



**Office of Information
Technology Services**

Enterprise Linear Referencing at the NYS Department of Transportation

One Highway Network to Support Many Business Processes

May 9, 2018

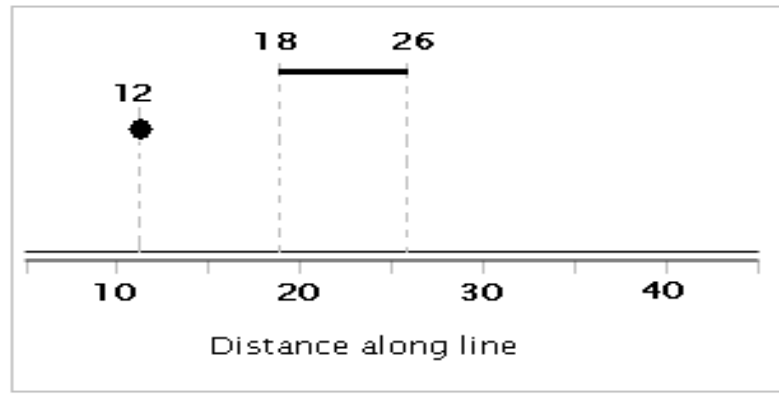
Agenda

- An overview of Linear Referencing
- How NYSDOT uses Linear Referencing
- NYSDOT's New Enterprise Linear Referencing System

Linear Referencing: a location reference for networks

Relies on uniquely identified lines and a known measuring system.

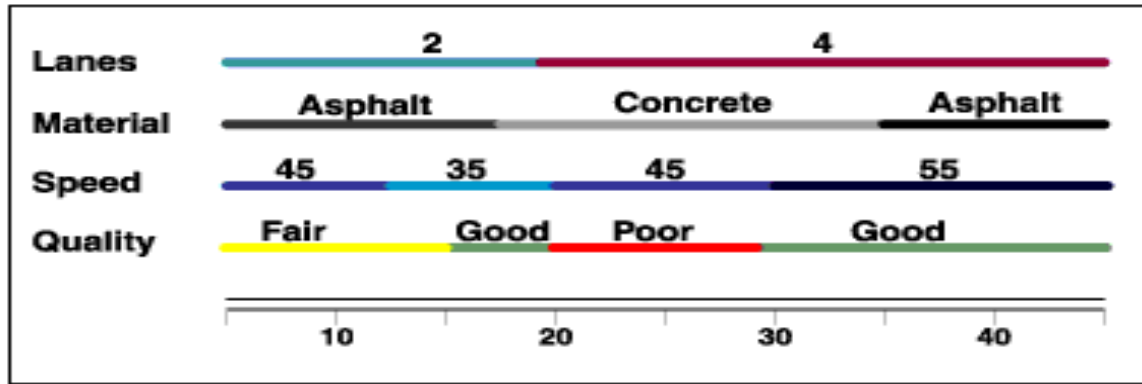
NYSDOT, along with every other State DOT, has used linear referencing to locate roadway data for decades...long before GIS!



Linear Referencing: a location reference for networks

A primary benefit of linear referencing is that it may be used to easily associate multiple sets of attributes to linear features.

The geometry of the road is stored once.



NYSDOT Linear Referencing Methods (LRM)

Milepoint

- Mileage based
- Roadway Inventory System (RIS) is the system of record.
- Locates roadway characteristics, administrative attributes, traffic data and highway projects from the Capital Program

