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A NEW DATABASE FRAMEWORK FOR FLORIDA'S TRANSPORTATION PLANNING: INTEGRATING WORK PROGRAM, MULTIMODAL TRANSPORTATION NETWORKS, PLANNING AND ENVIRONMENTAL DATABASES

FINAL REPORT

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16. Abstract

At present, the transportation planning databases, transportation networks and applications associated with the FDOT WPA, RCI, FIHS-DSS, FSUTMS, FGDL, ETDM and SIS are not fully integrated in a connected GIS environment which impedes the efficient exchange of information in transportation planning. The goal of this research was to develop a database framework that establishes connections among the transportation planning databases in order to facilitate data sharing and exchange. The analysis of the data connectivity identified problems that for the most part rise due to discrepancies among street reference data used at different levels of transportation planning, the lack of a database tracking mechanism of projects as they progress in the planning process and the lack of a database framework for management of the multimodal transportation data. Recommendations include (a) the use of a state-wide consistently maintained GIS street reference layer to mediate the exchange of information between local networks, FSUTMS network and RCI basemap; (b) a database structure to enable tracking of GIS project information from inception to RCI; (c) The use of ESRI's network dataset for organization and management of the intermodal transportation data that support SIS and (d) integration of socio-economic databases into a larger transportation database framework by geographic boundaries and similar data entities. It is envisioned that the documentation of the data connectivity, the methods for establishing the missing links and the tools developed for facilitating implementation will contribute to streamline data sharing and exchange among databases used in transportation planning.

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EXECUTIVE SUMMARY

PROBLEM STATEMENT

At present, the transportation planning databases, transportation networks and applications associated with the Florida Department of Transportation (FDOT) Work Program (WPA), Roads Characteristics Inventory (RCI), Florida Intrastate Highway System – Decision Support System (FIHS-DSS), Florida Standard Urban Transportation Model Structure (FSUTMS), Florida Geographic Data Library (FGDL), Efficient Transportation Decision Making (ETDM), and Strategic Intermodal System (SIS) are not fully integrated in a connected Geographic Information Systems (GIS) environment. The lack of integration impedes the efficient flow of information and exchange of variables among the databases and related applications, thus limiting the full potential for integrated transportation modeling and environmental analysis. In addition, the heterogenic nature of such information may contribute to the lack of awareness about its availability. Thus, when the identified information resources are available, there is a need for methods on how to make use of them for given applications.

OBJECTIVES

The overall goal of this research project is to develop a database framework that establishes connections among the databases used in transportation planning in order to facilitate data sharing and exchange. The specific objectives of this research project include the following:

1. Develop a methodology for the integration of existing transportation databases into a connected database framework.
2. Test the methodology by connecting selected databases into the database framework.
3. Develop user-friendly tools to facilitate the integration of Florida's transportation data to the database framework.

FINDINGS AND CONCLUSIONS

By analyzing the current transportation planning process and the related databases, the researchers identified four main data connectivity problems:

1. There is a discrepancy among street reference data used at different levels of transportation planning, from the Metropolitan Planning Organizations (MPO) mobility planning to FDOT WPA. Local GIS street data used by MPOs are different from the FDOT RCI-based linear-referenced department basemap. Additionally, transportation modeling stick network data lack accurate geographic reference and do not match either local data or the department basemap, which creates another layer of discrepancy among the transportation planning reference data. Such discrepancies hinder efficient exchange of information among related transportation planning applications.
2. There is no database tracking mechanism for transportation project reference and attribute data as they move from Long Range Transportation Plan (LRTP) to ETDM to WPA. A database mechanism is necessary to facilitate the information sharing during the different phases of the transportation planning lifecycle, from MPOs to FDOT.
3. There is no data structure to handle multimodal transportation data. The need to manage multimodal transportation planning data has increased with the development of the SIS. Further, a database organization is needed to integrate non-FDOT multimodal datasets, e.g., from federal or local sources.
4. Several socio-economic databases are used in transportation planning, such as landuse, demographics, and employment; but there is no documented method for connecting them in a larger transportation database framework.

To address these issues, the research team developed a concept for a connected database framework that would link the main databases used at different levels of the transportation planning process; examples of data that should be included are local reference, department reference basemap, socio-economic, and multimodal transportation planning data. Specific recommendations include the following:

1. Use a state-wide GIS street reference system to mediate the exchange of information between the local MPO street network and FDOT's RCI basemap. The ideal solution would be for FDOT and MPOs to use a single street reference system with a linear referencing system. This reference could be used to facilitate the exchange between the FSUTMS stick network and the department basemap. Dynamap/Transportation (D/T) streets, a commercial product purchased recently by FDOT, could serve this purpose. D/T includes local streets and is consistently updated from one source with a reasonable time sequence of six months. The research team developed a GIS data association tool that would help transfer attributes between different reference data. This solution extends the street network to include local streets, offers more accurate geometry and provides access to the RCI linear referencing system, all in the same street network. However, it does not solve current problems with inaccurate mapping of the RCI events.
2. To allow local transportation projects to be tracked from an MPO's LRTP to ETDM and to the WPA in the FDOT system, use a database structure with linkages that would allow access to project information from inception at the planning level to construction and, eventually, to RCI.
3. Adopt Environmental Systems Research Institute's (ESRI) network dataset for integrating multimodal transportation planning data. The network dataset would be appropriate as a data structure for managing SIS multimodal data as well as for related networking applications.
4. To integrate socio-economic data in the transportation planning database framework, most of the socio-economic polygon data should be related by a combination of common attributes and geographic boundaries. Specifically, for point employment data, such as InfoUSA data, aggregation to the TAZ level should be performed by geocoding using property parcel data and the D/T street network.

BENEFITS

This research contributes to streamlining data sharing and exchange among databases used in transportation planning by providing documentation of data and data connectivity, methods for establishing missing links, and tools for facilitating the implementation. The proposed database relationships among LRTP, ETDM, and WPA could be used to track and exchange project data from inception at the MPO level to the FDOT work program and RCI. The use of D/T streets, enhanced by the RCI linear referencing system, can be applied to planning applications that require more accurate GIS streets and need to include local streets in the same layer. Applications that could benefit from this solution include SIS Prioritization, Transportation Modeling, ETDM, Traffic and Criminal Software (TraCS), and Intelligent Tranportation System (ITS) traffic operation and planning. The network dataset model proposed for the SIS can support the overall database organization and management of SIS data as well as networking applications (e.g., determination of optimal routes, transportation modeling, and tracking of goods from origin to destination).

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LIST OF ACRONYMS

AADT	Annual Average Daily Traffic
ArcGIS	ESRI Desktop GIS Software
BEBR	Bureau of Economic and Business Research
BTS	Bureau of Transportation Statistics
CTPP	Census Transportation Planning Package
D/T	Dynamap Transportation
DSS	Decision Supporting System
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute, Inc
EST	Environmental Screening Tool
ETDM	Efficient Transportation Decision-making
FAA	Federal Aviation Administration
FDOT	Florida Department of Transportation
FGDL	Florida Geographic Data Library
FIHS	Florida Intrastate Highway System
FSUTMS	Florida Standard Urban Transportation Model Structure
FTP	Florida Transportation Plan
GIS	Geographic Information System
GIS-TM	Geographic Information System-Transportation Modeling
JACIP	Aviation Database
LOS	Level of Service
LRS	Linear Referencing System
LRTP	Long Range Transportation Planning
MPO	Metropolitan Planning Organization
NTAD	National Transportation Atlas Database
PIP	Public Involvement Plan
RCI	Roadway Characteristics Inventory
SIS	Strategic Intermodal System
TAZ	Transportation Analysis Zone
VBA	Visual Basic Application
WPA	Work Program

1. INTRODUCTION

At present, the transportation planning databases, transportation networks and analytical models associated with the FDOT Work Program (WPA), Roads Characteristics Inventory (RCI), Florida Intrastate Highway System (FIHS) – Decision Supporting System (DSS), Florida Standard Urban Transportation Model Structure (FSUTMS), Efficient Transportation Decision Making (ETDM) and Florida Geographic Data Library (FGDL) are not fully integrated in a unified Geographic Information System (GIS) environment. The lack of integration among these different sources impedes the efficient flow of information and exchange of variables among the databases and related applications thus limiting the full potential for integrated transportation modeling and environmental analysis.

In this situation, in order to move towards full GIS integration there is a need for conducting research into developing a methodology and a set of tools for the integration of a host of information sources into a new database framework. This process is likely to be a very complex exercise fraught with issues related to data formats, data exchange and flow between systems and platforms, consistency in level of detail, and data updating and maintenance (Transportation Research Board, 1998).

1.1 Research Goals

The aim of this project is to perform research into the integration of planning, environmental databases and transportation networks data into a connected database framework. These databases include WPA, Department Base Map and RCI, Strategic Intermodal System (SIS), ETDM, Transportation modeling (FSUTMS and GIS-TM) and FGDL. This research will be accomplished by connecting selected existing databases and their associated applications into the proposed framework. The specific objectives of the project are:

- To develop a methodology for the integration of existing transportation databases into a connected database framework
- To test the methodology by connecting selected databases into the database framework
- To develop a set of flexible and user friendly tools that can be used to facilitate the integration of Florida's transportation data to the database framework.

In this document we report our research effort, our findings, our recommendation, solutions and tools developed.

2. LITERATURE REVIEW

2.1 Review of other DOTs' efforts

Many state DOTs have made various efforts to develop database structures for facilitating data integration and management (Vandervalk-Ostrander et al. 2003). The following is a summary of some examples that are more relevant for the focus of this research:

- Virginia DOT's Inventory and Condition Assessment System: Virginia DOT's inventory and condition assessment system is a comprehensive asset management system that stores all assets (pavements, bridges, drainage, roadside, and traffic amenities and enhancements) and conditions for providing data for business decision systems (Larson and Skrypczuk, 2003).
- Ohio DOT's Base Transportation Reference System: Ohio DOT's Base Transportation Reference System is a point reference system that splits road inventory into a 0.01mile point table (Blackstone and Aquila, 2003). The table, which includes key highway location data, incorporates eleven critical enterprise systems (Automatic Traffic Recording, Bridge Management Systems, Construction, Management Systems, Culvert Inventory, Overweight Permitting, A Highway Safety Program, Pavement Management Systems, Project Development Management Systems, Roadway Inventory, Transportation Management Systems, and Weigh-In-Motion)
- Minnesota DOT's Roadway Network Database Project: This ongoing project develops a location reference system that provides transportation data integration and analysis functionality utilizing ESRI's Geodatabase and Oracle (Vandervalk-Ostrander et al. 2003).
- Oregon DOT's Transportation Management System: This project is a web-based data storage and management system that incorporates transportation datasets such as pavement, bridge, congestion, safety, an Integration Transportation Information System, freight/intermodal, and traffic monitoring.

- Vermont DOT’s Spatial Data Partnership Project: Vermont DOT’s Spatial Data Partnership Project is a project designed to bring stakeholders together to discuss how issues of data sharing, data development and maintenance, and data access can be addressed in a coordinated and efficient manner. This project has designated and defined a master road centerline data layer (Sharp, 1997).
- Colorado DOT’s Data Integration Project: The Colorado Department of Transportation (CDOT) has embarked on a project to redefine its transportation data model and to implement that new model for use in editing and publishing its transportation data. The entire current TranSys database will be migrated to the ArcGIS geodatabase form. In addition to this project, Colorado DOT also explored the building of industry standards for linear referencing methods (Henefeld and Butler, 2004).

In summary, many state DOTs’ efforts can be classified into three general categories. First, most of other DOTs’ efforts focus on developing unified reference systems of their roadway networks using either a point or linear system. Although these efforts bring various new ideas, they are not directly applicable to our effort which makes use of the FDOT linear referencing system already in place. Second, these efforts are primarily dealing with data sharing among state agencies. For our research project it was considered important to include data exchange between local MPOs and state DOTs because transportation planning start at the MPO level. Finally, most of other DOTs’ efforts focus on integrating roadway and asset management systems. Since major datasets that DOTs use are roadway datasets and asset management datasets, most of the other DOTs are primarily concerned with managing such datasets. The data integration focus of this research includes existing transportation databases and multimodal transportation datasets. It should be noted that Minnesota DOT’s Roadway Network Database Project (MNDOT) is closer to the database integration efforts of this project. MNDOT is working on developing an integrated relational database that incorporates transportation and planning data and is applied to multiple transportation decision-making processes. So far the project has developed a conceptual model and a logical model design.

2.2 Review of GIS data models and applications

In order to improve our understanding of transportation database structures and to facilitate future development of database frameworks, we reviewed currently available transportation database models. Due to the GIS focus of this research project, most of the database models we reviewed here are transportation GIS data models.

- **UNETRANS Model:** The UNETRANS model has a primary focus on the needs of organizations that manage road and rail transportation networks. It attempts to provide a transportation GIS Data Model to simplify enterprise project implementation, encourage consistency in data structures to facilitate data sharing and provide a common starting point for application developers. UNETRANS organizes data in 7 categories. They are *network analysis, point events, line events, routes, reference layer, basemap and digital orthophoto* (Curtin et al. 2003). This model aims to provide a basis for GIS applications that would support intermodal modeling and activities as well as the advancement of more commonplace single mode applications. It includes 8 parts. They are assets (bridge, streetlight, airport, etc.), activities (construction point, construction line etc.), incidents (traffic accidents, spills, etc.), mobile objects (vehicle locations), location referencing, routing (including public transportation systems), reference networks and street names, address ranges. This model can be useful reference about how to classify data into groups

  This data model provides a good example of how transportation data can be organized. It is a very generic data model. It is more data driven than application driven. Our research project focuses more on existing applications and development of a methodology and schema for data exchange and data integration of transportation planning and environmental databases.

- **UrbanSIM Model:** Metropolitan areas have come under intense pressure to respond to federal mandates to link planning, land use, transportation, and environmental quality; and from citizen concerns about managing the side effects of growth such as sprawl, congestion, housing affordability, and loss of open space. The planning models used by Metropolitan Planning Organizations

(MPOs) were generally not designed to address these questions, thus creating a gap in the ability of planners to systematically assess these issues. UrbanSim is a new model system that has been developed to respond to these emerging requirements. This approach simulates the choices (behaviors) of households, business, developers, and governments (as policy inputs) and their interactions in the real estate market. It includes five core models. They are *Demographic and Economic Transition Models, Household and Employment Mobility Models, Household and Employment Location Models, Real Estate Development Models, Land Price Models.* The input data used to construct the model database, called the data store, include parcel files from tax assessor offices, business establishment files from the state unemployment insurance database or from commercial sources, census data, GIS overlays representing environmental, political and planning boundaries, and a location grid. Although this research is very promising, it concentrates on modeling rather than data integration. For our research data integration project, future consideration should be directed towards integrating input data of these urban development models to the other transportation related databases (Waddell and Ulfarsson, 2004 and Waddell et al. 2003).

- **The ESRI address model:** The new ESRI address model provides a new method for geocoding or address matching. While most geocoding models depend on street data, this model introduces buildings with address, buildings with sub-addresses and zones for address matching methods. The matching rate and accuracy can be largely improved. This model can be useful for geocoding of InfoUSA employment data by using property parcels. The model may prove useful for PoBOX addresses as well provided that the link between the PoBOX and the real street address is available (ESRI Address Model 2005)
- **The ESRI Network Dataset:** Networks are conceptually simple. They are comprised of two fundamental components, edges and junctions. Streets, transmission lines, pipe, and stream reaches are examples of edges. Street intersections, fuses, switches, service taps, and the confluence of stream reaches are examples of junctions. Edges connect together at junctions, and the flow from one edge can be transferred to another edge. Automobiles, electrons and water can

be transferred to another edge. A Network data set allows for the creation and the managing of sophisticated network data sets and the generation of routing solutions. ArcGIS Network Analyst is a powerful extension for routing, and will provide a whole new framework for network-based spatial analysis (i.e., location analysis, drive time analysis, and spatial interaction modeling). This extension allows for the modeling of realistic network conditions and scenarios. ArcGIS Network Analyst enables the users with the ability to solve a variety of problems using geographic networks. Tasks such as finding the most efficient travel route, generating travel directions, finding the closest facility, or defining service areas based on travel time become greatly simplified (ESRI Network Analyst 2005). With ArcGIS Network Analyst, users can dynamically model realistic network conditions, including turn and height restrictions, speed limits, and traffic conditions at different times of the day. Using a sophisticated network data model, users can easily build networks from their GIS data.

3. RESEARCH PROCESS AND METHODOLOGY

In order to achieve the research goals, this research was conducted in four steps; review of current data and planning processes of FDOT and local MPOs, construction of data connectivity, identification of focused areas, and development of data integration strategies and tools.

3.1 Review of FDOT data and applications

As the first step of this research, we investigated the transportation related data that is currently or potentially used for transportation planning. We also reviewed the major transportation planning processes that require such datasets. The datasets reviewed include:

- RCI / Dynamap Transportation (D/T) / National Transportation Atlas Database (NTAD) / Census Transportation Planning Package (CTPP) / Census / FGDL / InfoUSA / ES 202 / Transportation modeling / WPA / Straight line diagram / Bureau of Economic and Business Research (BEBR) / MPO data (Broward county and District 7 data) / Parcel data/ SIS

We reviewed attributes and spatial components (when applicable) as well as database structures including the primary key and foreign key of each dataset. The detail data structures of these datasets is provided in Appendix 1. We also reviewed the main transportation planning activities performed by FDOT and local MPOs. A summarized description of the databases and applications reviewed is provided below.

