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16. Abstract

This research body of work addresses two outstanding needs of the FDOT. The first need is to support the FDOT's Strategic Intermodal System (SIS) initiative and their efforts to define and manage existing and proposed multimodal centers, modes (air, sea port, rail), and their respective supporting facilities (state and local). The second need of the FDOT is to generate other useful products from existing digital GIS and image resources.

The SIS database schemas designed for this project largely followed the logical design of an existing enterprise production database, the ETDM database, which GeoPlan maintains for the FDOT. The BRIDGE schema, created as part of this research, can be used as a model for future applications in which similar decision support tools are needed. Regarding existing digital imagery, both supervised and unsupervised image classifications were investigated to assess their potential efficiency in terms of time and costs to FDOT in the identification of hydric soils.

The research herein finds divergent conclusions for the two major data repositories investigated - SIS Needs Projects and Digital Imagery. While integration of SIS Needs Project data can be reasonably achieved for better decision support in the FDOT's transportation planning process, automated processing of digital imagery data cannot be reasonably achieved and is not an efficient use of the FDOT's resources.

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Executive Summary

Problem Statement

This research body of work addresses two outstanding needs of the Florida Department of Transportation (in this report referred to as FDOT). The first need is to support FDOT's Strategic Intermodal System (SIS) initiative and their efforts to define and manage existing and proposed multimodal centers, modes (air, sea port, rail), and their respective supporting facilities (state and local). This initiative requires the integration of many different spatial database feature types (points, lines, and polygons) within a single collection of features to describe the proposed project. Current Geographic Information System technologies do not adequately address this FDOT requirement. The second need of the FDOT is to generate other useful products from existing digital GIS resources. The FDOT has numerous data gaps in their inventory of natural resource data. It is believed that these data gaps can lead to poor project scoping efforts as projects move into the construction phases by not identifying certain natural features that would require avoidance, minimization, or mitigation strategies. Using image analysis techniques and high-resolution imagery data, it may be possible to extract information to help fill these data gaps.

Objectives

The goal of this project was to evaluate multiple existing inventories of digital data repositories (Strategic Intermodal Systems Needs Projects, imagery) and develop methods, processes, and customized interfaces to analyze the data. The intent is to provide better decision support to the FDOT and commenting agencies during review of proposed transportation improvement projects.

The specific objectives of this project include:

- Develop a methodology for the seamless integration and evaluation of multi-modal SIS Projects and disparate geographic feature types
- Evaluate the efficiency and utility of applying automated image classification and extraction methods to FDOT digital orthophotos to extract data products that could fill existing data gaps. In particular, this research effort will attempt to identify vegetation and soil signatures associated with hydric soils.

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Results

Database Design

The SIS database schemas designed for this project largely followed the logical design of an existing enterprise production database, the ETDM database, which GeoPlan maintains for the FDOT. The ETDM database structure was followed because it can be easily and quickly adapted to meet other needs and user applications. The BRIDGE schema, created as part of this research, can be used as a model for future applications in which similar decision support tools are needed. This schema contains the bare bones database infrastructure necessary to perform GIS analyses and store results in such a way that they can be easily accessed. This schema was designed generically so that virtually any project type can be input and have GIS analyses performed on project features. In addition to SIS Needs projects, Transportation Improvement Plans (TIP), Long-Range Transportation Plan (LRTP), and Needs Plans, can all be evaluated using the ETDM tools.

The BRIDGE schema was also designed for flexibility in supporting customized needs, such as defining analysis parameters, criteria, input data, buffer distances, etc. Customization is accomplished by simply changing values in database tables to reflect varying buffer distances or desired spatial layers to be used in the analyses. Fields are built into the table structure to easily accommodate new buffer distances and different spatial layers for GIS analyses. The database infrastructure and the GIS analysis code do not need to change to accommodate customization. This generic database design allows for rapid application development, while offering flexibility in decision-support needs. In addition, it serves as a model for other decision-support applications.

Image Analysis

Both supervised and unsupervised classifications were investigated to assess their potential efficiency in terms of time and costs to FDOT in the identification of hydric soils. A supervised classification requires the computer operator to identify and select training sets relevant to the desired land cover one hopes to extract from the image data. Training sets may reflect either individual pixels or groupings of pixels. They can also be derived from external supporting datasets. In this case, samples were selected from hydric polygons present in the NRCS soils data. In contrast, an unsupervised classification is primarily computer automated, searching for statistical similarities in the data. The pixels in the image are grouped according to the user-defined number of desired output classes or categories. The efficiency of this process is dependent on multiple variables; including the heterogeneity of the image data (range and total number of pixel values) and the number of desired output classes. These methods are in contrast to standard air photo interpretation methods, where the individual draws a polygon around areas that appear related based on vegetation or other land cover type.

Multiple issues were encountered with both classification methods. Where there is appropriate ancillary data to help create training sets, the supervised classification process is more efficient than the unsupervised process. Appropriate ancillary data is not available in all areas, and is therefore subject to greater operator bias in the choice of training sets. Classification results for any one FDOT image were promising, but the process had to be started anew for each image.

Conclusions

The research herein finds divergent conclusions for the two major data repositories investigated - SIS Needs Projects and Digital Imagery. While integration of SIS Needs Project data can be reasonably achieved for better decision support in the FDOT's transportation planning process, automated processing of digital imagery data cannot be reasonably achieved and is not an efficient use of the FDOT's resources.

Integration and Evaluation of Multi-modal SIS Projects

SIS Needs projects, which represent a variety of critical transportation facilities and multiple transportation modes, present a challenge of linking and synthesizing disparate databases into useful information to effectively evaluate the projects. One FDOT initiative, ETDM's Environmental Screening Tool, has already addressed some aspects of this challenge and should be used as a model for building decision support tools.

The EST represents a large FDOT investment of time, financial and human resources, and technological expertise. While it would be possible to derive stand-alone tools and interfaces for SIS, an easier and more cost-effective option would be to follow what has been demonstrated herein and use existing EST tools. The FDOT can and should leverage the resources already invested in the EST, by expanding and building upon the EST interface and tools. The database structure, programming and web interface, existing code base, and modules created for the EST can be quickly adapted for SIS needs, offering transportation planners and decision makers ready to use information that is accessible and valuable. Furthermore, the generic database structure designed for EST allows for flexible inputs and customization for use by a variety of applications.

In addition, to maximize efficiency amongst all parties involved in the transportation planning and decision-making process, it is essential that the information gathered while mapping and evaluating transportation projects be accessible and transferable to external applications and databases.

Digital Image Considerations

The automated analysis of the FDOT's digital orthophotos, in their current format, is not time or resource efficient for utilization in the EST. This is supported by the literature review and based on the results of application of various image classification methods to existing digital data, as described above. With an image library of well over 15,000 images, automated classification procedures would be time and cost prohibitive, requiring multiple iterations with substantial user interaction and revision.

FDOT owns and works with a variety of digital imagery. Considering the DMC, the current processing workflow includes automated and semi-automated procedures. Effective applications include digital surface modeling and high-resolution photogrammetric measurements. Examples are engineering site design, inventory of existing roadway features, urban land cover characterization, and quality assurance/quality control of various data and products.

ADS40 imagery has the potential to provide current, high-resolution data that can be processed in an automated or semi-automated fashion. As a pushbroom scanner, data could be collected in long, continuous and overlapping strips or swaths. Standard image processing methods could then be applied to the data to derive a variety of feature classifications. Examples of appropriate applications include filling of data gaps, updating existing data products, corridor feature mapping, and detailed analysis of natural and cultural resources. This information could be used to verify and supplement existing thematic spatial data layers (e.g. land cover, roadway features, etc.).

Benefits

This body of research yields practical methods for integrating inventories of data which can provide better decision support for the FDOT. Methods herein can be implemented in a resource efficient manner, leveraging and building on existing tools already utilized within the FDOT. This body of work clearly demonstrates how the existing tools built for ETDM can be extended to support additional inventories of data such as SIS Needs Projects.

One such ETDM tool extension should be highlighted for particular benefit to the FDOT: the development of feature-level analyses to evaluate SIS Project data. Feature-level analyses allow decision makers to drill down and evaluate individual components of a project, rather than being constrained to evaluating the project as a whole. In this way, the tool offers transportation planners a more detailed and effective way to evaluate multiple scenarios for project alternatives. For example, an SIS project may include an airport and a train terminal, connected by a roadway. The airport and train terminal may be considered static, while the roadway to connect the two may change depending on road conditions or other factors. Processing and storing analysis results for each individual feature allows for mixing and matching" of project components to evaluate the potential environmental impacts of various alternatives. With feature-level analyses, problem areas within the project can be pinpointed and attempts can be made to remedy those problems through alternative routes and facilities.

Alexis Thomas, Principal Investigator, of the GeoPlan Center, University of Florida, conducted this research project. For more information, contact Peter McGilvray, Project Manager, at (850) 414-5330, Peter.McGilvray@dot.state.fl.us

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Tables and Figures

List of Acronyms

ArcSDE	ESRI Spatial Database Engine
DMC	Digital Mapping Camera
DOQQ	Digital Orthophoto Quarter Quad
DSM	Digital Surface Models
ESRI	Environmental Systems Research Institute, Inc
EST	Environmental Screening Tool
ETDM	Efficient Transportation Decision-making
ETM+	Enhanced Thematic Mapper
FDOR	Florida Department of Revenue
FDOT	Florida Department of Transportation
FGDL	Florida Geographic Data Library
FIHS	Florida Intrastate Highway System
FLUCCS	Florida Land Use Land Cover Classification System
FWC	Florida Fish and Wildlife Commission
GIS	Geographic Information System
IHS	Intensity Hue Saturation
LRTP	Long Range Transportation Planning
MPO	Metropolitan Planning Organization
MTPO	Metropolitan Transportation Planning Organization
NDVI	Normalized Difference Vegetation Index
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
PCA	Principal Components Analysis
PDF	Portable Document Format
RDBMS	Relational database management system
SIS	Strategic Intermodal System
SJRWMD	St. Johns River Water Management District
SQL	Structured Query Language
TEA-21	Transportation Equity Act of 2001
TIFF	Tagged Image File Format
TIP	Transportation Improvement Plans
UF	University of Florida
VBA	Visual Basic Application
VNIR	Visible Near Infrared
XML	Extensible Markup Language

1 INTRODUCTION

This research body of work addresses two outstanding needs of the Florida Department of Transportation (in this report referred to as FDOT). The first need is to support FDOT's Strategic Intermodal System (SIS) initiative and their efforts to define and manage existing and proposed multimodal centers, modes (air, sea port, rail), and their respective supporting facilities (state and local). This initiative requires the integration of many different spatial database feature types (points, lines, and polygons) within a single collection of features to describe the proposed project. Current Geographic Information System technologies do not adequately address this FDOT requirement. The second need of the FDOT is to generate other potential useful data products from existing digital GIS resources. The FDOT has numerous data gaps in their inventory of natural resource data. It is believed that these data gaps can lead to poor project scoping efforts as projects move into the construction phases by not identifying certain natural features that could require avoidance, minimization, or mitigation strategies. Using image analysis techniques and high-resolution imagery data, it may be possible to extract information to help fill these data gaps.

1.1 Research Goals and Objectives

The goal of this project was to evaluate multiple existing inventories of digital data repositories (Strategic Intermodal Systems Needs Projects, imagery) and develop methods, processes, and customized interfaces to analyze the data. The intent is to provide better decision support to the FDOT and commenting agencies during review of proposed transportation improvement projects.

The specific objectives of this project include:

- Develop a methodology for the seamless integration and evaluation of multi-modal SIS Projects and disparate geographic feature types

- Evaluate the efficiency and utility of applying automated image classification to FDOT digital orthophotos to extract data products that could fill existing data gaps. In particular, this research effort will attempt to identify vegetation and soil signatures associated with hydric soils.

This document outlines in detail, our research effort, findings, and recommendations.

2 BACKGROUND

2.1 FDOT's Strategic Intermodal System

Established in 2003, Florida's Strategic Intermodal System (SIS) is a plan that identifies and integrates critical transportation facilities into a statewide network that efficiently moves people and goods within Florida and between Florida and other states (Florida Department of Transportation, 2005). SIS was developed to:

- Increase the safety and security of Florida's transportation system;
- Increase mobility of passenger and freight trips within Florida's transportation system;
- More efficiently leverage statewide resources by focusing on high priority transportation facilities;
- Coordinate land use and transportation planning to manage growth while protecting natural resources and quality of life.

The SIS currently includes multiple modes of key transportation facilities in the state, including airports, seaports, freight and passenger rail terminals, spaceport, waterways and highways. SIS facilities carry "more than 99 percent of all commercial air passengers, virtually all waterborne freight tonnage, almost all rail freight, and more than 68 percent of all truck traffic and 54 percent of total traffic on the State Highway System." (Florida Department of Transportation, 2005).

Florida's SIS has developed over three major phases:

- Phase 1 – Initial Designation of SIS Components. The first phase, led by a 41-member steering committee, defined the goals and principles for SIS, the criteria for designating SIS facilities, and which transportation facilities would form the initial SIS.
- Phase 2 – Development of SIS Strategic Plan. The second phase focused on the development of a strategic plan to direct future SIS efforts.

