U.S. Department of Transportation
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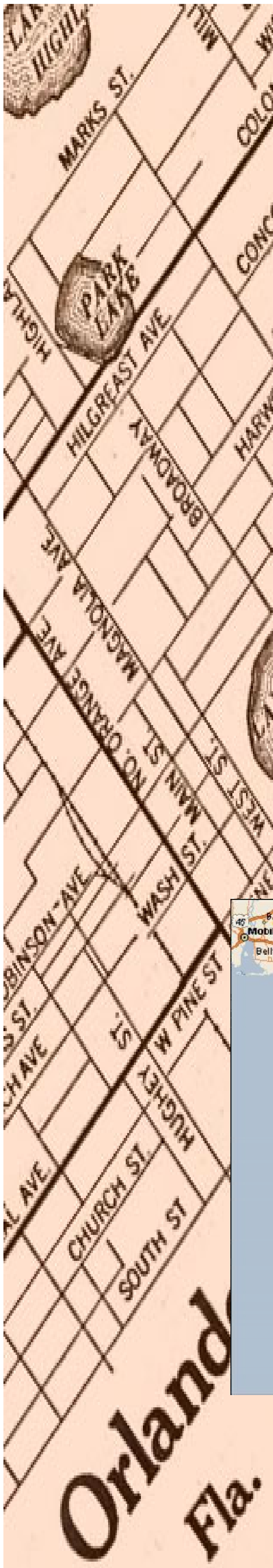
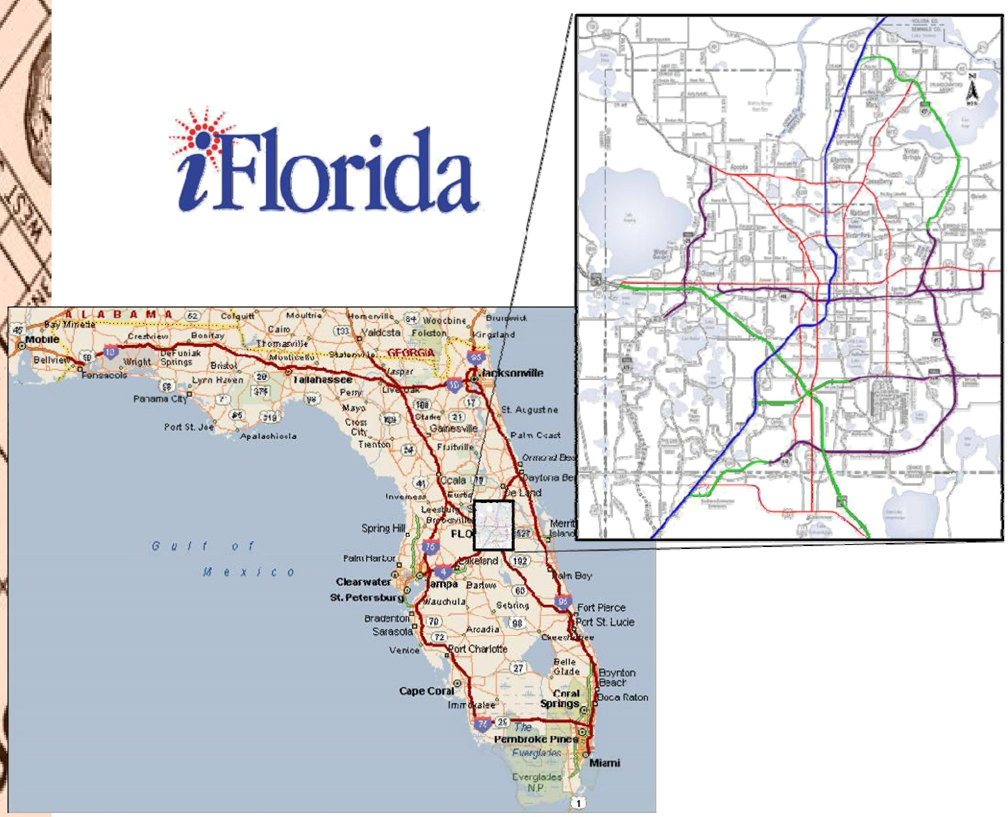


*i*Florida Model Deployment Final Evaluation Report

January 2009



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16. Abstract

This document is the final report for the evaluation of the USDOT-sponsored Surface Transportation Security and Reliability Information System Model Deployment, or *i*Florida Model Deployment. This report discusses findings in the following areas:

- ITS deployment and operations
- Maintaining a Network of Field Devices
- Using Toll Tag Readers for Traffic Monitoring
- Interfacing TMC and FHP CAD Systems
- Using Dynamic Message Signs for Traveler Information
- Implementing Variable Speed Limits
- Statewide Operations
- Evacuation Operations
- Traveler Information Operations
- Weather Data
- Transportation Security

It discusses costs and benefits associated with *i*Florida activities in each of these areas and lessons learned in pursuing those activities.

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Glossary of Acronyms

AVI	Automatic vehicle identification
CAD	Computer aided dispatch
CCTV	Closed circuit television
CFDW	Central Florida Data Warehouse
CRS	Condition Reporting System
DMS	Dynamic message sign
EOC	Emergency Operations Center
FDEM	Florida Division of Emergency Management
FDOT	Florida Department of Transportation, specifically referring to FDOT D5 within this document
FDOT D5	FDOT District 5
FHP	Florida Highway Patrol
FHP CAD	Florida Highway Patrol Computer Aided Dispatch
FHWA	Federal Highway Administration
FIHS	Florida Intrastate Highway System
FTP	File Transfer Protocol
GIS	Geographic Information System
HES	Hurricane Evacuation System
HLSCAM	Homeland Security Comprehensive Assessment Model
IOC	Integrated Operations Center
MADIS	Meteorological Assimilation Data Ingest System
NEXRAD	Next Generation Weather Radar
NWS	National Weather Service
OOCEA	Orlando-Orange County Expressway Authority
RFA	Request for applications
RTMC	Regional Traffic Management Center
RWIS	Road Weather Information System
SEOC	State Emergency Operations Center
SMIS	Surveillance Motorist Information System
SMS	Statewide microwave system
SOAP	Simple Object Access Protocol
TMC	Traffic Management Center
TTMS	Telemetered traffic monitoring site
UPS	Uninterruptible power supply
VSL	Variable speed limits

In Memoriam

Anne Brewer

Anne Brewer of the FDOT District 5 ITS Office was one of the originating forces behind FDOT's efforts to pursue the *i*Florida Model Deployment. She had a special gift for working with people, and it was through her efforts that the coalition of more than 20 partners was formed to propose *i*Florida to FHWA. Her power to bring people together continued to be a guiding force behind the *i*Florida Model Deployment throughout the first two years of the project.

Sadly, Anne died before seeing the project she helped begin come to fruition. Her guidance was missed on the *i*Florida project. More importantly, her joyous nature and her constant enthusiasm are missed by her family, her friends, and her co-workers—including those at FHWA and the evaluators who had the privilege of working with her. Anne, thank you for spreading your inner joy to all those who knew you.

Antoinette (Toni) Wilbur

Toni Wilbur passed away in April 2008 following a brief illness. She retired from the Federal Highway Administration following 35 years of distinguished service. As the Director of Operations Research and Technology at the Turner-Fairbanks Research Laboratory, Toni was a guiding force in crafting the *Surface Transportation Security and Reliability Information System Model Deployment* solicitation, which ultimately became awarded as the iFlorida Model Deployment.

Toni was the recipient of many service awards including the FHWA Administrator's Superior Achievement Award and the Strive for Excellence Team Performance Award. She was very much admired by her peers within the government and also with private sector partners of the transportation industry. Toni was also admired for her caring attitude, her generosity, her humor, and her patience. Toni, thank you for being a mentor to so many and a friend to all who knew you.

Executive Summary

The iFlorida Model Deployment began in May 2003 with ambitious goals and high hopes for what could be accomplished. *i*Florida plans called for the Florida Department of Transportation (FDOT) District 5 (D5) to complete the design, build, and integration of the infrastructure required to support *i*Florida operations in 2 years. The required infrastructure was extensive, spanned numerous stakeholders, and included many technologies that were new to FDOT D5, such as sophisticated traffic management center (TMC) operations software, a wireless network deployed along I-4, an interface to Florida Highway Patrol Computer Aided Dispatch (FHP CAD) data, statewide traffic monitoring, and many others. The *i*Florida plans also called for deployment of these technologies in ways that required coordination among more than 20 stakeholders. It was an ambitious plan that would result in dramatically different traffic management operations for FDOT D5 and other transportation stakeholders in the Orlando area.

