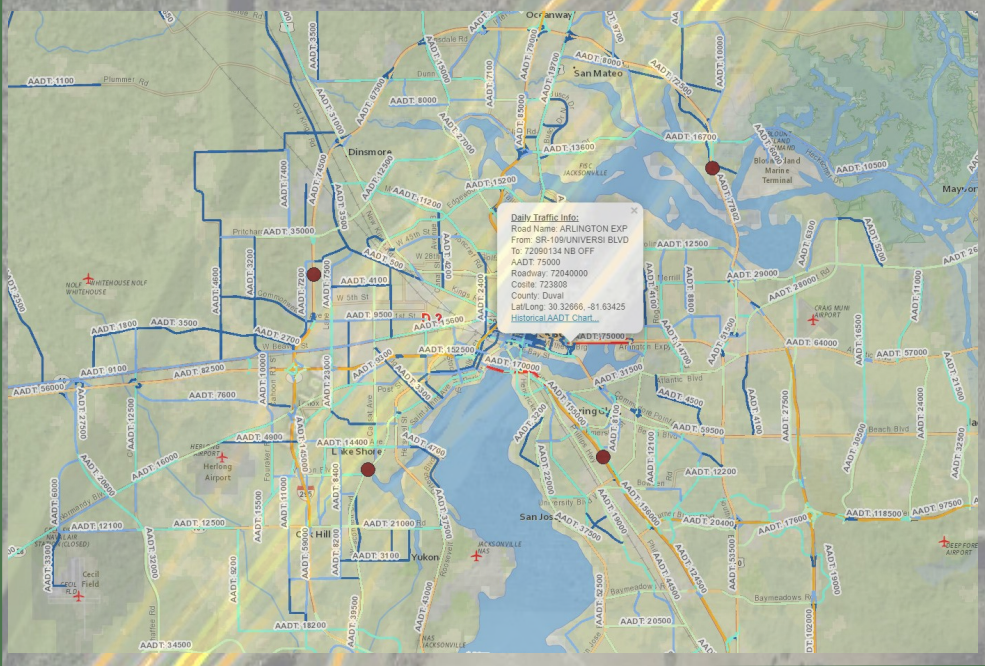
Transportation Data and Analytics Office

LRS HANDBOOK

Linear Referencing System



Published May 2020

Linear Referencing System (LRS)

Introduction to the Linear Referencing System

The FDOT Linear Referencing System (LRS) is an ESRI ArcGIS product with customized TDA GIS applications. The LRS is composed of arcs and routes that geographically represent specific roadways in the Roadway Characteristics Inventory (RCI). It is a method of spatial referencing by which the locations of physical features along a route are described in terms of a fixed point (milepoint) or line (thru lanes) along the route. The FDOT's LRS is projected in UTM17N.

The LRS routes are assigned an 8-digit roadway ID with each containing an Overall Status Field: Active On the State Highway System (02), Active Exclusive (07), Active Off the State Highway System (09), GIS Route (10), Active with Combination (12), Local Roads with FM Projects (16), and Active Off Exclusive (17).

Note: Roadway IDs with an Overall Status of 01-Pending or 05-Deleted are NOT in the LRS. Only existing roadways are incorporated into the database and displayed on official maps.

The LRS serves multiple purposes including:

- **Mandatory submittal to the Federal Highway Administration for annual HPMS reporting**
- Providing a Quality Assurance tool for RCI Feature lengths and alignment locations
- Dynamic segmentation – the creation of LRS data layers from RCI Features
- Creation of the State's city-to-city mileage matrix
- Data analysis, such as curve classification and compass bearing
- Map production

LRS Maintenance

The LRS Coordinator works with appropriate staff from the Central and District offices in order to make corrections to the LRS and to ensure that compatibility between the RCI and LRS roadway ID lengths and alignments are maintained.

Maintenance of the RCI/LRS is ongoing work that includes the following tasks:

- Adding new roadways
- Deleting roadways
- Lengthening or shortening existing roadway alignments
- Adjusting roadway alignments to aerial photography
- Verifying/adding exceptions (valid overlaps)
- Eliminating gaps
- Eliminating duplicate arcs and nodes
- Verifying valid dangling arcs
- Verifying/adding dual carriageways

The arcs in the LRS are digitized from data provided by the Districts in the form of shapefiles from GPSed alignments and/or maps compiled by the Districts. Each digitized arc in the LRS contains attributes indicating if the arc is a mainline, ramp, connector, or GIS route, If it is denoted as an LRS Connector, Dual Carriageway, or a GIS Route, then the arc is not included in the route information. LRS connectors are arcs that connect routes to other routes and are commonly used to connect a ramp to a mainline in order to provide connectivity of the roadways. They are also used when calculating the City to City Mileage. There are both dual carriageways and GIS routes in the LRS, however, they are created on a case-by-case basis and should not carry any data. All of the interstates, for example, have both dual carriageway routes and GIS routes in the LRS.

RCI/LRS Reconciliation Process

Each route in the LRS is composed of underlying arc(s) that transfer information to the route including a field for the LRS digitized length in miles, RTLENGTH. This value is compared with the RCI length as a part of the RCI/LRS Reconciliation Process.

The LRS Coordinator is responsible for providing monthly reports identifying those roadway IDs which have alignment lengths in the LRS that do not match the RCI lengths within the discrepancy selection criteria. The results of these reports determine which roadway IDs should then be addressed by the Districts through RCI/LRS Package submittals which detail the steps taken to correct the discrepancies.

The monthly discrepancy reports are located at: https://fmw.state.fl.us:8890/apps/gis/welcome. Discrepancies found by using the formula described in Discrepancy Selection Criteria are reported using the aggregate number of roadway IDs by District and County. Each aggregate number of County roadway IDs is separated by type of discrepancy and Overall Status and totaled for each County and District. A sample is shown below.

RCI/GIS Basemap Discrepancy SUMMARY 04/2020

Districts/Counties with Zero(0) Discrepancies have been removed

January 2005 began utilizing revised criteria

	Difference >=.10 mi OF RCI LENGTH				Difference >=05% OF RCI LENGTH				Missing Listed BY RCI Status				
District County Name	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**Total**
1-13-MANATEE	0	0	0	1	0	0	0	0	0	0	0	0	**1**
1-16-POLK	0	0	0	1	0	0	0	0	0	0	0	0	**1**
1-17-SARASOTA	0	0	0	0	0	0	0	0	0	0	0	1	**1**
1-District Total	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**3**

	Difference >=.10 mi OF RCI LENGTH				Difference >= 05% OF RCI LENGTH				Missing Listed BY RCI Status				
District County Name	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**Total**
5-11-LAKE	0	1	0	0	0	0	0	0	0	0	0	0	**1**
5-36-MARION	0	1	0	0	0	0	0	0	0	0	0	0	**1**
5-District Total	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**

	Difference >=.10 mi OF RCI LENGTH				Difference >= 05% OF RCI LENGTH				Missing Listed BY RCI Status				
District County Name	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**Total**
6-87-MIAMI-DADE	0	0	0	0	0	0	1	0	0	0	0	0	**1**
6-District Total	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**

	Difference >=.10 mi OF RCI LENGTH				Difference >= 05% OF RCI LENGTH				Missing Listed BY RCI Status				
District County Name	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**[02]**	**[12]**	**[07]**	**[09,16,17]**	**Total**
Statewide Total	**0**	**2**	**0**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**6**

District RCI/GIS Basemap Detail Report

At the bottom of the LRS Discrepancy Report, a link (District RCI/LRS Detail Report) is provided to each District's Detail Report (sample below). This listing is used to identify individual roadway IDs, their discrepancy type, whether they are excluded and any brief comments which might be of use. The roadway IDs are grouped by County and are in ascending order.