- Phase 3 – Implementation of SIS Strategic Plan. The third phase outlined specific activities necessary to implement in order to carry out the SIS Strategic Plan.

The SIS includes several multimodal facilities, which are defined 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 of statewide or interregional significance, but do not currently meet the criteria for inclusion in the SIS. These facilities are potential candidates for future inclusion in the SIS
- Hubs - 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 - highways, rail lines, and waterways that connect major markets within Florida or between Florida and other states or nations
- Intermodal Connectors - highways, rail lines, or waterways that connect hubs and corridors.

These facilities represent varied databases of geographic and non-geographic data, all of which need to be integrated into a common framework under which SIS components can be managed and organized.

2.1.1 SIS Implementation

Linking these different transportation modes into an integrated network will undoubtedly require coordination amongst various local, regional, and state agencies. In addition, tabular and geographic databases must be developed and combined to support mapping, planning, and management of these various facilities. Hence, SIS implementation plans involve the creation of a centralized database, which will store and manage spatial and attribute data. SIS plans also include development of a web interface for accessing data in the centralized database, and a software mechanism to connect SIS with other office databases. One specific implementation activity is to "Invest in databases and analytical tools as needed to support effective decision making" (Florida Department of Transportation, 2005), and this project specifically aims to support that goal.

Since 2002, the SIS database has developed over three primary phases. In the first phase, over 70 spatial layers were collected and compiled into ESRI shapefile format. In the second phase, these shapefiles and various SIS databases were integrated into an SIS Universe database, offering a snapshot of SIS data. The third phase focused on designing an enhanced SIS database to handle regular data input from associated databases.

To effectively implement SIS, planners will require decision-support tools that are easily accessible and readily available, delivering a wealth of information in a logical and digestible format. One such decision-support tool, FDOT's Environmental Screening Tool (EST), already achieves similar goals of integrating spatial and transportation project information into one common database and efficiently delivering information to decision makers via an internet-accessible application. The EST can be used as a model for statewide coordination amongst various governmental agencies, data sharing, database design, and decision-support tools.

2.2 FDOT's Efficient Transportation Decision Making Process

The Efficient Transportation Decision Making (ETDM) Process redefines how the State of Florida accomplishes transportation planning and project development. The overall intent of the ETDM process is to improve transportation decision-making in a way that protects the human and the natural environments. The approach includes active participation of federal, state, and local agencies, and the public.

The Central Environmental Management Office of the Florida Department of Transportation developed the ETDM process as a response to Congress' authorization of the Transportation Equity Act of 2001 (TEA-21). Some primary objectives of the TEA-21 legislation were:

- Effective/timely decision making without compromising environmental quality
- Integrating review and permitting processes
- Early NEPA reviews and approvals

- Full and early participation
- Meaningful dispute resolution

These initiatives were in response to concerns expressed by citizens for years about the amount of time it takes to implement a transportation project. It often takes 10 to 15 years or more from when a transportation need is first identified until the project is delivered.

As part of the ETDM process, the FDOT, with help from the University of Florida GeoPlan Center and URS, Inc., has implemented an Internet-accessible interactive database tool called the Environmental Screening Tool (EST). The EST is a comprehensive decision-support tool that offers centralized storage for transportation project information and GIS analyses for environmental permitting (NEPA) and facilitates communication, coordination, and feedback between various review agencies on transportation projects.

The foundation of the EST is a database system that stores transportation project information and hundreds of spatial layers. Oracle^{TM} is used as the relational database management system (RDBMS) software to store, organize, and manage the data, and ESRI's ArcSDE^{TM} is used to store and manage the spatial layers. The EST analyses incorporate spatial layers derived from the Florida Geographic Data Library (FGDL), a warehouse of statewide digital geographic data that is maintained and housed at the UF GeoPlan Center. The FGDL contains over 350 spatial data layers that are in a common format and geographic projection, and ready for utilization by decision makers.

The EST contains various tools to support the ETDM process.

- *Project Data Entry* – Allows transportation planners to enter project information and community characteristics into the ETDM database.
- *Standardized GIS Analyses* - Spatial overlays of GIS layers to determine the environmental and socio-cultural resources that may be directly impacted by the proposed project. The GIS analysis is used to provide resource agencies with information that can help determine the degree of impact.
- *Environmental Review Mechanisms* – Through the EST website, users can review project information, view and query project boundaries and GIS analyses via

interactive maps, and enter comments regarding potential effects of the project on their respective resource of interest.

3 RESEARCH PROCESS AND METHODOLOGY

To attain the first objective (to develop a methodology for the seamless integration and evaluation of multi-modal SIS Projects and disparate geographic feature types), work was completed in the following steps: review existing SIS Universe schema; develop database schemas and methodology for seamless data transfer and integration; and develop decision-support tools to evaluate proposed SIS projects and disparate feature types. To attain the second objective (to evaluate the efficiency and utility of applying automated image classification to FDOT digital orthophotos to extract data products which could fill existing data gaps), work was completed in the following steps: data acquisition and management, image processing, and land cover classification.

3.1 Review of Existing SIS database

GeoPlan received the aforementioned SIS Universe database in Access database format from Cambridge Systematics, Inc. and FDOT. This database contained actual data for existing and emerging SIS Projects. The database was examined to determine how relationships were established between spatial features and SIS Needs projects, in an effort to extract all the spatial features belonging to a particular SIS Needs project. Ideally the existing relationships would yield suitable candidate projects against which to test the development of a new GIS analysis routine to support projects with multiple features types.

In order to identify SIS projects comprising multiple feature types for use in developing and testing a new analysis routine it was necessary to link spatial layers to the MASTER_NEEDS table. While feature classes from the SIS Universe Database did not contain enough information on their own to link directly to the Master Needs table, the database did include relational classes for the purpose of associating data between the spatial features and specific SIS Needs Projects identified in the Master Needs table

After determining the relationships necessary to link spatial features to a SIS project, a subset of tables and spatial layers were selected for extraction from the SIS Universe Access database. SQL Developer was then used to extract this subset from the Access database and import it into the Oracle^{TM} RDBMS. Below are the details of the extracted subset from the SIS Universe database.

The following feature classes were chosen from the SIS database to use for testing:

AIRPORT_POLYGON
HIGHWAY_NEEDS (lines)
SPACEPORT_ POLYGONS
SEAPORT_ POLYGONS
WATERWAY_NEEDS (lines)

While there are data in the SIS Universe Database representing other transportation modes and facilities (e.g., Railroad Terminals), they were not linkable to the Master Needs table and hence only the subset of spatial layers shown above was extracted from the Universe database. The following relational classes or association tables, required for linking the spatial layers to the Master Needs table, were extracted from the SIS Universe Access database:

GEOREF_AIRPORT
GEOREF_HIGHWAY
GEOREF_SEAPORT
GEOREF_SPACEPORT
GEOREF_WATERWAY

The following non-spatial tables were extracted from the SIS Universe Access database:

- MASTER_NEEDS – Contains the fields and data necessary to identify spatial features of each SIS project.
- FIHS_IMPROVEMENTS – lookup table of improvement types. Identifies type of projects (widening, new lanes, etc) and links to Master Needs Table.

- COST_REF – provides information on funding sources and estimated costs with links to Master Needs Table.

Each spatial layer possesses a standardized unique identifier specific for the mode of transportation represented. This identifier links data in the spatial layer to data in the similarly named association table. For example, SPACEPORT_POLYGON links to GEOREF_SPACEPORT on the common field, STD_ID. The association table then links to the Master Needs Projects table on the common field, NEEDS_ID, thus establishing a relationship with the spatial layer. These tables were imported into an Oracle schema called SIS, which served as a staging schema from which data could be prepped for easy transfer to and from the ETDM schema.

3.2 Development of Database Schemas and Methods

Building effective decision-support tools requires thoughtful database design. The database structure serves as the foundation from which all tools and applications are built. A well-organized and constructed database allows for straightforward application development and efficient application performance (Ensor and Stevenson, 1997). The database design should be flexible enough to respond to the changing needs of its users, while maintaining the integrity of the data stored within the database.

Rather than building a separate database for this body of work, it was decided that the database developed herein should seamlessly integrate with existing databases built for FDOT, namely the ETDM database. The ETDM tools available in the EST (analysis tools, screening tools, map viewer, analysis report) have been designed to work within this ETDM database structure. Designing the SIS databases to be compatible with the ETDM databases allows for access to and utilization of the ETDM tools. Leveraging these existing tools already built for FDOT is an efficient use of resources and provides a logical framework under which future tools can be built and expanded.

Consequently, a new database schema named BRIDGE was designed to serve as a connector between the SIS database schema and the ETDM database schema. This schema, which is compatible with existing ETDM tools, contains the bare bones database infrastructure necessary to perform GIS analyses, yet provides for specific SIS needs such as customized buffer distances, non-standard GIS analyses, etc. Customization is accomplished by simply changing values in certain fields of specified database tables. The database infrastructure does not need to change to accommodate customization. Once SIS data is imported from the SIS schema into the BRIDGE schema, it is ready for utilization by ETDM tools.

The BRIDGE schema was derived from the following sources:

1. FDOT SIS Universe Database, including SIS Master Needs Table
2. FDOT ETDM Production Database

See Table 1, for an overview of database tables included in the BRIDGE schema.

TABLE NAME	DESCRIPTION
T_PROJECTS	Attribute data for a project
T_PROJECT_ALT	Attribute data for a project alternative
*T_PROJECT_FEATURES	Attribute data for a project alternative individual feature. Has one ID to link to each feature type, and indicates geographic feature type (point, line, polygon)
AT_REGIONS_PROJECTS	Association table between projects and the geographic regions they fall within
T_REGIONS	Lookup table of geographic regions (counties, FDOT districts, WMD districts)
S_POLYGONS	Spatial layer to hold polygon project features
S_SEGMENTS	Spatial layer to hold linear project features
*S_FEATURE_AREAS	Spatial layer which contains buffered project features (on which the GIS analyses will be performed). One record or polygon for each feature
S_ANALYSIS_AREAS	Spatial layer which stores unioned buffered areas for entire alternative
T_INPUT_QUEUE	Table responsible for triggering buffer routine
T_ANALYSIS_TYPES	List of GIS analyses to be performed, according to each data layer
T_ANALYSIS_BUFFERS	Stores buffer distances at which to perform each analysis type
T_ANALYSIS_FIELDS	Indicates which fields from each spatial layer to be included in analysis report for each analysis type
T_ANALYSIS_ISSUES	Issue category under which each analysis type falls. Used for reporting/ displaying analysis results
T_LAYER_DESCRIPT	Description of each spatial layer used in the EST, including data source, source date, feature type, etc.
T_ANALYSIS_QUEUE	Table in which project alternatives are queued for analysis. Projects are run on first-come, first-served basis
T_ANALYSIS_REPORT	Stores GIS analysis report on the alternative level
*T_ANALYSIS_REPORT_FEATURE	Stores GIS analysis report at the project, alternative, and feature level

*Tables marked with an asterisk are new tables created specifically to support projects with multiple spatial feature types.

Table 1: Overview of the BRIDGE Schema

Before transferring data from the SIS schema to the BRIDGE schema, some additional prepping was needed to conform to the database structure required by ETDM tools. First, identification (ID) fields were added to the spatial layers to define relationships and features. The ETDM tools use these ID fields. Next, database views were created to link data from the spatial layers, georef association tables, master needs table, costref table, and the FIHS type lookup table. A spatial view is a customized, dynamic representation of data in the database, based on a stored SQL query statement (Greenwald, et. al., 2001). In this case, these views were used to query and link all features and information associated with a particular SIS Needs project, and to conform the data to the ETDM database structure. More details on the database views are available in Appendix 1**.**

In addition to creating the BRIDGE schema, tables were created in the SIS staging schema to facilitate data transfer from the SIS schema to the BRIDGE schema. These tables are listed below in Table 2. An Entity Relationship Diagram (ER_Diagram_w_Legend.pdf), with all requisite SIS, ETDM and BRIDGE tables is available on the attached CD-ROM.

TABLE NAME	DESCRIPTION
AT_NEEDS_COUNTY	Association table between needs project and the county in which it is located
EXPORT_QUEUE	Stores queuing mechanism for transferring data to from the SIS schema to the BRIDGE schema. A database procedure queries this table to determine which SIS Needs Project data have been prepped and are ready for inclusion to the BRIDGE schema.

Table 2. Connector Tables in SIS Schema

In order to populate the BRIDGE schema with SIS data, a stored procedure was utilized. A stored procedure is a block of code, which is stored in the database and can be later executed (Greenwald, et. al., 2001). The stored procedure developed by GeoPlan enables the transfer of a specified set of SIS data to the BRIDGE schema upon initiation by a database analyst. This database procedure queries the EXPORT_QUEUE table to determine which SIS Needs Project data have been prepped and are ready for import to the BRIDGE schema. The procedure allows for data to quickly be transferred from the

SIS schema to the BRIDGE schema, after which it is ready for GIS analysis to be performed. Figure 1 below shows the primary steps involved in transferring data from the SIS schema to the ETDM schema.