While pursuing this plan, FDOT faced many challenges, ranging from higher failure rates than expected for some field hardware to difficulties with the Condition Reporting System (CRS) and Central Florida Data Warehouse (CFDW) software. Despite these challenges, it can be readily claimed that the overall *i*Florida Model Deployment was successful. When limitations within the automated systems were discovered, FDOT developed ways to continue to support key traffic management capabilities. When the reliability of the arterial toll tag readers was lower than expected, FDOT modified the way messages were presented in the 511 system to reduce the impact of the missing data on 511 messages. When the CRS travel time estimation process proved inaccurate, FDOT deactivated messages that were known to be flawed. Later, it developed standard messages that could be used during uncongested periods and had operators manually create messages when congestion occurred. When the FHP CAD interface failed, a new interface was developed so that RTMC operators could continue to receive data about FHP CAD incidents. After problems with the CRS's ability to manage sign messages were observed, FDOT had RTMC operators periodically review sign messages to ensure that the correct message was being displayed and, later, had RTMC operators manage all sign messages manually. When the CFDW failed to create useful archives of CRS data, FDOT archived copies of many of the raw data streams that were being provided to the CRS.

Many of the challenges faced by FDOT centered on limitations and failures of the CRS software. FDOT, aware of the problems with the CRS and anticipating the potential that it might fail, began testing SunGuide, a replacement for the CRS, in November 2006. First, FDOT installed an existing version of the SunGuide software and configuring it to manage recently deployed ITS equipment on and near I-95. When the CRS failed in May 2007, FDOT began expediting a transition to this new software. By September 2007, FDOT was operating a Beta release of the SunGuide 3.0 software, and sharing its operational experiences with the software developers. This close interaction enabled FDOT to continue to use the SunGuide software and regain the operational advantages that could not be obtained through the CRS.

Through its willingness to develop alternative means to overcome the challenges and barriers it faced, FDOT ensured continued traffic management operations. The difficulties associated with the *i*Florida Model Deployment also provided many opportunities to identify lessons learned from the experiences they had. The most important of these are described in the list below.

- **Following sound systems engineering practices is one key for successfully deploying a complex software system like the CRS.** The CRS project began with high-level requirements defined, and the CRS contractor did not refine those broad requirements into more detailed ones. Systems engineering approaches that are less reliant on detailed requirements, such as a spiral model, were not employed. Inadequate requirements led to misunderstandings about the capabilities expected from the CRS and to insufficient testing of the software. The software development process spiraled out of control and ended with CRS software that was not usable and that ultimately was abandoned. Applying sound systems engineering practices more rigorously could have resulted in more usable code or helped FDOT more quickly determine that the contractor was not performing. Better requirement definitions up front might have prevented changes that occurred throughout the development phase. More stringent testing by the contractor might have identified problems earlier in the development cycle when they could be more easily corrected. Closer monitoring of this testing might have allowed FDOT to more quickly determine that the software was not meeting requirements

- **It is important to devote a significant amount of time at the beginning of a software development project to ensure that all parties share a mutual vision for how the resulting software should operate.** The starting point of the CRS project was a set of high-level requirements developed by FDOT. A number of meetings were held between FDOT and CRS contractor staff to review these requirements. Despite this, the requirements often left room for interpretation, and differences of opinion between FDOT and the CRS contractor about how the CRS should operate continued throughout most of the time the CRS was under development. No mutual vision of how the software should operate was developed. With SunGuide, FDOT was provided with an early version of the software and FDOT configured the software to work with a set of recently installed FDOT hardware. FDOT worked directly with SunGuide technical staff to resolve difficulties and to define enhancements to current features needed to meet FDOT needs. This evolutionary approach resulted in a shared vision of how the software should operate.
- **Software must be capable of interfacing with subsystems and the nature of the interaction must be well-defined.** With the CRS, long-standing problems occurred with the interfaces between the CRS and almost every other external system with which it interfaced—the FHP CAD system, the weather provider, the travel time server, and the DMS signs. Only the interface between the CRS and the 511 system worked reliably.
- **Plan to integrate newly deployed field equipment into existing monitoring and maintenance processes.** Most *i*Florida field equipment included a two-year parts and labor warranty period that covered the planned two-year operational period for the iFlorida Model Deployment. FDOT seemed to have the expectation that most of the maintenance would be the responsibility of the contractors. FDOT found, however, that significant resources were still required to monitor the equipment and to manage the maintenance activities. For example, when a failure could be the responsibility of more than one contractor, FDOT was required to use their maintenance resources to identify the specific failure so that the appropriate contractor could perform the warranty repair. FDOT was not prepared for this increased demand on its own maintenance resources. The arterial toll tag readers were deployed and tested over a 4-month period beginning in February 2005, yet little or no follow up testing was performed on these devices to ensure they continued to operate until June 2005. By that time, almost half the readers had already failed. This caused a large surge in maintenance demand. FDOT did not have access to sufficient maintenance resources to diagnose these failures and the warranty contractor did not have access to sufficient spare parts to make repairs in a timely manner. Similar problems affected other iFlorida systems, including the Statewide Monitoring System, the

bridge security system, and the broadband wireless system; deployment of these systems was completed before FDOT had developed a process for monitoring and maintaining them.

- **Because traffic monitoring equipment will fail, systems that rely on data from this equipment should be designed to work well when these inevitable failures occur.** At FDOT, key equipment such as loop detectors, DMSs, and toll tag readers were available about 90 percent of the time. Reaching this level of service was difficult, and FDOT rose to the challenge of doing so. Even with this level of service, the *i*Florida systems were regularly required to operate with missing data. Initial *i*Florida plans called for filling in missing data with estimates from historical data or operator observations, but these plans did not come to fruition. Early in the operational period of the deployment, data gaps led to long periods of times where DMSs were blank and 511 messages were incomplete.
- **Use a staged approach for deploying new systems.** The schedule for the *i*Florida deployment called for the nearly simultaneous deployment of a large number of systems new to FDOT. In many cases, this resulted in deployment delays. For example, problems with the toll tag readers meant that data was not available to test the OOCEA travel time server and travel times were not available to test the CRS features that depended on them. This sometimes led to resource conflicts: it appeared that FDOT focused so many maintenance resources on repairing failed toll tag readers that maintenance of other equipment slipped. In the case of the VSL signs, the equipment was deployed, but variable speed limits were not implemented during the planned iFlorida operational period because the CRS features needed to manage variable speed limits did not work satisfactorily. (FDOT did use variable speed limits after the CRS was abandoned and FDOT began using SunGuide.) *i*Florida weather data was not used, in part because FDOT's focus on getting its primary traffic management tools working correctly prevented it from spending time on integrating weather data into its traffic management activities.
- **Traffic monitoring may not be the best approach to obtaining data for statewide traveler information.** FDOT found that the statewide monitoring system it deployed was too sparse to be an effective tool for obtaining statewide traffic information. Instead, it primarily used incident information from the FHP CAD system. However, the FHP CAD system did not cover all the roads for which FDOT wished to provide statewide traveler information. Some FDOT staff suggested that they could have had better statewide traveler information if they had developed methods for receiving incident data from other law enforcement organizations in the state. It should be noted that, while FDOT staff found the Statewide Monitoring System ineffective at supporting traveler information, SEOC staff members believed that the system would be very useful for monitoring hurricane evacuation traffic.
- **Travel time estimates should be validated before being used for traveler information.** The CRS software miscalculated travel times that were used for DMS messages, resulting in inaccurate travel times being displayed to the public. Concerns existed that the dissemination of inaccurate travel time messages on DMSs may have reduced public confidence in traveler information. One *i*Florida stakeholder suggested more stringent testing for all processes that produce traveler information for public consumption.
- **Estimates of future traffic demand were needed to support contraflow decision-making.** During Hurricane Frances, it was estimated that it would require 3 hours to set up contraflow on SR 528. The long setup time and the fact that contraflow operations were not allowed at night in Florida effectively required that a contraflow decision be made a day before such operations were to be implemented. Because contraflow decisions must be made based on estimates of

what is essentially future traffic demand, estimates of the number of people expected to evacuate may be more important for contraflow decision making than real-time traffic information. Also important are estimates of traffic demand in the opposite direction. In one case, FDOT expected significant eastbound demand due to cruise ship passengers flying in to Orlando before traveling to the coast to board ships. Concern for servicing this demand was one factor considered when determining whether to implement westbound contraflow on SR 528.