3.1.1 SIS

SIS is an inter-modal transportation plan that designates facilities, which play a critical role in moving people and goods to and from other nations and states, as well as among economic regions within Florida (Florida Department of Transportation, 2004). The main purposes of SIS can be described as:

- Incorporating transportation facilities to service areas of statewide and interregional significance
- Linking Florida's transportation policies and investments to the state's economic development strategy
- Focusing on end-to-end trips, rather than individual modes or facilities
- Redefining roles and responsibilities in the planning and managing of Florida's transportation system

This SIS plan includes several multimodal facilities, and the plan defines the facilities as

- SIS – facilities that play a critical role in moving people and goods to and from other nations and states, as well as among economic regions within Florida
- Emerging SIS – facilities that are statewide or of interregional significance, but do not currently meet the criteria for inclusion in the SIS. These facilities meet different thresholds today and are potential candidates for inclusion in future updates of the SIS
- Hubs are ports and terminals that move goods or people between regions in Florida or between Florida and other markets in the United States and the rest of the world
- Corridors are highways, rail lines and waterways that connect major markets within Florida or between Florida and other states or nations
- Intermodal Connectors are highways, rail lines, or waterways that connect hubs and corridors.

Facility Type	SIS	Emerging SIS
Commercial service airports	7	9
Spaceports	1	0
Deepwater seaports	7	3
Rail freight terminals	5	2
Passenger terminals	25	7
Rail corridors (miles)	1,600	340
High-speed rail	Initial phases	None
Waterways (miles)	900	310
Highways (miles)	3,500	700
Intermodal connectors	78	27

Table 1 Current SIS facilities

SIS			
Data Name	Data type	Primary Key	Description
Sis_pass_rail	Line	ID	Passenger rail corridors
Sis_airports	Point	Name	Airports
Sis_freight_rail_lines	Line	ID	Freight rail corridors
Sis_hwys	Line	Roadway	Highway corridors
Sis_int_freight_rail_term	Point		International freight rail terminals
Sis_pass_terms_no_se	Point	Name_ID	Passenger terminals (amtrak/greyhound)
Sis_waterways	Line		Waterways corridors
Stc	Line	Roadway	
Hsrail	Line		High speed rail corridor
Sis_seaports (missing)			
Emerging			
Emerging_airports	Point	Name	Airports
Emerging_freight_terms	Point		Freight terminals
Emerging_hwys	Line	Roadway	Highway corridors
Emerging_passenger_terms	Point		Passenger terminals (greyhound)
Emerging_rail_lakeok_offset	Line		
Emerging_rail_nolake	Line		
Emerging_waterways_detail	Line		Waterway corridors
Emerging_freight_rail (missing)			
Other transportation data			
Hsrailstops	Point	City_fips	High speed rail stops
Intermodal_centers	Point		
Pc_passenger_stations	Point	Name_id	Passenger station (tri-rail / Amtrak / greyhound)
Routes	Line	Roadway	US / Interstate highway / SR / USA / USB
Seaports	Point	ID	Seaport
Background data			
Basemap	Attribute	Roadway	
Boundary	Line		County boundary
Cntybndy	Line		County boundary
Cntypoly	Polygon	County_pl	County boundary
Cover	Attribute	Roadway	
Flapopdens	Polygon		Population density in 2000 & 2025
Lakeokechobee	Polygon		Lake Okechobee
Parks	Polygon		
Poptract	Polygon	STCTTR	Census tract
Tenmile	Polygon		
Urbn_xcity	Polygon	Urb_xcity_	City boundaries in urban area
Xcity	Polygon		Urban area boundaries

Table 2. SIS database structure

Table 1 shows the current number of facilities in the SIS plan. Table 2 illustrates the data structure of the geospatial datasets used for the SIS plan.

The purposes of SIS are to incorporate transportation facilities for services related to statewide and interregional significance and to link Florida's transportation policies and investments to the state's economic development strategy. There are 6 different SIS planning and management activities: designation needs assessment, project prioritization, project selection, design and operations, and funding. Designation is the process whereby transportation facilities are designated as part of the SIS. Needs assessment is the process that monitors and evaluates SIS facilities' effectiveness, and to evaluate deficiencies that need to be addressed in the department's investment program. Through this process, all needs and related projects are identified. Since identified needs and projects usually exceed FDOT's resources, projects need to be prioritized for funding purposes throughout the project prioritization process. Then, appropriate projects are selected, designed, operated, and finally the projects are funded. Figure 1 illustrates the SIS process along with required data.

SIS is a process that requires large amounts of data from many external sources. It needs data from several federal organizations such as Federal Aviation Administration (FAA) and Environmental Protection Agency (EPA), and it also needs data from FDOT and local MPOs. The current SIS database (work in progress by FDOT) is designed to work as a container for a large amount of data needed to support internal SIS process. The database is constructed by manually extracting and processing data from different sources. Two potential research directions can contribute to integration of the SIS database into the large DOT planning database framework: establishing relationships of SIS database to external data sources and developing an integrated database of SIS spatial features – points, lines and polygons

3.1.2 ETDM

ETDM is a new way of conducting transportation planning in Florida. For the purpose of data integration is important to understand how ETDM stores the proposed project information. The required ETDM project input information consists of project attributes, project alternatives, and a segment for each alternative. This information is organized in four tables related to each of the others as shown in figures, 2, 3 and 4.

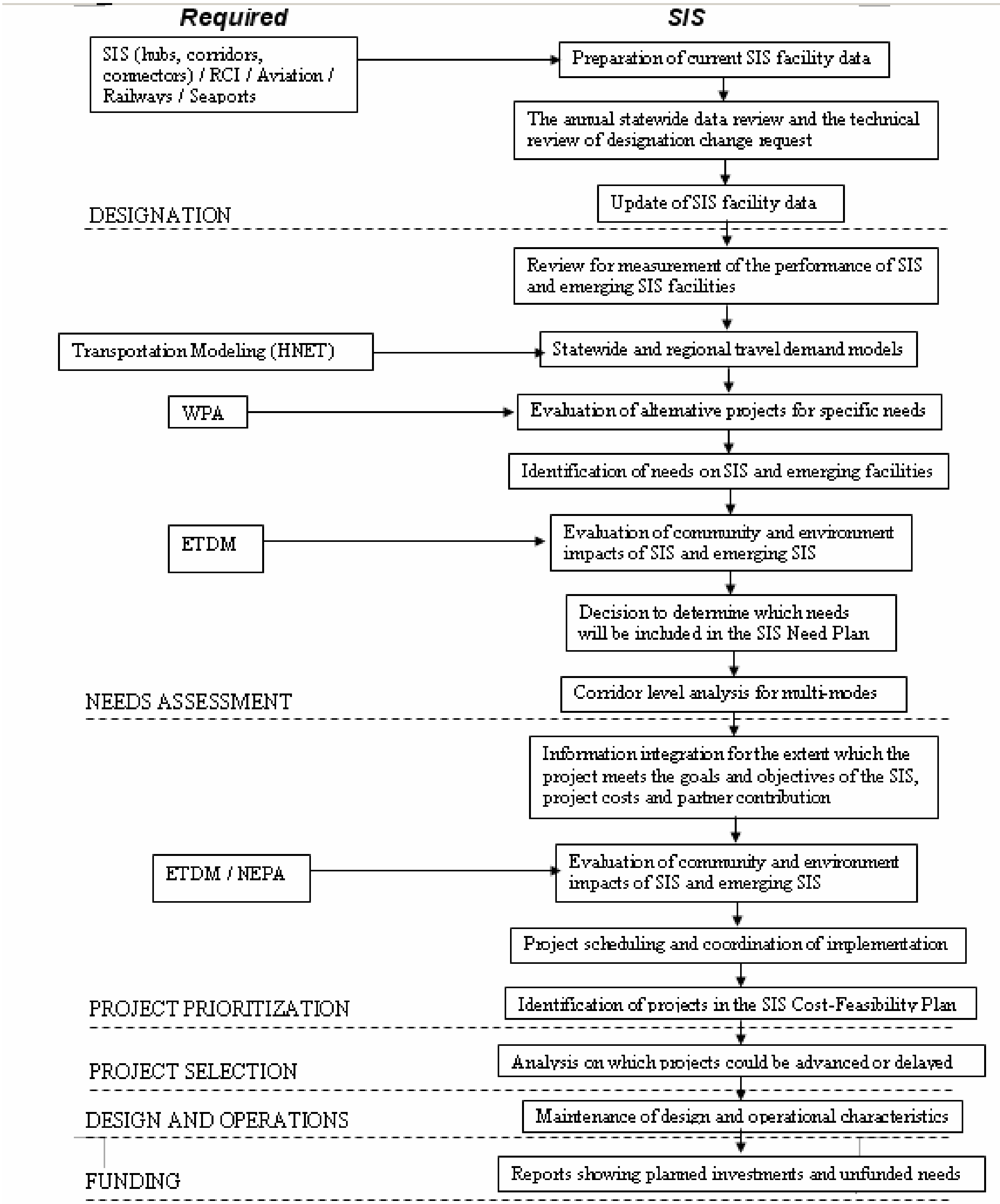


Figure 1. Process of SIS

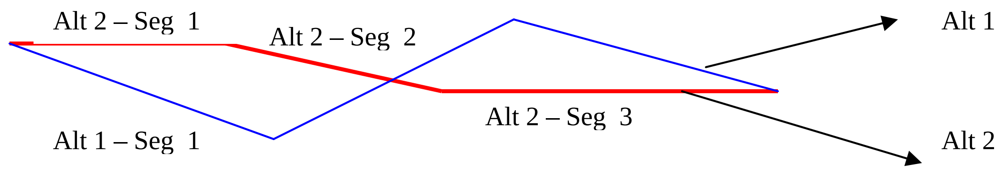


Figure 2. A project with two alternatives

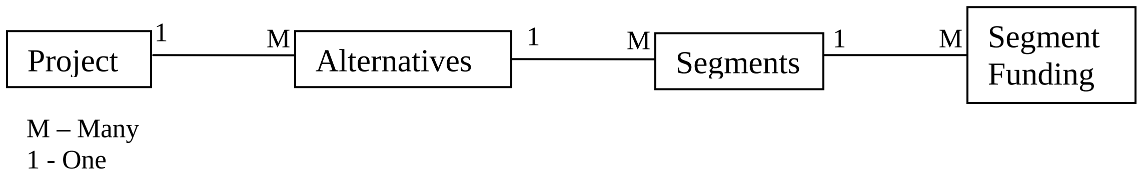


Figure 3. Relationship schema

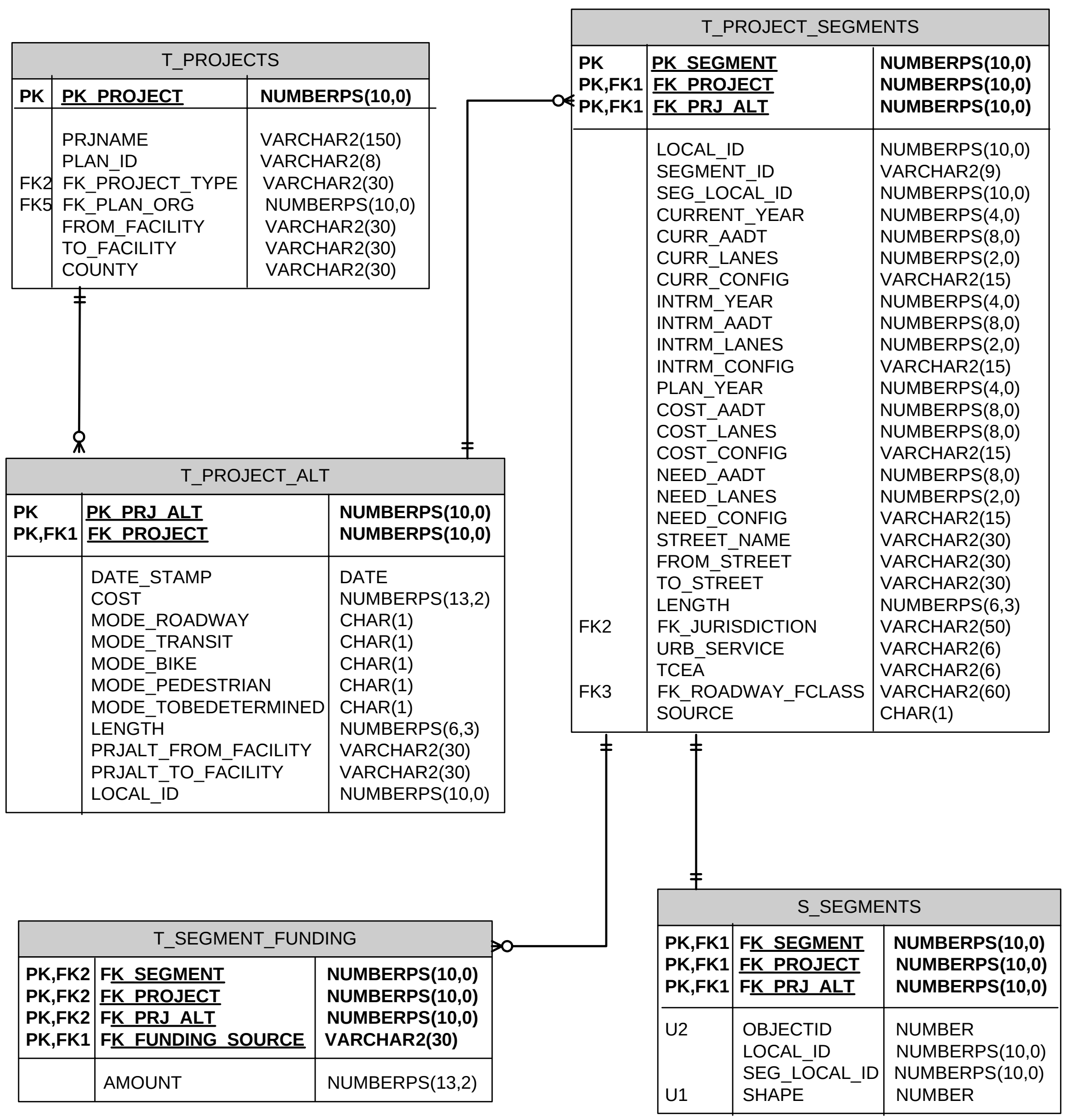


Figure 4. ETDM input project schema

3.1.3 LRTP

Since LRTP is one of the transportation planning processes conducted by local MPOs, the detailed procedures of LRTP may be different by each MPO. However, the MPOs LRTPs may share a common focus in fundamental goals and procedures. In order to have a basic understanding of the process of LRTP, we reviewed the 2025 LRTP of the Broward county Metropolitan Planning Organization.

The process to develop the 2025 plan began in November 2000 and had to be completed by December 2001 in time for the plan to be adopted by the Broward County Metropolitan Planning Organization (MPO) (Kittelson & Associate, Inc et al. 2002). The plan was also amended in September 2002. This planning process includes these nine tasks:

- Goals, Objectives and Policies: The Goals used to direct this long range transportation study for Broward County were developed and refined in a public forum.
- Public Involvement Plan: The Public Involvement Plan (PIP) was developed to ensure maximum public participation and to build a consensus in the community. The PIP is consistent with the Metropolitan Planning Organization (MPO) guidelines for public participation in the planning process, and places a particular emphasis on outreach to minorities and low-income groups, on environmental justice, and intergovernmental coordination.
- Data Compilation: More than fifteen transportation studies were compiled as part of the initial development of the Broward County LRTP to ensure that the most current and the most detailed information would be incorporated into further development of this plan. Specifically, data was collected for the four transportation modes: pedestrian, bicycle, transit and roadway
- Model Review: The FSUTMS travel demand model considers the transit and roadway modes only and these are the focus of the data development
- Financial Resources: This section provides an overview of transportation funds that will be available for the Broward County area through the period 2006-2025. Using these estimates, one can determine which improvements on the Transportation Needs Plan are financially feasible.

- 2025 Needs Plan: This section describes the process that assesses the transportation needs used to achieve that balanced multi-modal system. The Needs Assessment is not a plan but an identification of infrastructure needs to accommodate future travel demand at the currently adopted level of service standards without factoring in any economic, environmental, physical or political considerations. The transit and roadway needs are added to the assessed needs for the pedestrian and bicycle system needs to estimate the costs required to develop the ideal future transportation system for the County. This assessment then was evaluated in terms of the identified financial resources so that a cost feasible plan can be developed.
- 2025 Cost Feasible Plan: The cost of implementing the recommended multi-modal transportation needs assessment exceeds the anticipated revenues over the lifetime of the plan. It was therefore necessary to prioritize the improvements included in the needs plan to ensure that those projects which most closely address the Goals and Objectives of the 2025 LRTP would be included as cost-feasible and built with available moneys.
- Air Quality Determination: The Broward County MPO has determined that the implementation of the LRTP will contribute to annual emission reductions when compared to the 1990 base year network and that the same is true for each interim year. Thus the county conducts an analysis to indicate a reduction of Volatile Organic Compounds (VOCs) and Nitrogen Oxides (NOx) from the 1990 Motor Vehicle Emission Budget.
- 2025 Transportation Plan: Based on all the studies and analysis, the Broward County generates a long range transportation plan including pedestrian plan, bicycle plan, transit plan, and roadway plan.

