Phase I of an Enterprise Geographical Information System (GIS) for Transportation

Final Report

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16. Abstract

The use of GIS at FDOT has been steadily increasing over the last several years. However, as individual offices and districts invest independently in GIS technologies, the result has been fractured GIS, creating redundant data storage and ineffective workflow, which calls for the need for this research project, to formally analyze the requirements and evaluate the business case for an enterprise system at FDOT. The project includes three tasks as follows – Task 1 – Assembled and reviewed literature germane to the concept of Enterprise GIS, including all previous work completed by the Department; Task 2 – Past efforts (from Task 1) were compared against the adopted Information Systems Development Methodology (ISDM) manual, and missing products needed for evaluating a business case were identified; Task 3 – Used pertinent information from past efforts to create or update missing products.

As part of Task 3, business needs were analyzed through stakeholder interviews and data flow maps. The assessment indicated that there are several enterprise data flows that occur with no formal data standards or coordination mechanisms. From this assessment the current problem was identified and defined in terms of legacy databases and data collection practices, varying data needs across functional areas and jurisdictions, and lack of formal coordination mechanisms and standards. The current problem clearly indicated the need for an enterprise framework, and the term 'Enterprise GIS' was redefined. Four implementation options were proposed, including a no build case to maintain status quo (Option 1), a pseudo-Enterprise GIS for ad hoc data sharing (Option 2), a distributed Enterprise GIS with enterprise standards (Option 3) and a centralized Enterprise GIS (Option 4). These four options were evaluated using cost-benefit analysis and risk assessment. Based on the results of this analysis and considering current FDOT's environment, Option 3 was recommended as the preferred Enterprise GIS solution. Several critical success factors for successful implementation of this option were analyzed in detail, and recommendations were made for approval by the GIS Functional, GIS Management, and FDOT Executive committees, including – 1) Approve adoption of a common definition of an Enterprise GIS; 2) Approve the need for an Enterprise GIS and recommend implementation; and 3) Develop an updated strategic plan.

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Executive Summary

Almost every major business process within the Florida Department of Transportation (FDOT) requires the use of Geographic Information System (GIS) data. The Department has invested significantly in GIS technologies through the creation and maintenance of geospatial data. The Central Office maintains spatial enterprise data that are used by many applications within FDOT for spatial display and analysis. However, district-level responsibilities require more regional and local analysis and consequently, district offices have developed GIS data and applications to address more localized needs. The result is a fractured GIS, where data sharing, data creation, application development, and techniques are not shared across functional groups or regional offices, which in turn creates redundant data storage and ineffective workflow. The primary objective of this research project was to formally analyze the requirements for an Enterprise GIS at FDOT, evaluate the business case and determine whether to proceed with implementation of an Enterprise GIS.

The three tasks in the research project include:

- Task 1 – Assemble and review literature germane to the concept of Enterprise GIS, including all previous work completed by FDOT, as well as best business practices of peer agencies that can be applied to FDOT;
- Task 2 – Compare the work completed to date (from Task 1) against the adopted *Information Systems Development* Methodology (ISDM) manual requirements and identify products that are missing from the existing inventory of literature; and
- Task 3 – Update or create any missing products such as business case, cost/benefit analysis, risk analysis, detailed user requirements etc.

Under Task 1, a thorough literature review was conducted to bring the team up to speed with all Enterprise GIS related work that is currently going on or has already been completed by the Department. With assistance from the GIS Coordinator at FDOT Central Office and input from members of the GIS Functional Steering Committee (GFC), the project team identified over 60 relevant projects, including key literature such as the *2004 User Needs Assessment*, *2006 Technology Assessment*, *Enterprise SIS Development Efforts*, and earlier FDOT Enterprise efforts related to data warehouse and data stewardship in the Central Office and at the district level. The objectives, approach, and outputs of each relevant project were identified and analyzed, and the projects were then classified into four categories based on how well they meet the objectives of this research project:

- Category 1 – Projects that meet one of more elements of the Information Systems Development Methodology (ISDM) for building an Enterprise GIS;
- Category 2 – Projects that can serve as reference materials for the current research or for subsequent implementation phases of the Enterprise GIS project;

- Category 3 – Applications and tools that traverse across multiple systems or serve several functional areas, and therefore, fit into the framework of an Enterprise GIS; and

- Category 4 – Other localized applications, tools, and GIS efforts that do not fit directly into the framework of an Enterprise GIS.

Review of the past literature reveals that both the Central Office and some of the district offices have taken the initiative to move away from stovepiped GIS systems and replace them with a more integrated approach. Early Enterprise GIS efforts were mostly made at the Central Office level, but in recent years they have been occurring more prominently at the district level. However, most of the enterprise solutions were never implemented, and many of the recommendations are already outdated, and therefore can not be readily adopted by this research project. There are still a large number of applications that fall under Category 4, indicating dominant localized development without agency wide coordination. With different offices pursuing their own GIS objectives based on their specific business problems and needs, the result is a disjointed GIS system that meet individual business needs, but does not generally provide the optimal support to benefit the whole Department.

Task 2 compares past efforts against the *ISDM Manual*, and identifies products that may be missing from the existing inventory of literature. The ISDM manual establishes the standards for how information systems are developed and identifies the required documentation for those information systems. The key products that are missing from the past literature include:

- consistent definition of 'Enterprise GIS'
- complete understanding of business needs and associated data flows
- complete understanding of key data elements
- comprehensive compilation of FDOT specific success factors
- planning and development of a Unified Base Map

Since the ISDM is oriented toward application development rather than an encompassing system such as Enterprise GIS, it does not include enough business case components. In addition to what is required by ISDM, the following components were considered to be missing: complete business needs assessment with enough stakeholder involvement; comprehensive understanding of the problem; and clear identification and complete evaluation of available options.

Task 3 fills the gaps by completing or updating these missing products and evaluating the business case for building an Enterprise GIS. High level stakeholder interviews were conducted and data flow maps generated to help understand the existing data flow and desired business needs for data sharing across various functional areas. This analysis also led to a comprehensive understanding of the problem, including major issues such as the following:

- Many legacy databases and data collection practices cater to the needs of individual organizations. However, there is increasing pressure on business units to share their raw data with other parts of the agency, and there is a growing need for users to have better access and better understanding of the

data, including its content, quality, currency, and suitability for specific applications.
- There is no established coordination of key common databases. These databases should include, at a minimum, a statewide road network through which legacy databases can be linked.
- There are no set standards in terms of accuracy, resolution, attribution, projection, or documentation for sharing spatial data.
- There are no interoperability mechanisms that allow for easy data exchange between existing software platforms.
- The organizational locations for GIS staff at FDOT are not consistent at either the Central office or the districts.

The concept of Enterprise GIS has been defined in many different ways based on the different objectives of particular projects. While some defined it as a centralized repository of data, others called it a package of applications and tools. It is important to have a clear definition of the term so that all stakeholders involved in the process can share the common vision. Based on ideas from the past literature, thoughts from stakeholder interviews as well as inputs from the GIS Functional Steering Committee, the following definition of Enterprise GIS was formulated during the course of the project:

> *Enterprise Geographic Information Systems (GIS) is an organization wide framework for Department communication and collaboration of shared geospatial data and GIS resources that enhances existing business processes and provides an efficient way to plan, analyze, and manage transportation infrastructure and related elements*

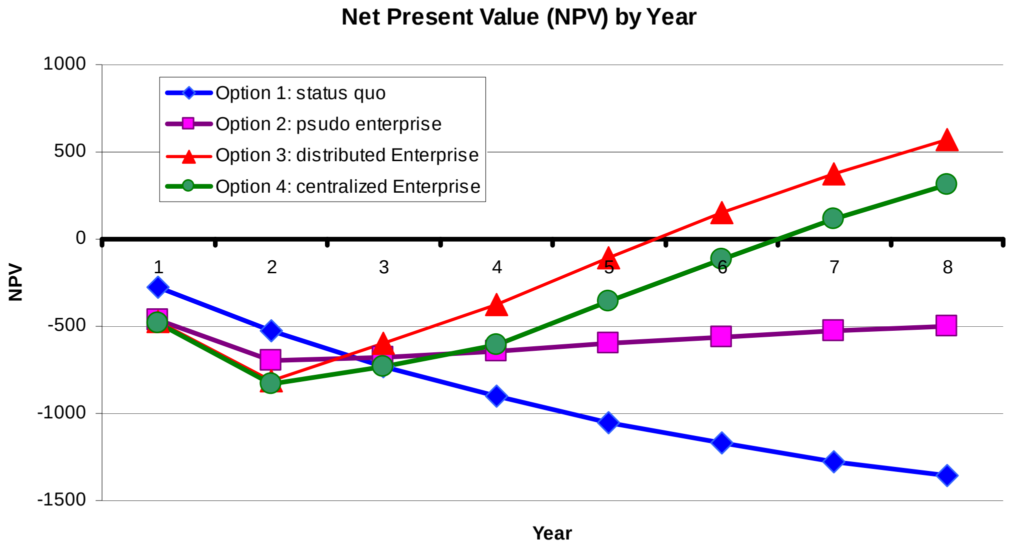
With this definition as a guideline, the following four options were proposed as possible solutions to the existing problems:

- Option 1: No build case to maintain status quo
- Option 2: A pseudo-Enterprise GIS for ad hoc data sharing
- Option 3: A distributed Enterprise GIS with enterprise standards
- Option 4: An Enterprise GIS with a centralized data repository

Each of the four options would require different technical architecture, staffing and organizational structure. Cost-benefit analysis and risk assessment were conducted for each option. Costs were measured in terms of hardware/software/infrastructure, data, training, and application programming while benefits were defined as organizational benefits, cost savings, and other benefits for external agencies. A range of risk factors were also assessed, including financial, organizational, project based, and technical risks. For each option, these risks were scored based on the probability and impacts, and mitigation strategies for each risk factor were discussed.

Results from the cost-benefit analysis suggest that Options 1 and 2 provide limited benefits, which are unlikely to exceed the associated costs. As seen in Figure E.1, the Net Present Value for both of these options is below the zero threshold.

Figure E.1 Cost-Benefit Comparison



Options 3 and 4 will eventually provide positive benefits to the organization once the initial implementation costs are recovered after year 6 for Option 3 and year 7 for Option 4. In terms of risks, there are various risks associated with each option, even Option 1, the no build case. The risks of Options 2, 3, and 4 are incrementally higher, but the increase from one option to another is not significantly high. Options one and 2 were eliminated from consideration due to the lack of realized benefits. Successful examples can be shown for both Options 3 and 4. However, due to higher benefits, and lower impact of implementation on the organization of a distributed Enterprise GIS, **it is our recommendation that Option 3 be adopted as the preferred approach for the implementation of an Enterprise GIS at FDOT**.

An implementation plan was then developed to build a distributed Enterprise GIS and critical key success factors for its implementation were identified and discussed in detail, including:

- clearly defining the initiative
- establishing a project champion
- acquiring sustained management support
- getting stakeholders on board
- building channels for good communication
- establishing clear designation of data stewardship
- choosing the tight technology and building the right team
- taking small steps

Following a thorough review of past efforts, detailed analysis of business needs, evaluation of available options, and the critical success factors associated with the implementation of Enterprise GIS, a list of recommendations was compiled for the GIS Functional Steering Committee to approve, including:

- Approve adoption of a common definition of an Enterprise GIS
- Approve the need for an Enterprise GIS and recommend implementation
- Develop an updated strategic plan—The current GIS strategic plan may be revised to include findings and recommendations from this research and may include components such as:
    - Development of a GIS Policy and Procedure that supports the strategic plan
    - Incorporation of GIS into Tier 1 and Tier 2 business plans
    - Reconfiguration of GIS Management Committee to include comprehensive representation from each district and functional area
    - Development of a Communication Plan that includes regular communication channels with stakeholders regarding project status and accomplishments
    - Continued funding for GIS enterprise implementation

The strategic plan, once approved, should lead to the development of a detailed implementation plan. This plan should include the following at a minimum:

- Build data inventory
- Identify and establish data standards and data business plan
- Coordinate with Unified base map initiative
- Conduct pilot study
- Design a data model
- Continue with education and research

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1.0 Introduction

Geographical Information Systems (GIS) provide a framework for collaboration and communication within and between agencies. Many departments of transportation (DOT), metropolitan planning organizations (MPO), and municipal governments have moved away from a traditional stovepipe business model (narrowly and rigid responsibilities, output and feedback) to an integrated enterprise solution by building an Enterprise GIS. The Florida Department of Transportation (FDOT) also has realized the importance of establishing relationships between spatial data and business processes, and integrating various localized information systems. Almost every major business process at FDOT requires the use of GIS data. The Department has invested significantly in GIS technologies through the creation and maintenance of geospatial data. The Central Office maintains enterprise data, which is mostly spatial and used with many applications within FDOT for spatial display and analysis. However, district-level responsibilities require more regional and local analysis and consequently, the districts have developed GIS data and applications to address more localized needs. The result is a fractured GIS, where data sharing, data creation, application development, and techniques are not shared across functional groups, which in turn creates redundant data storage and ineffective workflow. Therefore, there is a need to formally analyze the requirement for such an enterprise system at FDOT.

This FDOT Enterprise GIS research project aims to research, develop, and make recommendations for an Enterprise GIS decision framework with supporting data systems and infrastructure. The primary objective is to establish a business case for an Enterprise GIS within FDOT that enables data and technology sharing between FDOT Central Office and district offices, with support from FDOT management. To achieve this objective, the Department has laid out a three-phased approach. This research project addresses the objectives of Phase One, which are to identify key decision points in the project approval process, identify the business case, and complete the cost-benefit/risk analysis for an Enterprise GIS at FDOT. The purpose of this research is to evaluate the need for an Enterprise GIS across all business units at FDOT and hence, conclusions are drawn with regard to the department as a whole and not for any particular business unit, unless mentioned specifically. Phase One was divided into three tasks as follows:

Task 1: To assemble and review literature germane to the concept of Enterprise GIS, including all previous work completed by the Department, as well as best business practices that can be applied to the Department.

Task 2: To compare the work completed to date (from Task 1) against the adopted Information Systems Development Methodology (ISDM) manual requirements.

Task 3: To create or update any missing products such as business case, cost-benefit analysis, risk analysis, detailed user requirements, etc.

This *Final Report* summarizes the approach and results of each of these tasks. This report also provides insight, justification, and supporting information for the enhancement of the department's GIS Strategic Plan. Each of the three sections relate to each of the three tasks described above.

2.0 TASK 1: Literature Review

2.1 Introduction

Chapter 2 of the *Final Report* documents the results and findings of Task 1, the key purpose is to leverage all literature/studies/projects, completed or ongoing, that are pertinent to the concept of Enterprise GIS. A thorough review was necessary to avoid any redundant efforts in the domain of Enterprise GIS. As part of this task, best business practices by other transportation agencies across the nation were also identified and reviewed, with a focus on key aspects such as the organizational support and resource identification for preplanning an enterprise system.

It is important to clarify the definition of the term Enterprise GIS, which is often perceived as a tool or set of functionalities that enable intra-agency data exchange and availability. Another popular definition of Enterprise GIS is a technology umbrella, including spatial and non-spatial data, tools/applications, and database/repositories communicating through high-speed Internet. These are physical definitions of an Enterprise GIS, but they offer a poor perspective or definition of the core concept of *enterprise* because these definitions skip the underlying objective of viewing an agency as a whole. Enterprise GIS is better understood when defined in terms of a system that enables increased efficiency of core business processes that an agency needs to perform. The concept of Enterprise GIS, when understood as a system or process, rather than an application, will help management and stakeholders truly realize the objective and benefits of an enterprise system.

2.2 Methodology

The objective of Task 1 was to assemble and review literature pertinent to the concept of Enterprise GIS for transportation, including all previous work completed by FDOT, as well as any best business practices by other transportation agencies across the nation. A thorough literature review was conducted to bring the team up to speed with all the work that already has been completed by the Department on this topic, and Enterprise GIS efforts by other transportation agencies that are similar in scope to FDOT project. Examples of key literature includes the 2004 User Needs Analysis, 2006 Technology Assessment, Enterprise SIS (planned) (Strategic Intermodal System) Development Efforts, and other relevant studies, including older FDOT Enterprise Efforts related to data warehouse, data stewardship, a Geo-referenced Information Portal (GRIP), FDOT Statistics Office Efforts and other District efforts. Reports on other district studies were included, including District Four Enterprise data repository for transportation modeling data, District Five

Transportation Automated Information Management System (TAIMS), and District Three work on a Feasibility Study regarding the use of Remote Sensing to Roadway Data Collection that may have some relevance. The project team reviewed this literature and identified the objectives, approach, and outputs of each study (from a vendor and technology neutral standpoint). The team also reviewed similar work from other state agencies to apply best practices and assemble methodologies for implementing a successful Enterprise GIS for FDOT.

This phase of the project is intended to analyze a need for an Enterprise GIS system at FDOT and to acknowledge that it is indeed a viable and required alternative, therefore, the literature review focused on establishing a business case rather than actual implementation. However, all aspects of Enterprise GIS literature were collected assuming that such knowledge may provide a valuable reference to subsequent phases.

The literature was compiled with assistance from the GIS coordinator at FDOT Central Office, GIS Functional Steering Committee (GFC), and the resources available on FDOT's Internet and intranet sites. Information was first collected on prominent FDOT applications or projects such as Roadway Characteristics Information (RCI), Enterprise SIS (planned), and Efficient Transportation Decision-Making (ETDM). Upon compiling this initial list, the GFC was asked for any information on projects, reports, research activities, or applications that are ongoing or completed on all relevant topics, including Enterprise databases, data warehousing, data sharing, data integration, and data inventory efforts. Based on follow-up discussions with GFC members and other sources, a more comprehensive list was then compiled. This list was further refined through a web search on FDOT's Internet (especially the research office pages) and the intranet pages to ensure a complete list of literature.

In summary, the following information was collected to compile the best business practices related to the conceptualization and implementation of an Enterprise GIS:

- Literature developed by FDOT in the past
- Prominent literature published at a national level (Federal Highway Administration (FHWA)) and by other states that have been through this process
- Experience working on similar projects in other states

2.3 List of Literature Elements

Based on the methodology described above, a total of 60 projects were identified as relevant projects by the Central Office and the districts. These projects can be classified into four categories:

- Category 1 – Projects that meet one of more elements of the Information Systems Development Methodology (ISDM) for building an Enterprise GIS

- Category 2 – Projects that can serve as reference materials for the current research or for subsequent implementation phases of the Enterprise GIS project
- Category 3 – Applications and tools that traverse across multiple systems, or serve several functional areas and, therefore, fit into the framework of an Enterprise GIS
- Category 4 – Other localized applications, tools, and GIS efforts that do not fit directly into the framework of an Enterprise GIS

The following section lists the projects under each of the four categories. A brief description provided for each project summarizes the documents that will be pertinent to meeting ISDM requirements. Appendix A lists all of these projects by different offices of the Department.

2.3.1 Category 1

GIS PLANNING AND ANALYSIS REPORTS

Under the guidance of the GIS Functional Team (GFT), FDOT conducted a GIS Planning, Analysis, and Implementation (PAI) study during 1995-1996. The primary goals of the project were to:

- » Enable FDOT to realize the full potential benefits of GIS in Transportation (GIS-T)
- » Maximize existing FDOT resources
- » Increase the knowledge and understanding of GIS-T within FDOT
- » Minimize organizational issues within FDOT that have hindered GIS-T implementation in other states

The PAI project conducted extensive analysis on the GIS needs and organizational issues, which resulted in six reports as follows: 1) *GIS-T User Requirements, Data Collection, Compilation, and Analysis*; 2) Technical Memorandum on Base Map Recommendations; 3) *Technical Memorandum Comparing and Analyzing Alternative Infrastructure Configurations*; 4) *Technical Memorandum Addressing GIS Software and Hardware Specifications*; 5) *Final Report Summarizing Conclusions from Previous Reports and Providing Recommendations*; and 6) *Management Summary of the Final Report*.

The following provides additional explanation of these reports.

(1) GIS-T User Requirements, Data Collection, Compilation, and Analysis

- Defined all GIS-T users (internal production users, internal output users, external output users, and external data users) in terms of categories such as training, equipment, support, GIS product, software functional, and access requirements
- Identified distribution of users across Central Office and typical districts:
  - In Central Office, most users are in Transportation Statistics Office (TSO), Systems Planning Office (SPO), followed by the Central Offices of Design, Maintenance, and Safety
  - In districts, most users are in Survey, Construction, and Design
- Identified all required GIS Products based on discussions from Joint Application Development (JAD)sessions
- Conducted an evaluation on work flow (from inputs to processes and outputs) and dataset (in terms of data source/custodian, data manipulation, data view/use/analysis, and output)
- Identified data and map content requirements for all users
- Identified all GIS user applications
- Estimated production rates based on dataset attributes such as frequency of input, volume, and rate of data input;
- Estimated data volumes
- Described how public access will be provided
- Identified intra-agency data sharing requirements and opportunities such as:
  - Florida Growth Management Coordinating Council; Florida Base Map Advisory Committee; Florida Water Management districts; United States Geological Survey (USGS); Universities; and local governments
- Derived general specifications for software and hardware, and identified the requirements that are specific to FDOT

(2) Technical Memorandum on Base Map Recommendations

- Identified objectives, requirements, and needs for data standardization; structure of base map information; map accuracy; and need for additional base maps
- Identified how different base maps are required by multiple programs
- Made the following recommendations:
  - Coordination with other statewide efforts
  - Data Standardization – Minimum metadata and standards for base maps
  - Map Projection – Universal Transverse Mercator (UTM) Zone 17 and North American Datum (NAD) 83 projection

    - Partitioning
    - Coincident lines and tiling
    - Map accuracy requirements
    - Integration of different scales – pilot project
    - Content
    - Ownership and maintenance
    - Implication of single and dual platforms

(3) Technical Memorandum Comparing and Analyzing Alternative Infrastructure Configurations

(4) Technical Memorandum Addressing GIS Software and Hardware Specifications

  - Proposes a federated configuration with replicated data

(5) Final Report Summarizing Conclusions from Previous Reports and Providing Recommendations

  - Identified summaries from other tasks
  - Identified organizational elements
    - Particular attention should be paid to top management
    - GIS-T change management and diffusion strategy
    - Balancing short-term needs with longer-term system and data integrity
    - Management of user involvement process
    - Establishment of a career ladder for GIS-T staff
  - Identified Barriers:
    - Existing organizational structure
    - GIS knowledge and understanding
    - Available skill sets
    - Funding resources
    - Coordination of initiatives
    - Acceptance of technology
    - Duplication of efforts
    - Internal organizational affairs
    - Past lessons
    - Top management support
    - Central Office versus District functional needs

- Identified GIS Unit structures and definitions
- Made recommendation for an implementation plan in five phases:
  - » Phase 1 – Historical development
  - » Phase 2 – Planning and Analysis
  - » Phase 3 – GIS-T Pilot Projects
  - » Phase 4 – GIS-T System and Application Development
  - » Phase 5 – Implementation of GIS-T Application
- Discussed estimated costs and benefits:
  - » Analysis traditionally very difficult for GIS-T
  - » Implementation purely not based on cost for most FDOT implementations
  - » Different kinds of benefits
- Recommended next steps:
  - » Establish GIS-T technical working group
  - » Establish interim GIS-T manager
  - » Provide limited training to FDOT staff
  - » Ensure clear definition of pilot program

(6) Management Summary of the Final Report

- The management summary consists of an extended executive summary format summarizing the working results from all previous reports of the PAI project

GIS-T Strategic Plan – Mission, Vision, Goals, and Objectives

Developed in May 1997 by the GFT's Planning Subcommittee, the strategic plan identifies the mission, vision, goals, and objectives related to the development of GIS-T in FDOT. However, the strategic plan document appears to be incomplete with place holders for aspects regarding how these objectives will be met.

Geo-Referenced Information Portal (GRIP) and Enterprise Information System (EIS)

In 1998-1999, an effort was initiated to deploy an enterprise-wide Electronic Document Management System (EDMS) and related GIS applications. The plan was to improve the efficiency of operations, customer service, quality, and accessibility of information at FDOT, and to provide for graphical analysis of geo-referenced data. The project was initially implemented as an Enterprise Information System (EIS) and was later called Geo-Referenced Information Portal (GRIP). GRIP was a data centric server-based intranet application designed with particular emphasis on integrating disparate data and file formats into a single, user-friendly interface. The GRIP and EIS were to be owned by the Information Resource Management Council (IRMC).

The project suggested that diverse technologies and approaches are required to manage scattered needs of a decentralized departmental structure. In order to transition to this new business model, the following key components need to be addressed, including:

- data repository
- data migration and deployment strategy
- standardized GIS base map
- analysis and decision support strategy

The vision of this project was to have a centralized repository of information to support analysis and decision-making, and provide access to consistent and cross-sectional information. A review of several business units helped to identify the major components of the EIS, including:

- Inputs – Representing the sources of information for the repository such as RCI data, WPA data, CARS data, etc.
- Central Repository – Core of the system that will house textual and spatial data as well as metadata
- Enterprise GIS Environment – Representing the spatial component of the system incorporating tools to visually analyze and display spatial information
- Outputs – Representing the analysis functionality to utilize the data from this system

Several success factors were identified:

- executive leadership
- team ownership
- technology blueprint and proof of concept
- Linear Referencing Method (LRM)

Some of the issues/risks that were identified are as follows:

- changing requirements of applications
- dual alignment in TSO base map
- Link-Node LRM in TSO

- new Crash Analysis Reporting System (CARS)
- non-mandated LRS methods
- unknown database and GIS platforms
- frequency of data updates
- scope of external data sources
- inclusion of off-system roads
- undefined user group
- impacts of route realignments
- complexity of historic and temporal data
- replication of data

As a part of this effort to create an Enterprise Information System (EIS), guidelines also were developed for creating a GIS data stewardship program, including several major components, such as:

- definition of the concept of data stewardship
- organizational components
- program structural components such as identification of technical advisory council, coordinators, stewards, and their respective roles
- definition of transportation layer
- implementation issues such as authority and management support within and outside the Department, conflicting priorities, problems in vertical and horizontal integration, etc.

The document also stated that the EIS has the highest priority for systems such as Base Map, Crash Analysis Reporting System (CARS), Pavement Condition Survey (PCS), Work Program Administration (WPA), RCI, and Rail-Highway Crossing (RHC). The intent to integrate (not replace) these systems was clearly emphasized.

Data requirements then were identified in both the current and proposed environment. These requirements were classified in terms of WPA, RCI, RHC, CARS, and Pavement.

The document also described the efforts needed for developing the concept of an Enterprise GIS base map system. A base map is defined as a "digital atlas", a standardized geographic reference environment consisting of multipurpose cartographic data, specified map characteristics, and quality standards, which need to operate together. Standardization was considered as a key ingredient of this system; standards for data elements, data, and map views were identified in the document. The base map that the agency developed was intended to provide a common underlying item to facilitate department and cross-department analysis.

In 2001, the initial EIS system was reformatted to become GRIP. Software, hardware, and network components for an information portal were defined, and a pilot application was built and tested before it went into production mode in January 2002.

GRIP housed 15 different datasets with the capability for end users to view multiple data simultaneously. After the system was deployed, several user groups responded positively with regards to the effectiveness of the application. It was clear that, by strengthening data integration goals, the Department has saved more than just time and money.

FDOT Tier 1 and Tier 2 Business Plans

FDOT has developed a system of business plans with deploying strategies for five different levels ranging from the Executive Board (Tier 1) to every employee of the Department (Tier 5).

The Tier 1 business plan is the highest level of business plan for the whole department, defined by the executive board based on mission, vision, values, and objectives contained in the Department's strategic plan. The Tier 1 plan identifies objectives, activities, measures, and targets for various criteria such as leadership, strategic planning, customer and market focus, measurement, analysis, and knowledge management, human resource focus, process management, and organizational performance. The objectives and activities identified in this plan summarize the business processes that occur in the Department. It is critical to understand these processes in order to establish the business case for an Enterprise GIS.

The Tier 2 business plan defines the statewide functional plan for each of the 24 primary functional areas of FDOT such as maintenance, construction, personnel, etc. This tier defines how each of the 24 functions contributes to the accomplishment of the agency mission.

The concept of an Enterprise GIS, as defined earlier, involves viewing the agency in a holistic manner. Therefore, the first two tiers will provide an understanding of core business processes at the Departmental-wide and functional area levels.

Tier 3 plans were built by district, Turnpike, and Central Office functional areas. They will be referred to in the later stages of the project to help understand the district's involvement in meeting the agency's mission.

District Four – GIS Business Needs Analysis Report

In 2005-2006, District Four initiated a project to analyze the business needs for GIS. Following are the four phases of the project:

Phase 1:

» Research current GIS initiatives at FDOT and other state DOTs

» Document enabling technologies and industry trends

» Identify organizational structures and other business practices that will facilitate success

Phase 2:

» Identify and analyze District Four-specific GIS business needs

Phase 3:

» Develop a Master Plan to serve as the roadmap for delivering solutions in a phased manner that will meet District Four's business needs while following GIS best practices

Phase 4:

» Implement the Master Plan

Phase 1 of the District Four project has been completed and the project team is currently working on Phase 2. While Phase 1 of the project is considered an excellent resource for information for existing and past efforts, the planned activities and outcomes of Phase 2 will provide highly useful information for this department-wide Enterprise GIS project.

Here are the specific purposes for Phase 2:

» understand the business processes of each unit

» understand existing data processes and application being used

» identify what types of GIS applications could benefit each unit

The district activities (at D4) are divided into three categories – Transportation Support, Transportation Development, and Transportation Operations. The draft report of Phase 2 attempted to identify business and data driven processes, their current GIS capabilities, and GIS business needs for individual offices within these broad categories.

District Seven – User Needs Analysis; Technical Assessment; Data Component Report; Data Model

During 2003-2007, District Seven initiated their efforts on a multi-phased GIS planning, analysis, and implementation project. The following phases are complete: 1) User Needs Analysis; 2) Technology Assessment; and 3) Preliminary Geodatabase Model. The fourth phase of the project is to implement the CADD/GIS (computer aided design drawings) interoperability model, and it is currently underway. The following are summaries of the completed phases for this project.