- **Consider the needs of existing users when changing the 511 menu structure.** The *i*Florida deployment resulted in a significant change to the 511 menu structure. This change was necessary so that the 511 system could accommodate all the additional roads brought into the system by *i*Florida. When the the new 511 system was put into use, FDOT received a number of complaints from existing 511 users about the new menu. It appeared that many of these users may have reduced their usage once the new system was in place. Putting in place a mechanism to accommodate these existing users, such as providing access to the old menu structure, could have reduced the number of complaints received and the drop in callers that occurred.
- **The voice recognition system can be a source of problems with 511 systems.** About one time in seven, the *i*Florida 511 system rejected a user utterance as an invalid command. Because most calls required the user to make several commands to reach the desired information, almost 50 percent of calls included at least one case where the system rejected a user utterance. This meant that a number of 511 calls ended without the caller receiving any traffic information. FDOT's My511 program helped reduce the number of commands needed to reach traveler information for those that registered with the system.
- **Few 511 callers could be classified as frequent callers.** In a typical week, less than 300 users called the system at least four times during the week on at least three different days. Of the users that called frequently in a given week, less than half called frequently in the following week. This implied that few 511 callers use the system for daily trip planning. Instead, it appeared that most callers used the system to find out more information about unusual traffic conditions of which they were already aware.
- **Few callers took advantage of traveler information available for Orlando arterials and toll roads.** About 80 percent of the requests for traffic information from the Central Florida 511 system were for I-4 and I-95, with requests for information on toll roads and arterials being about 15 and 5 percent of calls, respectively. A survey of travelers in the Orlando area indicated that the traveler information of greatest interest to the respondents was related to diversions and detours, such as instructions for how to bypass an incident that has occurred.
- **False alarms can be a problem with a bridge security system.** The high number of false alarms in the *i*Florida Bridge Security Monitoring System meant that alarms were often ignored. It appeared that the highly dynamic environment of a bridge made it difficult to specify automated video monitoring tests that would alarm if suspicious activity occurred but that would not generate false alarms. It is not clear if additional tuning of the video monitoring settings could have resulted in a better balance between sensitivity to suspicious activity and ability to reject false alarms or if a better balance is not possible with current automated video monitoring technology.

There were also opportunities to observe lessons learned about FHWA's role in the model deployment, such as those listed below.

- **Clarify expectations for a model deployment.** As FDOT struggled to get most of the arterial toll tag readers operational for the *i*Florida unveiling, FHWA staff noted that it might have been better to begin *i*Florida operations with only a subset of the readers operational, phasing in the other readers over time. FDOT staff received this recommendation with surprise, as they were under the impression that the entire suite of *i*Florida systems should be operational throughout the planned *i*Florida operational period. FHWA staff noted that a model deployment, by its very nature, involves many leading edge technologies and that problems should be expected.

- **Leverage FHWA experience and expertise.** Some members of the FHWA team had experience and expertise that could have benefited FDOT. For example, FDOT had little experience with large, software acquisitions, and FHWA offered to provide the US DOT Research and Innovative Technology Administration (RITA) ITS Software Acquisition course to FDOT personnel involved in the *i*Florida deployment – this offer was declined. FHWA also suggested that developing a detailed *i*Florida Concept of Operations would help guide the deployment and operations after the deployment was completed. Following these suggestions could have helped avoid some of the problems that occurred related to the development of the CRS.
- **Maintain a local presence of experienced FHWA personnel at the deployment.** While FHWA participated in key meetings, such as those to review requirements and *i*Florida designs, there was little FHWA presence at FDOT between those meetings. This sometimes reduced the extent to which FHWA recommendations were followed during the deployment activities because FHWA staff members were not onsite to continue to push these recommendations. It is also possible that local presence of FHWA staff members would have helped FDOT understand that it was acceptable to incrementally deploy *i*Florida capabilities, which could have eliminated some of the problems that occurred as FDOT attempted to simultaneously deploy so many new traffic management capabilities. There were also times when FHWA was not fully aware of potential for the *i*Florida schedule to slip because of the deployment problems that were occurring. A local presence would have been more aware of these problems.

Many other observations were made during the evaluation over a broad range of topics, ranging from general suggestions regarding how to design, deploy, and maintain transportation system hardware and software to specific suggestions related to the operation of specific types of transportation management systems, such as interfacing with FHP CAD systems, using DMSs, and implementing traveler information. These observations are noted throughout the body of this report.

As a Model Deployment, the *i*Florida project was a success. It demonstrated the capabilities of several leading edge transportation technologies, such as using toll tag readers to collect arterial travel times and automated generation of travel time information. It also demonstrated the integration of these technologies with traffic management software used to help perform and automate traffic management activities. Even the challenges faced by FDOT during the deployment – challenges that sometimes limited the benfits seen by FDOT – provided useful lessons learned that can benefit future deployments.

For example, the lack of a clear *i*Florida concept of operations led to uncertainties about the basic operational practices that the CRS should support. The CRS requirements were vague and left some of these uncertainties unresolved almost 2 years into the deployment efforts, only months before *i*Florida operations were scheduled to begin. The operational concepts and requirements also did not consider how operations would be affected by different failures that might occur. For example, FDOT purchased new VSL signs in 2008, in part because the signs originally purchased did not operate in an acceptable manner if communication was lost to one of two signs deployed at a single location. Future deployments should consider developing a detailed concept of operations that describes how the system will be used, including how it will operate when different failures occur.

Another source of these challenges was trying to accomplish too much too quickly. *i*Florida had the potential to dramatically change the way FDOT D5 and other *i*Florida stakeholders managed traffic. It greatly increased the number and types of field hardware that needed to be maintained. It also extended the scope of RTMC operations from managing traffic on I-4 to helping to manage traffic on Interstates, toll roads, and arterials in the Orlando area and on major highways statewide. RTMC operations also became responsible for working with both new types of data (e.g., automated travel times, FHP CAD incidents, weather conditions) and new systems (e.g., bridge security, LYNX bus security). The RTMC operations environment also needed to evolve from one in which RTMC operators manually managed resources such as DMS and 511 messages to one in which many activities were automated.

The compressed *i*Florida schedule also led to challenges. Many systems were under simultaneous design and the interdependencies between these systems were difficult to manage. Problems with the deployment of the arterial toll tag readers made it difficult for OOCEA to test the travel time server they were developing. Delays in the availability of OOCEA travel time data made it difficult to test the CRS travel time processing tools. Problems with CRS travel time processing made it difficult to test the CRS travel time DMS message tools. When problems were discovered after the initial version of the CRS software was released in November 2005, it was not clear which of the various components that made up the *i*Florida suite of interdependent software and hardware were working reliably and which were not. Future deployments should consider implementing these changes incrementally rather than simultaneously.

FDOT staffing plans may not have full considered the demands that would be placed on their staff by the simultaneous deployment of so many new systems. FDOT staff was sometimes stretched thin, simultaneously trying to manage *i*Florida deployment projects, integrating new hardware into their maintenance process, and developing new procedures for managing *i*Florida operations. Maintenance staff and procedures, appropriate for pre-*i*Florida levels of field hardware, proved insufficient for the increased workloads that came with maintaining the *i*Florida field equipment. When problems with individual *i*Florida projects developed, the situation worsened. Efforts to repair toll tag readers that had failed affected FDOT's ability to maintain other field hardware. Eventually, a de facto triage occurred as resources were focused on maintaining critical field hardware (e.g., loop detectors, toll tag readers, DMSs) and performing critical transportation activities (e.g., managing DMS and 511 messages), leaving less critical hardware (e.g., RWIS stations, statewide monitoring stations) and less critical operations (e.g., bridge security, LYNX bus security, use of weather data, VSL, data warehousing) to languish. Future deployments should consider estimating the demands that new deployment activities will place on existing staff to ensure that sufficient staff exists to handle the increased demands. Scheduling activities so that periods of high staff demand (e.g., requirements development, verification and validation) do not occur simultaneously for different projects can help reduce the impact on DOT staff.

By the end of the *i*Florida operational period, FDOT was beginning to overcome the last of the challenges they faced with the *i*Florida Model Deployment and were beginning to see the full benefits they had expected. FDOT had abandoned the CRS software and acquired new software, SunGuide, which provided more of the functionality that the agency was seeking. Interfaces that were unreliable under CRS (e.g., DMS, FHP CAD) were working under SunGuide. With critical operations working more reliably, FDOT began to focus on adding new capabilities to their traffic management operations, and new features were added to the 511 system. FDOT implemented variable speed limits and began to consider how to integrate weather data into its traffic management operations. Other regional transportation stakeholders began discussions with FDOT about using SunGuide and gaining access to *i*Florida data. FDOT was, at last, beginning to realize the full potential that was visualized when the *i*Florida Model Deployment began.