Table 3 illustrates the datasets used for the Broward County 2025 LRTP.

Data Name	Data type	Primary Key	Description
Pedestrian / Bike			
Bike2025 not found in table	Line		
Bike2025	Line	BikID(?)	Planned bicycle projects
Bikefcl	Line		Existing bikepaths, bikelanes, wide curb lanes, and paved shoulders
Critsidewalks	Line	Fclass_ID	Critical missing sidewalk
Greenways	Line	Bigroads	Locations of greenways proposed in the greenways master plan
Pedsafe	Point	Pedid	Pedestrian safety enhancements
Pedsafe2	Line	Pedid	Pedestrian safety enhancements
Pedstud	Point	Pedid	Pedestrian mobility enhancements
Pedstud2	Line	Pedid	Pedestrian mobility enhancements
Tip_02_03_bike	Line		
Tip_02_03_sidewalk	Line		
Trailcorridor	Polygon		
Transit			
Headwayimprv	Polygon		Headway improvement plan
Headwayimprv2	Polygon		Headway improvement plan
2025transfer	Point		Transit stops (intermediate stop / station / super stop / community transit center)
Bct0402_new	Line	ID / route	New bus route
Brt	Line	Fclass	Proposed bus rapid transit
Brt_offset	Line	Fclass	Proposed bus rapid transit
Brthpt	Line	Fclass	Bus rapid transit + high performance transit
Feccorridor	Polygon		FEC light / commuter rail
Feccorridor2	Polygon		FEC light / commuter rail
Headway05	Polygon		750 unit buffer from bus routes having 5 minute headway
Headway10	Polygon		500 unit buffer from bus routes having 10 minute headway
Headway15	Polygon		500 unit buffer from bus routes having 15 minute headway
Headway20	Polygon		750 unit buffer from bus routes having 20 minute headway
Headway25plus	Polygon		750 unit buffer from bus routes having 25 minute and more headway
Hpt	Line	Fclass_	Proposed high performance transit
Hpt_offset	Line	Fclass_	Proposed high performance transit
Newbus2025	Line	ID	New local bus route
Newbus2025_offset	Line	ID	New local bus route
Highways			
Highway2025	Line		Proposed highway
Highway2025b	Point		New / modified interchanges
Interstate_master_plan	Polygon		Interstate master plan corridors

Table 3. Datasets for Broward County 2025 LRTP

3.1.4 DSS (SIS Prioritization)

DSS is a tool that is used for prioritizing each transportation project for SIS. Thus, it is important to identify the current data structures and the data flows between two programs in order to improve data structures and data flows in the two programs.

Prior to perform the SIS prioritization process, DSS needs to prepare input data. The data preparation process can be classified with three steps. For each step, the procedure requires a variety of different data that is processed by a combination of manual and automated procedures (Vidya, 2003). The process is illustrated in Appendix 2.

The first step of the data preparation is initiated with acquiring local level of service (LOS) data from the FDOT districts. The FDOT Districts define their LOS segments by specifying the segment of roadway, the beginning and ending milepost. Since the LOS segments that are submitted by the FDOT Districts do not perfectly match with the segments on the FIHS/SIS network definition, two additional tables, TRAFFICBREAKS and NETWORK, are used for trimming segments and filling gaps to match the segments on the FIHS/SIS network definition. After generating a correct FIHS/SIS network, the incorrect district provided data is identified and overridden by three supplemental tables, OVERRIDE_FACLITY_TYPE, OVERRIDE_BASEAADT, and OVERRIDE_NUMLANES. The results from the data preparation of this first step are finally stored in a table named DISTRICTLOS_ON_NETWORK. The data provided by the district is the source of the segmentation and attributes for 98% of records in DISTRICTLOS_ON_NETWORK. The source of the remaining 2% is RCI/TCI via the TRAFFICBREAKS segments or the manually collected field information.

Based on the FDOT Districts' LOS data generated from the first step, some additional data such as prediction for the future traffic, safety, and freight is added to the DISTRICTLOS_ON_NETWORK in the second step. The future traffic data and the future Annual Annual Daily Traffic (AADT), is generated with the SPO traffic trend generator. Based on the county, the area type, the base AADT, and the access code of the segment, the generator predicts future traffic for the next 25 years, and stores the results in a table, SPO_TREND. Safety data are safety scores for each segment in DISTRICTLOS_ON_NETWORK. The safety scores are acquired from the FDOT safety office. In order to generate scores for segments in DISTRICTLOS_ON_NETWORK, the segments from the safety office should be combined using a weighted average of the safety office score based on length since the segments from the safety office are in very small pieces. Freight data includes scores for each segment in DISTRICTLOS_ON_NETWORK. The freight score is the distance of the segment to the nearest freight terminal.

In the last step of the data preparation process, WPA project data is joined to DISTRICTLOS_ON_NETWORK. A data query process extracts records of projects where additional lanes will be added in the future from the main WPA database, and then stores the results in a table, WORK_PROGRAM. Another table, UNDER_CONSTRUCTION, contains records of projects that will be built in the near future or are currently under construction, but have not been included in the number of lanes reported by the FDOT Districts. These tables are joined to the main table, DISTRICTLOS_ON_NETWORK, and then converted to a final table, DISTRICTLOS_WP. Through this data preparation process, all tables, which are necessary for the current desktop application of SIS prioritization process, are prepared.

The only four tables, DISTRICTLOS_WP, DISTRICT_FUTURE_TRAFFIC, SPO_TREND, and the union of WORK_PROGRAM and UNDER_CONSTRUCTION are required to run the current desktop application. Based on the data provided by the data preparation process, the desktop application allows a user to do simulations with a variety of different scenarios. As a user chooses a scenario to simulate, the application calculates and provides proper scores for several categories such as safety, operation, mobility, economic, and community. Those scores will be used for making decisions for updating and improving the SIS program.

3.1.5 FIHS cost-feasibility plan

Preparation of corridor plans began in 1990 and is nearing completion. The corridor plans identify short and long-term capacity improvements through the examination of the need for highway projects and public transit (bus and rail improvements). These plans are coordinated with other local and regional transportation plans. A range of transportation, growth management and community development issues is considered. Investment alternatives are then defined and evaluated with the involvement of the public, local governments, MPOs, private industry, and other groups.

In order to identify the system-wide improvement needs for the various components of the FIHS, a comprehensive review of all completed and on-going corridor plans was conducted. All corridor plans were reviewed to compile the following information:

- Location of study corridor (district, route, beginning milepost, ending milepost, and length)
- Type of recommended improvements (capacity or operational)
- Limits of proposed improvements
- Project area type (urbanized, urban or rural)
- Phasing of the improvements (year needed)
- Interim improvement plans
- Ultimate improvement plans
- Estimated preliminary engineering costs
- Estimated right-of-way acquisition costs
- Estimated construction and construction engineering inspection costs including cost allowances for contingencies, mobilization, and maintenance of traffic
- Explanatory notes about the proposed improvement

All costs were calculated in year 2000 dollar value. If a cost estimate for a project was not available, it was developed using the unit costs ($ per mile) identified in the Department's *1996-1997 Transportation Cost Primer* (published in February 1998) and unit costs supported by estimates of other similar facilities in the Department's Five-Year Work Program. Engineering estimates were used to identify costs for projects lacking sufficient detail for project-level estimates by the Department or for which unit cost data could not be obtained.

In addition to compiling information from corridor plans, the FIHS was also reviewed for capacity and safety problems for projected traffic to 2010 and 2020. An improvement was then defined to address the problem, costs calculated, and appropriate database entries made. Analysis was also performed on the FIHS to ensure there was logical connectivity and consistency along the corridors (Florida Department of Transportation, 2004).

The following figure illustrates, in simplified form, the relationship between FIHS planning, programming, and construction. Similar relationships exist in the Department for each transportation mode.

The Florida Transportation Plan (FTP) is developed to define the goals, objectives and policies to be followed by the Department in providing transportation systems to the people of Florida. The FIHS Modal Plan is developed based on the goals, objectives and policies set forth in the FTP. The FIHS Needs Plan is developed unconstrained by funding availability.

The priority corridor improvement needs identified in developing the FIHS Needs Plan are balanced against forecasted revenue to develop the FIHS Cost Feasible Plan. Priority cost feasible corridor improvements are then identified for inclusion in the FIHS Ten-Year Plan, which consists of the Five-Year Work Program plus an additional five years. Projects entering the Five-Year Work Program come from years 6 through 10 of the FIHS Ten-Year Plan.

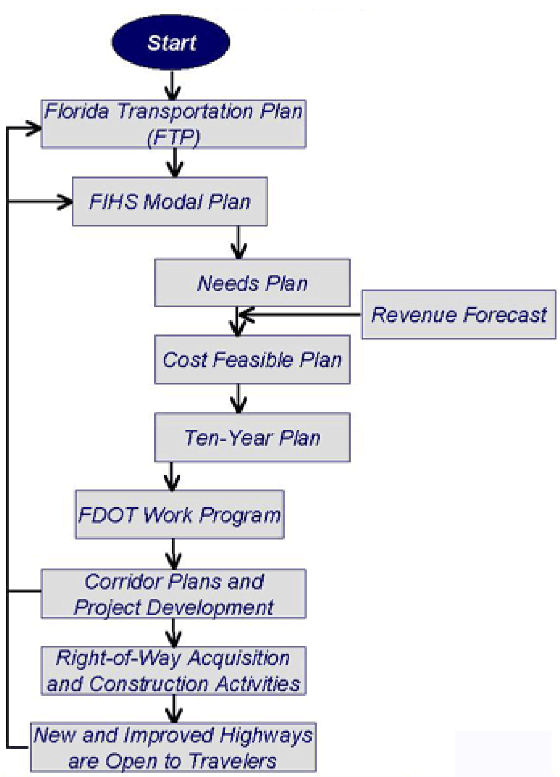


Figure 5. FIHS cost feasibility planning process

Once in the Five-Year Work Program, pre-construction activities begin. These include corridor planning, project development and environmental activities, design, and right-of-way acquisition. Construction begins when right of way is obtained and funding is available.

We analyzed these planning processes from a database perspective. Thus, we primarily focused on the data sources used for each process, data processing throughout each process, and the flow of production data from each process.

3.2 Construction of data connectivity

The review described below supported the understanding of the relationship between the transportation data and the transportation planning process. In order to understand the data flow among those datasets and processes and also to identify the current issues of data integration, we started constructing data relationships between datasets and planning applications. We categorized the datasets and planning processes, and developed a conceptual flow and relationship diagram. (Figure 6).

In this diagram, we classified transportation datasets into six categories, namely reference, roadway features, facilities, multimodal, land use, and socio-economic. The diagram contains a separate section that depict the planning process and how each process segment relate to the data as well as how the data flows among the different levels of the process.

The database structure of each dataset were documented and analyzed. The diagram presented in Appendix 1 illustrates the spatial relationships and attribute relationships among datasets. In this process, we identified existing and missing data connectivity, and determined the research focus areas.

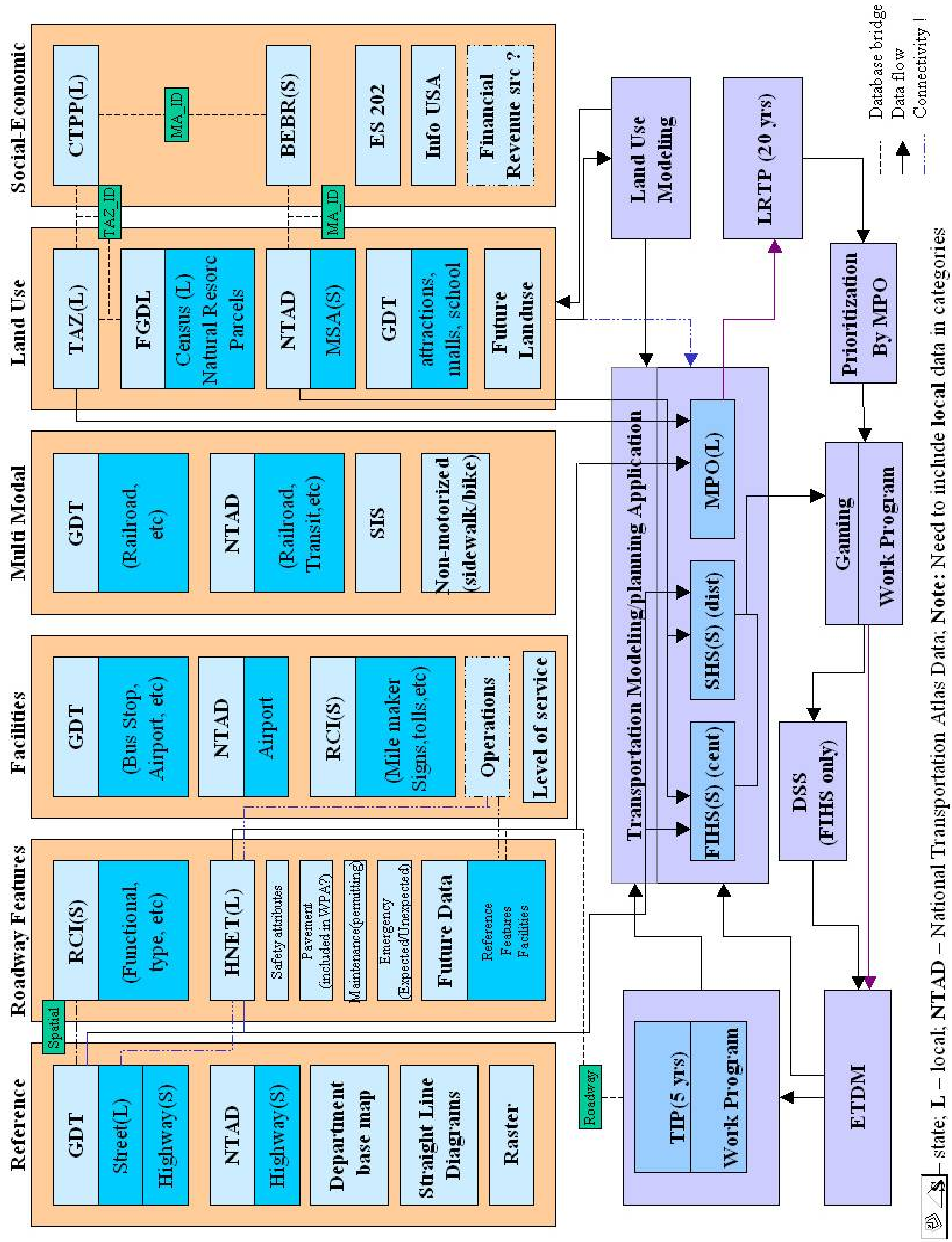


Figure 6. Transportation data and information flow

3.3 Selection of focused areas

Figure 7 shows a schematic of the components of the transportation planning process and their related databases that were chosen to be examined more closely by this research. Mobility planning that starts at the MPO level determines the Needs Plan. Development of this plan may make use of a variety of input data including Transportation Modeling, RCI and Work Program data, and Local Reference Data. During the progress of the proposed projects from LRTP (for MPOs) and FHIS Cost Feasible Planning (for FDOT) into the ETDM, a variety of other data sources are needed to support environmental and socio-cultural impact analysis. Such data include many GIS data from the FGDL, Census and landuse.

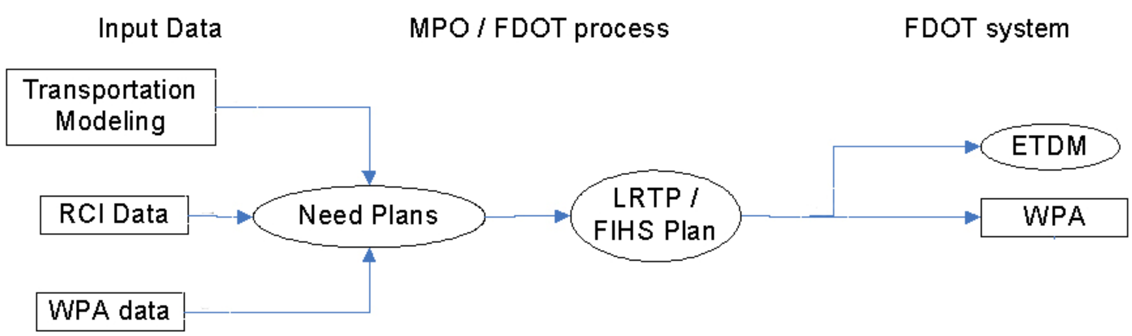


Figure 7. Simplified transportation planning process and related databases

Additionally, we looked at the SIS database as one of the important transportation planning systems that will need to make use of some of the databases mentioned above as well as additional data from federal and local sources such as the NTAD and CTPP as well as socio-economic data from commercial vendors such as InfoUSA employment data (Figure 8)

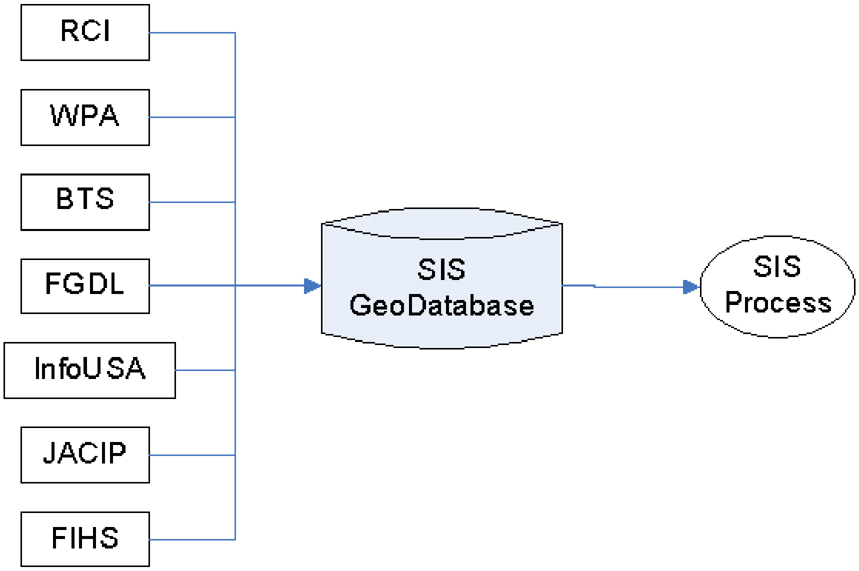


Figure 8. Sources of SIS database

4. FINDINGS AND DISCUSSIONS

Throughout the research process, we mainly followed major planning processes in FDOT and local MPOs. The goal of this research project is to interconnect these main planning processes with the data used and exchanged by each planning process. In order to achieve this goal, the strategy we used was to identify missing connections and relationships between planning processes, and fill the gap of the missing relationships.

