CHAPTER 6

LINEAR REFERENCING SYSTEM

FDOT

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CHAPTER 6. LINEAR REFERENCING SYSTEM

6

This chapter provides an overview of Florida Department of Transportation (FDOT)'s Linear Reference System (LRS), an ESRI ArcGIS data model, augmented with Transportation Data and Analytics (TDA) GIS customizations. To aid the Districts in recording all revisions, updates, and modifications to roads in Roadway Characteristics Inventory (RCI) and the LRS, the TDA Office developed the MyFloridaLRS Package Process (RCI/LRS Package Process). This chapter describes the MyFloridaLRS Package Process in detail to help Districts send revisions to the TDA Office through the MyFloridaLRS application, which will allow the office to track and complete changes in a timely manner. Additionally, this chapter provides an overview of the GIS programs and associated products used with RCI.

This chapter also provides an overview of Federal Highway Administration (FHWA)'s Highway Performance Monitoring System's (HPMS) reporting requirements to submit an LRS that includes all public roads. This requirement is known as the "All Roads Network of Linear Referenced Data" (ARNOLD), where all state departments of transportation are responsible for maintaining a geospatial dataset and its associated attributes on all roads open to public travel.

6.1 Linear Referencing System

The FDOT's LRS is composed of arcs and routes that geographically represent specific roadways in the RCI. The LRS is a method of spatial referencing that describes the location of physical features along a route in terms of a fixed point (begin point, end point) or line (through lanes) along the route. The FDOT's LRS is projected in UTM 17N NAD 83.

FDOT assigns the LRS routes an eight-character roadway ID; each route contains 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). Roadway IDs with an Overall Status of Pending (01), Inactive (04) or Deleted (05) are not in the LRS. The official FDOT maps only display existing roadways in the database that are open to traffic.

The LRS serves multiple purposes:

- Be used for the Department's mandatory submittal to the FHWA for annual HPMS reporting.
- Provide a quality assurance tool for RCI Feature lengths and alignment locations.
- Produce dynamic segmentation—LRS data layers from RCI Features.
- Create the state's city-to-city mileage matrix.
- Perform data analysis, such as compass bearing.
- Produce maps.

6.1.1 LRS Maintenance

The TDA LRS Coordinator works with appropriate staff from the Central and District offices to make additions, corrections, or deletions to the LRS, ensuring compatibility between the RCI and LRS roadway ID lengths and maintaining alignments.

RCI/LRS maintenance includes the following tasks:

- Add new roadway alignments.
- Delete roadway alignments.
- Lengthen or shorten existing roadway alignments.
- Modify roadway alignments to aerial photography.
- Verify and add exceptions (validate overlaps).
- Eliminate gaps.
- Eliminate duplicate arcs and nodes.
- Verify valid dangling arcs.

- Verify/add dual carriageways.

Each digitized arc in the LRS contains attributes indicating if the arc is a mainline, ramp, connector, or dual carriageway. If it is denoted as an LRS connector 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 network. They are also used when calculating the city-to-city mileage matrix.

Dual carriageways and GIS routes exist in the LRS and are created on an individual basis. They should not carry any data. All interstates, for example, have dual carriageways/GIS routes in the LRS.

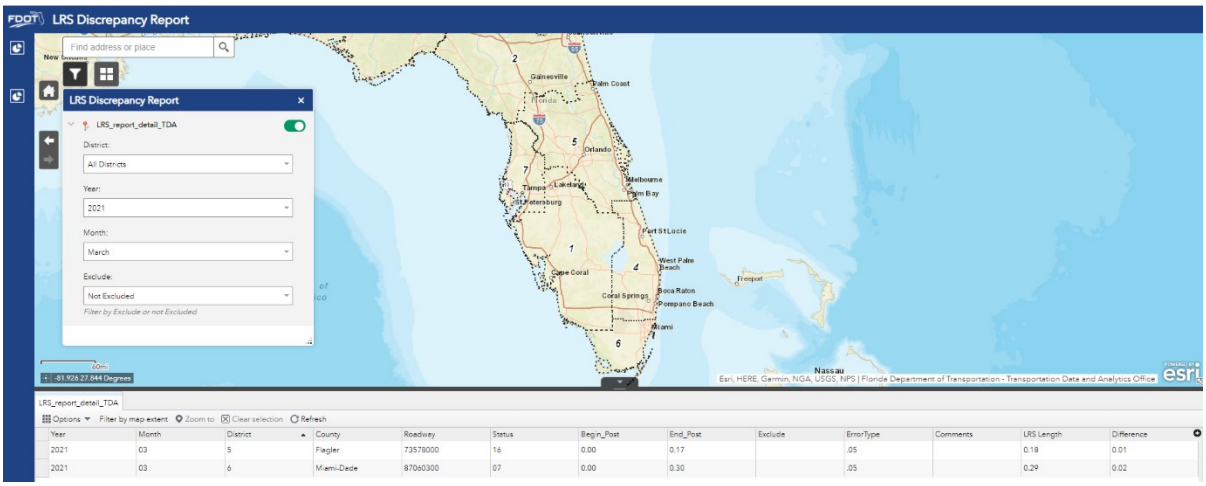
6.1.2 RCI/LRS Reconciliation Process

Each route in the LRS is composed of underlying arc(s) that transfer information to the route. This includes a field for the LRS digitized length in miles, RTLENGTH, which is compared with the RCI field inventory length, HIGHMEASURE, as a part of the RCI/LRS reconciliation process.

The LRS Coordinator provides monthly reports to identify the roadway IDs with alignment lengths that do not match the RCI lengths within the discrepancy selection criteria. The results of these reports determine which roadway IDs the Districts should address through MyFloridaLRS package submittals, which detail the steps taken to correct the discrepancies.