RCI/GIS Basemap Detail Report for District: 1 For Period 04/2020

CNTY	SECTION	RDST	BGN	END	BM_LNGH	DIFF	ERR	IND	EXC	COMMENTS
03	03000524	12	0.000	6.700	4.057	2.643	.10	N	E	part Pending 9/14/15-3/6/2019
END COLLIER										
CNTY	SECTION	RDST	BGN	END	BM_LNGH	DIFF	ERR	IND	EXC	COMMENTS
12	12000050	12	0.000	3.000	1.392	1.608	.10	N	E	10/14/2019
END LEE										
CNTY	SECTION	RDST	BGN	END	BM_LNGH	DIFF	ERR	IND	EXC	COMMENTS
13	13000140	09	0.000	3.108	3.348	0.240	.10	N		
END MANATEE										
CNTY	SECTION	RDST	BGN	END	BM_LNGH	DIFF	ERR	IND	EXC	COMMENTS
16	16160500	09	0.000	1.088	1.935	0.847	.10	N		
16	16390000	12	0.000	7.000	2.058	4.942	.10	N	E	part Pending 3/3/14
16	16900003	16	0.000	0.200			MIS	N	E	bridge off road FM 11/9/2016
END POLK										
CNTY	SECTION	RDST	BGN	END	BM_LNGH	DIFF	ERR	IND	EXC	COMMENTS
17	17900002	16	0.000	0.100			MIS	N		Pkg needed-see notes KP-469-7/10/19
END SARASOTA										
CNTY	SECTION	RDST	BGN	END	BM_LNGH	DIFF	ERR	IND	EXC	COMMENTS

Discrepancy Selection Criteria

The acceptable deviation (as of 9/20/2006) between the LRS and RCI mileage lengths for each roadway ID should be less than 0.100 mile, less than 5% of the RCI gross length value, ignoring any that are less than 0.009 miles. Additionally, if the deviation is greater than 0.100 mile and less than 1.00% of RCI, such a route will be removed from both the Summary Report and the Detailed Listing Report (unless the discrepancy can be resolved). If an alignment has a valid roadway ID number in RCI and is missing from the LRS, it is automatically placed in the selection criteria list. Not considered are roadway IDs with RDSTATUS of 01, 04, 05, or 10.

Exclusion Status of Sections

Within the Detailed Listing Report, there is a column with a header of 'EXC', denoting 'excluded from the Summary Report.' If any roadway ID has an entry of 'E' in this column, it means that it is not included in the Summary Report for that County/District until such time that it is excluded status is rescinded. The result of being categorized as 'excluded' is that the District is not held accountable grade-wise for that roadway ID until the data in the 'COMMENTS' column are cleared up. Exclusions must be reapproved at least once every six months in order to maintain an excluded status. Attaining an 'excluded' status is based upon mutually agreed factors between the Districts and the LRS Coordinator. The most commonly used but not exclusive factors are:

- Unavailability of newer aerials
- Inability to field inventory due to construction
- Inability to research or gather spatial reference
- Inability to resolve the factors causing the discrepancy by CO or District involved

Delivered Data File Format and Other Specifications

GPS or other field data shall be collected so as to capture the center of the roadbed as defined by the outside edge of pavement to the outside edge of pavement of the through lanes. For some field situations, the GPS user may need to consider using an offset to capture the center of the roadbed.

For the purpose of reference/inclusion in the FDOT LRS, collected data should be provided in shapefile format in UTM 17N projection. A map in pdf format is also sufficient in most cases.

RCI/LRS PACKAGE PROCESS

Introduction to the RCI/LRS Package Process

The RCI/LRS Package Process was developed by the Transportation Data and Analytics Office (TDA) to aid the Districts in recording all revisions, updates, and modifications to roads in RCI and the LRS. This process facilitates the requirement that Districts send revisions to TDA through the MyFloridaLRS application so that changes can be tracked and completed in a timely manner.

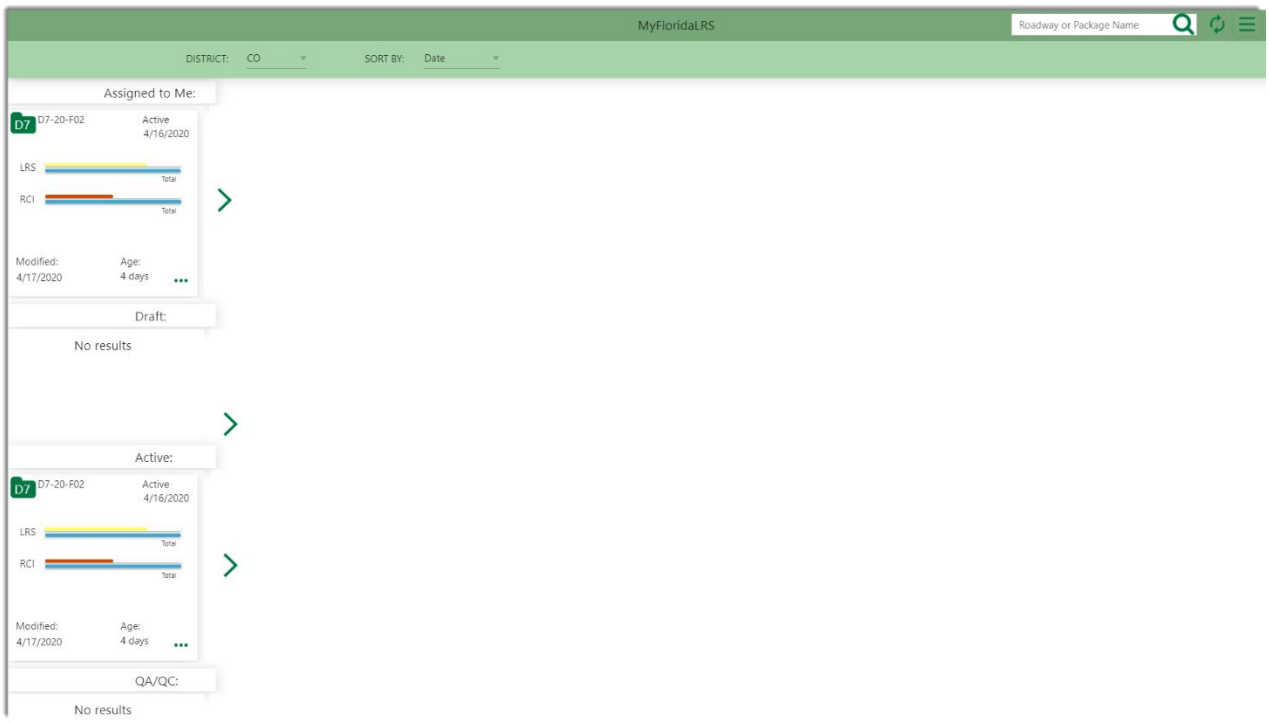
RCI changes that require an RCI/LRS Package include:

- Adding a new Roadway ID
- Deleting a Roadway ID
- Inactivating a Roadway ID
- Lengthening or shortening a Roadway ID
- Changing an Overall Status, Governmental Jurisdiction or any other information field on the RCI View/Update/Delete (V/U/D) screen **with the exception of Overall Description and General Compass Direction.**

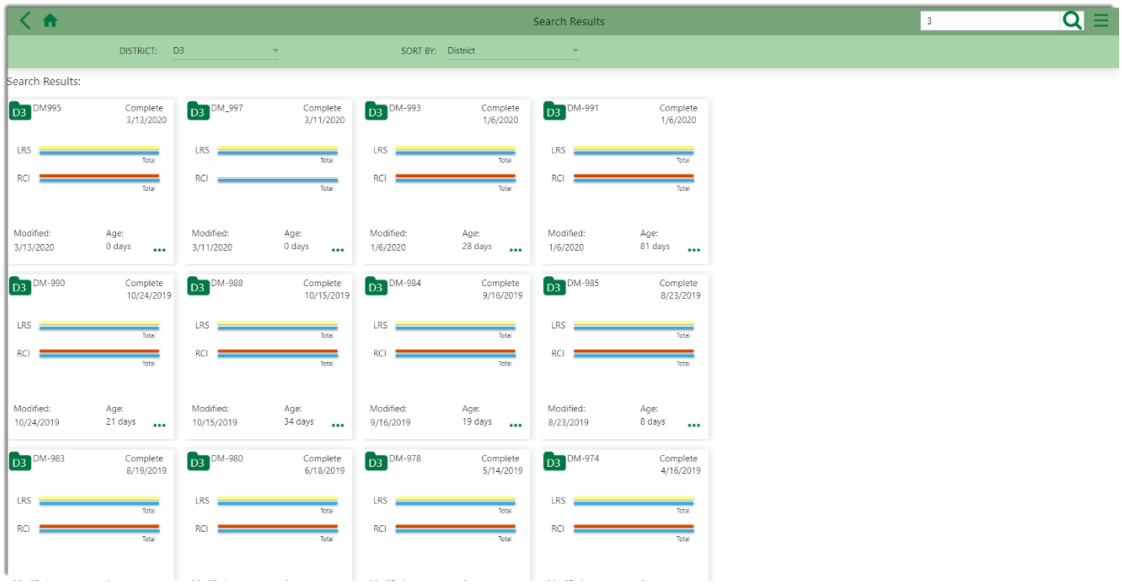
MyFloridaLRS Application

The MyFloridaLRS application was developed to both assist the Districts with RCI/LRS package submittal and to allow more transparency to the Districts in order to track where the package currently is in the process. The MyFloridaLRS application can be found at the link below:

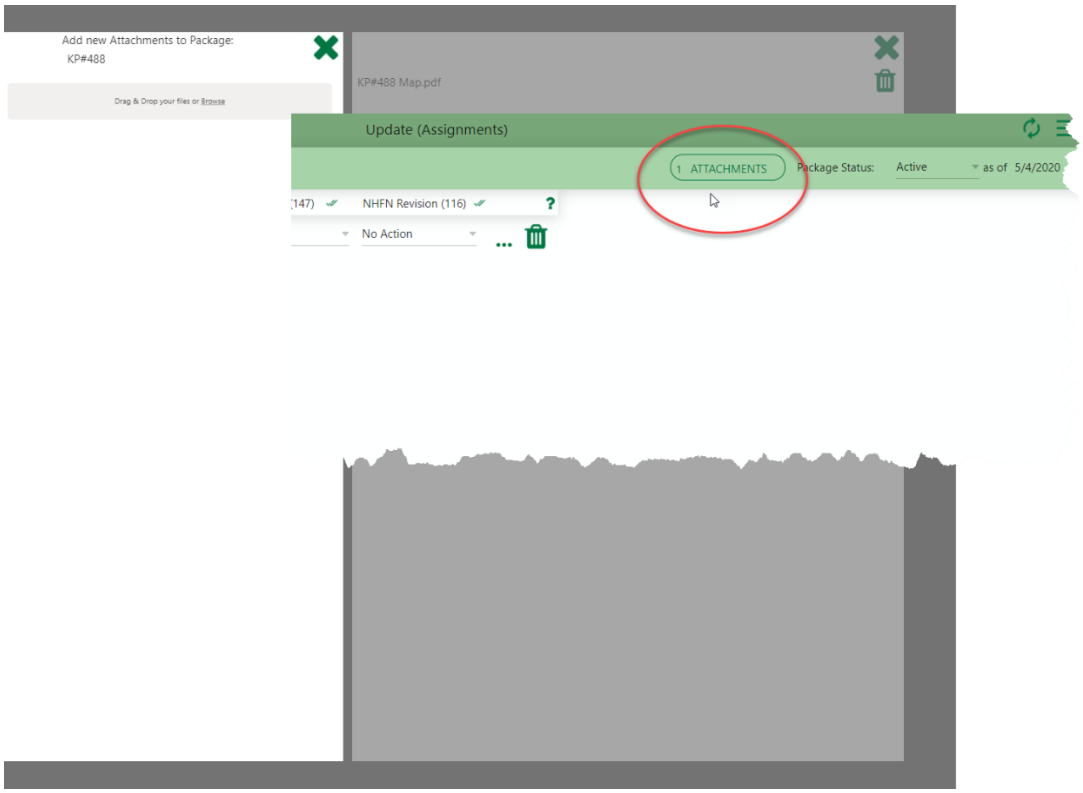
https://tdaappsprod.dot.state.fl.us/prv/myfllrs/ **(Opens in Google Chrome)**



The Search function allows the user to search by a roadway, package number, or District:

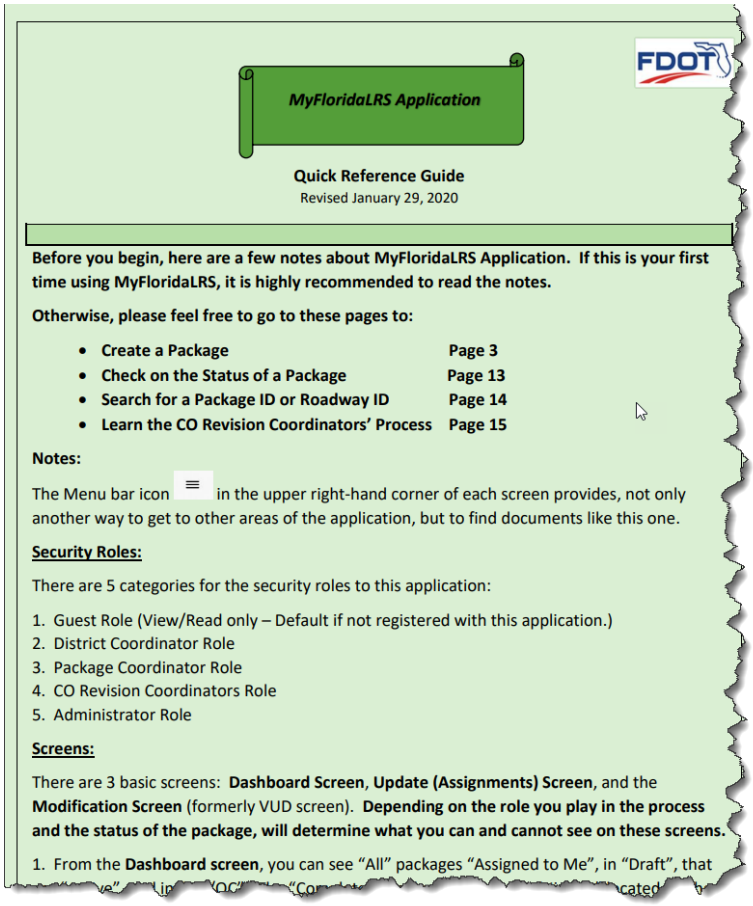


The attachments link allows the user to upload documents in multiple formats for use in processing the package. These formats include .pdf, .docx and .shp (in UTM17N).



The Quick Reference Guide walks the user through all of the package process steps and can be accessed from the link below:

https://tdaappsprod.dot.state.fl.us/prv/myfllrs_attachments/MyFloridaLRS_QuickRefGuide.pdf **(Opens in Google Chrome)**



MyFloridaLRS Application

Quick Reference Guide
Revised January 29, 2020

Before you begin, here are a few notes about MyFloridaLRS Application. If this is your first time using MyFloridaLRS, it is highly recommended to read the notes.

Otherwise, please feel free to go to these pages to:

- **Create a Package** **Page 3**
- **Check on the Status of a Package** **Page 13**
- **Search for a Package ID or Roadway ID** **Page 14**
- **Learn the CO Revision Coordinators' Process** **Page 15**

Notes:

The Menu bar icon ≡ in the upper right-hand corner of each screen provides, not only another way to get to other areas of the application, but to find documents like this one.

Security Roles:

There are 5 categories for the security roles to this application:

1. Guest Role (View/Read only – Default if not registered with this application.)
2. District Coordinator Role
3. Package Coordinator Role
4. CO Revision Coordinators Role
5. Administrator Role

Screens:

There are 3 basic screens: **Dashboard Screen**, **Update (Assignments) Screen**, and the **Modification Screen** (formerly VUD screen). **Depending on the role you play in the process and the status of the package, will determine what you can and cannot see on these screens.**

1. From the **Dashboard screen**, you can see "All" packages "Assigned to Me", in "Draft", that

All questions regarding the MyFloridaLRS Application should be directed to: CO-MYFLLRS@dot.state.fl.us

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RCI/LRS Package Checklist

An RCI/LRS Correction Checklist has been assembled for District use to aid in putting together package requirements before final submittal to the TDA Office. This checklist ensures that each District sends packages with the essential information required by TDA to effectively make the necessary revisions t0 both RCI and the LRS.

Note* Please limit the number of roadways to 15 per package submittal in order to process in a timely manner.

☐ Always review the LRS first before submitting GIS roadway updates to TDA.

☐ Make sure all information is complete on the Modification screen when creating a new Roadway ID.

☐ Make sure that the Proposed side is filled out on the Modification screen when modifying an existing roadway.

☐ Include additional instructions, if necessary, in the comment fields on the Modification screen.

☐ Feature 112 has been reviewed and appropriate paperwork for road transfers or add/deletion of SHS mileage is included

☐ All Features have been shortened in RCI before submitting to Central Office.

If necessary, run a Propose New Roadway Section Boundaries report in RCI to verify that all Features have been shortened before requesting a length change. Also, remember the net length is automatically adjusted in RCI once the gross length and Feature 140 have been corrected.

☐ All spatial data should be in UTM17N, if no data files are needed, a location map is sufficient

☐ Features 140 and 141 have been reviewed and addressed for exceptions on roadways to be updated in the RCI/LRS.

☐ District Maintenance and Central Safety Office have been notified of RCI data updates/ deletions to Features 251, 326, 330 and 331

☐ Include updates, creation, or deletion to Feature 147-Strategic Intermodal Systems

OTHER LRS/RCI DATA RESOURCES AND TOOLS

A number of other GIS programs and associated products are used with RCI. These programs add functionality to the use of RCI and its output. Guidance for the use of these programs is presented in detail in various user guides and instruction manuals, but they are described briefly here. The products include:

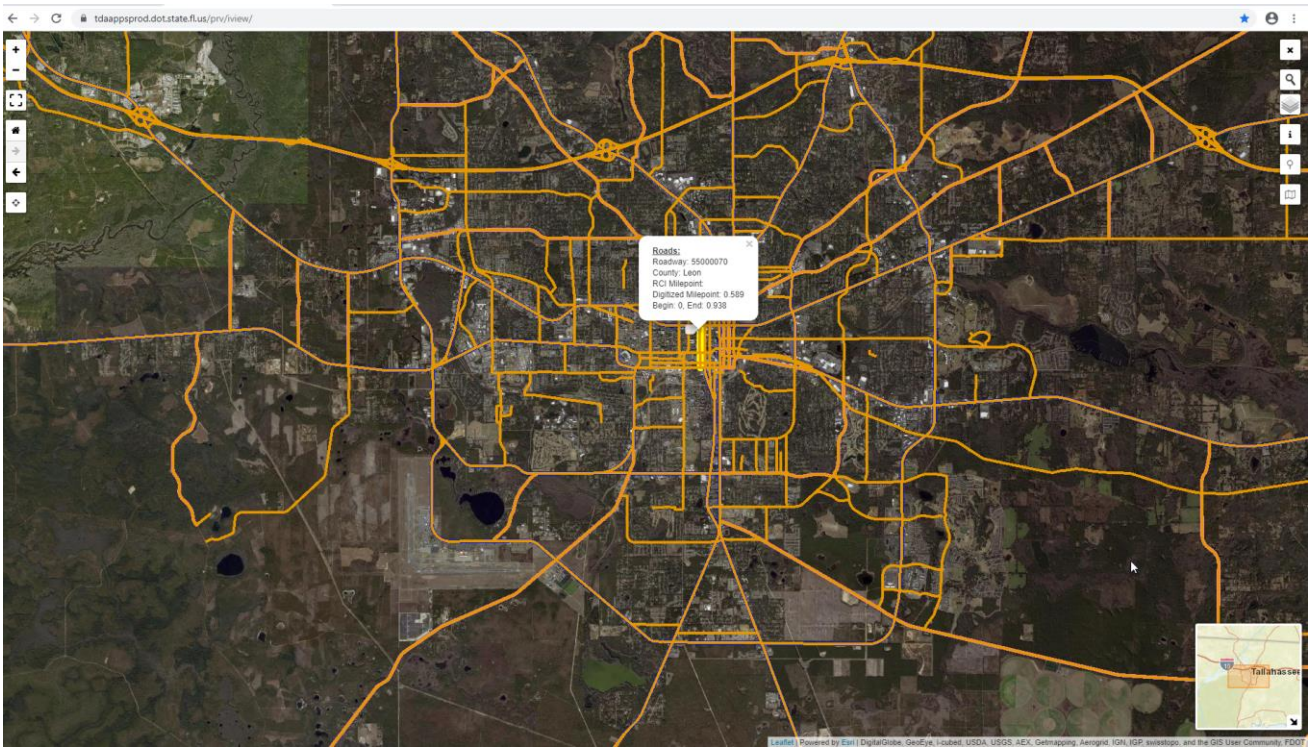
- IView
- Florida Traffic Online
- Data Download Tool
- Data Library Tool for ArcMap
- GIS Application Manager for ArcMap
- Compass Direction Extension for ArcMap
- Curvature Extension for ArcMap
- Intersection Direction Tools for ArcMap

For additional information please visit the website: https://www.fdot.gov/statistics/gis/default.shtm

IView

IView is a map-based web application designed to provide linear referencing functionality to support agency data collection and verification. It contains the 3 official agency Linear Referencing Systems (LRS) (LRS routes, rail, and SUNTrail). Identify milepoint and zoom to milepoint tools facilitate identifying and verifying milepoint locations along an LRS. In addition, a user can select and label a number of Roadway Characteristics Inventory (RCI) layers as well as choose from a variety of background basemaps provided by Esri. These background layers include imagery.

The site can be accessed here: https://tdaappsprod.dot.state.fl.us/prv/iview/

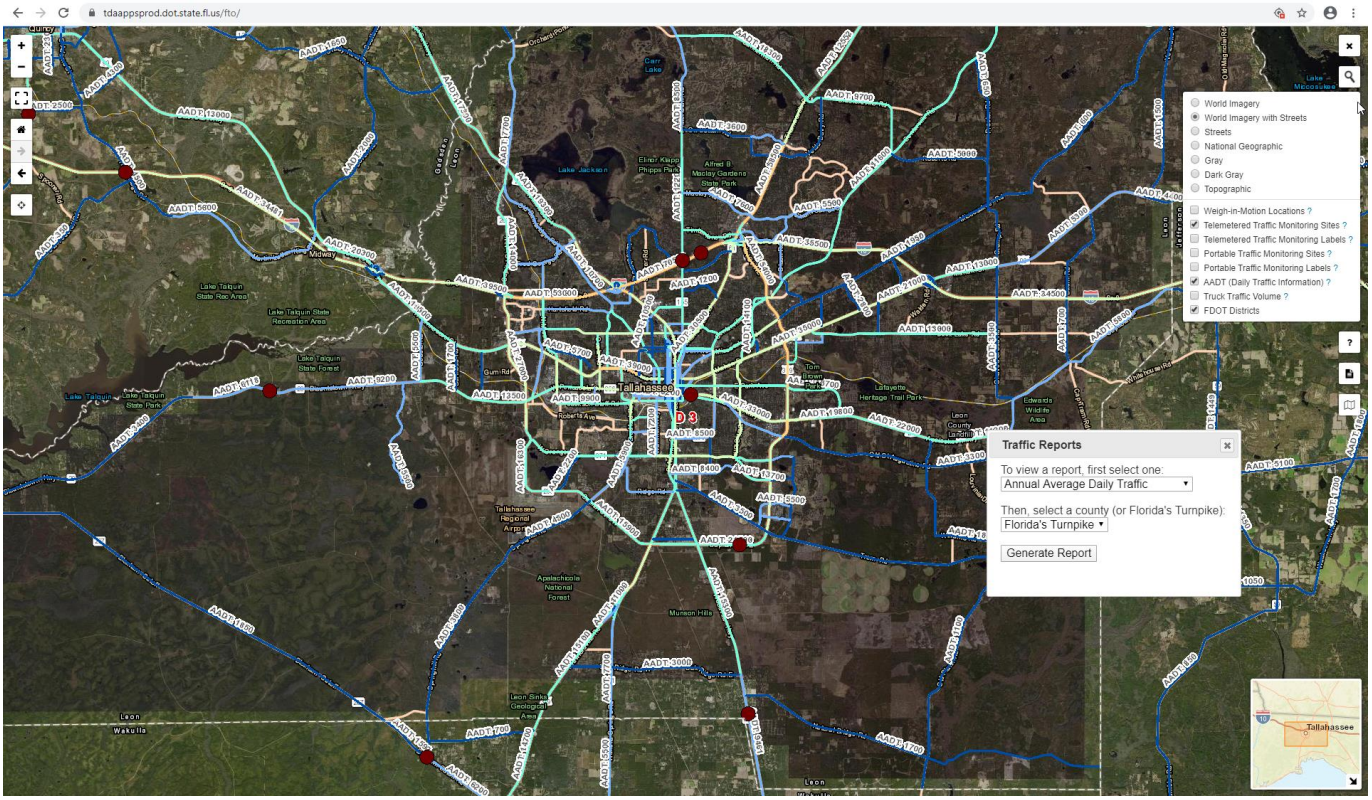


Florida Traffic Online

The Florida Traffic Online site is used to access Florida traffic information over the internet. Traffic information accessed through the site is released annually while other transportation data, such as the road networks displayed on the site, are updated monthly. The following traffic information is provided by the site:

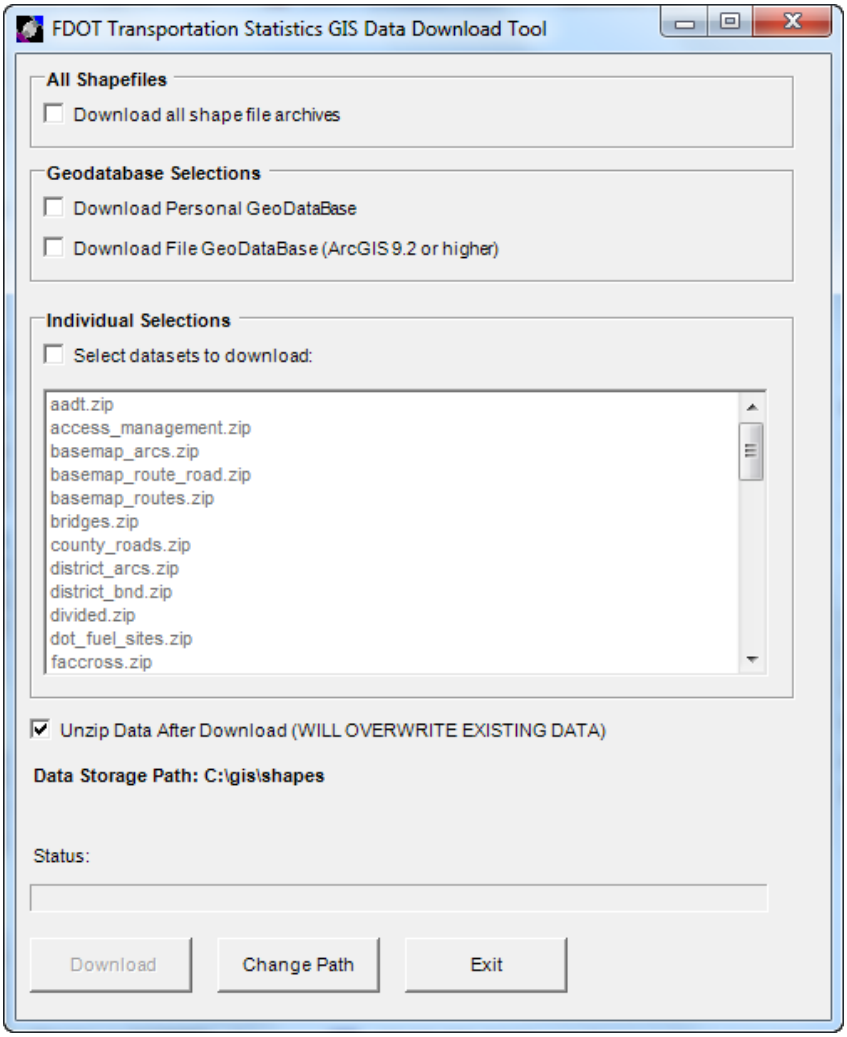
- Annual Average Daily Traffic (AADT) - the total volume of traffic on a highway segment for one year, divided by the number of days in the year.
- Truck Volume - The total volume of truck traffic on a highway segment for one year. This number is determined as a percentage of AADT.
- Portable Traffic Monitoring Sites (PTMS) - A traffic monitoring site that has loops and/or axle sensors in the roadway with leads running back into a cabinet located on the shoulder.
- Telemetered Traffic Monitoring Sites (TTMS) - A continuous traffic monitoring site that transmits traffic data to the TDA Office via telephone or wireless communications.

The FTO site can be accessed here: https://tdaappsprod.dot.state.fl.us/fto/ (Opens in Google Chrome)



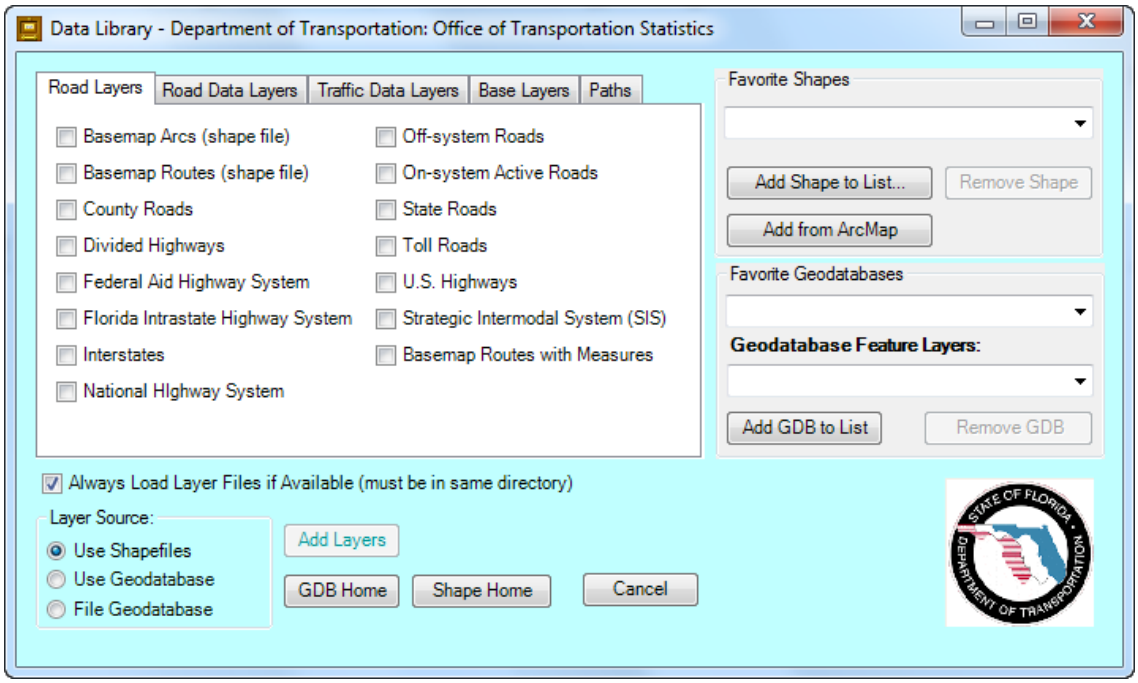
Data Download Tool

The Data Download Tool is used to automate the acquisition of TDA GIS datasets. It will automatically download and unzip the TDA GIS data to a local or network folder. The Data Library Tool can also be pointed to this location, ensuring that the most recent GIS datasets are used in all map documents.