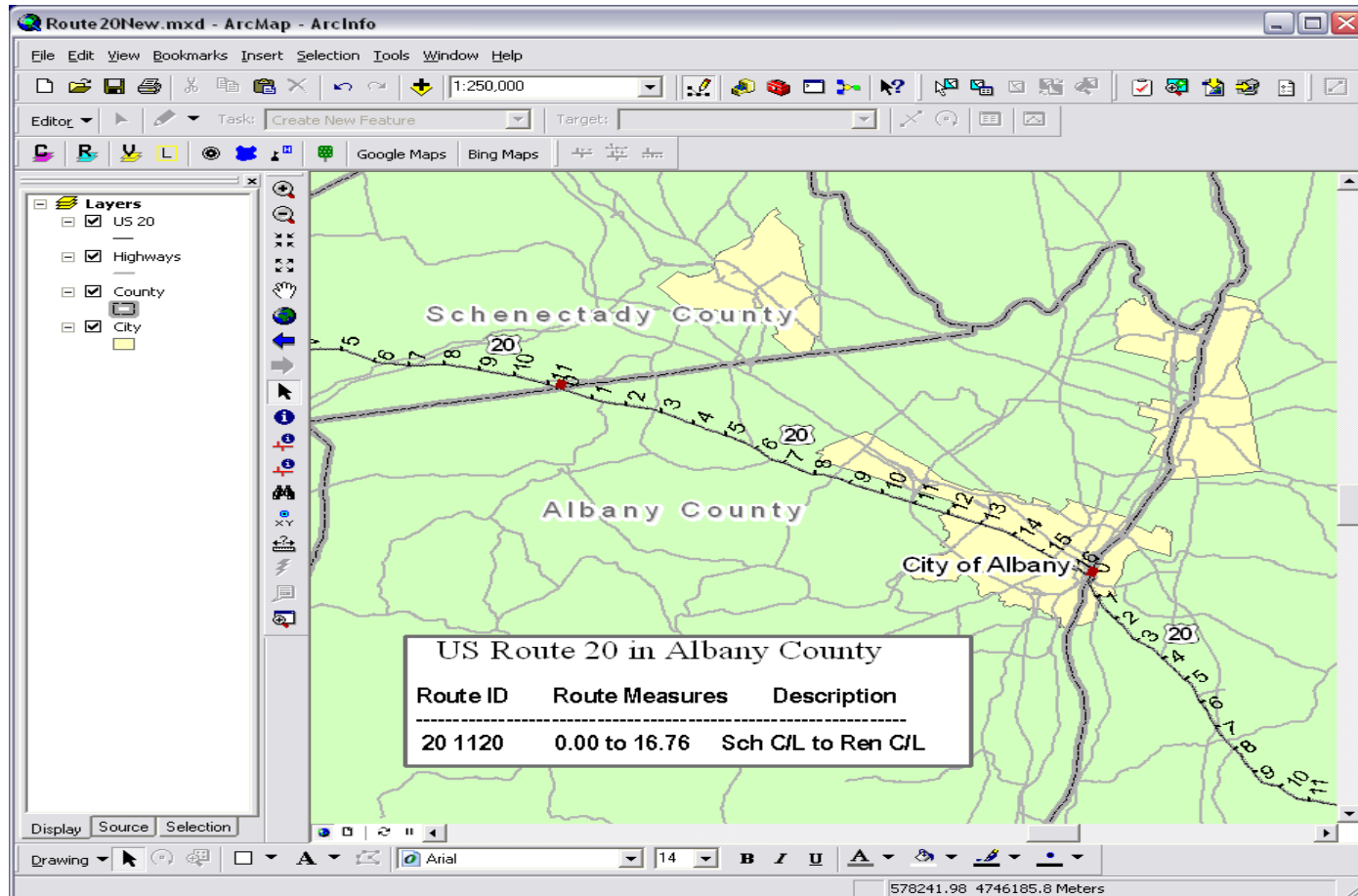


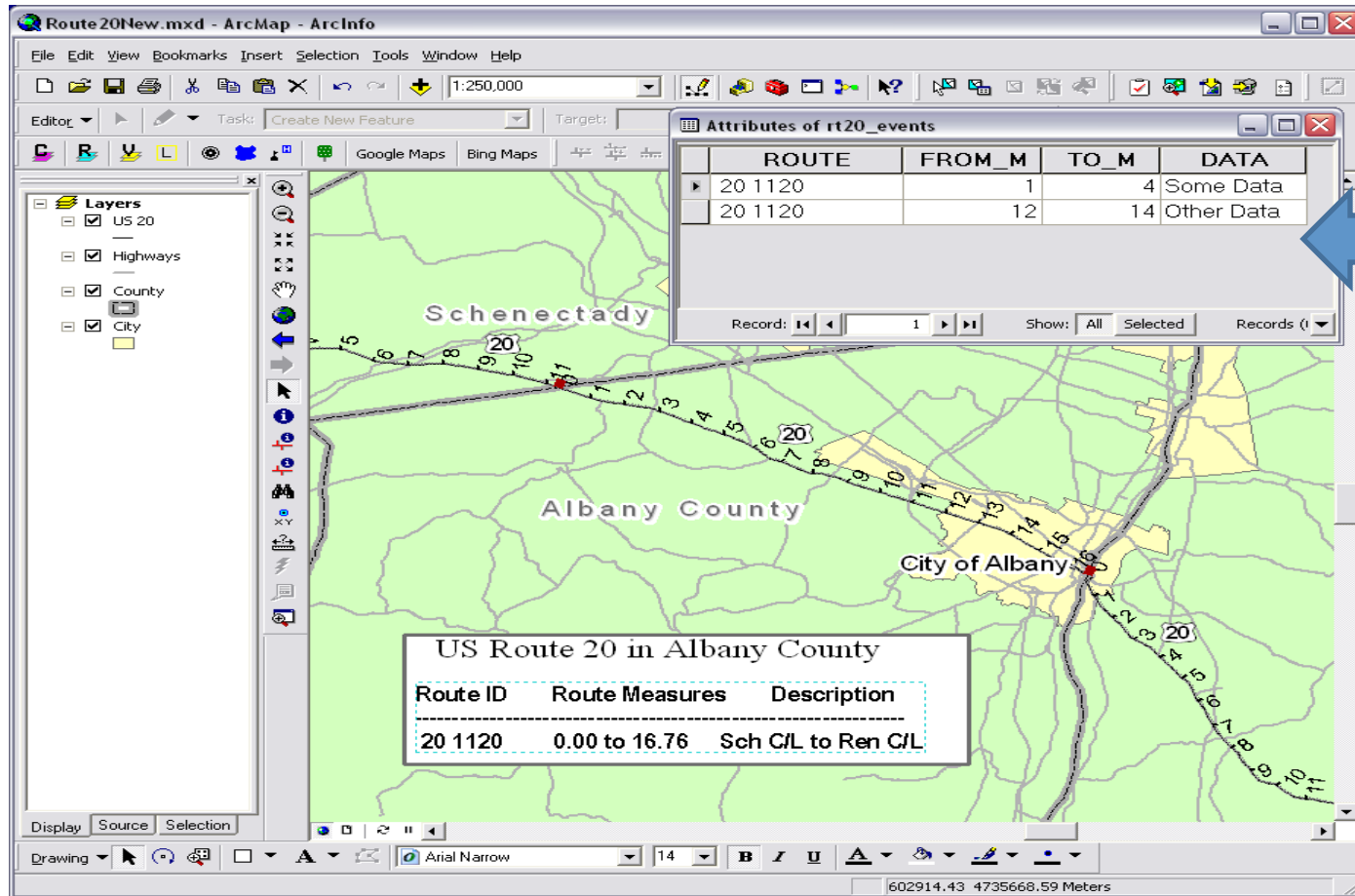
Reference Marker

- Field posted
- Safety Information Management System (SIMS) is the system of record.
- Locates accident records and maintenance work

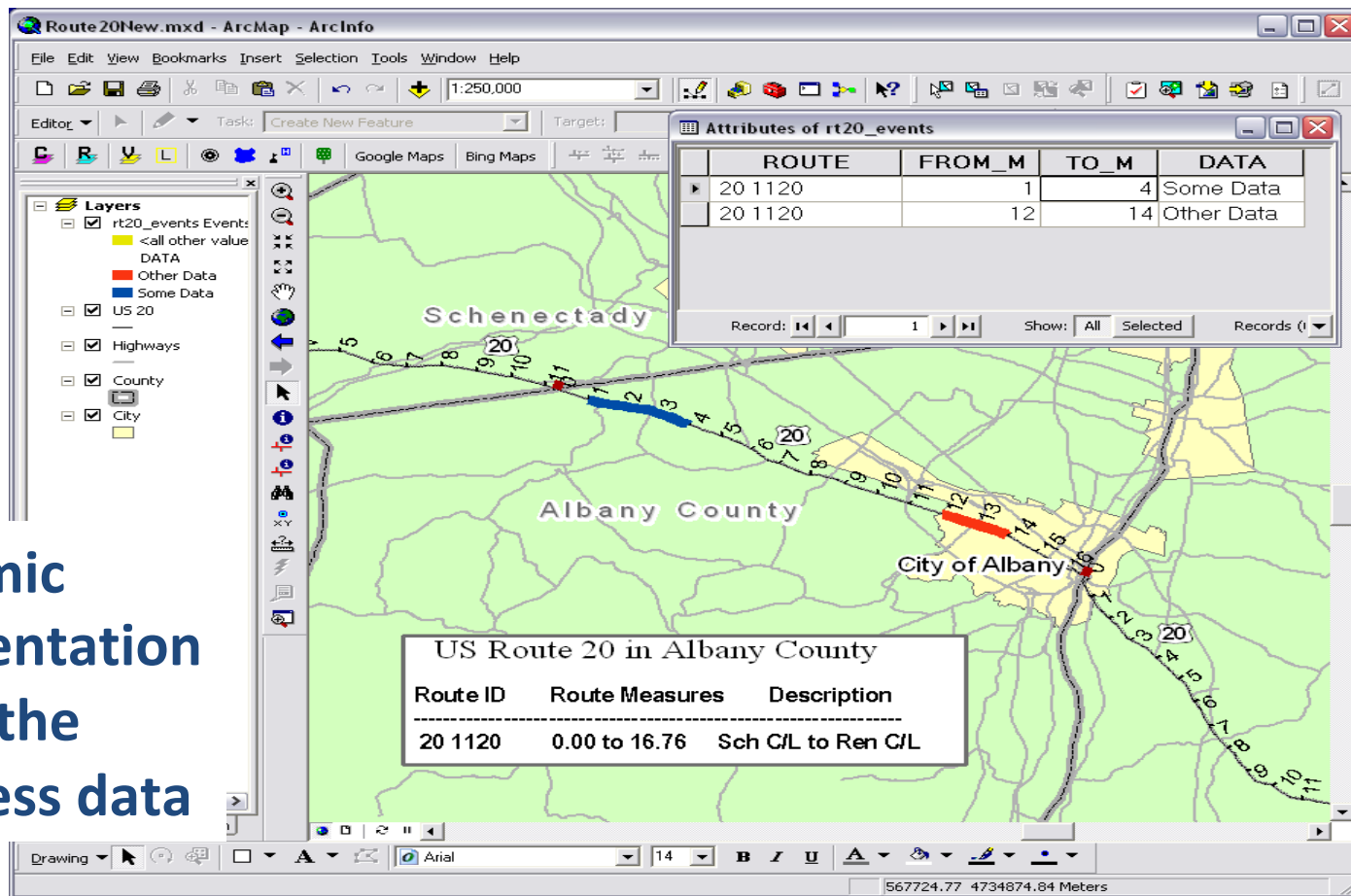


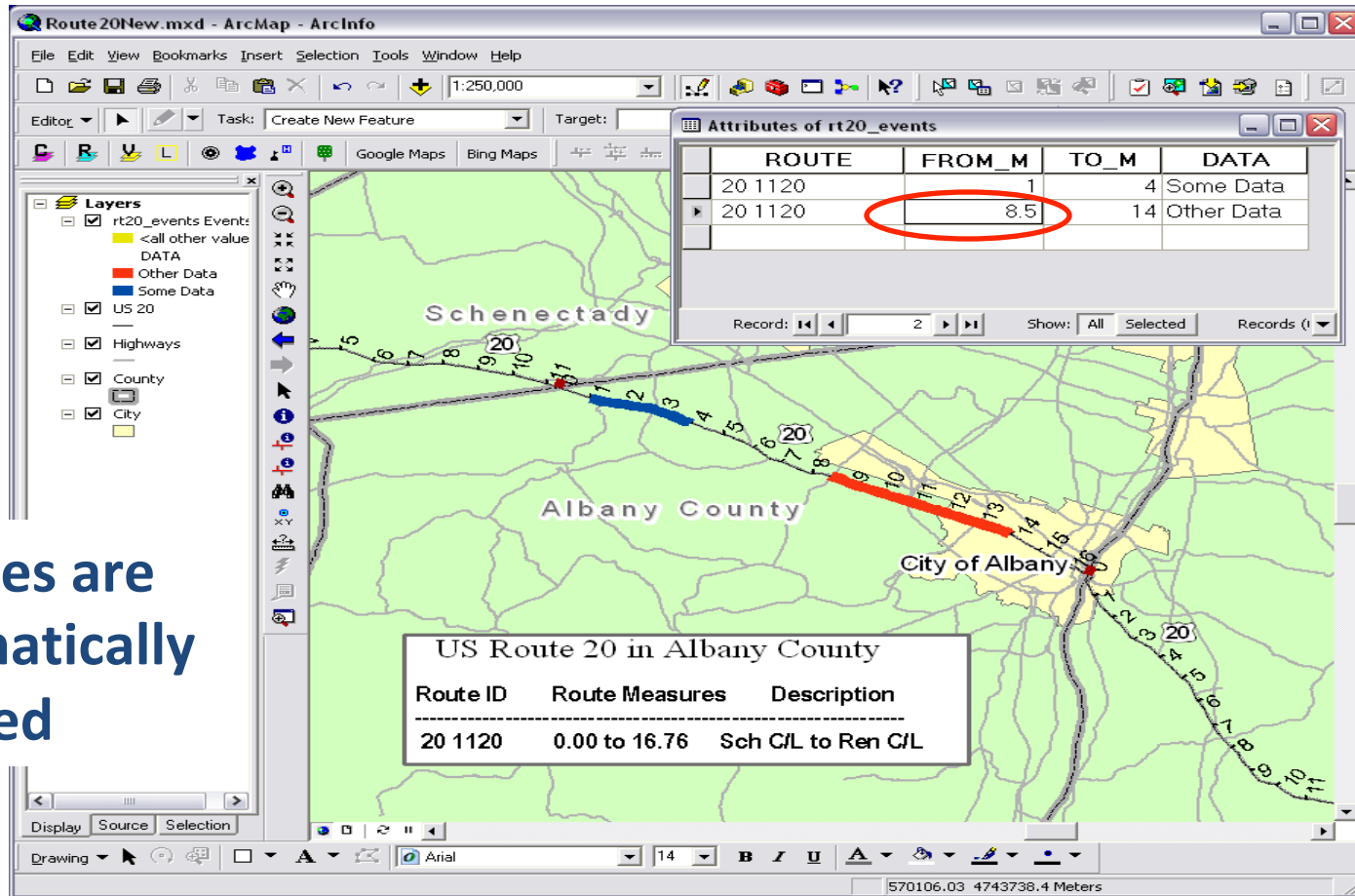
Linear Referencing and Dynamic Segmentation