1. Introduction

The *i*Florida Model Deployment began with the Federal Highway Administration's (FHWA) release of a request for applications (RFA) entitled *Surface Transportation Security and Reliability Information System Model Deployment*. In this document, FHWA called for a model deployment to examine how the widespread availability of real-time transportation information would enhance the security and reliability of the surface transportation system. Florida Department of Transportation (FDOT) District 5 (D5) responded to this request with a proposal for a model deployment entitled "*i*Florida."[1] This proposal laid out plans for a model deployment that consisted of activities in the following seven areas:

- The *i*Florida plans for *metropolitan operations* would be supported by deploying a network of real-time traffic sensors and traffic surveillance cameras on both limited access highways and arterials in the Orlando metropolitan area, as well as interfacing to the Florida Highway Patrol Computer Aided Design (FHP CAD) system and contracting for receipt of weather data. Data from these sources would be consolidated by Transportation Management Center (TMC) decision support software and used to control traffic management resources such as dynamic message signs (DMS), variable speed limits (VSL), 511 messages, and road ranger (motorist assistance) activities. Other activities would help coordinate between organizations involved in traffic management in the Orlando area. The City of Orlando Integrated Operations Center (IOC), the Brevard County Emergency Operations Center (EOC), Orlando-Orange County Expressway Authority (OOCEA), and the LYNX transit agency would all be connected to the FDOT Intelligent Transportation Systems (ITS) network to facilitate sharing information. FHP patrol cars would be issued laptops that could connect to the ITS network through a broadband wireless system deployed along a portion of I-4.
- The *i*Florida plans for *statewide operations* would be supported by deploying a statewide network of traffic sensors and surveillance cameras at select locations throughout the state. This data, as well as incident data from the FHP CAD system and weather data, provided the basis for supporting statewide traveler information systems (i.e., 511 and a Web site). One novel feature of the statewide data collection was the use of available bandwidth in an existing microwave network to provide network connectivity to the statewide network of traffic sensors and cameras.
- The *i*Florida plans for *traveler information operations* would be supported primarily through Central Florida and a Statewide 511 system and a Web site that provided access to both Central Florida and statewide traveler information. A large number of additional dynamic message signs would also be deployed along with variable speed limit signs to provide other means of providing traveler information to the public.
- The *i*Florida plans for *evacuation operations* would be supported by deploying a series of traffic monitoring stations along SR 528, a key evacuation route between the east coast and Orlando. This route is one for which contraflow, the temporary reversal of traffic direction, might be used during an evacuation. Several organizations involved in evacuation decision making, including the Orlando IOC, the Brevard County EOC, and the State EOC, would be provided with network connectivity so that they could access *i*Florida data. Bridge wind speed monitors were

[1] The *i*Florida deployment was led by FDOT D5, not the FDOT central office. To improve readability of this document, the acronym FDOT is used to refer to FDOT D5 throughout this document. When there is a possibility of confusion, "Florida Department of Transportation" rather than "FDOT" is used to refer to the department as a whole.

deployed on two bridges to support bridge closure decision making in case of high winds. FDOT also expected to use its traveler information resources to support evacuation operations.

- The *i*Florida plans for *weather information* included two types of weather data to support FDOT traffic management activities. FDOT would deploy a number of road weather information system (RWIS) stations, including wind speed stations on two bridges. FDOT also would contract to receive weather data from a company that specializes in providing weather data customized to specific assets.
- The *i*Florida plans included five projects, listed below, related to *security*:
  - An automated system to monitor the security of high-priority bridges.
  - An on-board alarm system on Orlando LYNX transit system buses that can transmit real-time video from the bus interior to the LYNX operations center.
  - A vulnerability assessment of the FDOT D5 Regional Traffic Management Center (RTMC).
  - The use of traffic modeling to test transportation strategies that might be applied if a security incident occurs.
  - The development of an emergency evacuation plan for the Daytona International Speedway and recommended practices for similar emergency evacuations.
- The *i*Florida plans called for consolidating all of the data described above in a *data warehouse* and archiving the data for future analysis. Other organizations could request access to this data warehouse.

The remainder of this section provides a more detailed description of the model deployment activities and the software and hardware and deployed to support it.

1.1. Metropolitan Traffic Operations

Before *i*Florida, the primary traffic monitoring system being used in the Orlando area was the I-4 Surveillance Motorist Information System (SMIS), which included 70 loop detectors spaced at roughly half-mile intervals over a 39-mile stretch of I-4 with 50 closed circuit television (CCTV) cameras. The FHP Troop D dispatch center, which was co-located with FDOT in the D5 RTMC, also received 911 and FHP calls reporting information about incidents.

Several additions to Orlando traffic monitoring were programmed outside of the *i*Florida deployment. The SMIS was extended an additional 26 miles so that it reaches from US 27 in Kissimmee in the west to Daytona Beach in the east. A similar network of sensors and cameras was deployed on I-95 as part of the Daytona Area Smart Highways (DASH) project. The OOCEA implemented a transponder-based travel time data collection system that covered all of the toll roads under its authority and began deploying 111 CCTVs throughout its network. Eight CCTVs were deployed on the Florida Turnpike between mileposts 263 and 267. On the arterials, the City of Orlando deployed 9 CCTVs at key intersections and Orange County deployed an additional 7 CCTVs.

The *i*Florida deployment complemented these programmed changes with the following additional traffic monitoring capabilities:

- Transponder-based travel time monitoring was implemented on the Florida Turnpike, the western end of SR 528, and the northern and southern ends of SR 417. These travel times complemented those delivered by OOCEA to provide complete travel time coverage for toll roads in the Orlando area.

- The seven highest priority arterials were equipped with transponder-based travel time monitoring. The monitored arterials were US 17, US 441, SR 50, SR 436, SR 423, and SR 414.
- License plate readers were deployed to monitor travel times on US 192 and SR 520.
- Eighteen micro-loop detectors were deployed at about 1-mile intervals along SR 528 from SR 520 in the west to almost A1A in the east. Four additional detectors were placed on the parallel portion of SR 520. (This traffic monitoring capability was meant primarily for monitoring evacuation traffic.)
- CCTVs were deployed at 12 key arterial intersections, with 2 additional cameras deployed to monitor traffic at the intersections of A1A with SR 528 and SR 520, respectively.

Altogether, the programmed and *i*Florida deployments provided complete traffic flow monitoring on Orlando limited access highways and on 128 miles of the most important arterials, as depicted in Figure 1. In this figure, the shaded roads are those for which traffic monitoring was available after the *i*Florida deployment was complete. This included roads that were instrumented as part of *i*Florida (e.g., red for arterials, green for Florida Turnpike), as well as roads that were instrumented as part of other initiatives (e.g., blue for SMIS on I-4, purple for OOCEA travel time program on toll roads).

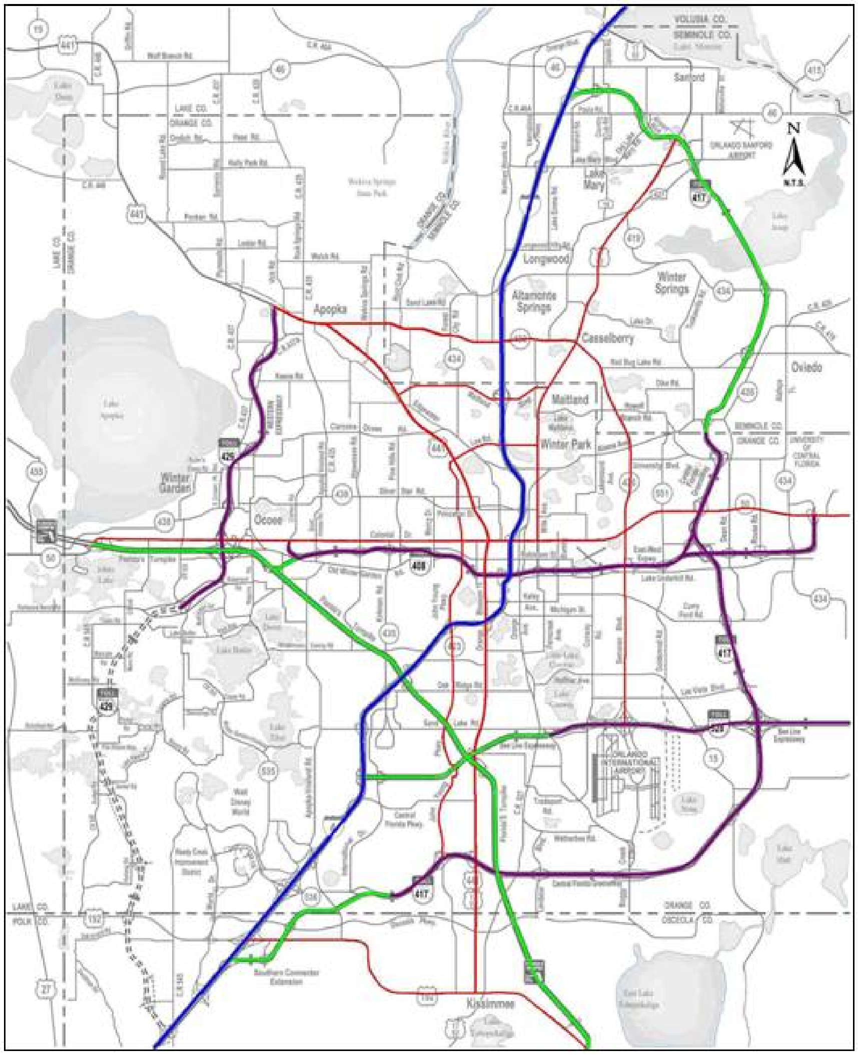


Figure 1. Orlando Metropolitan Area Operations

Not shown in this figure are the traffic monitoring on I-4 that extends north and east to the intersection of I-4 with I-95, the traffic monitoring on I-95 east of Orlando near the coast, and the traffic monitoring on SR 520 and SR 528 between the eastern coastline and Orlando.