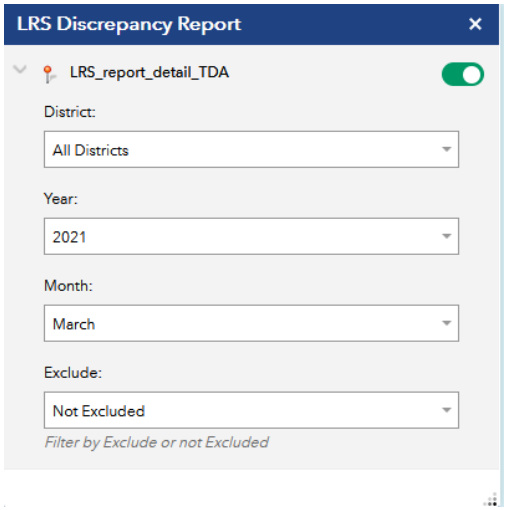
The LRS/RCI Discrepancy report is located:
https://fdot.maps.arcgis.com/apps/webappviewer/index.html?id=83ca03aff9344e63931db9155afd4433

FIGURE 6.1 | RCI/GIS LRS DISCREPANCY REPORT

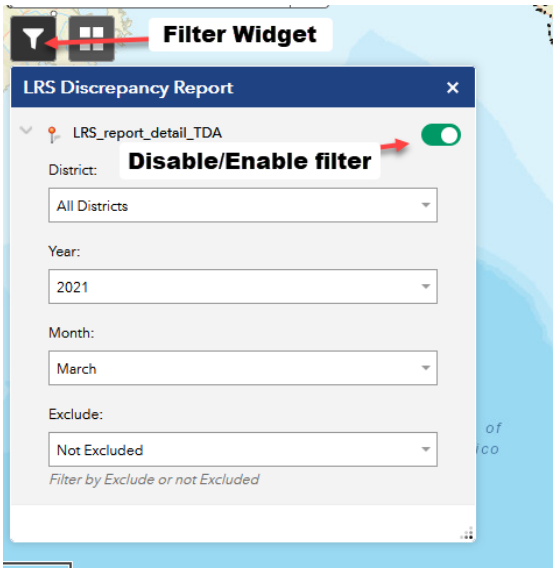


When initially opened, the Discrepancy Report displays a map and a data filter. The data filter is configured to show All Districts (that have a discrepancy that is not excluded), the current year, the current month, and show any non-excluded errors:

FIGURE 6.2 | RCI/GIS LRS DISCREPANCY REPORT- FILTERS



The filter can be configured to show other kinds of data. If you close the filter, it can be re-opened by clicking on the filter widget. You can also disable the filter (and re-enable) by turning the filter on and off:



6.1.3 Discrepancy Selection Criteria

The acceptable deviation (as of 9/20/2006) between the LRS and RCI (field inventory) mileage lengths for each roadway ID should be less than 0.100 mile or less than five percent 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 percent 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-Pending, 04-Inactive, 05-Deleted, or 10=GIS Route.

Exclusion Status of Sections

Within the Detailed Listing Report, there is a column with a header of "EXC," which indicates "excluded from the Summary Report." If any roadway ID has an entry of "E" in this column, it means that the Summary Report for the County/District will not include the roadway ID until such time that its 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 to maintain an excluded status. Attaining an "excluded" status is based upon mutually agreed factors between the Districts and the LRS Coordinator. The most used 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 Central Office or District involved.

6.1.4 Delivered Data File Format and Other Specifications

GPS or other field data shall be collected to capture the center of the roadbed, which is measured from 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 use an offset to capture the center of the roadbed.

For the purpose of reference/inclusion in the FDOT LRS, collected data should be provided to Central Office in shapefile format in UTM 17N NAD 83 projection. Alignments should also be submitted through the LRS Edit Submission Application found here:

https://fdot.maps.arcgis.com/apps/webappviewer/index.html?id=1cad34e1055e48bba9dfd31d63a821b1

6.2 MyFloridaLRS Package Process

The TDA Office developed the MyFloridaLRS Package Process to aid the Districts in recording all revisions, updates, and modifications to roads in the RCI and LRS. This process facilitates the requirement that Districts send revisions to TDA Office through the MyFloridaLRS application, which allows the TDA Office to track and complete changes in a timely manner.

RCI changes that require a MyFloridaLRS Package include:

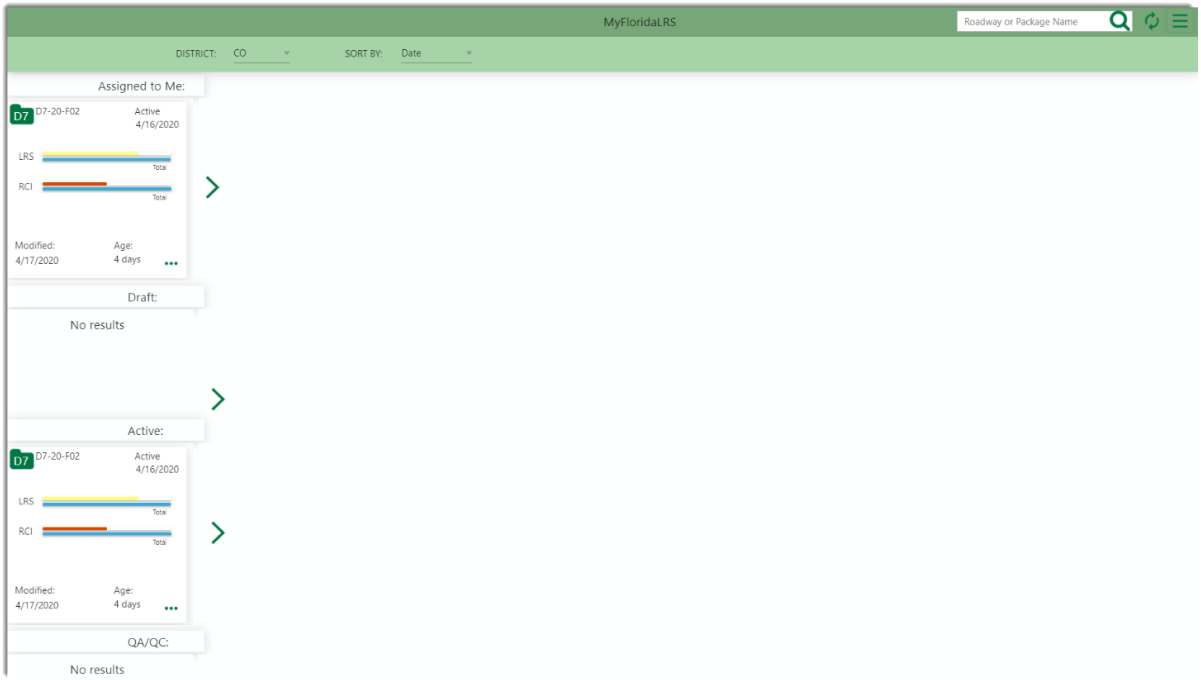
- Add a new Roadway ID.
- Delete a Roadway ID.
- Inactivate a Roadway ID.
- Lengthen or shorten a Roadway ID.
- Changes to Overall Status, Governmental Jurisdiction, or any other information field on the RCI View/Update/Delete (V/U/D) screen except the Overall Description and General Compass Direction.