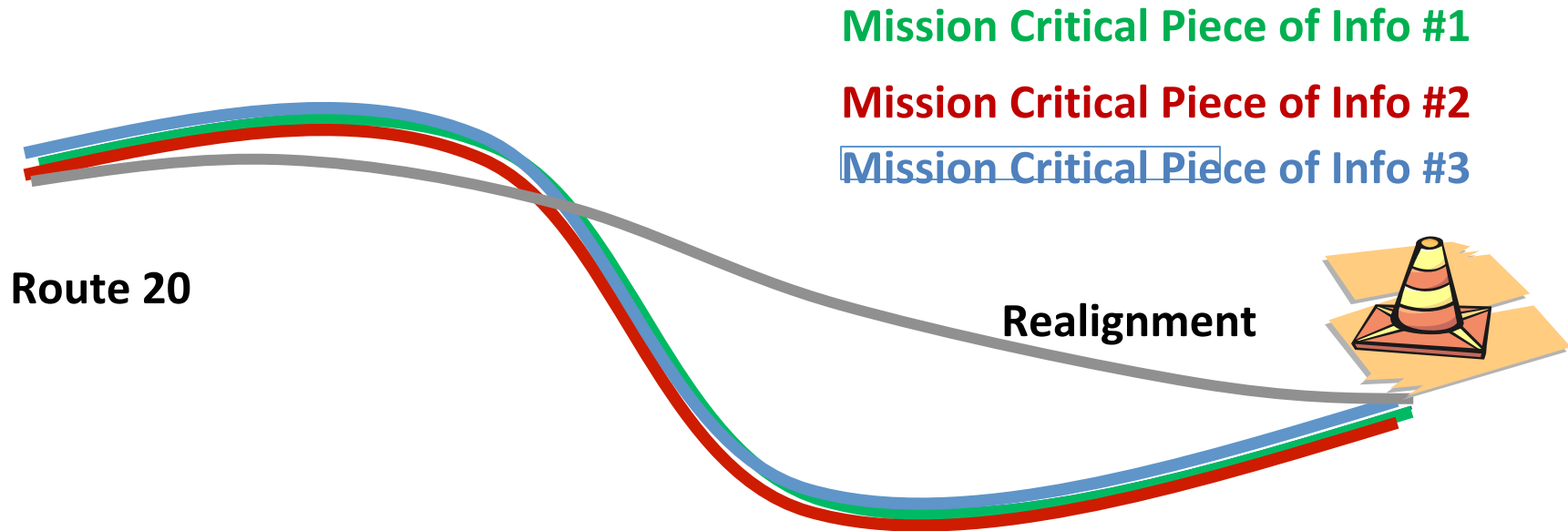
Event
Table





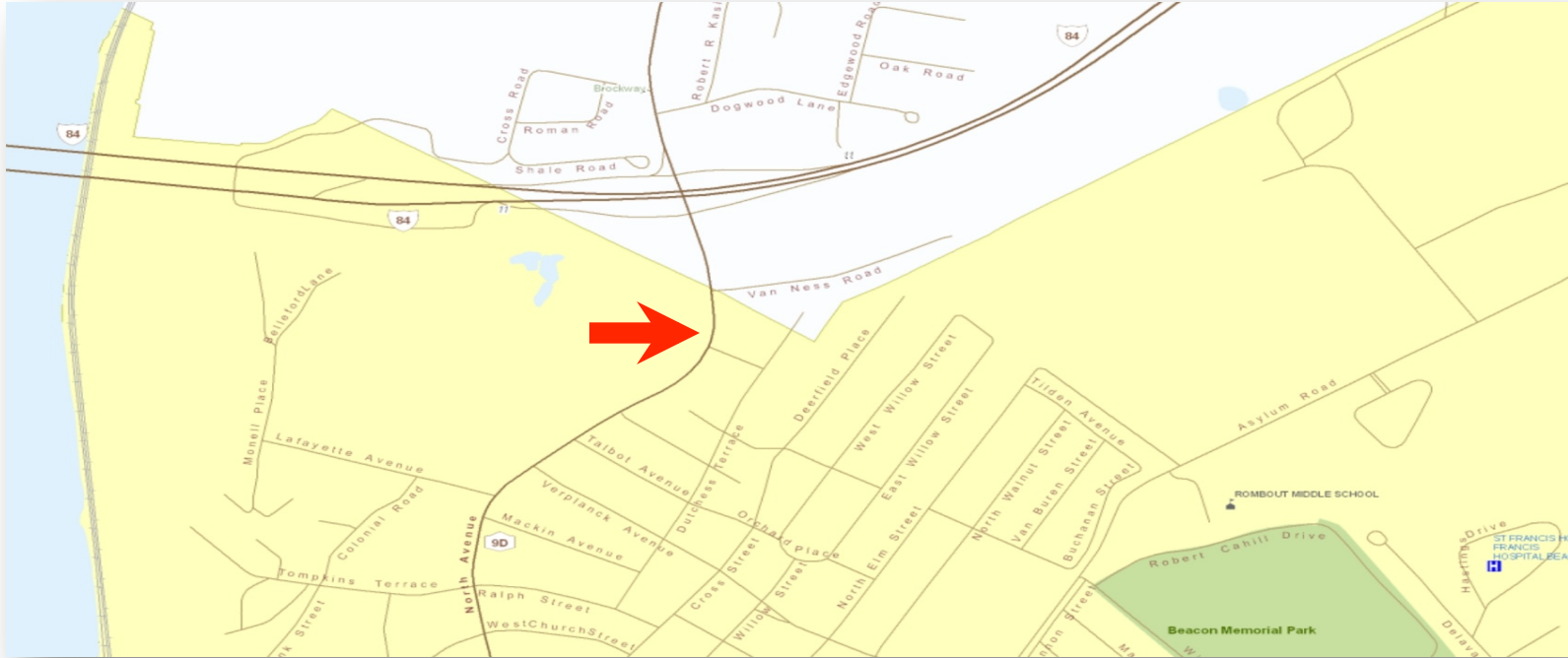
Updates are
automatically
mapped

What happens when we don't use linear referencing?



NYSDOT still maintains dozens of highway layers as individual GIS layers.

What is this road called?



a) State Route 9D b) Route 9D c) NY9D d) North Ave

Answer: all of the above

In Milepoint: 10050503

NYSDOT LRS in GIS

Where we are...

RIS - Segment Maintenance - Windows Internet Explorer provided by NYSDOT

Save | Reset | Export to Excel | Criteria | Help | Show Errors | ☒ Default | ☐ Length Correction | ☐ New Construction | ☐ Realignment | ☐ Cascade | Lane Miles