Phase 1 – User Needs Analysis

In 2003, the Central Office approved a plan submitted by District Seven to revisit the GIS needs of the districts from a statewide perspective. Sponsored by both the Central Office and the districts, a revised User Needs Analysis began in February 2004 and the final report was published in June 2004. The primary goal of the project was to identify information products used by the districts and how GIS technologies could help business functions for all districts. The plan was to use this information to help with the development of long-term district-level GIS efforts. The information collected during this assessment led to the creation of four broad strategies:

1. formalize inter-district/Central Office GIS coordination and standards creation
2. investigate enabling technologies
3. centralize district-level GIS data in a spatially enabled relational database
4. build targeted browser-based and desktop GIS applications that accommodate the needs of district staff

Phase 2 – Technology Assessment

The technology assessment was undertaken by FDOT to capture necessary information to couple the end-user requirements. This understanding will help to gain knowledge of the systems that need to be considered during the planning, design, and implementation processes. The information analyzed from this assessment was aggregated into four categories:

1. district's role in Enterprise system data stewardship
2. enterprise repository technologies
3. data distribution strategies
4. use of enterprise middleware technologies

The assessment also provided several near-, mid-, and long-term recommendations such as:

1. Undertake an iterative data modeling approach to publish the enterprise geospatial repository data model
2. Establish a data modeling advisory group within the GIS Functional Committee
3. Establish geospatial data and metadata standards
4. Establish a framework that the geodatabase could interface with other enterprise systems
5. Align existing and future spatial development activities with the enterprise
6. Include asset management information requirements within the Enterprise GIS FDOT Enterprise GIS Technology Assessment: Order No. DO163408 14
7. Include state materials office requirements within the Enterprise GIS effort
8. Utilize an existing district application as a prototype
9. Create interfaces to external data repositories
10. Expose enterprise data through web services
11. Implement the WebFocus GIS adapter with the Enterprise GIS view
12. Extend the use of WebFocus reporting for mainframe systems
13. Continue to advance the programmatic foundation to sustain the Enterprise GIS

Phase 3 – Development of Preliminary Geodatabase Model

This research effort is the third phase of an ongoing initiative within FDOT to develop an Enterprise geodatabase. This phase involves developing a framework to catalog GIS and CADD data and includes:

1. Identifying core data objects that will participate in FDOT's geospatial data infrastructure with an emphasis on mission-critical CADD data
2. Establishing the composition and attributes of each data object and the relationship between those data objects
3. Providing a framework that could be considered as part of other Enterprise GIS efforts sponsored by the Central Office

An outcome from this phase was the development of a preliminary geodatabase model with CADD/GIS interoperability design.

Phase 4 – CADD/GIS Interoperability Project

This phase of the project was initiated in July 2007 and efforts are underway to implement the CADD/GIS interoperability model through a series of tasks such as installing and configuring ArcGIS server, populating and modifying the geodatabase, installing and configuring Bentley's ProjectWise software, building prototype applications, and developing data and metadata standards and maintenance methods.

2.3.2 Category 2

The following projects in Category 2 will serve as reference materials for the current research or for subsequent implementation phases of the Enterprise GIS project.

DISTRICT FOUR – GIS RESEARCH AND RECOMMENDATIONS WHITE PAPER

As a result of the growing GIS needs in the district, a team was organized by the Transportation Development Division to conduct research about current GIS best practices within FDOT and in other government agencies, to document and analyze GIS user business needs, and to develop a strategy for delivering solutions. This white paper summarizes key findings of the research project, and makes recommendations to be evaluated by the district's upper managers. The white paper suggests that very few of the existing GIS solutions developed by the districts have taken full advantage of enterprise-level resources and technologies. Due to the lack of an organizational structure that encourages district-wide coordination, and the fact that most existing solutions were developed in isolation, there have been duplicating GIS efforts across business units in the district.

Based on these findings, the GIS team recommends the following key activities within District Four:

» Establish a dedicated, district-wide GIS business unit that oversees and coordinates the various GIS initiatives across the district and with Central Office

» Develop a district-wide GIS vision statement, guiding principles, and goals that are consistent with FDOT statewide GIS initiatives

» Develop a district-wide GIS Master Plan to guide the GIS implementation. Yearly updates are recommended to ensure the GIS Master Plan reflects any changes in user needs, enabling technologies, and priorities

» Develop GIS standards and guidelines in coordination with the Central Office and other districts

» Consolidate ESRI (Environmental Systems Research Institute) GIS licensing via the implementation of a district-wide license pool to reduce the overall software licensing costs and to make desktop GIS available to more district users

- » Develop a district-wide GIS repository and spatial database, using ArcSDE with Oracle, to serve all district users, along with a well-documented data maintenance plan
- » Integrate GIS data with other business systems using scalable and inter-operable server-based technologies
- » Implement district-wide solutions using a combination of desktop, mobile, and server-based solutions
- » Enhance the functionality and performance of existing ESRI web-based solutions to increase the availability and usefulness of more data with more end users
- » Support interagency sharing initiatives and formalize data sharing agreements with local agencies

SYSTEMS PLANNING RESEARCH – MULTIMODAL DATABASE FRAMEWORK FOR TRANSPORTATION PLANNING

The University of Florida conducted research in early 2006 to identify a multimodal database framework for transportation planning at FDOT. Currently, the transportation planning databases such as Work Program, RCI, Model Datasets, ETDM, SIS, etc., are not integrated; therefore, it is not possible to perform seamless information exchange between these databases. The study stated that most problems are associated with the fact that different levels of street reference data are used for various purposes of transportation planning.

Recommendations include use of well-maintained statewide GIS street reference layer to mediate data exchange between various systems; a database structure to enable tracking of GIS information from inception to RCI; use of ESRI's network data model for organization and management of intermodal transportation data; and integration of socioeconomic databases into a larger transportation database framework.

RESEARCH ON DEVELOPMENT OF GIS-BASED CONFLATION TOOLS FOR DATA INTEGRATION AND MATCHING

This research was conducted in 2002 by the University of South Florida to investigate algorithms that enable improved conflation process between various roadway networks (node-matching, segment matching, and edge matching).

2.3.3 Category 3

The following describes applications that traverse across multiple systems, or serve several functional areas and, therefore, must be considered in the Enterprise GIS project.

Efficient Transportation Decision-Making (ETDM/EST)

When Congress passed TEA-21 (Transportation Equity Act for the 21st Century), the Central Environmental Management Office of FDOT decided to reexamine the Department's entire process from the very early stages of planning through project development and permitting. Revamping the entire process required that a more efficient methodology be used to present project planning information and to gather input from agencies and the affected community. As part of the new Efficient Transportation Decision-Making (ETDM) process, FDOT implemented an Internet-accessible interactive database tool called the Environmental Screening Tool (EST). The EST provides tools to input and update information about transportation projects, perform standardized analyses, gather and report comments, and help synthesize and communicate that information.

Enterprise SIS (Planned)

The Florida Legislature enacted legislation to establish the Strategic Intermodal System (SIS) in 2003. FDOT has initiated a comprehensive effort to develop and implement policies and procedures to govern the SIS. The Enterprise Strategic Intermodal System (E-SIS) project was established in July of 2005 to integrate and automate certain processes established during the implementation of the SIS. An E-SIS Management Steering Committee (MSC) and Functional Steering Committee (FSC) were established with representatives from each of the Intermodal System Development (ISD) offices directly involved in the SIS initiative, including:

- Environmental Management Office (EMO)
- Office of Policy Planning (OPP)
- Public Transportation Offices (PTO)
- Systems Planning Office (SPO)
- Transportation Statistics Office (TSO)

The Office of Information Systems (OIS) has just completed finalization of a user needs and requirements document for this project and is starting the data model development and prototype creation.

Roadway Characteristics Inventory

RCI is a database of various physical and administrative data, such as federal functional classification, pavement, shoulder, and median data related to the roadway facilities that are either maintained by, or are of special interest to, FDOT.

Enterprise View

Available via FDOT's Enterprise Information Portal (EIP), GIS Enterprise View provides an interface with basic GIS viewing functionality. It is the main GIS viewer used by Central Office for graphically displaying base map layers, as well as some information in other Central Office databases, including RCI. It also ties with the Video Log web application, providing some level of interaction between the two applications.

FLORIDA UNIFIED BASE MAP

For agencies to effectively communicate information with regard to roadway business data, the Florida Safety Office initiated a project to evaluate the feasibility of a comprehensive roadway network accessible over the Internet, managed and maintained through documented procedures, standards, partnerships, and cooperative agreements. The feasibility study completed early this year (2007) indicated a need for a comprehensive roadway network. Currently, an implementation plan is being developed to effectively implement this initiative.

TRANSPORTATION AUTOMATED INFORMATION MANAGEMENT SYSTEM (TAIMS)

TAIMS is a web-based system originally developed by District Five's Planning Office, but currently is under Production Management. The system consists of 10 modules, including Transportation Modeling; Level of Service; Design Traffic; Environmental; Public Transportation; Work Program; RCI; and Growth Management, to name a few. Each module has a consistent interface that, depending on the module, may include data entry forms, query screens, reports, and interactive maps. Tools available include the ability to produce mailing labels from buffered corridors. TAIMS includes over 80 GIS layers. RCI and Work Program data are automatically downloaded on a daily basis from the Central Office servers. Other data layers include level of service (LOS), adopted models, access management, Developments of Regional Impact (DRI), and many others.

TURNPIKE ENTERPRISE ASSET MANAGEMENT SYSTEM (TEAMS)

TEAMS is a comprehensive management tool for Turnpike assets and related information. It contains an inventory of the Turnpike's fixed assets, including condition assessment and replacement costs. The system also calculates predicted time for renewal and replacement, and provides support for budget development. Asset-related modules in TEAMS include facilities, roadway, structures, National Pollutant Discharge Elimination System (NPDES), pavement, and work program. It is integrated with several of FDOT's systems, including Work Program, RCI, DataStream Work Order System, and PONTIS®. It dynamically maps milepost-based data on the fly, including RCI, pavement, and crash data, among many others. Reports and maps are inter-related allowing the users to go from an asset report to a map showing its location and vice versa. It also includes links to Microstation files, inspection reports, and other documents, as well as a video log.

TURNPIKE MANAGEMENT INFORMATION SYSTEM (TMIS)

TMIS is a web-based GIS system that serves several types of GIS data layers, including aerials, via an ArcIMS web interface. Data is stored in an ArcSDE system running on SQL (structured query language) Server. All GIS data has metadata that meets Federal Geospatial Data Committee (FGDC) standards. The spatial database administration has a timetable for data maintenance with most datasets updated annually.

2.3.4 Category 4

Several other research projects, tools, and applications were identified while collecting information in this task or from the reports that are reviewed so far that fall into this category. These applications and/or projects do not fit directly into the framework of an Enterprise GIS:

- Research on evaluation, development, and implementation of a central data warehouse for statewide intelligent transportation systems (ITS) and transportation data, and alternative map approaches for SunGuide System, by the Central Office – ITS
- Research on highway feature and characteristics database development using commercial remote sensing technology, combined with mobile mapping and GIS and GPS by statistics office – Central Office
- City-to-city mileage, Data Library tool, Desktop Extensions, Florida Traffic On-Line web site, and iView applications from TSO
- A-Plus developed by Surveying and Mapping Office
- Crash Data Management System at District One and 7
- ArcIMS web sites developed at District Four and District Three
- Data Catalog tool at District Four
- iFlorida Conditions Reporting System (CRS), Project Traffic Forecasting (PTF) web site, and Railroad Crossing Index (RoXI) developed at District Five
- Several applications at District Seven such as Drainage-Related Permit GIS Application, PD&E (project development and environment) and Interchange Web Site, Production Scheduling, Signalized Intersections, GIS Crash Database, and GIS Traffic Signal Database
- Research on the Efficacy of Utility Database Management at District Seven

- Applications at the Turnpike Enterprise such as Aerial Photography Viewer, Turnpike GIS Metadata, Turnpike Map Catalog, and Turnpike Toll Calculator

Several other enterprise applications such as RHCI (Rail Highway Crossing Inventory), CARS, and LRE that were mentioned in the District Seven's technology assessment are to be considered under this category.

2.4 Preliminary Observations

Based on the initial review of all the projects, following are some key preliminary observations.

- There are several categories of use for these documents – some are district-specific, some are outdated, and some are good ideas.
- Several project reports (including the ones that fall into Category 1) are application-oriented rather than process-oriented. As explained in the introduction section of this document, viewing Enterprise GIS as a mechanism to improve day-to-day business processes provides a better perspective for management. There was no consistent definition of Enterprise GIS in the existing literature.
- The timeline shows recurring efforts between 1995 and 2007: 1 PAIs (1996), GRIP (1998-2002), and D7/D4 Efforts (2004-2007). In the past, these efforts were concentrated at the Central Office level, but now they are occurring more prominently at the district level. This trend calls for the need for the Central Office to provide guidance and support to the district offices in Enterprise GIS implementation.
- There are a large number of applications that fall under Category 4, indicating dominant localized development. This further builds the case for Central Office to establish statewide data standards and information exchange mechanisms.
- Several projects that were initiated in the past seem to have failed in the implementation stage. An understanding of why these projects failed may provide helpful information for successfully moving forward with the Enterprise GIS initiative.
- Software and hardware requirements in the past studies are clearly out of date. Technology advancements, not only in the field of GIS but also in the field of information technology, may significantly affect the reliability of some of the technical assessments in the past.

- » The Florida Statewide Business Plan states the development of a department-wide Enterprise System as one of the Tier 1 objectives. An Enterprise GIS system clearly lines up well with this objective.
- » Several efforts indicated the need for a standardized base map as a mechanism for information exchange. This means that the Florida Unified Base Map Initiative may be one of the critical components for building an Enterprise GIS at FDOT.
- » Organizational structure and the importance of institutional framework were emphasized to be critical for success in FDOT. Several projects identify the need and the requirement for restructuring functional areas to efficiently implement an enterprise system.
- » Comprehensive inputs from stakeholders are somewhat limited from the previous projects.

2.5 Critical Success Factors

The use of geospatial technologies in state DOTs has significantly contributed to enhance cost-effectiveness and improve transportation decision-making. Though most data in these DOTs are tied to geography, the format and representation of data are different because data is collected, referenced, and maintained in different ways by different parties. Divisions and departments within DOTs generally have their own legacy databases to store data. This often leads to circumstances where the data from one division cannot be easily integrated with data from another division. The idea of an Enterprise GIS is an integrated (often confused to be centralized), multi-departmental system that is composed of interoperable components providing broad access to geospatial data and common infrastructure to build and deploy GIS applications. Depending on the extent of integration and desired interoperability, DOTs often interpret the role of Enterprise GIS differently in the organization thus warranting different design requirements and architectures. This section described some of the key success factors synthesized from past research conducted by FDOT (District Four white paper) and recent review of the state-of-the-art practice.[1]

The role of an Enterprise GIS and the challenges for its implementation depend upon the organizational set-up of the Department or the division tasked with developing, installing, and maintaining the Enterprise GIS. GIS divisions/departments in state DOTs have been traditionally part of planning (as in FDOT), Information

[1] Business Models for Implementing Geospatial Technologies in Transportation Decision-Making – Prepared for: Office of Interstate and Border Planning, Federal Highway Administration, U.S. Department of Transportation by Planning and Policy Analysis Division, John A. Volpe National Transportation Systems Center, Research and Innovative Technology Administration.

Services/Technology, or an independent department/division. In some state DOTs, like FDOT, the GIS staff is dispersed throughout various divisions, including planning, traffic, highways, and safety to provide GIS services that are specific to different divisions.

In general, our research and experience regarding preplanning for an Enterprise GIS can be synthesized into following recommendations:

- Tread in Small Steps **–** The consensus when it comes to setting goals for Enterprise GIS development is to tread in small steps. This helps in summarizing success and failure at each stage, and learning lessons before moving too far down the road. In our research from other state DOTs where Enterprise GIS has been implemented, its success has been demonstrated at smaller scales. This helps win support and attracts user divisions' in pursuit of streamlined and cost-effective business processes with the rest of the organization. For example, the Oklahoma Department of Transportation has demonstrated successful experience in that the idea of an enterprise started modestly, but gained momentum by showcasing achievements at every step of implementation, and eventually, it evolved to an organization-wide enterprise system.
- Support at upper and implementation levels (vertical and horizontal) is the universal key irrespective of the organizational set-up. If a mammoth goal is set at the outset and presented to the upper levels of management, any pitfalls in development and implementation would result in the loss of confidence about the idea of Enterprise GIS and could result in the loss of support from upper management. Every case study has champions and supporters for an Enterprise GIS who are enthusiastic about the contribution of Enterprise GIS to the business needs of user divisions and organization as a whole.
- Coordination oils the wheels of an enterprise machine and keeps it moving smoothly. Better coordination with user divisions and having GIS point person in those divisions will help avoid the perception of Enterprise GIS as a data take-over program by the GIS group. Rather, coordinators in the user divisions should be used effectively to relay the utility of the geospatial applications for their business needs. It helps to avoid alienating user divisions and increase support. A successful Enterprise GIS system should obtain a clear understanding of the system from the user and business process perspective and be able to balance interests of all involved parties.
- Perception of what an Enterprise GIS is – Enterprise GIS means different things in different state DOTs depending on the business requirements, the extent of data integration, and the will of user divisions depending on the perception of utility that an Enterprise GIS could provide to their needs. The perception of what an Enterprise GIS could offer often gives a

set of expectations, which might be different from the immediate goals that need to be realized.

» Track time and cost savings, if possible, to be able to showcase and quantify achievements. This might not be considered feasible in some state DOTs due to procedural issues in recording time, but any cost/benefit analysis can be an assertive tool to demonstrate the success of implementing an Enterprise GIS. Also, several case studies warn against having an intuitive understanding of benefits, rather than quantitative understanding.

These success factors are derived from reviewing experiences of other state DOTs. They are generic at this stage. Later recommendations are more specific to FDOT.

3.0 TASK 2: Verification and Areas for Development

3.1 Introduction

Chapter 3 of the *Final Report* summarizes Task 2 of FDOT Enterprise GIS Research Project. The objective of this task was to assemble and verify the work completed to date against the adopted Information Systems Development Methodology (ISDM) Manual, and identify products that may be missing from the existing inventory of literature.

Chapter 3 contains the following sections:

ISDM and Business Case Requirements – Describes the requirements for ISDM and identifies additional ones that are necessary to establish a business case for an Enterprise GIS within the Department.

Comparison of ISDM and Business Case to Key Literature documents – Describes the process and results of comparing all documents identified in Task 1 against the ISDM and additional business case components.

Stakeholder Involvement – Describes the extent of stakeholder involvement in all Enterprise GIS efforts described in Task 1.

Work Plan – Summarizes steps required to fill in the major gaps identified in this task.

3.2 Information Systems Development Methodology (ISDM) and Business Case Requirements

3.2.1 ISDM

The Information Systems Development Methodology (ISDM) is FDOT Procedure Topic No. 325-A15-001-e, adopted October 15, 2004. Its purpose is to establish the standards methodology and deliverables for development of information technology applications. It states that the seven phases of an application development life cycle are:

Phase I: Identification and Assessment

Phase II: Planning

Phase III: User Requirement Analysis

Phase IV: System Design

Phase V: Construction

Phase VI: Implementation

Phase VII: Production and System Maintenance

The ISDM manual clearly describes various products that act as deliverables in each of the phases. These products range from a benefit/cost analysis to a feasibility study of the application to a maintenance plan that provides long-term sustainable framework for the system. The scope for the Enterprise GIS project requires a comparison of previous documents (as identified in Task 1) to be compared against the deliverables indicated in ISDM. The following references for deliverables are used from the ISDM Methodology:

Phase I – 4.2.4

Phase II – 4.3.4

Phase III – 4.4.4

Phase IV – 4.5.4

Clearly, the phases related to construction, implementation and production are not applicable at this stage of the GIS Enterprise.

3.2.2 Business Case Components

ISDM is designed to be used for application development. Since Enterprise GIS is much more encompassing than an application, additional business case components should be considered. The following table was compiled based on the best practices research from other state DOT Enterprise GIS implementation; Tomlinson's methodology of implementing GIS, as described in his book *Thinking About GIS* and an Enterprise GIS best practices booklet published by ESRI in January 2007.

Table 3.1 List of Business Case Components

1	**Define Enterprise GIS**
2	**Gather User needs, Requirements and Processes**
	Business
	Understanding Organization Business plan (Mission, Vision and Goals) along with existing mandates and organizational responsibilities

	Identify functional areas and understand the mandates, responsibilities for each functional division
	Understand current work flows, users, inputs and outputs and role of spatial data in each division
	A description of how the information is captured or entered - Identification of data elements that traverse across functional divisions
	Data
	Categorize as foundational, interdepartmental and departmental data needs of each functional division
	For each data source - Identify data elements, sources, updates, accuracies and validation methods
	Financial (sources and amounts)
	Understand GIS resources by each functional division and the department as a whole
	Current expenditure for GIS software, hardware and services
	Current level of resources/personnel
	Technology and Architecture
	Understand departmental technology framework
	List of acceptable software, hardware, database and network technologies
	Existing levels of technology resources - number of licenses, CPUs, Band widths, applications etc
	Identification of existing and proposed databases, applications by each functional division
3	**Identification and Understanding of the Problem**
	Business
	Identification of redundancies and inefficiencies in the processes/work flows at the departmental level
	Identification of redundancies and inefficiencies in the processes/work flows at the functional division level
	Data
	Redundant data sources
	Varying data accuracies
	Varying versions of similar datasets
	Financial
	Identification of investments into similar applications and projects
	Approximate financial implications of redundant processes
	Increasing redundant maintenance costs
	Technology and Architecture
	Redundancies in licensing and software procurement
	Inefficiency in utilizing available band widths
	Redundant applications for the same purpose
	Replicated local databases
4	**Identify Available Options**
	Base Case/ No-Build Option
	Enterprise GIS - Option 1
	Enterprise GIS - Option 2
	Other GIS - Option 3

5	**Evaluation of Options (No-Build vs. Enterprise vs. Other)**
ISDM - Phase 1	**Business and Operational Impacts - Initial impact assessment**
	Identification of Business impacts - change in workflow
	Identification of operational impacts - change in resources
	Cost/Benefit Analysis
	Define Benefits and costs
	Quantify direct, indirect and external benefits due to Enterprise GIS under existing conditions
	Quantify approximate costs of implementing and maintaining Enterprise GIS under existing conditions
	Understand cost savings throughout the department
	Project Risk Assessment
	Identify risks and potential negativities of proceeding and not proceeding with Enterprise alternative
	Sustainability of resources and support - Availability and Commitment
	Identify Critical Success Factors
	Management Support
	Funding Support
	Stakeholder Support
	Recommendation
	Project Approval / Rejection

Table 3.1 indicates the major components that need to be analyzed for establishing a business case:

- **Gathering User Needs, Requirements, and Processes** – This should not be confused with the user needs that dictate the implementation of an Enterprise GIS. These user needs are derivations of current mandates and responsibilities of the Department and various functional areas within FDOT. Understanding these needs will help determine the essential work flows related to the overall departmental vision and those that typically use/require spatial data flows and datasets. For the purposes of determining the business case for an Enterprise GIS, only the data flows that are interdepartmental (and not intra-departmental) will be considered and analyzed. This will assist in understanding the concept of Enterprise GIS in a broader sense rather than any particular functional area.
- **Identification and Understanding of the Problem** – This step identifies any existing inefficiencies and redundancies that are inherent in these processes. These inefficiencies can manifest themselves as redundant data sources for similar datasets, redundant investments in applications that cater similar purposes, inefficient access of interdepartmental data elements, etc. Identification of such inefficiencies will help in understanding the processes at FDOT.
- **Identify Available Options** – The available options are then evaluated.

3.3 Comparison of ISDM and Business Case to Key Literature Documents

The ISDM and additional business case components were combined and compared against the Category 1 and 2 documents identified in Task 1.

The rows of the matrix in Table 3.2 correspond to business case components, phases of ISDM and all products that are required for each phase. The columns in this matrix correspond to each literature product, such as the *2004 User Needs Analysis* and the *2006 Technology Assessment*.

Various components of the existing literature identified in Task 1 relate to different levels to these various phases. Though the focus of this project is clearly on the first three phases of the ISDM, the literature was reviewed and compared against all seven phases of ISDM. This assists in understanding what lessons can be learned from previous work, and how the Enterprise GIS project can benefit from the groundwork that has already been laid. Two of the main literature pieces, the *2004 User Needs Analysis* and the *2006 Technology Assessment*, relate substantially to the Phase I of the ISDM and to lesser extents to the subsequent phases.

Table A.1 in Appendix A indicates specific references including associated page numbers for each relevant reference. For example, the first reference in the first row indicates that the GRIP – Geo-Referenced Information Portal contains a reference in Section 2, page 3 that corresponds to the definition of an Enterprise GIS. These references will be useful in Task 3 for completing the gaps.

The intent of this task was to identify missing products, so another more summarized matrix (Table 3.2) was prepared to show information regarding the extent that a certain body of literature corresponds to ISDM shown by a quarter-circle, semi-circle, or solid circle. A quarter-circle indicates that the document refers to the aspect, but cannot be used. A semi-circle indicates that the material can be used to complete the work product, but needs to be reviewed, supplemented, and/or updated. A solid circle indicates that the material is very appropriate for the work product and can be used as is. Any material that is not covered at all in the existing documentation is indicated by a blank in the matrix. The table shows the headings of the business case and ISDM requirements along with an assessment of how well the existing literature covers that section. The existing literature is summarized into headings that are more general as well. For example, all District Seven reports are referred to as "D7 Reports" and the PAI series of reports are shown as "PAI".

Table 3.2 Summary Reference Matrix

	Components for Establishing Business Case	GRIP - Georeferenced Information Portal	PAI reports	GIS-T Strategic Plan, Mission, Vision	FDOT Business Plans	A New Database Framework for Florida's Transportation Planning: Integrating Work Program, Multimodal Transportation Networks, Planning and Environmental Databases	Development of GIS-Based Conflation Tools for Data Integration and Matching	ITS Central Florida Warehouse	D4 Enterprise Data Repository for Transportation Modeling Data	D4 White Paper/Business Needs Report	D5 CIA/ETDM/TAIMS	D7 Reports	GIS-T Reports	Turnpike Reports
1	Define Enterprise GIS	◑		◑					◔	◔	◑		◑	
2	Gather User needs, Requirements and Processes													
	Business	◑	◑	◑	●	◑	◔		◔	◑	◑	◑	◑	◔
	Data	◑	◑						◑		◑	◑		◔
	Financial (sources and amounts)		◑						◔		◔			◔
	Technology and Architecture	◔	◑					◔		◔		◑		◔
3	Identification and Understanding of the Problem													
	Business	◑	◑			●		◔		◔	◑	◑		
	Data	◔	◑			◑		◔		◔	◑	◑		
	Financial													
	Technology and Architecture									◔				◔
4	Identify Available Options													◔
	Base Case/ No-Build Option	◔												
	Enterprise GIS - Option 1										◔			
	Enterprise GIS - Option 2													
	Other GIS - Option 3													
5	Evaluation of Options (No-Build vs. Enterprise vs. Other)													
	Business and Operational Impacts - Initial impact assessment					◑			◑		◑			
	Cost/Benefit Analysis	◔	◑						◔		◔	◑		
	Project Risk Assessment	◑						◔						
	Identify Critical Success Factors	◑	◑							◑		◑		
	Recommendation													
ISDM - Phase 1	Identification and Assessment Deliverables													
A	Request(s) for Service													
A.1	Cost/benefit Analysis	◔	◑						◔		◔	◑		
A.2	Risk assessment/critical success factors	◑						◔						
A.3	Priority assessment													
A.4	Availability and commitment of resources													
A.5	Recommendation													
A.6	Project Approval/Rejection													
B	Initial Project Plan (if approved)			◔										
C	Initial impact assessment											◑		
D	Potential Budget issue(s)													
E	Service Request Evaluation													
F	Initial metadata documentation													
ISDM - Phase 2														
4.3.4	Planning Deliverables													
A	Project Plan		◔	◑						◑		◑		
B	Initialized Project Notebooks													
C	Updated metadata documentation													

	Components for Establishing Business Case	GRIP - Georeferenced Information Portal	PAI reports	GIS-T Strategic Plan, Mission, Vision	FDOT Business Plans	A New Database Framework for Florida's Transportation Planning: Integrating Work Program, Multimodal Transportation Networks, Planning and Environmental Databases	Development of GIS-Based Conflation Tools for Data Integration and Matching	ITS Central Florida Warehouse	D4 Enterprise Data Repository for Transportation Modeling Data	D4 White Paper/Business Needs Report	D5 CIA/ETDM/TAIMS	D7 Reports	GIS-T Reports	Turnpike Reports
ISDM - Phase 3														
4.4.4	User Requirements Analysis Deliverables													
A	Requirements Definition	◔	◑									◑		
B	Functional specifications	◔	◑		◔		◔	◔	◔	◔		◑		
C	Hardware/software/database/communication assessment		◔							◔				◔
D	Updated project plan													
E	Updated Project Notebooks													
F	Updated metadata documentation													
ISDM - Phase 4														
4.5.4	System Design Deliverables													
A	System Design					◔		◔				◔		
B	Detailed Design													
C	Technical architecture													
D	Conversion Plan													
E	Updated project plan													
F	Updated Project Notebooks													
G	Updated metadata documentation													
ISDM - Phase 5														
4.6.4	Construction Deliverables													
A	Business System													
B	Implementation Plan													
C	Updated Project Plan													
D	Updated Project Notebooks													
E	Updated metadata documentation													
ISDM - Phase 6														
4.7.4	Implementation Deliverables													
A	Production Application													
B	Acquired hardware and software													
C	Operator/Operations instructions													
D	Training Package													
E	Project report - final version of the project plan													
F	Completed metadata documentation													
G	Project Notebooks													
H	Post implementation review summary and recommendations													
I	New and/or revised standards and procedures													
ISDM - Phase 7 Maintenance	Production and System Maintenance													

As indicated in the table, there is a large number of documents that are directly relevant to meeting business case and ISDM requirements. There are also many gaps, particularly in terms of updating the content of past literature to meet the present context. The following are some of the key observations and gaps from the past literature:

- Inconsistent definition of the term "Enterprise GIS" – Several documents/projects defined the concept of Enterprise GIS in different ways. While a few defined it in terms of being a centralized database, some defined it more loosely as an amalgamation of major applications. In order to successfully proceed along the path of an Enterprise GIS, this definition must be clear and accepted by all stakeholders.
- Incomplete business needs assessment – Several documents touched upon understanding the business needs and requirements at either the Department or functional area level. While this reinforces the importance of business needs as a foundational element of an Enterprise GIS, most documents/projects touched upon only a limited number of stakeholders. This may be attributed to the fact that these studies were conducted by different functional areas with different objectives at different points in time. Hence, information provided from past literature may need to be complemented with additional stakeholder input, especially from the functional areas that were not represented in past studies.
- Incomplete understanding of key data elements - Several studies in the past have identified some of the key data elements that are currently used in the Department. While these studies provide descriptions of these data elements, the information is still incomplete due to the period that certain studies such as PAI were conducted and due to the localized nature of other studies from Districts 4 and 5.
- Incomplete understanding of financial and technical aspects – Although these aspects may be secondary in nature when compared to business aspects, past studies touched this aspect only to a limited extent. The PAI study that discussed these aspects in detail needs to be updated to reflect today's technology and resources.
- Lack of comprehensive understanding of the problem – As past studies were conducted at different points of time for various purposes, a comprehensive understanding of redundancies and inconsistencies across the interdepartmental data flows is non-existent. Though several studies point to the aspect of redundant data sources and inefficient business processes, none of them comprehensively tied those to the business mandates of the Department. This tie will enable upper management truly appreciate the need for a change in current GIS.
- Incomplete evaluation of the available options – Very few past studies discussed whether an Enterprise GIS option is feasible or even cost effective for the Department. Though few studies discuss the operational impacts (both negative and positive) of an Enterprise GIS concept, there is a lack of understanding of the

potential impacts, as well as cost-benefit analysis and risks of such investment in current FDOT's environment.