1.1.1. Traffic Detection on I-4

Figure 2 depicts the locations of the SMIS traffic monitoring stations on I-4 in the Orlando area.

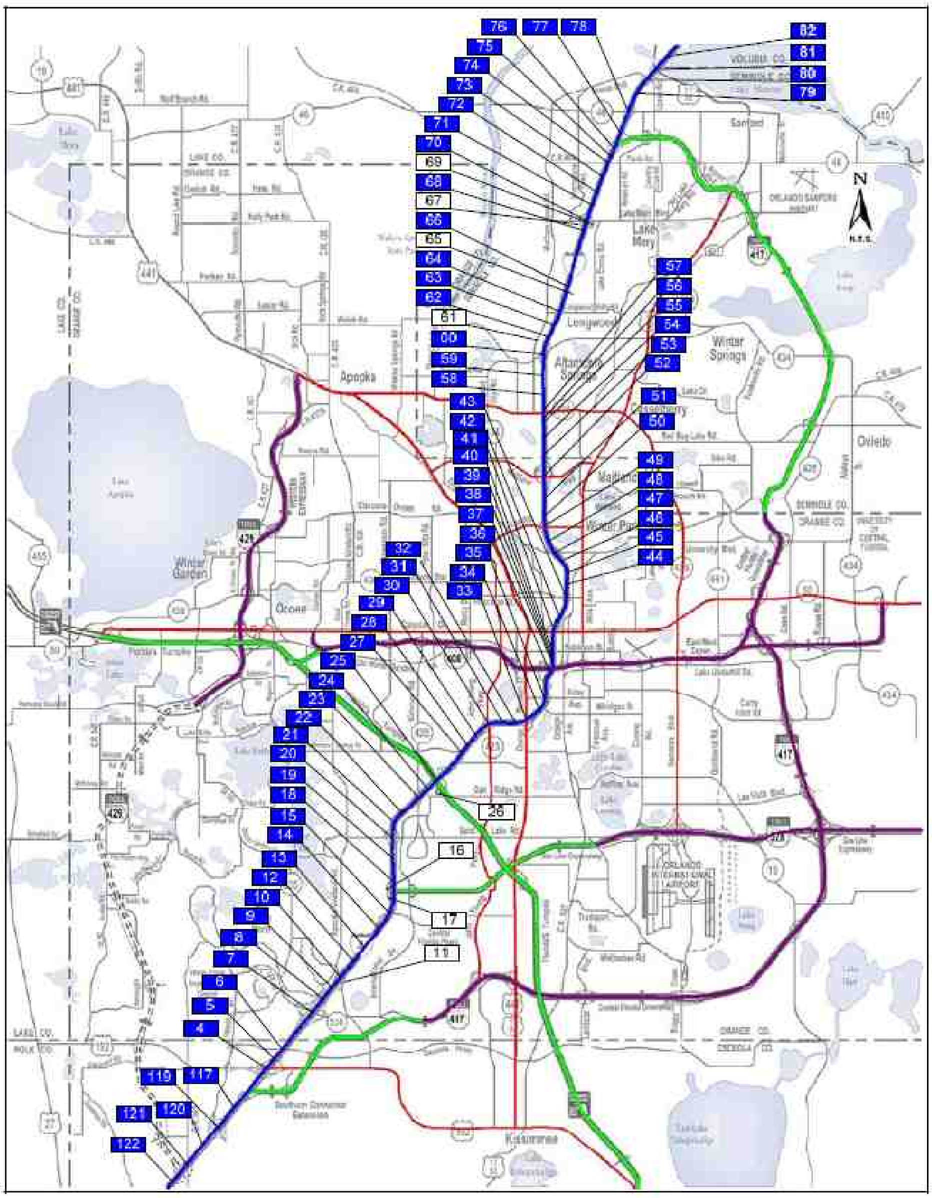


Figure 2. SMIS Traffic Monitoring on I-4 in the Orlando Area

Each traffic monitoring station measured volume, speed, and occupancy, either using dual loops or Wavetronix radar. The stations on the mainline (shaded blue in the figure) were spaced at roughly half-mile intervals. Additional stations (not shaded in the figure) were used at some entrances and exits. Traffic monitoring on the depicted region of I-4 existed prior to the *i*Florida Model Deployment.

1.1.2. The FDOT AVI Travel Time Network

In order to monitor traffic conditions on other roads in the Orlando area, FDOT deployed a collection of toll tag readers, as shown in Figure 3.

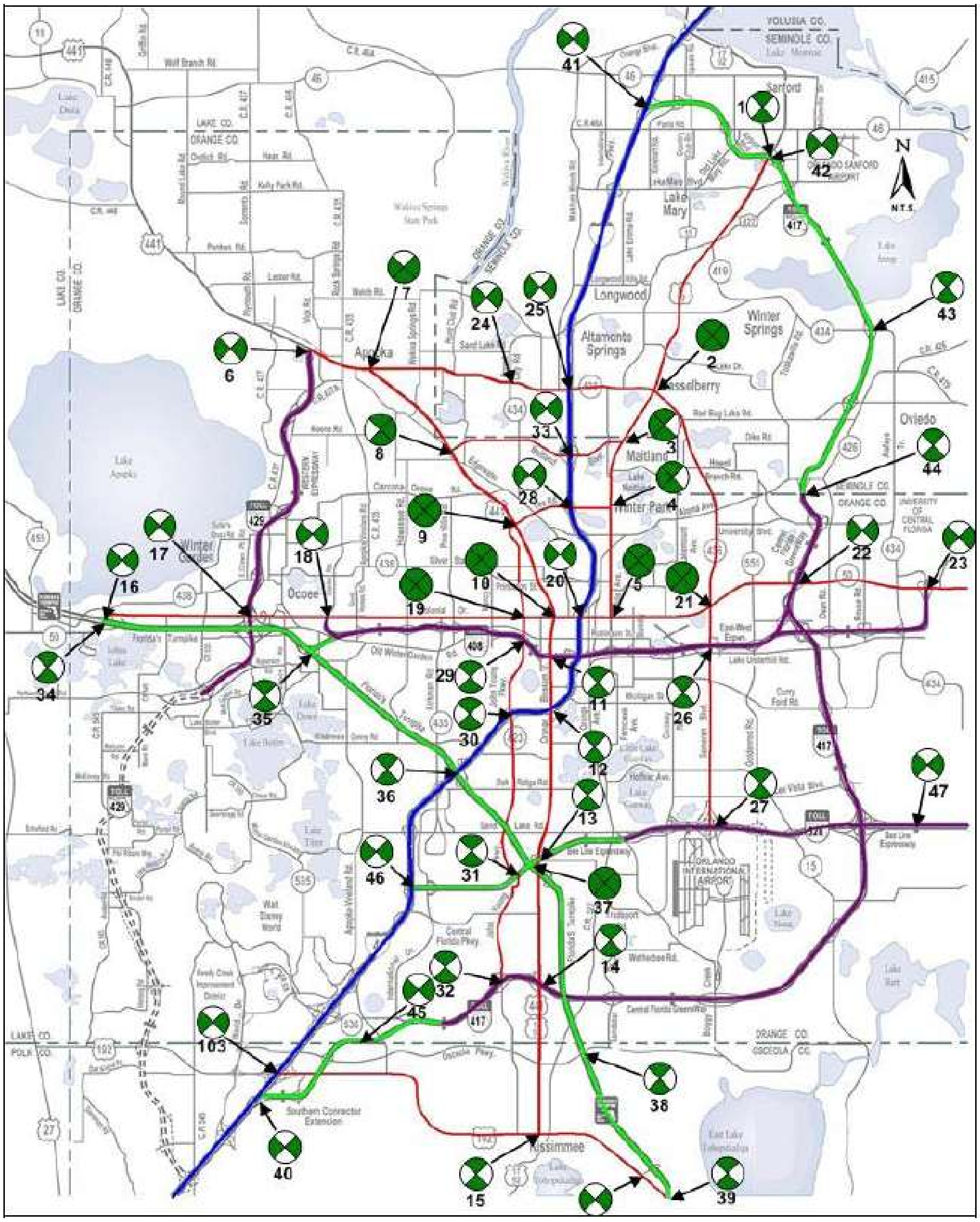


Figure 3. The *i*Florida AVI Network

In this figure, each circular icon represents a location at which toll readers were deployed, with the shaded quadrants indicating the directions of travel that were monitored. For example, if the upper quadrant is shaded, then toll tags are read for northbound traffic. In total, FDOT deployed 119 toll tag readers that provided travel times on 78 arterial travel time links and 24 toll road travel time links. The average length of the arterial travel time links was about 3.5 miles, with the average length on the toll roads being just over 6 miles.