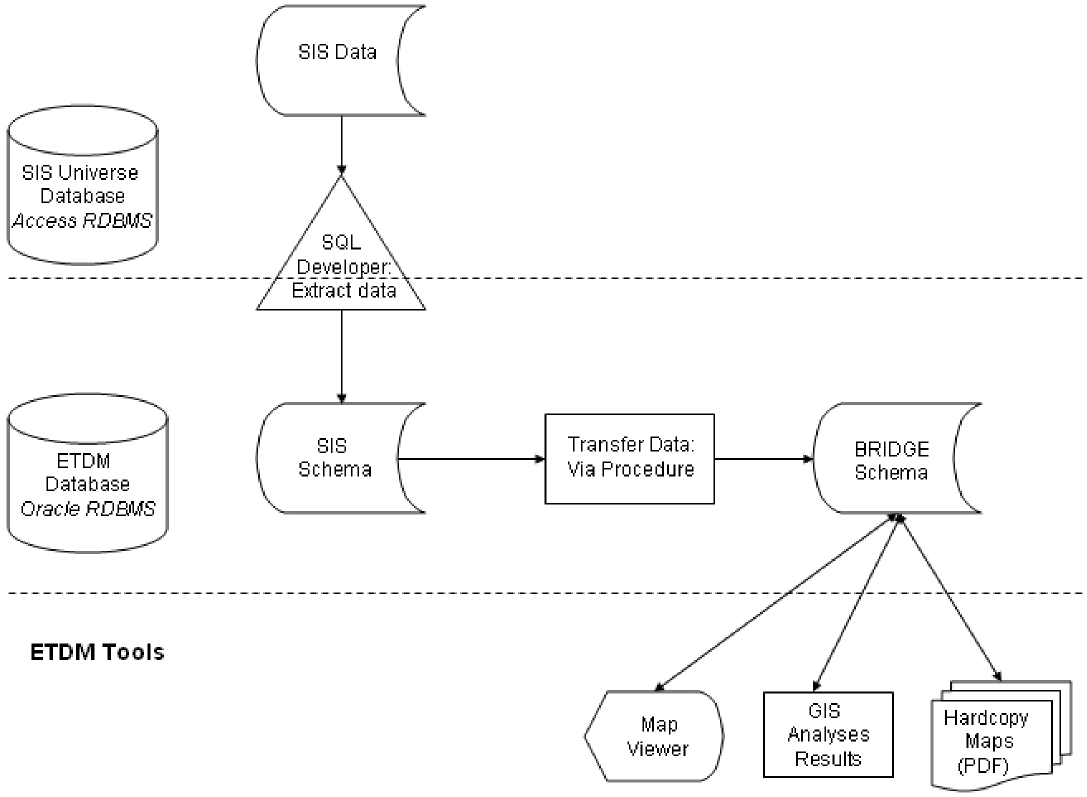

Figure 1. Import and Integration of SIS Data into ETDM

With the database pieces in place, future inputs of updated SIS data can be accommodated. With minimal processing, updated SIS data can be prepped and ready for GIS analysis. The described process can be streamlined if future inputs of SIS data are supplied in a standard, consistent format.

3.3 Develop Decision-Support Tools

Once the database foundation is in place, new decision support tools are designed and efficiently built to work within the ETDM compatible database structure.

3.3.1 GIS Analysis Support for Multi-Modal Projects and Disparate Geographic Feature Types

In order to evaluate proposed SIS Projects and disparate feature types, modifications to the EST GIS analysis tool were made. The database infrastructure discussed in the previous section of this report provided a logical storage and retrieval mechanism for the SIS project boundaries, components and GIS analysis results.

The existing analysis tool performs spatial overlays of specific GIS data layers within certain buffer distances of a given ETDM project to determine the environmental and socio-cultural resources that may be directly impacted by the proposed project. The ETDM analysis tool (before the start of this project) only accepted single-mode (road) projects of linear geographic feature type. SIS Projects can comprise diverse features such as a port, a waterway, a highway, or an airport. Those data represent multiple modes of transportation and geographic feature types. Modifications to the analysis tool were necessary to support multiple modes of transportation and geographic feature types other than lines.

The existing GIS analysis tool employs Visual Basic Application (VBA) and ESRI ArcObjects^{TM} code to perform GIS functions. Those GIS functions include:

- *Buffering*. This function creates the polygonal analysis areas around the project centerlines based on the buffer distances specified. These are referred to as analysis areas.
- *Attribute filters*. For some GIS layers only some specific features may be used for specific analyses. Attribute filters are query expressions used to select only relevant features applicable to an analysis type, e.g. the query expression FLUCCS >= 2000 and FLUCCS < 3000 is performed on the land use layer in

order to select only the agricultural lands necessary for an analysis of a given issue. FLUCCS is the field in the land use layer that stores the Florida Land Use Codes. 2000-3000 is the range for agricultural lands.

- *Spatial filters.* Filters are used to select the features that are completely within or intersect the analysis areas. This operation reduces the selection of features to a subset that coincides spatially with any of the analysis areas.
- *Clipping/Intersection* This function is used to determine the area of polygonal features and the length of the lines that cross the analysis area.
- *Summarization* Used to calculate the total acres of polygons in the buffer area or count the number of features intersecting the buffer area.

The GIS analysis is fully automated and is triggered anytime a new project is uploaded in the system. The GIS analysis is also triggered when the project is updated. The results of the analysis are stored in tabular format inside the ETDM database to be retrieved whenever needed during the review process.

GIS analysis results are summarized for the entire ETDM project. For example, analysis results for a proposed transportation project would summarize all features of various GIS layers that were found within a certain distance of the entire project length. For large and diverse SIS projects, summarizing results for the entire project may not be the most effective way to evaluate a project. As an example, if the SIS project includes an airport, a roadway, and a train terminal, then decision makers would likely want to evaluate the GIS analysis results of the airport separate from the roadway and train terminal, and vice versa for the other components. One component may have more potential permitting issues, and hence it is helpful to have the ability to evaluate each component individually. Analysis results can also be aggregated for all project components, in order to evaluate the project as a whole.

To support multiple geographic feature types in the analysis tool, the underlying analysis code was modified. First, the analysis code was changed to create minimal buffers around each feature, effectively converting all features types to polygons. This minimal size buffer is negligible, since the scale of the data is not resolute enough to gauge that distance. These new, buffered polygons are called Analysis Areas. After the buffer, all features are unioned, or merged together to treat the project as one feature. The relevant VBA code for the 'Buffer' module is available in the attached CD-ROM.

GIS analyses are then run both for the entire unioned project feature, and on each individual project feature. GIS analyses are run at the standard buffer sizes for all features within a project: 100-ft, 200-ft, 500-ft, 0.25-mile, 0.5-mile, 1-mile. However, custom-size buffers can be easily accommodated, as these parameters are stored in the database – not in the VBA/ ArcObjects™ code that performs the GIS analysis functions. The relevant VBA code for the 'Analysis' module is available in the attached CD-ROM.

It should be noted that once the SIS Universe database was fully examined and relations were mapped, it was discovered that no current SIS projects within the database contained multiple feature types. Nonetheless, this exploration work was necessary to understand the structure of the SIS database, and to test the import of SIS data from a different database format (Access) and schema into one that is compatible with the ETDM database. GIS analyses were run on the imported SIS data to show complete success of using imported data. However, in order to test multi-modal projects, sample ETDM project data was used. Furthermore, since analyses were run on real SIS projects provided, these analysis results are available for the projects.

3.3.2 Analysis Results Output

Currently, GIS analysis results may be viewed online through the EST website and exported to Adobe Acrobat™ Portable Document Format (PDF). Depending on the continued development of the SIS database, it may be necessary to access and utilize the GIS analysis results for SIS projects outside of the ETDM system. Hence various data formats for storage and multiple software tools for portability from Oracle to the SIS database were identified and compared, including:

- Oracle XML Publisher
- Oracle Reports Developer

- Oracle SQL Developer

Each of the above software tools were researched as potential means of outputting GIS analysis results to portable file formats. Research findings are listed in the Findings and Discussion section.

3.4 Evaluation of Methods for Digital Image Processing

The Florida Department of Transportation (FDOT) has an extensive in-house inventory of analog and digital image products. The focus of this research is digital orthophotos. Digital orthophotos are sourced from contractors using the Leica Geosystems ADS40 or from the FDOT Zeiss/Intergraph Imaging Digital mapping Camera (DMC).

Methods applied for this portion of the project consisted of a literature review and image processing of selected representative digital images. The review was focused on sensor geometric and radiometric characteristics, as well as examples of research and applications employing these sensors. Examples of publications reviewed are listed in the list of References and relevant examples are discussed in the Results section.

Image processing steps were designed to determine whether it is operationally feasible to develop an automated procedure to extract data, which could be applied to any number of digital images. If feasible, the resulting data product could then be utilized within the EST (Environmental Screening Tool) to supplement existing data sources and provide better decision support. Image data management and processing procedures are described below.

3.4.1 Data Acquisition and Management

Before image-processing methods could be examined, the GeoPlan Center first acquired and archived over 15,000 aerials from FDOT, Florida Department of Revenue (FDOR) and other sources. See Appendix 2 for details on location, currency, format and resolution. In addition, the original satellite (Landsat 7) data used to develop the Florida Fish and Wildlife Commission (FWC) 2004 Vegetation and Land Cover classification

(Stys, et. al., 2004) was obtained. The Landsat data was used in conjunction with the most current available NRCS (Natural Resources Conservation Service) soils maps to aid in the selection and development of training sets. Figures 2 and 3 below represent the respective individual FDOT and Landsat 7 FWC image footprints.