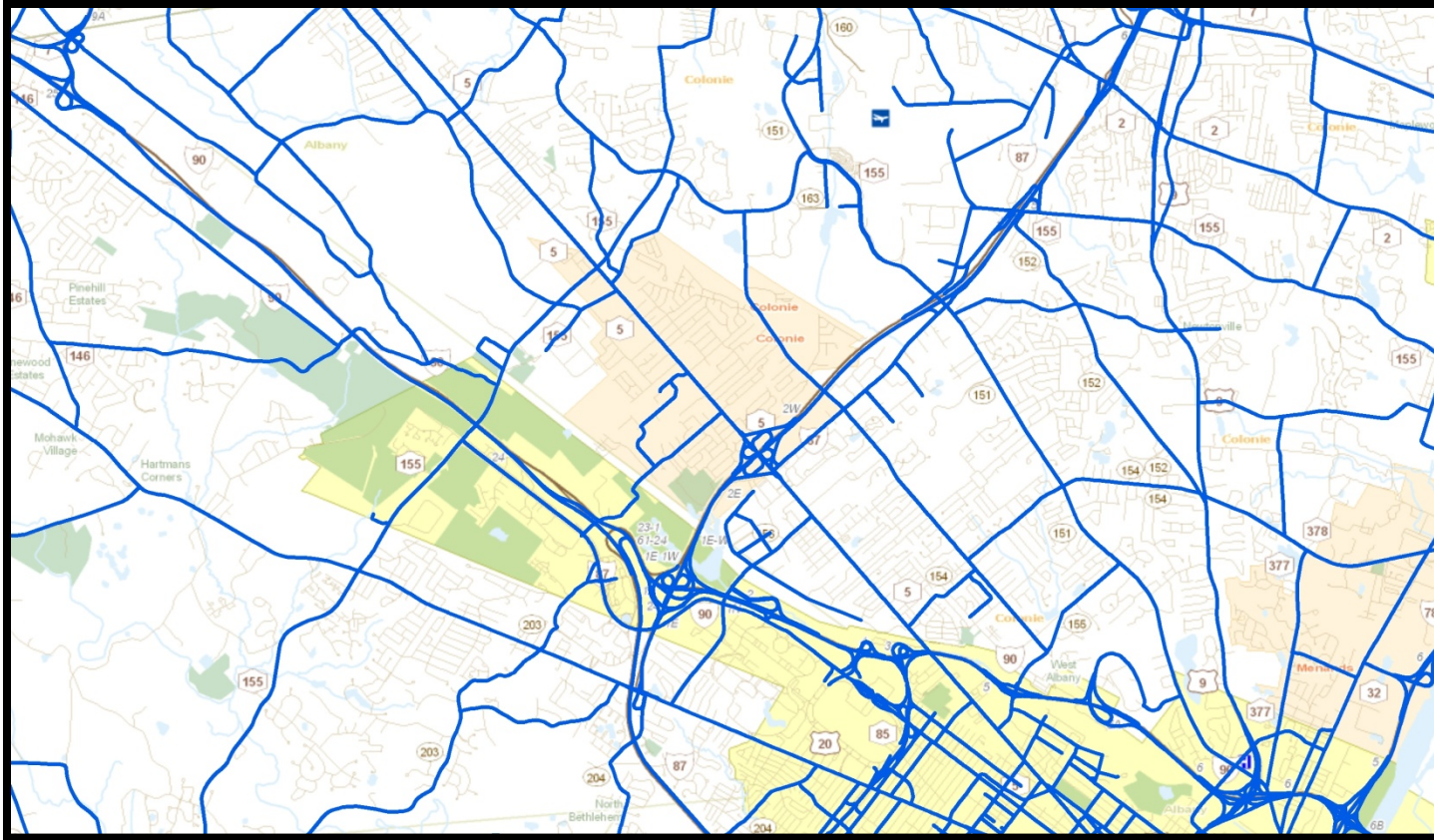
Route View | DOT Id : 100233 | Rte : NY275 | Beg : 1.47 | End : 1.61 | Len : 0.14 | Co Order : 1 | Primary Segments |

End Desc : | Jump To: Select a Column | Column

DOT Id	Rte	Beg	*End	*Len	CO	Olap	Div ...	Begin Desc	End Desc	PF	LF	SH	*Maint Jur	Owning Jur	*Co	*FC	Sta	*Muni	Owner	HPMS	UAC	MPA	Name
100233	NY275	0.00	0.09	0.09	1			RT 417 BOLIVAR	PLUM ST	=	=	9382	01	01	ALLEG	7	0218	1049 - Boliv					
100233	NY275	0.09	0.47	0.38	1			PLUM ST		=	=	1246	01	01	ALLEG	7	0218	1049 - Boliv					
100233	NY275	0.47	0.99	0.52	1					=	=	1246	01	01	ALLEG	7	0218	1049 - Boliv					
100233	NY275	0.99	1.03	0.04	1				VILLAGE RICHBURG	=	=	1246	01	01	ALLEG	7	0218	1049 - Boliv					
100233	NY275	1.03	1.15	0.12	1			VILLAGE RICHBURG		=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	1.15	1.30	0.15	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	1.30	1.40	0.10	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	1.40	1.47	0.07	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	1.47	1.61	0.14	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	1.61	1.67	0.06	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	1.67	1.78	0.11	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	1.78	2.08	0.30	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	2.08	2.13	0.05	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	2.13	2.21	0.08	1					=	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	2.21	2.22	0.01	1				VILLAGE RICHBURG	√	=	1246	01	01	ALLEG	7	0218	1420 - Richb					
100233	NY275	2.22	2.45	0.23	1			VILLAGE RICHBURG		=	=	1246	01	01	ALLEG	7	0218	0921 - Wirt					
100233	NY275	2.45	2.46	0.01	1					=	=	1246	01	01	ALLEG	7	0218	0921 - Wirt					
100233	NY275	2.46	2.52	0.06	1				CR 8 INVALE RD	√	=	1246	01	01	ALLEG	7	0218	0921 - Wirt					
100233	NY275	2.52	4.31	1.79	1			CR 8 INVALE RD		=	=	1246	01	01	ALLEG	7	0006	0921 - Wirt					
100233	NY275	4.31	4.94	0.63	1					=	=	964	01	01	ALLEG	7	0006	0921 - Wirt					
100233	NY275	4.94	6.47	1.53	1					=	=	964	01	01	ALLEG	7	0006	0921 - Wirt					
100233	NY275	6.47	6.89	0.42	1					=	=	964	01	01	ALLEG	7	0006	0921 - Wirt					
100233	NY275	6.89	6.90	0.01	1					=	=	964	01	01	ALLEG	7	0006	0921 - Wirt					
100233	NY275	6.90	7.29	0.39	1					=	=	964	01	01	ALLEG	7	0006	0921 - Wirt					
100233	NY275	7.29	7.30	0.01	1					=	=	964	01	01	ALLEG	7	0006	0921 - Wirt					

Page 1 of 2 | Show 25 records | Displaying records 1 - 25 of 44

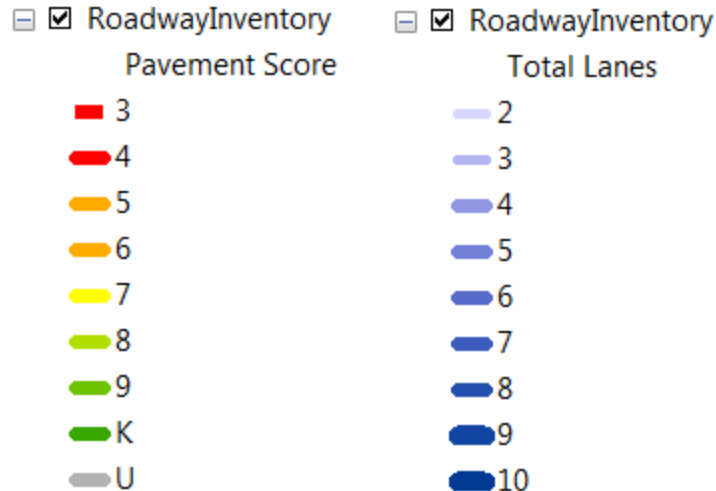
NYSDOT's Roadway Inventory System (RIS) maintains roadway attributes for all public roads. System of record for Milepoint

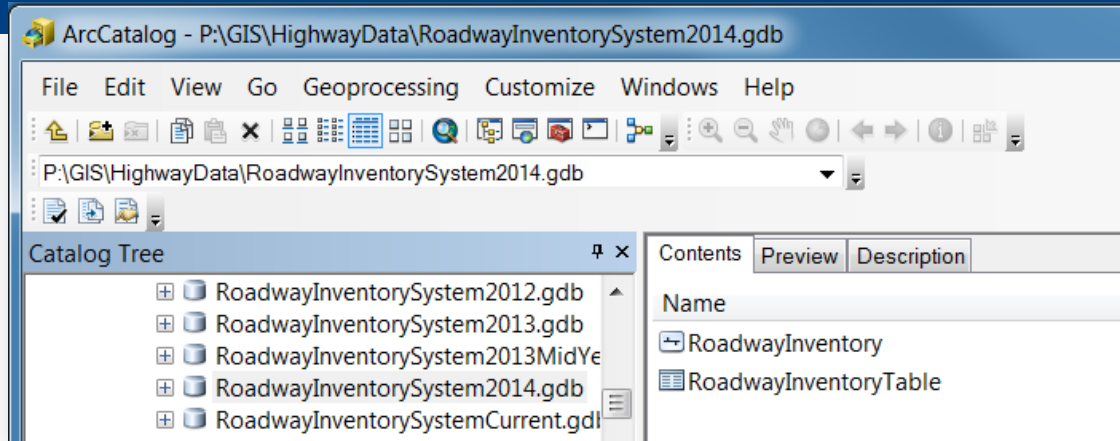


Current Milepoint LRM Network - the “Federal Aid Eligible” system

Roadway Inventory System Table + Milepoint LRM Network

Roadway Inventory System Geodatabase





20. **NYS Roadway Inventory System Geodatabase**



[Data Set Details](#)

Revised: 2014

A highway layer generated from NYSDOT's Roadway Inventory System showing roadway characteristics and administrative attributes. The layer covers the state highway system and major local roads that are part of the federal aid eligible system. UTM NAD 83 Zone 18N.


The Roadway Inventory System geodatabase is available to NYS Clearinghouse members on the NYSDOT page on the NYS GIS Clearinghouse:

<http://gis.ny.gov/gisdata/inventories/member.cfm?organizationID=539>

FHWA “ARNOLD” Requirements

In August 2012, FHWA expands HPMS requirement for GIS LRS network to cover to all public roads

NYSDOT's Highway Data Services is constructing the Milepoint network for the remaining 85,000 miles of local public roads

 U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: INFORMATION: Geospatial Network for All Public Roads **Date:** AUG 07 2012

From: David R. White, P.E. *[Signature]*
Director, Office of Highway Policy Information
James Chatham, *[Signature]*
Director, Office of Planning, Environment, and Realty

To: Division Administrators
Resource Center Directors

Re: HPMS-20

The *Highway Performance Monitoring System (HPMS) Field Manual* includes the requirement for States to submit their linear referencing system (LRS) network for all roads eligible for Federal Aid. The purpose of this memorandum is to announce that this requirement will be expanded to cover all public roads including dual carriageways on divided highways for the HPMS submodel of 2013 due June 15, 2014. This is consistent with the updated HPMS information collection approval from the Office of Management and Budget (2125-0028). To ensure compliance, we are also asking for a plan on how each State will meet the requirement by June 15, 2013.