1.1.3. The OOCEA AVI Network

OOCEA deployed a denser network of toll tag readers, deploying about 150 readers to create 163 travel time links with an average link length of 1.6 miles (see Figure 4).

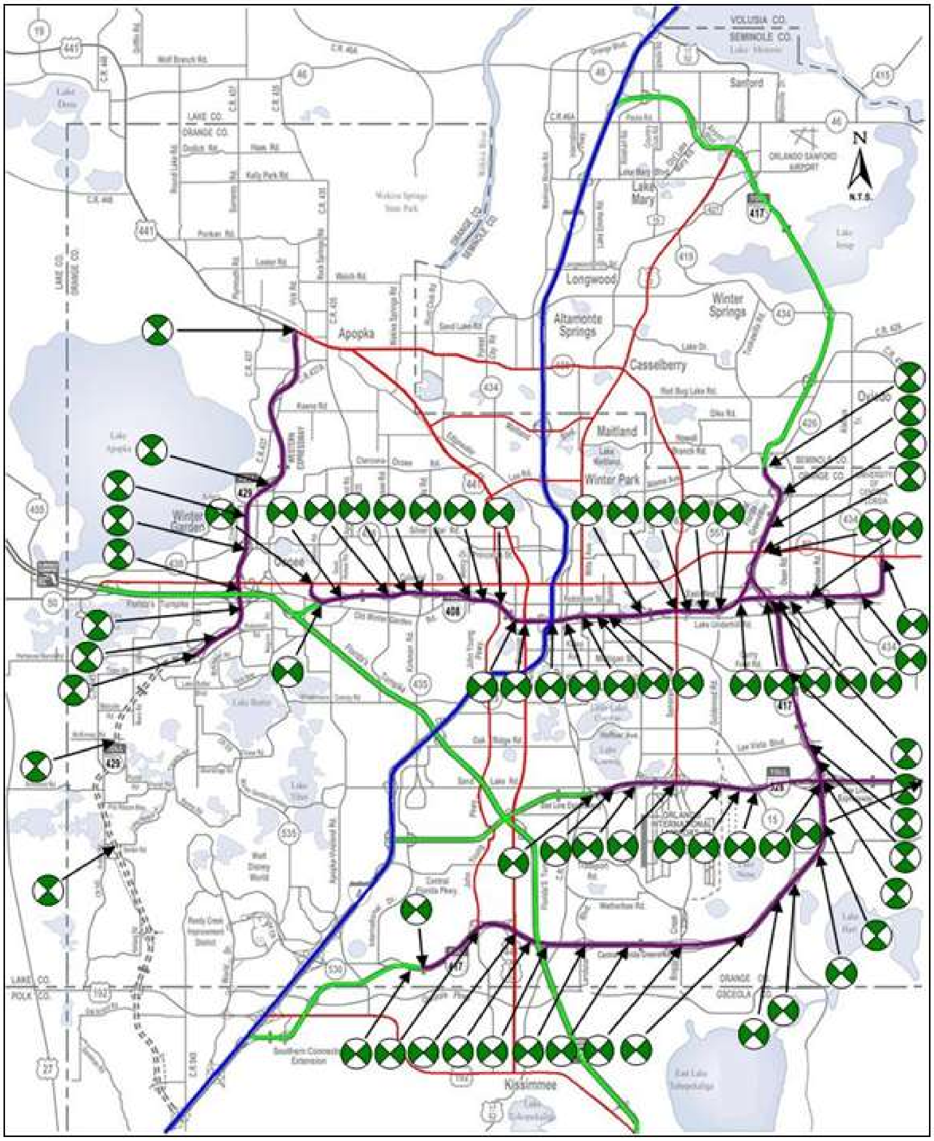


Figure 4. The OOCEA AVI Network

The dense network of detectors meant that the OOCEA network provided several capabilities not possible for the sparser *i*Florida AVI network:

- *More accurate estimates of the average travel time.* The closer sensor spacing of the OOCEA AVI network provides fewer opportunities for vehicles to divert between the sensors, which will result in more travel time measurements and fewer outliers caused by vehicle diversions. Both of these factors make the average of the travel time measurements a more accurate estimate of the average travel time. In the case of the OOCEA AVI network, greater travel time accuracy was also achieved by separately measuring travel times for long interchange ramps. This allows route travel times to better consider the time required to navigate interchanges.
- *More timely travel time estimates.* In general, closer sensor spacing for a toll tag travel time network does not directly result in more accurate travel time measurements; each measurement is an accurate measurement of a vehicle travel time. Closer sensor spacing does reduce the latency of

the travel time measurements. (A travel time measurement is completed when a vehicle reaches the endpoint of a segment, so receipt of that measurement is delayed by the time it takes the vehicle to drive the segment. A longer segment results in a greater delay.) More timely travel time estimates more accurately represent current traffic conditions.

- *Resilience in case of a detector failure*. If a sensor failed in the OOCEA AVI network, the travel time generation software would automatically combine adjacent travel time segments so that travel times were still produced for the combined segment. The short spacing between the toll tag readers in the OOCEA AVI network meant that segments created by combining nearby segments were still short enough to provide useful travel time data.[2]
- *Potential for incident detection*. The short sensor spacing in the OOCEA AVI network and high travel speeds on the toll roads it covers means that the time between reads at successive toll tag readers is typically between one and two minutes, and shorter on the more heavily traveled roads where a more dense sensor spacing was used. This opens up the possibility of using differences in the expected arrival times to detect incidents that might occur in a timely enough manner to assist with incident response.

1.1.4. Evacuation Route Monitoring

Traffic monitoring was also implemented on SR 520 and SR 528, two key evacuation routes between the coast east of Orlando and Orlando. On SR 520, license plate readers were deployed at two locations to estimate the evacuation travel time along this route. One reader was deployed near the coast at the I-95 interchange and the other near Orlando at the SR 528 interchange. On SR 528, a series of microloop detectors were used to monitor evacuation traffic.

1.1.5. Traffic Cameras

Before *i*Florida, FDOT maintained an extensive set of traffic monitoring cameras deployed on I-4, as depicted in Figure 5, and a less extensive set of cameras on Orlando arterial highways. In this figure, the I-4 cameras are shaded blue and numbered, while the arterial cameras are shaded red and not numbered.

[2] Because the CRS design could not accommodate on-the-fly combination of travel time segments, this feature could not be used in the *i*Florida system.