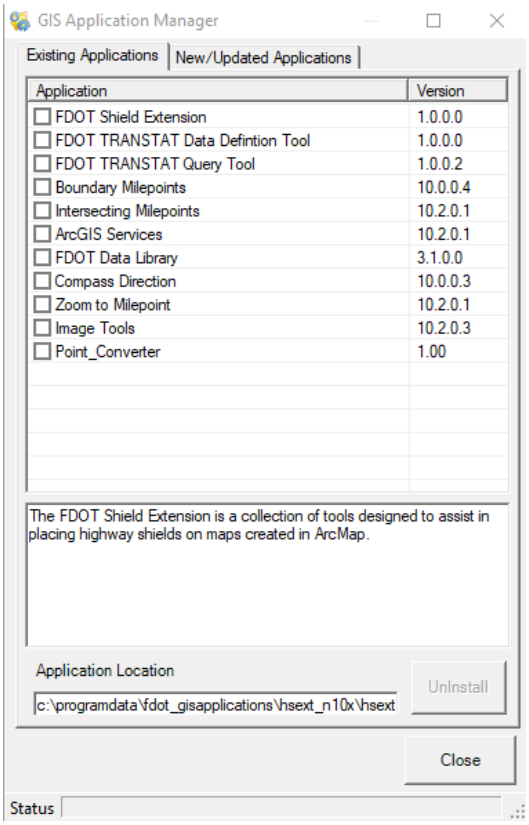
Data Library Tool for ArcMap

The Data Library Tool for ArcMap is reached through a button on the ArcMap interface that opens a form listing many of the available GIS vector layers. This makes it very easy to access and add data to an ArcMap document.



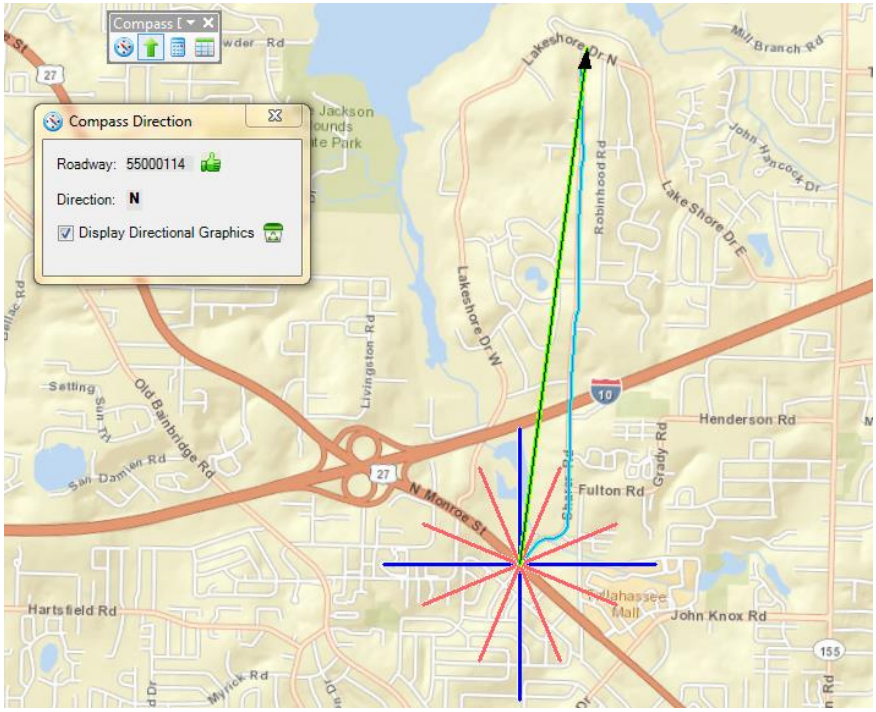
GIS Application Manager

The GIS Application Manager is used to easily install, uninstall, and update the various GIS customizations provided by the Transportation Data and Analytics Office. It consists of a desktop application used for the installation of the GIS customizations, as well as an ArcMap extension used to alert users about new or updated applications.



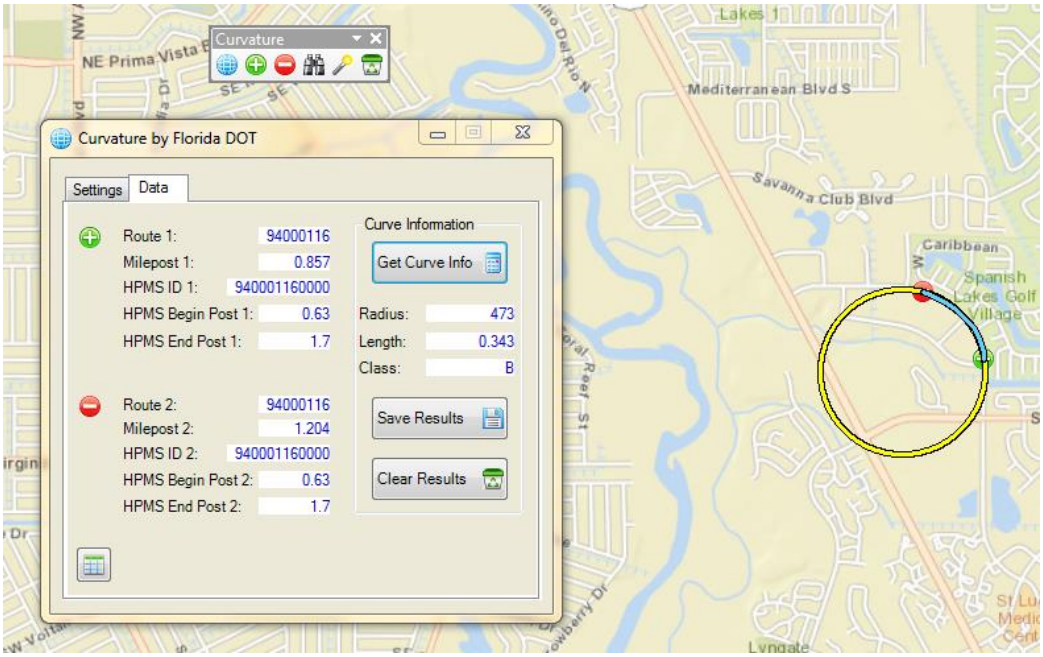
Compass Direction Extension for ArcMap

The Compass Direction Extension can be used to quickly and easily derive the compass direction for any roadway ID in the TDA LRS (basemap_route_road.shp).



Curvature Extension for ArcMap

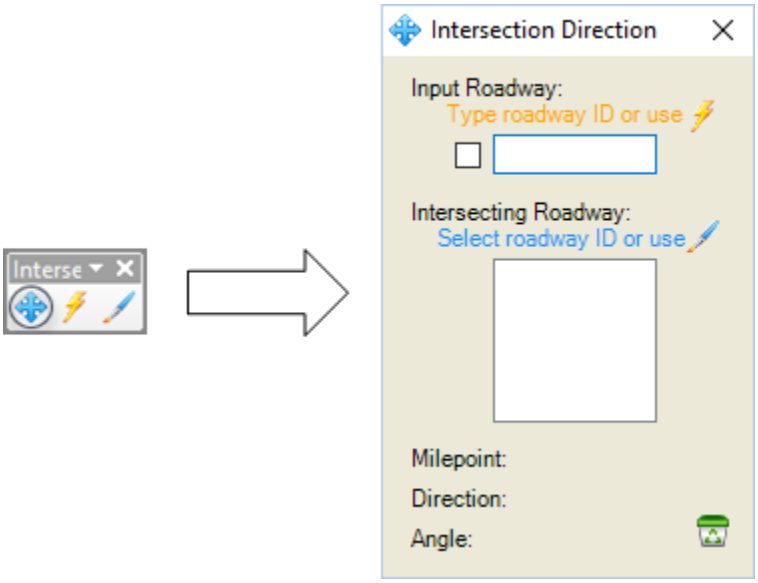
The Curvature Extension for ArcMap provides custom functionality to measure and classify curves within a GIS-based route system (e.g. feature class/shape file with or without measures). Curves are measured based on user input of the start and end points of the curve. The classification of the curve (A - F) is derived automatically by the application, eliminating any guesswork as to which classification a curve belongs to. The Curvature Extension was originally intended to be used to measure and classify curves along HPMS samples, and it will accomplish this. However, it can also be useful for classifying curves outside of the world of HPMS, and was written with this in mind.