- Need for comprehensive compilation of success factors – Several critical success factors were documented in past studies. However, there is a need to operationalize these success factors into tasks that are specific to FDOT.
- Need for a Unified Base Map – Though not explicitly identified in the table or in the ISDM, several of these past efforts and studies demonstrated a clear need for a comprehensive roadway base map that includes all roads in the state of Florida. These efforts identified several aspects that may be updated and used to develop a roadway base map at FDOT.

3.4 Stakeholder Involvement

Given that a critical success factor for an Enterprise GIS is stakeholder involvement and agreement, an assessment of the extent of FDOT stakeholder involvement conducted to date through the main documents identified in Task 1 was conducted. Table A.2 in Appendix A shows these documents along the left and FDOT stakeholder groups organized by business function across the top. Each document was reviewed thoroughly and stakeholders referenced are indicated in the table.

It was clear that stakeholder involvement to date has not been entirely comprehensive.

3.5 Next Steps

The following summarizes the steps required to complete the missing products. As stated earlier, not all aspects of the ISDM were covered. The following is a list of tasks that were identified in Task 2 and completed in Task 3.

- Define Enterprise GIS and gain consensus from the GIS FSC
  - Compile definitions from past efforts
  - Formulate new definition and present to GIS FSC
- Incomplete business needs assessment
  - Identify stakeholder gaps
  - Stakeholder outreach
  - Identification of business mandates that require interdepartmental data flows
  - Map interdepartmental data flows with proper representation of stakeholders (from past studies and through interviews)

- Identify key data elements
    - Identify key databases and applications that pertain to the key interdepartmental data flows
    - Identify data sources
- Incomplete understanding of financial and technical
    - Obtain a big picture understanding of existing financial and technical resources and barriers (from past studies and through interviews)
- Lack of comprehensive understanding of the problem
    - Identify inefficiencies and redundancies in data flows and data links
    - Identify duplicate applications, datasets and data sources
- Incomplete evaluation of the available options
    - Identify higher level impacts of Enterprise GIS option
    - Identify probable resource requirements
    - Conduct a brief cost-benefit analysis
    - Identify risks from past studies and through similar implementations at other DOTs
- Need for comprehensive compilation of success factors
    - Compile all success factors and classify them meaningfully
    - Identify distinct tasks for FDOT to implement, that are associated with each of the success factors
- Need for a Unified Base Map
    - Summarize findings from past literature
    - Identify aspects for implementation at FDOT

4.0 TASK 3: Identification and Creation of Missing Products

4.1 Introduction

This chapter of the *Final Report* summarizes Task 3 of FDOT Enterprise GIS Research Project. The objective of this task was to create and update any products found to be missing as a result of Task 2. The missing products are provided in the following sections:

- Business Needs Assessment. Includes summaries of stakeholder summaries and data flow maps within the Department.
- Understanding of the Problem. Summarizes the issues that need to be resolved with an Enterprise GIS.
- Definition of Enterprise GIS. Proposes a detailed definition of the Enterprise GIS along with several key characteristics.
- Identification and Evaluation of Options. Four options are described and analyzed in terms of benefit/cost and risk.
- Project Plan. Includes recommendations and a proposed implementation plan for the Enterprise GIS.

4.2 Business Needs Assessment

The first critical component missing from previous documentation is a clear, thorough assessment of the business need for an Enterprise GIS. This includes understanding the organization's mission, mandates, and responsibilities and how an Enterprise GIS could enable the Department to more effectively meet those goals. An assessment was accomplished through stakeholder interviews and documented in a series of data flow diagrams indicating how the data flows within and between offices. The data flow diagrams show the role of spatial data and are used to demonstrate how improved sharing of data in a geospatial sense will provide for more efficient operations within FDOT.

4.3 Stakeholder Interviews

The objective of the stakeholder interviews was to understand office business mandates, enterprise data flows required by those mandates, how Enterprise GIS could assist in complementing such data flows and stakeholder perspectives on Enterprise GIS.

Offices whose core processes fall into the categories of planning, producing, delivering, and operating were interviewed for this research project. The FDOT Performance Management office defines a core process as "a group of functions or systems that are most important to carrying out the mission of the Department."

The following are the functional areas that were interviewed at FDOT Central Office:

- Systems Planning Office
- Transportation Statistics Office
- Environmental Management Office (EMO)
- State Roadway Design Office
- Structures Design Office
- Engineering Office
- Surveying and Mapping Office
- Maintenance Office
- Construction Office
- State Traffic Engineering and Operations Office – ITS Office
- State Materials & Research Office
- Office of Information Systems (OIS)

4.3.1 Interview Results

The stakeholder interviews provided an excellent opportunity for communicating the potential benefits of an Enterprise GIS. Stakeholders were enthusiastic and supportive of the efforts. Continued coordination with these stakeholders will be critical to the success of implementation of an Enterprise GIS.

Sixteen stakeholder meetings were held at the Central Office and District Four. The interviews covered all business areas including planning, environmental management, design, construction, maintenance, operations and materials.

Detailed summaries are included in Appendix A.

The following summarizes key issues and insights provided by the wide range of stakeholders.

DEFINITION

All of the stakeholders agreed that a clear, succinct definition of Enterprise GIS must be proposed and agreed to by all. Some desirable characteristics cited by the stakeholders included:

- building up from existing applications;
- needing a two-way process – all functions are either contributing or taking away from the Enterprise GIS;
- a complimentary process for everything in the Department;
- physical needs to establish protocol and framework;
- complimenting all other GIS activities in FDOT;
- needing an infrastructural policy framework;
- GIS Enterprise assisting in defining how overall base map fits into FDOT base map and others;
- everyone using the Department-wide information resource, and establishing a clear ownership regarding data;
- high-level roadmap.

OFFICE BUSINESS PROCESSES

Office business processes are documented in Appendix A and depicted in data flow diagrams in Section 4.4.

CONSTRAINTS FOR ENTERPRISE GIS

Several constraints were cited related to adopting an Enterprise GIS. Some of them are:

- lack of data
- not having access to Google Earth in FDOT
- price of GIS software
- FDOT firewall
- network capacity
- financial – can only spend funding in certain areas to meet federal requirements
- centralized or distributed hardware
- lack of polices for data sharing

- licenses
- too many ways to reference projects – Financial Management (FM) number, Work program identifier, contract number, begin/end point
- several districts have developed their own mapping interfaces

Benefits of Enterprise GIS

A large number of benefits were identified as summarized below:

- Data sharing and communication – more users could be made aware of what is available
- Efficient business processes (value)
- Roadmap to standardization
- Guidelines to indicate how and when to share data within FDOT
- Inefficiency and redundancy elimination
- Accuracy, timeliness and coverage improvement
- Ensures methodology for consistent district applications
- Correct source for data
- One stop shopping with identified common data sources
- Uniform statewide metadata with global definitions
- Standardized GIS data base map

Needs for Enterprise GIS

When asked about the need for an Enterprise GIS, the following was highlighted:

- Several districts are doing their own thing – Central Office is not sure what they are doing, not sure if they are pulling data from the correct sources;
- The official source of data is not clear. This can be overcome with better communication.
- Need a source that everyone pulls from (i.e., facilities level) – scale depends on needed level of accuracy; and
- Needs to reference geography and define layers for all five modes.

Success Factors

Stakeholders offered a large number of very relevant success factors for GIS Enterprise within FDOT, as follows:

- Technical expertise
- Coordination and communication during implementation

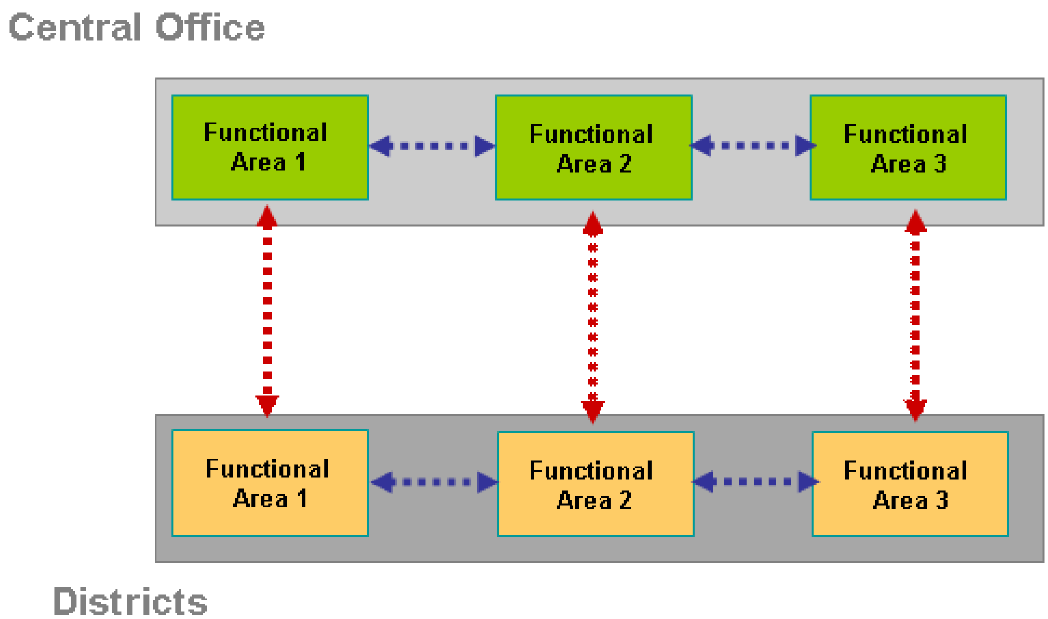
- Don't try to roll everything up into one application
- Emphasize sharing
- High level management support and approval
- Clearly defined data owners (they create, maintain, update)
- A successful pilot
- Established policies communicated to the user community
- A high level GIS officer to promote top down implementation
- A strong financial case
- Everyone needs to see obvious value
- JAD sessions for stakeholders to share ideas
- Numerous stakeholder meetings
- All steps taken are well planned

4.4 Data Flow Maps

Data flow mapping was used in this project to evaluate enterprise-level spatial data exchange. Typically, a data flow map represents the flow of data from one location to another.

To analyze the need for an Enterprise GIS that will potentially enhance spatial data exchange across the organization as a whole, focus was placed on enterprise level inter-departmental flows rather than intra-departmental flows. As shown Figure 4.1, enterprise level flows are those that occur between various functional areas (blue lines) or jurisdictions (red lines). These flows can potentially be enhanced or affected by Enterprise GIS.

Figure 4.1 Enterprise Level Flows



4.4.1 Data Flow Map Components

The data flow maps included in this section of the report will include the following components:

- Organization and destination offices. These offices are represented as orange boxes in the data flow maps.
- Subsidiary offices that are located within a functional area are represented as green boxes.
- External offices that participate in data exchange with FDOT functional areas are represented as blue boxes.
- The line that connects the origin and destination offices are color coded into three different categories:
  - » Blue lines connect two functional areas located in the Central Office or a district office.
  - » Red lines connect a functional area from the Central Office to a functional area in a district office.
  - » Dotted lines indicate a data flow that is currently non-existent and is desired by a particular functional area.

- Details regarding the data flow are indicated with the line that connects the origin and destination offices. These details are documented between two horizontal lines placed along the connecting line.
- The database that exists either inside a particular office or outside of the Department. Databases that belong to an office within FDOT are represented as green cylinders and external databases are represented as blue cylinders.

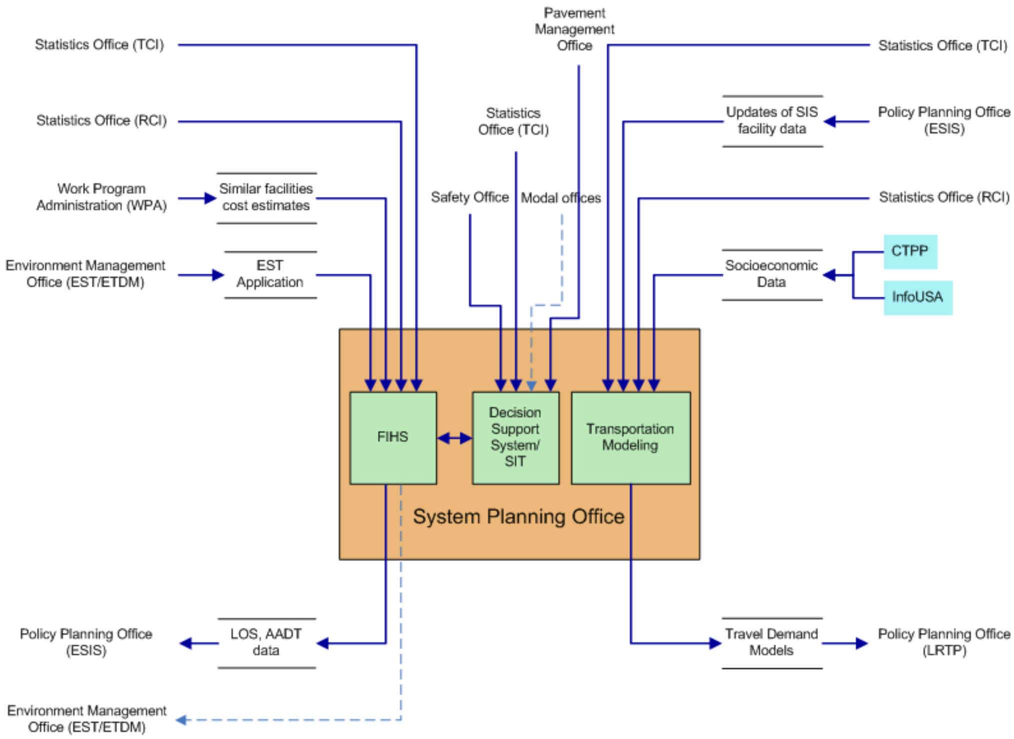
4.4.2 Functional Area Data Flow Maps

Data flow maps were created for various functional areas in the Central Office and for similar functional areas at the sample FDOT district. These maps were created using information obtained through stakeholder interviews along with data compiled from previous studies. Although interviews were conducted at both the Central Office and district level, the data flow maps described in the following sections are organized by office and not by geographic jurisdiction.

Systems Planning Office

Figure 4.2 shows the data flow map for the Systems Planning office.

Figure 4.2 Systems Planning Office Data Flow Map



Existing Data Flows

The Systems Planning Office includes the offices of Florida Intrastate Highway System (FIHS), Decision Support System (DSS)/Strategic Investment Tool (SIT) and Transportation Modeling. Existing inflows include the following:

- Roadway Characteristics Inventory (RCI) and Traffic Characteristics Inventory (TCI) data are received from the Statistics Office.
- Cost estimates for similar roadway facilities are received from Work Program Administration (WPA).
- Environmental Screening Tool (EST) data is received from the Environment Management Office (EMO).
- SIS facility data is received from Enterprise SIS (planned).
- Pavement Condition data is received from the Pavement Management Office.
- Safety related data is received from the Safety Office.
- Socioeconomic data is obtained from the Census Transportation Planning Package (CTPP) and InfoUSA (external datasets).

Outflows include the following:

- LOS and AADT data is used by the Office of Policy Planning.
- Travel Demand Model data/outputs are used by the Office of Policy Planning to support the development of the Long Range Transportation Plan (LRTP).

Planned/Desired Data Flows

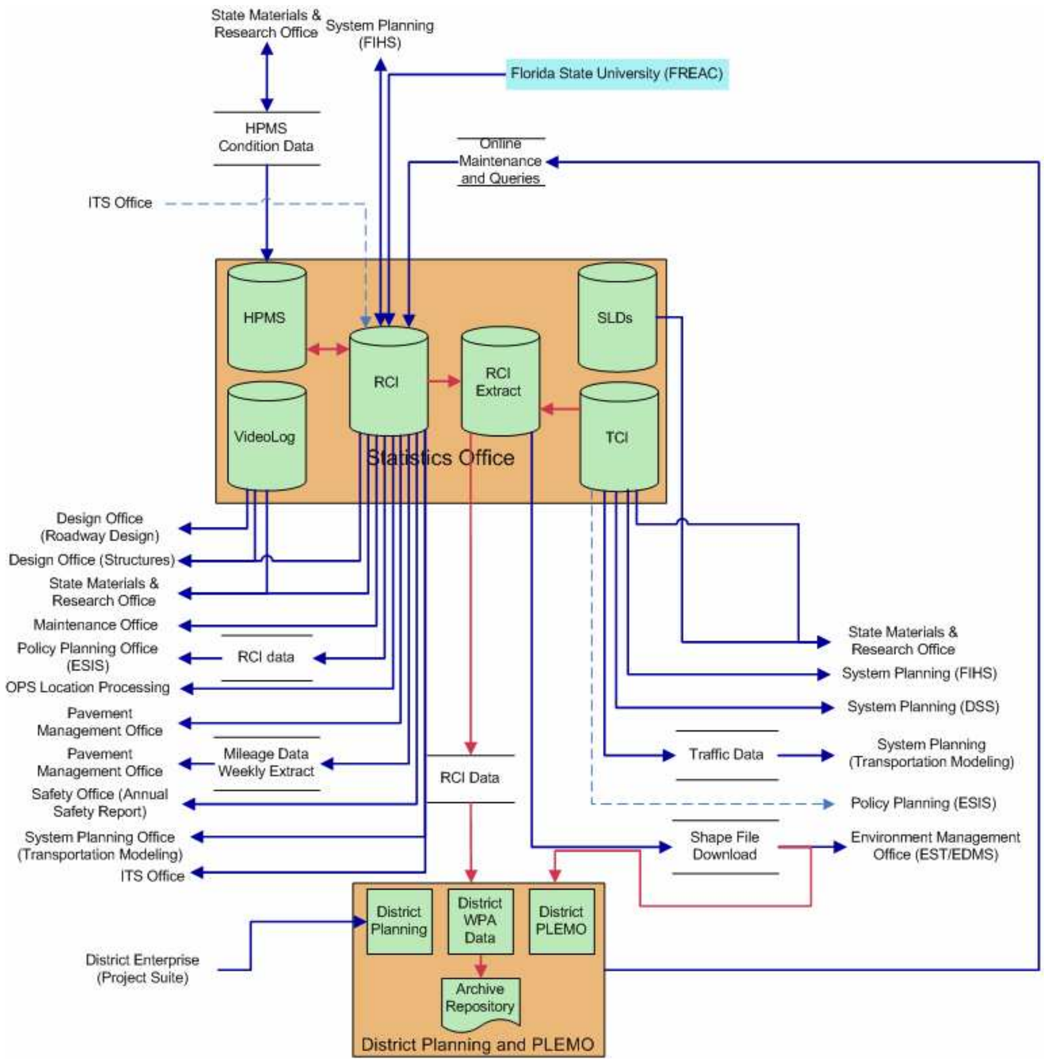
Planned/desired data flows include the following:

- More dynamic connections are needed to the existing datasets.
- Mode specific data is needed from modal offices.
- Project information needs to flow from the FIHS to the EST.

Statistics Office

Figure 4.3 shows the data flow map for the Statistics Office.

Figure 4.3 Statistics Office Data Flow Map



Existing Data Flows

As one of the largest data providers throughout the Department, the Statistics Office maintains the following databases: (1) Highway Performance Monitoring System; (2) VideoLog; (3) Roadway Characteristics Inventory (RCI); (4) Roadway Characteristics Inventory Extract; (5) Traffic Characteristics Inventory (TCI); and (6) Straight Line Diagrams (SLDs). A summary of existing data flows include the following:

- The Highway Performance Monitoring System (HPMS) database receives condition data from the State Materials and Research Office (SMRO). HPMS condition data flows internally between the RCI and HPMS databases.
- The VideoLog is a standalone application that provides sequential images (jpeg format) along state highway facilities throughout the state. VideoLog data is used by the offices of Roadway Design, Structures, and SMRO.
- Roadway Characteristics Inventory (RCI) data inflows include the following: (1) a bi-directional flow with the System Planning Office (FIHS), and (2) on-line maintenance data inputs from district offices. RCI data is used by the following groups: (1) Maintenance Office's PONTIS Bridge Management System, (2) Enterprise SIS (E-SIS) -planned, (3) OPS location processing, (4) Pavement Management Office for weekly extracts of mileage data, (5) Safety Office for their annual safety report, (6) Systems Planning Office for transportation modeling, (7) ITS Office, and (8) online maintenance queries by district offices.
- The RCI Extract receives data directly from the Roadway Characteristics Inventory and Traffic Characteristics Inventory (TCI) databases. Shapefile-based extracts of RCI data are used by the Environment Management Office for their Environmental Screening Tool (EST). In addition, traffic data from the TCI database is used by the Systems Planning Office to support transportation modeling, as well as the Decision Support System (DSS) / Strategic Investment Tool (SIT).

Planned/Desired Data Flows

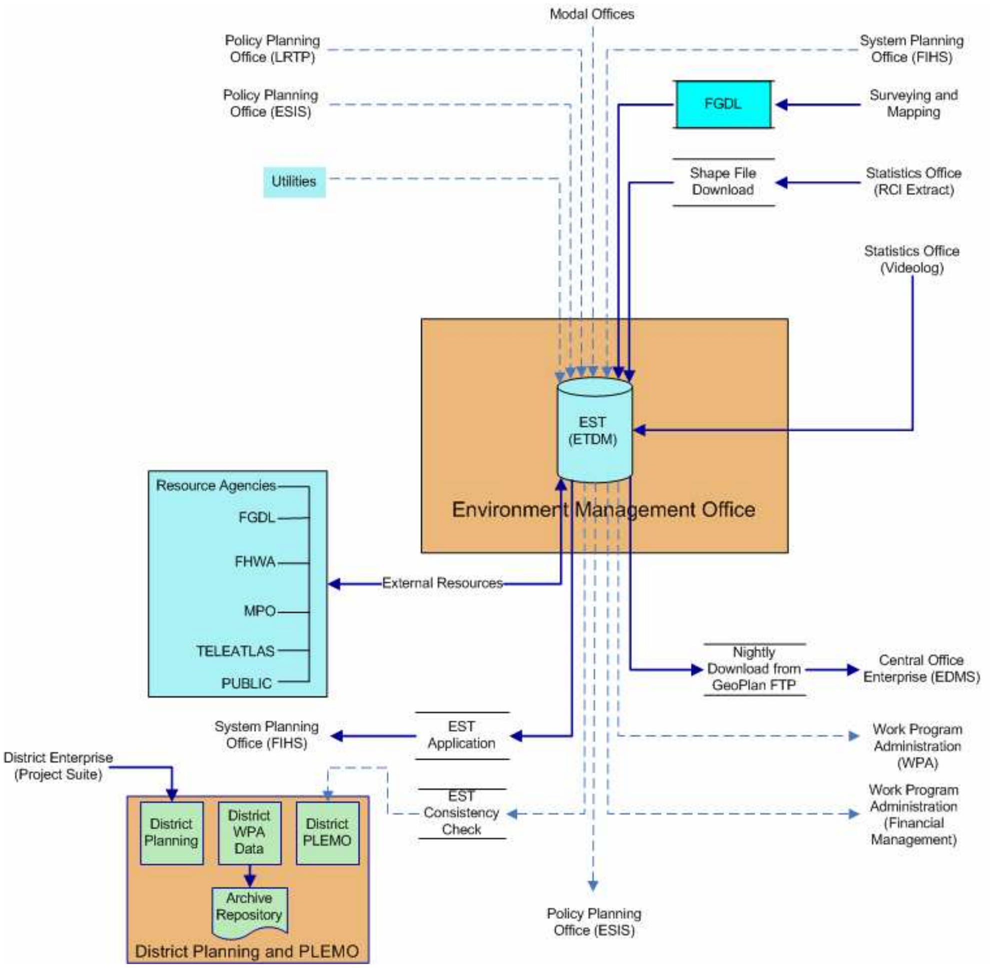
Planned/desired data flows include the following:

- More dynamic connections rather than shapefile-based extracts of RCI data.
- A data flow is planned to provide TCI data to the Policy Planning Office for their Enterprise SIS (planned).
- The Systems Planning Office needs additional TCI data for the FIHS.

ENVIRONMENTAL MANAGEMENT OFFICE

Figure 4.4 shows the data flow map for the Environmental Management Office.

Figure 4.4 Environmental Management Office (EMO) Data Flow Map



Existing Data Flows

The Environmental Management Office maintains the Environmental Screening Tool (EST) as part of the Efficient Transportation Decision Making (ETDM) process. Existing data flows include the following:

- The Environmental Screening Tool (EST) database receives data from the Florida Geographic Data Library (FGDL), which includes hundreds of statewide data sets containing transportation, environmental, and community characteristics data. The EST also utilizes a shapefile download of RCI data from the Statistics Office.
- EST data is used by the Central Office Electronic Data Management System (EDMS), that provides a nightly download of EST information from the GeoPlan

Center at the University of Florida. In addition, the Systems Planning Office (FIHS) accesses data for the FIHS using the EST application.

- Other external users of EST data include: (1) Resource Agencies, (2) Federal Highway Administration (FHWA), (3) Metropolitan Planning Organizations (MPOs), (4) TeleAtlas – statewide roadway centerline database, and (5) Public.

Planned/Desired Data Flows

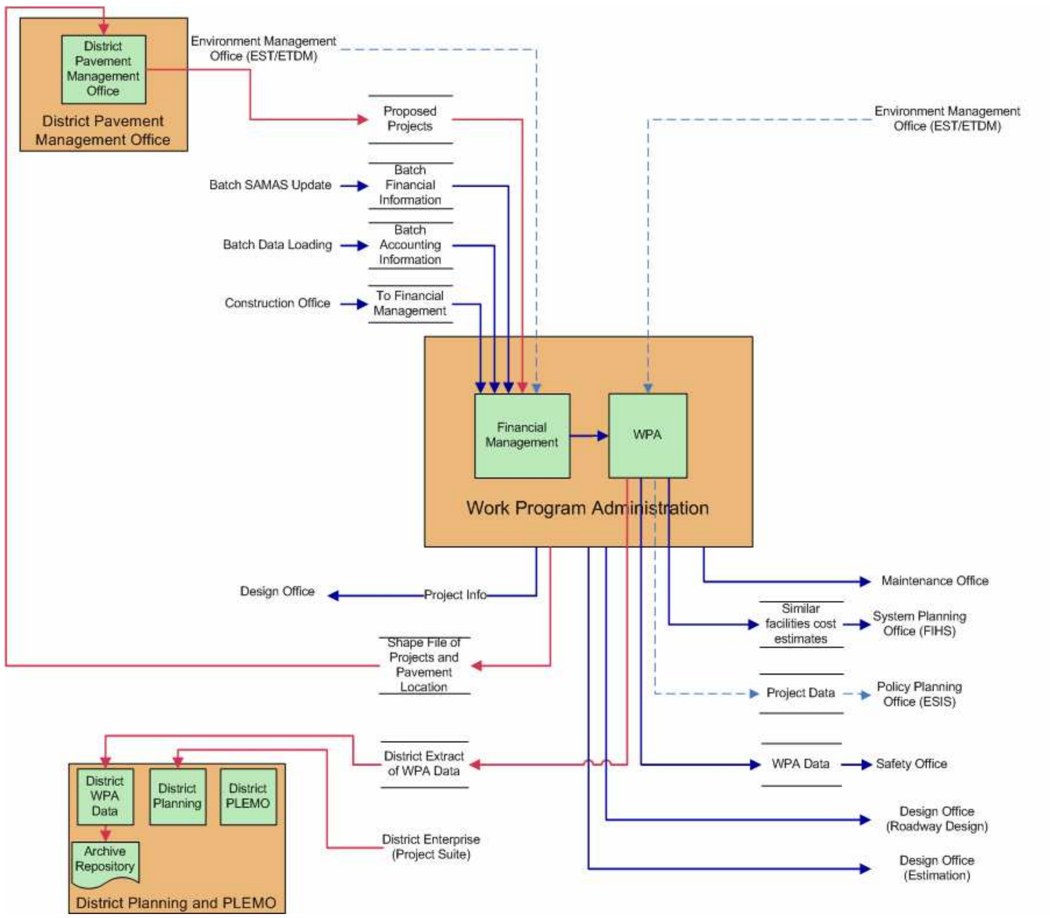
Planned/desired data flows include the following:

- Data outputs/sharing with: (1) EST consistency check with district level PLEMO offices, (2) dynamic connection to the E-SIS (planned), and (3) WPA and Financial Management systems.

Work Program Administration Office

Figure 4.5 shows the data flow map for the Work Program Administration (WPA) office.

Figure 4.5 Work Program Administration (WPA) Data Flow Map



Existing Data Flows

WPA maintains critical data related to the Work Program and Financial Management for all programmed transportation improvements throughout the state. Existing data flows are as follows:

- Proposed pavement management projects are coordinated through the district Maintenance Offices

- Batch financial and accounting information obtained from the batch SAMAS update flows into the financial management system
- Construction Office Financial Information flows into the financial management system
- District Pavement Management Office provides proposed project information into the financial management system
- Several offices access the work program database. These include Systems Planning, Design, Safety, Materials, and Maintenance offices
- Shapefiles of projects and pavement information are sent to the district Pavement Management offices
- District extracts of WPA data are sent to district offices

Planned/Desired Data Flows

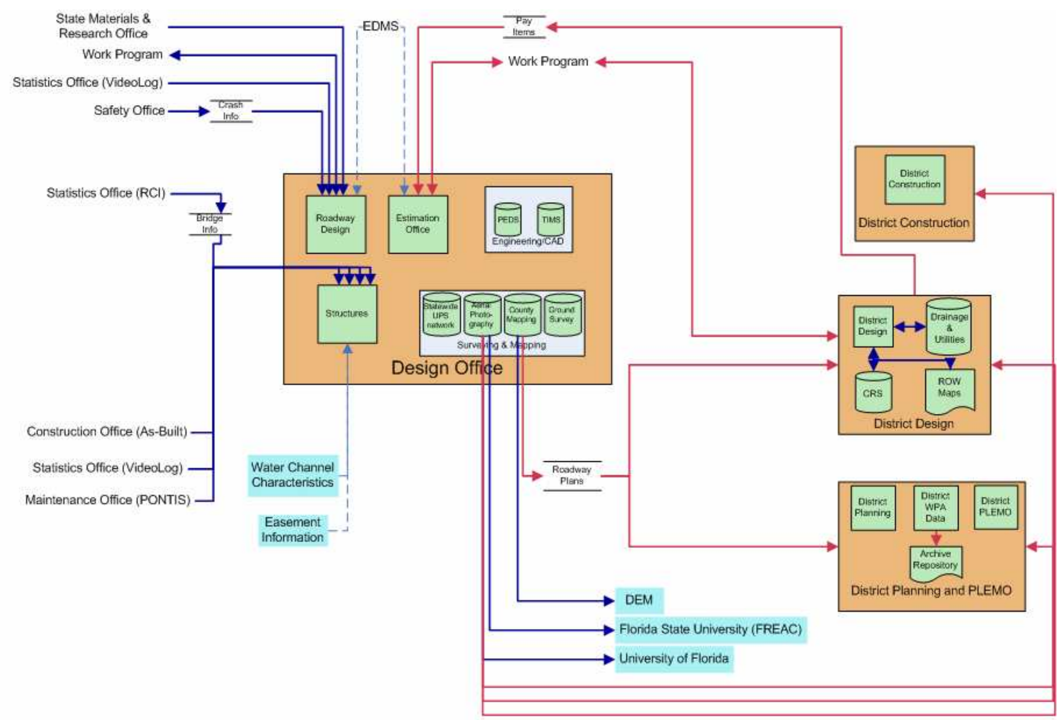
Planned/desired data flows include the following:

- More dynamic linkage to the work program database.
- Most stakeholders suggested a geographic interface for the work program database

DESIGN OFFICE

Figure 4.6 shows the data flow map for the Design Office.