4.1 Discrepancy among major street reference data

We found that the discrepancy among street reference data is a major obstacle for data exchange among state level and local agencies. For example, although all state level transportation data are based on RCI linear reference system, most MPO and other local agencies have their own local reference data. In most cases, these local reference datasets are not geographically consistent with each other, nor they are consistent with RCI reference data. To solve these issues, we propose to use D/T reference street data as a mechanism to establish connections between local and state reference data in order to facilitate the exchange of information. D/T is a commercial product for which the FDOT has a site license. D/T is a street dataset of good quality and spatial consistency at the state level and incorporates both state streets and local streets. The relationship between RCI, D/T and local reference data is explained below.

4.1.1 The relationship between local data and D/T

The relationship between local data and D/T is many to many. In some special cases there are no records in each database that correspond to the other database. Most of these exceptions occur in community level streets or new development FDOT Districts where D/T may not be updated as frequently as local reference data. However, in more than 95% of the cases, the relationship between local reference data and D/T is one to many. Figure 9 illustrates the relationships between local data and D/T

Most cases: One (Local) to Many(D/T)

Exceptions: One (Local) to None(D/T)

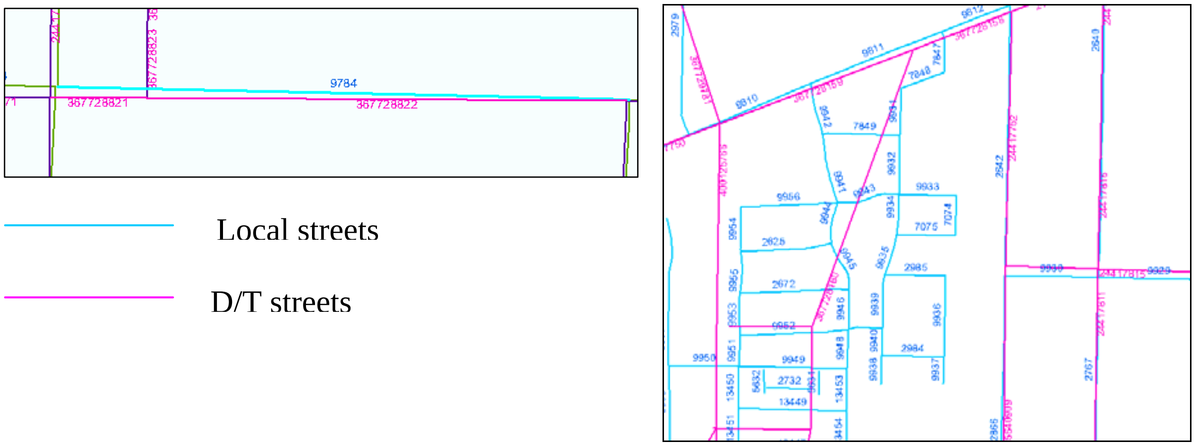


Figure 9. Relationships between local data and D/T

4.1.2 The relationship between D/T and RCI

The relationship between D/T and RCI is many to one: many D/T segments relate to one RCI route. The following figure illustrates this relationship.

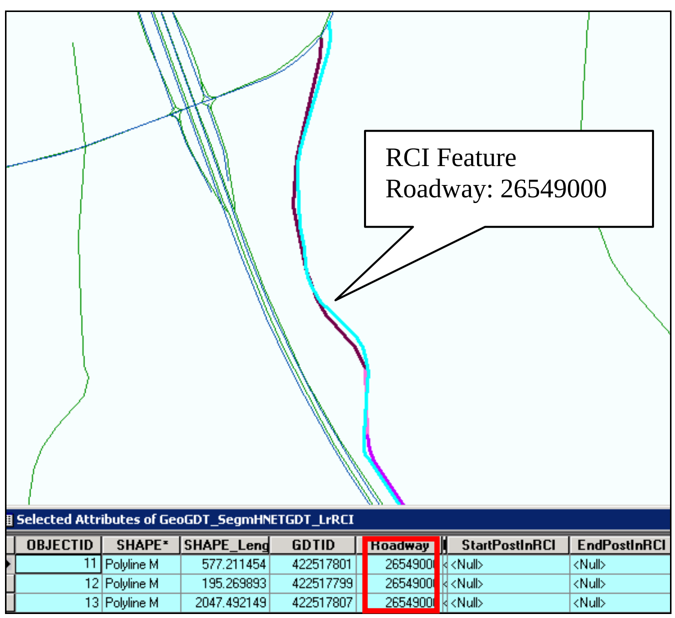


Figure 10. Relationships between D/T and RCI

4.1.3 Issues with original RCI datasets.

We have noticed accuracy problems with the RCI basemap data. Here we explain problems that relate specific to street intersections. The original shapefile of RCI intersections is not very accurate. There are two major problems with the original RCI intersection shapefile.

- The first is related to intersections mapped on two intersecting RCI roadways. For this type of intersection point, every point has two records with corresponding mileposts on each intersecting RCI road. These two points should spatially overlap with each other. However, as shown in figure 11 below that uses the RCI intersection shapefile, they do not overlap.

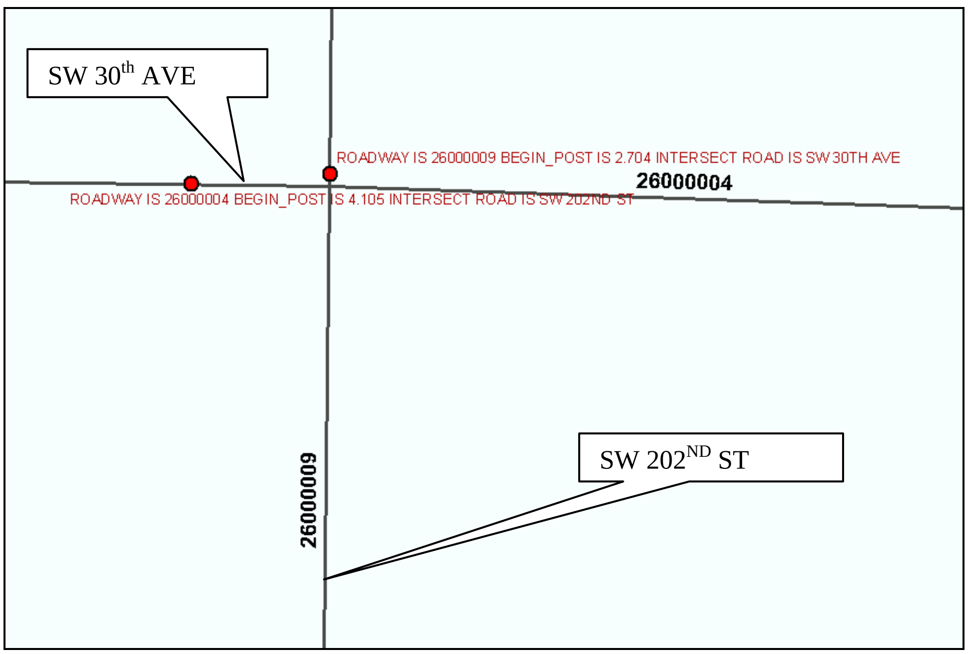
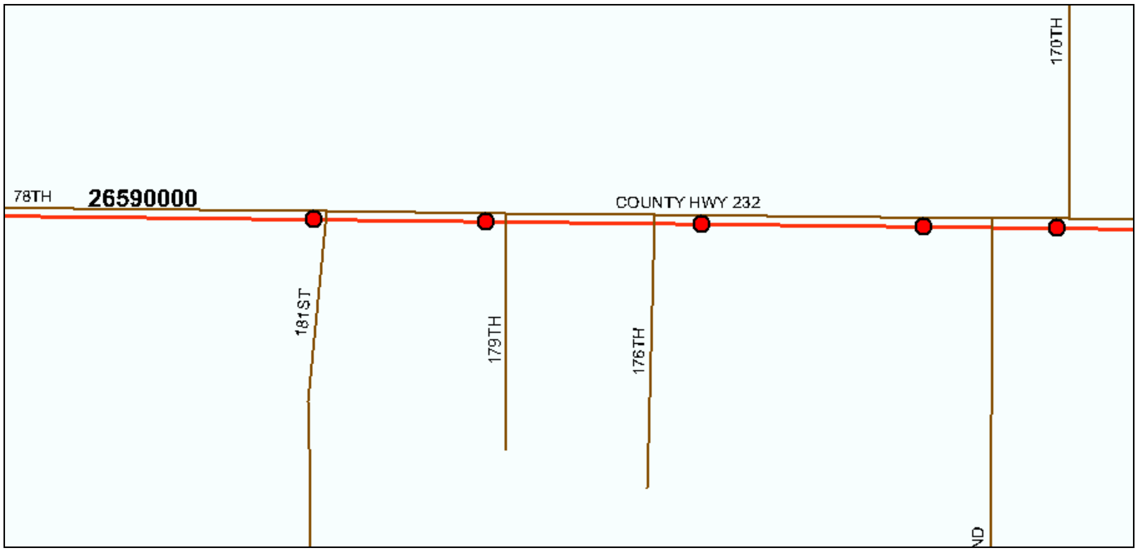


Figure 11. Non-overlapping intersection points

- The second problem concerns intersections of RCI roads and local roads. As the local street shapefiles commonly are not consistent with the RCI basemap, there is some discrepancy between local intersections and intersection points mapped on RCI. The issue can be resolved when both RCI and local streets are based on common geography (e.g. D/T) and the intersection points' mileposts are updated accordingly.



RCI basemap centerline
D/T street centerline
Intersection points in original RCI intersections shapefile

Figure 12. The relationship of RCI intersections and local streets

4.2 Lack of mechanism among LRTP, ETDM, and WPA

Since FDOT recently implemented ETDM as a new transportation planning process, ETDM has played a role in connecting local MPOs' planning processes and FDOT's state level transportation planning. Figure 13 illustrates the planning procedure as it moves from MPOs to FDOT.

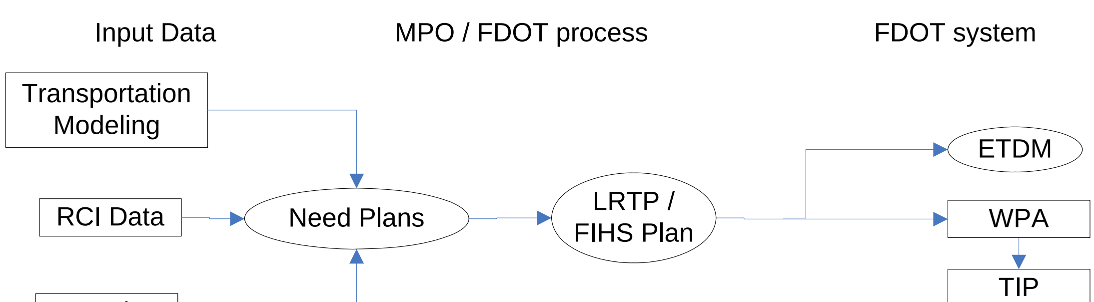


Figure 13. Current transportation planning procedure

At present, local MPOs submit their future projects to both ETDM and WPA. This procedure may present some issues regarding the data connection betweeen MPOs and FDOT.. *First*, this procedure presents redundancy when local MPOs submit the same information to two different systems. *Second*, there is no mechanism to track local projects data in FDOT system. The review of local projects in the FDOT system may vary depending on the types of the projects, budget for the projects, and relationship with other FDOT planning process such as FHIS and/or SIS. One method is to use local project ID. However, the local project ID maybe unique for local projects but is not useful in FDOT system because FDOT handles local projects from multiple jurisdictions. *Last*, there data sharing channel between ETDM and WPA has not been determined yet. ETDM and WPA are the essential processes that local projects should go through after the local projects are submitted to the FDOT system. Coordination among local projects, ETDM and WPA databases is important to avoid redundancies and to allow tracking the local projects in the FDOT system throughout the project lifecycle.

4.3 Data management of multimodal data

Owing to its emphasis upon transit systems and alternative transportation methods, multimodal transportation planning has recently become an important topic in transportation planning. A variety of different multimodal transportation data sources reflect this current trend. From the national level (e.g., National Transportation Atlas Data (NTAD)) to the local level (e.g., local MPOs transit bus stop data), a variety of multimodal data is being used or may possibly be used for transportation planning.

However, multimodal datasets are different from other transportation datasets in terms of the format of data. FDOT's major transportation datasets, RCI, is a linear dataset including several attribute tables that are associated with the linear data through a linear reference system. On the other hand, most of the other multimodal datasets are point data, although some multimodal datasets are lines and polygons. For this reason, multimodal datasets present some difficulties to integrate and manage in a unified system. At present the FDOT doesn't make use of any system that integrates GIS multimodal datasets.

This issue becomes more important for SIS. As described earlier, the SIS is an inter-modal transportation plan that designates facilities, which play a critical role in moving people and goods to and from other nations and states, as well as among economic regions within Florida. By its definition, multimodal datasets are essential data for SIS, and a variety of multimodal data is currently collected and utilized for SIS. This data needs to be organized into a database structure that would support multimodal data input and management for SIS and it should be connected to the rest of the FDOT and external data sources.

4.4 Integration of socio-economic data for transportation planning

In general transportation planning requires many socio-economic data such as land use, points of interest, demographic, employment information and many more. In particular, such data are useful for transportation modeling. However, there are currently no documented database links that connect socio-economic data to existing transportation datasets. The main reason for such lack of data connectivity is the difference in spatial organization of socio-economic data, which are points or polygons and transportation data that are primarily linear. Socio-economic data is usually organized by geographic jurisdictions such as census blocks, Transportation Analysis Zones (TAZs), and county boundaries. These differences and the fact that different applications make use of socio-economic data organized by geographic boundaries at different scales, makes it difficult to develop a standardized database structure to connect socio-economic data to the rest of the transportation planning data.

5. RECOMMENDATIONS

5.1 Information flow in transportation planning process

Due to the implementation of new transportation planning processes such as ETDM and SIS and in order to track local project in the FDOT system we recommend the information flow in the transportation planning process as shown in Figure 14.

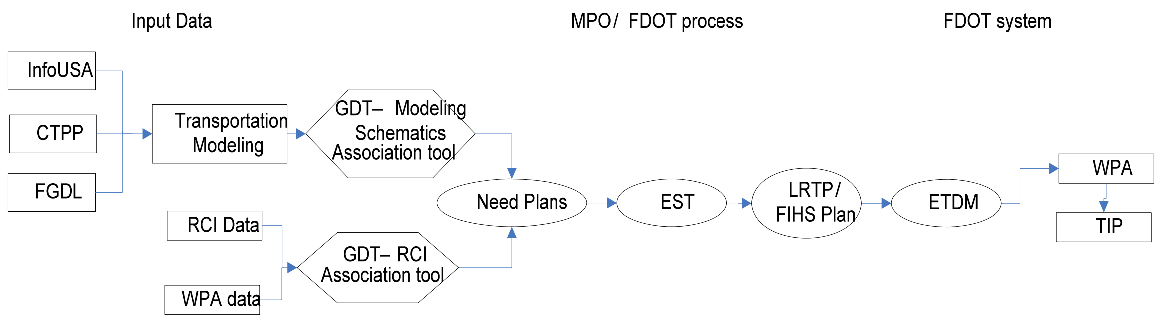


Figure 14. Recommended information flow

This recommendation seeks to facilitate data exchange between local MPOs and FDOT and the data exchange within the FDOT system. In order to support the data exchange between local MPOs planning street network and FDOT's RCI basemap, a data association tool has been developed (the tool will be explained in more details in the following section). The tool associates the unique IDs of the local streets to RCI's roadway ID utilizing D/T data as a middle layer. RCI routes can be ported to D/T streets and RCI events can be mapped against the D/T street network. Local streets can be associated with D/T segments as well, thus facilitating exchange between state and local data.