Based on existing requirements for bridge inspection and reporting, safety analysis, and certified public road mileage, it is expected that States have this information or are in the process of acquiring it. Each State governor or their designee must report annually the mileage for all public roads within their State for the apportionment of Highway Safety Funds (23 CFR 460). To enable HPMS to validate this mileage requires that the network for all public roads be provided to the Federal Highway Administration (FHWA).

23 U.S.C. 148 requires States to advance their capabilities for traffic records data collection, analysis, and integration with other sources of safety data (such as road inventories).

The national bridge inventory (NBI) covers each highway bridge carrying a public road and the location of bridges within an LRS network. To enable coordination and data integration of the NBI and HPMS, the LRS network for both must be the same.

The expansion of LRS network reporting to include all public roads supports the U.S. Department of Transportation initiative "Transportation for the Nation" (TPN). The vision of

NYSDOT's Enterprise Linear Referencing System Project

Goals for the Enterprise Linear Referencing System:

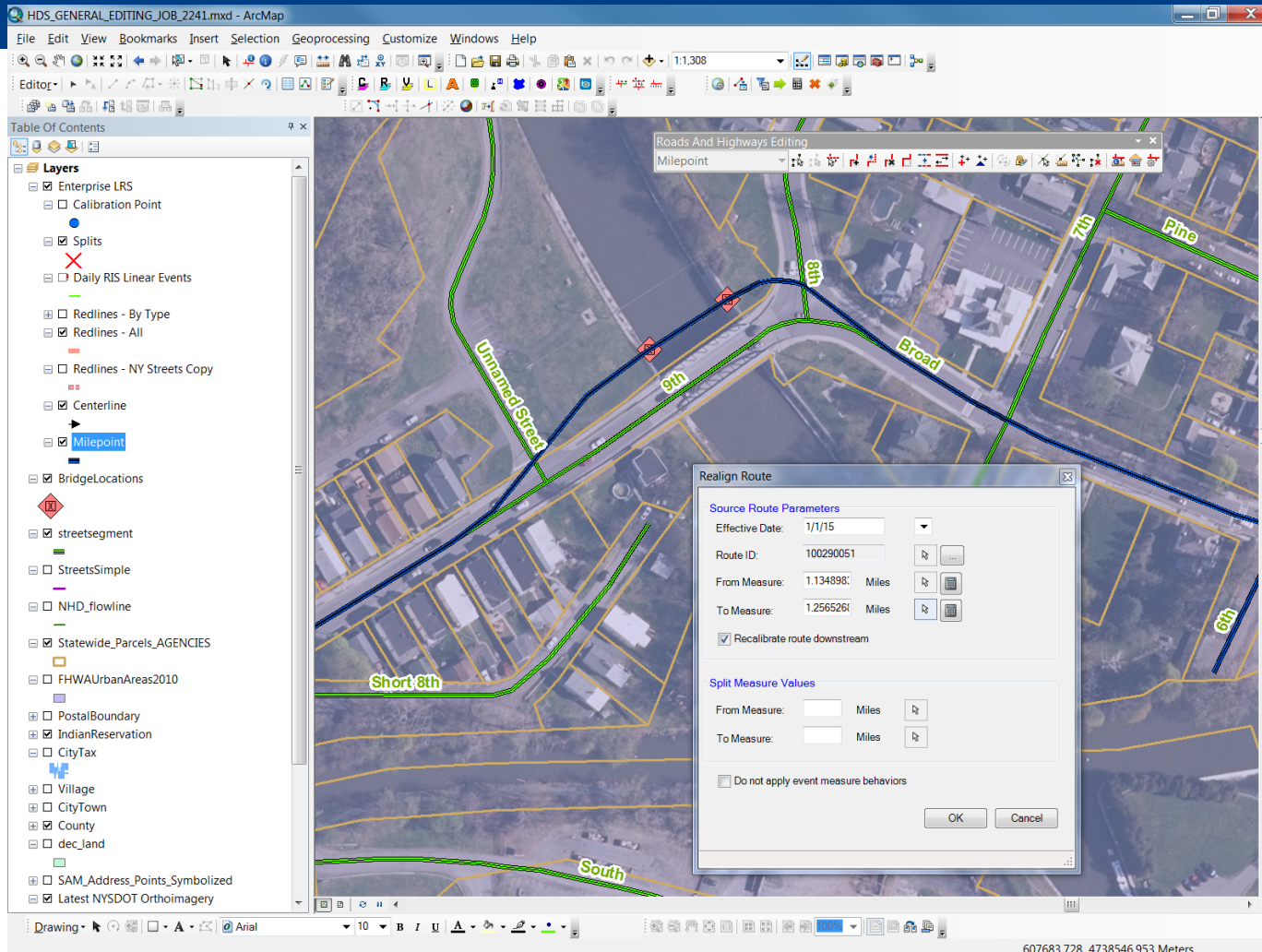
1. Maintain a single representation of the NYS highway network
2. Allow NYSDOT business units to more easily maintain asset locations and highway information using the Milepoint LRM
3. Enable business system and data integration through the common location reference (Milepoint)

Enterprise Linear Referencing System Project

- NYS Department of Transportation (NYSDOT)
- NYS Office of Information Technology Services (NYS ITS)
- Esri

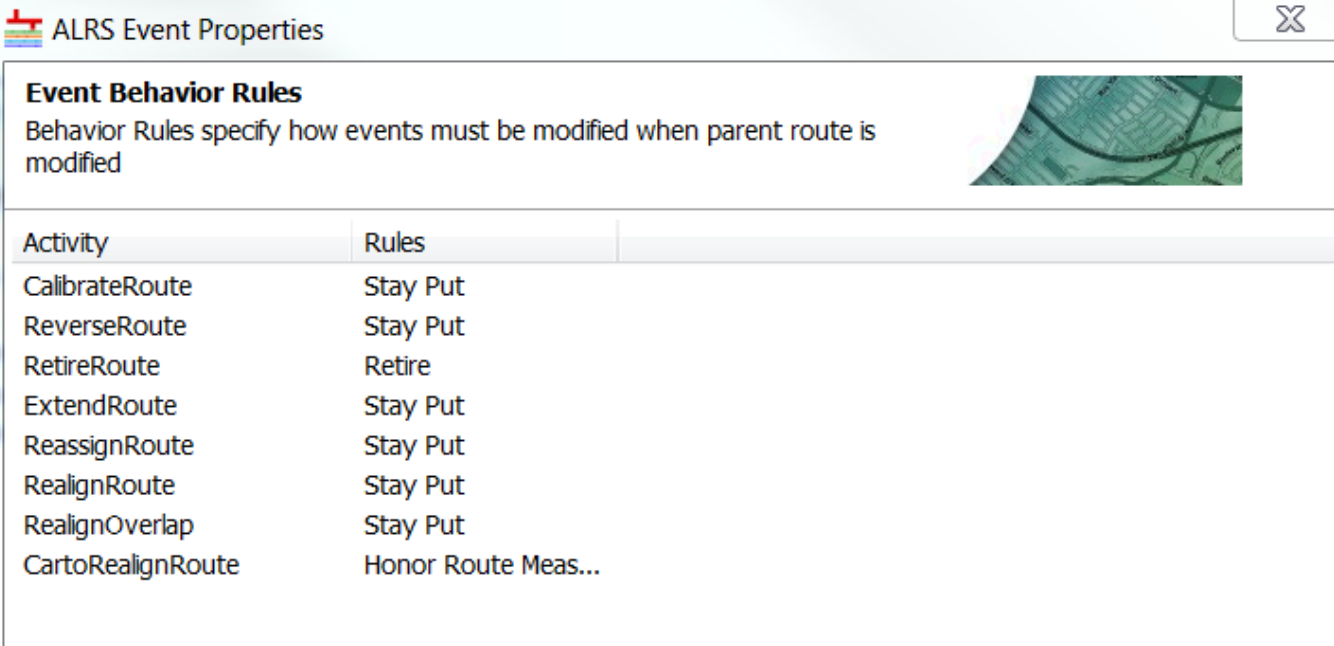
Configure and implement the **Esri Roads and Highways** solution to maintain NYSDOT's Linear Reference System

What does Roads and Highways do?



Allows NYSDOT to maintain a temporal network in ArcMap...

...using the latest NYS Streets geometry...

A screenshot of a software window titled "ALRS Event Properties". The window has a close button in the top right corner. Below the title bar, there is a section titled "Event Behavior Rules" with a description: "Behavior Rules specify how events must be modified when parent route is modified". To the right of the text is a small map icon. Below this is a table with two columns: "Activity" and "Rules". The table lists several activities and their corresponding rules.