Intersection Direction Tools

For any given roadway, the Intersection Direction Tools derive the angle of an intersecting roadway and identify the corresponding intersection code. This code is based on the angle and the side of the roadway that the intersecting road comes from. The milepoint of the intersection is also derived.

This information is used in support of Intersections - Feature 251, characteristic INTSDIRx (with "x" being the intersection code) in RCI.



All Roads Network of Linear Referenced Data (ARNOLD)

OVERVIEW OF ARNOLD DATASET

In 2012, The Federal Highway Administration (FHWA) expanded the Highway Performance Monitoring System's (HPMS) reporting requirements for State Departments of Transportation to submit a Linear Reference System (LRS) that includes all public roads. This requirement is known as the "All Roads Network of Linear Referenced Data" (ARNOLD), where all state DOTs are responsible for maintaining a geospatial dataset and associated attributes on all roads open to public travel. This dataset includes road centerline geometry, basic road attributes, address ranges, LRS control, and network topology (Table 1). The following sections give a brief overview of each task associated with the creation and submission of the ARNOLD dataset to FHWA as part of the yearly HPMS submission. Detailed workflows for each task are documented separately and can be requested from the staff member who oversees the creation of the ARNOLD dataset.

Network Requirements

Road Centerline Geometry	Road Centerline Attributes	Street Addresses	Linear Reference Control	Network/Linear Topology
• All Public and Private Roads • Frontage Roads • Ramps • Traffic Circles • Dual Carriageway • Update Cycle: certified annually • 1:5,000 scale • WGS 84 Coordinates	• Persistent Road ID number • Road/Street Name • Functional Class • Year • State (FL)	• Right side/Left side Address ranges	• Linear precision: 0.001 miles • Centerline Mileage Begin/End accuracy: 0.001 miles	• Common topology for road network models

Table 1 Florida Highway Administration Network Requirements for ARNOLD

FDOT maintains a linear reference system (LRS) that is driven by the Roadway Characteristic Inventory (RCI). The FDOT LRS is composed of arcs and routes that geographically represent specific roadways in RCI. FDOT would like to maintain their current LRS and RCI datasets while also supporting the ARNOLD. The ARNOLD network is compiled from two primary sources: FDOT's Linear Referencing System (LRS) and Census TIGER files. The TIGER data are used primarily for local roads. Secondary geospatial datasets, such as Parcel data, Florida Land Managed Areas, aerial imagery, etc. are used to complete and/or verify attributes and geometry (Table 2).

ARNOLD DATA CREATION AND PROCESS OVERVIEW

The following tasks are implemented in the creation of the ARNOLD dataset. Yearly updates repeat these tasks with minor variations. Information on detailed workflows can be provided upon request.

- *Task 1: Remove all overlaps from the TIGER dataset*
- *Task 2: Flag line segments in the TIGER dataset that are already represented in the RCI LRS/Arcs Dataset*
- *Task 3: Format Road Names to USPS Standards*
- *Task 4: HPMS Attribution of local Roads (adding attributes values represented in Table 2):* HPMS fields are added and computed for the local roads dataset: YEAR_RECORD, F_SYSTEM, SOURCE_AGENCY, FACILITY_TYPE, OWNERSHIP, and STATE CODE.
- *Task 5: Creating Unique Roadway IDs* -- Local routes were assigned new IDs according to the following format: the first two digits are the county code, followed by 'L', and then followed by the street name. Functionally continuous road segments that were within the same county and shared a street name were assigned the same Route ID. Additionally, since Route IDs must be unique for roadways that are not contiguous but have the same street name, a number was assigned at the end of the route ID to distinguish it from other roadways of the same name (01_L_Main St_1 vs. 01_L Main St_2).
- *Task 6: Creating, QAQCing, Enhancing Local Roads Topology*

- *Task 7: Preparing Non-Routed RCI Arcs not included in RCI LRS (Dual Alignments, Connectors, Ramps)*
- *Task 8: Create Routes and QAQC for M-Value and Topology Errors*
- *Task 9: Prepare ARNOLD dataset for HPMS submittal* -- The final ARNOLD dataset is exported to a shapefile format and the attribute table is exported as a CSV. These datasets are sent to the HPMS coordinator on April 15 of each year who then uploads them and checks for errors or inconsistencies using the HPMS upload software.

Required ARNOLD Fields	Description
Route_ID	Route identifier (up to 120 alphanumeric characters). Must be unique within the state.
Road Name	Road name
Functional Classification	FHWA-approved functional class
Ownership	Administrative Ownership
Facility Type	Operational characteristic of the roadway
State Code	2-digit FIPS code for Florida
Year_Record	The year (4 digits) that the data represents
Source	Source agency providing the data
Geometry	Linework (shape, PolylineM) with LRS measures

Table 2 ARNOLD data model with FHWA Required Attributes

INTEGRATING YEARLY US CENSUS TIGER DATA AND RCI LRS UPDATES

ARNOLD updates are conducted once a year when the newest release of TIGER data is published by the US Census. Raw TIGER datasets (e.g. 2016 vs 2017) are compared against each other to identify new/updated TIGER features. After these features are identified a series of automated steps are taken to attribute and topologically connect and replace these features into the previous year's local dataset. All of the tasks summarized above are utilized to incorporate the updated TIGER features. Additionally, any changes to the RCI LRS are incorporated into the ARNOLD dataset after the snapshot is taken at the end of the year (December 31) for the HPMS submittal.

ARNOLD UPDATE SCHEDULE

- **Fall of each year:** The US Census releases an updated version of TIGER data. Release dates are not consistent and have occurred between the months of August and October.
- **December 31 of each year:** A snapshot of the RCI Arcs and LRS is taken for the HPMS submittal and to incorporate yearly RCI updates into the ARNOLD dataset.
- **April 15 of each year:** Submit the updated ARNOLD dataset to the HPMS coordinator for review and final submission.
- **June 15 of each year:** Final HPMS submission to FHWA is due.