6.2.1 MyFloridaLRS Application

The MyFloridaLRS application was developed to assist the Districts with MyFloridaLRS Package submittal and to allow the Districts to track where the package currently is in the process. The MyFloridaLRS application can be found at the link below:

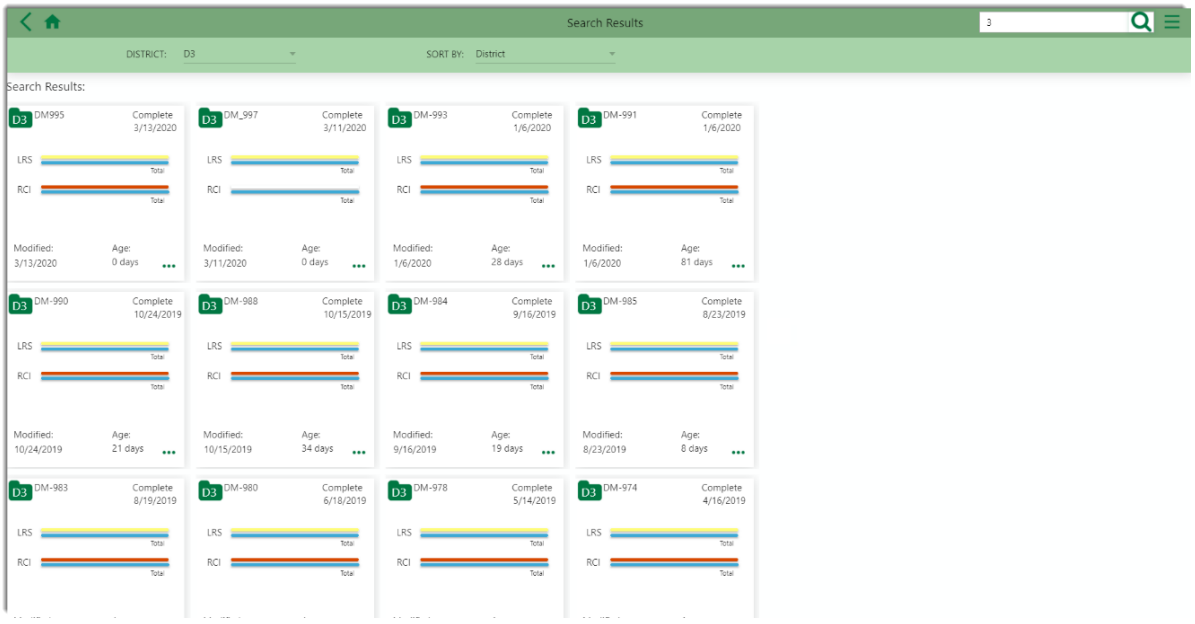
https://tdaappsprod.dot.state.fl.us/prv/myfllrs/ (Opens in Google Chrome)

FIGURE 6.3 | MYFLORIDALRS APPLICATION



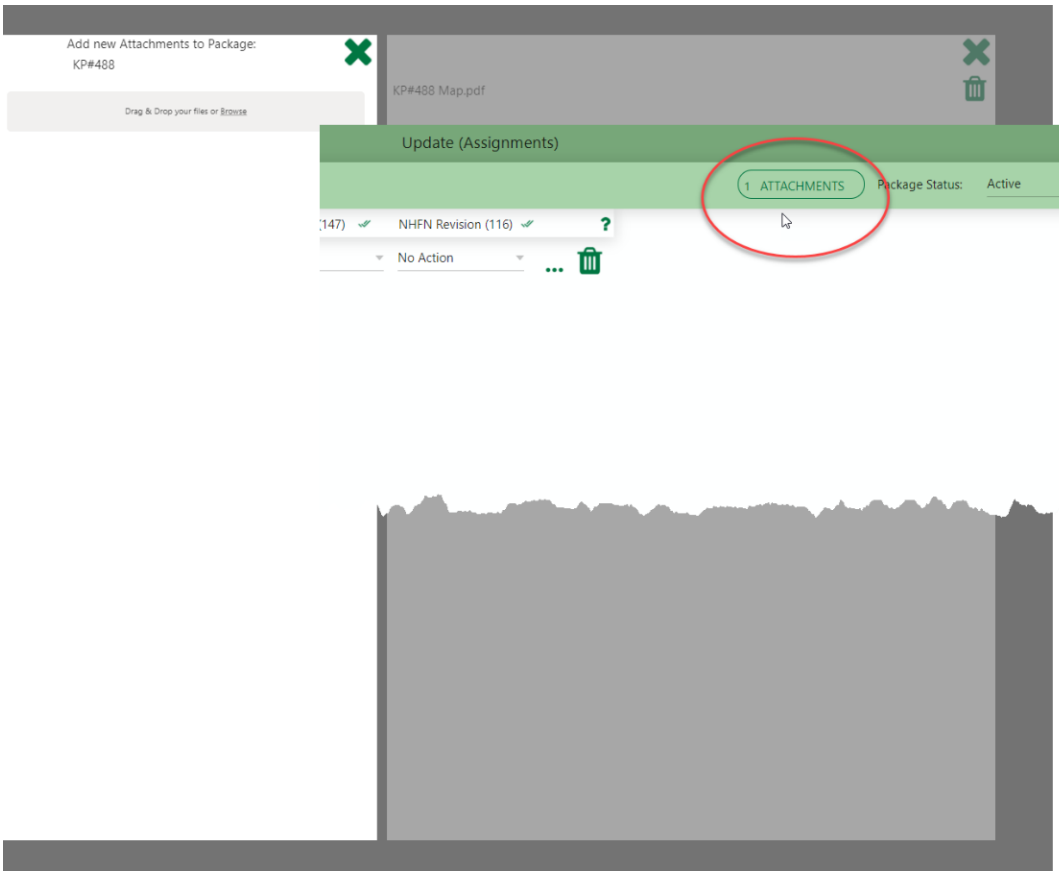
The Search function allows the user to search by a roadway ID, package number, or District.

FIGURE 6.4 | SEARCH FUNCTION OF MYFLORIDALRS APPLICATION



The attachments link allows the user to upload documents in multiple formats for use in processing the package. These formats include: .pdf, .docx, and esri shapefile format (UTM17N NAD 83).