Activity	Rules
CalibrateRoute	Stay Put
ReverseRoute	Stay Put
RetireRoute	Retire
ExtendRoute	Stay Put
ReassignRoute	Stay Put
RealignRoute	Stay Put
RealignOverlap	Stay Put
CartoRealignRoute	Honor Route Meas...

...while managing event data on the network based on predefined rules.

https://elrsqa.dot.ny.gov/rce

File Edit View Favorites Tools Help

Share Browser WebEx

ITS TED - Home LATSNet Login NYeNet User Managemen... RMFT Web Slice Gallery

NYSDOT ELRS Roadway Characteristics Editor - Esri Roads and Highways v10.3.1.515

Map Edit Review

Layer: Bridge

Attribute Set: Default

Version: ELRS.RCE_Structures

Not configured.

Layers

- ☒ Markup
- ☒ RCE Struct BRMP
- ☒ Bridge
- ☒ MilePoint
- ☒ RCE Struct Read Only
- ☐ Bridge Point
- ☒ Reference_Marker
- ☐ Calibration Point
- ☐ Redline
- ☐ Street Segment
- ☐ Centerline
- ☐ Statewide
- ☐ Basemap
- ☒ World Topo Map
- Citations

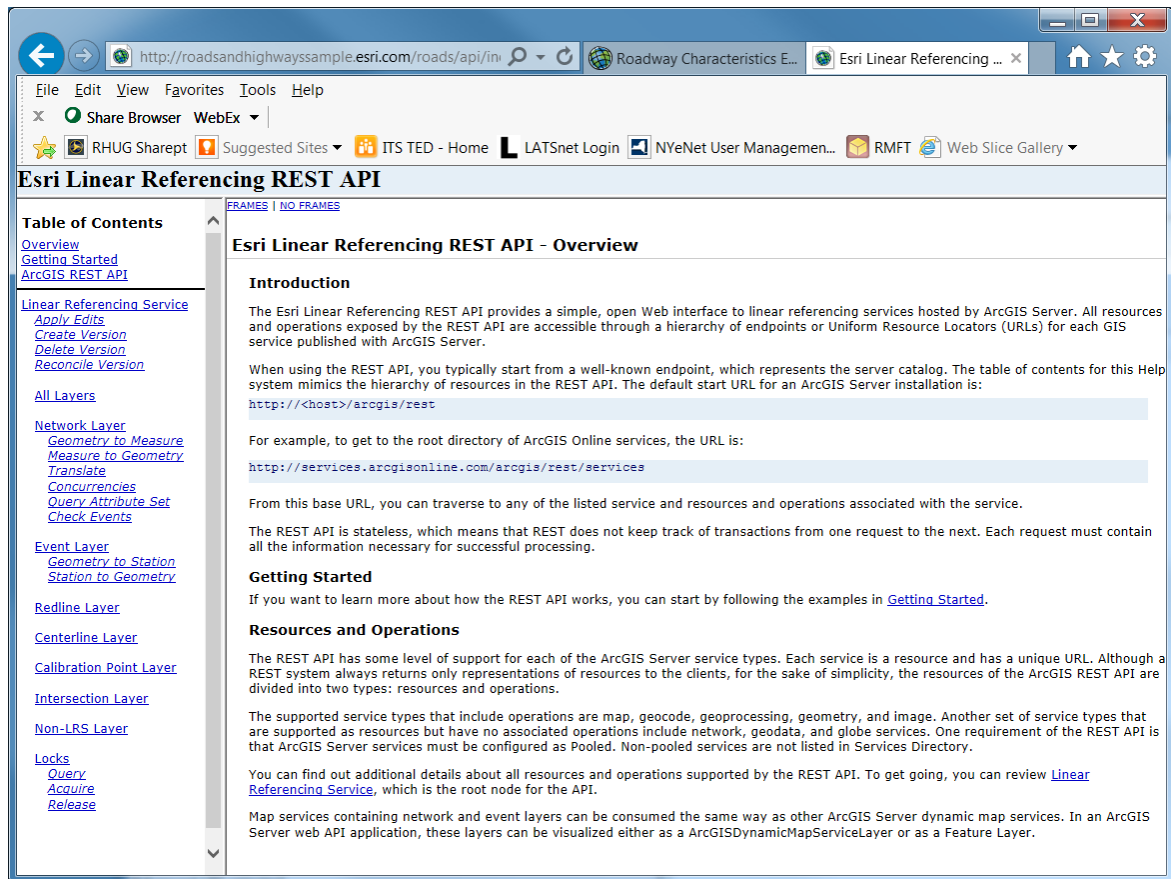
OBJECTID	From Date	To Date	Edited Date	Edited By	Event_ID	Route_ID	From Measure	To Measure	BIN	Carried	Crossed
6204	07/27/2015	<null>	<null>	<null>	1014693	100414011	2.0598024	2.0897995	2200460	470 470 110120	W BR MOHAWK R

Page 1 of 1 | 1 | Record 1 to 1 | Total 1 Records

Event Attributes

Allows users to create and edit asset locations or highway information from a map-based interface from within the browser.

NYSDOT is starting with refining asset locations (eg. bridges, large culverts, overhead signs) and moving on to other roadway attributes (eg. bike routes, scenic byways, snowplow beats)



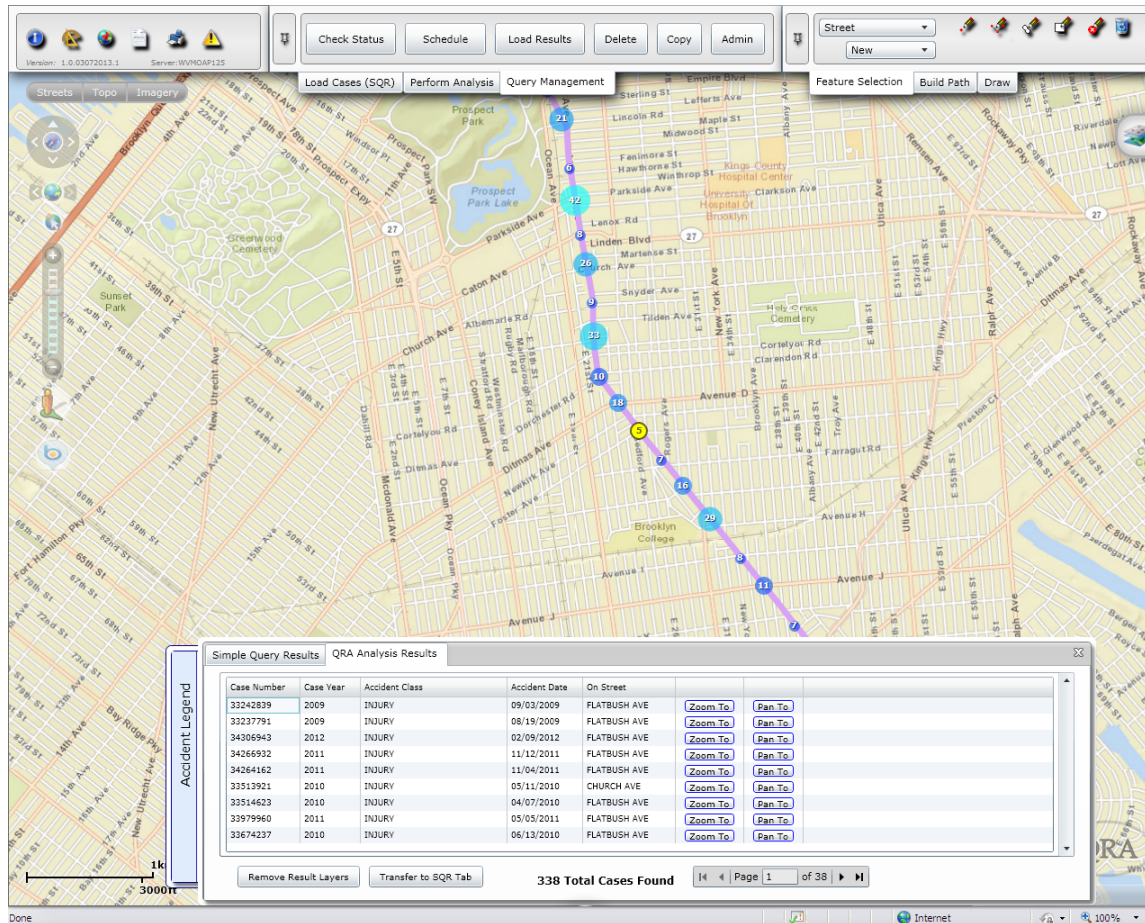
The screenshot shows a web browser window displaying the Esri Linear Referencing REST API documentation. The browser's address bar shows the URL <http://roadsandhighwayssample.esri.com/roads/api/in/>. The page title is "Esri Linear Referencing REST API". The left sidebar contains a "Table of Contents" with links to "Overview", "Getting Started", "ArcGIS REST API", "Linear Referencing Service", "All Layers", "Network Layer", "Event Layer", "Redline Layer", "Centerline Layer", "Calibration Point Layer", "Intersection Layer", "Non-LRS Layer", and "Locks". The main content area is titled "Esri Linear Referencing REST API - Overview" and includes an "Introduction" section. The introduction states that the Esri Linear Referencing REST API provides a simple, open Web interface to linear referencing services hosted by ArcGIS Server. It also provides the default start URL for an ArcGIS Server installation: `http://<host>/arcgis/rest`. The "Getting Started" section mentions that the REST API is stateless and that each request must contain all the information necessary for successful processing. The "Resources and Operations" section states that the REST API has some level of support for each of the ArcGIS Server service types and that the resources of the ArcGIS REST API are divided into two types: resources and operations. The supported service types include map, geocode, geoprocessing, geometry, and image. The page also mentions that map services containing network and event layers can be visualized either as a `ArcGISDynamicMapServiceLayer` or as a `Feature Layer`.

