID	Turn Seg. Name	Begin Junction ID	End Junction ID	Route ID	Begin, End Measure	Turn Segment Type	Topology Connector	Geometry
1	LCTurn-1	10	15			Channelized		
2	TC-2	10	11					
3	TC-3	11	12	I-70 WB	-		Yes	Yes
4	TC-4	12	13	-	-		Yes	Yes
5	TC-5	13	14	I-70 EB			Yes	Yes
6	TC-6	11	15				Yes	Yes

INT ID	...
101	
102	
103	

JunctionID	INT ID
10	102
11	102
12	102
13	102
14	102
15	102
4	101
5	101
6	101
7	101
40	103
50	103
60	103
70	103

Named Routes (All Roads)

Route_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	NetworkID	Type
FK	StateCode	Type
PK	**RouteID**	String(100)
UI	RoadName	String(500)
	BeginMeasure	Dec(22,3)*
	EndMeasure	Dec(22,3)*
	DateCreated	Date
	RecordDate	Date
FK	RecStatusID	Integer
	RecStatusBeginDate	Date
	RecStatusEndDate	Date
	SourceCheckSum	LongInteger
	<Metadata Fields>	Type
	Geom	Geometry

InventoryRoute_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	NetworkID	Integer
FK	RouteID	String(100)
PK	**InventoryRouteID**	String(100)
FK	OverlapObjectID	String(100)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
	BeginMeasure	Dec(22,3)*
	EndMeasure	Dec(22,3)*
	DateCreated	Date
	RecordDate	Date
	RecStatusID	Integer
	RecStatusBeginDate	Date
	RecStatusEndDate	Date
	SourceCheckSum	LongInteger
	<Metadata Fields>	Type
	Geom	Geometry

HPMSSampleSections_Active

PK	ObjectID	Type
Key	GlobalID	Type
FK	ObjectTypeID	Type
FK	RouteID	Type
	BeginMeasure	Type
	EndMeasure	Type
FK	RecStatusID	Type
	RecordDate	Type
	AffectedRecordDate	Type
	RecStatusBeginDate	Type
	SourceCheckSum	Type
	Geom	Type

IntersectionApproach_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
PK	**IntersectionApproachID (MIRE-129*)**	Integer
FK	IntersectionID	Integer
UI	IntersectionApproachName	String(100)
	<MIRE Intersection Leg Fields>	...
	<TemporalityFieldsActiveTable>	...
	SourceCheckSum	Type
	Geom	Geometry

Named Routes broken down into Inventory Routes at Ownership Boundaries and divided/undivided transition points

Intersection_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
PK	**IntersectionID (M-110)**	Integer
FK	IntersectionTypeID (M-111)	Type
FK	IntersectionGeometryTypeID (MIRE-126)	Type
FK	IntersectionTrafficControlID (MIRE-121)	Type
FK	SignalizationPresenceTypeID (MIRE-122)	Type
	NumberOfLegs (MIRE-125)	Integer
	IntersectionAngle (MIRE-119)	Type
	<TemporalityFieldsActiveTable>	Type
	<MetadataFields>	Type
	Geom (MIRE-126)	Geometry

IntersectionRoute_Active

PK	ObjectID	Integer
FK	IntersectionRouteID	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
	<TemporalityFields>	Type
	SourceCheckSum	Type
	Geom	Type

RoadSegment_Active (LNKS)

PK	ObjectID	Integer
PK	GlobalID	Integer
PK	**RoadSegmentID**	Integer
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
	DateCreated	Type
	RecordDate	Type
	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	Type
	<MetadataFields>	Type
	Geom	Geometry

Junction_Active (NODE)

PK	ObjectID	Type
PK	**JunctiionID**	Type
FK, Null	InteresectionID	Type
FK	JunctionTypeID	Type
	<TemporalityFields>	Type
	<MetadataFields>	Type
	Geom	Geometry

JunctionRouteMeasure_Active

FK	JunctionID	Integer
FK	RouteID	String(100)
	Measure	Dec(22,3)
	<TemporalityFields>	

Publishing Turn Lanes/Segments (HPMS-12, 13) Median Crossovers (MIRE 62) and Turns

TurnSegment_Active (H12, H13)

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**TurnSegmentID**	Integer
	TurnSegmentName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
FK	TurnSegmentTypeID	Integer
FK	Date Created	Integer
	RecordDate	Type
FK	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	Type
	<MetadataFields>	Type
	Geom	Geometry

MedianCrossover_Active (M62)

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**MedianCrossoverID**	Integer
	MedianCrossoverName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
FK	MedianCrossoverTypeID	Integer
FK	Date Created	Integer
	RecordDate	Type
	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	Type
Key	*<MetadataFields>*	Type
	Geom	Geometry

Turns_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**TurnID**	Integer
	TurnName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	ThroughJunctionID	Type
FK	EndJunctionID	Integer
FK	Date Created	Integer
	RecordDate	Type
FK	RecStatusID	Type
	RecStatusBeginDate	Type
	RecStatusEndDate	Type
	SourceCheckSum	LongInteger
Key	*<MetadataFields>*	Type
	Geom	Geometry