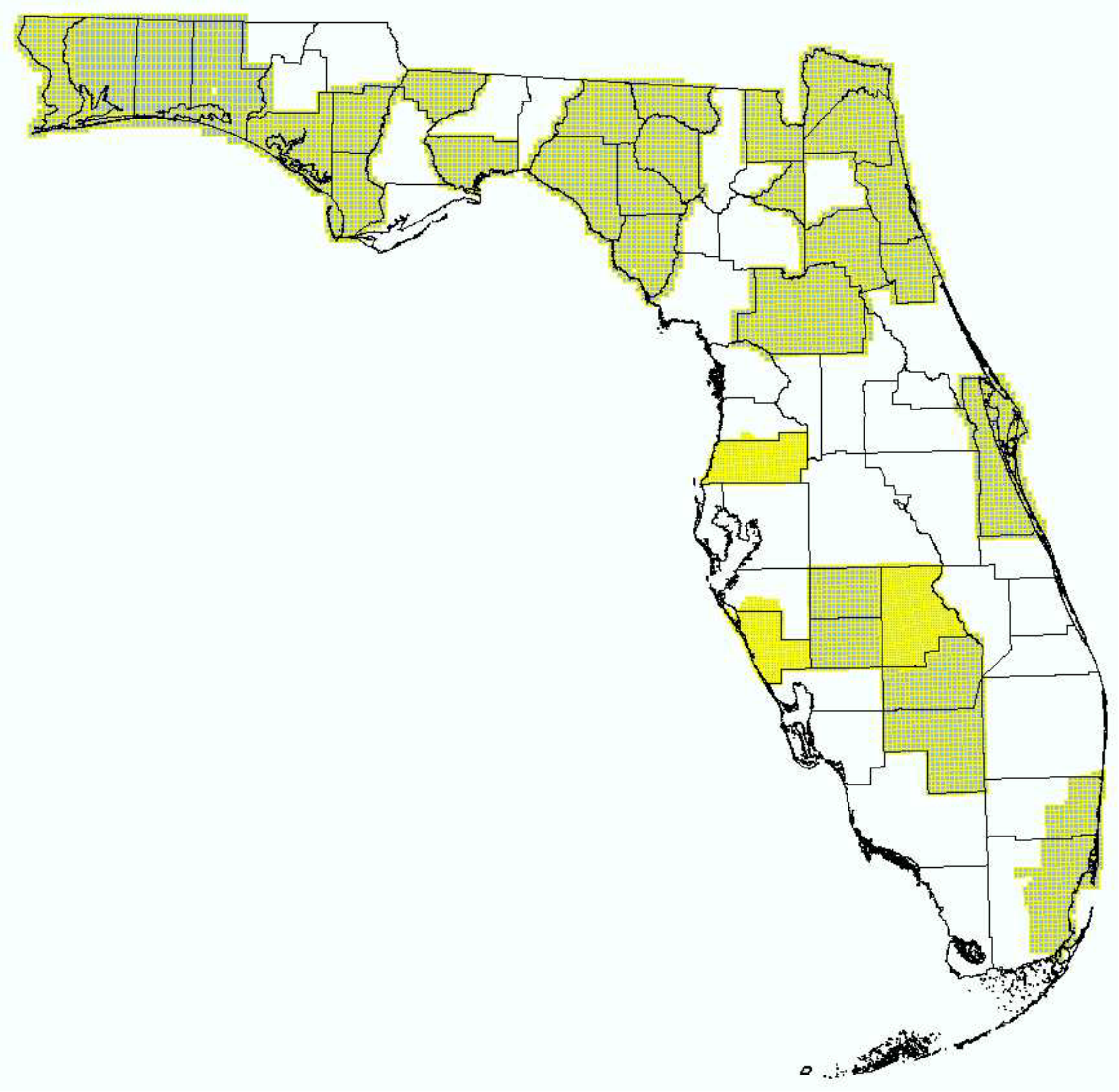

Figure 2. FDOT Aerial Image Footprints

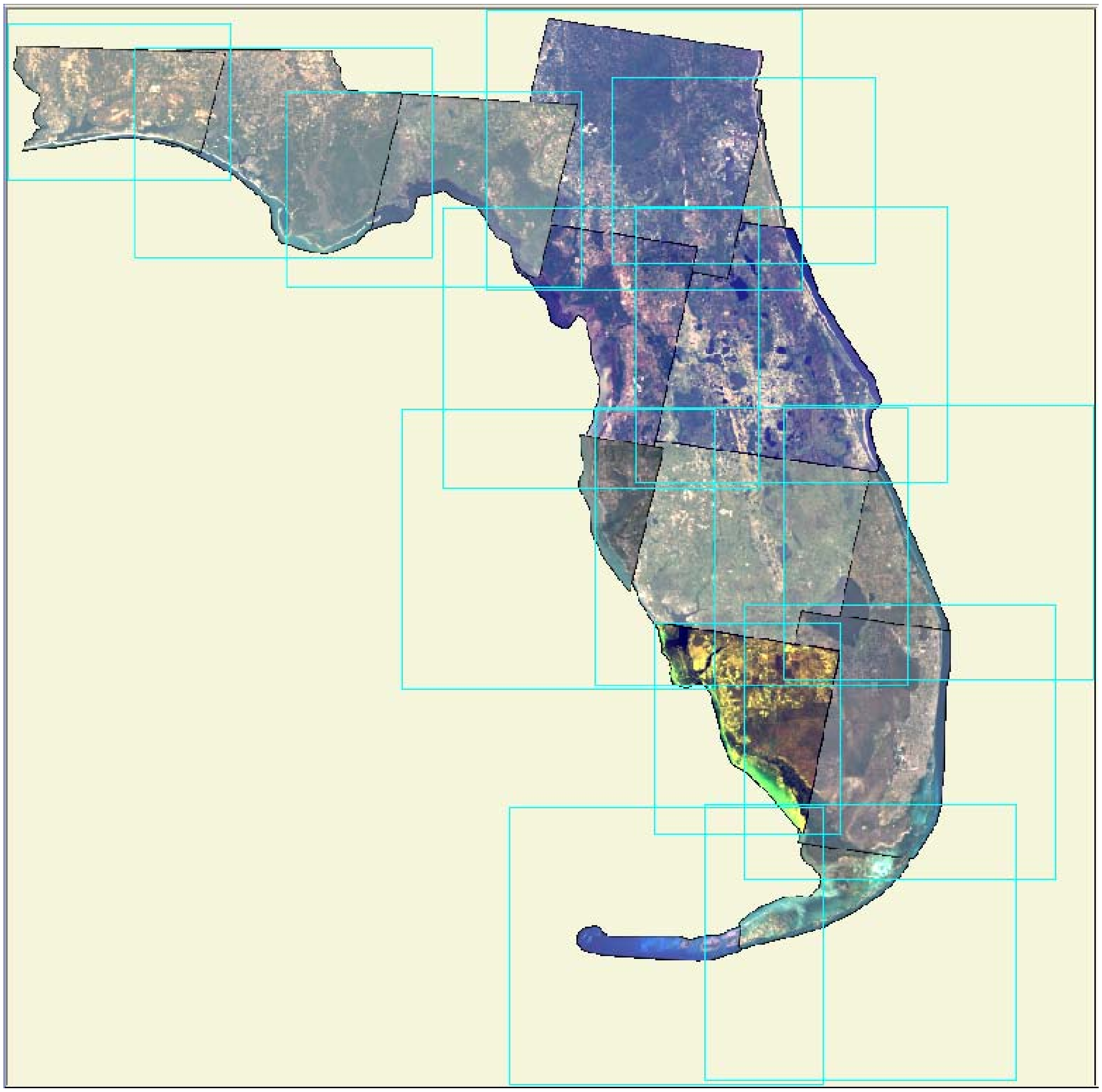

Figure 3. Landsat 7 Satellite Image Footprints

3.4.2 Image Processing

FDOT aerials were visually reviewed and representative samples in the St. Johns River Water Management District (SJRWMD) were selected for various image enhancements (spatial, radiometric and spectral). A spectral enhancement such as the Normalized Difference Vegetation Index (NDVI) was calculated on the sample images to examine the ability of the image spectral data to segment vegetated and nonvegetated areas. Other image band arithmetic methods included band ratios and band subtraction. A principal components analysis (PCA) was applied to the imagery. PCA is a statistical procedure used to reduce the dimensionality of the image data by quantitatively describing the variance in spectral signatures that each image band accounts for.

Several image merge algorithms were applied and compared to determine if there is added value in using the high-resolution (1-foot) FDOT orthophotos to enhance the spatial resolution and visual appearance of other imagery. These algorithms included multiplicative, Brovey transform and Ehlers fusion. The multiplicative procedure multiplies corresponding pixels values from each band in the source file against each band in the destination file. The square root of the resulting digital numbers is taken in order to account for increased brightness values. The Brovey Transform is a ratio method that divides all band pixel values of the source data set by the sum of all pixel values, then multiplies the result times the target band pixel values. Finally, the Ehlers fusion approach is a modification of the Intensity Hue Saturation (IHS) transform, which generally converts an RGB image into an IHS image, then replaces the intensity band (I) with a higher resolution panchromatic band.

3.4.3 Land Cover Classification

Land cover classification activities included investigating the crosswalk between ETM+ imagery and high-resolution (1-meter) color infrared imagery. The idea was to examine the consistency and correspondence of land cover categories derived from the two image sources by the Florida Fish and Wildlife Commission and the Water Management Districts, respectively. These two raster image sources were selected as baseline datasets as they were used to develop key ‘Land Cover’ data classifications used throughout the State in environmental reviews. They are important datasets within the ETDM GIS analysis routine used to help determine potential habitat impacts and are often the basis for participating state and federal resource agency comments. Metadata files provide details on these datasets (Florida Fish and Wildlife Conservation Commission, 1989; SJRWMD, 2006 and 2007).

A Tasseled Cap transformation was applied to select pilot areas within the ETM+ (Enhanced Thematic Mapper) baseline image index. Tasseled Cap is a spectral enhancement method aimed primarily at analyzing vegetation. It is of particular use in differentiating and segmenting brightness, greenness and wetness. The results of this transformation were used in attempts to identify hydric soil types from imagery that approximate latest NRCS soils data. Hydric soil field identification is a common activity for natural resource professionals and planners, but it can be both time consuming and labor intensive (Galbraith, J.M., Donovan, P.F., Smith, K.M., Zipper, C.E., 2003). Hydric soils are described as being saturated or flooded long enough to promote the development of anaerobic conditions in the topsoil. These soils are often used in conjunction with vegetation and hydrology in the delineation of wetlands.

Finally, various image mosaicking methods and processes were evaluated to determine the utility of expanding the spatial extent of orthophoto coverage. The purpose of this effort was to identify and classify land cover over larger areas.

4 RESULTS

4.1 Database Design for Rapid Application Development

The SIS database schemas designed for this project largely followed the logical design and flow of the ETDM database. The ETDM database structure meets the current needs of the ETDM process, but can be easily and quickly adapted to meet other needs and user applications. The BRIDGE schema, created as part of this research, can be used as a model for future applications in which similar decision support tools are needed. This schema contains the bare bones database infrastructure necessary to perform GIS analyses and store results in such a way that they can be easily accessed. This schema was designed generically so that virtually any project type can be input and have GIS analyses performed on project features. In addition to SIS Needs projects, Transportation Improvement Plans (TIP), Long-Range Transportation Plan (LRTP), and Needs Plans, can all be evaluated using the ETDM tools. Once projects are evaluated, the results can be exported into another format, which can then be uploaded into external databases. This allows for existing agencies such as FDOT District offices, MPOs, and MTPOs to maintain investments in their existing database infrastructures while utilizing the tools created for ETDM.

The BRIDGE schema was also designed for flexibility in supporting customized needs, such as defining analysis parameters, criteria, input data, buffer distances, etc. Customization is accomplished by simply changing values in database tables to reflect varying buffer distances or desired spatial layers to be used in the analyses. Fields are built into the table structure to easily accommodate new buffer distances and different spatial layers for GIS analyses. The database infrastructure and the GIS analysis code do not need to change to accommodate customization.

This generic database design allows for rapid application development, while offering flexibility in decision-support needs. In addition, it serves as a model for other decision-support applications.

4.2 Feature-Level Analyses

In order to effectively evaluate SIS projects, an approach that differs from the ETDM method of analyzing projects was explored. Instead of analyzing and storing results of an entire project at the alternative level, each spatial feature within the SIS project was analyzed and stored individually. This method can be referred to as feature-level analysis. This departure from the alternative-level analysis yielded numerous benefits. First, decision makers working with the analysis results can drill down and evaluate portions or components of the project, allowing for a more detailed and meaningful assessment of project components. If results are given at the alternative level, they are not necessarily meaningful, as a project may cover a large geographic area and results are not tied to a specific project component. With feature-level analyses, problem areas within the project can be pinpointed and attempts can be made to remedy those problems through alternative routes and facilities.

Secondly, feature-level analyses result in more effective decision making by allowing transportation planners to quickly evaluate multiple scenarios for project alternatives. For example, an SIS project may include an airport and a train terminal, connected by a roadway. The airport and train terminal may be considered static, while the roadway to connect the two may change depending on road conditions or other factors. Storing analysis results for individual features allows for mixing and matching of project components to evaluate the potential environmental impacts of various alternatives.

4.3 Portable Analysis Results

Mechanisms for facilitating the flow of data into and out of the ETDM system, as well as into and out of the SIS database are important considerations for carrying out SIS implementation plans. The central SIS database should maintain the most current SIS project information, and hence mechanisms for streamlined data transfer into the database need to be developed. Furthermore, methods for extracting data from the SIS database are necessary so that the data can be used in external applications or databases (ETDM, FDOT district offices, etc).

Database triggers and procedures can be used to move data within a database and to prepare data for export. In this particular project, a stored procedure (see Appendix 3) was used to move data within the database. To export data from the database for use with external applications, various data formats and software tools were researched for exporting and storing analysis results from Oracle. The research details are as follows:

- Oracle XML Publisher - Investigated potential advantages of using XML for storage and Oracle XML Publisher for portability needs. Oracle XML Publisher was found to be cost-prohibitive, as it requires licensing fees.
- Oracle Reports Developer – Oracle Reports Developer is a component of Oracle Developer 10g. This software requires licensing fees for the production use of this software. Oracle Reports Developer exports to various output formats including PDF, HTML, RTF, XLS, and XML.
- Oracle SQL Developer – Oracle SQL Developer is a free software development tool that is fully supported by Oracle technical support for Oracle customers. The software provides tools for exporting table data and reports to various formats including Microsoft Access database files (.mdb), Microsoft Excel spreadsheet files (.xls), and XML.

The export and reporting capabilities of each of the above software tools were researched as potential means of outputting GIS analysis results to portable file formats. Output options provided through the free software, SQL Developer, were explored and tested in detail. SQL Developer is recommended for its flexibility, allowing export of multiple widely used file formats (XML, Microsoft Excel^{TM}, and Microsoft Access^{TM}), and because it is available free of charge. Furthermore, the output to Excel^{TM} spreadsheet tool allows for discrete manipulation and customization of analysis data results. If analysis results need to be accessed and utilized outside the ETDM interface, the GeoPlan Center would recommend that SQL Developer be used to export them to Microsoft Access^{TM} database (.mdb) files since the existing SIS Universe Database is stored as such.

Figure 3 below shows the transfer of SIS data into the ETDM database, and the analysis results as portable components, which can be exported out of the database for use in other systems.