Figure 4.6 Design Offices Data Flow Map



Existing Data Flows

Several offices within the Design Office were interviewed in the process. Existing data flows are as follows:

- State Materials and Research Office provides materials data to the Roadway Design office
- Work Program Administration has bi-directional data flows to the Roadway Design office
- VideoLog information from the Statistics Office is used by the Roadway Design office. Bridge location information from the Roadway Characteristics Inventory is used by the Structures office
- Crash/safety related data from the Safety Office is used by the Roadway Design office
- As-built drawings from the Construction Office are used by the Structures office
- PONTIS data from the Maintenance Office are used by the Structures office

- The Estimates Office provides pay item information for districts to build long range estimates
- The Surveying and Mapping office provides aerial photography and roadway plan data to district planning, design and construction offices. The aerial photography and the survey data are used by several other offices within the Department on an ad-hoc basis
- Other external datasets: Surveying and Mapping Office provides data to several external agencies such as the Division of Emergency Management

Planned/Desired Data Flows

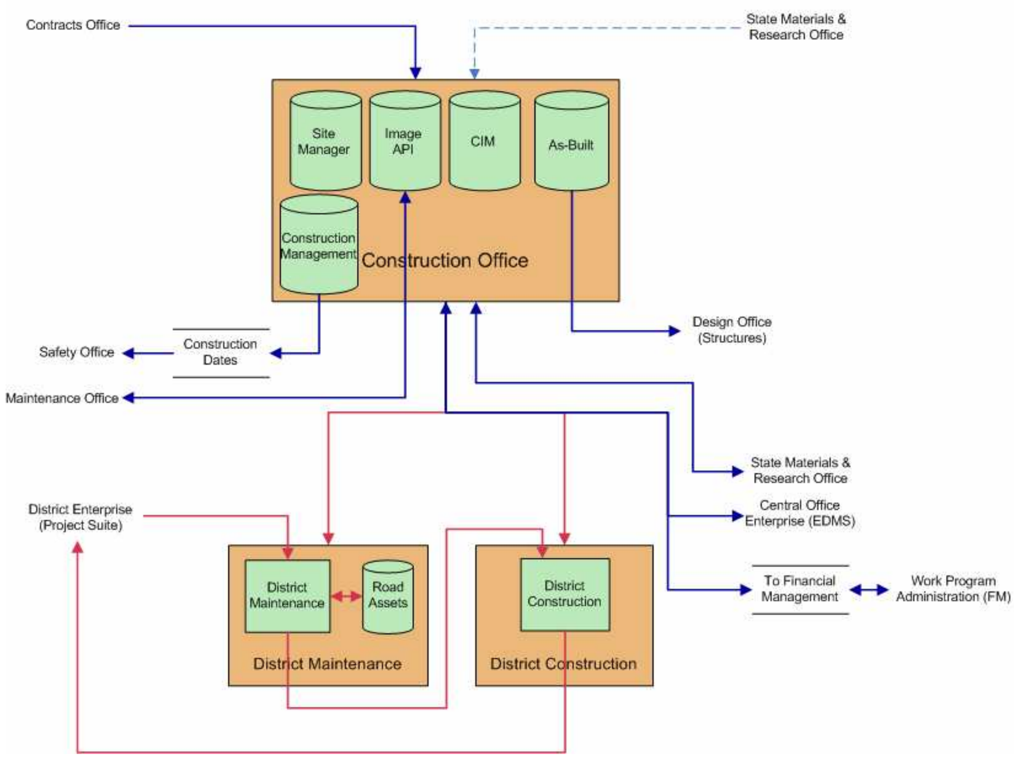
Planned/desired data flows include the following:

- More dynamic linkage to Central Office Electronic Data Management System (EDMS)
- Information on easement and waterway channel characteristics

CONSTRUCTION OFFICE

Figure 4.7 shows the data flow map for the Construction Office.

Figure 4.7 Construction Office Data Flow Map



Existing Data Flows

The Construction Office maintains several databases including: (1) Site Manager, (2) Image API (document management for as-builts), (3) Construction Management System (CMS), (4) Contract Information Monitoring (CIM), and (5) additional as-builts. Existing data flows are as follows:

- Data inflow is received from the Contracts Office
- Maintenance and Materials Office: Bidirectional data flows identified
- The Construction Management System accesses funding information from the financial management database and project description information from the work program database located in the Work Program Administration Office
- The Safety Office accesses construction date information from the construction management database

- Various datasets are sent to (1) District Maintenance and Construction Offices, (2) WPA Financial Management, and (3) Central Office Enterprise Electronic Document Management System (EDMS)
- The Design Office utilizes the information from the as-built database

Planned/Desired Data Flows

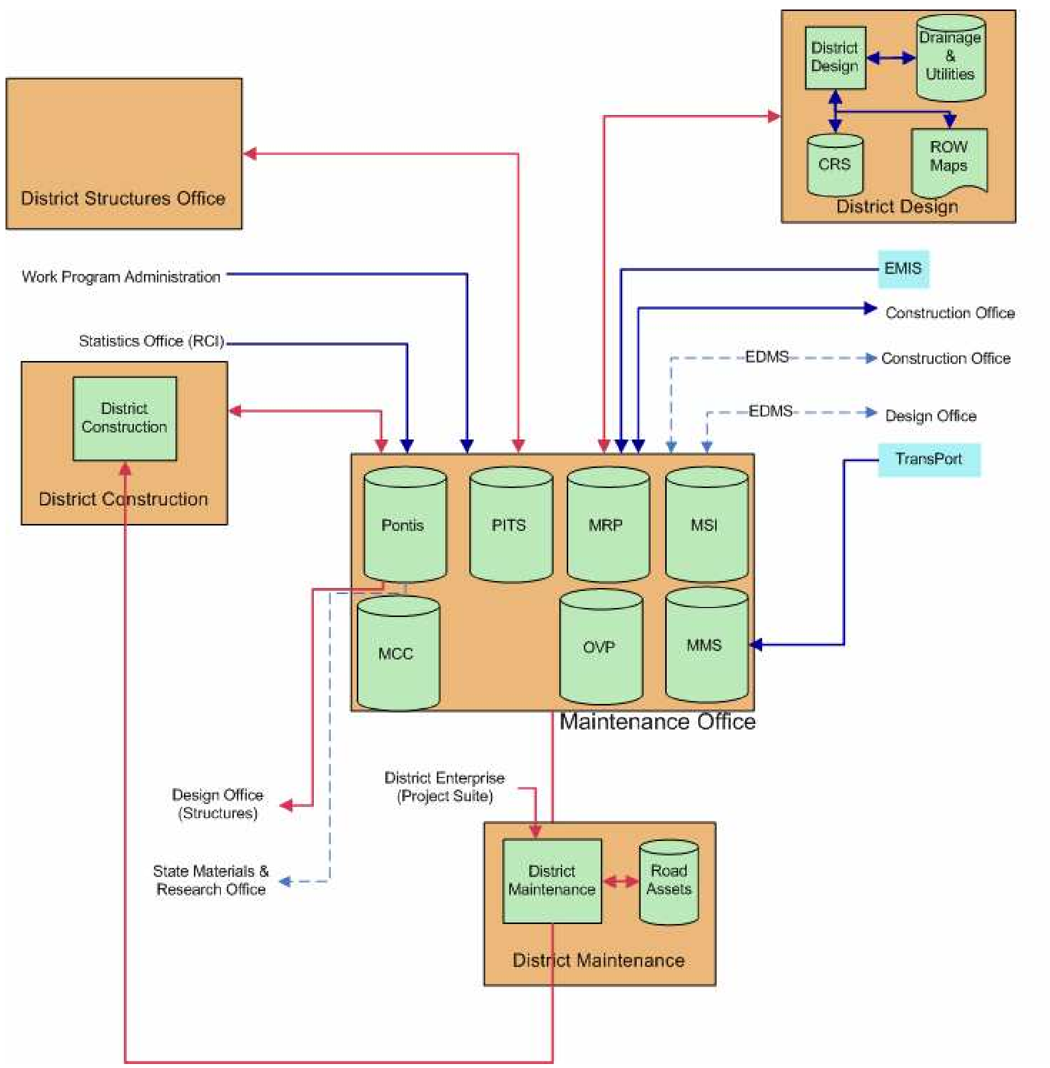
Planned/desired data flows include the following:

- State Materials and Research Office to have more dynamic access to the construction databases

MAINTENANCE OFFICE

Figure 4.8 shows the data flow map for the Maintenance Office.

Figure 4.8 Maintenance Office Data Flow Map



Existing Data Flows

The Maintenance Office maintains and updates several critical databases including: (1) PONTIS, (2) Permit Information Tracking System (PITS), (3) Maintenance Rating Program (MRP), (4) MRS, (5) Maintenance Management System (MMS), (6) Oversized Vehicle Permit (OVP), and (7) Motor Carrier Compliance (MCC). Existing data flows in the Maintenance Office include:

- The Work Program Administration receives planned project information and deficient bridge data
- RCI data is received from the Statistics office
- Construction Office: Image API (document management system for as-builts)
- PONTIS and MMS: Information to district Offices and to Design and State Materials and Research Office
- District maintenance, construction and structures offices interact with the Maintenance Central Office
- Data from external systems Equipment Management Information System (EMIS) and TrnsPort

District Maintenance Offices currently maintain some roadway asset data internally and provide maintenance information to the district Construction offices.

Planned/Desired Data Flows

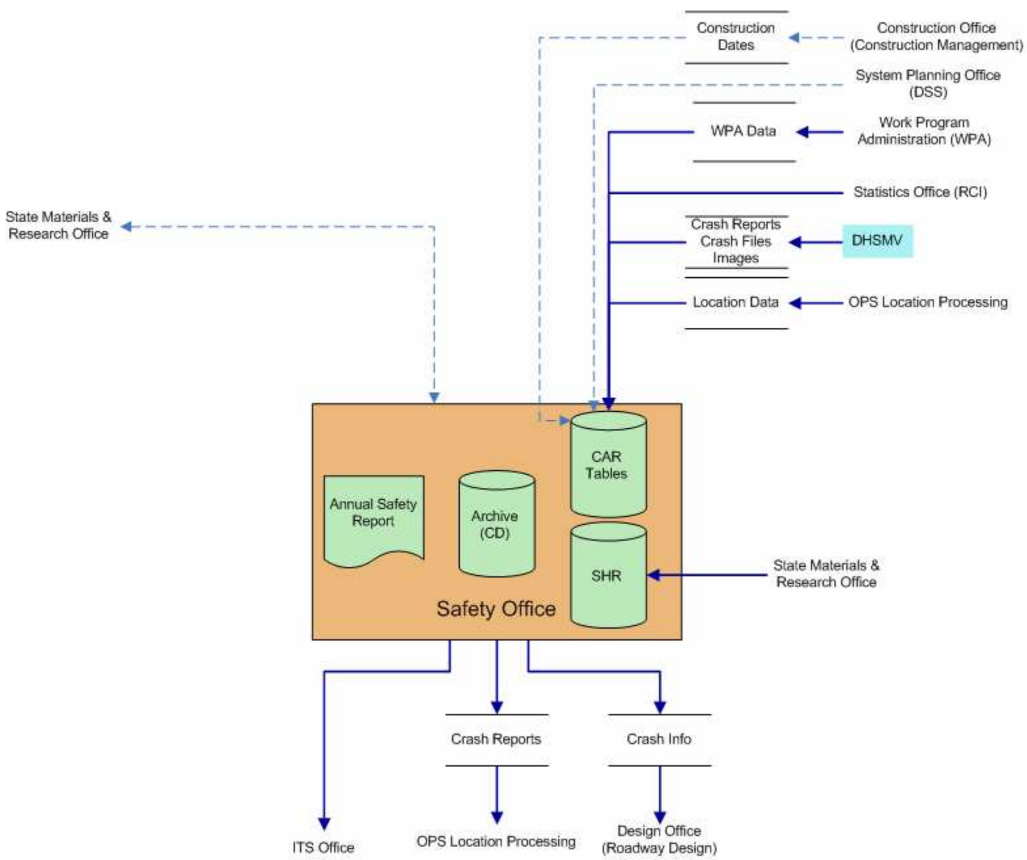
Planned/desired data flows include the following:

- More real-time access to construction and maintenance EDMS
- State Materials and Research Office to have more dynamic connection to the PONTIS system

SAFETY OFFICE

Figure 4.9 shows the data flow map for the Safety Office.

Figure 4.9 Safety Office Data Flow Map



Existing Data Flows

Existing data flows include data sources from:

- RCI data is received from the Statistics Office
- WPA data is received from Work Program Administration for the Crash Analysis Reporting System (CARS)
- Crash reports and crash file images are received from Department of Highway Safety and Motor Vehicles (DHSMV - external agency)
- OPS Location Processing provides location data and receives crash reports

- State Materials and Research office provide input data for Skid Hazard Reporting (SHR)
- The ITS and Design Offices uses crash data from CARS

Planned/Desired Data Flows

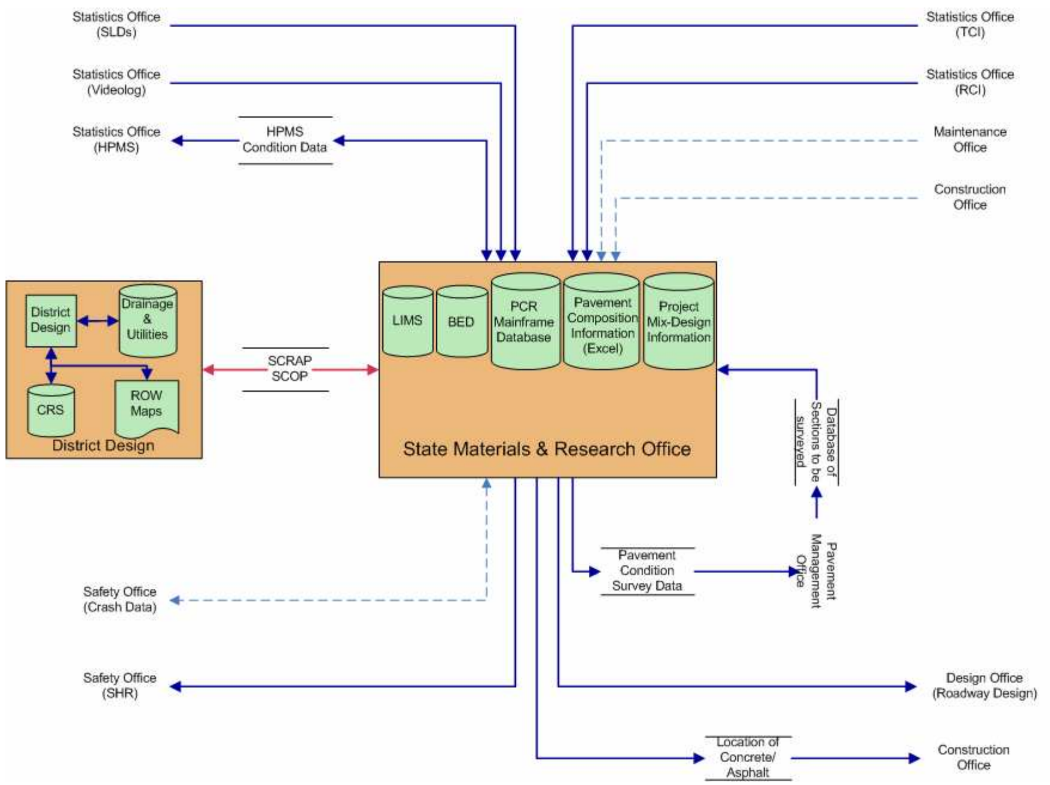
Planned/desired data flows include the following:

- Construction Office: Timely access to construction dates information is needed from the construction management system
- A more direct connection to the Decision Support System/SIT in the Systems Planning Office
- More dynamic linkage to the State Materials and Research Office (SMRO)

STATE MATERIALS AND RESEARCH OFFICE (SMRO)

Figure 4.10 shows the data flow map for the State Materials and Research Office (SMRO).

Figure 4.10 State Materials and Research Office (SMRO) Data Flow Map



Existing Data Flows

The State Materials and Research Office maintains a number of databases, including: (1) Laboratory Information Management System (LIMS), (2) Bridge Environmental Database (BED), (3) Pavement Condition Rating (PCR) Mainframe, (4) Pavement Composition Information, and (5) Project Mix-Design Information. Existing data flows include data sources from:

- Videologs, HPMS Condition Data, TCI, RCI and Straight Line Diagrams (SLDs) are received from the Statistics Office
- Bi-directional flows with the Pavement Management Office in terms of sending out the pavement condition data and receiving data on structures that need to be surveyed

- Safety Office, Design Office and the Construction Office use data from the SMRO
- Bi-directional flows based on the Small County Road Assistance Program (SCRAP) and Small County Outreach Program (SCOP) with the district design office

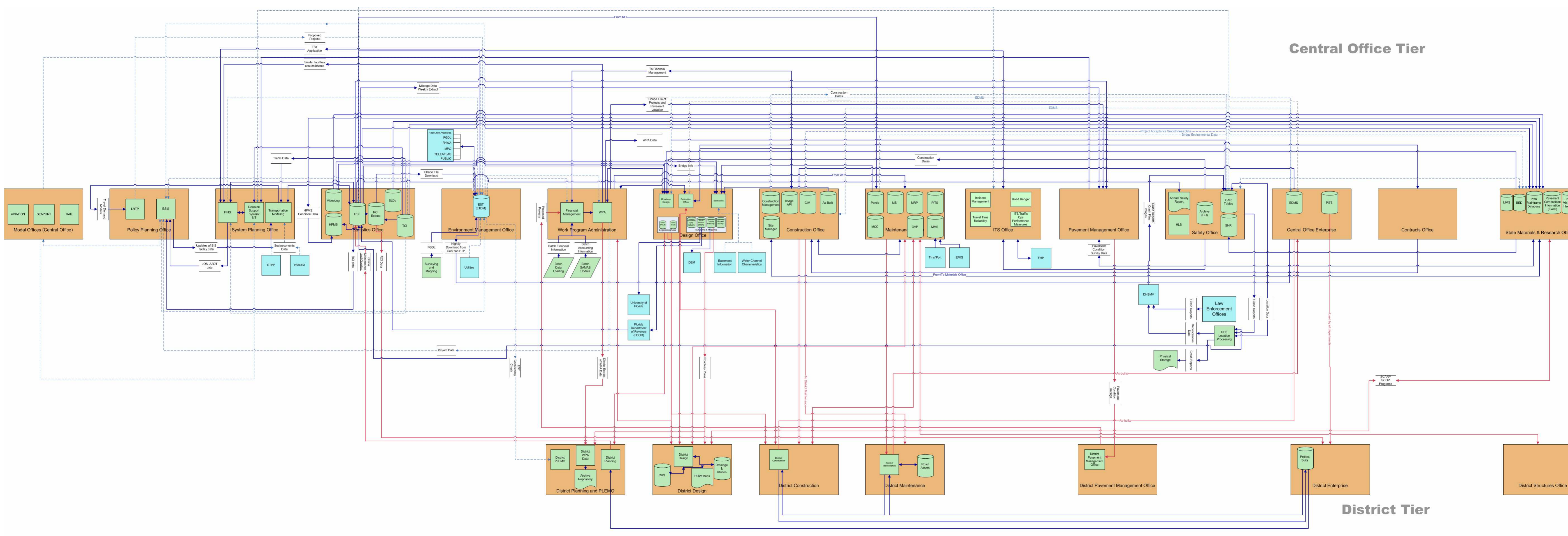
Planned/Desired Data Flows

- More timely access to information from the Maintenance and Construction offices
- Dynamic linkage to the safety data
- Ability to visualize and use materials data more efficiently

4.4.3 Department Wide Data Flow Map

The overall objective of a data flow map is to depict current business needs and translate them into data needs that are pertinent at the enterprise level. Hence, the data flow maps that created for each office can be stitched together to depict the flows at the Departmental level, as shown in Figure 4.11.

Figure 4.11 Department-Wide Data Flow Map



4.5 Summary of Findings

The following are the observations that were derived from the data flow maps in conjunction with their corresponding stakeholder interviews.

Several inter-departmental spatial data flows. It is apparent from the data flow maps, especially from the master data flow map, that there are several data flows that occur between functional areas (indicated as blue lines) and jurisdictions (indicated as red lines).

Most inter-departmental data flows are based on informal methods of sharing. From the stakeholder interviews, it was evident that most of these data flows are based on informal methods of sharing typically driven by the needs of the receiving entity. Several offices within Central Office/district hence created their own modules or applications to extract data from other offices. This led to creation of multiple versions of similar applications, leading to redundancies in the investment.

No specific standards for spatial data within the Department. Although there are several informal methods in place, there are no specific standards for collecting, storing, representing and sharing spatial data within the Department. Some functional areas have developed these standards but they are not applied outside of their area. The lack of standards has led to inconsistent access and storage of similar datasets. FDOT offices invest a great deal of time transforming current datasets into geospatial information.

Multiple sources of similar datasets with no formal coordination. Informal methods of data sharing without standards or protocols has led to redundant sources of similar datasets being used in various offices within the Department. Although few processes like ETDM are implemented along with formal agreements, schedules and formats, in general, there is a lack of formal coordination regarding these similar datasets leading to redundant investments to collect, maintain and manage these datasets.

No single reliable source for common data layers. There are several base data layers such as roadway networks, railway networks, jurisdictional boundaries, etc. that are commonly used by several functional areas. However, the lack of a single reliable source to obtain this data within the Department or else a lack of knowledge regarding such availability led offices to obtain and maintain their own versions of these base layers. This may be a communication/education issue.

Several desired data flows/processes cannot be accommodated through existing framework. During the interviews, several offices identified processes and data flows that cannot be accommodated or are very difficult to accommodate through existing frameworks. These desired data flows pertain to either improving the existing processes or to developing new methodologies that aid in data analysis, if only the framework allows for the same. Several of the desired data flows can potentially be accommodated through an Enterprise GIS implementation.

Several data flows involve existing enterprise databases – RCI, WPA, ETDM etc. It was evident from the data flow maps that there are several flows in and out of the existing enterprise level databases such as RCI, WPA, or ETDM. This clearly indicates the success of existing enterprise databases and their usage. However, the lack of a dynamic link between these databases led to development of mechanisms to extract data independently from these systems.

Several offices require real-time and more dynamic data access to the existing databases. During the stakeholder interviews, several offices clearly indicated the need for improving their current data flows by providing a framework for timely, accurate, and easily accessed information. Several district functional areas expressed the desire for real-time data accessibility.

Offices that are not currently using GIS could benefit from incorporating GIS into their processes. Several offices that currently do not have GIS could potentially benefit from a standardized GIS framework by the ability to access spatial data and incorporate that into their processes and enhance the way they currently analyze their business information.

4.6 Understanding of the Problem

This section summarizes the basic issues or problems that an Enterprise GIS is expected to resolve, together with acknowledged barriers that have been experienced by other state DOTs in implementing an agency-wide Enterprise GIS. The issues are categorized into three groups: Organizational and Business Processes, Data and Technology, and Defining and Measuring Benefits. For each grouping, the key issues or problems are discussed along with the extent that these issues have been addressed in previous FDOT reports or in implementations by other state DOTs. Also included for each group are observations regarding Florida's current status related to the issue.

4.6.1 Organizational and Business Processes

One of the primary justifications cited for implementing an Enterprise GIS is to eliminate or at least reduce redundancies in agency work flow processes, both across functional areas (e.g., planning, operations, construction), and geographic divisions (e.g., between headquarters and district offices). FDOT, like most state DOTs is organized along several dimensions, the two most prominent being **functional area** (e.g., planning, traffic operations, design, information systems, etc.) and **geographic** (e.g., Central Office, district offices, Florida's Turnpike Enterprise). Each functional office and district has its own specific mission and a unique history as to how that mission is carried out, including legacy data, data collection practices, and applications. Any attempt to coordinate or consolidate data and/or applications across the agency must recognize the current needs and business practices of each organizational unit, and be able to either fully accommodate current practices, or facilitate transition to improved practices that meet all critical mission requirements. Equally important, each organizational unit must be satisfied that making a transition improves the unit's ability to carry out its own mission. The Department's business planning process characterized by coordinated tiered plans will assist in these aligning issues

Some specific issues that relate to organizational and business processes that need to be addressed are discussed below.

LEGACY DATABASES AND DATA COLLECTION PRACTICES

Most typical state department of transportation functional offices maintain and use specific data to support their programs. In many cases these data are collected according to well established procedures and are stored in formats that are designed to efficiently interface with specific analysis tools, applications, and reports used by the individual organizational unit. Historically, organizational units did not share their raw data, only the information that resulted from statistical summaries or analyses of the data. A good example is the collection of Developments of Regional Impact (DRI) data in certain FDOT district offices. Typically, raw DRI data associated with traffic information is maintained locally at some Districts whereas summarized data is provided to the Department of Community Affairs.

In an enterprise data environment, there is increased pressure on organizational units to share their raw data with other parts of the agency, and a corresponding need for other potential users to better understand the data, including its content, quality, currency, and suitability for specific applications. Each shared database must be documented to provide potential users with information on the definition, format, and domain values for each database attribute (metadata). Additional information on the source of the data (i.e., how it is collected and processed) and its accuracy and currency are generally needed to enable potential users to assess the data's suitability for their specific application. The burden of producing this documentation typically rests with the organizational unit that maintains the database. While documentation is clearly beneficial, whether the data is shared or not, it is generally perceived by the individual organizational units as an additional cost associated with data sharing. This information, known as *metadata* is often overlooked and undervalued. Whereas many enterprise datasets at FDOT are well documented, such as the Roadway Characteristics Inventory others are not (i.e., the Work Program contains hundreds of tables, with only some containing metadata).

Data documentation inevitably reveals inconsistencies and differences across databases with respect to attribute definitions and formats, domain values or ranges (e.g., different upper and lower values for income ranges), positional accuracies and location referencing methods for geo-referenced data, and/or data collection methods. Resolution of these differences often leads to developing and implementing standards across all agency databases. While such standards may facilitate data exchange and improve the utility of agency data in the long term, the initial costs associated with converting legacy databases (and applications build on those database) to be compatible with such standards can be substantial.

In the case of FDOT, several key databases have been identified throughout documentation related to GIS Enterprise. These include RCI, Work Program, and Traffic Characteristics Inventory (TCI). A large percentage of agency critical data resides in other databases where no sharing mechanism or protocols are used. Limited data exchange formats are in place to share data among these key databases. Use of metadata to describe data sets is limited.

DIFFERENT DATA NEEDS AND APPLICATIONS ACROSS ORGANIZATIONAL UNITS

Not all the data used by specific organizational units needs to or even should be shared throughout the agency. This applies both to functional units, and to FDOT district offices. For example, individual districts may use detailed local data that has been collected by specific counties or organizations (e.g., land use or cadastral data, environmental and cultural features, etc.), which may not exist statewide. Organizational units should be free to supplement enterprise data with data collected only for a specific geographic area or for a specific application. However, data sharing for key enterprise data must be regulated by policy and protocols.

COORDINATION OF KEY COMMON DATABASES

An Enterprise GIS should maintain a set of agency-wide geospatial databases that are commonly used by all organizational units. These databases should include, at a minimum, the statewide road network that most legacy databases can be linked. Identifying these common datasets is an important and necessary next step. Accuracy and feature resolution issues associated with this database are discussed in the next section.

Organizational units may use different location referencing methods for linking their legacy data to the road network, including planar coordinates (e.g., Lat/Long, State Plane, UTM) or a linear referencing method (e.g., physical or virtual milepost, reference point offset, etc.) All of these methods must be supported to the level of accuracy required by each organizational unit. For linear referencing methods, maintenance protocols must be developed to deal with updates in either the physical road network (e.g., realignments) or changes in the designated route system. Currently, some of the geospatial datasets maintained by FDOT's Central Office are based on linear referencing systems (LRS). A good example is the Roadway Characteristics Inventory. Attribute data such as pavement condition, surface type, and shoulder width, to name a few, can be related to state, U.S., or Interstate Highways and subsequently mapped using the LRS. However, other important datasets have to go through a series of data transformations to support mapping along the LRS including Level-of-Service, Design Traffic, and Work Program information.

A relevant initiative underway within the Department is the Unified Base Map project funded by the Safety Office. This project will result in the purchase of a statewide unified mapping system to allow for more efficient sharing and reporting of safety data (vehicle miles traveled and crash statistics). Coordination with that imitative is critical for the Enterprise GIS project.

Organizational Location of Enterprise GIS Staff

Another important consideration is where the GIS core staff are located organizationally within the agency. In most state DOTs, the GIS core staff are located either in planning or in information/data services, or are split between these two functional units. At FDOT, the core GIS staff location is not consistent among districts. For instance, District Four has created a Program Management group that supports the entire district's GIS, scheduling and web development. Other districts, such as District Five, have many core GIS staff in their Planning group. Ideally, core GIS staff should have technical expertise in geospatial science that goes beyond just proficiency in one or more GIS software packages, expertise in database design and maintenance, as well as an understanding and appreciation of the various transportation application areas where GIS and geospatial will be used throughout the agency.