ReverseSegment_Active

PK	ObjectID	Integer
PK	GlobalID	Integer
FK	ObjectTypeID	Integer
PK	**ReverseSegmentID**	Integer
	ReverseSegmentName	String(100)
FK	RouteID	String(100)
	BeginMeasure	Dec(22,3)
	EndMeasure	Dec(22,3)
FK	BeginJunctionID	Integer
FK	EndJunctionID	Integer
FK	Date Created	Integer
	RecordDate	Date
FK	RecStatusID	Type
	RecStatusBeginDate	Date
	RecStatusEndDate	Date
	SourceCheckSum	LongInteger
	<MetadataFields>	Type
	Geom	Geometry

Segment and Nodes for Connectivity & Routability

Session 3 Objective: Breakout Discussion/Inputs on Listed Rules

Breakout Group 1: Justin Brunetti
Patrick Whiteford and Jim Meyer

Breakout Group 2: Greg Ciparelli
Abhishek Bhargava and Joe Breyer

Review Content Related to these Rules; Discuss During Breakouts; Follow-up with Debrief, Polling.

- Rule 4.1: Road Segments should begin and end at Junction Points. Setup as LRS Events and TDM Links.
- Rule 4.2: No tapering/bending of Road Segments at Hashtag Intersections (so that length can be used as true indicator of route length). But, at undivided-undivided intersections tapering happens and starts at junctions?
- Rule 4.3: Junctions created at: Intersection, TAZ Centroid, Bridge, Crosswalk, Intersection Leg (begin/end), etc.
- Rule 4.4: Junctions can coincide with Intersection Point (INTP) at intersections of undivided highways
- Rule 4.5: Topological Features begin/end at junctions: (a) Internal Intersection Connectors (b) Turn Segments (HPMS-12, 13) (c) Median Crossover (d) Reverse Segments
- Rule 4.6: Topological Features can be setup as (a) Spatial Features (b) Road Centerline/Routes (c) LRS Events
- Rule 4.7: Median Cut Intersections (MIRE-126) are stored along with other at-grade intersections
- Rule 4.8: Median Crossover (MIRE-62) serves as Topological Connector on Dual Geometry Roads.
- Rule 4.9: Median Crossover (MIRE-62) starts/ends at Junctions, passes through Median-Cut Intersection (MIRE-126)
- **Rule 4.10: Turns modeled with three nodes in GIS. Turn Restrictions & Penalty are Junction (Node) Attributes.**
- **Rule 4.11: Topological Connectivity is created between: (a) Road Segments & Junctions (b) Junctions and Turns (c) Median Crossovers and Junctions (d) Turn Lanes/Segments and Junctions (e) Intersection Routes, Junctions and Intersection Leg**

U.S. Department of Transportation
Federal Highway Administration

Summary, Wrap-Up and Next Steps

Workshop Summary

		Objective 1: Publishing Routes with Z-Values & Concurrency		Objective 2: Modeling, Road Segments, Junctions, Intersections, Turn Segments, Median Crossovers & Turns		
ID	**Business Use Case Name and Description**	**Route Elevation, Z-Values, Vertical Alignment**	**Route Topology: Single/Dual, Concurrency, Frontage, HOV**	**Road Segment: Junction to Junction; and Intersection Points**	**Topological Connectors: Turn Segments, Median Crossovers**	**Turns: Restrictions, Penalty for Routing & Turn-by-turn directions**
1	**GIS Network for Travel Demand Modeling** and Forecasting Systems (e.g. Emme, Cube, TransCAD, Open Street Maps, GMNS)		✓	✓		✓
2	**Safety Analysis** – Crash Assignment, Network Screening, Level of Service Score (LOSS); Spatial Econometric Models and Predictive Models for Safety Performance Functions (SPFs) with MIRE & HPMS Items; HSIP Plan;	✓	✓		✓	
3	**Bridge and Pavement Life-Cycle Analysis**, Risk, Resiliency and Vulnerability Assessment, Flood Impact, Routine Condition Assessment, Work History and Future Work Planning	✓	✓		✓	
4	**Oversized/Overweight Heavy Vehicles** Permits: Routing, Connectivity, Restrictions; Freight Network Modeling.			✓		✓
5	**Road Network for Linear Referencing:** LRS Measures, Data Quality, Dominant/Sub, HPMS-ARNOLD, MIRE, Road Mileage		✓	✓	✓	

AEGIST Implementation Activities at PFS States

AEGIST Goals and Objectives	CA	CT	GA	ID	TN	PA	OH	KS	AZ	NC
Spatial Data Governance, Management *Strategy, Roadmap, Metadata, Data Portfolio, Workshops*			✓	✓	✓	✓	✓			
Spatial Data Modeling										
Roads Data Modeling & Business Rules *DOT, Federal, Local: HPMS, ARNOLD, NG911*	✓					✓		✓	✓	✓
Intersections Data Model *HPMS 9.0, MIRE, GDF, IFC Roads & Bridge*			✓							
Data Quality Automation *HPMS, MIRE & Assets*		✓								
Spatial Data Integration and Engineering										
Roads Data Integration, Authoritative Data Mgmt. *DOT, Federal, Local Roads Data Sharing & Federation*	✓									
Road Network and Events Data Publication: Pilots *Data Model for Data Warehouses. Data Models & Engineering in Data Hubs*		✓								
Spatial Data Analytics										
Spatial Statistics, Econometrics, AI/ML, Optimization *Descriptive, Diagnostics, Predictive, Prescriptive Analytics;*						✓				