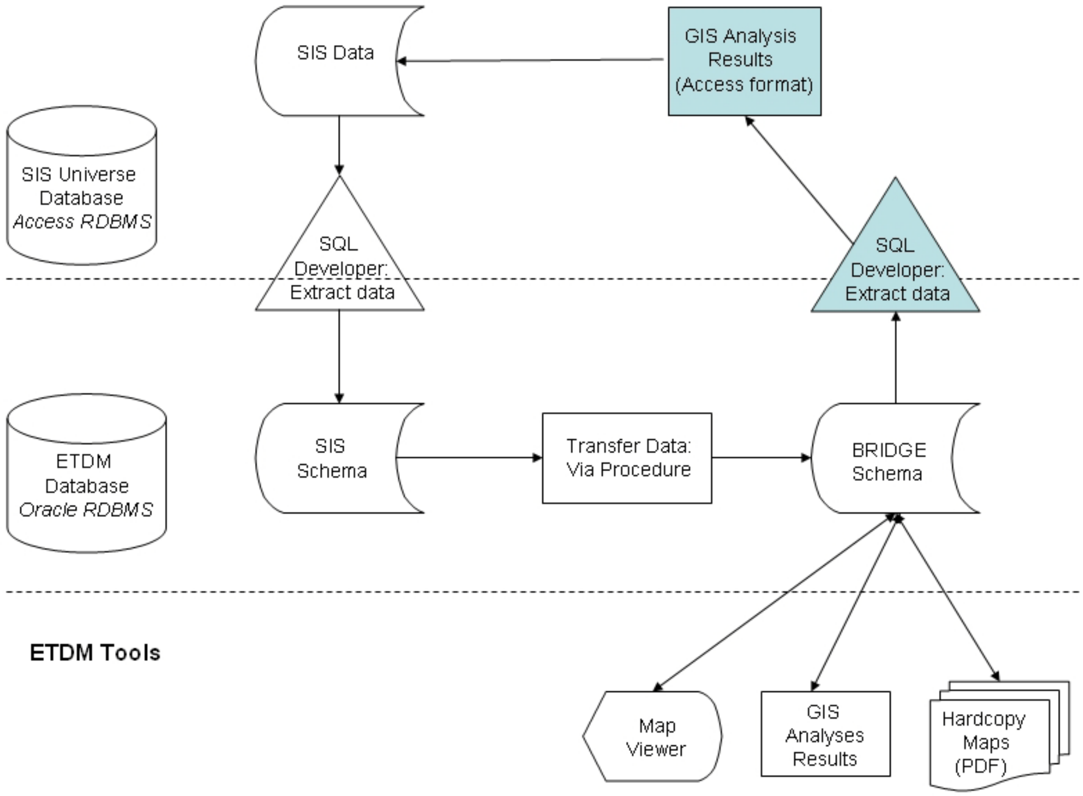

Figure 4. **Data Flow and Portability between SIS and ETDM**

Furthermore, analysis results generated and stored in the ETDM database can be exported as PDFs. In particular, there are two PDF products:

1. Analysis reports in tabular form
2. Multiple hardcopy maps showing project boundaries, overlaid with the spatial layers used in the GIS analyses

Each hardcopy map displays a logical grouping of spatial layers used in the analyses. For example the “Water Resources Map” includes the following spatial layers:

- Drainage Basins (Used in GIS analyses)
- Navigable Waterways (Used in GIS analyses)
- National Hydrography Dataset Reaches (Used in GIS analyses)
- National Hydrography Dataset Water Bodies (Used in GIS analyses)
- Outstanding Florida Waters (Used in GIS analyses)
- First Magnitude Springs (Used in GIS analyses)
- Surface Water Classifications (Used in GIS analyses)
- Highways (Used for Basemap Basic Orientation))
- Railroads (Used for Basemap/ Basic Orientation)
- Roads (Used for Basemap/ Basic Orientation)

A complete list of the hardcopy map groupings is below:

- Age Distribution Map
- Coastal and Marine Map
- Community Services Map
- Contamination Map
- Farmlands Map
- Floodplains Map
- Historic Resource Map
- Hydrogeology Map
- Income Map
- Integrated Wildlife Model Map
- Land Use Map
- Minority Population Map
- Population Density Map
- Potential Impact Basemap
- Potential Impact Contamination Map
- Potential Impact Historical Resources Map
- Potential Impact Index Map
- Potential Impact Natural Resources Map
- Potential Impact Social Map
- Potential Impact Wildlife and Habitat Map
- Project Aerial Map
- Project Base Map

- Project County Location Map
- Recreational Areas Map
- Species Potential Map
- Vegetation Map
- Water Resource Map
- Wetlands Map

4.4 Digital Image Analysis

4.4.1 Image Types and Resolution

The following 3 figures reflect typical sample images for the same geographic area at a scale of 1:24,000 and highlight the differences in image resolution and what may be readily identified.

Figure 5 is a representative sample of Landsat 7 data and its applicable use to broad stroke land cover characterization. Note the inability to distinguish between objects such as houses and trees due to the coarse image resolution.

Figure 6 is an example of a digital orthophoto quarter quad (DOQQ) with one-meter resolution, illustrating a representative sample of urban, disturbed and vegetated land covers. The higher level of resolution allows for the discrimination of feature classes as opposed to objects, such as housing density and vegetation type.

Figure 7 is a typical FDOT true or natural color aerial image with one-foot resolution, of the same area. This level of resolution also facilitates the increased discrimination of features as opposed to objects. It should be noted that while the true color image is a familiar representation as seen by the human eye, it is more difficult to discriminate transition edges and variability in some land cover features when compared to the color infrared imagery.

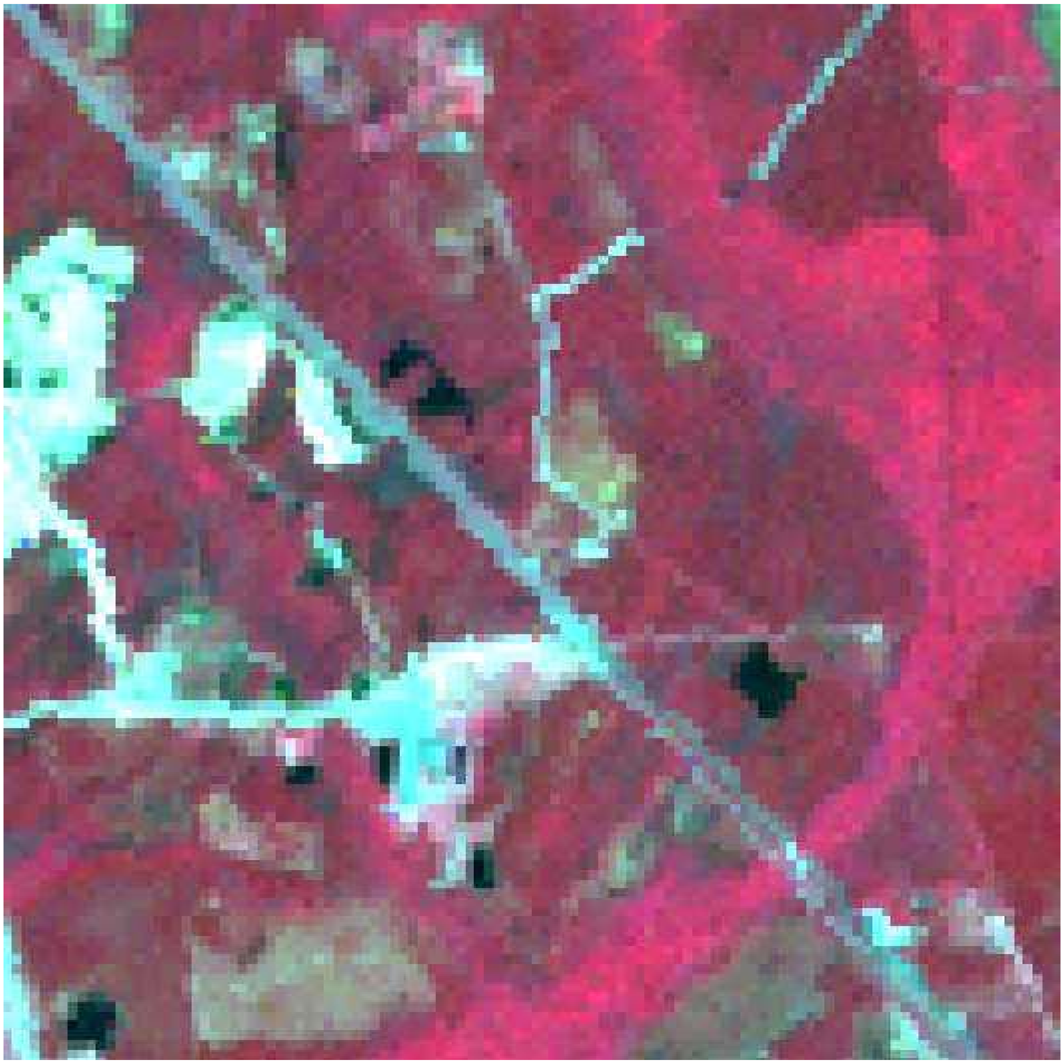

Figure 5. Landsat 7 3-Band Composite Satellite Image (30-meter resolution)

Figure 6. Color Infrared DOQQ (1-meter resolution)

Figure 7. FDOT True Color Aerial Photo (1-foot resolution)

4.4.2 Image Processing Results

Spectral enhancements to imagery may be used to extract new data from within an image. These types of enhancements remove redundancy within the original data. This new data output may in turn be easier to interpret, both to the eye and in an image classification. The NDVI, PCA and Tasseled Cap processes were successful in reducing the number of individual image bands needed to distinguish between vegetation types associated with hydric soils. These types of spectral enhancements require the image data to be multispectral, and in some cases derived from the infrared portion of the spectrum. The

Tasseled Cap algorithm is dependent on coefficients that are data sensor specific and may only be applied to the appropriate raw data. Figure 8 shows Tasseled Cap transformation applied to Landsat TM image. Light green denotes vegetated areas with high moisture content, indicative of hydric soils. Areas in blue represent other vegetated areas and areas in red indicate urban or bare soil.

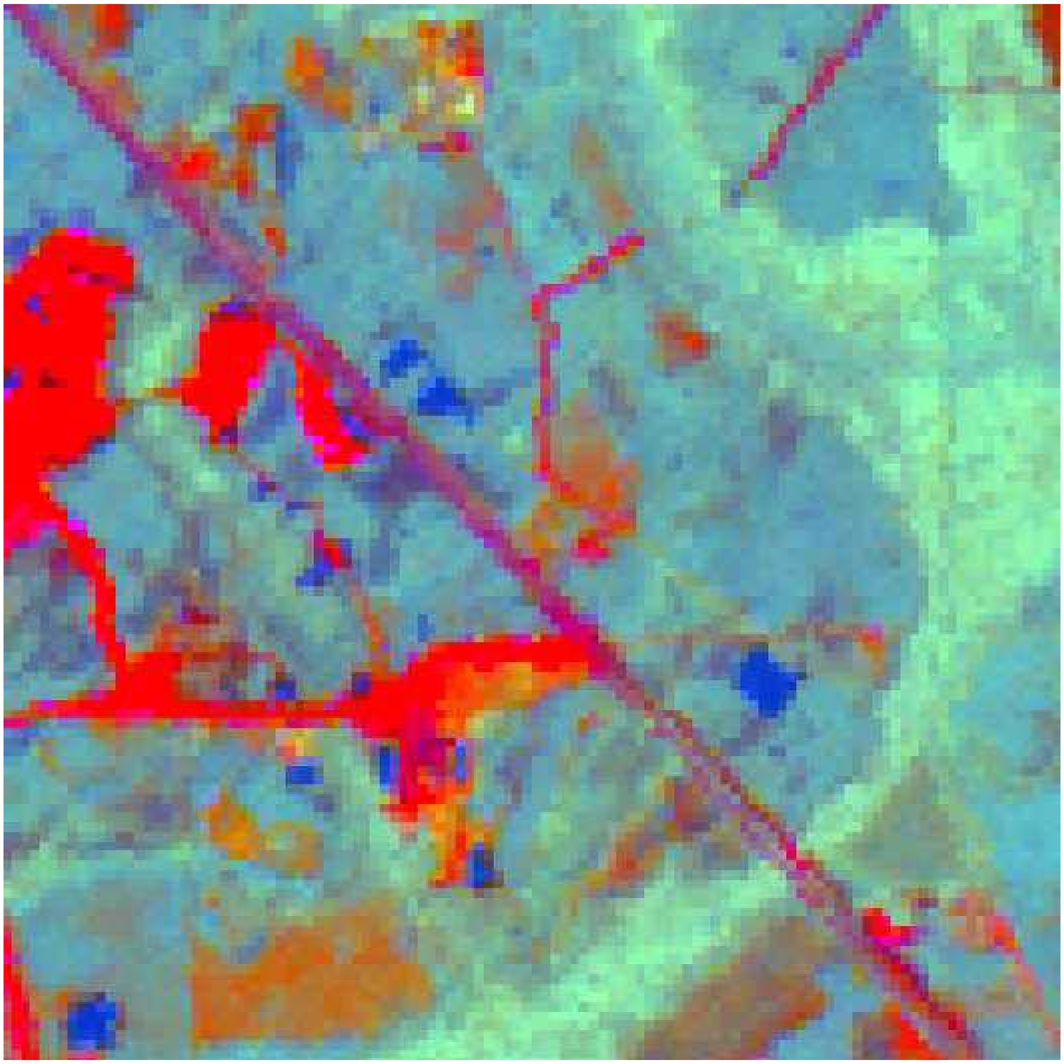

Figure 8. Sample Tasseled Cap Image Derived from Landsat TM

The various resolution merge algorithms are all types of spatial enhancements. These spatial enhancements were applied to the imagery to examine the possibility of combining the benefits of high level individual feature extraction associated with the high resolution imagery and the greater spectral range associated with the satellite imagery. These data merge enhancements are computationally intensive, requiring both large amounts of computer cycles and disk storage space (for every twofold increase in pixel resolution there is a corresponding fourfold increase in disk storage requirements). These types of spatial enhancements are of limited value at this time, as the FDOT is acquiring multispectral image data natively and is no longer only acquiring panchromatic data.