The other general recommendation is that the LRTP projects data should be loaded and tracked in the ETDM and then the information of only those projects, which get through ETDM's screening process, should be passed to WPA. Links that connect these projects should be established among the three systems -local, ETDM and WPA – to allow tracking of projects from planning to construction. Detailed recommendations are provided below:

- Recommendation 1: One of the well-known problems of current transportation modeling (FUSTMS or GIS-TM) is use of the straight line network which is not geographically accurate. Because of this it is difficult to transfer the results of transportation modeling to other spatial data such as GIS based planning street networks. A conflation method was explored to resolve this problem in the early stage of this project. However, it turned out that less than 20 % of segments can be successfully matched through automatic conflation. Otherwise, the segment match should be manually done. Thus, a semi-automatic data transfer method and application has been developed. This application makes it possible to identify corresponding street segments in two different data sets, and to exchange related attribute data between two data sets. This application allows transferring the results of transportation modeling to local MPOs' street network data.. Ideally, the long term recommendation would be that local MPOs utilize D/T street network. The D/T street network, which is comprised of accurate commercial street network data, has been recently adopted by FDOT and is available to MPOs. If local MPOs use D/T street network data, individual MPOs can be removed from the burden of street data update and management and at the same time all MPOs can have one unified statewide data set. In addition this will facilitate data exchange at the statewide level.
- Recommendation 2: The problem of communication between RCI and local street network is exactly the same as the problem between local street network and transportation modeling. Their primary keys cannot be associated, and they do not spatially overlay each other. The application described in the first recommendation, can facilitate the solution of this problem to support information exchange between these datasets. In the case that local MPOs adapt and use D/T street data, the application allows developing data relationships between D/T and RCI that seamlessly can exchange their data. Once the RCI routes are ported to D/T along with the RCI Linear Referencing System (LRS), all the event tables in the RCI system can be mapped on the D/T layer. WPA data can similarly be mapped on the D/T layer.

- Recommendation 3: ETDM has been recently adopted as a new transportation planning process. As required by this process, local MPOs should submit their capacity improvement to ETDM. Eventually, the approved ETDM projects will be passed to the FDOT WPA. We have two recommendations to address the exchange of information as projects move from the MPOs in the FDOT system.
  First, we recommend that local project information should be uploaded first in the ETDM system before submitted to FDOT WPA. This applies to most projects. There may be exceptions to this general flow for specific projects that don't need to go through ETDM. However we have observed that MPOs are using ETDM as a tool to analyze their projects even before they are required to submit them for formal review or even project that may not need to go through ETDM. This presents an opportunity to use ETDM as a repository of all future projects to create consistency in the information flow from MPOs to the FDOT system. *Second*, we propose to track the local projects from the MPO to FDOT by using project ID associations. E.g. MPO local project ID can be associated with an ETDM project ID which in turn can be associated with WPA project ID. At present it is unclear which WPA field would be used to associate the projects with the ETDM project ID. Potentially FM ID would be a feasible candidate. The choice of the appropriate WPA ID that would be associated with the ETDM ID requires additional discussions among FDOT ETDM and WPA representatives.

5.2 Reference data association tool

As stated earlier, the discrepancy between street reference datasets prevents efficient data exchange among FDOT and local sources. To solve this issue, D/T is utilized as a bridge to connect state and local reference data (Figure 15). D/T street file has the advantage of providing statewide consistent street data that include both state and local streets. By linking both the RCI basemap and local data to the D/T street file, information exchange between them would be feasible. The following sections introduce the concepts, procedures, application tools, and data structure for associating local and state reference datasets through D/T.

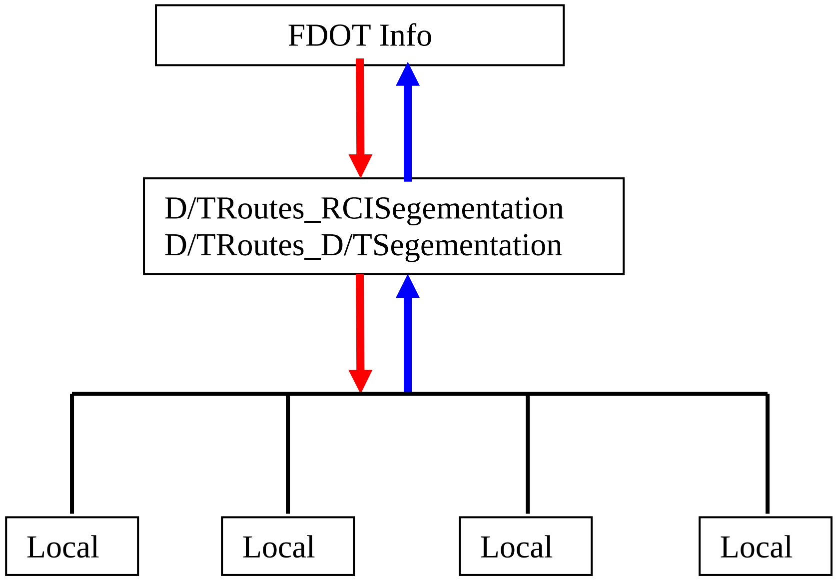


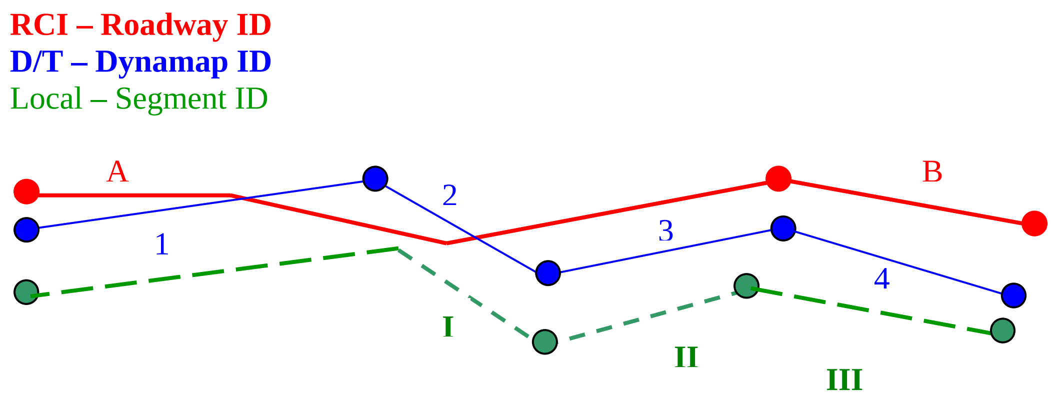
Figure 15. Employing D/T to connect state and local reference data

5.2.1 Concept

This section introduces two data-association models. The first is a simplified model which can handle most association cases with less effort. However, some special cases can not be incorporated into this model. The second model is a complete model which can deal with all possible association cases among RCI, D/T and local reference data. The trade off is that the effort needed to maintain the association among the data sources is more intensive than for the simplified model.

The figure below demonstrates the simplified data-association model. For every D/T segment (using dynamap ID as unique ID), its corresponding Local ID and Roadway ID are recorded. The begin post and end post in roadway are also recorded. With this association in place data can be exchanged among RCI, D/T and local data.

The simplified model is based on two assumptions: the relationship between D/T and Local Street is *many to one* and the relationship between D/T and RCI is also *many to one*. For the first assumption, based on our data exploration, we found that it is true for 95% of the cases. Furthermore, the majority of these exceptions occurs in community streets rather than collector or arterial streets. As such these exceptions will not affect the data exchange between state and local data for planning purposes. No exceptions were found for the second assumption.



DynampID	RoadwayID	BPInRd	EPInRD	Local ID
1	**A**	0	40	**I**
2	**A**	40	65	**I**
3	**A**	65	100	**II**
4	**B**	0	100	**III**

Figure 16. A conceptual diagram of data association

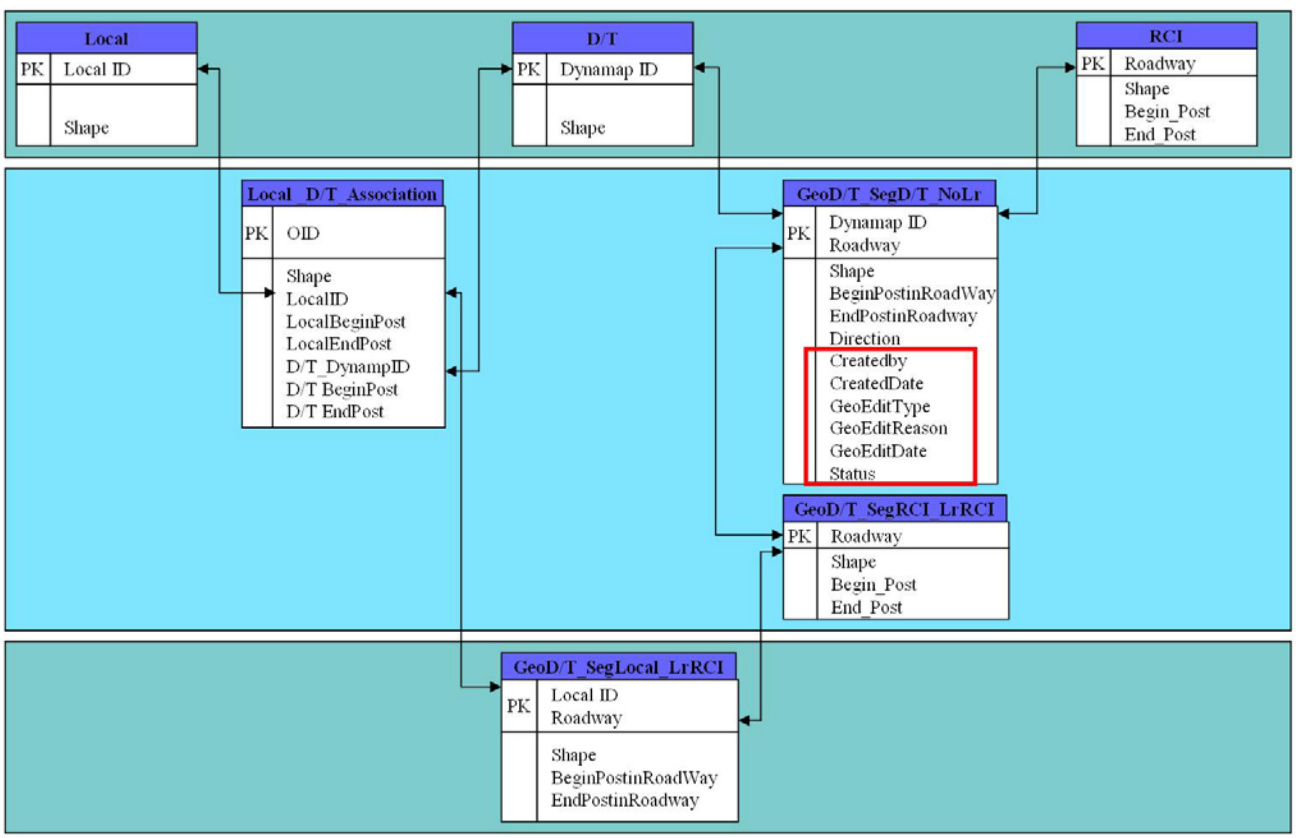


Figure 17. The expanded model for data association

To support all possible relationships between D/T and local data, we have also developed an expanded data model as shown in Figure 17 above. This model can handle the many to many relationship between local reference data and D/T street data, which applies specifically to the case when there are records in local data with no D/T correspondence and vice versa. . The local-D/T association can be a combination. For street segments with a record match in D/T, the geography of D/T is used. Otherwise, local spatial information can be used. This file can handle all the complex relationships between D/T and local. For example, local segmentation that cannot find matchable D/T segments can be recorded in the table with local spatial info, while the D/T_Id will be empty.

As the simplified model is sufficient for building associations between local reference data and state data for most cases, the following recommendations about data association tools and procedures are based on the simplified model.

5.2.2 Database organization

Based on the need for creating and updating the associated datasets, we recommend organizing the data in a geodatabase that is composed of five datasets. They are Original Street Feature, Original RCI Feature, Converted Street Feature, Converted RCI Feature and Connection File for Association. . Each dataset contains several corresponding feature classes. Figure below shows the data structure.

The original street feature dataset contains three reference data, D/T street file, RCI basemap file and a local street file. The original RCI feature dataset can contain any RCI features such as intersections, bridges, AADT etc. These RCI feature files do not affect the base map association procedure. They are kept in the dataset for comparisons. Connection File for Association dataset contains all middle products for reference map convertions. It contains two files, D/TStreet_IDS and GeoD/T_SegRCI_LrNone. D/TStreet_IDS is a file with D/T geography, D/T segmentation and four extra fields: Local ID, Roadway ID, BpinRd and EpinRd. This file records the relationship between RCI, D/T and Local data. GeoD/T_SegRCI_LrNone is derived by D/TStreet_IDS by dissolving the geometry based on roadway ID field. This file has D/T geography, RCI segmentation and no linear referencing information. Converted street feature contains two important outputs, GeoD/T_SegLocal_LrNone and the D/TreferenceLRS file. The D/TreferenceLRS file is a new reference map with D/T geography, RCI segmentation and RCI linear referencing. By using this file all the original RCI features can be re-mapped into the D/T geography.

Original Street Feature	**Original RCI Feature**
D/T Streets RCI Basemap Local Streets	Intersections Bridges AADT

Connection File for Association
D/TStreet_IDS GeoD/T_SegRCI_LrNone

Converted Street Feature	**Converted RCI Feature**
GeoD/T_SegLocal_LrNone D/TreferenceLRS	Intersection_D/TreferenceLRS Bridge_D/TbridgeLRS AADT D/TreferenceLRS

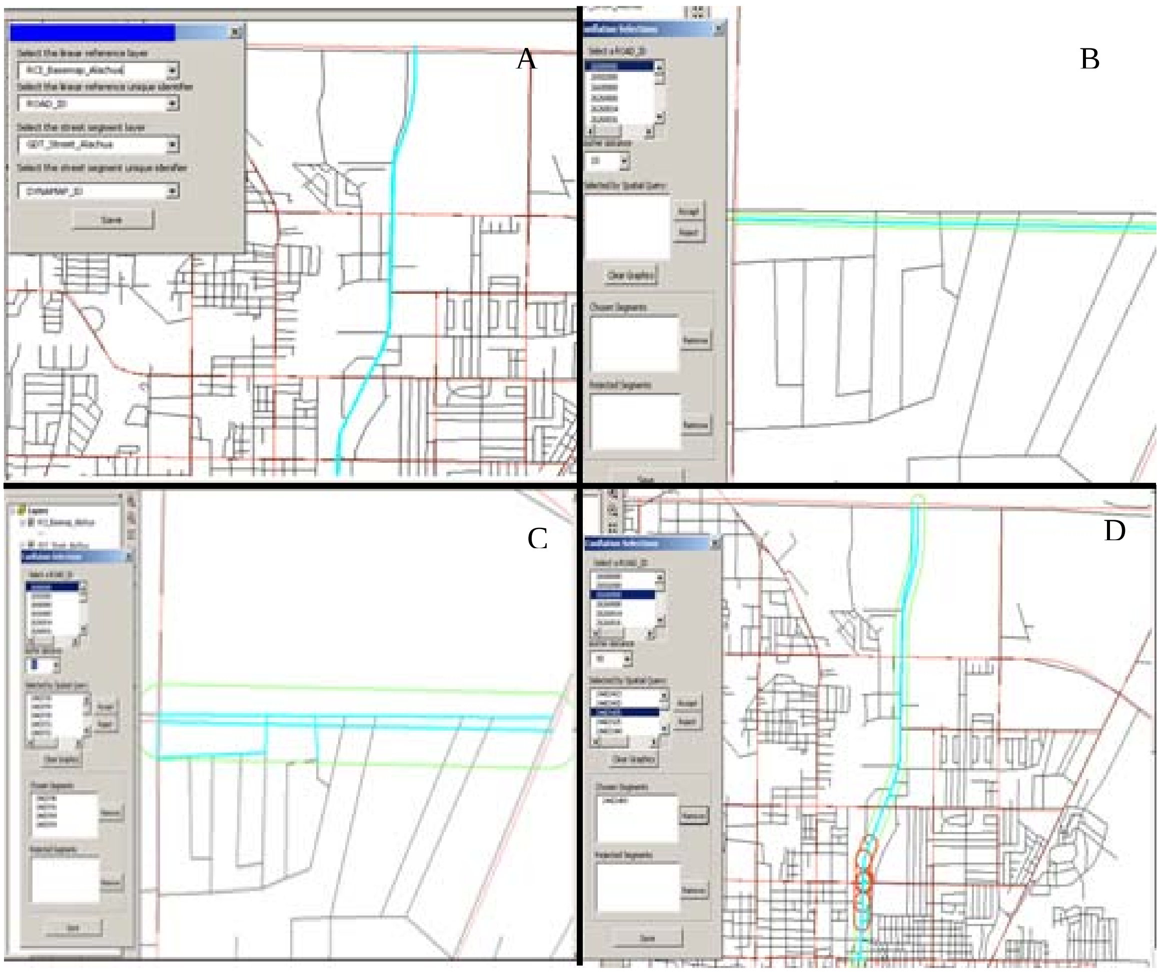
Figure 18. Database organization

5.2.3 Data association methodology

The methodology of creating reference data association involves six steps. They are:

- Dissolve D/T street Shapefile based on Dynamp ID
- Assign Roadway ID and Local ID to D/T Dynamp ID
- Dissolve D/T street Shapefile based on Roadway ID
- Find the Begin Post and End Post for each roadway
- Create new D/T geography reference map based on Roadway ID, Begin Post and End Post
- Verify and correct the direction of RCI routes on the D/T reference map

Among these steps, the second step, assign Roadway ID and Local ID to D/T Dynamap ID, is the most time consuming one. A tool is developed to assist this step. Although several automatic conflation tools are available, none of them is applicable because of the complicated situations among reference data. Due to this complexity we concluded that a fully automated procedure may produce inaccurate results. Instead, we developed a tool that combines automatic selection and manual check. Although the tool provides candidate segments based on a buffer distance, it is the user rather than any formula that makes the final decision about the segment which should be chosen. The user friendly interface improves the efficiency while the user decision guarantees accuracy. The tool is developed in ArcGIS using Visual Basic Application (VBA). The tool user interface is illustrated in Figure 19 below. The tool and the source code is included in the report CDROM.