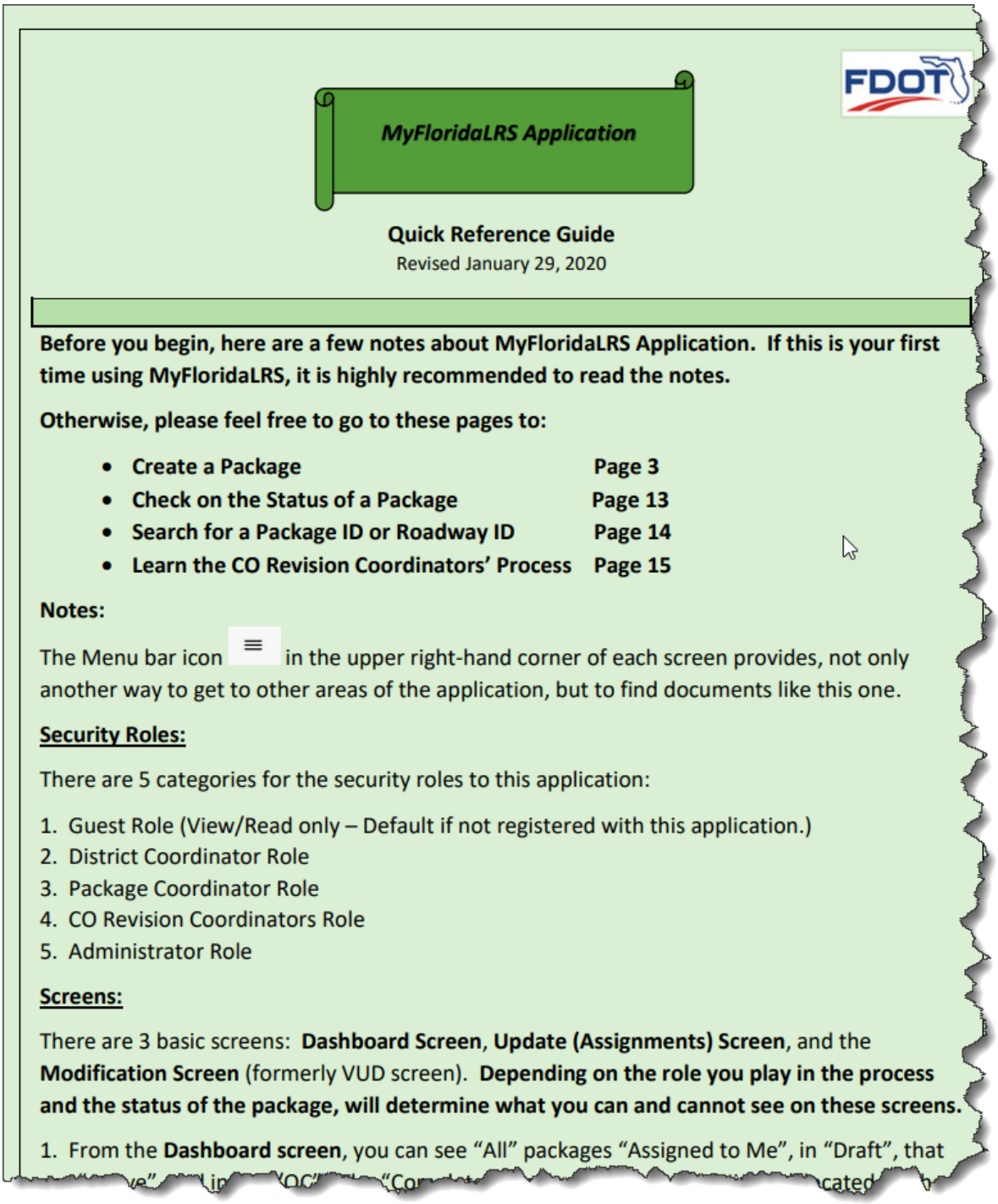
FIGURE 6.5 | ATTACHMENT FUNCTION OF MYFLORIDALRS APPLICATION



The Quick Reference Guide walks the user through 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).

FIGURE 6.6 | QUICK REFERENCE GUIDE OF MYFLORIDALRS APPLICATION



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

Please direct questions regarding the MyFloridaLRS Application to: CO-MYFLLRS@dot.state.fl.us.

6.2.2 MyFloridaLRS Package Checklist

The MyFloridaLRS Package Checklist details the required information from the Districts to assist the TDA Office in package processing. This checklist ensures that each District sends packages with the information required by the TDA Office to effectively revise both the RCI and the LRS.

Please limit the number of roadways to 15 per package submittal so the TDA Office can process submissions in a timely manner.

- Review the LRS first before submitting GIS roadway updates to the TDA Office.
- All spatial data should be in UTM 17N NAD 83.
- Alignments of new Roadways or alignment changes to existing roadways should be submitted through the LRS Edit Submission Application.
- 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 in the comment fields on the Modification screen.
- Shorten all features in RCI before submitting to Central Office. If District features are not shortened the entire package will be returned to draft and moved to the bottom of the current package list.
    - If shortening a roadway, please run a Propose New Roadway Section Boundaries report in RCI to verify that all Features have been shortened before requesting a length change.
- Review any Transportation System Designations and include appropriate completed paperwork for any addition/deletion of State Highway System (SHS) or Non-SHS mileage. Coordinate with TDA's Multimodal Data System Coordinator, and refer to the Transportation System Designation and Road Jurisdiction Transfer Handbook and the Urban Boundary and Functional Classification Handbook for more information on how to coordinate designations and obtain the required paperwork before submitting a package.
    - For > 0.100 of SHS mileage changes: Review Feature 111 for State Road extents and Feature 140 Road Status extents and include appropriate completed paperwork in the package.
    - For any mileage changes on the SHS based on a Road Jurisdiction Transfer: Review Feature 111 for State Road extents and Feature 140 Road Status extents and include appropriate completed paperwork in the package.
    - For > 0.100 of SHS or non-SHS mileage changes, coordinate the mileage changes, obtain approvals, and include the appropriate completed paperwork in the package for changes to Feature 112 (NHS), Federal System Designations, or Feature 121 (Functional Classification).

- For > 0.100 of SHS, review Feature 113 for designations of U.S. Route Number extents and include appropriate completed paperwork for any addition/deletion of U.S. Routes to roadway sections.

- Review and address Features 140 and 141 for exceptions on roadways to be updated in the RCI/LRS.
- Include requested updates, creations, or deletions to Feature 147—Strategic Intermodal Systems.

6.3 Other LRS/RCI Data Resources and Tools

The following GIS programs and associated products are used with RCI:

- 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.