4.4.3 Land Cover Classification

Both supervised and unsupervised classifications were investigated to assess their potential efficiency in terms of time and costs to FDOT in the identification of hydric soils. A supervised classification requires the computer operator to identify and select training sets relevant to the desired land cover one hopes to extract from the image data. Training sets may reflect either individual pixels or groupings of pixels. They can also be derived from external supporting datasets. In this case, samples were selected from hydric polygons present in the NRCS soils data. In contrast, an unsupervised classification is primarily computer automated, searching for statistical similarities in the data. The pixels in the image are grouped according to the user-defined number of desired output classes or categories. The efficiency of this process is dependent on multiple variables; including the heterogeneity of the image data (range and total number of pixel values) and the number of desired output classes. These methods are in contrast to standard air photo interpretation methods, where the individual draws a polygon around areas that appear related based on vegetation or other land cover type.

Multiple issues were encountered with both classification methods. Where there is appropriate ancillary data such as hydric soils to help create training sets, the supervised classification process is more efficient than the unsupervised process. Appropriate ancillary data is not available in all areas, and is therefore subject to greater operator bias in the choice of training sets. Data source accuracy and currency are significant considerations in terms of selecting ancillary data to be used as training sets. The following 2 figures reflect the significant differences and issues present between data versions, in this case the hydric soils data derived from original NRCS data and the updated version. The significant differences in both shape and extent of the polygons cause equally significant problems in the classification process and results.

Figure 9. Original Hydric Soils Data

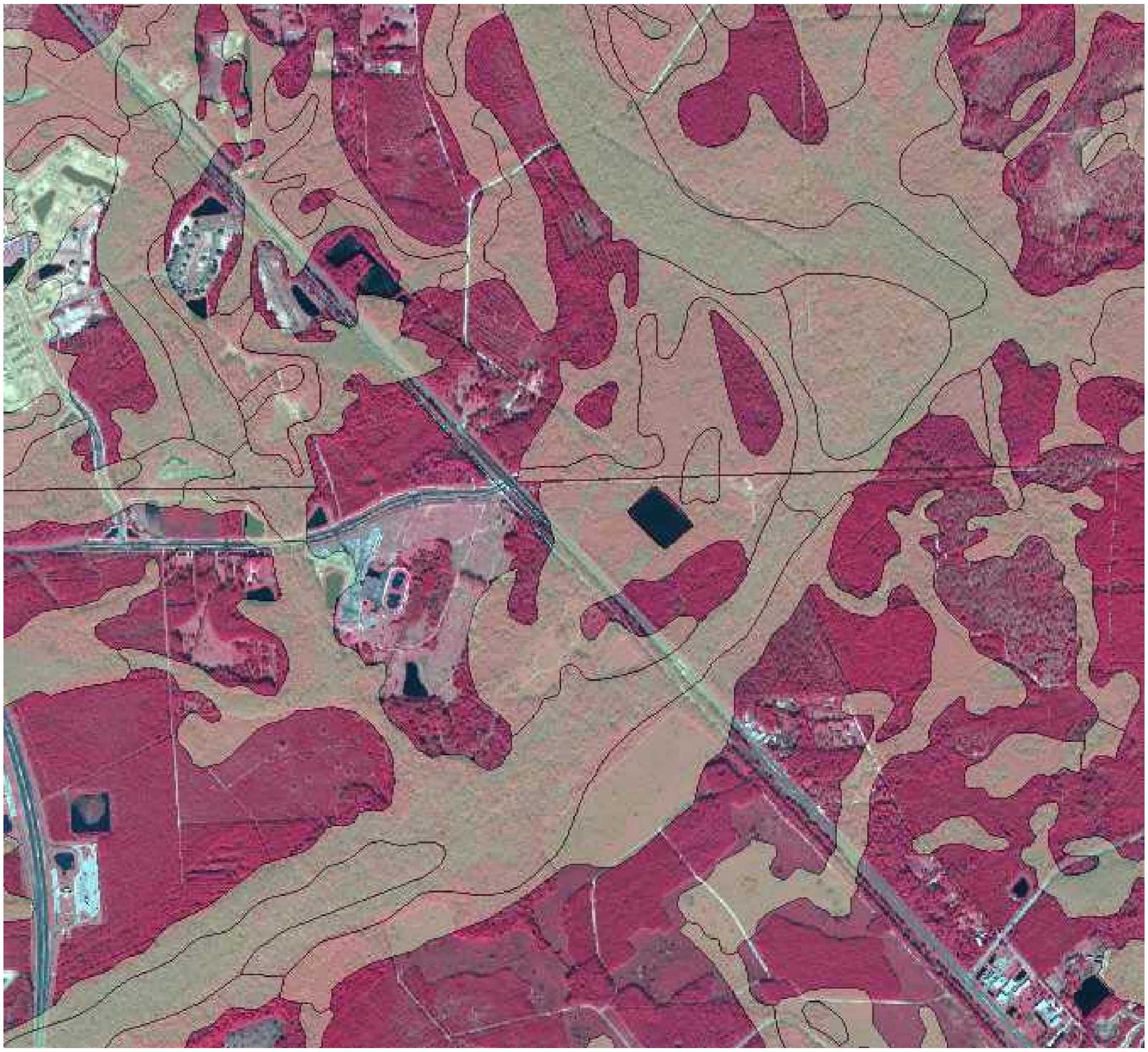

Figure 10. Updated Hydric Soils Data

Classification results for any one FDOT image were promising and could be made to approximate the same geographic extent as the hydric soils data. Unfortunately the process had to be started anew for each image, removing the option for automation. Additionally, the process was operator intensive in terms of time and iterations in order to achieve similar results.

5 DISCUSSION

5.1 Maintain Unique Identifier to Join and Manage Project Facilities

SIS projects incorporate a variety of spatial and attribute data, representing multiple transportation facilities, transportation modes, and project information. Therefore it is essential that a unique identifier be maintained in order to link all features associated with a particular SIS alternative. This identifier should be assigned for each SIS Needs Project and each spatial component associated with a Needs project should have a reference to that unique identifier. In addition, the Master Needs Table, or another similar table that contains the master list of SIS Needs Projects should be maintained and used to organize the relationships amongst SIS project components. Having this unique identifier will allow for quick identification, mapping, and organization of all spatial features and attribute data associated with a particular project.

5.2 Leverage Existing Resources and Maximize Efficiency

The EST and other related ETDM decision-support tools represent a large FDOT investment of time, financial and human resources, and technological expertise. As previously discussed in this paper, many of the tools created for ETDM can be customized for use in other applications. While it would be possible to derive a stand-alone web-interface for SIS, an easier and more cost-effective option would be to follow what has been demonstrated in this body of work and simply use the existing tools in ETDM. The database structure, programming and web interface, existing code base, and modules created for ETDM can be quickly adapted for SIS needs by utilizing EST user *roles*.

Currently there are over 30 roles used in ETDM to allow or prohibit access to different reports and tools. Each role provides varying levels of read and write privileges on project data. A project designated for SIS-use only could be excluded from map views, GIS analysis reports, etc. for users who do not have the necessary role and permissions. If it were deemed necessary, visibility and access to SIS project data could be limited to certain users, by assigning to them a special role, such as that for FIHS Central Office. Besides being the most cost-effective option, it would also allow SIS projects to be viewed in full context with other transportation projects that have been input to the ETDM database, providing additional and meaningful information. Furthermore, following this approach would mean that any enhancements made to the EST would immediately be available for SIS-specific use, without having to update/apply the same modifications to a second web-interface.

If an SIS role through the EST interface is utilized, the following ETDM tools would be readily available for evaluation of SIS Needs projects:

GIS Analyses and Analysis Results – The GIS analysis tool performs spatial overlays of GIS layers to determine the impacts to environmental and socio-cultural resources by the proposed project. As tested in this research project, the GIS analyses can be performed on SIS Needs projects with multiple transportation modes and multiple geographic feature types. The spatial layers chosen for GIS analyses can easily be modified to meet the needs of SIS project evaluation. The analysis results are stored in the database, but can be exported to Access database format, MS Excel spreadsheet, or XML for use in external applications.

Project Evaluation and Display Mechanisms – The EST website offers a readily-available web portal from which users can review SIS Needs project information, view and query GIS analyses via interactive maps, and enter comments regarding the project.

Hard-Copy PDF Maps – As tested in this research project, PDF maps displaying SIS Needs project facilities in relation to environmental and community resources can be exported from the EST.

5.3 Digital Image Considerations

There are two components of the ETDM process where digital imagery and derived products are useful – the Planning screen and the Programming screen. This information is accessible for compilation and analysis through the web-based Environmental Screening Tool (EST). The Planning component provides an opportunity for ETDM partner agencies to review proposed projects and suggest alternatives to reduce the potential effects on “natural and human environments” (Florida Department of Transportation, 2006, p.5). The Programming component is the last step before finalization of the Work Program. In this component, engineering and planning technical issues are identified as well as completion of relevant NEPA requirements (Florida Department of Transportation, 2006, p.5). Information derived from digital image analysis can play a significant role in this phase due to the currency of the data, large area coverage, and the ability to delineate land cover and roadway features.

Included in the FDOT/ETDM inventory of digital imagery are statewide Landsat ETM+ scenes and a variety of analogue and digital aerial imagery.

Digital imagery is sourced from either contracts with private sector aerial mapping firms or from in-house aerial data collections. Contractor-supplied imagery is typically collected using the Leica Geosystems ADS40, while the FDOT Surveying and Mapping Office owns a Zeiss/Intergraph Imaging Digital Mapping Camera (DMC).

Specific design and functional details of the ADS40 are well documented in the literature (Kellenberger and Nagy, 2008; Honkavaara and Markelin, 2007; Alhamlan, et. al., 2004; Beisl, 2006; Cassella, et. al., 2008a; Fricker, et. al., 2001; Hu, et. al., 2008; Reulke, et. al., 2004). It is a pushbroom CCD line scanner with a single lens and a beam-splitter that produces five VNIR spectral bands with a radiometric resolution of 12 bits. Each spectral band is collected in the nadir and (rear) oblique perspective, which can yield a stereoscopic digital image. The DMC is also well documented (Zhao, et. al, 2008; Hinz, 2001; Alamus, 2008; Hintz, et. al., 2001; Madani, and Shkolnikov, 2008; Madani, et. al., 2004; Talaya, et. al., 2008) and is essentially a structure that allows for the coincident utilization of up eight digital cameras to image in the VNIR spectrum (4 panchromatic; one each for blue, green, red, infrared).

Sensor design and characteristics have direct implications for FDOT task requirements, applications and the goal of this study. The ADS40 has greater radiometric accuracy and resolution, while the DMC has greater geometric accuracy and resolution (Schroth, 2007). Of importance to discrimination of soil vegetation spectral signatures, ADS40 multispectral data has discrete bands with a nominal bandwidth of 50nm. This contrasts with the DMC, which collects multispectral data with overlapping bands, nominally ranging from 60 to 130nm in width (Honkavaara and Markelin, 2007; Wan and Hsu, 2008). The higher resolution pan sensors within the DMC collect data spanning the multispectral bands, which facilitates improving image resolution through “pan-sharpening” (Wan and Hsu, 2008).

As a pushbroom scanner, the ADS40 has the capability to acquire relatively long continuous swaths of data, which should enable consistent radiometric correction and spectral signatures, allowing for automated processing and analysis. This implies that the ADS40 is preferable for environmental identification and mapping applications. The DMC is essentially a digital frame camera, but its geometric integrity and resolution facilitates the production of accurate image mosaics. Individual images and mosaics have utility for photogrammetric measurements, engineering studies and the generation of digital surface models (DSM) from stereo pairs.

Investigation of automated processing of ADS40 image products in both research and pilot project mode has been reported in the scientific and professional literature. Samples of topics of interest include vegetation and soils mapping, as well as urban areas and archaeological sites (Bogrekci, et. al., 2005; Gruen, 2008; Hu, 2008; Kellenberger and Nagy, 2008; Madhavan, 2004; Sah, 2002; Welter and Morin, 2003).

Currently, the ADS40 data is delivered to FDOT in 8-bit TIFF file format, with a “tonal curve” radiometric correction applied (Woolpert, 2006). FDOT then converts the TIFF file to multiresolution seamless image database (MrSID^{TM}) file format (Thomas, 2006).

The conversion process utilizes a lossy compression procedure that further modifies the radiometric/spectral integrity of the ADS40 data. DMC data as collected by the Florida Department of Transportation may be processed according to application. For DMC orthophoto production, a series of manual and automatic geometric corrections are applied (e.g. aerotriangulation bundle adjustment, orthorectification) and color balancing is used to produce visually consistent mosaics (Florida Department of Transportation, 2007).