A) Step 1: Selection of the RCI basemap and the GDT-D/T streets layer as well as primary key field for each
B) Step 2: Selection of an RCI basemap segment and a buffer distance to find the corresponding GDT-D/T segments
C) Step 3: User accepts or rejects GDT-D/T segments that match RCI route as it applies
D) Step 4: Each GDT-D/T segments can be visualized on the screen with a buffer around to assist user's decision to include or exclude it from the correct association

Figure 19. Data Association Tool

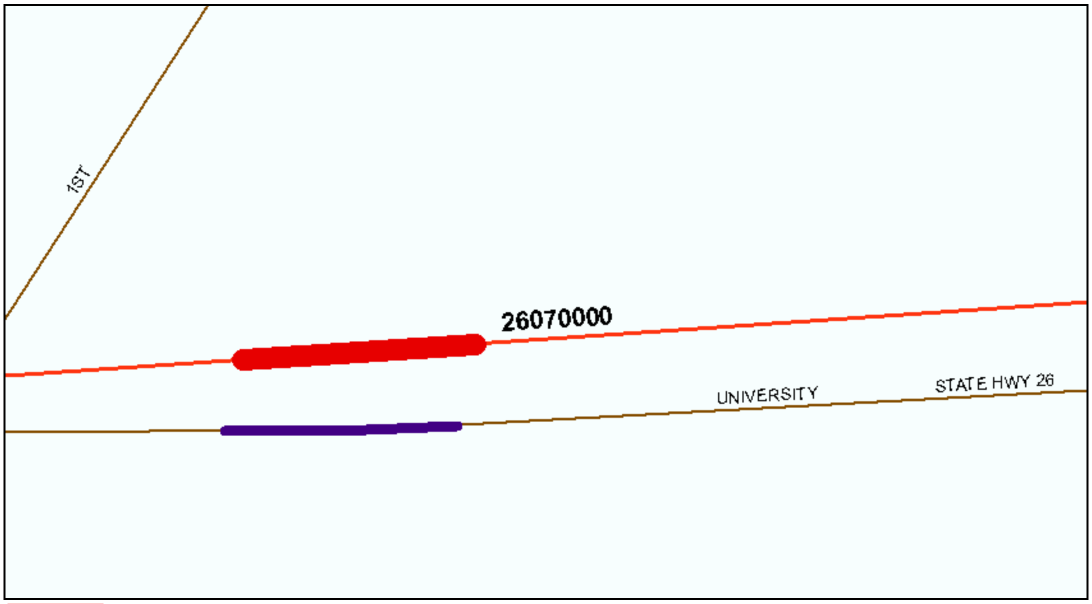
5.2.4 Methodology for updating data association

Since D/T updates data every six months, and RCI also needs to update their basic map occasionally, it would be tedious to recreate the whole reference file for every updating event. To handle this issue, we use some label to record all the changes. When original D/T or RCI files are updated, only those changed segments would be updated in the connecting file and the reason, date and type for updating are also recorded. The update procedure is provided below:

- Label all changes for both new data and original data. The label will be saved in the 'Edited' field
- Loop through all features which have been labeled as "Edited" in both original and new data, update the info in the connection data (D/TStreet_Roadway) and record the reason for editing, and at the same time, label the updated features in "UpdateRef" field
- Update the final linear reference file (D/TBasemapLRS) based on new connection file.

5.2.5 Potential Solutions to RCI issues

When a new D/T geography RCI linear reference dataset is created, it is very straightforward to convert RCI non-basemap features from original RCI basemap geography to D/T geography. Based on the milepost in these features, new shapefiles can be created based on D/T geography linear reference basemap. This procedure also provides us an opportunity to correct some of the issues noted in chapter 4, such as the location of street intersections. For example, in the case when the same intersection is mapped inaccurately in two different roadways, we can measure the intersection milepost value from the D/T layer and adjust the intersection milepost in the RCI event table. The same idea can be applied to the intersections of RCI routes to local streets provided that both RCI basemap and local streets are migrated to the common geography (e.g. D/T)., However, not all RCI events e.g. bridges or AADT, can be validated in the conversion process due to the lack of a static the physical reference. Because D/T geography and RCI basemap geography may be very close, while features based on new D/T geography reference map may be mapped close to the RCI original location, some discrepancy may still remain for dynamic events that don't have a physical reference that can be used to adjust the locations.



Bridge line based on original RCI basemap
Bridge line based on new D/T geography reference map

Figure 20. Line features on original RCI basemap and new D/T geography basemap

5.3 Network Dataset for multimodal data

In order to address the complexity of multimodal datasets, we recommend adopting ESRI's new data model, the network dataset. Among many application, SIS is the one that may benefit from this model the most due to its capabilities for handling multimodal datasets. In this section, we introduce briefly the concepts of network dataset, and explain its application to the SIS process.

5.3.1 Network dataset concept

Networks are conceptually simple. They are comprised of two fundamental components, edges and junctions. Streets, transmission lines, pipe, and stream reaches are examples of edges. Street intersections, fuses, switches, service taps, and the confluence of stream reaches are examples of junctions. Edges connect together at junctions, and the flow from one edge. Automobiles, electrons, water can be transferred to another edge (ESRI Network Model 2005).

A network dataset contains network elements built from features in network sources. Network elements are made from features when a network data set is built. The network elements and their connectivity are discovered by finding geometric coincidences of points, polyline endpoints, and polyline vertices. The network elements and connectivity information are stored in the logical network, a set of element and index tables inside a network data set. Edges are network elements that connect junctions. Edges are the links over which resources flow. Each edge has exactly two junctions. Junctions connect edges and facilitate navigation. A junction may be connected to one or many edges. Turns record information about a sequence of two or more connected edges. Turns model restrictions, such as no left turns, and additional costs of travel for turns.

A network data set allows creating and managing sophisticated network data sets and generating routing solutions. ArcGIS Network Analyst is a powerful extension for routing, and will provide a whole new framework for network-based spatial analysis (i.e., location analysis, drive time analysis, and spatial interaction modeling). This extension allows modeling realistic network conditions and scenarios. ArcGIS Network Analyst enables the user to solve a variety of problems using geographic networks. Tasks such as finding the most efficient travel route, generating travel directions, finding the closest facility, or defining service areas based on travel time become greatly simplified (http://www.esri.com/software/arcgis/extensions/networkanalyst/about/multi-modal.html). With ArcGIS Network Analyst, users can dynamically model realistic network conditions, including turn restrictions, speed limits, height restrictions, and traffic conditions, at different times of the day. Using a sophisticated network data model, users can easily build networks from their GIS data.

5.3.2 Network dataset for SIS

The new network data set in ArcGIS 9.1 incorporates an advanced connectivity model that can represent complex scenarios such as multi-modal transportation networks. This enables users to efficiently model multiple forms of transportation across a single data set by using points of coincidence, such as rail stations or bus stops, which form the linkages between several different forms of transportation. This is a more accurate representation of real-world integrated transportation networks and it can support transportation modeling. Multimodal networks allow organizations in both the public and private sector to better perform transportation planning analysis and accessibility modeling. End-user services, such as trip planners, can easily be created that combine multiple forms of transport such as rail and bus. For example, a regional transportation authority can establish a trip planner that shows passengers how to access light rail, bus line, subway, and other networks.

Sophisticated users and developers can implement their own custom solvers to take advantage of the powerful network data set and its multimodal attribution for generating transportation modeling. The network data set offers a robust data management structure for creating, editing, and maintaining network data.

This feature of network data set has great advantages for integrating SIS data sets. SIS data sets include a variety of polylines and points that represent transportation routes and hubs. These hubs and routes are many multimodal transportation facilities such as airports, seaports, passenger terminals, roadways, railways, and waterways. Network data set allows connecting all of those hubs and routes, managing all the data sets as one data set, and applying to further analysis such as finding the best route and finding the closest facilities. However, building a network data set requires that the network be seamlessly connected. This presents some difficulties due to the following issues with the SIS database.

First, the RCI base map is not seamlessly connected. The roadway data set in SIS database is developed from the RCI base map. However, many gaps present in the RCI base map make it difficult to build a network data out of the roadway data. All of the gaps in the RCI base map should be found and connected to proper segments. To reduce the problems with this issue, other sources of road data, such as D/T, can be used to build the network data set.

Second, hubs and routes in SIS database should be connected. SIS database contains two different types of data sets, transportation hubs represented by points (e.g., airports, seaports, passenger terminals, and freight terminals) and transportation routes represented by lines (e.g., roadways, waterways, high speed railways, and railways). There are currently no connections between these two data sets. In order to a build network dataset, the hubs and routes must be connected to each other. Local knowledge is necessary in order to connect hubs and routes. Additionally, reference data such as aerial photography can be useful to identify connectivity between hubs and routes. *Third*, several data sets are required for network analysis. The network analysis is based on weights used to store the cost of traversing across an edge or through a junction. There are several different types of data that can improve weight in network analysis such as turns, direction, cost and barriers.

Turns refer to automobiles' turning directions. Network data set can store possible turning directions at each intersection, and uses such information for more realistic simulation of transportation flow. Another data is line direction. One example for direction is a one-way street. Network data set allows a user to specify one-way streets which prevents vehicles from driving in the opposite direction. Another variable that can be used as weight is cost. Cost can include a variety of factors that affect travel through a route. A typical cost variable is the travel distance. Time, slope, speed limit, and average daily traffic can be also used as cost factors. Last, barriers can be used to achieve more accurate network analysis. Barriers are used to represent disabled network elements. In the case when roadway construction is going on or a freight station is temporarily closed, a user can apply such instances as barriers, and perform more realistic simulation. SIS geodatabase currently lacks this information. Thus, all the necessary information needed for network analysis should be collected and added to the network data set.

5.3.3 Pilot study: construction of network dataset for Tampa and St. Petersburg area

In order to explore the possibility of network for SIS database integration, we build a sample network data set using the SIS data for Tampa and St. Petersburg. These two areas contain four different types of transportation hubs and three different types of transportation routes, hubs, and connectors. The hubs refer transportation facilities such as airport, seaports, and terminals. The routes are transportation corridors such as roadways, railways, and waterways. The connectors refer to streets seamlessly connected to the hubs and routes. Figure 21 illustrates the conceptual database structure of the SIS network dataset.

In order to create the network dataset, the first step was to collect necessary data. The data for hubs and routes were extracted from SIS geodatabase except railway and roadway. RCI basemap coverage was used for roadway. No alternative data sets (not in SIS) were found for waterway data. D/T data is used for the railway data, although even this dataset did have some connectivity issues. For roadway data, two alternative data sets were tested: D/T and RCI. The first data set used for SIS network data set was the RCI base map. All the street segments in this base map are connected to each other, and in some cases, dummy segments are used to connect broken street segments. Two geodatabases, one based on RCI and the other based on D/T were created.

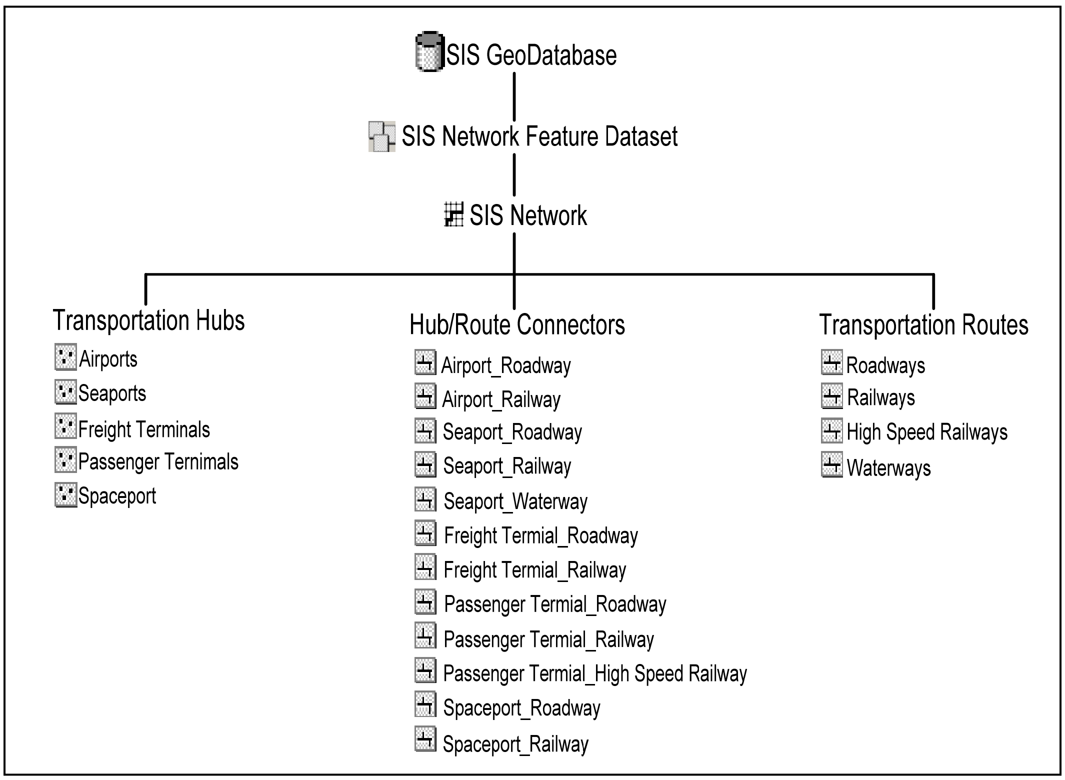


Figure 21. Database structure of the SIS network dataset

Connectors were constructed next. These connectors are line segments connecting transportation hubs (points) and transportation routes (polylines). Since there is no information available that can be used to identify accurate connections, the hubs are connected with straight lines to the closest routes. Constructing connectors was a manual process. The connectors must be properly snapped on both hubs and routes to ensure that all the line segments are seamlessly connected.

After collecting and creating all the data, we imported all the data into a geodatabase. Each data set should be stored as a feature class under a feature dataset. The feature classes in the geodatabase can be classified into the following three categories.

- Transportation Hubs
    - Airports
    - FRT_terminals (freight terminals)
    - Pass_terminals (passenger terminals)
    - Seaports
- Transportation Routes
    - Arc_highways (RCI base map)
    - Railways_D/T (D/T railroad data)
    - Waterways (SIS waterway data)
- Connectors
    - Air_rail_con (connector between airports and railways)
    - Air_road_con (connector between airports and roadways)
    - FRT_rail_con (connector between freight terminals and railways)
    - FRT_road_con (connector between freight terminals and roadways)
    - Pass_rail_con (connector between passenger terminals and railways)
    - Pass_road_con (connector between passenger terminals and roadways)
    - Port_rail_con (connector between seaports and railways)
    - Port_road_con (connector between seaports and roadways)
    - Port_water_con (connector between seaports and waterways)

Next, the network dataset was created based on the given feature classes. This involves several steps clearly documented in ArcCatalog. One step that should be clarified is the establishment of connectivity. In most networks, not all edge types can logically be connected to all junction types. Similarly, not all edge types can logically be connected to all other edge types through all junction types. This is controlled by connectivity rules which constrain the type of network features that may be connected to another type, and the number of features of any particular type that can be connected to features of another type. For example, a seaport may be connected to waterways, railways, and roadways, but an airport may not necessarily be connected to waterways. Figure 22 illustrates the network data set that integrates transportation hubs, routes and connectors.