Many state DOTs have established a more decentralized GIS organizational structure that includes a relatively small, 5 to 7 person full-time core GIS staff, and associated GIS coordinators in each functional and district office. The core staff provides agency-wide expertise in geospatial data, GIS software and application development, and is responsible for developing and maintaining the common agency-wide geospatial data, including the statewide road network. The GIS coordinators are typically full-time staff in their specific organizational units who have expressed interest in GIS and received additional GIS training. These GIS coordinators serve as the liaison between the core GIS staff and the end users in each organizational unit. They provide initial technical assistance to end users, help specify and develop new GIS applications, and coordinate with the core GIS staff on issues related to data standards, common database development and maintenance, GIS software support, etc. This approach helps disperse GIS knowledge throughout the agency, and allows the GIS core staff to remain relatively small. FDOT has established a similar approach through the implementation of GIS Functional Committee consisting of GIS subject matter representatives from each district.

Standard Project ID for Tracking Projects from Planning through Construction and Operations

Another issue that is becoming increasingly problematic in many state DOTs and MPOs concerns the ability to track transportation projects from the long range plan through the Transportation Improvement Program (TIP) development and project selection, and into engineering design, construction, maintenance and traffic operations. This issue becomes especially visible when projects are located geospatially and displayed on maps. It is sometimes very difficult to determine if two closely located projects associated with different organizational units are actually the same project or two different projects.

To help address this issue, many agencies are adopting a standardized agency-wide identification procedure for projects, consisting of a general project ID, assigned during the planning stage that is retained as an attribute in subsequent project development stages. A planning project may be split during subsequent stages into two or more projects, which would be assigned their own unique project ID in addition to the planning ID. Retaining the planning ID through subsequent stages allows the project and key project attributes such as funding to be tracked and summarized for use in policy decision-making and presentations in public meetings. Additionally, it may make sense to consider the use of alternate IDs to track project alternatives.

FDOT District Five has implemented what is know as the Project Diary as a web-based data repository that resolves some of the issues related above. The Project Diary provides a file, document, image, graph, map storage system that tracks project information from inception in the Efficient Transportation Decision-Making (ETDM) process through Construction. However, to date, only the first few stages of the transportation development process has been implemented through the Project Development and Environmental (PD&E) phase.

4.6.2 Data and Technology Issues

In developing an agency-wide Enterprise GIS, decisions need to be made about the format and content of the common geospatial databases that are used by all organizational units. These decisions can have significant impacts on the ability of specific units to share and integrate their legacy data, as well as the ability of other units to use the enterprise data effectively for display and analysis purposes. These decisions should not be made unilaterally by a single organizational unit, but should be coordinated among all participating units.

Geographic Scale and Accuracy

A key decision concerns the geographic scale and positional accuracy of the common enterprise geospatial databases, particularly the statewide road network. While increased positional accuracy is generally desirable, it is also important to consider the current positional accuracy of other geospatial data that will be used in conjunction with the road network, including other common databases and legacy data maintained by specific organizational units. Large discrepancies in positional accuracy can result in map displays that are both aesthetically unattractive and misleading (e.g., displaying a feature on the wrong side of a roadway, or having a roadway appear to cross into a lake rather than run along its shoreline). Equally, important, large differences in positional accuracy make it more difficult to utilize key geospatial analysis tools like buffering, overlays, and conflation with any measure of confidence.

Geospatial databases commonly used in the Enterprise GIS should have similar levels of positional accuracy, and those databases that have significantly different positional accuracy should be replaced or upgraded. Depending on the desired level of accuracy for enterprise data and the number of common databases that currently do not meet that accuracy, this can be a costly and time-consuming task.

According to the 2007 AASHTO survey of state DOT GIS coordinators, approximately 70 percent of state DOTs have, or are developing a statewide road network database at a positional accuracy consistent with a 1:10,000 scale base map or better. These road networks are being created using either digital orthoimagery or kinematic GPS. The Base Map project mentioned earlier will establish geographic scale and accuracy standards for a roadway base map that can be used throughout the state in the future.

Feature Resolution

Closely related to positional accuracy is the issue of feature resolution and level of detail used to depict a specific road network. For example, should a divided highway be represented as a single centerline within the highway right-of-way, or as two or more lines depicting each physically separated roadway? Similarly, should a highway interchange be represented as a single node, or should all ramps be included as individual line segments? These issues have been considered by FDOT Statistics office related to maintaining FDOT’s base map.

The combination of increased positional accuracy and more detailed feature resolution can enhance the ability to display and analyze some data (e.g., showing crash locations that occur on a specific freeway ramp), but can also make the display of other legacy data more ambiguous (e.g., Highway Performance Monitoring System (HPMS) data items are reported for a single roadway centerline, with no allowance for differences in attribute values based on direction). In addition, without enhanced feature resolution, higher positional accuracies result in ambiguities (e.g., Where should the single centerline representing a divided highway be placed; or Where should a single node representing a complex highway interchange be located?).

As with positional accuracy, the issue of feature resolution should be coordinated among all affected organizational units, and a data enhancement plan should be developed to upgrade legacy data to be consistent with the adopted accuracy and feature resolution targets.

INTEGRATING CADD AND GIS DATA

Many state DOTs are currently wrestling with the issue of integrating high resolution engineering data, such as computer aided design drawings (CADD) into their agency-wide Enterprise GIS. The problem is not just a question of feature resolution, however, but rather a fundamental difference in the underlying data structures between CADD and GIS. In GIS, the geometric lines and symbols (i.e., points, lines, areas), also serve as repositories for attribute data associated with the individual features they represent (e.g., a line representing a segment of highway is associated with a database record containing information on its route designation, traffic volume, pavement condition, etc.). In a CADD drawing, multiple geometric lines may be used to illustrate a single feature (e.g., an intersection drawing may show sidewalks, curbs and curb cuts, crosswalks, pavement markings, and utility poles. No single line is associated with any specific feature.)

CADD drawings can be drawn using precise geographic coordinates rather than arbitrary Cartesian coordinates, and therefore can be displayed together with other geospatial data using GIS. However, the potential benefits of integrating all CADD drawings within an Enterprise GIS should be weighed against the costs of converting legacy CADD drawings to geospatial coordinates. A careful and objective analysis may suggest that certain functional areas, such as engineering, which rely extensively on CADD data, should not be fully integrated into the Enterprise GIS environment, at least initially.

A much simpler and lower cost option than full geo-referencing of CADD data would be to create a geospatial database of markers depicting locations where detailed CADD images exist. Clicking on a marker location in the GIS would invoke a hyperlink to a file containing the CADD image (or images) associated with the location. Thus, the GIS might simply function as a geo-referenced index to a repository of CADD images. Currently, FDOT District Seven is undertaking a project that will result in specific CADD to GIS data integration tools and procedures. The project is expected to be completed in 2008.

DATA TRANSFER BETWEEN GIS SOFTWARE PLATFORMS

Many of the problems associated with transferring geospatial data between commercial GIS software platforms have been resolved through technological advances and adoption of data standards by the commercial software developers. Virtually any geospatial database containing coordinate information and metadata describing the coordinate system and map projection in which the coordinates are stored (e.g., UTM zone 15), can be displayed and imported into most commercial GIS software packages.

Data that is geo-located using linear referencing is more difficult to transfer between commercial GIS software, because each GIS developer has implemented their own data model for linking linear reference measures (e.g., route name, distance, direction) with the corresponding geographic feature. Successful transfer of linearly referenced data may require development of a translation program to restructure the linear reference attributes. FDOT is currently working on this.

By standardizing on a specific GIS software platform (i.e., ESRI), FDOT has significantly reduced the problem of transferring linearly referenced data, at least internally. Some potential data transfer issues may remain for those organizational units that use Intergraph software for CADD applications, but the likelihood that these units would utilize the linear referencing features extensively is low. Linear referencing may be a somewhat more significant issue in sharing data between FDOT and other data partners throughout the state, but will depend on the software platforms used by the partners, and on their specific needs for linear referenced data.

DATA SHARING WITH EXTERNAL PARTNERS

Much of the non-transportation geospatial data that FDOT uses in map production and geospatial analysis, will likely come from external sources, including federal, state and local government agencies, non-public agencies (e.g., utility companies), or commercial data developers. Establishment of data sharing cooperative agreements among key data producers can significantly reduce the institutional barriers to obtaining the most current and enhanced data from these external sources. However, the level of involvement by FDOT staff in statewide data coordination should be commensurate with the benefits anticipated from enhanced data. Data coordination can be very time-consuming, particularly if efforts are undertaken to develop data standards.

Data coordination often involves the establishment of a data clearinghouse, where data sharing partners can obtain updated versions of geospatial data, along with sufficient metadata documentation describing the data content, format, source, etc. Establishing a data clearinghouse within an agency requires some front-end expenditure to create and maintain a web site, prepare documentation, and provide tools for downloading the database itself. However, over the long term, a data clearinghouse can reduce the burden on agency staff in responding to individual requests for data, documentation, and technical assistance in importing and interpreting the data.

In many states, a consolidated statewide data clearinghouse has been established to handle the dissemination of geospatial data produced and maintained by various data sharing partners. Some level of continuing financial support may be required from each data partner to maintain the clearinghouse, but the costs of contributing to a single consolidated clearinghouse are very likely less than maintaining a separate clearinghouse within the agency.

In FDOT District Five, coordination efforts with local and regional agencies through Joint Participation Agreements (JPAs) resulted in the development of a web-based data repository know as Central Florida GIS (CFGIS) to facilitate data sharing with external partners. This coordination effort has been implemented for the past six years with great success. Similarly, District Four has recently established the Treasure Coast GIS User's Group, whose inaugural meeting will be held January 31st, 2008 with the goal of creating similar data sharing successes as District Five. In Central Office, the Efficient Transportation Decision-Making (ETDM) process includes interagency agreements with environmental agencies to share data. Most agencies involved in the ETDM process have provided their data to Florida Geographic Data Library (FGDL) which is housed at the GeoPlan center at the University of Florida and FGDL and provides a mechanism for distribution of this spatial data through the state of Florida.

4.6.3 Summary of Problem Statement

FDOT has been active in GIS for many years. Investments have been made in GIS data and the technology, but early investments in GIS were mostly made by individual offices, usually focused on individual projects where users created and maintained data sets on their own desktop computers. Due to growing interaction between different projects, several FDOT offices have in recent years switched from independent, stand-alone GIS systems to more integrated approaches that share resources and applications. Different offices are pursuing their own Enterprise GIS objectives based on their specific business problems and needs, and the result is portions of GIS systems that meet individual business needs, but do not generally provide the optimal support to benefit FDOT.

Many planning and programming activities all of cross jurisdictional boundaries, so teams or divisions within FDOT have to rely on data from other teams. Information that is required to answer one specific question is often found in different departments and in different formats. Though most data in these FDOT offices are tied to geography, the format and representation of the data are different. Although the primary reason may be the specific requirements of a business unit, the differences in the way the data is collected, referenced, and maintained may also contribute to the inconsistency. Divisions and departments within FDOT generally have their own legacy databases to store data. This often leads to circumstances where the data from a division cannot easily be integrated with data from other divisions. Requesting the information and coding it correctly typically requires significant effort, resulting in redundant secondary data collection processes and multiple manual repositories that can lead to errors. Though there are GIS activities and the flow of GIS data occurs between various entities, the information exchange occurs in an informal fashion without one reliable data sharing channel to establish effective communication between all FDOT entities on a regular basis. FDOT is still faced with several stovepipe data sources, causing duplication of effort or lost opportunities to work cooperatively throughout FDOT system.

4.7 Definition of Enterprise GIS

Prior to identifying solutions to the current challenges, it is beneficial to define Enterprise GIS, particularly for FDOT. Defining this concept will provide a common vision for all the stakeholders in the process. In the past, this concept was defined in several different ways based on the objectives of the projects. While some defined it as a centralized repository of data, some defined it as a package of applications and tools. Even the definitions and perspectives obtained from the stakeholder interviews were inconsistent. Several stakeholders were not clear as to what Enterprise GIS means. Some perceived it as a monstrous database that would replace existing databases, some perceived it as centralized management and some even perceived it as a utopian idea that is not feasible to implement. In order to move forward in identifying Enterprise GIS solutions, it is important to define what we mean by Enterprise GIS today and obtain an agreement on that definition.

During the course of this project, a definition for Enterprise GIS was formulated using ideas from past efforts and thoughts from stakeholder interviews. This definition was then shared with the GIS Functional Steering Committee for its members to comment. The iterative feedback was incorporated and the following definition was finally formulated:

> *Enterprise Geographic Information Systems (GIS) is an organization wide framework for Department communication and collaboration of shared geospatial data and GIS resources that enhances existing business processes and provides an efficient way to plan, analyze, and manage transportation infrastructure and related elements.*

The following is an explanation of some of key terms/phrases (underlined) used in the definition:

Framework. The framework of Enterprise GIS is both technical and institutional. From a technical standpoint, the framework refers to the Enterprise GIS architecture of hardware, software, and network components. From an institutional standpoint, it refers to project champions, program managers, data and application developers, as well as geospatial data and application users, owners and maintainers.

Communication and Collaboration. Through a well-established Enterprise GIS framework, individual functional area offices will be able to communicate information pertaining to their business data with other offices in a timely manner. This information helps other offices within FDOT avoid similar redundant or localized efforts and collaborates with the parent office to best utilize department's resources. Currently there are duplicative efforts in design traffic data capture where district Traffic Operations Offices are updating and maintaining their data locally without updating Central Office because of the difficulty uploading data to Central Office design traffic application.

Shared Geospatial Data and GIS Resources. In terms of Enterprise GIS, sharing refers to maintaining a valuable web resource that includes a Unified Roadway Base

Map that can be utilized by state, regional, and local governments across the state. The Enterprise GIS would include a data warehouse of existing and future FDOT assets including, but not limited to Work Program, Roadway Characteristics Inventory, As-built documents, Environmental, etc. accessible through a web interface. In addition, Enterprise GIS would include an application that allows views and retrieval of shared GIS data, provides map, query, and reporting capabilities. Depending on Enterprise GIS requirements, it may also include a series of integrated applications that serve various functions (e.g., PITS, CIMS, SIS, WPA, RCI, etc.).

Complements Existing Business Process. Enterprise GIS will open the channels of communication and collaboration across the Department and does not intend to override existing business process, but rather complement existing applications and solutions. Access to department-wide shared GIS resources, which are continuously maintained by their owners, will increase the value of the data and add to the efficiencies of the current applications and processes. For example, the District Four Project Suite application that serves as a local Enterprise application will be complemented with new, refreshed data from the Central Office Enterprise GIS.

4.7.1 Characteristics of Enterprise GIS

Based on the above definition of the term 'Enterprise GIS', the following are some of the characteristics envisioned for an Enterprise GIS at FDOT:

Standards Driven. A methodology of development, deployment, and maintenance of Enterprise GIS that is based on industry spatial data standards that facilitate ease of application operability and scalability to large numbers of users.

Interoperable Technologies. The ability of Enterprise GIS to work with other systems or products without additional effort because it is based on industry spatial data standards and compatible code.

Integrated and Shared GIS Datasets. Local and regional datasets from district-level geospatial information integrated with similar datasets and shared throughout the state, enabled by Enterprise GIS. In addition, these shared datasets eliminate redundant data collection, storage and management.

Supports cross-departmental, multipurpose operations. Enterprise GIS will provide a web-based resource for geospatial data review, analysis, and query that can be utilized cross-departmentally for multiple operations (i.e., emergency, safety) in order to become more efficient and informed regarding resources, infrastructure, and the activities that are affecting them.

Supports business critical systems (e.g., public safety, water distribution, etc.). Enterprise GIS will provide support to business critical systems through the supply of accurate and up-to-date geospatial data through an easy-to-use web interface.

Comprehensive governance structure to ensure data consistency, quality, and reliability: refers to establishing clearly defined roles and responsibilities as well as having the appropriate rights and decision-making authority to implement the structure.

Comprehensive metadata for Enterprise GIS layers. Has metadata (data about data) that is compliant with the Federal Geographic Data Committee (FGDC) standards ensuring that at least the following information (at a minimum) is captured for each Enterprise GIS layer:

- citation (source)
- description (definition of data layer)
- time period (latest update)
- status
- spatial domain and resolution (projection and scale)
- keywords
- contact information
- data type (format)
- data lineage (historical process of layer development)
- attribute data description associated with each GIS dataset

Extensible and scalable design to facilitate adding departments, users, groups at various levels of government outside of FDOT as well as the public. Flexibility of the Enterprise GIS to enable system and functionality growth for years to come.

Integration of GIS data analysis and visualization with other department information systems, some that have traditionally not included visualization and mapping as part of their capabilities.

Contains tools to support data download, mapping, querying, and reporting.

The major components that encompass any implementation of Enterprise GIS are the following:

- Data. Includes point, line, polygonal, vector and raster datasets and relational databases, including detailed metadata to describe its characteristics
- Software. Includes the Internet, GIS, and relational database platforms to run the Enterprise GIS
- Hardware. Includes the physical hardware to run the Enterprise GIS such as servers, plotters, input/output devices, scanners, etc.
- Procedures. Includes how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in Enterprise GIS

The procedures are the steps taken to retrieve, share, update and maintain the data

- Personnel. Includes the developers, users, analysts, and maintainers of the Enterprise GIS system

4.8 Identification and Evaluation of Options (ISDM Phase 1)

The main challenge for developing a successful GIS system is to integrate these disparate data sources through an enterprise system and enable business units to exchange information that supports their respective business processes. As the demand for GIS data sharing grows, traditional data storage and sharing methods have become ineffective and inefficient. The rapid advancement of information technology, especially the technology of relational database management, has enabled GIS to move away from an isolated model of single business units to cooperative enterprise-wide operations. The basic idea of an Enterprise GIS is to deal with departmental needs collectively instead of individually. It refers to a GIS system that integrates spatial data across multiple business units and serves the whole Department.

The idea of an Enterprise GIS is an integrated (often confused with centralized), multi-departmental system that is composed of interoperable components providing broad access to geospatial data and common infrastructure to build and deploy GIS applications. Depending on the extent of integration and interoperability desired, there are different ways of interpreting the role of an Enterprise GIS in the organization thus warranting different design requirements and architecture of Enterprise GIS. At the low end of the spectrum for data integration, individual GIS users maintain local datasets, and the *enterprise* aspect is limited to standardized software and policies on metadata, data quality, standardized formats, and data sharing. At the high end of the spectrum, data and metadata are stored in a centralized repository available to all users. This research suggests that there are 4 available options for FDOT regarding developing an Enterprise GIS system:

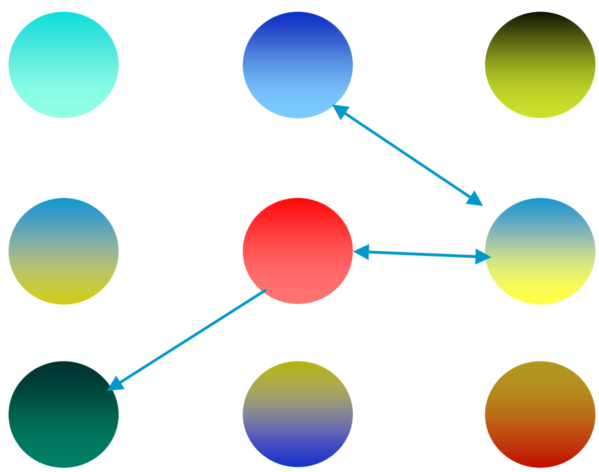
- Option 1. No build case to maintain status quo
- Option 2. Build a pseudo-Enterprise GIS for ad hoc data sharing
- Option 3. Build an Enterprise GIS with distributed data storage and enterprise standards
- Option 4. Build an Enterprise GIS with a centralized data repository

The following sections discuss each of the available options.

Option 1. No Build Case

Option 1 is the no build scenario where there would be various levels of data sharing efforts within different functional areas or district offices at FDOT, but limited data sharing and coordination between them. This option maintains the status quo. Individual working relationships rather than any standard rules or procedures determine the ease and efficiency of data sharing. Users develop informal understanding among themselves about the existence, accuracy, currency, and format of individual GIS datasets. There would be no enterprise-wide data sharing or coordination. Figure 4.12 shows the schematic relationship between various business units under this scenario.

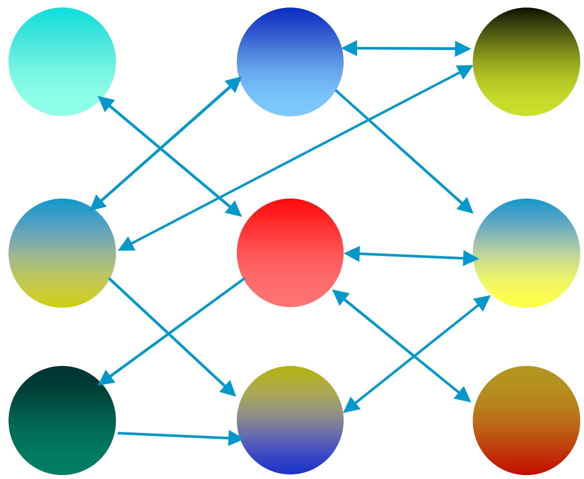
Figure 4.12 Option 1 – No Build



Option 2. Pseudo-Enterprise GIS

Option 2 is to develop a pseudo Enterprise GIS with ad hoc data integration following certain rules and standards. Under this option FDOT would establish a statewide GIS data inventory, define metadata requirements to enable data sharing and establish procedures for its offices to publish and share data. It would be up to the individual users to follow the standards for data sharing. This option puts minimum burden on individual GIS stakeholders and keeps the responsibility of data stewardship with the data owner. Though there would be no formal Enterprise GIS system throughout FDOT, the pseudo enterprise system option would lay the foundation and promote agency wide data coordination and sharing (Figure 4.13).

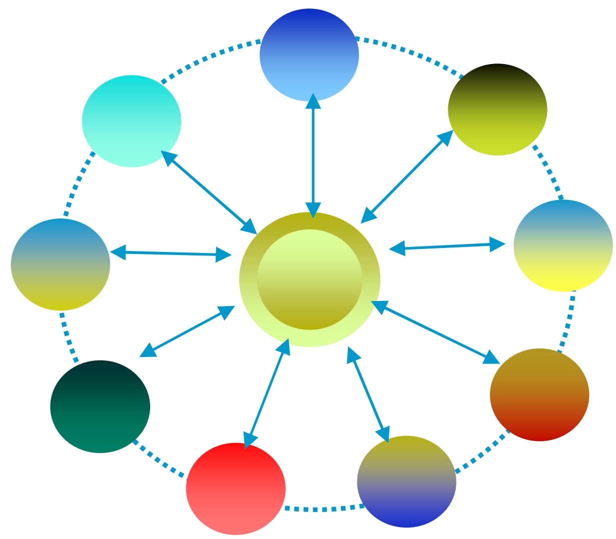
Figure 4.13 Option 2 – Pseudo Enterprise GIS



Option 3. Distributed Enterprise GIS

Option 3 advises the development of a distributed data system with decentralized architecture and enterprise standards. This option calls for only as much centralized storage of GIS data as is necessary for programmatic or operational needs. Many datasets could remain in the stewardship (and storage) of the data owner, but enterprise standards for data quality, metadata, format, and access would be defined to allow efficient data sharing. The only uniformly centralized aspect of this model would be a metadata clearinghouse and a centralized distribution point accessible to members of the enterprise. This could be a GIS data warehouse, a GIS Internet or FTP site, or even a read-only shared drive or folder on FDOT's network. From the information in the metadata repository, a user could contact the data owner for more details and obtain the data from the access point. Under this option, the responsibility lies clearly with the data steward to properly document, archive, and provide access to data. Figure 4.14 shows the schematic relationship between various business units (surrounding circles) and the distributed Enterprise GIS (central circle). Arrows stand for data inputs and retrieval between various business units and the Enterprise GIS, and dotted lines represent direct data exchanges between various business units.

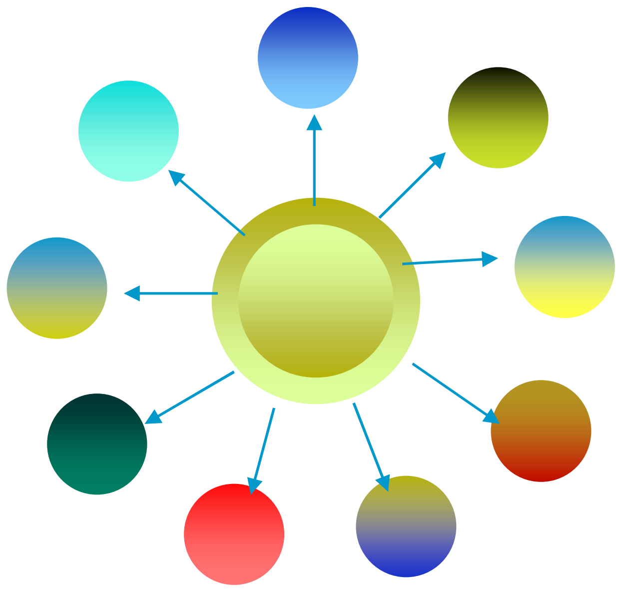
Figure 4.14 Option 3 – Distributed System



Option 4. Centralized Enterprise GIS

The centralized Enterprise GIS model involves centralized management of GIS development and operations coupled with centralized use. The components that would be centrally managed include the database and metadata systems, participant and user coordination, and often GIS budgetary control. All geospatial data and pertinent tabular data are entered into a statewide data repository with enterprise-wide data standards that ensure data quality, format, and metadata. The central data repository would be administered by a dedicated team. A central metadata clearinghouse would also reside with this group though data stewardship and responsibility for data currency and accuracy remain with the data owner/generator. A major advantage is that centralization could ensure adherence to policies and standards, data availability, security, and completeness. Figure 4.15 shows the schematic relationship between various business units (surrounding circles) and the centralized Enterprise GIS (central circle). Arrows represent data retrieval from the Enterprise GIS by various business units.

Figure 4.15 Option 4 – Centralized Enterprise GIS



4.8.1 Evaluation of Options

EVALUATION CRITERIA – COST-BENEFIT AND RISK ANALYSIS

Both the initial acceptance and long term success of an Enterprise GIS depends on the understanding by key agency decision-makers that benefits attributable to an Enterprise GIS exceed the costs associated with establishing and maintaining it. The challenge is that it is very difficult to isolate and attribute specific costs to an internal agency initiative, and even more difficult to define and measure the benefits attributable to the effort.

The costs of Enterprise GIS implementation can be anticipated and accounted for. Costs attributable to developing an Enterprise GIS may include hardware and software acquisitions associated with establishing an efficient geospatial database management system, additional GIS staff hired to support Enterprise GIS functions (such as data processing and migration, development of data sharing standards and rules), and efforts required for developing tools or applications to specifically support the Enterprise GIS (for example, reprogramming existing applications to work with the Enterprise GIS and programming of new applications to support Enterprise GIS functions).

Regarding benefits, both tangible benefits in terms of upfront cost savings and intangible benefits such as gains due to increased efficiency of the processes should be included in the assessment. Many of the purported benefits cited for

Enterprise GIS are associated with cost savings, with the most obvious cost savings resulting from the elimination of redundant expenditures by organizational units. There are also the intangible benefits that can be difficult to measure, for example, the benefit of gaining improvements in the quality and timeliness of agency products as the result of having an Enterprise GIS system.

Justification of public investment is usually accompanied by some level of analysis related to the costs and benefits of the investment, and the associated risks.

The assessment of costs, benefits, and risks plays an important role the decision-making process for building an Enterprise GIS, allowing for:

- estimated cost of implementing the system to be compared against the expected benefits
- determination of whether the implementation makes financial sense in terms of investment returns
- indication of when a financial return could be seen
- outlook of uncertain possibilities that might occur during the plan and implementation of an enterprise system

In addition to providing some assurance of the prudence of the expenditures, both the initial acceptance and long term success of an Enterprise GIS depends on the perception by key decision-makers that the benefits exceed the costs associated with establishing and maintaining it, and the risk for building an Enterprise GIS is not significantly high.

Upon agreement of what constitutes a *cost* factor and what constitutes a *benefit* factor, cost-benefit analysis was conducted for each of the identified options. Ideally the final outcome of a cost-benefit analysis would be in monetary terms. For example, both cost and productivity improvement benefits could be derived from current salary and direct benefits of affected FDOT staff. Using salary as a measure of value provides a useful approximation mechanism for quantification of increases in productivity. The assumption is that what a staff person is paid reflects what he/she produces, and the long-term productivity of GIS staff will increase, since less time is spent on data acquisition and pre-processing. Rarely, however, do such productivity increases result in staff reductions. Instead, most state DOTs have increased the amount of analytical support provided to various functional units with existing staff resources, and have developed new GIS applications. These applications clearly represent a benefit to the agency; but they are very difficult to quantify. Therefore this study does not intend to quantify the benefits or costs in exact monetary terms. It does not identify the full list of staff who will support the Enterprise GIS operation, or those who will benefit from the existence of an Enterprise GIS. Instead, this analysis scores the costs and benefits in relative terms when comparing one option against another.

This allows different types of non-monetarily costs and benefits to be included in the analysis.

Tomlinson[2] suggests a four-stage cost-benefit analysis of building a GIS system, and this is the methodology used for the cost-benefit analysis of this study:

1. identifying costs by time period
2. calculating benefits by time period
3. comparing costs and benefits
4. calculating cost-benefit ratios

COST/BENEFIT ANALYSIS FOR EACH OPTION

Each of the four options would require different technical architecture and configuration, hardware and software, staffing and organizational structure. The following sections analyze the costs and benefits for each option associated with the enterprise solution. Table 5.1-Table 5.4 list the detailed cost and benefit breakdown by year for each option. The cumulative costs, benefits, and Net Present Value (NPV) for each option are also summarized in these tables.

(1) IDENTIFYING COSTS BY TIME PERIOD

All costs that are incurred in the course of the implementation need to be documented in the context of the specific time period (i.e., monthly, yearly). They need to include both the initial purchase and setup costs as well as the ongoing maintenance costs in future time periods. The costs can be broken down into a number of categories, including hardware/software/infrastructure, data, training, and application programming.

- **Hardware/software/infrastructure.** This includes the costs for any additional hardware (i.e., servers, desktops, storage, backup devices, printers, etc.), upgrading of the existing network infrastructure (i.e., new routers, increased bandwidth, etc.), and the purchasing of software licenses required for an Enterprise GIS. Both the initial purchase expense and the subsequent costs for maintenance need to be included.
- **Data**. The cost of manipulating existing data and acquiring new data needs to be defined. Since data is one of the most significant investments in any GIS program, any approach that reduces data acquisition and management costs while maintaining data quality is important. The cost for developing data sharing standards and rules should also be accounted for **.**

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[2] Tomlinson, Roger, 2003, Thinking about GIS: geographic information system planning for managers, ESRI Press.