6 CONCLUSIONS

The goal of this project was to evaluate multiple existing inventories of digital data repositories and develop methods, processes, and customized interfaces to analyze the data. The intent is to provide better decision support to the FDOT and commenting agencies during review of proposed transportation improvement projects. The research herein finds divergent conclusions for the two major data repositories investigated - SIS Needs Projects and Digital Imagery. While SIS Needs Project data can be reasonably integrated into the ETDM process and utilize EST tools, automated processing of digital imagery data is not currently an efficient use of the FDOT's resources.

6.1 SIS Needs Projects

SIS Needs projects, which represent a variety of critical transportation facilities and multiple transportation modes, present a challenge of linking and synthesizing disparate databases into useful information to effectively evaluate the projects. One FDOT initiative, ETDM's Environmental Screening Tool, has already addressed some aspects of this challenge and should be used as a model for building decision support tools.

The FDOT can leverage the existing temporal, financial, and human resources already invested in the EST, by expanding and building upon the EST interface and tools. Additional tools can be quickly and efficiently built from the existing EST infrastructure, offering transportation planners and decision makers ready to use information that is accessible and valuable. Furthermore, the generic database structure designed for ETDM allows for flexible inputs and customization for use by a variety of applications.

MPOs/MTPOs, Counties, and the FDOT use various external databases and applications to assist in the transportation planning process. These external databases and applications represent substantial resources and investments made by each agency. As expected, agencies are reluctant to diverge from these investments to conform to other databases, but can offer methods to facilitate information sharing between the databases. To maximize efficiency amongst all parties involved in the transportation planning and decision-making process, it is essential that the information gathered while mapping and evaluating transportation projects be accessible and transferable to external applications and databases.

6.2 Digital Image Processing

The automated analysis of the FDOT's digital orthophotos, in their current format, is not time or resource efficient for utilization in the EST. This is supported by the literature review and based on the results of application of various image classification methods to existing digital data, as described above. With an image library of well over 15,000 images, automated classification procedures would be time and cost prohibitive, requiring multiple iterations with substantial user interaction and revision.

Automated processing, classification, and interpretation of digital imagery are challenging applications. Primary considerations include radiometric and geometric calibration and correction, as well as validation of classification results. Factors affecting these considerations include sensor design, feature characteristics and environmental conditions. Higher resolution, large-scale data is particularly challenging, while providing greater information about ground features (Gruen, 2008).

As described above, FDOT owns and works with a variety of digital imagery. Considering the DMC, the current processing workflow includes automated and semi-automated procedures. Effective applications include digital surface modeling and high-resolution photogrammetric measurements. Examples are engineering site design, inventory of existing roadway features, urban land cover characterization, and quality assurance/quality control of various data and products.

ADS40 imagery has the potential to provide current, high-resolution data that can be processed in an automated or semi-automated fashion. As a pushbroom scanner, data could be collected in long, continuous and overlapping strips or swaths. Data acquired by contractors would be processed to Level 1, which would include sensor noise correction (e.g. dark current and non-uniformity) as well as calibration for at-sensor radiance and geometric corrections (Beisel, 2006; Kellenberger and Nagy, 2008). Reflectance data can be developed using empirical or physically based models. Empirical methods include flat fielding and empirical line, which are interactive, or dark object subtraction, which is an automated statistical method (Beisel and Woodhouse, 2004). For example, one version of the empirical line method standardizes digital numbers (spectral values) within a swath by using "spectrally stable" ground measurements of stationary features such as gravel or concrete (Kellenberger and Nagy, 2008; Ferrier, 1995; Smith and Milton, 1999). As an extension of this method, adjacent swaths are then normalized to the initially corrected swath. Standard image processing methods could then be applied to the data to derive a variety of feature classifications. Examples of appropriate applications include filling of data gaps, updating existing data products, corridor feature mapping, and detailed analysis of natural and cultural resources. This information could be used to verify and supplement existing thematic spatial data layers (e.g. land cover, roadway features, etc.).

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APPENDIX 1 – DATABASE VIEWS

```
---------------------
-- V_NEEDS_FEATURES --
---------------------
```

Regular db view, req'd by the spatial view, EXPORT_PROJECT_ALT_FEATURE, below.

QUERY:

```
select at.needs_id,at.autoid,'AIRPORT' as mode_type,to_char(std_id) std_id,name,null as begin_post, null as end_post
from at_needs_airport at,airport_polygons a where at.autoid = a.autoid
union
select at.needs_id,at.autoid,'HIGHWAY',to_char(roadway_id),null,begin_post,end_post
from at_needs_highway at
union
select at.needs_id,at.autoid,'SEAPORT',to_char(std_id),port_name,null,null
from at_needs_seaport at
union
select at.needs_id,at.autoid,'SPACEPORT',to_char(std_id),at.name,null,null
from at_needs_spaceport at, spaceport_polygons s where at.autoid = s.autoid
union
select at.needs_id,at.autoid,'WATERWAY',to_char(std_id),waterway_name,at.begin_post,at.end_post
from at_needs_waterway at, waterway_needs w where at.autoid=w.autoid WITH READ ONLY
```

COLUMNS:

```
 Name                            Null?    Type
 ----------------------- -------- ----------------
 NEEDS_ID                                 NUMBER(6)
 AUTOID                                   NUMBER(10)
 MODE_TYPE                                VARCHAR2(9)
 STD_ID                                   VARCHAR2(40)
 NAME                                     VARCHAR2(255)
 BEGIN_POST                               NUMBER
 END_POST                                 NUMBER
```

```
-------------------------------
-- EXPORT_PROJECT_ALT_FEATURE --
-------------------------------
```

Spatial view. Joins data from highway_needs layer (segments), georef_highway (table), the Master Needs table, the export_queue table, and costref table

QUERY:

```
select exp.fk_project, /************* HIGHWAY ***************/
       mn.description as "PRJNAME",
       USERNAME,
       nvl(hwy.begin_text,gref.begin_text) as "FROM_FACILITY",
       nvl(hwy.end_text,gref.end_text) as "TO_FACILITY",
       101 as "FK_ORG",  /*FIHS Central Office*/
       42 as "FK_ORG_USER", /*superuser*/
       2 as "FK_PROJECT_GROUP", /*SIS*/
       exp.needs_id as source_id,
       1 as "FK_PRJ_ALT",
       exp.fk_project_alt,
       "COST",
       decode(mode_type,'HIGHWAY','Y',null) as "MODE_ROADWAY",
       --"LENGTH",
       decode(mode_type,'RAILWAY','Y',null) as "MODE_RAIL",
       to_char(hwy.roadway_id) as "MODE_ID",
       hwy.begin_post as "BMP",
       hwy.end_post as "EMP",
       exp.fk_feature,
       'L' as "FEATURE_TYPE",
       exp.autoid as "SOURCE_AUTOID",
       null as "FEATURE_NAME",
       exp."MODE_TYPE"
from highway_needs hwy,
     georef_highway gref,
     master_np mn,
     export_queue exp,
     (select needs_id,sum(cost) as cost from costref group by needs_id) cost
where hwy.needs_id = mn.needs_id
  and hwy.needs_id = gref.needs_id
  and hwy.roadway_id = gref.roadway_id
  and hwy.begin_post = gref.begin_post
  and hwy.end_post = gref.end_post
  and hwy.needs_id = exp.needs_id
  and hwy.autoid = exp.autoid
  and exp.needs_id = cost.needs_id
  and exp.mode_type = 'HIGHWAY'
  and exp.qflag = 1
UNION
select exp.fk_project, /************* WATERWAY ***************/
       mn.description as "PRJNAME",
       'superuser' as "USERNAME",
       null as "FROM_FACILITY",
       null as "TO_FACILITY",
       101 as "FK_ORG",  /*FIHS Central Office*/
```

```
       42 as "FK_ORG_USER", /*superuser*/
       2 as "FK_PROJECT_GROUP", /*SIS*/
       exp.needs_id as source_id,
       1 as "FK_PRJ_ALT",
       exp.fk_project_alt,
       "COST",
       decode(mode_type,'HIGHWAY','Y',null) as "MODE_ROADWAY",
       --"LENGTH",
       decode(mode_type,'RAILWAY','Y',null) as "MODE_RAIL",
       to_char(wtr.std_id) as "MODE_ID",
       wtr.begin_post as "BMP",
       wtr.end_post as "EMP",
       exp.fk_feature,
       'L' as "FEATURE_TYPE",
       exp.autoid as "SOURCE_AUTOID",
       waterway_name as "FEATURE_NAME",
       exp."MODE_TYPE"
from waterway_needs wtr,
     at_needs_waterway gref,
     master_np mn,
     export_queue exp,
     (select needs_id,sum(cost) as cost from costref group by needs_id) cost
where wtr.needs_id = mn.needs_id
  and wtr.needs_id = gref.needs_id
  and wtr.autoid = gref.autoid
  and wtr.needs_id = exp.needs_id
  and wtr.autoid = exp.autoid
  and exp.needs_id = cost.needs_id
  and exp.mode_type = 'WATERWAY'
  and exp.qflag = 1
UNION
select exp.fk_project, /************* OTHER MODES ***************/
       mn.description as "PRJNAME",
       'superuser' as "USERNAME",
       null as "FROM_FACILITY",
       null as "TO_FACILITY",
       101 as "FK_ORG",  /*FIHS Central Office*/
       42 as "FK_ORG_USER", /*superuser*/
       2 as "FK_PROJECT_GROUP", /*SIS*/
       exp.needs_id as source_id,
       1 as "FK_PRJ_ALT",
       exp.fk_project_alt,
       "COST",
       decode(exp.mode_type,'HIGHWAY','Y',null) as "MODE_ROADWAY",
       --"LENGTH",
       decode(exp.mode_type,'RAILWAY','Y',null) as "MODE_RAIL",
```

```
       v.std_id as "MODE_ID",
       null as "BMP",
       null as "EMP",
       exp.fk_feature,
       'A' as "FEATURE_TYPE",
       exp.autoid as "SOURCE_AUTOID",
       v.name as "FEATURE_NAME",
       exp."MODE_TYPE"
from master_np mn,
     export_queue exp,
     v_needs_features v,
     (select needs_id,sum(cost) as cost from costref group by needs_id) cost
where mn.needs_id = exp.needs_id
  and exp.needs_id = cost.needs_id
  and exp.needs_id = v.needs_id
  and exp.autoid = v.autoid
  and exp.mode_type = v.mode_type
  and exp.mode_type in  ('AIRPORT','SEAPORT','SPACEPORT')
  and exp.qflag = 1 WITH READ ONLY

 Name                   Null?    Type
 ---------------------- -------- ----------------
 FK_PROJECT                      NUMBER(10)
 PRJNAME                         VARCHAR2(220)
 USERNAME                        CHAR(9)
 FROM_FACILITY                   VARCHAR2(255)
 TO_FACILITY                     VARCHAR2(255)
 FK_ORG                          NUMBER
 FK_ORG_USER                     NUMBER
 FK_PROJECT_GROUP                NUMBER
 SOURCE_ID                       NUMBER(6)
 FK_PRJ_ALT                      NUMBER
 FK_PROJECT_ALT                  NUMBER(10)
 COST                            NUMBER
 MODE_ROADWAY                    VARCHAR2(1)
 MODE_RAIL                       VARCHAR2(1)
 MODE_ID                         VARCHAR2(255)
 BMP                             NUMBER
 EMP                             NUMBER
 FK_FEATURE                      NUMBER(10)
 FEATURE_TYPE                    CHAR(1)
 SOURCE_AUTOID                   NUMBER(10)
 FEATURE_NAME                    VARCHAR2(255)
 MODE_TYPE                       VARCHAR2(10)
```

-- EXPORT_PROJECT_ALT --

Spatial view. Joins data from highway_needs layer (segments), georef_highway (table), the Master Needs table, the export_queue table, and costref table