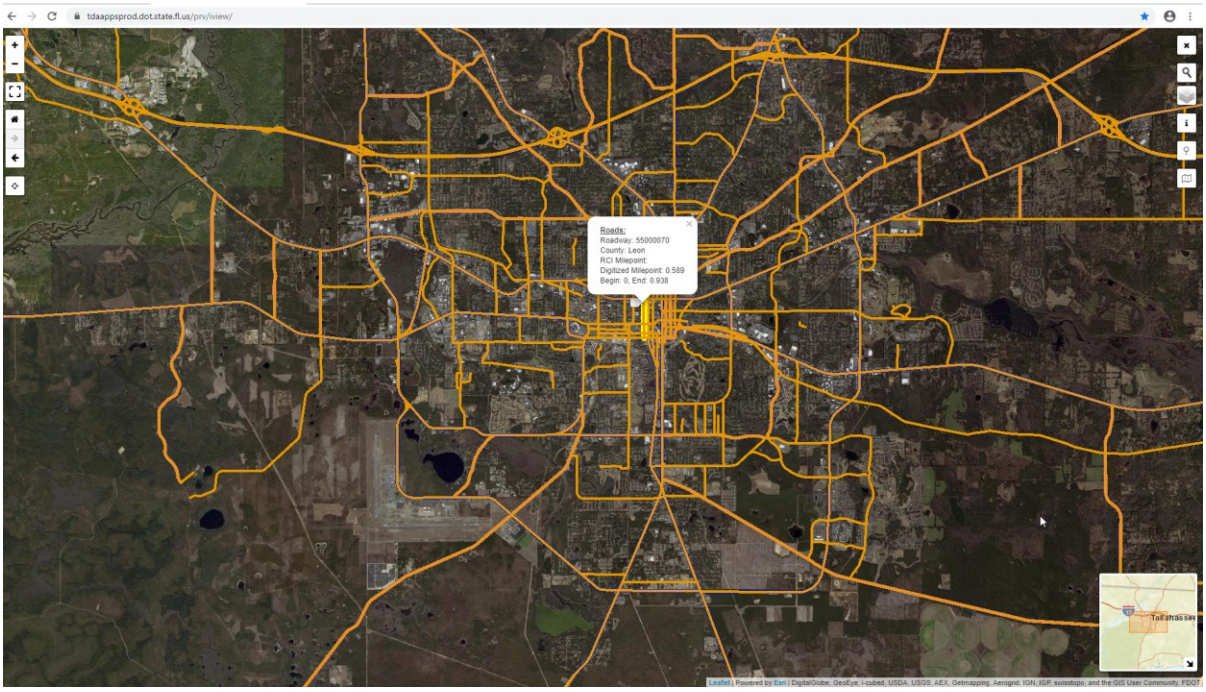
These programs add functionality to facilitate the use of RCI and its output. Various user guides and instruction manuals present guidance for these programs, but they are described briefly in this handbook. For additional information please visit the website: https://www.fdot.gov/statistics/gis/default.shtm.

6.3.1 IView

IView is a map-based web application designed to provide linear referencing functionality to support agency data collection and verification. It contains the three official agency linear referencing systems (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 RCI layers and choose from a variety of background basemaps provided by ESRI. These background layers include imagery, streets, topographic and others.

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

FIGURE 6.7 | IVIEW



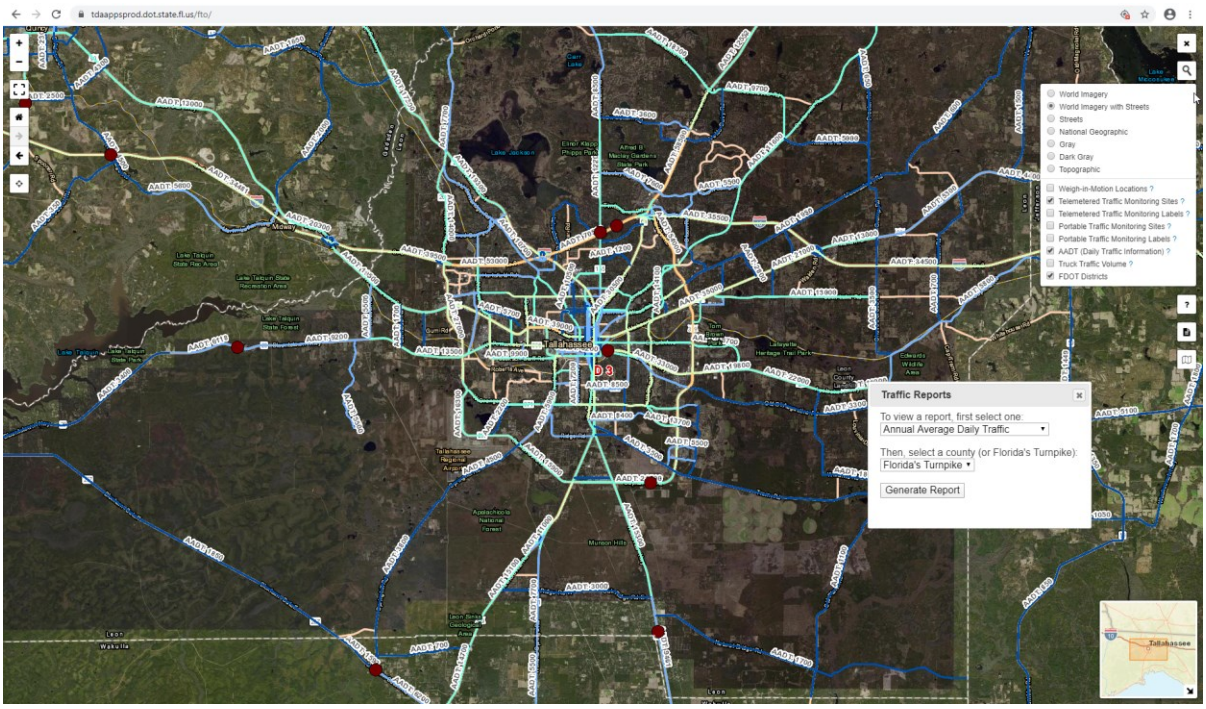
6.3.2 Florida Traffic Online

The Florida Traffic Online (FTO) site provides users with access to 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 site provides the following traffic information:

- 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.
- Historical AADT data is available via the popup information window.
- 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)