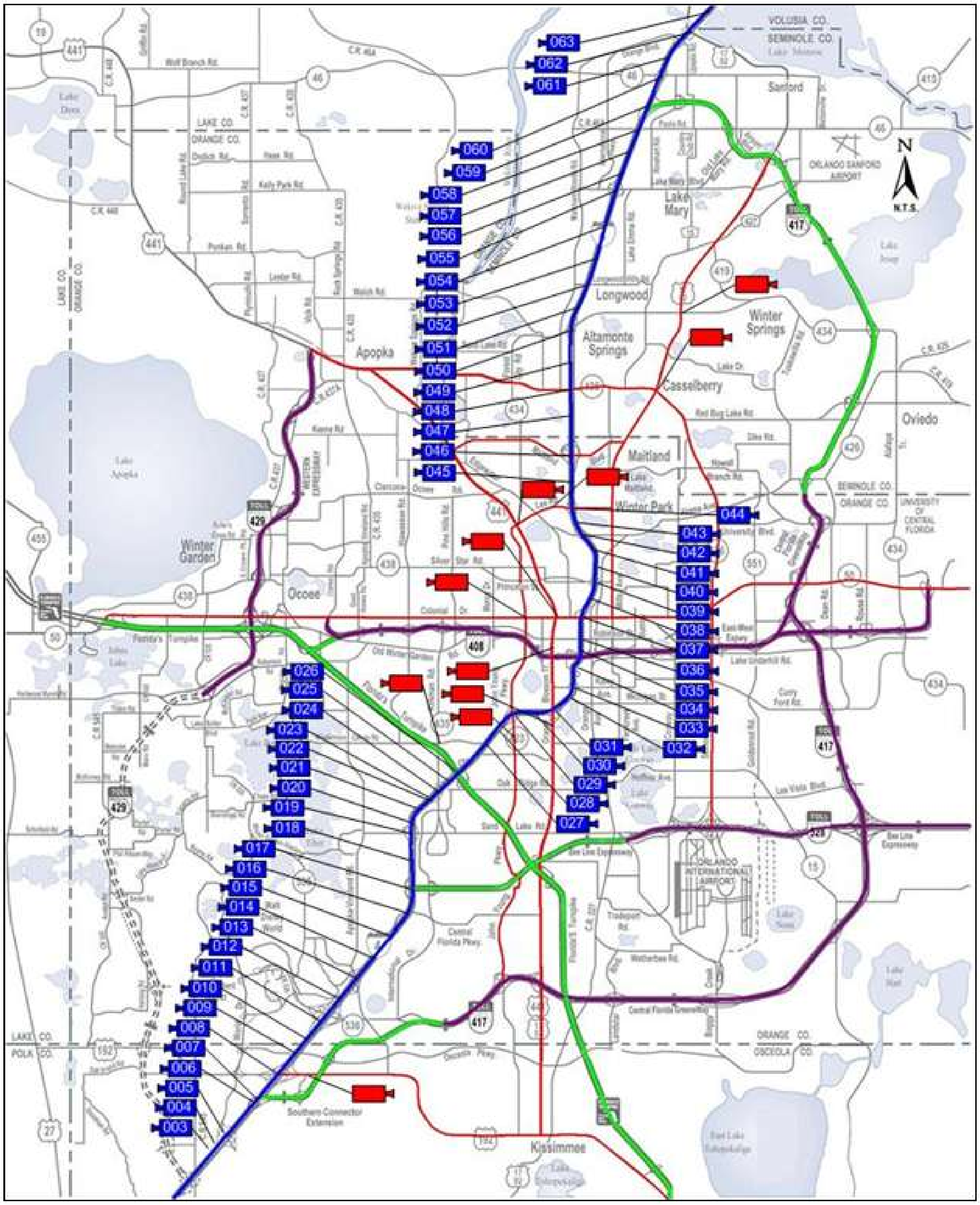


Figure 5. FDOT Cameras in the Orlando Area

1.1.6. Dynamic Message Signs

Another feature of the *i*Florida system is the collection of dynamic message signs deployed along I-4, as shown in Figure 6. These signs include both standard DMSs (depicted as shaded boxes) and variable speed limit (VSL) signs (depicted as boxes containing the number 55).

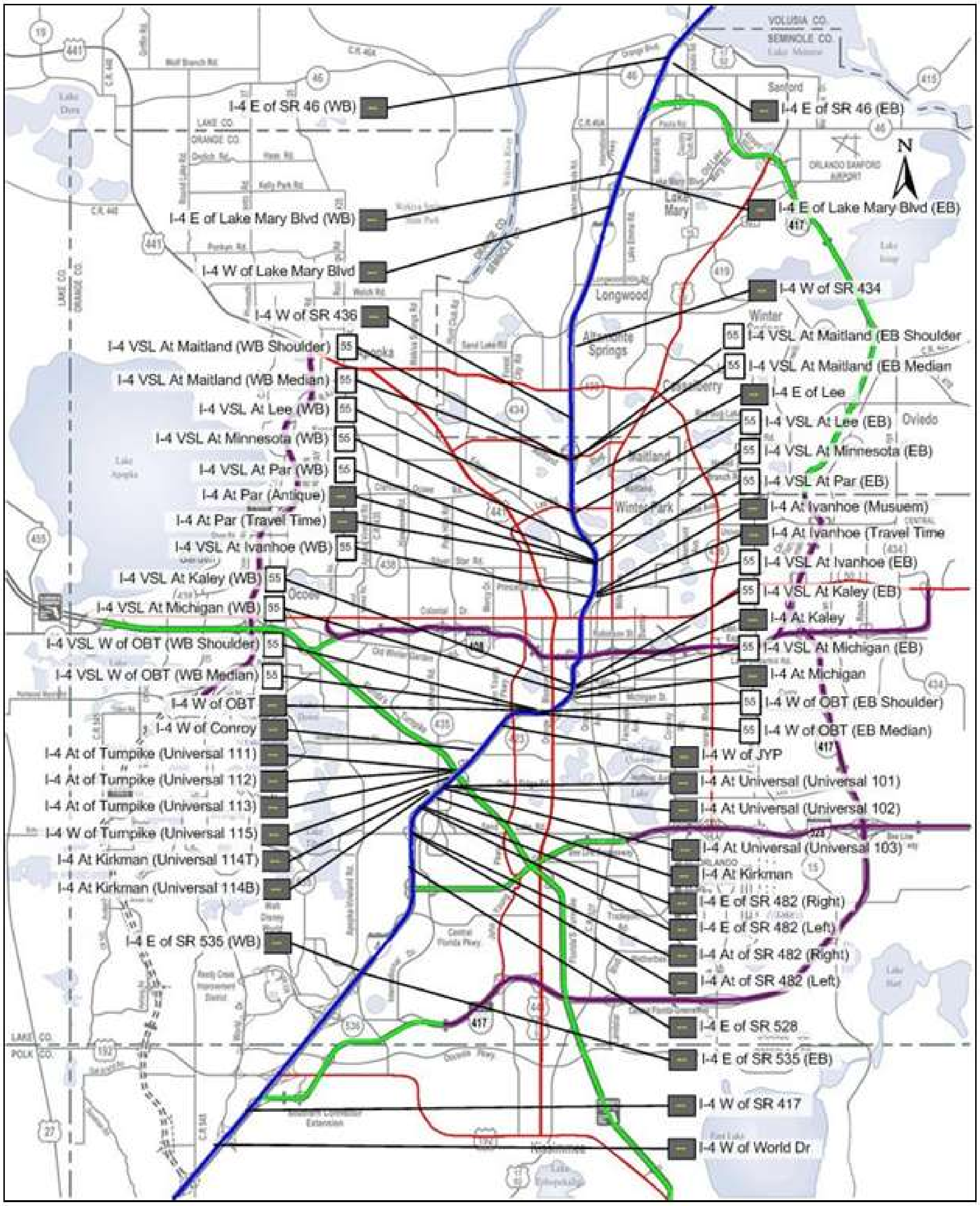


Figure 6. Dynamic Message and Variable Speed Limit Signs in the Orlando Area

The DMS signs themselves were used in a number of different ways. Some of the signs were devoted to displaying information about nearby cultural and entertainment facilities. Some were used to suggest alternates to Orlando attractions. Some were primarily used to provide travel time information. Some were blank or carried informational messages (e.g., "For Traffic Information Dial 511") until an incident or congestion occurred, in which case the messages were changed to provide information to travelers about the incident or congestion.

FDOT also deployed DMSs along I-95 and on arterials located near the interchange between I-95 and I-4. The locations of these signs are depicted in Figure 7.