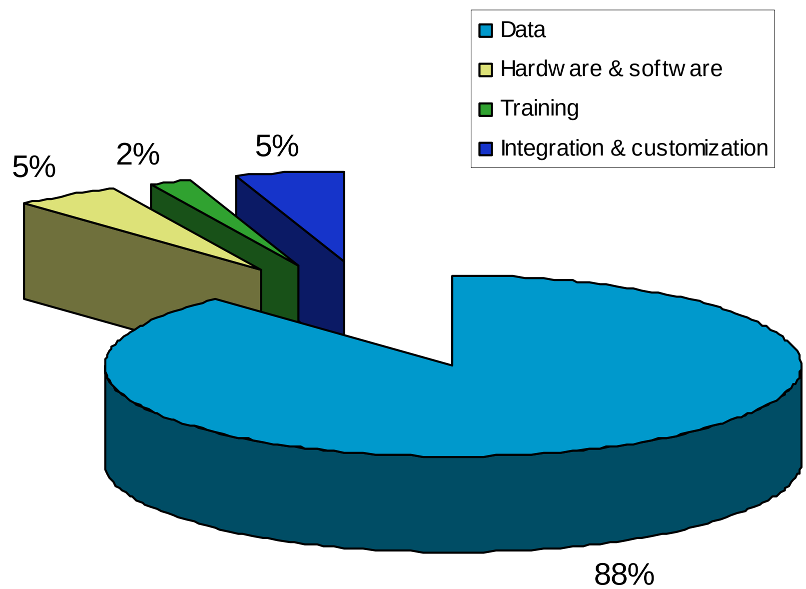
- **Training**. A critical component of the Enterprise GIS program is to provide the training needed to develop staff skills and capabilities to implement and maintain the enterprise solution. It is also important to train staff in the Departments who are new to GIS in the effective use of GIS specific to their business needs.
- **Application Programming**. If any existing applications need to be updated to work with the Enterprise GIS or any new applications are planned, the full cost of their update and implementation should be considered.

In Tables 4.1 through 4.4, each cost category is assigned a score ranging from 0 to 5, with 0 meaning no associated cost, and 5 meaning the highest cost in a particular year. It is expected that, for both of the enterprise solutions (Option 3 and Option 4), data and application programming may require substantial initial expenditure therefore the scores of these two categories are much higher in the first few years when compared with the other two options (Options 1 and 2). The costs associated with hardware, software and infrastructure will be incurred closer to the time of Enterprise deployment, which is why Options 3 and 4 have peaks of hardware/software/infrastructure cost during years 2 and 3. Another assumption is that comprehensive training program is required for all levels of staff, with a combination of standard training in the GIS software used as well as specific training in the use of organization-wide data and applications that are developed as part of the Enterprise GIS program. Therefore, Options 3 and 4 have a relatively higher training cost.

Each cost score within the same cost category is comparable among different years and for different options. However, different cost categories have different impacts on the cost structure, which is why a weight factor is assigned to each cost category. Research[3] indicates that a typical transportation agency's GIS spending has the following structure (Figure 4.16): 88% of spending on data, 2% on training and 5% each for software/hardware and integration/customization. These percentages are used as the weight for each of the cost category in this study. Thus a category with a higher weight will be more costly than one with a lower weight.

[3] Enterprise GIS: Realizing a Return on Investment. By Landmark Geographic Services, 2002.

Figure 4.16 Typical Transportation Agency's GIS Spending Structure



(2) Calculating Benefits by Time Period

The benefits of implementing an Enterprise GIS are more challenging to quantify than the financial costs. The following are realistic estimates of the benefits:

- **Organizational**. By defining and enforcing data standards, and making that data available across the organization, benefits should be seen in operational efficiency, improved workflow, enhanced decision-making and more effective use of future expenditure. Beyond the potential costs savings associated with elimination of redundancies, many of the benefits associated with an Enterprise GIS come from improvements in the timeliness of agency products. This is an important benefit especially for functional areas or districts that do not have strong GIS capabilities or resources. For example, easy access to GIS data layers allows staff to respond to ad hoc policy questions much faster, by eliminating the time-consuming preliminary steps of finding appropriate data, evaluating the suitability of the data, and merging and conflating data from different sources. Eliminating these data tasks can reduce response time from several days to a few hours or less.

- **Savings.** Reductions in staff workload, due to improved productivity and efficiency, and eliminating redundant or duplicated data and tasks. An Enterprise GIS would require certain costs to set up the system; but it may reduce the overall GIS maintenance and support costs providing more effective use of departmental GIS resources. While many of the purported benefits cited for an Enterprise GIS are associated with cost savings, in reality such savings are often small and difficult to measure. The more obvious cost savings are those that may result from elimination of redundant expenditures by organizational units. For example, different functional or geographic units within FDOT may currently purchase their own GIS software licenses, which are utilized only part-time. By consolidating GIS software licenses in one unit and utilizing floating seat licenses that are assigned through a centralized application server, it may be possible to reduce the number of software licenses required by the agency. Other redundancies may involve different organizational units maintaining separate versions of the same GIS database, or developing separate GIS software tools that perform essentially the same task. By facilitating the coordination of GIS applications across the agency, organizational units can pool resources to develop more comprehensive application tools and database that address multiple needs.

- **External benefits.** External beneficiaries may include FDOT offices that are not directly contributing to the Enterprise GIS, other state agencies, MPOs, citizens, engineering, and planning firms, surveyors, developers etc. The external benefits may not initially be identified, but they would be realized in expanded use of GIS across the organization. Although potentially very significant, external benefits are generally not a critical factor in the initial decision making of an Enterprise GIS system. However, they are important when trying to account for tangible external benefits of an Enterprise GIS system serving the public good.

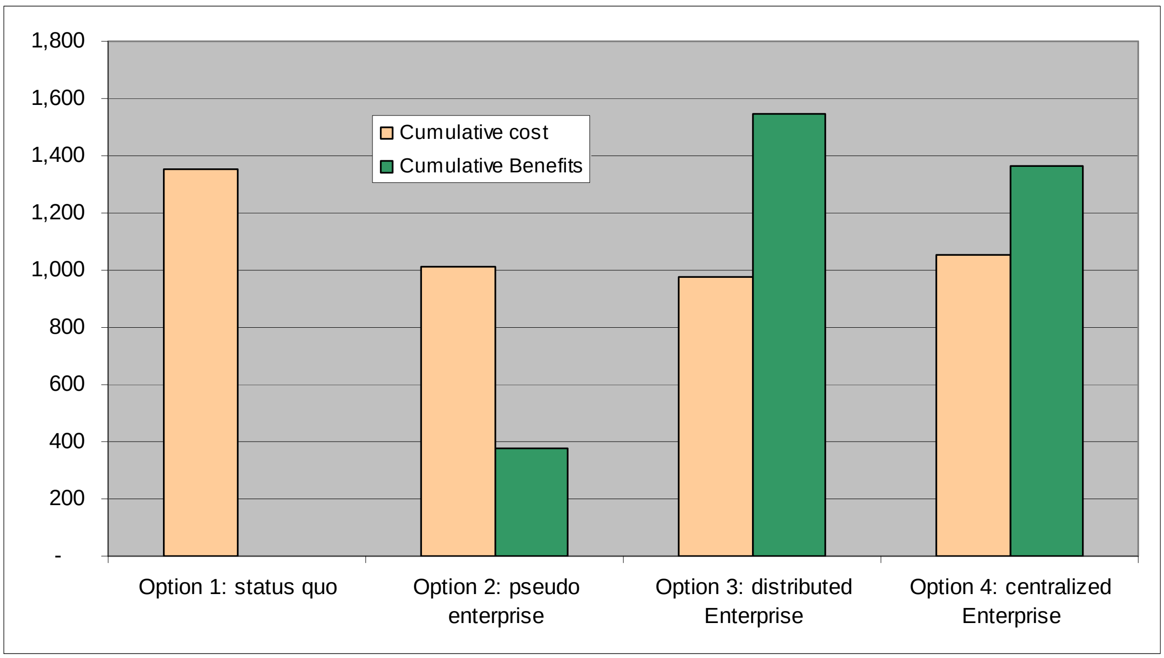
The various components of the Enterprise GIS may be phased in over time, so the associated benefits may not be evident immediately within the organization. For example, one of the major benefits of Enterprise GIS is to enable data sharing. However, the benefits of improved data sharing may not be apparent until implemented. Therefore, benefits will be calculated after the first component of Enterprise GIS is implemented that is assumed to be Year 3.

The same ranking method as cost calculation is used for benefit calculation. Each benefit category is assigned with a score ranging from 0 to 5, with 0 meaning no benefit, and 5 meaning the highest benefit in a particular year. Each benefit category has different financial impacts, so a weight factor is also assigned. Unfortunately, only limited empirical evidence is available for the benefits of implementing an Enterprise GIS. In this study a weight of 30 is assigned for organizational benefits, 60 for savings, and 10 for external benefits. These weighting factors s are subject to further research.

(3) COMPARING COSTS AND BENEFITS

Once all of the costs and the accrued benefits have been determined, they can be compared. This comparison can either be in the form of direct period-by-period cost versus benefit comparison in absolute dollars, or the cumulative costs and benefits comparison in discounted (i.e., adjusted for inflation) dollars[4]. In the latter comparison, it should be clear at what time the benefits will outweigh the costs. Figure 4.17 shows the cumulative costs and benefits for each of the four options. The benefit for Option 1 is set to be zero, which will serve as the reference point of the benefits for the other three options. No spending is set to be the reference point for the calculations for all options. Figure 4.17 shows that Option 1 is actually the costliest option. Moving from Option 2 to Option 3 and Option 4, the cumulative costs will increase, though not significantly. Yet the benefits of these three options do vary significantly, with Option 3 having the highest benefits.

Figure 4.17 Cumulative Costs and Benefits for Each Option



(4) Calculating Cost-Benefit Ratios

Expressing the costs and benefits in discounted dollars, the Net Present Value (NPV), is calculated as:

$NPV = PVB - PVC$

where:

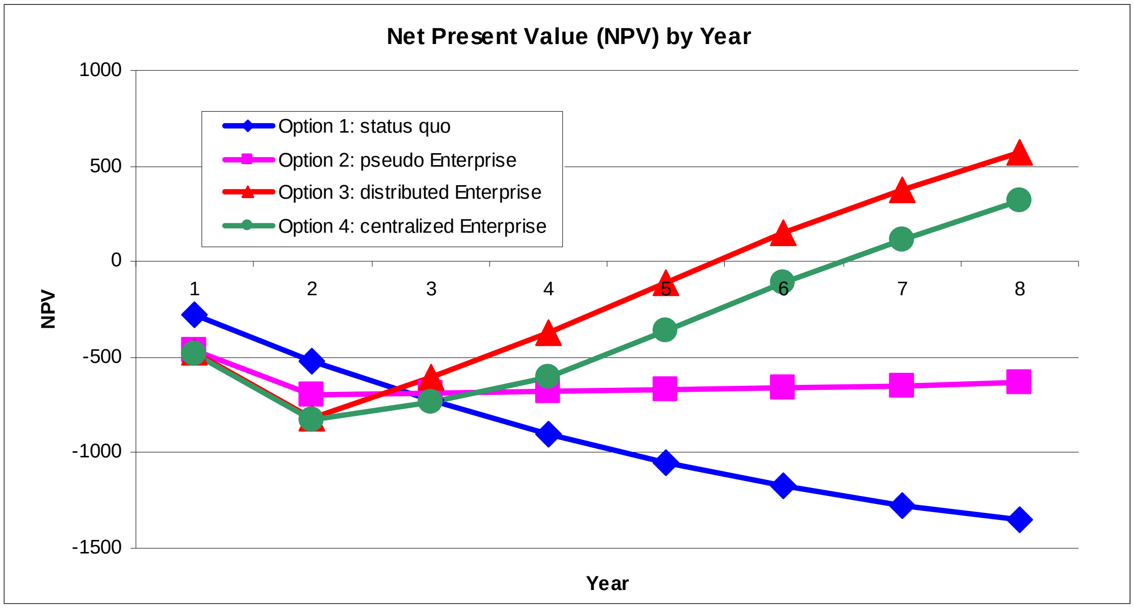
PVB = Present value of benefits

[4] Tomlinson suggests using an annual discount rate of 7 percent. For example, a $100 cost in the base year will only be worth $93 in Year 1 and $86 in Year 2.

PVC = Present value of costs

A positive NPV (i.e., benefits outweigh costs) is a normal criteria for a project. The cost-benefits analysis principles outlined above were applied to each of the four options. Figure 4.18 shows a summary of the NPV for each option.

Figure 4.18 Net Present Value by Year



From the figure it is obvious that Options 1 and 2 provide limited benefits, which are unlikely to exceed the additional costs associated with the approach. The NPV for both of the options are below the zero thresholds.

For Options 3 and 4, each one eventually provides a positive benefit to the organization once the initial implementation cost has been recovered. With each additional time period, the expected NPV will continue to improve especially if additional external benefits (i.e., increased use of the Enterprise GIS for previously unforeseen tasks) are realized. The NPV for Option 3 will turn positive at Year 6 while the NPV for Option 4 will become positive at Year 7. Research[5] shows that the typical Return of Investment (ROI) timeframe for an Enterprise GIS is between 5-10 years. The results of this cost-benefit analysis fall well within this typical range.

[5] Enterprise GIS: Realizing a Return on Investment. By Landmark Geographic Services, 2002.

Table 4.1 Cost-Benefits Analysis for Option 1

	Time Period								Total Cost	
Cost (weight)	1	2	3	4	5	6	7	8	Unweighted	Weighted
Hardware/software/infrastructure (5)	1	1	1	1	1	1	1	1	8	40
Data (88)	3	3	3	3	3	3	3	3	24	2112
Training (2)	1	1	1	1	1	1	1	1	8	16
Application Programming (5)	2	2	2	2	2	2	2	2	16	80
Weighted Total (100)	281	281	281	281	281	281	281	281	56	2248

	Time Period								Total Benefit	
Benefit	1	2	3	4	5	6	7	8	Unweighted	Weighted
Organizational (30)	0	0	0	0	0	0	0	0	0	0
Savings (60)	0	0	0	0	0	0	0	0	0	0
External (10)	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0		0

	Time Period							
Cumulative	1	2	3	4	5	6	7	8
Cost	281	523	729	904	1051	1173	1273	1353
Benefit	0	0	0	0	0	0	0	0
NPV	-281	-523	-729	-904	-1051	-1173	-1273	-1353

Table 4.2 Cost-Benefits Analysis for Option 2

	Time Period								Total Cost	
Cost	1	2	3	4	5	6	7	8	Unweighted	Weighted
Hardware/software/infrastructure (5)	1	2	2	1	1	1	1	1	10	50
Data (88)	5	3	2	1	1	1	1	1	15	1320
Training (2)	3	2	1	1	1	1	1	1	11	22
Application Programming (5)	2	2	1.5	1.5	1.5	1.5	1.5	1.5	13	65
Weighted Total (100)	461	288	195.5	102.5	102.5	102.5	102.5	102.5	49	1457

	Time Period								Total Benefit	
Benefit	1	2	3	4	5	6	7	8	Unweighted	Weighted
Organizational (30)	0	0	1	1	1	1	1	1	6	180
Savings (60)	0	0	2	1	1	1	1	1	7	420
External (10)	0	0	0.5	0.5	0.5	0.5	0.5	0.5	3	30
	0	0	155	95	95	95	95	95		

	Time Period							
Cumulative	1	2	3	4	5	6	7	8
Cost	461	697	817	842	860	871	876	877
Benefit	0	0	134	201	258	306	346	379
NPV	-461	-697	-683	-641	-602	-565	-530	-498

Table 4.3 Cost-Benefits Analysis for Option 3

	Time Period								Total Cost	
Cost	1	2	3	4	5	6	7	8	Unweighted	Weighted
Hardware/software/infrastructure (5)	1	4	2	1	1	1	1	1	12	60
Data (88)	5	4	3	2	1	0.5	0.5	0.5	16.5	1452
Training (2)	4	3	2	2	1	1	1	1	15	30
Application Programming (5)	4	5	2	1	1	1	1	1	16	80
Weighted Total (100)	473	403	288	190	100	56	56	56	59.5	1622

	Time Period								Total Benefit	
Benefit	1	2	3	4	5	6	7	8	Unweighted	Weighted
Organizational (30)	0	0	5	5	5	5	5	5	30	900
Savings (60)	0	0	5	4	4	4	4	4	25	1500
External (10)	0	0	2	3	3	3	3	3	17	170
	0	0	470	420	420	420	420	420		

	Time Period							
Cumulative	1	2	3	4	5	6	7	8
Cost	473	815	1007	1089	1088	1051	1013	976
Benefit	0	0	407	716	980	1204	1391	1547
NPV	-473	-815	-600	-373	-108	153	378	571

Table 4.4 Cost-Benefits Analysis for Option 4

	Time Period								Total Cost	
Cost	1	2	3	4	5	6	7	8	Unweighted	Weighted
Hardware/software/infrastructure (5)	1	5	2	1	1	1	1	1	13	65
Data (88)	5	4	4	3	1	0.5	0.25	0.25	18	1584
Training (2)	5	4	3	2	2	1	1	1	19	38
Application Programming (5)	5	5	2	1	0	0	0	0	13	65
Weighted Total (100)	480	410	378	278	97	51	29	29	63	1752

	Time Period								Total Benefit	
Benefit	1	2	3	4	5	6	7	8	Unweighted	Weighted
Organizational (30)	0	0	3	3	3	3	3	3	18	540
Savings (60)	0	0	5	4	4	4	4	4	25	1500
External (10)	0	0	3	4	4	4	4	4	23	230
	0	0	420	370	370	370	370	370		

	Time Period							
Cumulative	1	2	3	4	5	6	7	8
Cost	480	828	1097	1243	1229	1179	1115	1055
Benefit	0	0	363	635	868	1065	1229	1367
NPV	-480	-828	-734	-608	-361	-114	115	312

Risk Analysis for each Option

There are a number of risks associated with the decision to implement, or not to implement an Enterprise GIS. Among the questions that need to be asked are:

- Does it make financial sense for the organization to fully implement the Enterprise GIS?
- Can the organization afford not to implement the Enterprise GIS, when taking into account how this would affect future growth?
- Is the Enterprise GIS technical feasible?
- Do all stakeholders fully support the Enterprise GIS?
- Does the current infrastructure support the proposed Enterprise GIS?

For an Enterprise GIS to be successful, all of the risks need to be thoroughly considered and assessed. The risk analysis needs to identify and acknowledge the constraints in terms of budget, scope, schedule, or personnel resources contributing to various stages of implementation of the Enterprise GIS. These risks were ranked based on the probability of occurrence to provide for better understanding of a risk. Each risk factor was also assigned a weight factor depending on the seriousness of its impact. Table 4.5 presents the detailed risk analysis results. The following general approach was used to assess risks:

- identify the type of risk
- discuss the risk in the context of the planned implementation of an Enterprise GIS
- describe the mitigating factors
- score the likelihood and seriousness of the risk
- summarize the score to evaluate overall risk

Step 1. Risk Identification

The risk factors that need to be considered cover all aspects of the project. They are described together with the impacts they have on the implementation, including financial, organizational, project and technical risks.

1. Financial
    a. Is the implementation adequately funded?
    b. What is the implied cost of failure to implement?
    c. What if continued investment would yield none or negative benefits?
2. Organizational

a. How is the data ownership issues addressed?

b. Does the implementation have managerial support? User support?

c. Can a user have immediate access to other people's data when they need it?

3. Project

a. How complex is the implementation?

b. Is the project well defined?

c. Are proven methods being used?

d. Is there built-in accountability and quality control?

e. What is the implementation schedule?

f. Are the project management tools available to keep the implementation on schedule and within budget?

4. Technical

a. Is the implementation technically feasible?

b. Is there data consistency across all of the databases?

c. Will existing applications be compatible with the Enterprise GIS? If not, what will it take to make them compatible?

d. Will the existing network infrastructure support the proposed implementation?

e. Are there constraints on the use of the Enterprise GIS?

f. Does the existing staff have the knowledge to support the implementation?

Step 2. Risk Discussions

For each of the identified risks, the impacts on the implementation in relation to the existing setup were evaluated. These led to a greater understanding of the risk and identify possible mitigation steps. For example, will the existing network infrastructure support the proposed implementation or will there be bottlenecks and restrictions?

Step 3. Mitigation Strategies

Various mitigation steps can be undertaken to minimize the risk to the organization. For example, to minimize network infrastructure risk, the network could be upgraded to increase bandwidth to cope with the estimated increase in network traffic.

Step 4. Score Risks

Each risk was ranked regarding its likelihood, using a numerical weight. For example, a Centralized Enterprise GIS (Option 4) would be highly dependent on the network, so the risk may be high. On the other hand, a Distributed Enterprise GIS

(Option 3) has smaller network overhead and the risk is assumed to be medium. In this analysis, the following valuation scale was used:

- 0 = No risk
- 1 = Low risk
- 2 = Low-medium risk
- 3 = Medium risk
- 4 = Medium-high risk
- 5 = High risk

A weight with a range of 1-5 was then assigned to each risk factor depending on the seriousness of its consequence. For example, in Table 5.5, the "database size" factor in the technical risk category has a risk weight of one, which means it is a risk that has minimal impacts, while the "loss of ownership" factor in the organizational risk category has a risk weight of five, implying a major threat factor.

Step 5. Summarization

Once the level of risk for each of the applicable risk factors was scored, an overall score was determined and the project should only be allowed to continue if the overall risk level is manageable. Figure 4.19 presents the overall weighted risk scores for each option. It shows risks are associated with each of the four options, including Option 1 – No build case. The risks of Option 2, 3, and 4 are higher then Option 1, but the increase from one option to another is not significantly high.

Figure 4.19 Risk Analysis for Each Option

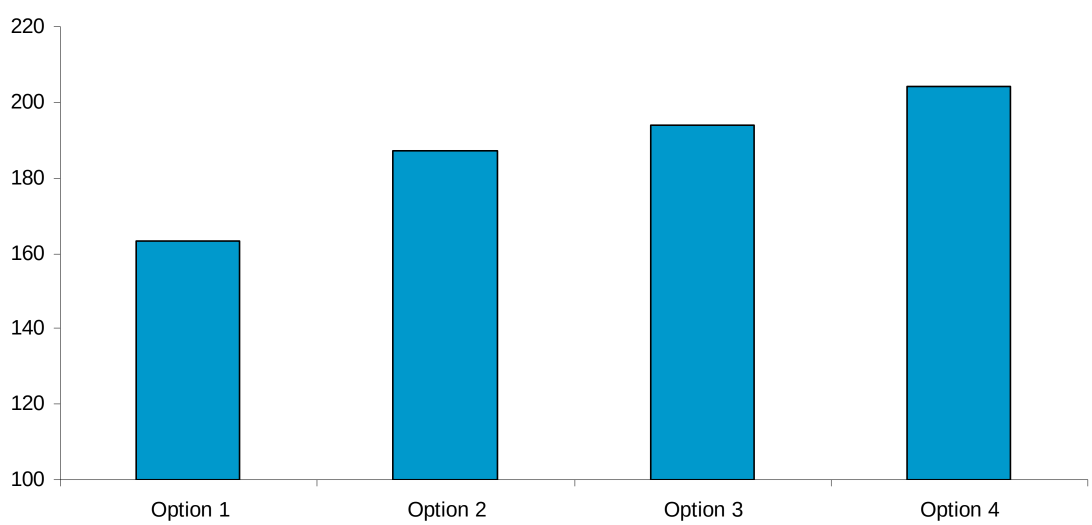


Table 4.5 Risk Analysis

Risk	Description	Impact(s)	Relative Impact	Probabilty for Each Option Option 1	Option 2	Option 3	Option 4	Mitigation Strategy
Financial								
Funding	Is there sufficient funding? Have all the costs been assessed?	Implementation may not be completed within defined cost	3	1	2	4	5	Increase funding; Reduce functionality.
Negative benefits	What if continued investement would yeild no benefits or negative benefits	investment be wasted	4	5	4	2	1	Improved strategic planning
Risk of Failure	What is the implication of not completing the project?	Investment in the project may be partially or totally lost	3	1	2	3	4	Document implications of failure and explain to stakeholders
Organizational								
Loss of Ownership	Data stewards my feel that they are losing ownership of data	Stewards may oppose implementation	5	0	1	3	5	Write agreements to formalize data ownership
Stakeholder Not Buy-In	Does the implementation have managerial/user support?	Without buy-in, stakeholders will not be committed to the implementation	4	1	3	3	2	Early and continual involvement of stakeholders;Stakeholders sign-off on major decisions and at milestones.
Stagnation	Does the Enterprise GIS provide opportunity for innovation?	No development or innovation is undertaken;Databases are not maintained and used.	2	5	4	3	3	Promote benefits of Enterprise GIS;Implement Option 3 or 4.
Failure to follow standards		Data will not be maintained at required standards	3	5	4	3	2	Fully document standards that need to be followed;Setup mechanism to enforce standards.
Database Knowledge	Knowledge regarding the data contained within the database is only known to a few individuals, and may be lost when individuals leave	Hard to determine data that is available	4	4	4	2	1	Fully document database designs, including metadata; Train individuals to expand database knowledge.
Data Access	Can user access data when it is needed?	Cannot access data owned by other people	4	5	4	2	1	Centralize data that is commonly being utilized across functional areas or district offices

Project								
Project Complexity	How complex is the proposed implementation?	Increased complexity will make the Enterprise GIS harder to implement	3	1	2	3	4	Reduce complexity; start small and build incrementally
Project Definition	Is the project well defined?	Badly defined project will cause scope creep; Hard to evaluate options.	5	1	2	3	3	Correctly define project
Data Standards and Consistency	Similar data is stored differently in each database	Hard to compare/relate data from different databases	5	4	3	2	1	Document and distribute required data standards; Enforce standards.
Future Usage	Difficult to expand/enhance the database(s) to allow for usage	Databases will becoming increasingly difficult to use and maintain, limiting their use	3	5	5	3	4	Attempt to make allowance for changing future use in implementation.
Technical								
Feasibility	Is the implementation technically feasible?	Project complexity may exceed current capabilities	3	0	2	3	4	Improve staff competencies via new hires and/or training
Data currency	Hard to determine the vintage of shared data	May, unintentionally, be using out-of-date data	3	3	4	2	2	Use date tagging to store data currency; Use Option 3 or 4.
Network Infrastructure	Does the existing network infrastructure support the Enterprise GIS?	May cause slow data access/transfer; Data copy processes may fail.	2	1	2	3	5	Minimize network traffic; Upgrade network.
Instability	Will the Enterprise GIS be unstable?	Users will not be able to access data affecting productivity	4	1	2	4	5	
Application Incompatibility	Will existing applications work with the Enterprise GIS?	Existing applications will not work correctly	4	2	2	4	4	Review all existing applications; Update applications as necessary.
Hardware	Does the existing hardware exist to support the Enterprise GIS?	Response times will be too long	2	2	2	4	4	Rework design to meet hardware constraints; Update hardware.
Database Size	Will the total size of the implementation be excessive?	Larger size increased storage and backup issues	1	2	2	3	4	Improve database design to reduce size by analyzing data field sizes, redundant data, etc.
Overall Risk				163	187	194	204	

5.0 Recommendations

5.1 Recommended Option

ASSESSMENT OF OPTIONS

During interviews with key stakeholders, the need for coordination and communication across the functional areas and district offices, and for leadership on data quality and sharing, were clearly and frequently expressed. Combining this with the cost-benefit analysis and the risk analysis, each of the proposed options were reviewed to determine the best approach for implementing an Enterprise GIS at FDOT.

From a pure cost point of view in the short term, Option 1 (maintaining the status quo) requires the least financial commitment from FDOT, and has minimal risk. However, it quickly becomes clear that Option 1 would likely increase the long-term costs to FDOT, due to inefficiencies and diseconomies of redundant investment. It can, therefore, be quickly eliminated as a viable option.

Each of the remaining three options, addresses the concerns of the key officials and stakeholders to various degrees.

Option 2, a Pseudo Enterprise GIS, would encourage sharing data across the organization although it still places much of the responsibility on individual staff to discover data availability and determine a method for data sharing. The option also has relatively low cost and risk when compared to Options 3 and 4.

The final two options of implementing either a distributed or centralized Enterprise GIS both obtain a positive NPV approximately within the 6^{th} -7^{th} time period, and have comparable levels of overall cost and risks. Therefore when attempting to assess the merits of the two options, a finer level of detail needs to be used, especially when each option is not mutually exclusive. For example, there is little difference between a Distributed Enterprise GIS that incorporates a centralized Data Warehouse, and a pure Centralized Enterprise GIS. Both options allow the power of GIS to be leveraged enterprise-wide with data consistently and accurately shared across the organization, allowing for improved decision-making while reducing duplicated efforts. However, Options 3 and 4 require different institutional tolerance for centralizing information and processes within a dedicated team, with issues of data security and accessibility. While a dedicated team should have experience with the implementation and maintenance of a centralized Enterprise GIS, it is unlikely that their knowledge of the individual pieces of data will be as extensive as available within the distributed systems. However, by implementing a Centralized Enterprise GIS, it is highly likely that data accessibility will be simplified and the data will be more secure as there will be fewer points of access.

OPTION RECOMMENDATION

Based upon the assessment of the four options, Options 1 and 2 were eliminated from consideration due to the lack of realized benefits. With regards to Options 3 and 4, successful examples can be shown for both of these approaches. However, due to higher benefits, and lower impact of implementation on the organization, it is our recommendation that Option 3 be adopted as the preferred approach for the implementation of an Enterprise GIS at FDOT.

The role of an Enterprise GIS and challenges related to its implementation depend upon the organizational set-up of the Department or division tasked with developing, installing and maintaining it. GIS divisions/departments in FDOT have been traditionally part of Planning, Information Services/Technology, or an independent department/division. The organizational structure at FDOT also makes Option 3 more feasible than Option 4. The organizational structure of establishing system governance for a distributed Enterprise GIS would streamline the GIS solution prioritization, development, and deployment process, so that all GIS related initiatives could focus on service delivery and provide users with a collective mechanism to develop and maintain the data they need while adhering to interoperability standards within FDOT. Besides enabling central data management in an enterprise environment, Option 3 would allow for distributed ownership and maintenance of the geodatabase layers, which means it would not necessarily require dramatic changes in the existing databases and business processes at business functional areas or district levels, but the databases could still be centrally accessible in an enterprise environment.

Though the recommendation is clearly Option 3, it should be noted that these are not mutually exclusive options. Instead, they could be viewed as four incremental levels of Enterprise GIS that could progress from one to another. Often times a GIS starts out as a single-purpose system developed to satisfy the needs of a specific project or business unit. Frequently, disparate GIS systems emerge within the organization, which then leads to attempted coordination among the various systems. The coordination may finally evolve into an enterprise system. Therefore if there are funding or other constraints at FDOT that prevent the implementation of Option 3, it is also possible that FDOT could start with Option 2 as the first step before Option 3 is implemented.

5.2 Critical Success Factors

Success can mean different things to different people. For example, project managers may think a project is successful if it is completed on time and within budget, while users may emphasize improved data access and decision support as the critical factors for success. In terms of the implementation of an Enterprise GIS, Critical success Factors (CSFs) define key areas of performance that are essential for the successful implementation of the Enterprise GIS.