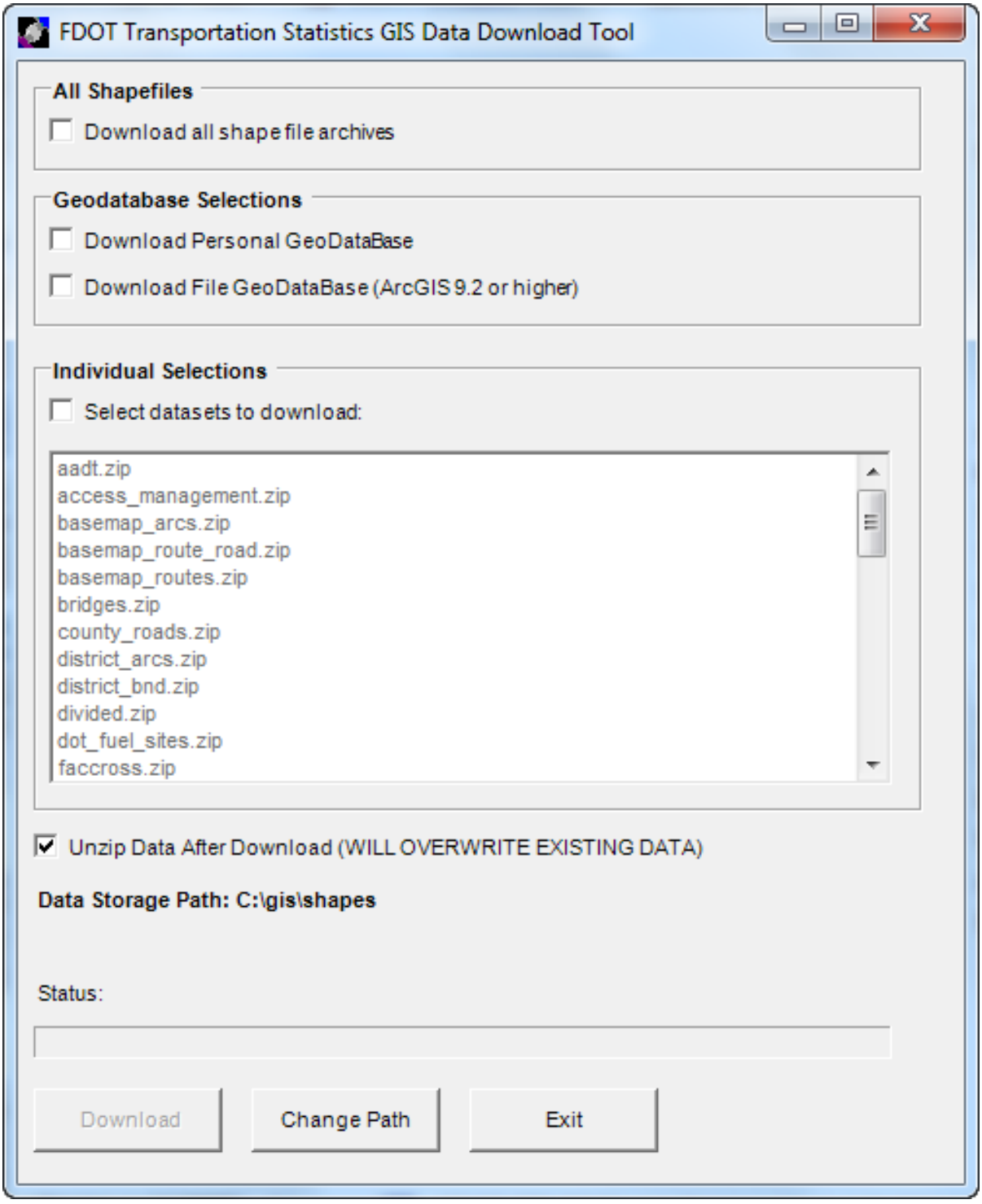
FIGURE 6.8 | FLORIDA TRAFFIC ONLINE



6.3.3 Data Download Tool

The Data Download Tool can automate the acquisition of the TDA Office's GIS datasets. It will automatically download and unzip the TDA Office's GIS data to a local or network folder. Users can point the Data Library Tool to this location, ensuring that the most recent GIS vector RCI layers are used in all map documents.

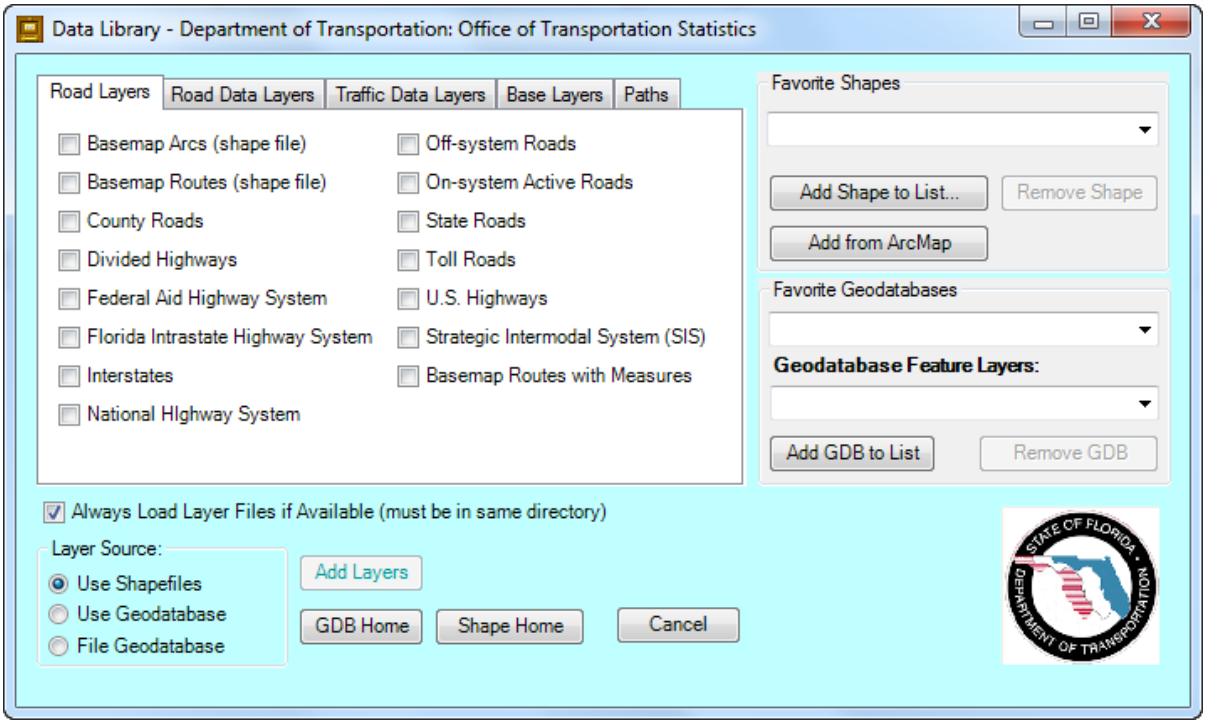
FIGURE 6.9 | GIS DATA DOWNLOAD TOOL



6.3.4 Data Library Tool for ArcMap

Users can reach the Data Library Tool for ArcMap 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.