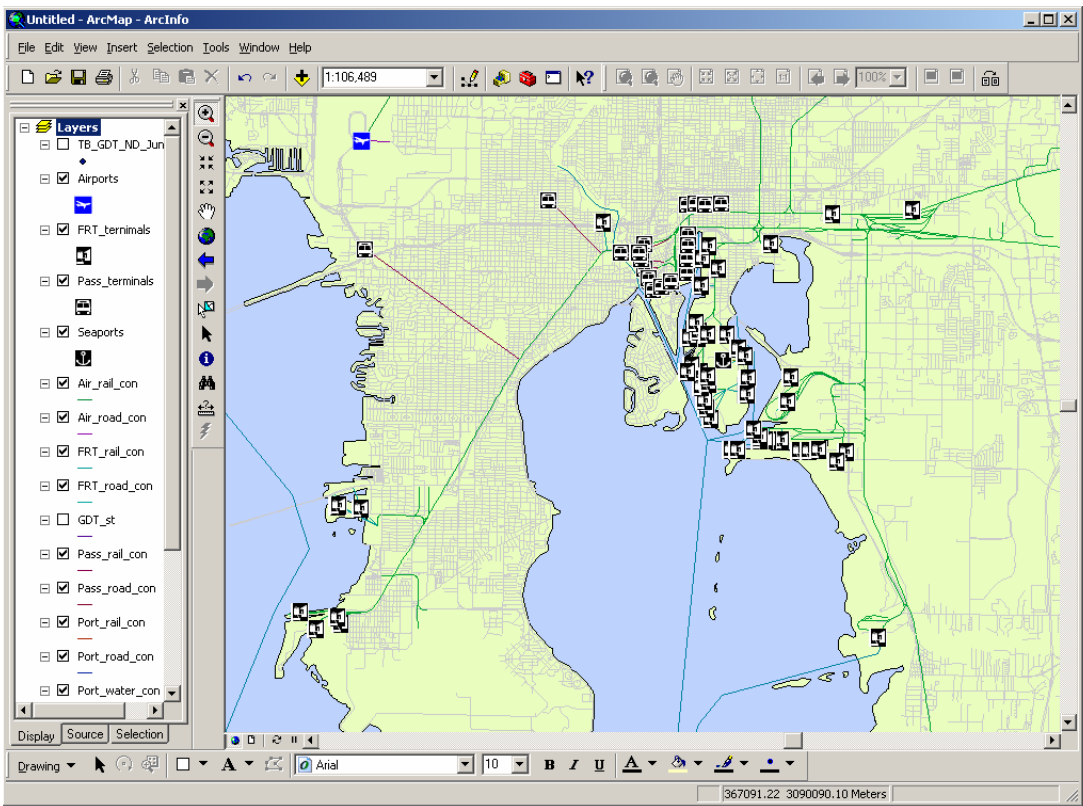


Figure 22. Network dataset for SIS in Tampa and St. Petersburg area

5.3.4 Recommended database structure for SIS

In the case when the SIS process may incorporate a network dataset, all the multimodal datasets can be integrated and managed by the network dataset. Thus recommendations for SIS process can be summarized into two categories. Figure 23 compares the current database framework to the database framework that we recommend. Since the network dataset includes all the necessary datasets that are required for the SIS process, the network dataset can be used as the database organization structure for SIS.

Additionally, it is recommended to utilize more socio-economic data in addition to currently used socio-economic data. The SIS process considers transportation facilities that have greater possibilities for services of statewide and interregional significance, with links to Florida's transportation policies and investments and to the state's economic development strategy. Thus, rich socio-economic data can support the SIS facility review process.. These recommended data can be organized by county and can be integrated with current socio-economic data. Since the SIS process is a state-wide planning process, the county level data may be suitable.

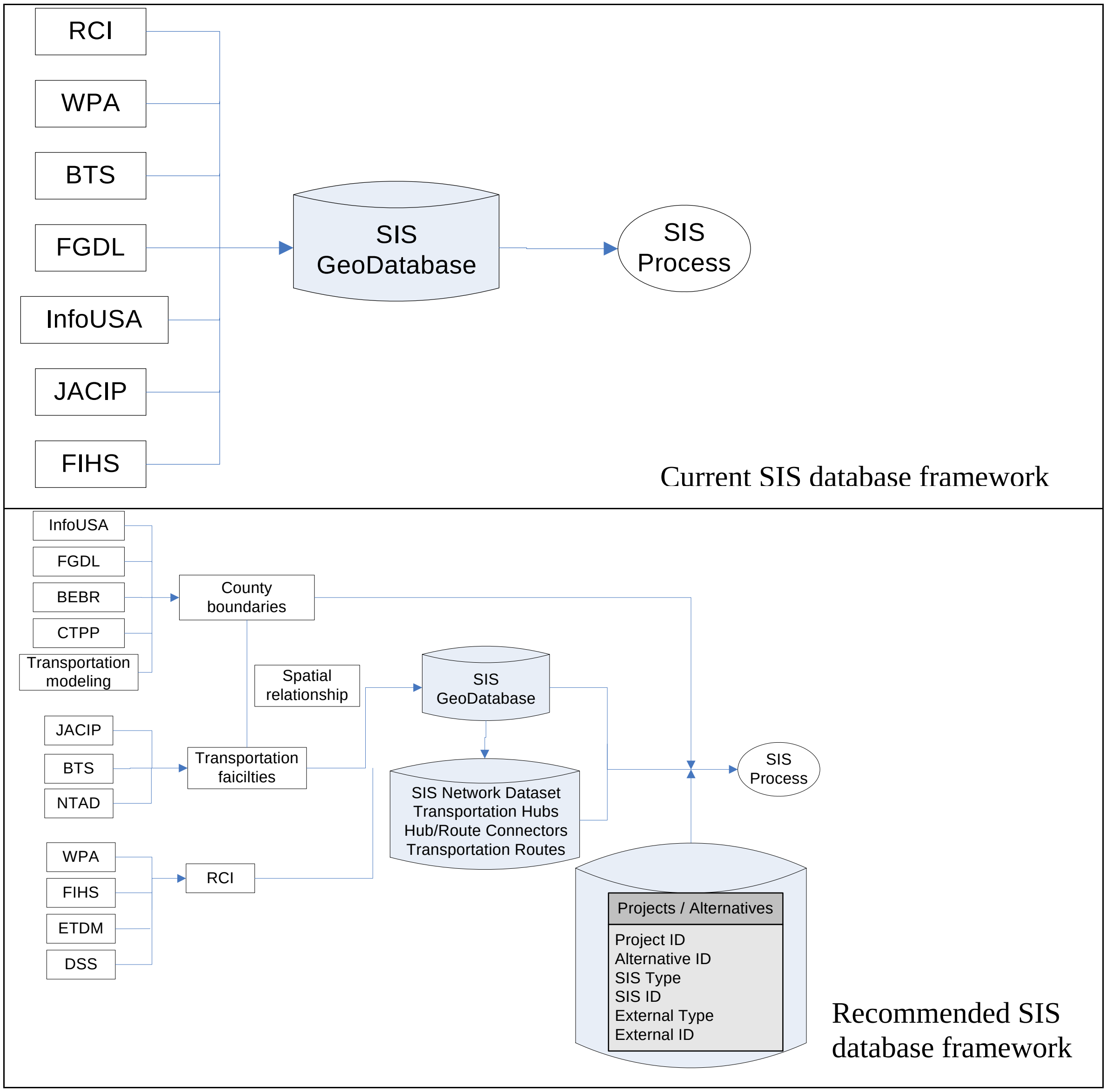


Figure 23. Comparison of the current and recommended SIS database framework

5.3.5 Future Considerations

In addition to issues identified earlier, there are several concerns regarding the integration of the SIS network data set and other transportation data and related applications. *First,* relations between network data set and RCI linear referencing system should be considered. FDOT's RCI system uses a linear referencing system in order to store and map related transportation information. When the transportation information of RCI is joined to a network data set, the network data set has the potential to support information rich analysis application tools. Some information of RCI can be associated with network data sets as cost weight. Network dataset can handle only one weight. This requires that, complex cost variables from RCI must be aggregated before being applied to the network dataset.

Second, the use of D/T street data for SIS network data set should be explored. In this project, a network data set was constructed using D/T street data. Overall D/T street data matched well with other data sets and the network data was created successfully. The D/T street data used for this project was limited to the Tampa and the St. Petersburg areas. Further experimentation will be needed for a statewide implementation.

Last, it is important to develop methods that can make use of a network data set. As we describe briefly above, the network dataset can be utilized for network analysis. Provided the network data set is equipped with proper information, it can be useful for SIS prioritization process. In order to utilize network data set for further analysis, first of all, the purpose and scope of the analysis should be clearly defined. Then, all of the necessary information should be collected, and carefully weighted for the purpose of the analysis. As the weighted information is added to a network dataset as costs or barriers, the network dataset may be used to prioritize possible roadway projects based on the costs and barriers. However we don't recommend this a s replacement for the SIS prioritization process but rather as an enhancement that allows consideration of additional variables.

5.4 Integration of socio-economic data with transportation planning

We classified all the reviewed socio-economic datasets by the formats of datasets such as polygons, points and non-spatial or attributes only. Datasets in the polygon format are mainly spatial data (GIS data) organized by geographical boundaries such as census tracks or TAZs. Census data, FGDL data, and parcel data belong to this category. Attribute only data include datasets such as CTPP and BEBR. These datasets are organized by unique IDs that serve as identifiers for geographic boundaries (e.g., county

FIPS code), but they don't have a spatial component. Socio-economic spatial point data include data used for transportation modeling such InfoUSA employment data. Based on this classification, we put forward two different recommendations, organization of socio-economic data by geographic jurisdictions and the InfoUSA data model. The first recommendation is to address polygon and attribute socio-economic data and the second one is for the point data..

5.4.1 Organization of socio-economic data by geographic jurisdictions

Many socio-economic data are provided in tabular format and contain unique identifiers that represent geographic boundaries. This offers the opportunity to connect non-spatial and spatial data by associating them using unique IDs. The level of associations can change based on the application needs. For example, the transportation modeling process needs socio-economic datasets at TAZ level, while SIS may require socio-economic data by county. Thus organizing socio-economic data and their associations by a variety of geographic boundaries can serve multiple planning purposes, and may reduce data redundancy.

Figure 24 illustrates an example of data connectivity between CTPP data and transportation modeling process. The CTPP data is organized by TAZs, which match Zone data organization used in the FSUTM transportation modeling application. Other attribute and polygon data can be connected to the transportation modeling data in the same way. The abundant socio-economic information can support the transportation modeling process to make better projections of future traffic demands. On the other hand, the socio-economic data organized by TAZs can also be useful information to improve decision making in the LRTP process by providing a wide spectrum of socio-economic characteristics for a particular study area.

5.4.2 InfoUSA data model

InfoUSA provides two important datasets, business data and household data. Business data contains information about location, company name, employee number and type of

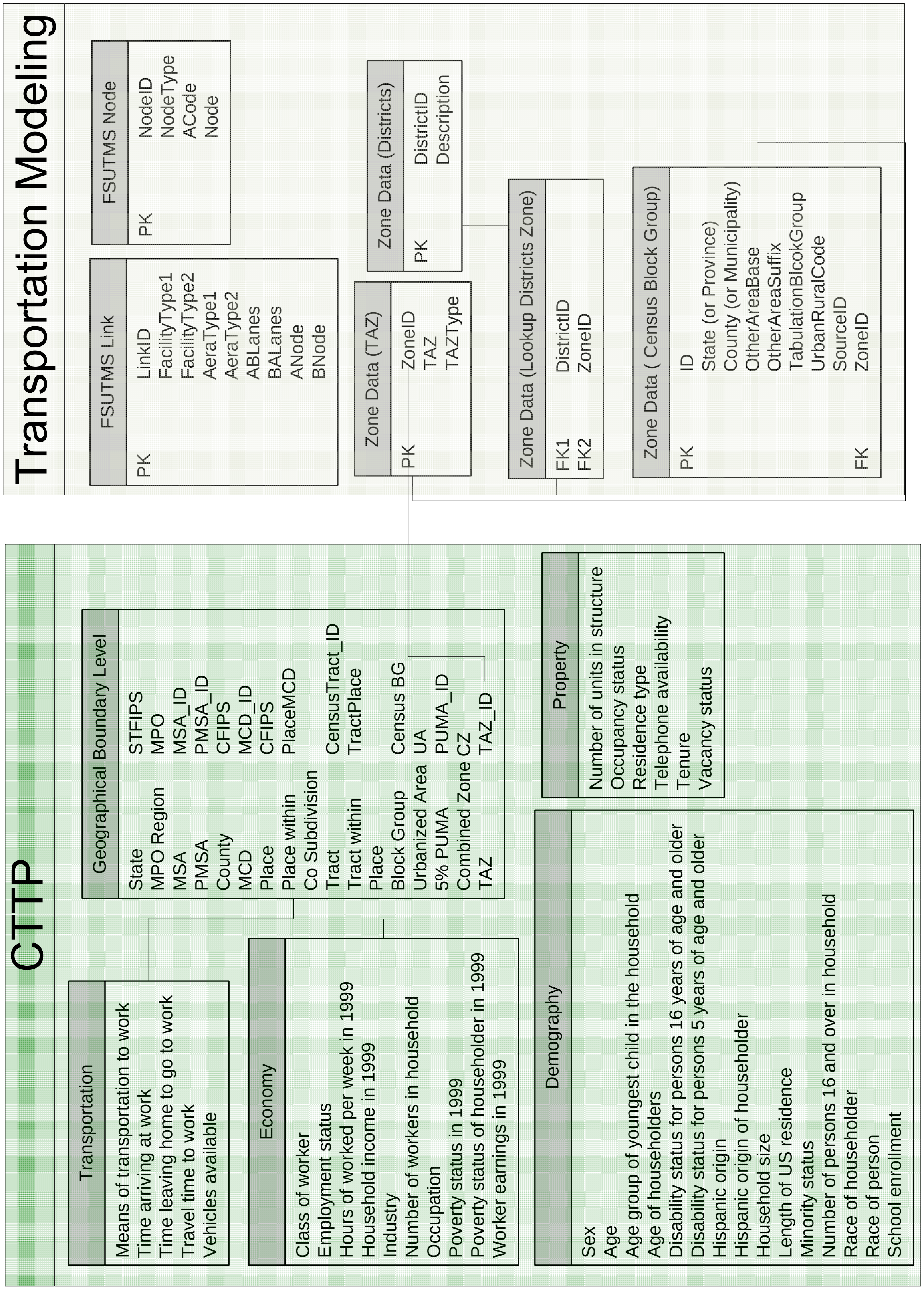


Figure 24. Data connectivity between CTPP and transportation modeling

industry. Household data contains information about location, income, population and number of automobiles. Both business and household datasets provide important information for transportation planning, especially, for zdata. At present, FDOT makes use of only the InfoUSA business dataset.

InfoUSA is an important source of socio-economic data for transportation planning. However, there are several concerns about the location accuracy of infoUSA records. One example is the discrepancy between county code and spatial location. The following part explores the issues with infoUSA location accuracy and proposes a method to solve these issues. Alachua County InfoUSA data is used for demonstration.

5.4.2.1 Accuracy at the county level

By querying the county code field, 8398 records are attributed as located in the Alachua County boundary while 301 of them fall outside the county boundary (Figure 25).

Method	Total	Consistent	Inconsistent	Error
By code	8398	8097	301	3.58%
By spatial location	8100	8097	3	0.04%

Table 4. Alachua County InfoUSA data accuracy

At the same time, 8100 records are spatially located in the Alachua County boundary while three of these records are attributed to a neighboring County and all three points are located close to the boundary. The error rate by county code is about 4%. At the same time, the error rate by spatial location is only about 0.04%. Furthermore, for the 301 records that fall out of the county limit, only 10 of them can find corresponding parcels with the same address. The match rate is 3%, which is much lower than the overall parcel address match rate, which is about 60%. All these information implies that at the county level, the spatial location may be more reliable than the county code.

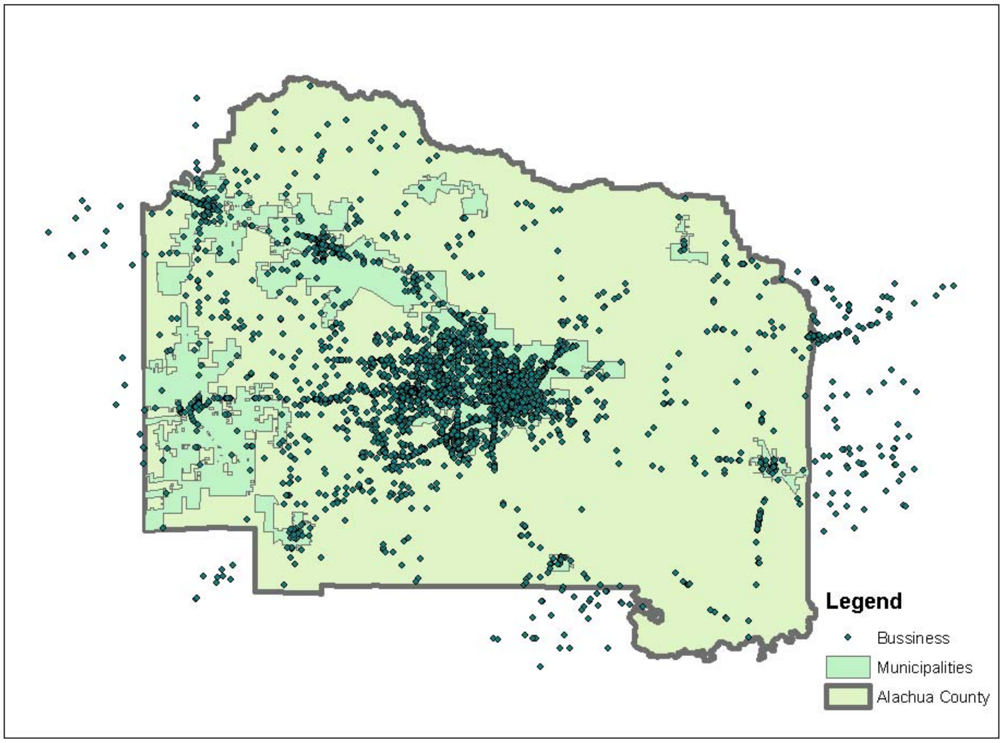


Figure 25. Business records attributed as falling in Alachua County

5.4.2.2 Accuracy in TAZ level

To find the accuracy of InfoUSA location in the TAZ level, we linked this dataset to parcel data by standardized addresses. Among the 8100 records which fall in the Alachua County limit, 5027 of them can be linked to a parcel based on standardized addresses. The match rate is around 63%. Among the matched 5027 records, 1182 records, which are about 24% of the matched records and 14.6% of all records in Alachua, fall in different TAZ districts than those that fall in parcels. The figure below shows that these records (points highlighted) all are close to the TAZ boundary but may be on the wrong side. This implies that that the accuracy of infoUSA location needs improvement.