Below are CSFs that are critical for the success of an Enterprise GIS at FDOT:

- **Clear Definition of the Initiative**. In order to successfully move forward with an organization wide initiative like Enterprise GIS, it is important to ensure that all participating stakeholders are on the same page with respect to the definition. Defining the concept of Enterprise GIS at FDOT and acquiring an agreement on the definition are key success factors as they ensure a common understanding and agreement on what it means and how it is perceived.

- **Establishing Project Champion**. Every successful project has champions and supporters who are enthusiastic about the potential contribution of Enterprise GIS to the business needs of user divisions and organization as a whole. These people are critical to the successful implementation and they should have both the position and skills required to ensure project completion. The GIS Coordinator at FDOT serves multiple departments by providing central representation for GIS solution support, and he should continue to champion the efforts of developing an Enterprise GIS.

- **Acquiring Sustained Management Support**. Management support is important for accomplishing project goals and objectives that are aligned with agency strategic goals. One of the key predictors of a successful Enterprise GIS deployment is the level of support and committed financial support from the senior decision-makers in the agency (and possibly in the State as a whole). Support at upper and implementation levels (vertical and horizontal) is critical irrespective of the organizational set-up. If a mammoth goal is set at the outset and presented to the upper levels of management, any pitfalls in development and implementation would result in loss of confidence regarding the idea of an Enterprise GIS and could result in the loss of management support. Hence, a sustained effort is needed to ensure that any progress on implementation of Enterprise GIS framework is communicated to the GIS Management Steering Committee. In order to obtain continual management support, the current GIS Management Steering Committee must have representation from all functional areas.

- **Getting Stakeholders on Board.** User adoption is the key to the success of any Enterprise GIS. In order to develop and sustain a successful Enterprise GIS system it is absolutely necessary to involve stakeholders from the start of the project. Stakeholder interviews were conducted to obtain a clear understanding of the GIS system from the user and business process perspectives; these also offered an opportunity for stakeholders to articulate their information needs and data flow issues, and understand the benefits and perceptions of having an enterprise system. Additional stakeholder interviews are recommended for current and perspective users of the data to improve the understanding of user needs and requirements for the Enterprise GIS. Better determination and implementation of user requirements will result in better system quality, use, and acceptance. Since each organization is unique with its own culture, business processes, methodologies, and GIS-related processes, a successful Enterprise GIS system should obtain a clear understanding of the system from the user and business process perspective and be able to balance interests for all involved parties.

- **Building Channels for Good Communication**. Success requires better education and communication across different departments and regional offices regarding the use and advantages of an Enterprise GIS. A training program is needed to provide staff, both technical and end-users, with the skills and knowledge to successfully implement and use the Enterprise GIS. Regular communication of the project goals both within the project team (GIS Functional Steering Committee) and within the agency is also necessary. Better coordination with user divisions and having GIS point persons in those divisions will also help avoid the perception of Enterprise GIS as a top down initiative. Coordinators in the user divisions should be used effectively to relay the utility of the geospatial applications for their business needs. Sensitivities associated with district involvement, attention to all business areas within the Department and the coordination with the Office of Information Systems are all critical components under this category. FDOT could establish a project website to continually post progress, issues and invite comments and feedback regarding the Enterprise GIS implementation.
- **Establishing Clear Designation of Data Stewardship –** A successful Enterprise GIS or geodatabase requires clear designation of data stewardship for each database, with clearly defined responsibilities by department or person. It also requires clear designation of the data maintenance responsibilities. Important metadata needs to be documented using metadata standards, such as those set up by the Federal Geographic Data Committee (FGDC) and the Geospatial Onestop initiative, which has developed metadata for transportation data as part of the National Spatial Data Infrastructure (NSDI). Universal metadata standards need to be adopted within FDOT. A clearly defined plan that establishes these roles and responsibilities and identifies additional needs of these data owners is a critical factor to ensure participation from data providers and efficient maintenance of the data in the enterprise system.
- **Choosing the Right Technology and Building the Right Team**. Like any other enterprise information system, GIS must serve the needs of an organization. One of most common mistakes is to select a GIS technology before fully assessing organizational and end user needs. Managers then tailor business processes to their chosen technology in order to make it work. This approach may produce a system that end users do not want to use and adds no value to business operations. The project should build an adequate team with knowledge of all components of the project and have a wide breadth of experience in building an Enterprise GIS. Team members should believe in the project and have time dedicated to the implementation. They should be empowered to make efficient decisions so as not to delay or derail the implementation. Another critical factor is a well defined project scope, plan, and schedule with appropriate budget and

resources. Close monitoring needs to occur to confirm the project is on time and within budget.

- **Taking Small Steps.** When it comes to setting goals for Enterprise GIS development it is important to take small steps. This helps to summarize success and failure at each stage and lessons can be learned prior to moving to the next step. Based on the research of existing FDOT studies and other state DOTs where Enterprise GIS has been implemented, success has been demonstrated at smaller scales. Based on this philosophy, the subsequent phases and tasks in this project should be carefully planned in order to ensure small, distinct, and independently useful steps so that success/failure can be demonstrated prior to proceeding further in the project.

5.3 Recommendations to the GIS Functional Steering Committee

The primary goal of this research project was to evaluate the need for an Enterprise GIS in FDOT. After careful analysis of past efforts, consideration of business needs, evaluation of options, and incorporation of critical success factors associated with the implementation of Enterprise GIS, following are the recommendations made to the GIS Functional Steering Committee.

1. Approve adoption of a common definition of an Enterprise GIS

Enterprise GIS has been defined in many different ways for many different projects. A few stakeholders defined it in terms of being a centralized database; some defined it more loosely as an amalgamation of major applications. In order to proceed along the path of an Enterprise GIS, a definition must be clear and accepted by all stakeholders. The research team reviewed definitions of Enterprise GIS from past project efforts, stakeholder interviews, and feedback from the GIS Functional Steering Committee and recommend the following definition:

> *Enterprise Geographic Information Systems (GIS) is an organization wide framework for Department communication and collaboration of shared geospatial data and GIS resources that enhances existing business processes and provides an efficient way to plan, analyze, and manage transportation infrastructure and related element.*

2. Approve the need for an Enterprise GIS and recommend implementation

Findings from the current research indicate a clear need for Enterprise GIS at FDOT. It is apparent that decentralized GIS resources and activities need to be consolidated into a comprehensive enterprise suite of GIS services and data resources to support sharing and utilization of geospatial information. The following observations based on business needs analysis and stakeholder interviews support the recommendation:

- Need to address varying data needs and applications across organizational units, functional areas and districts
- Need to accommodate legacy databases and data collection practices based on requirements of an individual unit
- Need for formal coordination of key common data used by both districts and Central office
- Need for a clear organizational home for enterprise GIS staff (pseudo structure through GIS Functional Steering Committee)
- Need for a standard location ID for tracking projects – from planning through construction, operations and maintenance
- Need for formal spatial data standards (projections, scale, resolution, accuracy, attribution, security and documentation) – Current standards focus on application development
- Need to address inconsistent data quality, geographic scale and accuracy – Inconsistent feature resolution (e.g., representing an interchange as a single node vs. showing all ramps)
- Need for interoperability standards

Depending on the extent of integration and interoperability desired, there are different ways to implement Enterprise GIS. After evaluating 4 available options and considering the current organizational setting at FDOT, the project team recommends that the Department move forward with decentralized implementation of Enterprise GIS, where data can still be centrally accessible in an enterprise environment while allowing for distributed ownership and maintenance of data.

3. Develop an updated Strategic Plan

A GIS strategic plan would define the strategy, or direction, that would guide allocation of resources (capital and people) in FDOT. The current GIS strategic plan should be revised to include findings and recommendations from this research and could include components such as:

- Development of a GIS Policy and Procedure that supports the strategic plan
- Incorporation of GIS into Tier 1 and Tier 2 business plans
- Reconfiguration of the GIS Management Committee to include comprehensive representation from each district and functional area
- Development of a Communication Plan that includes regular communication channels with stakeholders regarding project status and accomplishments
- Continued funding for GIS enterprise implementation

The strategic plan, once approved, should lead to the development of a detailed Implementation Plan. An implementation plan would provide detailed steps involved to implementing the Enterprise GIS along with their respective resource requirements. The plan should include the following at a minimum –

A. Build Data Inventory

This task involves conducting a comprehensive inventory of all spatial data and GIS applications used within FDOT. The inventory would document several attributes of these data and applications such as the purpose, time period, source, data owners, users, update frequencies, and maintenance mechanisms. Unlike other similar data inventories such as Florida's Geographic Data Library (FGDL), this data inventory is proposed to be specific to FDOT data but could potentially build on established FGDL's framework. The data inventory would be published across the Department for various offices to know what kinds of data are available and with whom. As a next step in the process, the inventory data would be analyzed according to usage. These data and applications would be prioritized to build a priority list to further support the rollout of Enterprise GIS.

B. Identify/Establish Data Standards and Business Plan

Data sharing, data standards are key in implementing an Enterprise GIS. Standards are typically an agreed-upon set of guidelines for interoperability[6] and allow better communication among offices.

The following are some of the kinds of standards that should be identified/developed:

- Data standards such as scale, accuracy, resolution, and projections
- Naming standards for layers and attributes
- Documentation standards for data dictionaries and meta data

While the data standards establish a standardized framework for exchanging data, a data business plan would assist in identifying and defining data stewardship responsibilities. A data business plan would establish a roadmap of how existing data is managed and how it would be managed upon implementation of Enterprise GIS.

C. Coordinate with Unified Base Map initiative

Several efforts in the past emphasized the need for standardized network base map that would enable linkage between various business processes and associated databases. Currently, FDOT's Safety Office is heading an initiative to develop such a network known as *Unified Roadway Base Map*. A base map is a

[6] Tomlinson, Roger, 2003, Thinking about GIS: geographic information system planning for managers, ESRI Press.

critical component of Enterprise GIS and, proper coordination with the current initiative would avoid redundant efforts in the process.

D. Conduct a Pilot Study

One of the main components of an incremental approach is a pilot study. A pilot is a test run for part of the project involving a few offices. Implementing a pilot assists in gaining an understanding of the kind of technical and institutional issues associated with implementation of Enterprise GIS. One of the preliminary steps in a pilot study would be to determine and agree upon the objectives and measures of success for the study. This would provide guidelines in terms of assessing the success of the pilot. A pilot study for this project would potentially involve application of data standards and the components of the business plan to one or more offices within the Central Office and a sample district. Based on the success or failure in such small-scale implementation, the concept would be adjusted and incrementally applied to other offices.

E. Design a Data Model

Upon identification of key data elements, applications, users and user responsibilities, the Enterprise GIS architecture should be defined. This architecture would determine how the common data elements would be collected, stored, and maintained. Complementing this architecture would be the definition of required hardware, software, and network capabilities.

F. Continue with Education and Research

This task focuses on educating the functional area managers to understand the benefits and need for an Enterprise GIS and to embrace the concept. This education is critical as it ensures the managers understand the real value of Enterprise GIS in terms of complementing their existing processes. Research also needs to be conducted on a continual basis to evaluate and identify a probable institutional framework that would facilitate in implementing and sustaining Enterprise GIS.

6.0 Conclusion

This research evaluated the business case for an Enterprise GIS and paves the way for integrating disparate data systems and processes at FDOT. Many past projects emphasized applications while this research emphasizes process improvements. This research was conducted at a different stage of readiness within FDOT with an established GIS coordinator and a strong committee structure.

The research compiled and utilized all pertinent information from past efforts and evaluated the business case for an Enterprise GIS at FDOT. The results overwhelmingly indicate a need for formal integration of systems and processes. In order to understand the repercussions of the existing situation, a no-build option was evaluated with several other Enterprise GIS implementation options. The evaluation indicated that continued investment in the existing processes would lead to increased inefficiencies and negative benefits to the Department. Of all the options that were evaluated in terms of cost-benefit comparison and risk assessment, a distributed Enterprise GIS implementation was identified as the most beneficial option with moderate risk. Several success factors were identified to aid in the implementation of this option. The most important one is the need for strong management and stakeholder involvement.

In conclusion, it is anticipated that the findings and recommendations in this research will increase the awareness regarding the need for an Enterprise GIS and establish a case for implementation of an Enterprise GIS within the Department.

7.0 Appendix A – Relevant Projects

Table A.1 Relevant Projects

SNO	Title	Year
Central Office		
1	ETDM – Environmental Screening Tool	2003
2	An Evaluation Plan for the Conceptual Design of the Florida Transportation Data Warehouse – Phase 1	2002
3	Feasibility Study for an Integrated Network of Data Sources	2004
4	The Central Florida Data Warehouse – Phase 2 – Central ITS Office Funding	2004
5	SunGuideSM: Alternative Map Approaches	2006
6	Development of a Central Data Warehouse for Statewide ITS and Transportation Data, Phase II: Proof of Concept – Proof of Concept Phase 2	Ongoing
7	GIS Planning, Analysis, and Implementation (PAI) Report	1996
8	GIS-T Strategic Plan	1997
9	GRIP – Geo-Referenced Information Portal	Nonexistent
10	Enterprise SIS (planned)	Ongoing
11	Enterprise View	
12	FDOT Business Plan Development	2003
13	FDOT Statewide Business Plan – Tier 1	2005
14	Several Tier 2 Plans – Construction, ISD, Maintenance, Materials, OIS, ROW, Safety, Financial Development, and Work Program	Varies
15	Florida Unified Base Map	Ongoing
16	Highway Feature and Characteristics Database Development Using Commercial Remote Sensing Technology, Combined with Mobile Mapping, GIS, and GPS	2004
17	RCI/RCI2	
18	City-to-City Mileage	
19	Data Library Tool/Image Tools	
20	Florida Traffic On-Line	
21	Iview	
22	A-PLUS	
23	Development of GIS-Based Conflation Tools for Data Integration and Matching	2002
24	A New Database Framework for Florida's Transportation Planning: Integrating Work Program, Multimodal Transportation Networks, Planning, and Environmental Databases	2006
25	Decision Support System (DSS)	
District One		
26	Streets and Maps Based GPS Database	

27	Crash Data Management System (CDMS)	
28	Access Management	
29	Operations – Analysis Section GIS efforts	
District Two		
30	ArcIMS Applications	
District Three		
District Four		
31	GIS Business Needs Analysis Report	Ongoing
32	Data Catalog Tool	
33	GIS Research and Recommendations White Paper	2006
District Five		
34	A Transportation Automated Information Management System – TAIMS	
35	iFlorida Conditions Reporting System (CRS)	
36	Project Traffic Forecasting (PTF) Web Site	
37	Railroad Crossing Index (RoXI)	
District Six		
District Seven		
38	Bicycle/Pedestrian Crash – Crash Data Management System	
39	Drainage-Related Permit GIS Application	
40	PD&E and Interchange Web Site	
41	Production Scheduling	
42	Signalized Intersections	
43	Geodatabase Model	
44	CADD/GIS Interoperability Project	Ongoing
45	Technology Assessment	2006
46	The Efficacy of Utility Database Management	2007
47	GIS Crash Database	
48	GIS Traffic Signal Database	
49	User Needs Analysis	2004
50	Data Component Report	2007
51	Define Utility Needs and Criteria for GIS Support	Proposed
52	Development of an Organizational Strategic Plan for Florida Department of Transportation's AM/FM/GIS Transportation Program (GIS-T)	1997
53	Development of an Organizational Vision for Florida Department of Transportation's AM/FM/GIS for Transportation Program (GIS-T)	1997
54	Development of an Organizational Mission for Florida Department of Transportation's GIS for Transportation Program (GIS-T)	1997
District 8		
55	Turnpike Enterprise Asset Management System (TEAMS) Report	2007

56	Turnpike Management Information System (TMIS)
57	Aerial Photography Viewer
58	Turnpike GIS Metadata
59	Turnpike Map Catalog
60	Turnpike Toll Calculator

8.0 Appendix B – Stakeholder Summaries

Stakeholder interviews were held with Central Office and District Four. The interview guide used is included below.

8.1 Interview Guide

1. Review Objectives of Project – To evaluate existing documentation related to an FDOT GIS Enterprise, complete a business case and identify products that are required to meet ISDM requirements

    a. Phases

    - Phase 1 – Establish a business case to determine whether to proceed with the implementation of Enterprise GIS-T (RESEARCH PROJECT)
    - Phase 2 – Formulate pilots and develop implementation plan detailing steps for successful implementation of Enterprise GIS-T
    - Phase 3 – Implement Enterprise GIS-T along with documented procedures and policies

    b. Tasks

    - Task 1 – Literature Review
    - Assemble and review literature pertinent to the concept of Enterprise GIS
    - Task 2 – Identify Missing Products
    - Assemble and verify the work completed to date against the ISDM and identify missing products
    - Task 3 – Complete Missing Products
    - Create or update approved missing information product deliverables

2. Summary of Task 1 – Refer to PowerPoint (Sept 28 GIS Functional Steering Committee), including definition

3. Stakeholder Business Needs

   a. Review Tier 1 and 2 plans

   b. What are your key business needs driving data flow or need for E GIS?

   c. Note – Data flow is interdepartmental or with the Central Office

4. Stakeholder Data Flows

   a. What are your key existing and future (needed) spatial data flows and links? Clearly identify inputs, outputs and the flow

   b. Which enterprise databases are involved (both Central Office and district level enterprise databases) ? (i.e., SIS, WPA, RCI, etc.)

   c. What are the key GIS applications used for enterprise data flow?

   d. Any policies and programs that seem to affect data flows and links?

5. Stakeholder Technology and Architecture

   a. What are your key technology barriers for an Enterprise GIS?

   b. What is the profile of GIS resource personnel? How many of what kind (Advanced GIS users vs. Basic GIS users; internal vs. external users)

6. Stakeholder Financial GIS issues

   a. What are your key financial needs/barriers for an Enterprise GIS?

   b. Current levels of investments into GIS applications, datasets and personnel?

7. Review below table with stakeholder

	Gather User needs, Requirements and Processes
	Business
	Understanding Organization Business plan (Mission, Vision and Goals) along with existing mandates and organizational responsibilities
	Identify functional areas and understand the mandates, responsibilities for each functional
	Understand current work flows, users, inputs and outputs and role of spatial data in each
	A description of how the information is captured or entered – Identification of data elements that traverse across functional divisions
	Data
	Categorize as foundational, interdepartmental and departmental data needs of each functional
	For each data source – Identify data elements, sources, updates, accuracies and validation

	Financial (sources and amounts)
	Understand GIS resources by each functional division and the Department as a whole
	Current expenditure for GIS software, hardware and services
	Current level of resources/personnel
	Technology and Architecture
	Understand departmental technology framework
	List of acceptable software, hardware, database and network technologies
	Existing levels of technology resources – number of licenses, CPUs, Band widths, applications
	Identification of existing and proposed databases, applications by each functional division
	Identification and Understanding of the Problem
	Business
	Identification of redundancies and inefficiencies in the processes/work flows at the Departmental
	Identification of redundancies and inefficiencies in the processes/work flows at the functional division level
	Data
	Redundant data sources
	Varying data accuracies
	Varying versions of similar datasets
	Financial
	Identification of investments into similar applications and projects
	Approximate financial implications of redundant processes
	Increasing redundant maintenance costs
	Technology and Architecture
	Redundancies in licensing and software procurement
	Inefficiency in utilizing available band widths
	Redundant applications for the same purpose
	Replicated local databases

8. Quality of Data Flow

   a. For existing data flows:

   b. To what extent are the data links providing for quality in terms of:

   c. Accuracy? Timeliness? Accessibility? Completeness? Coverage?

   d. How could Enterprise GIS provide for quality in terms of:

e. Accuracy? Timeliness? Accessibility? Completeness? Coverage?

9. Enterprise GIS benefits

   a. What would you like to see come out of Enterprise GIS?

   b. What do you think are the critical success factors for Enterprise GIS at FDOT?

8.2 Central Office Interview Summaries

The following key Central Office stakeholders were interviewed during October, November, December, 2007 and January 2008.: Paul O'Rourke, Statistics Office; Vidya Mysore, Systems Planning; David Davis, Office of Information Systems; Rick White, Office of Information Systems; Pete McGilvray, EMO; and Larry Ferguson, Quality Initiatives; Liang Hsia, Operations TERL Center; Jim Johnson, Central Office Construction; Tim Lattner/Central Office Maintenance Staff; Design Office; and Abdenour Nazef (State Materials Office). Each interview is summarized below.

PAUL O'ROURKE, STATISTICS

DEFINITION

- Be sure to clearly define – Enterprise GIS can have many meanings
- Focus on process, not physical aspects
- Promote better communication and data sharing
- Use as a roadmap
- Build up from existing applications

OFFICE BUSINESS PROCESSES

- 2 main databases – RCI and Traffic Data (TCI)
- FDOT Offices that use them – Systems, Safety, EMO, Design (Roadway and Bridge)
- Data for viewing – Aerial photography, functional classification/urban boundary, boundary layers
- GIS Tools used – Arc View, Arc Map, Image tools

- » Data sharing applications – Florida Traffic On-line, Iview, City to City Mileage

Constraints/Enablers for Enterprise GIS

- » Not successful with getting Florida Traffic on-line due to inability to get into OIS Work Program = data sharing barrier
- » No technology barriers for Statistics – they have resources (funding and personnel)
- » Advanced GIS expertise in Statistics
- » Applications are user driven (mostly by districts)
- » Lack of data could be a barrier
- » Ability to connect outside of the firewall would enable

Data Quality

- » Need to carefully define data needs
- » Accessibility could be improved by Enterprise GIS
- » Enterprise GIS has no role in comprehensive coverage – RCI defines the coverage

Benefits of Enterprise GIS

- » Data sharing and communication – more users could be made aware of what is available

Success Factors

- » Having the right technical expertise to drive it
- » The right people need to be involved
- » Decision-making must be by knowledge people
- » Coordination and communication during implementation are key
- » Having a central communication center to get the word out
- » Present at internal conferences
- » Define buy-in and then make sure to obtain it
- » Don't try to roll everything up into one application – emphasize sharing

VIDYA MYSORE, SYSTEMS PLANNING

DEFINITION

- Enterprise GIS is a moving target, technology is changing rapidly
- Should already have in place at FDOT – 80% of FDOT data is spatial
- Enterprise GIS should be one central foundation including technology, a means of delivery and an adoptable framework
- Needs to be a 2-way process – all functions are either contributing or taking away from the Enterprise GIS
- A complimentary process for everything in the Department
- Physical – need to establish protocol and framework
- Compliment all other GIS activities in FDOT
- Need an infrastructural policy framework

OFFICE BUSINESS PROCESSES

- Data sources – Statistics (RCI and TCI), Traffic Operations (5 year forecasting)
- Planning needs to access several outside data sources (i.e., MPOs)
- Users – SIS, WPA, RCI
- Systems Planning needs a circuit to plug the data in
- Systems uses ETDM process

NEED FOR ENTERPRISE GIS

- Inefficiencies due to various districts signing similar agreements to obtain data from the same external sources
- Several districts are accessing data from same sources
- Offices are establishing their own links to data sources
- Need real time access to data for dynamic applications – i.e., WPA data is lagging (this is critical for decision-making) results in reduced accuracy
- Business and data inefficiencies are well documented in Vidya's research

CONSTRAINTS/ENABLERS FOR ENTERPRISE GIS

- Barriers for external web development (such as ADA)
- User concerns that Enterprise GIS will replace what they are doing
- IT standards – open architectural and platform for sharing data
- Need a mechanism to share data outside of the Department

- » Data from the outside comes in native format – difficult to get into correct format
- » May need to sign disclosure agreement to resole institutional issues
- » Quickly changing technology could be a barrier or enabler (need to be open minded)
- » Not having access to Google Earth in FDOT is a barrier
- » High volumes of data – needing to notify IT of large transfers is a barrier
- » GIS expertise limited within Systems – mostly use consultant support
- » No financial constraints within Systems Planning

BENEFITS OF ENTERPRISE GIS

- » Adds value – ensures more efficient business processes
- » Provides a roadmap to standardize
- » Provides guidelines to indicate how and when to share data within FDOT
- » Eliminate inefficiencies and redundancies
- » Would improve accuracy, timeliness and coverage

SUCCESS FACTORS

- » Perform a successful pilot
- » Go beyond research – employ from a practical sense
- » Have a holistic approach
- » GIS Office needs to be clear on definition of Enterprise GIS and communicate it
- » Establish policies and communicate to user community
- » Need a high level GIS officer to promote top down implementation
- » IT needs to inherit Enterprise GIS
- » Vision needs to be a "rebirth of information sharing"
- » "DOT needs to centralize administrative level GIS Stewardship" within well defined goals and adequate resources
- » Business knowledge is key

"While creating a blueprint for Enterprise GIS framework, we should emphasis the importance of Department moving in the direction of 'Geoenabling organization'. This can be achieved ONLY through holistic (top-down) approach with a plan for a paradigm shift in data collection and maintain that was never planned before."

"Approach should be in two fold. First, focus on <u>what needs to be preserved?</u> That is establishing Geoenabled Asset Management Information System. This should able to store and cross reference every aspect of the Department business functions (such as RCI, TCI, WPA, Pavement, Design & Engineering, Construction, Safety, Right-of-way, Maintenance – Bridge, materials). All of these internal generated source data. Source of the information should include time dependent knowledge base. Not just what we see what we get."

"Once we have Geoenabled Asset Information system, we should be sitting on excellent accounts of activities that can maximize the capabilities of Geospatial enabled tools to update, maintain and preserve our infrastructure more efficiently and effectively."

"Secondly, <u>what does need to plan and build infrastructure for future?</u> We need a system that would support the analysis of what-if scenarios for optimal planning process. As we discussed, in order to be successful planning, we should have mechanism to capture both internal (first part described above) and external source of information (discussed in 'Multimodal transportation plans…' research document)."

Rick White, OIS Database Administration

Definition

- Enterprise = single point of control
- High level roadmap

Office Business Processes

- Office does not document metadata but they are starting to
- Business data belongs to a custodian
- They house DOQQs on their site – OIS uses Alberts projection and Statistics uses UTM-17
- They will provide a list of databases
- Metadata is more for the users
- E-SIS will answer many questions regarding data sources on a large scale level
- Key Databases - A plus (Survey and Mapping), GIS Enterprise View (takes from RCI, WPA, Safety, Bridge, Planning Base Map, external), Bridge Management, Crash Locator, SIS, Oversized Vehicle Weight

Need for Enterprise GIS

- » Several districts are doing their own thing – Central Office is not sure what they are doing, not sure if they are pulling data from the correct sources
- » A simplified view would eliminate technology issues
- » There are a large number of data sources (i.e., Rail data can be represented different ways) – therefore it is not clear what the official source is – this could be overcome with better communication
- » To address data redundancy
- » Need standards service level

Constraints/Enablers for Enterprise GIS

- » Database office would need more GIS resources to manage GIS data
- » Barrier = price of GIS software
- » Uptime of databases is an issue i.e., some databases do not operate 24/7
- » Source will drive when updates occur

Benefits of Enterprise GIS

- » Non redundant data
- » Will ensure methodology for consistent district applications
- » Will define right source for data
- » Single source
- » Able to customize report
- » Timeliness – be able to generate multiple extracts for a single location

Success Factors

- » High level management support, buy in and approval
- » Centralized GIS Group – not Planning's role
- » Clearly define data owners (they create, maintain, update)

Peter McGilvray, Environmental Management Office

Also Mike and Ruth, URS

Definition

- » Need to clearly define Enterprise GIS

- » What does it look like? What are the communication protocols
- » Process to increase efficiency of business processes
- » Develops linkages/integration of information and communication
- » EMO will send proposed definition

OFFICE BUSINESS PROCESSES

- Major business processes are the support ETDM, environmental screening tool (EST) and SAFETEA LU to facilitate NEPA approval of projects
- Environment includes human components as well
- Community impact and socio cultural effects also important (for community outreach)
- Users of Environmental Screening Tool – districts, MPOs, over 500 users
- Data Flows – See PowerPoint

  - Project entered by MPO, FDOT or others – entered either in GIS (digitized) or documented or uploaded to spatial databases
  - Type of data – project, resource data (from FGDL), community liaison coordinators, environmental reviews (comments from agencies), agreement information

- They have significant agreements with data providers (formal agreement with approx 20 agencies)
- Planning also uses EST for *what if* scenarios
- Sources – RCI, FGDL, teleatlas
- They use best available data, snap shot, not live

NEED FOR ENTERPRISE GIS

- » Would like to have aviation, seaport, rail layers and data
- » Would like more than E-SIS
- » Need off system road networks available in GIS

CONSTRAINTS/ENABLERS FOR ENTERPRISE GIS

- » Firewall is a barrier – therefore they house EST at Geoplan center – however, if Enterprise GIS is internal only, firewall may not be an issue
- » Network capacity
- » Financial – can only spend funding in certain areas to meet federal requirements

» Centralized or distributed hardware

BENEFITS OF ENTERPRISE GIS

» Would allow for access to data that is not normally available

» Would improve timeliness

» One stop shop for Department resources (asset inventories)

» Success Factors

» Need to build a financial case

» Everyone needs to see value

» Get all stakeholders in a large JAD session so they can share ideas (especially for requirements of ENTERPRISE GIS)

» Implement top down and bottom up, across districts and functional areas

» Everyone must see the added value

» Cannot negatively impact business processes

» Ask stakeholders for improvement ideas and respond quickly to requests

» Take small, well thought out steps

» Address enterprise licensing

DAVID DAVIS, E-SIS, OIS

DEFINITION

» GIS enterprise assists in defining how overall base map fits into FDOT base map and others

» Enterprise level includes statewide extent, across all boundaries, reputable source (ensuring up to date on a regular basis)

OFFICE BUSINESS PROCESSES

» Key challenge for E-SIS – defining data sources, recognizing that there are different degrees of detail within each source

» Flows include ETDM, RCI, WPA, Federal Aviation Database, Rail, Seaport

» SIS policy drives E-SIS

NEED FOR ENTERPRISE GIS

» Need a source that everyone pulls from (i.e., facilities level) – scale depends on needed level of accuracy

- Needs to link to outside (E-SIS and ETDM)
- Define overall layer and base map, then fit existing applications (such as RCI) into it
- Needs to take care of geography and define layers for all 5 modes
- Lack of data flow standards – unregulated data sharing
- Need internal standards (like ISDM)
- Redundant sources pulling data – i.e., Project Suite in D4, D2 may be using outdated sources for GIS applications

CONSTRAINTS/ENABLERS FOR ENTERPRISE GIS

- Lack of polices for data sharing
- ESRI licenses
- Different versions of GIS software could be an issue
- Versioning could be a problem

BENEFITS OF ENTERPRISE GIS

- One stop shopping with identified common data sources
- Eliminate redundancy in uses of data
- Promote use of data in areas where others are not aware of certain sources

SUCCESS FACTORS

- Don't get too detailed
- Everyone needs to agree on certain physical boundaries
- Recognize that certain offices need different level so scale of detail and accuracy
- Communicate often – be very clear
- Need a good sales pitch to justify funding Enterprise GIS
- Have a clear starting point (like ISDM)
- Have well defined steps
- Establish clear process rules
- Identify where connections between databases are needed (along with business needs)
- Clearly list characterizes if Enterprise GIS

- » Idea could be to develop a form that needs to be filled out by GIS project owners prior to beginning project. It could be part of the project documentation. Answers to questions would define whether a proposed application is enterprise or not. Scoring could be applied to the answers and weighted. A certain score could reflect whether the application is enterprise. This would expose GIS projects to a larger group of people. Questions could include: Does your application share data with other offices? Does it need a boundary level? What level of accuracy is needed? Does it serve a key business Tier 1, 2 need?