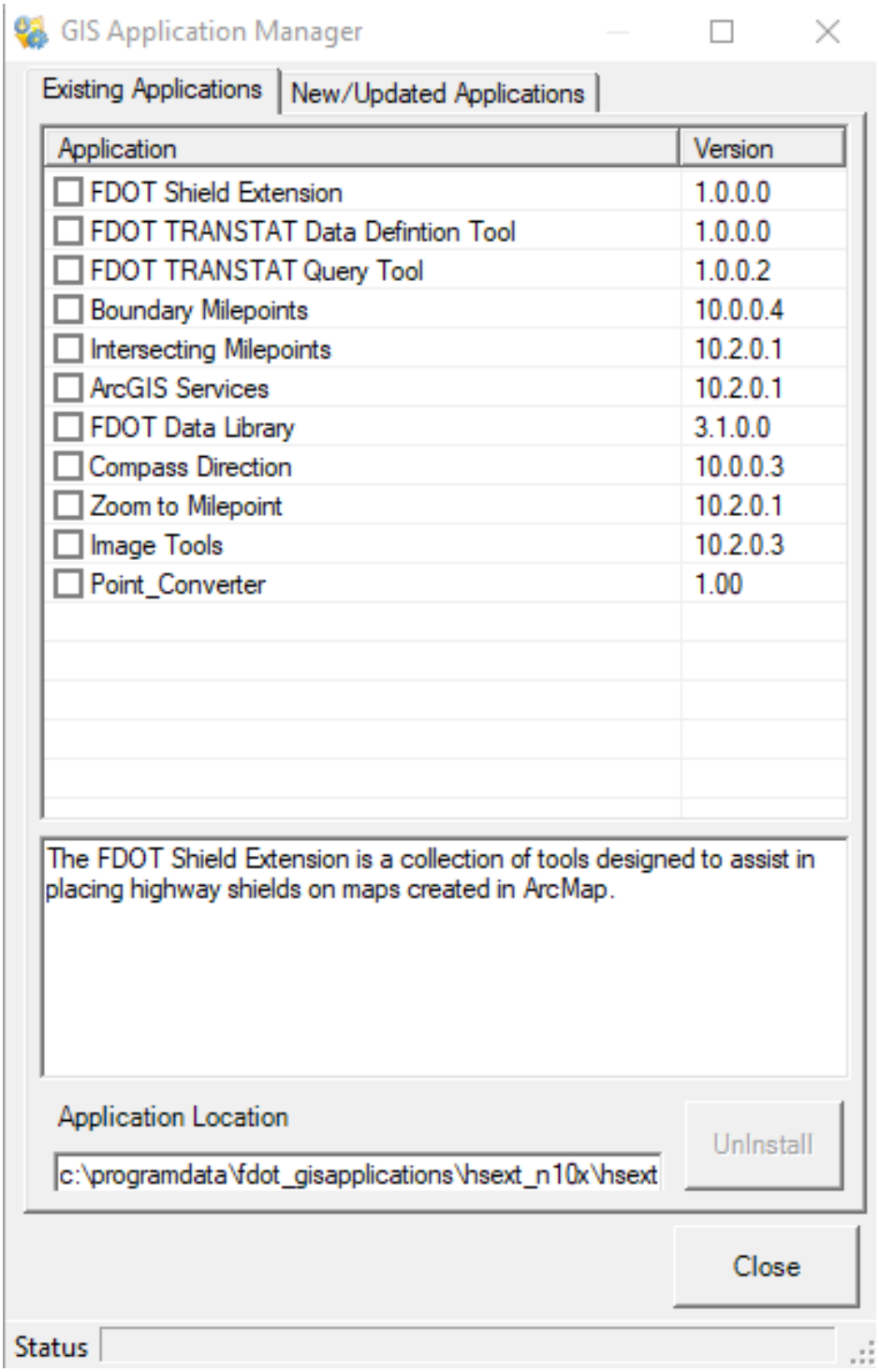
FIGURE 6.10 | DATA LIBRARY TOOL FOR ARCMAP



6.3.5 GIS Application Manager

The GIS Application Manager can easily install, uninstall, and update the various GIS customizations provided by the TDA Office. This desktop application can install the GIS customizations and an ArcMap extension used to alert users about new or updated applications.