A REST endpoint that completes LRS work for external systems.

1. Geometry to measure
 2. Measure to geometry
 3. Check Events
- ...and others

These capabilities allow us to leverage the Milepoint LRS for external systems...

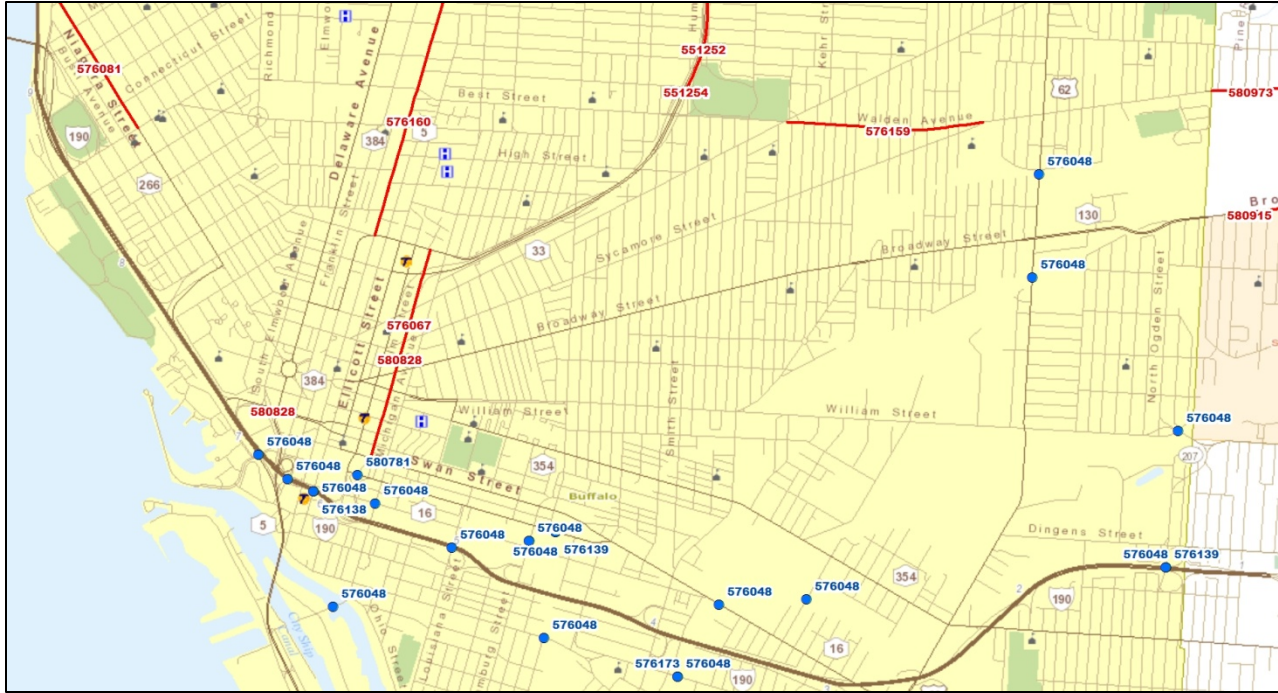
A BIG deal



Find highway crash locations on the Milepoint LRS as they are retrieved by NYS' Accident Location Information System (ALIS)

(Geometry to Measure)

What is the traffic count and pavement condition at a given safety investigation location?



Develop an application that provides an easy to use interface to locate proposed Capital Project locations.

The screenshot displays the Comprehensive Asset Management System (AgileAssets) interface. The browser window at the top shows the URL <http://wmoap134/html5viewer/?viewer=camci>. The menu bar includes File, Edit, View, Favorites, Tools, and Help. The toolbar contains icons for Initial View, Print, Zoom to Place, Distance, Area, Find BIN/CIN, Find RM, Query, and Clear Selection. The layers panel on the left lists the following categories and items:

- ☒ CAMCI
 - ☒ System Map
 - ☒ Structures
 - ☒ Bridges (Condition)
 - ☐ Bridges (Posting)
 - ☐ Bridge Needs
 - ☒ Large Culverts (Gen Rec)
 - ☐ Small Culverts (Gen Rec)
 - ☒ Pavement
 - ☐ IRI Ranges
 - ☒ Surface Rating
 - ☐ Pavement Need
 - ☐ End of Good Window
 - ☐ End of Fair Window
 - ☒ Safety
 - ☒ Capital Program
 - ☐ Planned Bridge Projects
 - ☐ Planned Highway Projects
 - ☐ NHS
 - ☒ Accessibility
 - ☒ Flooding Vulnerability
 - ☒ Legislative

The map shows a city area with various infrastructure assets overlaid, including roads, bridges, and culverts. A scale bar at the bottom left indicates distances up to 0.3 miles.

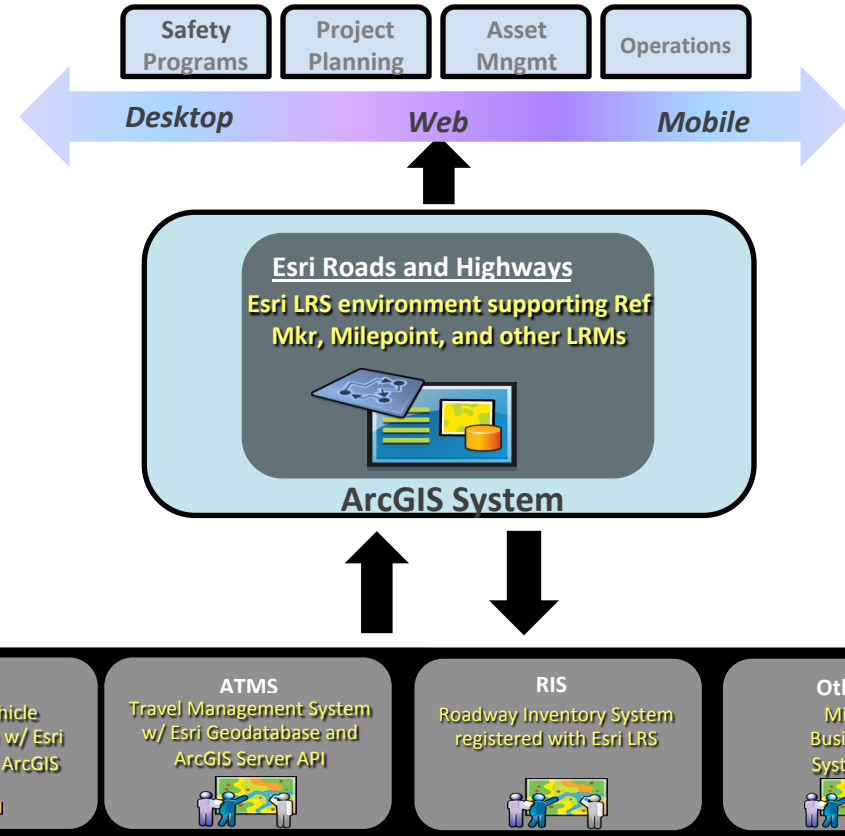
Make the NYSDOT Enterprise Asset Management System (AgileAssets) aware of updates to the Milepoint LRS and Roadway Inventory data that impact the agency's bridge and pavement programs.

Integrating Business Systems

Unified Linear Referencing Platform

Benefits

- Common, consistent location reference across all business systems
- Data can be consumed by different systems
- Integration simplified; consolidation of redundant data
- GIS can serve many systems and functions
- Expanded spatial and temporal capabilities across enterprise



NYSDOT's Enterprise Linear Referencing System

- Establishes a common representation of New York's highway system based on the NYS Streets layer
- Allows NYSDOT data owners to more easily maintain roadway information on the Milepoint LRM network
- Provides a common location reference for transportation business data
- Effectively integrates enterprise data for better decision making.
- Provides web based capabilities for roadway data maintenance and reporting that could eventually be extended to cooperating agencies.

Thank you!