Larry Ferguson, Quality Initiatives

Tier 1 plans

- » Broad overarching goals and objectives in 3 areas – 2025 FTP, Short Range Component, Strategic Objectives (including Executive Board Initiative)

Tier 2

- » Primary 22 functions of the Department
- » GIS would make it 23
- » They look at Tier 1, identify what they are responsible for, identify what else they are responsible for, look at 1 or 2 things that they can do better

Tier 3

- » Organizational jump
- » Build district and Co plans
- » They look at Tier 2 and ask same 3 questions

Tier 4

- » Office Location

Tier 5

- » Each person

Enterprise GIS should be in Tier 1 and 2 plans

Need to answer:

1. Where is GIS mentioned in Tier 2
2. Tier 1 – where are links to GIS?

3. In Tier 2 – which functions need GIS to do their job?
4. Investigate Tier 3 at district level – Leo Bray in D4
5. Identify 2-3 cross links
6. Identify one Tier 1 objective and 2-3 actions

GIS Objective could be Integrate GIS into all Tier 2 plans

LIANG HSIA, OPERATIONS TERL CENTER (11-15-07)

DEFINITION

- » Statewide unique GIS database that ensures that information is not different when sources are compared.
- » Data is global and speaks with one voice
- » Everyone uses the Department wide information resource and there is clear ownership regarding data

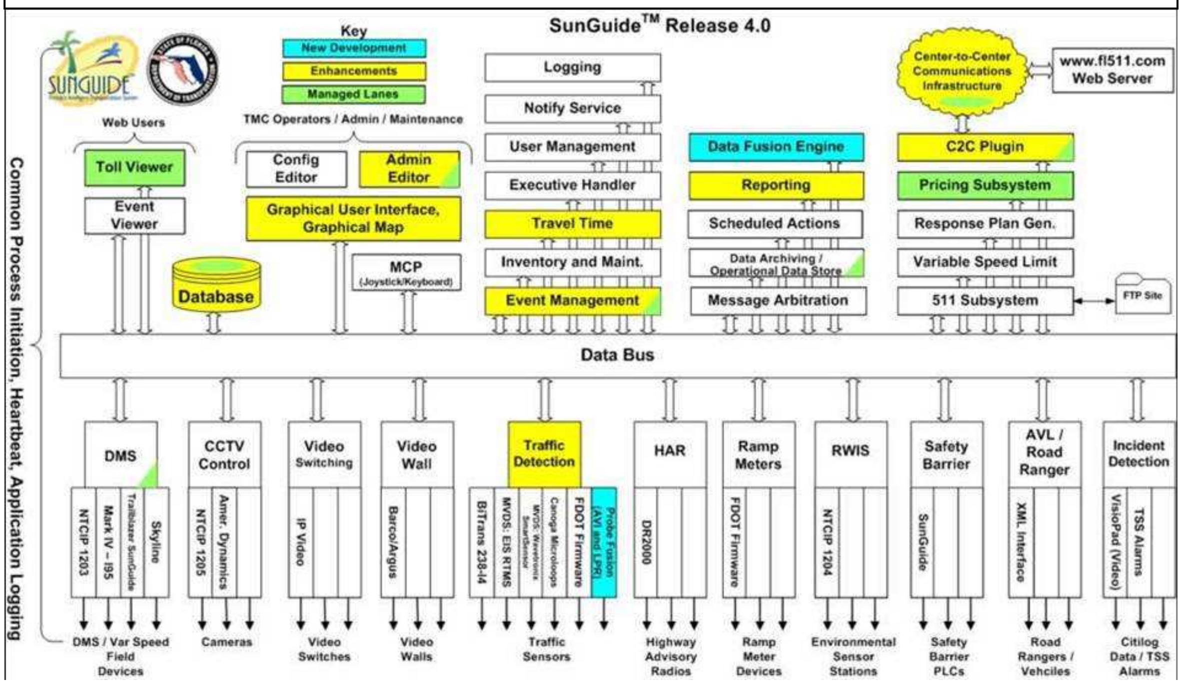
OFFICE BUSINESS PROCESSES

- » ITS General Consultant fund for SunGuide Software Project
- » Telecommunication General Consultant fund for statewide microwave, fiber optic GIS database
- » District Safety Office contracts – Cross referencing crashes
- » GIS based statewide central data warehouse
- » Statewide 511 System
- » Microwave communications and towers GIS database
- » District Seven GIS crash data base
- » District Seven Traffic signal GIS database
- » Memorandum between FHP and FDOT about incident management report sets guidelines
- » Incident management
- » Road Ranger
- » Work zone
- » Travel time reliability
- » ITS performance measures

» Traffic operations performance measures

» Freeway speed, volume, occupancy, density, and level of services

Figure 8.1



NEED FOR ENTERPRISE GIS

» Asset Management (sign, signal inventory)

» Enterprise GIS could improve:

» Accuracy – Good transportation sensor systems data, Enterprise GIS will improve data accuracy by applying statewide uniform standards

» Timeliness – Real-time, Increase band width will provide both image and data for emergency evacuation

» Accessibility – 511, TMC Web sites, Improved Web site will provide users with one stop information source

» Completeness – Comprehensive, Cross-references of data will provide user with comprehensive GIS information

- » Coverage – Good coverage in urban area, minimum coverage in rural area, Enterprise GIS will gradually fill the gap in rural areas

Constraints/Enablers for Enterprise GIS

- » Hardened network and computer systems
- » Fail safe redundant network
- » Human resource for GIS database management
- » Software, hardware supports
- » Stakeholders do not want integrity of their data compromised

Benefits of Enterprise GIS

- » Standardized statewide database without duplicated and redundant data (internal microwave tower information is redundant)
- » Uniformed statewide metadata with global definitions
- » Standardized data definition
- » Standardized GIS data base map

Success Factors

- » Stakeholders' participation and buy-in
- » Clearly identified requirements and make sure needs are met
- » Excellent, knowledgeable, experienced in-house and consultant teams
- » Many more stakeholder meetings

Jim Johnson, Central Office Construction

Definition

- » Statewide unique GIS database

Office Business Processes

- » Plotting maps to evaluate where contractors are doing work – be able to query by location and contractor
- » Construction uses:
- » EDMS – Hummingbird
- » As Built database (images scanned within 45 days)
- » CIM – Construction Management System

- » Has no GIS interface
- » Connects to management system and cost/time
- » Will link to As Builts next year
- » Need Maps and map views
- » To public
- » Detours
- » Help plan construction locations better
- » Site Manager
- » No current investment in GIS in Construction – they are waiting for an Enterprise GIS

NEED FOR ENTERPRISE GIS

- » Current Enterprise GIS Map view could be better – faster, easier to view

CONSTRAINTS/ENABLERS FOR ENTERPRISE GIS

- » Currently there are too many ways to reference projects – FM#, WPA, contract #, begin/end point
- » Developing a consistent view of data does not seem to be a priority for FDOT
- » Several districts have developed their own mapping interfaces

BENEFITS OF ENTERPRISE GIS

- » GIS Standards within FDOT
- » Easy access to projects inside and outside the Department

SUCCESS FACTORS

- » Accessibility to all data Stakeholders' participation and buy-in
- » Easy to understand and use – intuitive and web based
- » Build in work flows
- » Coordinates with OIS efforts

TIM LATTNER AND CENTRAL OFFICE MAINTENANCE STAFF

OFFICE BUSINESS PROCESSES

- » GIS needs to drill down from Statewide to district to Maintenance Area to County to Facility type
- » Need to access/pull from EDMS (both Design and Maintenance versions), PEDs
- » Oversize vehicle map application
- » District STRAHNET Bridge Clearance Application
- » Would like access to signs, maintenance rating (MRP) and geographic picture of roads
- » Databases accessed:
- » RCI
- » WP
- » PONTIS
- » PEDs
- » As Builts
- » EDMS

NEED FOR ENTERPRISE GIS

- » Need public and non public views
- » Need to link attributes (contract #, Bridge #, FM #, etc.)
- » Redundancies/overlaps/inconsistencies between data in different databases (i.e., Construction, maintenance, design)

CONSTRAINTS/ENABLERS FOR ENTERPRISE GIS

- » Current constraint is interoffice issues – i.e., maintenance does not have access to all construction databases and vice versa
- » paranoia/litigations issues surrounding access to others data – i.e., access to bridge documents are limited due to security issues

DESIGN OFFICE

Several offices are located under the design office. The offices that were interviewed include Roadway Design (David O'Hagan), Specifications and Estimates (Duane F Brautigam), Engineering/CADD (Bruce Dana), Structures Design (Thomas Andres) and Surveying and Mapping (Beverly Sutphin).

Definition

» Emphasized the need of clearly defining the concept and associated terms.

Office Business Processes

» Roadway design office interacts with several databases such as video log, work program, materials, and crash data from the safety office. Currently, they have plans to create more dynamic linkage to the electronic document management system (EDMS).

» Specifications office does not see a huge role for GIS as their office provides specifications for various aspects of roadway design. However, they do interact with the district design offices to coordinate and review the long range estimates.

» Engineering/CADD office is the tool maker for CADD in terms of software and standards. They use Micro station as their base CADD program. They currently have two document management systems – TIMS and PEDDS DB. TIMS is an internal system for active file management over the server. PEDDS DB is an archival system with an ability to query for project sheets based on several criteria. This system has potential to have to a GIS interface for querying these project sheets.

» Structures office provides support to the design efforts in terms of establishing policies and standards for structures. They currently access data from several systems such as RCI, Videolog, PONTIS, As-Built plans from the construction office and the Federal Highway System. They intend to have access to geospatial information related to water channel characteristics, easements, and sensors that are deployed across the state.

» Surveying and Mapping office holds several datasets such as County mapping, Aerial photography, Ground Survey, Statewide GPS networks. These datasets are used and updated by different internal and external partners such as district design and planning offices, Division of Emergency Management, University of Florida and Florida State University (FREAC). Their 50 station GPS statewide network is used to increase accuracy and precision of surveyed geospatial data.

Constraints/Enablers for Enterprise GIS

» Security aspects associated with certain datasets like As-built plans need to be accounted for.

» Would like to see standardization in terms of CADD geometry – attributes of symbology, base map precision and some standards to enhance the graphics.

- » Need interoperability mechanisms for CADD to GIS to CADD transformations.
- » Would like to have easy and user friendly one-stop access to departmental databases.
- » No standard projections or procedural standards for data collection and storage across the Department.
- » Usefulness of Enterprise GIS depends upon accuracy and precision of the data within.
- » Standardized system that should be a single reliable source of data for the Department.

SUCCESS FACTORS

- » Utilization is the key to success. Ensuring the usefulness of the Enterprise GIS is important.
- » Educating the program managers on how Enterprise GIS can help their respective program specifically would increase the probability of their participation. Users should have incentives for participation.

STATE MATERIALS AND RESEARCH OFFICE (SMRO)

Representatives from several offices such as Geo-technical materials, Bituminous materials, Pavement materials, Structural materials, Quality systems, and Office of Information Systems, under SMRO participated in the interview.

DEFINITION

The characteristics of an Enterprise GIS should focus on the increasing the efficiency of existing systems and processes through spatial visualization.

OFFICE BUSINESS PROCESSES

- » Primary process is to ensure that the materials used in transportation construction projects meet the required Department specifications.
- » They collect a lot of material data that they intend to analyze in conjunction with other layers of information using GIS interface.
- » They currently do not have any formal GIS and they anticipate using the Enterprise GIS framework to drive GIS in their business unit. They are looking to develop a GIS business plan for their business unit that corresponds with the Enterprise GIS framework.
- » They have several databases that they maintain internally that utilize data from other systems such as RCI, Videologs, Straight Line Diagrams

(SLDs), HPMS and provide data to support processes in pavement management, construction and design offices.

CONSTRAINTS/ENABLERS FOR ENTERPRISE GIS

» Enterprise GIS can provide standardization of data and associated procedures.

» Should include a data inventory that provides a single source of reliable data that is managed by the data owner.

BENEFITS

» Current data that are stored in flat files can be visualized in a GIS interface and can aid in efficient decision-making

» Ability to cross walk between multiple databases

» Currently, it involves a lot of effort to finding and converting the data into required format for analysis

» Being able to visualize data from multiple systems on a single interface would greatly help their current business processes

SUCCESS FACTORS

» Ensuring customer satisfaction is the key

» Buy-in at management level

» Framework should include necessary flexibility and maintenance protocols

8.3 District Four Interview Summaries

The following summarizes the District Four interviews.

DISTRICT FOUR PROGRAM MANAGEMENT OFFICE

Jose Theiler, E.I – Program Services Administrator

Sifu Zhou, PhD, PE – GIS Services Administrator

Michele Chalfant – GIS Specialist

OFFICE BUSINESS PROCESSES

- Office is responsible for three key areas of support for all departments throughout the district: 1) GIS, 2) Web Development, and 3) Scheduling. This responsibility includes coordination and storage of project level data first and foremost, with a secondary vision of enterprise-wide data sets and applications. The Program Management Office is involved with application development efforts that work to integrate GIS, Web, and Scheduling components.
- The primary function of the Program Management Office is to develop tools for users. It developed *Project Suite* for tracking projects and querying projects information. (Internal FDOT access only, http://dotsd4design4b.d4b.dot.state.fl.us/PSuiteProd/default.aspx.) For introduction of the *Project Suite*, please refer to:
- http://www.dot.state.fl.us/projectmanagementoffice/PMConference2007/Presentations/6-4_Project_Suite-miro_files/frame.htm#slide0052.htm
- The office is undertaking an effort to make *Project Suite* a more compatible and powerful from a GIS perspective. This *Project Suite* interacts with other applications, e.g., SiteManager (SIM).
- D4 has undertaken a data integration project with a central repository called Project Suite (described above). It incorporates (SIM) from the Oracle instance in Central Office down to a local MS SQL Server implementation.
- Oversize vehicle map application

NEED FOR ENTERPRISE GIS

- District Four is characterized by three different types of users: 1) power users, 2) intermediate users, and 3) casual users. Intermediate users are the fastest growing group within the district, hungry for web-based tools and mapping capabilities similar to Google Earth, etc.

CONSTRAINTS/ENABLERS FOR ENTERPRISE GIS

- Issues with current GIS applications (statewide): Roadway Characteristics Inventory is a top priority. Currently, there is difficultly searching this resource. There is a need to search PITS data in an automated fashion.
- Asset Management in general appears to be totally lacking throughout FDOT accordingly to the Program Management Office. Very little of the data collected in the field (currently rolling out ArcPAD applications) is uploaded to the Central Office RCI for various reasons; hence, it ends up being stored locally in district spreadsheets and Access databases. This is a KEY problem that leads to data redundancies, lack of data conformity,

and poor data maintenance and upkeep. RCI data updating tools (i.e., web forms, etc) from Central Office are lacking and inadequate. Also, RCI is incomplete for several variables such as sidewalk, guardrail, light poles, and signs.

» Several field data collection issues. When coming back to sync data updates the same data must be entered multiple times in the RCI, MMS, and local databases.

» Videolog is not adequately utilized. Could be used for asset inventories (signs, signals, etc.) in an Enterprise GIS environment, but currently is only utilized to "virtually drive the roadway rights-of-way". District Four has linked the videolog into their Project Suite tools.

» Another key dataset used is stored within the Electronic Data Management System (EDMS). This dataset is as-builts. As-builts are construction plans and drawings that are utilized on a daily basis within the district. Unfortunately, there are data inconsistencies associated with this dataset as about half the as-builts are stored locally within the district and the other half is stored in the EDMS. Additionally, there are data access issues associated with both the locally stored and EDMS that makes it difficult for the users to find required information. Another issue is that the EDMS does not include spatial reference data, hence, the user has to remember a specific project number or description to access the as-built. An Enterprise GIS interface would be helpful to easily access this information.

» The Work Program is an essential part of district business. A few of the issues that could potentially be addressed through an Enterprise GIS include: 1) identification of non-road projects, 2) airport/trails/transit,(3) local roads (potentially supported by a Unified Base Map), and 4) SCOP/SCRAP/LAP/CIGP. District Four noted that it would be beneficial if Central Office would collect and provide information such as street names, city/county names, prefix, and suffix information (i.e., requirement for Unified Base Map)..

» Permitting Data: District Four identified a need for an Enterprise GIS interface to accessing permit data.

» Right-of-way Management: Current issue is every parcel needs to be digitized and referenced upon acquisition parcel number. Parcels need to be polygons, currently using intersecting lines in CADD format. Another opportunity for Enterprise GIS support.

» Aerial Photography: Current IVIEW application appears to have dated (2004?) imagery available. Need more frequently updated data. District Four currently collects 6-inch pixel data from participation with County governments. Need a raster catalog with tile caching to support faster access to image stores.

- PONTIS: GPS data included is currently erroneous in some places. Also, difficulty in data visualization/mapping.
- Safety: Interest in understanding Central Office and District Seven studies to see if applications/processes can be leverages in District Four.
- Drainage: Interest in getting better information regarding quantities, estimates, and permit inspection information in a live (mobile) environment.
- Railroads: Need to interface the current RHIC application for crossing location with other statewide datasets. Potential for Enterprise GIS integration.
- Airports: Apparently difficult for districts to access the statewide application airport GIS application. Therefore, District Four maintains their own data for this attribute.
- CADD Standards: State standards not firmly applied at the district level.
- Field Data Collection: There is a desire and need for hardware/software support: 1) SDE, 2) floating licenses, 3) Server/IMS, 4) management support, and 5) ArcGIS.
- Barriers: 1) Geodatabase version of district data is desired, 2) integrate Asset IDs to inventory, 3) management commitment, and 4) redundant Access databases throughout district need to be consolidated.

SUCCESS FACTORS

- District Four believes that the most efficient way to share and distribute data through the enterprise is through replication processes down to the district OIS groups via Oracle Clusters nightly, which would ensure timely responsiveness of the Enterprise GIS application. Currently, this has proven successful for the Central Office Primivera nightly data pushes.
- District preference to having Enterprise GIS system that is not over-customized so barriers to entry, training, etc. are reduced.

DISTRICT FOUR PLANNING AND EMO MANAGEMENT OFFICE

DEFINITION

- Enterprise GIS means to planning: collaborate, cooperate, and integrate.

Office Business Processes

- » Currently, Planning is developing an internal application called ESTlite to support development and upload of information to the EST, which functions are sometimes seen as too complicated.
- » Planning has been incorporating GIS in their Tier III Business Plan.

Need for Enterprise GIS

- » Planning's Management Team sees the need for a dashboard-type of application associated with the Enterprise GIS system. The Dashboard would provide performance information, easy access to the system (one click), and updates on when new data was added to Enterprise GIS.

Constraints/Enablers for Enterprise GIS

- Several issues with Structures (PONTIS) data. Limited access to the district. Also, there appears to be ownership issues with the TCI and PITS databases leading to data redundancy.
- Program Management Office notes that a new ArcServer application will be available in December that will have integrated access to PITS and SLD information.

- The PLEMO group has been maintaining contamination data local, but not updating Central Office or Statewide data sets. Therefore, this perpetuates the local data usage and development that is not available to other offices, departments, or districts. In addition, it is believed that the contamination data that is available from a statewide level is at least 25% inaccurate.
- CARS data is over 2 years old and not usable in its current state. Planning would like to have access to more timely CARS data.

Success Factors

- » Ownership of data is a key issue. A critical success factor for Enterprise GIS is that bad, inaccurate, not timely, and redundant data has to be fixed in the enterprise. A data validation tool with bulk uploads is needed from the districts to Central Office if the Enterprise GIS is to be successful.
- » There are financial barriers with the new funding allocation of 50% statutory and 50% needs based funding to support district data development and delivery needs. Perhaps Enterprise GIS can take some of the burden off the districts given these barriers.
- » Feedback is a critical success factor. Enterprise has been discussed and tried several times in the past and there is a continued feeling of "is something going to happen?" Follow-up will be essential to success.

District Four Design Office

Office Business Processes

» Design is maintaining some of their own databases that are not necessarily GIS enabled for drainage and utilities.

» Design uses the PEDS DB database from the Construction Department to review plans. This system is not user friendly.

Need for Enterprise GIS

» The Design group was very interested in implementing Google Maps as its mapping platform. They stated that they had difficultly using the internal District Four Web-GIS applications. It is undetermined how much of this may simply be a training issue.

» Design has needs for noise and environmental data, FM system, and SLDs.

Constraints/Enablers for Enterprise GIS

» There appears to be problems accessing as-builts and a standard naming convention was requested.

» Interested in having Right-of-Way maps in a digital format.

» Difficultly accessing permit information through PITS. Data is difficult to find.

» Design mentioned several issues with the road base map they are using and its inaccuracies. It is undetermined what was the source of the base map.

» It appears that the EDMS only stores documents and not plans. However, there remains to be a duplication of effort to store data in EDMS and PEDS DB.

Success Factors

» A critical success factor for Design is that they would like to see a professional software company design and develop the Enterprise GIS, rather than an engineering firm.

District Four Maintenance Office

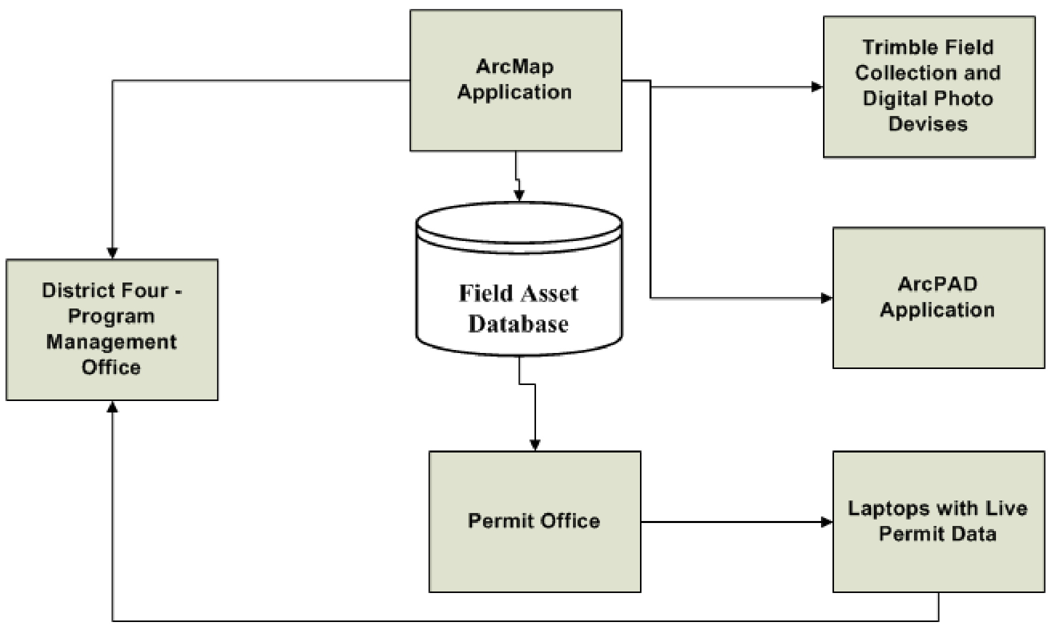
Office Business Processes

» Currently the yards are using ArcPAD for data collection of sign information including size, type, and condition data as well as digital photos. In the near future, they will be collecting guardrail and potentially sidewalk data.

» The maintenance group uses RCI, the Videolog, and PITS to extract permit data. However, there appears to be some double entry/data redundancy as Maintenance also maintains a local database of permit information.

» Maintenance has targeted an accuracy standard of submeter.

» Process flow for Field Collection:



NEED FOR ENTERPRISE GIS

» Maintenance would like for PONTIS to have a GIS interface to pull historical information.

» Maintenance envisions having a web-based GIS architecture to support MOAs and agreements at locations in the field as well as as-built accessible documents.

» Maintenance has some innovative ideas about the utilization of GIS for hurricane management (document damage and clean-up), NPDES – ponds and drainage inlets, and HazMat spill location analysis.

» Looking in the future to hopefully upgrade to ArcGIS Server to support mobile applications.

- » Maintenance would like a better tracker system for service calls.

Constraints/Enablers for Enterprise GIS

- The EDMS is not working for Maintenance. They have to look in two different places to find the plans information they need: EDMS and Image API. Often there are issues with finding plans and there is no GIS connection to either system to aid in searching.
- MOAs are stored in GIS and are working well.
- The Maintenance Management System (MMS) store bridge work orders, but there is not a GIS connection.
- Maintenance would be interested in an application to support routing and scheduling to MOA/permit areas.
- Maintenance brought up Site Manager for construction information, but there is no GIS connection.

Benefits of Enterprise GIS

- » The Maintenance Department and the Yards (from Palm Beach and Broward Operations) are energetic users of GIS. They see a great benefit in expanding the use of GIS to collect and maintain roadway assets in the field.

Success Factors

- » Maintenance supports the idea of Enterprise GIS having standards, WITH flexibility.

District Four Construction Office

Office Business Processes

- » Construction does not use GIS extensively at this time. The Department has one copy of ArcGIS.
- » Construction uses the internal web-based GIS supported by Program Management called Project Suite. In addition, they use the Planning Atlas Map made available from the Planning Office.
- » Construction uses Site Manager and EDMS, which currently does not have a GIS connection, but they would be interested in one.

Need for Enterprise GIS

- Construction would be interested in a GIS application that highlights construction status on a map as well as supports the development of the monthly Construction Progress Reports.
- Construction would like to see a GIS application that overlays FDOT construction projects with City/County/local construction projects in order to coordinate better on regionwide timing and issues associated with lane closures, etc.

Constraints/Enablers for Enterprise GIS

- Same issues with dual storage of plans in EDMS and Image API.
- Construction mentioned that there was a Central Office initiative called CIMS (Construction Information Management System) that was supposed to integrate Site Manager, EDMS, Work Program, and FLAIR (financial program) information. CIMS in the first Phase does not include a GIS link, but may in future phases. Jim Johnson, Kathy Lovett, and Don Sangrio, OIS can be contacted to learn more.

Success Factors

- Constructions key success factor is to be able to retrieve and use data easier.

9.0 Appendix C – Acronyms

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
AM	Automated Mapping
API	Application Programming Interface
A-PLUS	Aerial Photo Look-Up System
ARCIMS	Arc Internet Map Server
ARCSDE	Arc Spatial Database Engine
BED	Bridge Environmental Database
CADD	computer aided design drawings
CARS	Crash Analysis and Reporting System
CDMS	Crash Data Management System
CFGIS	Central Florida Geographic Information Systems
CIGP	County Incentive Grant Program Agreement
CIM	Contract Information Monitoring
CMS	Construction Management System
CPU	Central Processing Unit
CRS	Conditions Reporting System
CTPP	Census Transportation Planning Package
DBMS	Database Management System
DEM	Division of Emergency Management
DHSMV	Department of Highway Safety & Motor Vehicles
DRI	Developments of Regional Impact
DSS	Decision Support System
EDMS	Electronic Document Management System
EIP	Enterprise Information Portal
EIS	Enterprise Information System
EMIS	Equipment Management Information System

EMO	Environmental Management Office
E-SIS	Enterprise SIS (Planned)
ESRI	Environmental Systems Research Institute
EST (ETDM)	Environmental Screening Tool
ETDM	Efficient Transportation Decision-making
FDOT	Florida Department of Transportation
FGDC	Federal Geographic Data Committee
FGDL	Florida Geographic Data Library
FHP	Florida Highway Patrol
FHWA	Federal Highway Administration
FIHS	Florida Intrastate Highway System
FM	Facilities Management
FREAC	Florida Resources and Environmental Analysis Center
FSC	Functional Steering Committee
GFC	GIS Functional Steering Committee
GFT	GIS Functional Team
GIS	Geographic Information System
GIS-T	GIS for Transportation
GPS	Global Positioning System
GRIP	Geo-Referenced Information Portal
HPMS	Highway Performance Monitoring System
IMS	Internet Map Server
IRMC	Information Resource Management Council
ISD	Intermodal System Development
ISDM	Information System Development Methodology
ITS	Intelligent Transportation System
JAD	Joint Application Development
LAP	Local Assistance Program
LIMS	Laboratory Information Management System
LOS	Level of Service
LRM	Linear referencing method
LRS	Linear referencing system

LRTP	Long Range Transportation Plan
MCC	Motor Carrier Compliance
MMS	Maintenance Management System
MPO	Metropolitan Planning Organization
MRP	Maintenance Rating Program
MSC	Management Steering Committee
MSI	Materials and Supply Inventory system
NAD	North American Datum
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
OIS	Office of Information Systems
OPP	Office of Policy Planning
OVP	Oversized/overweight vehicles permit
PAI	Planning, Analysis, and Implementation
PCR	Pavement Condition Rating
PCS	Pavement Condition Survey
PD&E	project development and environment
PEDS	Professionals' Electronic Document Delivery System
PITS	Permit Information Tracking System
PLEMO	Planning and Environmental Management Program
PTF	Project Traffic Forecasting
PTO	Public Transportation Offices
PVB	Present Value of Benefits
PVC	Present Value of Costs
RCI	Roadway Characteristics Inventory
RHC	Rail Highway Crossing
RHCI	Rail Highway Crossing Inventory
ROI	Return of Investment
ROW	Right of Way
RoXI	Railroad Crossing Index
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act

SCRAP	Small County Road Assistance Program
SCOP	Small County Outreach Program
SDE	Spatial Database Engine
SHR	Skid Hazard Reporting
SIM	SiteManager
SIS	Strategic Intermodal System
SIT	Strategic Investment Tool
SLD	Straight Line Diagram
SMRO	State Materials and Research Office
SPO	Systems Planning Office
SQL	Structured query language
STRAHNET	Strategic Highway Network
TAIMS	Transportation Automated Information Management System
TCI	Traffic Characteristics Inventory
TEA 21	Transportation Equity Act for the 21st Century
TEAMS	Turnpike Enterprise Asset Management System
TERL	Traffic Engineering Research Laboratory
TIMS	Technical Information Management System
TIP	Transportation Improvement Program
TMC	Traffic Management Center
TMIS	Turnpike Management Information System
TSO	Transportation Statistics Office
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WP	Work Program
WPA	Work Program Administration