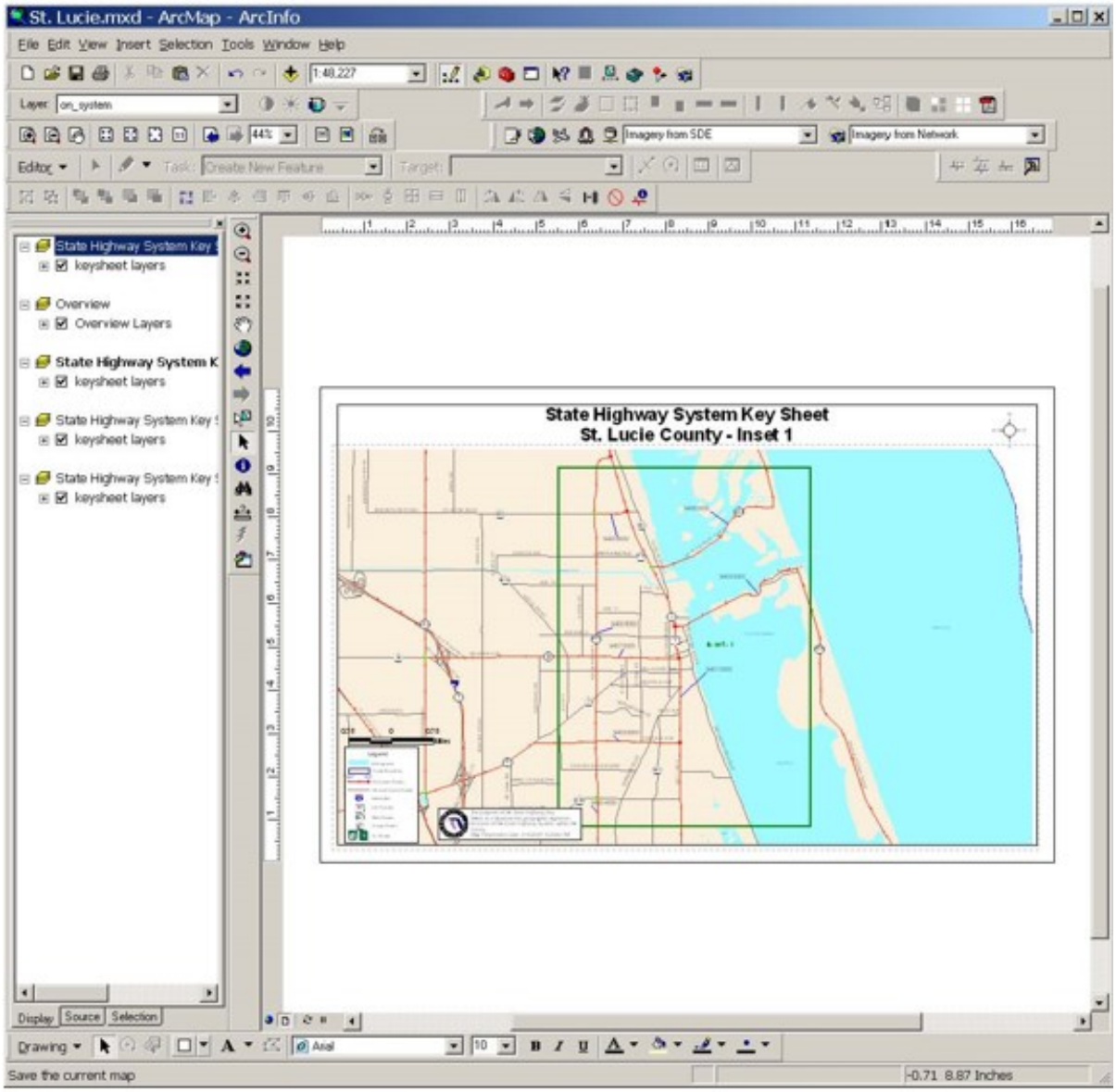
FIGURE 6.11 | GIS APPLICATION MANAGER



6.3.6 County Section Number Key Sheets

The County Section Number Key Sheet extension allows the user to create custom key sheet insets in accordance with the General Interest Roadway Data (GIRD) and MAP-21.

FIGURE 6.12 | COUNTY SECTION NUMBER KEY SHEET EXTENSION



For more information on the County Section Number Key Sheets, please visit the following link: https://www.fdot.gov/statistics/sld.shtm

6.4 All Roads Network of Linear Referenced Data (ARNOLD)

6.4.1 Overview of ARNOLD Dataset

In 2012, the FHWA expanded the HPMS' reporting requirements, mandating that state DOTs submit an 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 6.1). The following sections give a brief overview of each task associated with the creation and submission of the ARNOLD dataset to the 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.

TABLE 6.1 | FLORIDA HIGHWAY ADMINISTRATION NETWORK REQUIREMENTS FOR ARNOLD

Road Centerline Geometry	Road Centerline Attributes	Street Addresses	Linear Control	Network/Linear Topology
• All Public and Private Roads • Frontage Roads • Ramps • Traffic Circles • Dual Carriageway • Update Cycle: certified annually • 1:5,000 scale • WGA 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

FDOT maintains an LRS driven by the RCI, composed of arcs and routes that geographically represent specific roadways in the 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 LRS and Census TIGER (Topologically Integrated Geographic Encoding and Referencing) road data. The TIGER data is used primarily for local roads. Secondary geospatial datasets, such as Parcel data, Florida Land Managed Areas, and aerial imagery, are used to complete and verify attributes and geometry (Table 6.2).

6.4.2 ARNOLD Data Creation and Process Overview

The creation of the ARNOLD dataset requires the following tasks:

- 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 United States Postal Service (USPS) Standards.

- Task 4: Attribute HPMS to local roads (add attribute values represented in Table 2). Following 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: Create Unique Roadway IDs. Local routes were assigned new roadway 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 within the same county that share 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: Create, quality check, and enhance Local Roads Topology.

- Task 7: Prepare Non-Routed RCI Arcs that are not included in RCI LRS (Dual Alignments, Connectors, Ramps).

- Task 8: Create routes and quality control for M-Value and Topology Errors.

- Task 9: Prepare ARNOLD dataset for HPMS submittal. Export the final ARNOLD dataset to a shapefile format and the attribute table 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.

Yearly updates repeat these tasks with minor variations. Information on detailed workflows can be provided upon request.

TABLE 6.2 | ARNOLD DATA MODEL WITH FHWA REQUIRED ATTRIBUTES

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

6.4.3 Integrating Yearly U.S. Census TIGER Data and RCI LRS Updates

FDOT conducts ARNOLD updates once a year when the U.S. Census Bureau publishes the newest set of TIGER data. FDOT compares raw TIGER datasets (e.g., 2016 versus 2017) against each other to identify new/updated TIGER features. After identifying these features, a series of automated steps are taken to attribute and topologically connect and replace these features in the previous year's local dataset. The tasks summarized above are used 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.

6.4.4 ARNOLD Update Schedule

- Fall of each year: The U.S. Census Bureau releases an updated version of the TIGER data. Release dates are not consistent and have occurred between the months of August and October.
- December 31 of each year: FDOT takes a snapshot of the RCI Arcs and LRS for the HPMS submittal and incorporates 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.

6.5 Unified LRS

In conjunction with two Federal Highway Association (FHWA) pooled fund studies that are underway, Applications of Enterprise GIS for Transportation (AEGIST) and the National Road Network (NRN), there is a need to incorporate roadway features from local governments into the Department's linear referencing system (LRS). This Unified LRS is envisioned as a product that includes local data, associated geometric modeling (e.g., intersections), and standard attribution, per guidance from the pooled fund studies.

Upon completion of this multi-year effort, the Unified LRS will accommodate State of Florida requirements for asset management, safety, travel demand modeling, maintenance, and other program areas. It will also meet federal initiatives such as reporting for the Highway Performance Monitoring System (HPMS) and ultimately serve as a component of a national transportation network, per Congressional mandate.

Please visit the following link for more information on the Unified LRS:
https://fdot-tda-unified-lrs-fdot.hub.arcgis.com/