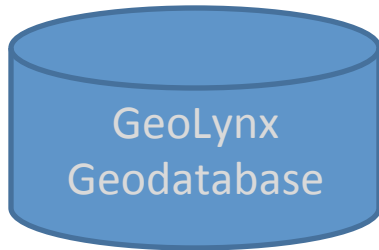
Kevin Hunt

Office of Information Technology Services

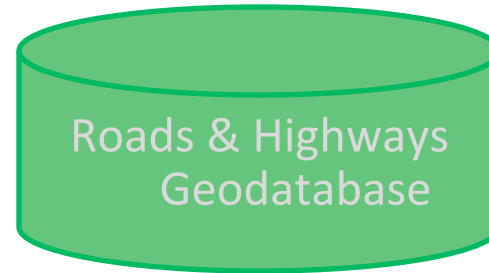
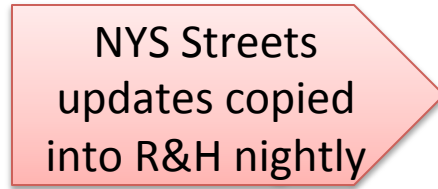
Revenue and Transportation Cluster

518-485-7152 | Kevin.Hunt@its.ny.gov

Maintaining a Single Highway Network



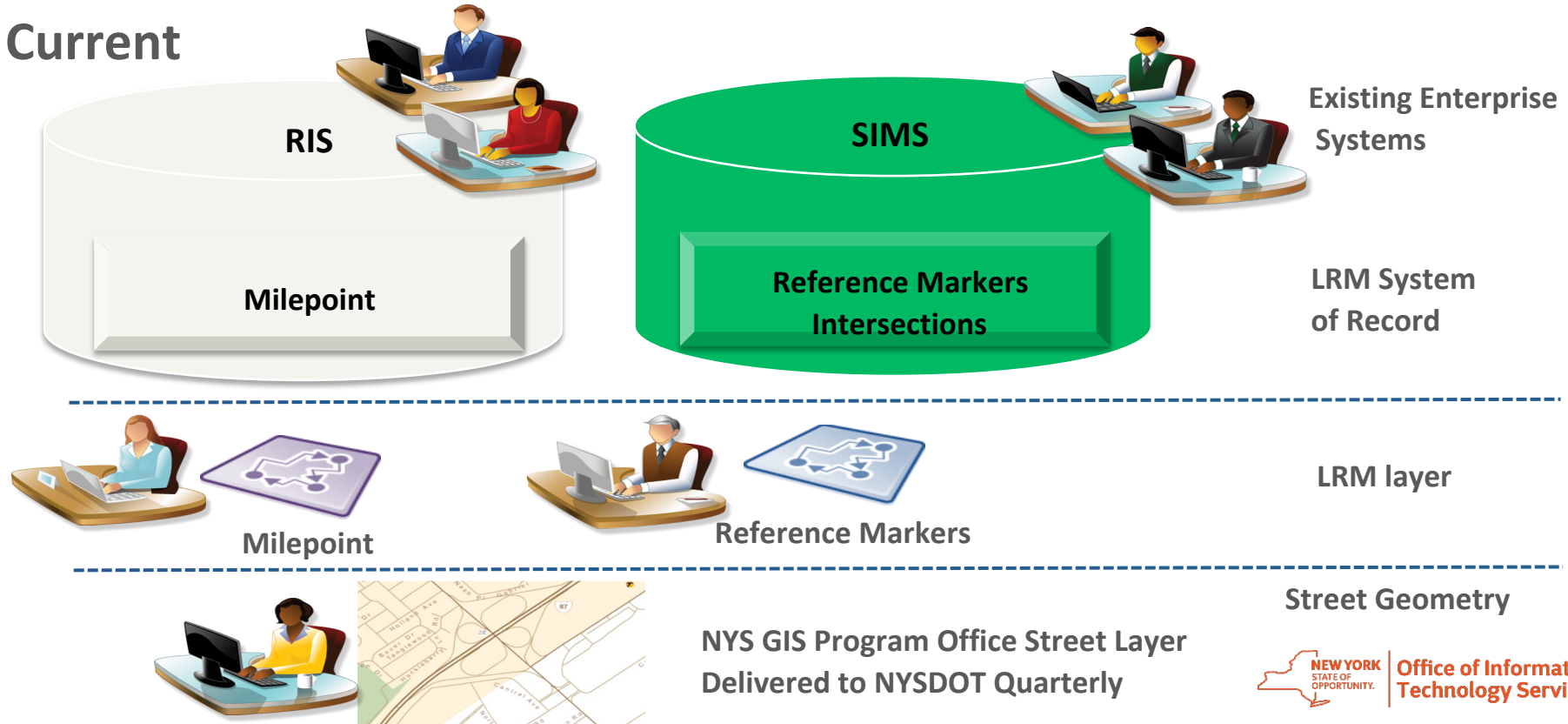
GIS Program Office,
NYSDOT, Municipalities
update NYS Streets using
GeoLynx system



NYSDOT Highway Data
Services updates the
Milepoint network based
on NYS Street updates

Consolidating maintenance of NYSDOT's LRMs

Current



Consolidating maintenance of NYSDOT's LRM

Esri Roads and Highways

...provide users with a GIS interface to maintain the system...



The Esri Roads and Highways Geodatabase becomes the System of Record for Linear Referencing Methods



Milepoint



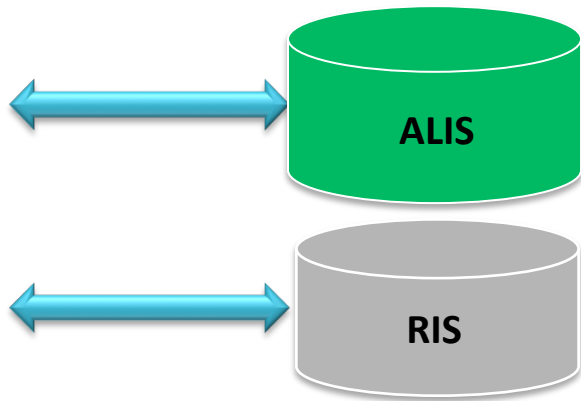
Reference Markers



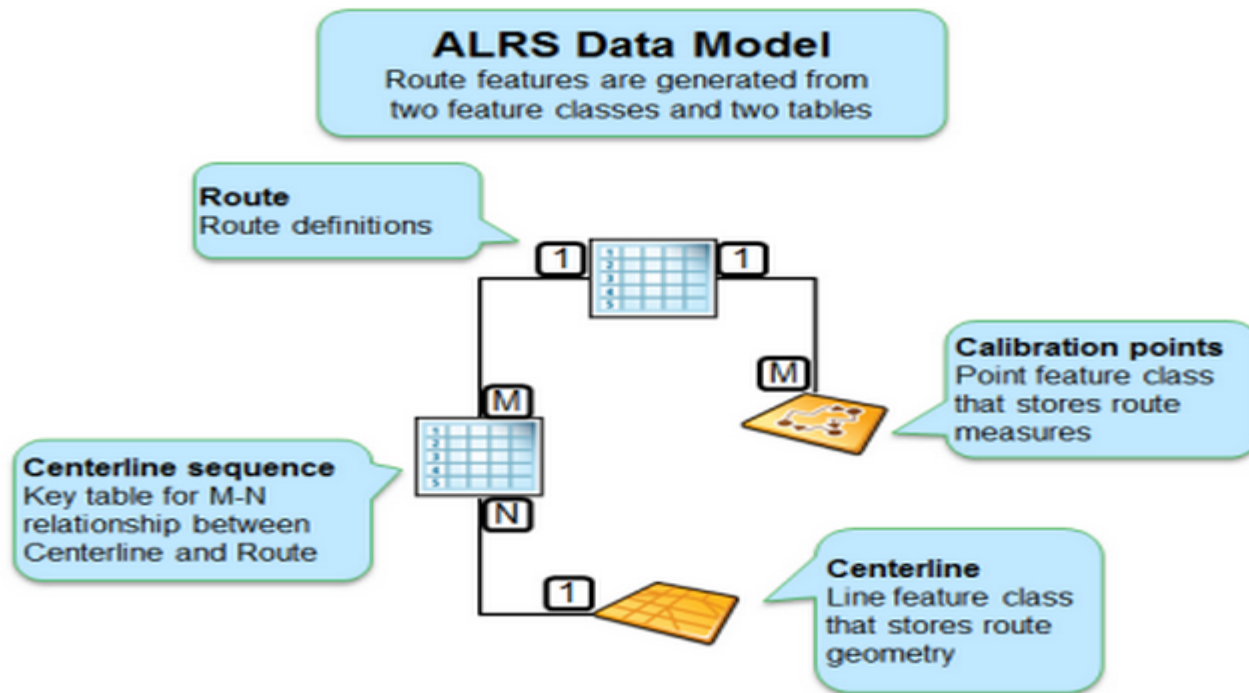
Interstate



...and keeps business systems aware of changes to the network.



The NYS Streets layer is the base geometry



....so NYSDOT's Milepoint system stays aligned

LRS web services

**Roads and Highways REST API provides external systems access to the LRS...
...and everything stored on it.**

- What is the Milepoint location at this coordinate x/y location?
- What is the traffic count and pavement condition at a given safety investigation location
- How do recent updates in the Milepoint network impact my external business (event) data?

Integrating the LRS with NYSDOT business systems

- Accident Location Information System (ALIS)
 - Automatically assign Milepoint locations to incoming accident records
 - Better support the Highway Safety Program
- Roadway Inventory System (RIS)
 - Report discrepancies between the GIS network and the Roadway Inventory
 - Provide RIS data to other business systems
- Enterprise Asset Management
 - Provide the Milepoint LRM network to the NYSDOT's AgileAssets enterprise asset management system for consistent asset location and analysis.