QUERY:

```
select distinct "FK_PRJ_ALT",
      "FK_PROJECT",
      "COST",
      "MODE_ROADWAY",
      null as "MODE_TRANSIT",
      null as "MODE_BIKE",
      null as "MODE_PEDESTRIAN",
      null as "LENGTH",
      null as "XMIN",
      null as "XMAX",
      null as "YMIN",
      null as "YMAX",
      from_facility as "PRJALT_FROM_FACILITY",
      to_facility as "PRJALT_TO_FACILITY",
      null as "LOCAL_ID",
      sysdate as "TIME_STAMP",
      null as "MODE_TOBEDETERMINED",
      "MODE_RAIL",
      'Editing' as "FK_STATUS",
      1 as "EDIT_REVIEW_CYCLE",
      null as "CURRENT_REVIEW_START",
      null as "REVIEW_DURATION",
      'superuser' as "USERNAME",
      null as "FK_ALT_TYPE",
      'Y' as "FIHS",
      decode(mode_type,'HIGHWAY',mode_id,null) as "RDWYID",
      "BMP",
      "EMP",
      "FK_PROJECT_ALT",
      1 as "FK_ETDM_STATUS",
      "FK_ORG_USER",
      "SOURCE_ID" /*needs_id*/
  from export_project_alt_feature
 where source_id in (select source_id from export_project_alt_feature group by source_id
having count(*) = 1)
UNION
select distinct "FK_PRJ_ALT",
      "FK_PROJECT",
```

```
       "COST",
       null as "MODE_ROADWAY",
       null as "MODE_TRANSIT",
       null as "MODE_BIKE",
       null as "MODE_PEDESTRIAN",
       null as "LENGTH",
       null as "XMIN",
       null as "XMAX",
       null as "YMIN",
       null as "YMAX",
       null as "PRJALT_FROM_FACILITY",
       null as "PRJALT_TO_FACILITY",
       null as "LOCAL_ID",
       sysdate as "TIME_STAMP",
       null as "MODE_TOBEDETERMINED",
       null as "MODE_RAIL",
       'Editing' as "FK_STATUS",
       1 as "EDIT_REVIEW_CYCLE",
       null as "CURRENT_REVIEW_START",
       null as "REVIEW_DURATION",
       'superuser' as "USERNAME",
       null as "FK_ALT_TYPE",
       'Y' as "FIHS",
       null as "RDWYID",
       null as "BMP",
       null as "EMP",
       "FK_PROJECT_ALT",
       1 as "FK_ETDM_STATUS",
       "FK_ORG_USER",
       "SOURCE_ID" /*needs_id*/
  from export_project_alt_feature
 where source_id in (select source_id from export_project_alt_feature group by source_id
having count(*) > 1) WITH READ ONLY
```

COLUMNS:

```
 Name                    Null?    Type
 ----------------------- -------- ----------------
 PK_PRJ_ALT                       NUMBER
 FK_PROJECT                       NUMBER
 COST                             NUMBER
 MODE_ROADWAY                     VARCHAR2(1)
 MODE_TRANSIT                     VARCHAR2
 MODE_BIKE                        VARCHAR2
 MODE_PEDESTRIAN                  VARCHAR2
 LENGTH                           VARCHAR2
```

XMIN	VARCHAR2
XMAX	VARCHAR2
YMIN	VARCHAR2
YMAX	VARCHAR2
PRJALT_FROM_FACILITY	VARCHAR2(255)
PRJALT_TO_FACILITY	VARCHAR2(255)
LOCAL_ID	VARCHAR2
TIME_STAMP	DATE
MODE_TOBEDETERMINED	VARCHAR2
MODE_RAIL	VARCHAR2(1)
FK_STATUS	CHAR(7)
EDIT_REVIEW_CYCLE	NUMBER
CURRENT_REVIEW_START	VARCHAR2
REVIEW_DURATION	VARCHAR2
USERNAME	CHAR(9)
FK_ALT_TYPE	VARCHAR2
FIHS	CHAR(1)
RDWYID	VARCHAR2(255)
BMP	NUMBER
EMP	NUMBER
FK_PROJECT_ALT	NUMBER
FK_ETDM_STATUS	NUMBER
FK_ORG_USER	NUMBER
SOURCE_ID	NUMBER

```
--------------------
-- EXPORT_PROJECT --
--------------------
```

Spatial view. Joins data from highway_needs layer (segments), georef_highway (table), the Master Needs table, the export_queue table, and costref table.

QUERY:

```
select "FK_PROJECT",
      "PRJNAME",
      "USERNAME",
      sysdate as "TIME_STAMP",
      "FROM_FACILITY",
      "TO_FACILITY",
      "FK_ORG",
      "FK_ORG_USER",
      "FK_PROJECT_GROUP",
      "SOURCE_ID"
  from export_project_alt_feature
```

```
 where source_id in (select source_id from export_project_alt_feature group by source_id
having count(*) = 1)
UNION
select distinct "FK_PROJECT",
       "PRJNAME",
       "USERNAME",
       sysdate as "TIME_STAMP",
       null as "FROM_FACILITY",
       null as "TO_FACILITY",
       "FK_ORG",
       "FK_ORG_USER",
       "FK_PROJECT_GROUP",
       "SOURCE_ID"
  from export_project_alt_feature
 where source_id in (select source_id from export_project_alt_feature group by source_id
having count(*) > 1) WITH READ ONLY
```

COLUMNS:

```
 Name                    Null?    Type
 ----------------------- -------- ----------------
 FK_PROJECT                       NUMBER
 PRJNAME                        VARCHAR2(220)
 USERNAME                         CHAR(9)
 TIME_STAMP                        DATE
 FROM_FACILITY                       VARCHAR2(255)
 TO_FACILITY                       VARCHAR2(255)
 FK_ORG                         NUMBER
 FK_ORG_USER                        NUMBER
 FK_PROJECT_GROUP                       NUMBER
 SOURCE_ID                       NUMBER
```

APPENDIX 2 –INVENTORY OF AERIAL IMAGERY

County	Month	Year	# Images	Gig	Metadata	Source	B&W	True Color	Infrared	Pixel
Alachua	4	2004	282	1.60	Y	FDOT	Y	N	N	1 ft
Baker	12		190	1.60	Y	FDOT	N	Y	Y	1 ft
Bay	11		275	2.20	Y	FDOT	N	Y	Y	1 ft
Bradford	10-11		107	0.88	Y	FDOT	N	Y	Y	1 ft
Brevard	02	2005	430	3.00	Y	FDOT	N	Y	N	1 ft
Broward	?	2004	141	0.93	Y	FDOR	N	Y	N	1 ft
Calhoun	12	2004	198	1.70	Y	FDOT	N	Y	N	1 ft
Charlotte										
Citrus	?	2004	435	1.97	N	FDOT	N	Y	N	1 ft
Clay	?	2003/04	188	1.38	N	FDOT	N	Y	N	1 ft
Collier										
Columbia										
Dade	?	2005	306	2.20	N	FDOR	N	Y	N	1 ft
Desoto	03	2004	176	1.50	Y	FDOR	N	Y	N	1 ft
Dixie	03-04	2004	252	2.10	Y	FDOT	N	Y	Y	1 ft
Duval	03-04		290	2.20	Y	FDOT	N	Y	N	1 ft
Escambia	12	2004	303	2.20	Y	FDOT	N	Y	Y	1 ft
Flagler	04		175	1.40	Y	FDOT	N	Y	Y	1 ft
Franklin	03-04	2004	246	1.38	Y	FDOT	Y	N	N	1 ft
Gadsden	11-01	2004/05	168	1.40	Y	FDOT	N	Y	N	1 ft
Gilchrist	04	2004	114	0.64	Y	FDOT	Y	N	N	1 ft
Glades	01		303	5.20	Y	FDOR	N	Y	N	1 ft
Gulf	11-02	2005/06	210	1.80	Y	FDOT	N	Y	N	1 ft
Hamilton	01	2005	195	1.60	Y	FDOT	N	Y	N	1 ft
Hardee	03	2004	176	1.50	Y	FDOR	N	Y	N	1 ft
Hendry	01		354	6.10	Y	FDOR	N	Y	N	1 ft
Hernando	04	2004	155	1.20	Y	FDOT	N	Y	N	1 ft
Highlands	?	2004	1275	21.00	N	FDOR	N	Y	N	.5 ft
Hillsborough										
Holmes	09	2003	151	0.89	Y	FDOT	Y	N	N	1 ft
Indian River										
Jackson	04	2004	272	1.45	Y		Y	N	N	1 ft
Jefferson										
Lafayette	03-04	2005	199	1.60	Y	FDOT	N	Y	N	1 ft
Lake	?	2004	1	7.30	?	FDOR	N	Y	N	1 ft
Lee	01	2005	35	7.30	N	FDOR	N	Y	N	.5 ft
Leon										
Levy										
Liberty	04	2004	258	1.50	Y	FDOT	Y	N	N	1 ft
Madison	10	2005	222	1.90	Y	FDOT	N	Y	Y	1 ft
Manatee										
Marion	10-11	2004	508	4.00	Y	FDOT	N	Y	N	1 ft
Martin										

County	Month	Year	# Images	Gig	Metadata	Source	B&W	True Color	Infrared	Pixel
Monroe										
Nassau	04		250	2.00	Y	FDOT	N	Y	N	1 ft
Okaloosa	10	2005	182	5.40	Y	FDOT	N	Y	N	1 ft
Okeechobee										
Orange										
Osceola										
Palm Beach										
Pasco	?	2004	937	1.60	N	FDOR	N	Y	N	1 ft
Pinellas										
Polk	02	2005	2396	8.60	Y	SW	N	Y	N	1 ft
Putnam	12		268	2.10	Y	FDOT	N	Y	Y	1 ft
Santa Rosa	07		215	6.70	Y	FDOT	N	Y	N	1 ft
Sarasota	?	2004	855	2.80	N	FDOR	N	Y	N	1 ft
Seminole	01-02	2006	136	0.95	Y	FDOT	N	Y	Y	1 ft
St. Johns	03		220	4.30	Y	FDOR	N	Y	N	1 ft
St. Lucie										
Sumter										
Suwannee	01-03	2005	229	1.80	Y	FDOT	N	Y	N	1 ft
Taylor	11	2004	331	2.70	Y	FDOT	N	Y	N	1 ft
Union	05	2004	85	0.51	Y	FDOT	Y	N	Y	1 ft
Volusia	12-01	2005/06	439	3.17	Y	FDOT	N	Y	N	1 ft
Wakulla	03-04	2004	196	1.62	Y	FDOT	N	Y	N	1 ft
Walton	07		216	6.20	Y	FDOT	N	Y	N	1 ft
Washington	04	2004	195	1.10	Y	FDOT	Y	N	N	1 ft
			15,740	**146.17**						

APPENDIX 3 – STORED PROCEDURE

```
procedure export_for_analysis()
 as

   prj number;
   alt number;
   feat number;
   fType char(1);

begin
for i in (select distinct needs_id,feature_grouping from export_queue where qflag=1 and
fk_project is null order by needs_id)
loop

   select t_projects_seq.nextval into prj from dual;
   select t_project_alt_seq.nextval into alt from dual;

   update export_queue set fk_project = prj, fk_project_alt = alt where needs_id = i.needs_id
and qflag=1 and feature_grouping=i.feature_grouping;
   commit;

end loop; /* i */

insert into t_projects select * from export_project where fk_project is not null order by
fk_project;
insert into t_project_alt select * from export_project_alt where fk_project_alt is not null
order by fk_project_alt;

for j in (select autoid, mode_type, needs_id, feature_grouping from export_queue where
qflag=1 and fk_project_alt is not null and fk_feature is null order by needs_id,autoid)
loop

   select t_project_features_seq.nextval into feat from dual;

   update export_queue set fk_feature = feat where needs_id = j.needs_id and autoid =
j.autoid and mode_type = j.mode_type and qflag=1 and
feature_grouping=j.feature_grouping;
   commit;

end loop; /* j */

for k in (select * from export_project_alt_feature)
loop

      case k.mode_type
      when 'AIRPORT' then
```

```
        update airport_polygons
           set fk_project=k.fk_project, fk_project_alt=k.fk_project_alt,
fk_polygon=k.fk_feature, fk_prj_alt=k.fk_prj_alt
         where autoid = k.source_autoid
           and fk_polygon is null;


      when 'SEAPORT' then

        update seaport_polygons
           set fk_project=k.fk_project, fk_project_alt=k.fk_project_alt,
fk_polygon=k.fk_feature, fk_prj_alt=k.fk_prj_alt
         where autoid = k.source_autoid
           and fk_polygon is null;

      when 'SPACEPORT' then

        update spaceport_polygons
           set fk_project=k.fk_project, fk_project_alt=k.fk_project_alt,
fk_polygon=k.fk_feature, fk_prj_alt=k.fk_prj_alt
         where autoid = k.source_autoid
           and fk_polygon is null;

      when 'HIGHWAY' then

        update highway_needs
           set fk_project=k.fk_project, fk_project_alt=k.fk_project_alt,
fk_segment=k.fk_feature, fk_prj_alt=k.fk_prj_alt
         where autoid = k.source_autoid and needs_id = k.source_id
           and fk_segment is null;

      when 'WATERWAY' then

        update waterway_needs
           set fk_project=k.fk_project, fk_project_alt=k.fk_project_alt,
fk_segment=k.fk_feature, fk_prj_alt=k.fk_prj_alt
         where autoid = k.source_autoid and needs_id = k.source_id
           ;--and fk_segment is null;

      else
        raise_application_error(-20000,'mode_type not supported');
      end case;

end loop; /* k */

--sdeexport from sv_polygons | sdeimport to s_polygons
```

```
--sdeexport from sv_segments | sdeimport to s_segments
--insert into t_project_features select * from export_project_feature;
--insert into at_regions_projects select * from export_regions_projects;
--insert into at_project_road_system select * from export_project_roadsystem;
--insert into t_input_queue select * from export_input_queue order by feat_id; /* where
fk_feature in v_alt_features */
--insert into t_analysis_queue select * from export_analysis_queue order by fk_project_alt; /*
where fk_feature in v_alt features */
--update export_queue set exported = sysdate, qflag=0 where qflag=1 and fk_feature in
(select fk_feature from v_alt_feautures)

end;
```