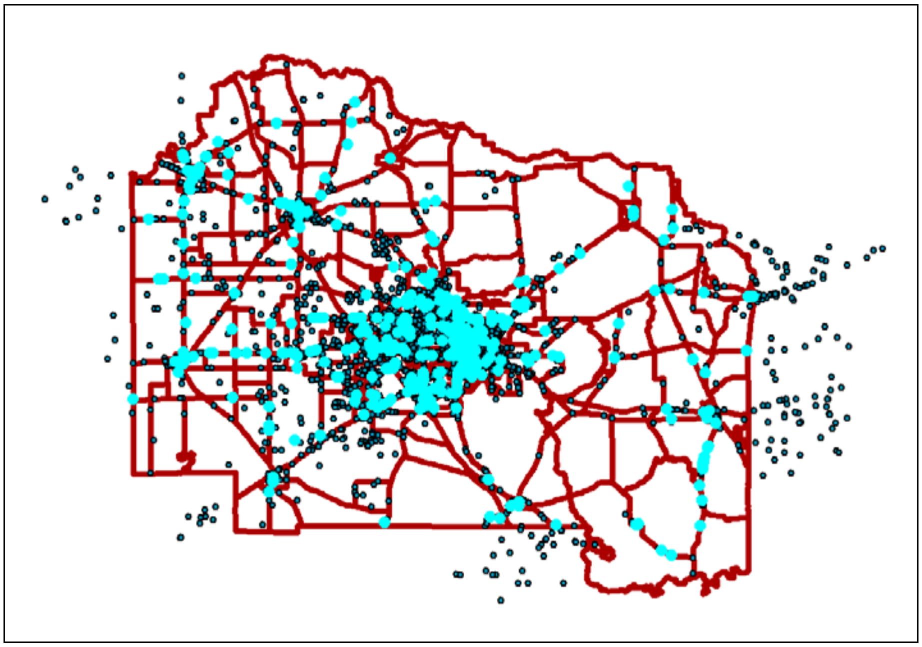


Figure 26. Business records fall in wrong TAZ

5.4.2.3 Method to improve InfoUSA location accuracy

Spatial location accuracy of InfoUSA data can be improved by geocoding based on parcel data for records that have regular street addresses.. Although street geocoding can also be an option, as this method derives location by assuming street addresses increase proportionally, it may introduce more problems than it can solve. Furthermore, D/T Street that is typically used for geocoding is not consistent with TAZ boundaries. Based on these considerations, we recommend validating and improving InfoUSA location quality by using parcel data.

Assuming that parcel data is more accurate for spatial location of businesses, parcel data can provide the most accurate location and TAZ ID for InfoUSA. The higher the match rate, the larger the number of records with better locational accuracy. There are two major obstacles in connecting InfoUSA's addresses with parcel data addresses. First, not all county appraiser offices are collecting location addresses for parcels. For example, Alachua County began to collect the parcel's address in addition to the owner's mail address in 2004. Although most parcels do contain a location address, still there are parcels that do not have the location address. Second, the quality and format of the address recorded are somewhat inconsistent between records. For example, for some records, there are two text spaces between street directions and street names whereas for other records there is only one text space. Moreover, in contrast to some records in which street types such as Street, Road and Avenue are recorded in full, for many records abbreviations like St, Rd and Ave are used. For example, "115 NW 10th ST" is also documented as "115 NW 10 Street". As the mechanism of parcel address matching is address text string comparison, the spelling variation could reduce matching rate significantly. To maximize the match rate, we suggest the following method.

- Standardizing addresses in InfoUSA dataset with the help of ArcGIS geocoding engine
- Standardizing addresses in parcel dataset with the help of ArcGIS geocoding engine
- Get the central point for all parcels, find the corresponding TAZ ID of each parcel's central point by the spatial join function provided by ArcGIS
- By linking the standardized address in InfoUSA with the standardized address in parcel's central point data, get the correct TAZ ID for matched business record.

5.4.2.4 Database Connectivity

Although InfoUSA provides location information in addition to X, Y coordinates, such as county code, zip code, zip-10 code and census block group ID, none of them is useful in determining the TAZ for each business point due to the fact that generally they may relate to more than one TAZ. The best link between InfoUSA and TAZ is a spatial location provided that the location accuracy is improved. When TAZ and InfoUSA datasets are connected, Zdata for transportation modeling, like HotelTotal, EmpInd and so on can be derived quickly. Figure below shows the database diagram for linking InfoUSA to Zdata through parcel data.

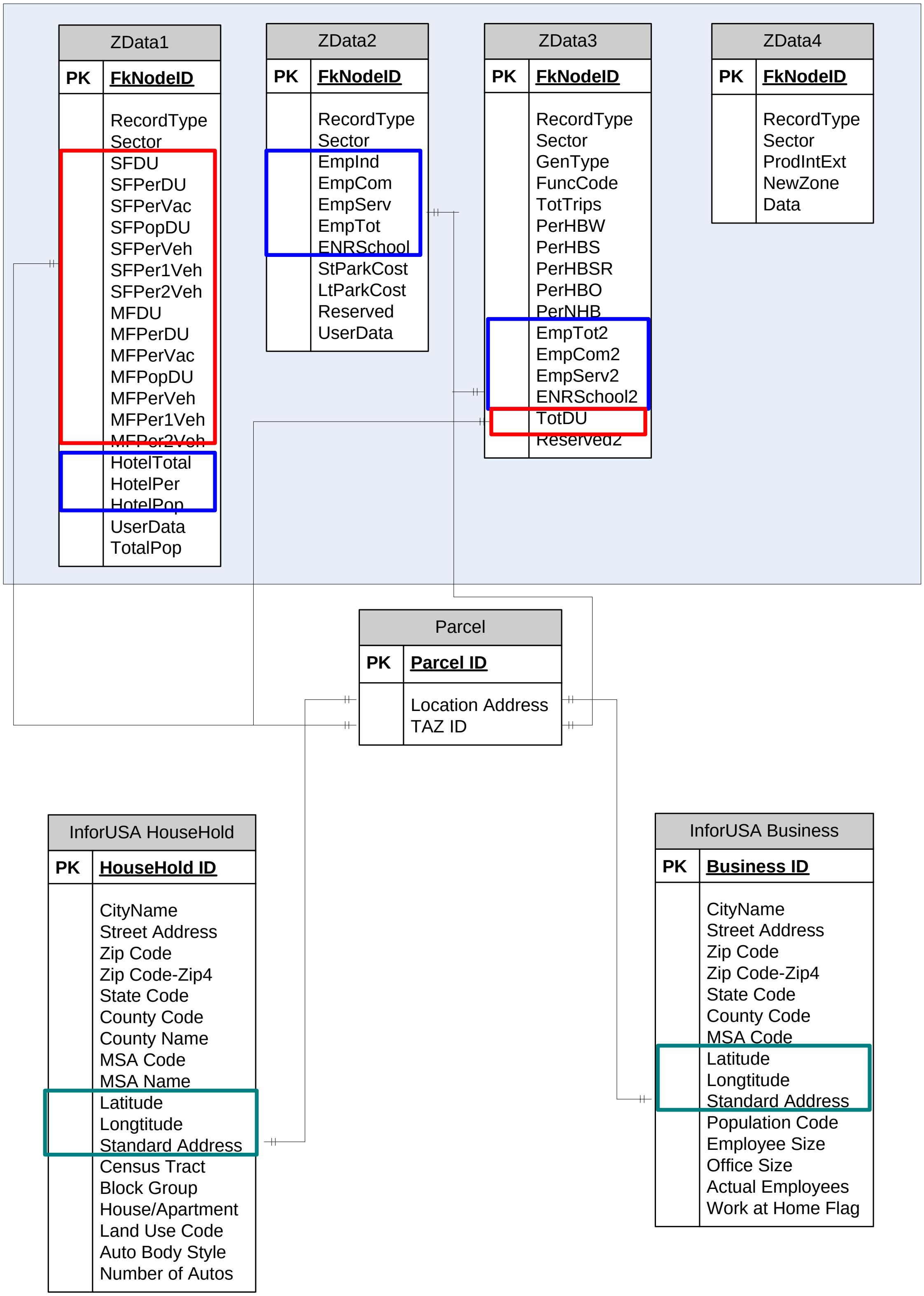


Figure 27. Connection of InfoUSA with TAZ

5.5 Diagram of the connected database framework

Based on the recommendations and solutions presented in this research, we have developed a connected database framework that can support multimodal transportation planning. This framework is presented in the diagram of Appendix 3. It includes all the datasets of the focus areas that we identified in earlier stages of this research as well as a flow chart of the transportation planning process in Florida with the inclusion of the ETDM process.

The flow chart part of the diagram under the heading ‘Florida Transportation Planning’, illustrates the recommended information connectivity mechanisms for the information flow between local MPOs and FDOT presented in the recommendation section of this report.

The database part of the diagram is organized in 6 main sections grouped in two categories which are illustrated by different colors. The first category contains the data organized by type. It includes Socio-economic data shown in purple, the Roadway Reference data shown in light blue and Transportation Facilities data shown in orange. The second category includes data that pertain to specific application areas such as ETDM data shown in brown, SIS data shown in pink and Transportation Modeling data shown in yellow. The major databases are related through unique IDs or spatial relationships.

The data presented in the connected database framework can be organized in a physical geospatial relational database, for example, in a geodatabase. This geodatabase can support different levels of transportation planning and related applications. Although the actual implementation of such database may vary depending on needs, the database may include additional local data which can be integrated by establishing links to the applicable existing data.

6. CONCLUSIONS

This research aimed at developing a connected database framework for transportation planning in order to facilitate GIS information flow in different stages of planning. The research focused on identifying the missing links and developed methodologies to establish connections among a variety of databases such as local reference data, the department reference basemap, socio-economic and multimodal transportation planning data. First, we recommend makes use of a state-wide GIS street reference system to mediate the exchange of information between local MPO street network and FDOT's RCI basemap. The same reference can be used to facilitate the exchange between FSUTMS stick network and the department basemap. D/T streets, a commercial product purchased recently by FDOT, can serve as such reference. This solution is supported by a GIS data association tool that can help transfer attributes between linear reference data system. Second, to enable tracking of local transportation projects from MPOs' LRTP to ETDM and to the WPA in the FDOT system we propose a database structure with linkages that would allow access to project information from inception at the planning level to construction and eventually to RCI. Third, we recommend adopting ESRI's network dataset for integrating multimodal transportation planning data. The network dataset would be appropriate as a data structure for management of SIS multimodal data as well as for related networking application. Last, in order to integrate socio-economic data in the transportation planning database framework we recommend relating most of the socio-economic polygon data by a combination of common attributes and geographic boundaries. Specifically for point employment data, such as InfoUSA data, we recommend that the aggregation to the TAZ level is performed by geocoding using a combination of property parcel data and D/T street network.

We acknowledge that this project has limitations. First, the scope of the research was primarily focused on selected transportation planning databases. As such, it didn't include other databases that support additional DOT activities. One of the future research directions could be the expansion of the database framework with other databases such as Commodity Flow Survey and National Household Travel Survey (by FHWA), CARS

(Safety office database), FDOT Maintenance database, ITS regional Framework database as well as the SIS multi-modal characteristics Inventory (MCI) database that is planed to be developed in two to four years Second, the solution of using D/T as a common reference data layer, doesn't solve all inherit problems in RCI basemap. Some inaccuracies that exist in RCI basemap may be corrected by referencing fixed physical features such as street intersections but other events that are more dynamic in nature, such as street pavement, or crash locations may still suffer from inaccuracies when carried over to D/T. The most important aspect of recommending the use the D/T is the ability to extend the street network to include local streets as well as to have access to the RCI linear referencing system in the same street network. Third, a decision still has to be made on the actual implementation of the linkage of ETDM project data and WPA. We are recommending a connection between these two databases by using a primary key foreign key concept that would link an ETDM project ID with the WPA primary ID, such as the FM number. The actual establishment of values for such a linkage requires further discussion between involved parties at the FDOT.

In conclusion, this research contributed to streamlining of data sharing and exchange among databases used in transportation planning by providing documentation of data and data connectivity, methods for establishing missing links, and tools for facilitating the implementation.

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APPENDICES

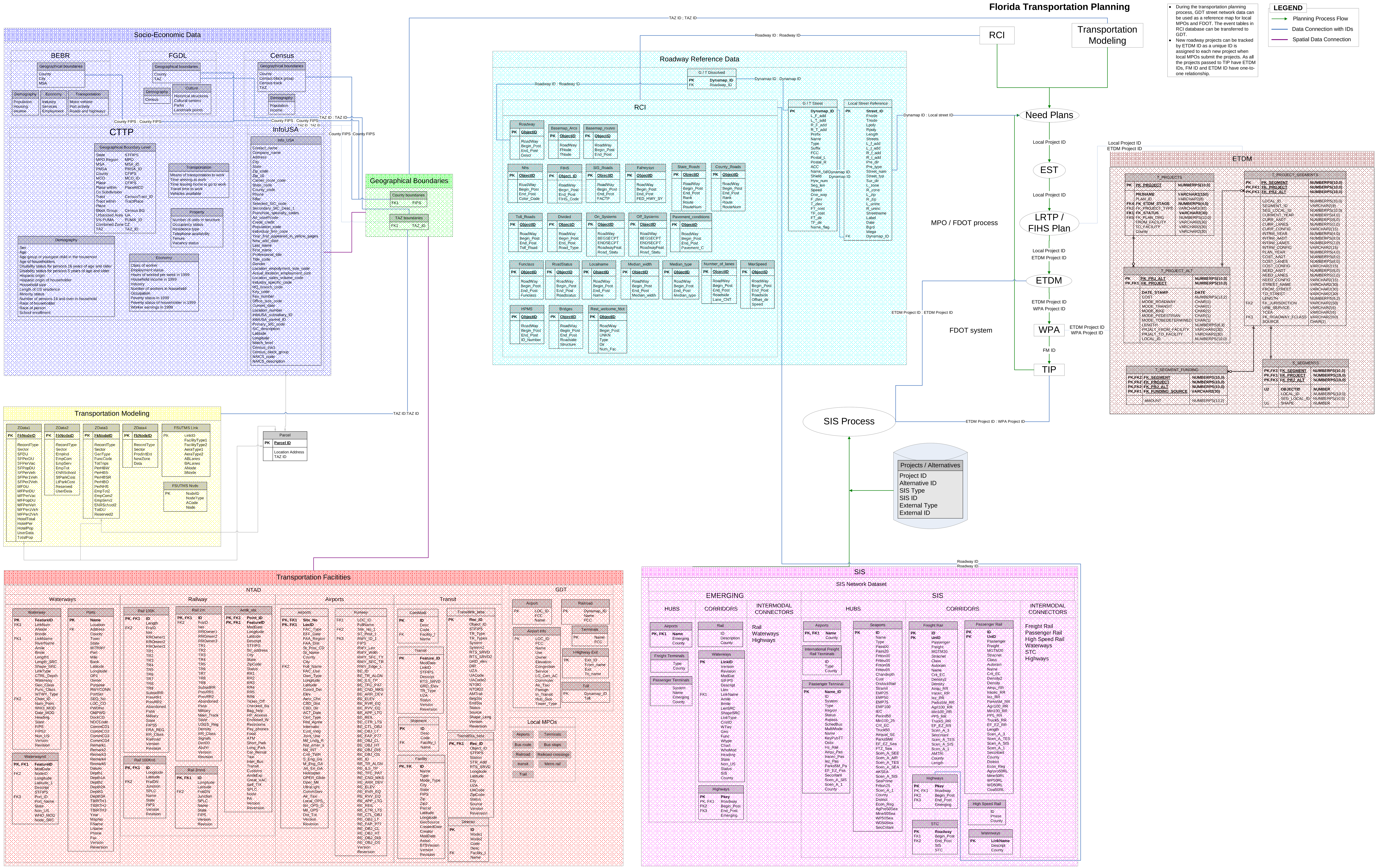
Appendix 1 Analysis of Data and Applications Connectivity

Appendix 2 DSS (SIS – Prioritization) Process

Appendix 3 Database Framework for Transportation Planning

APPENDIX 3

DATABASE FRAMEWORK FOR TRANSPORTATION PLANNING



APPENDIX 1

ANALYSIS OF DATA AND APPLICATIONS CONNECTIVITY

APPENDIX 2

DSS (SIS – PRIORITIZATION) PROCESS