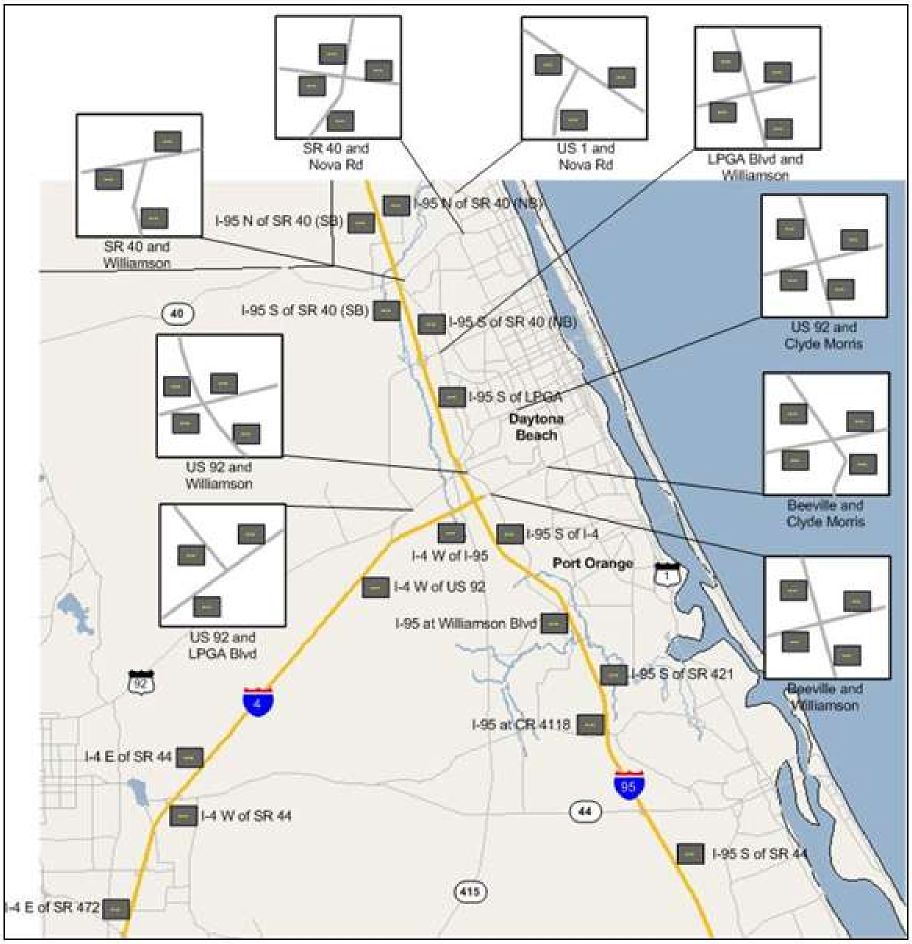


Figure 7. Dynamic Message Signs Near the I-95 / I-4 Interchange

The message signs along I-4 and I-95 were used primarily for travel time and incident information. The arterial message signs were used to help manage traffic during events at the Daytona International Speedway and when traffic was diverted onto arterials after a significant incident on I-95 or I-4.

1.1.7. Incident Data

Before *i*Florida, considerable coordination existed between FDOT and FHP. The FHP dispatchers and RTMC operators shared a single room. FHP dispatchers often informed RTMC operators when an incident occurred and sometimes requested that RTMC operators move a camera so they could get a better view of an incident. FHP also maintained a Web site that provided incident information to the public, which the RTMC operators sometimes consulted.

The *i*Florida project introduced automated exchange of incident information by developing an interface through which incident data from the FHP CAD system was transferred to FDOT. The intention was for data from FHP CAD incidents to be transmitted to the RTMC Condition Reporting System (CRS), where operators could choose whether to integrate the data into the CRS traffic data. If it was integrated into the CRS data, the information would appear on the traveler information Web site and could be used to trigger other traveler information activities. Otherwise, the data was ignored.[3]

1.1.8. Weather Data

The *i*Florida deployment contracted for the receipt of weather data. Three different types of weather data were provided. First, RWIS stations were deployed, including stations on bridges that provided information about bridge wind speeds that could be used to guide bridge closure decision making. Second, FDOT contracted with a third party to receive road-specific current and forecast weather data for road monitored by *i*Florida. Through this contractor, FDOT also received severe weather alerts for specific areas and roads.

1.1.9. Traffic Management

A key part of the *i*Florida Model Deployment was the development of new software to support RTMC operations. The Condition Reporting System (CRS) was to integrate data from all of the sources of metropolitan traffic information and provide tools to support traffic management activities based on this data, such as:

- Managing 511 messages.
- Managing DMS messages.
- Determining speed limits to display on VSL signs.
- Providing data to the FDOT traveler information Web site.
- Dispatching road rangers.
- Sharing data with other transportation organizations.

The Central Florida Data Warehouse (CFDW) was to archive *i*Florida data to support future analysis of the data. Neither the CRS nor the CFDW worked as expected, which limited the benefits seen by FDOT during the *i*Florida deployment.

1.2. Statewide Traffic Operations

A second part of the *i*Florida deployment focused on monitoring statewide traffic, with the primary objectives being to support statewide traveler information systems and hurricane evacuation decision making. Statewide traffic operations were managed at the D5 RTMC and covered 10 key highways in the State: the Florida Turnpike, I-4, I-10, I-75, I-95, SR 60, SR 70, SR 528, US 19, and US 27. These roads are highlighted in Figure 8 below.

[3] Problems with the CRS prevented this interface from working reliably, with RTMC operators often using the FHP Web site for FHP CAD incident information.

Figure 8. Statewide Traffic Operations

FDOT used the same CRS/CFDW software systems to support statewide traffic operations. The agency also relied on the FHP CAD system for incident data and contracted weather services for weather data. FDOT supplemented this information with a Statewide Monitoring System (see Figure 9), which consisted of radar speed and volume counts with traffic monitoring cameras at 25 sites in locations across the State. FDOT also established a method in which other FDOT districts could report construction and maintenance operations.

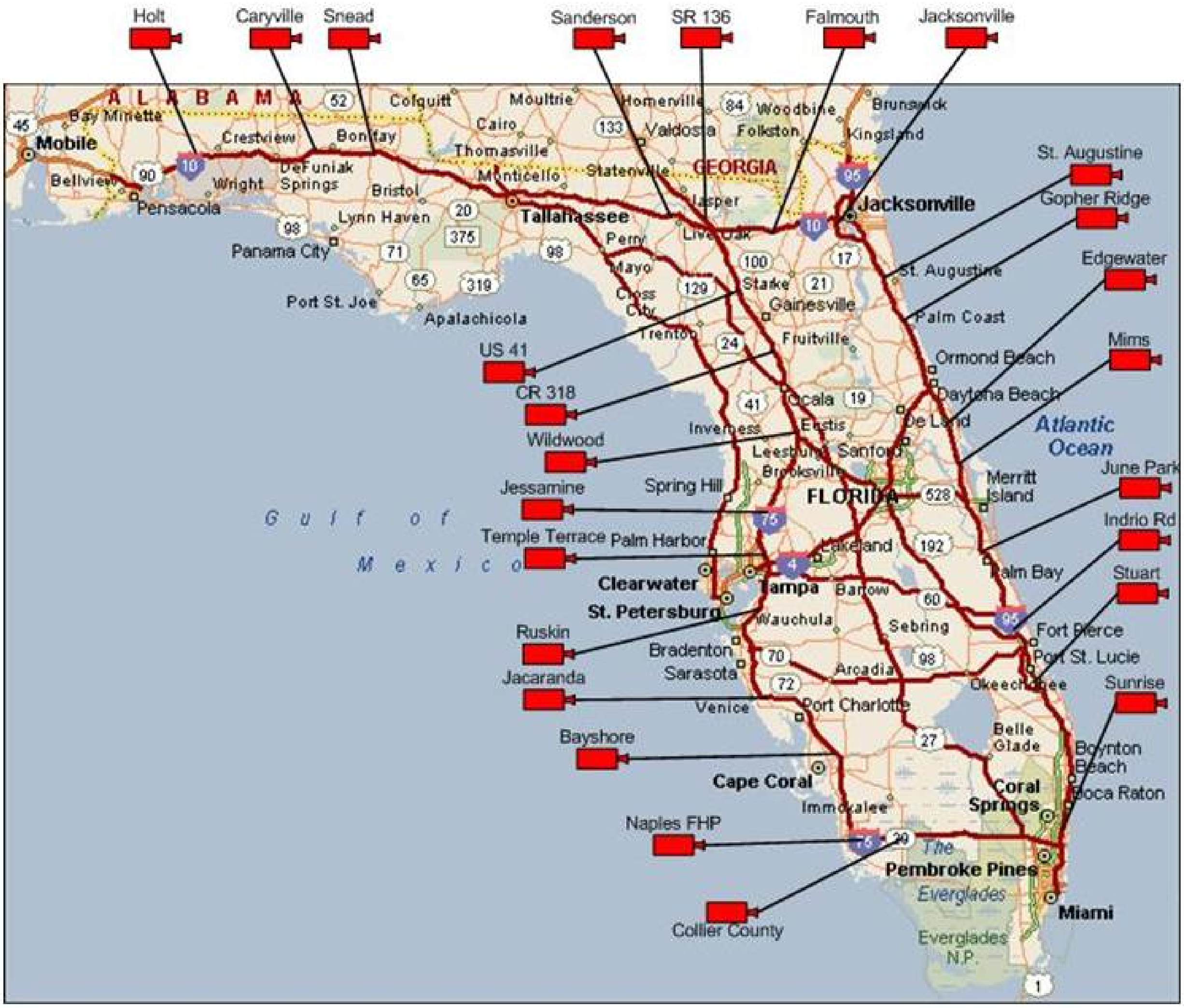


Figure 9. The Statewide Monitoring System

FDOT used the same CRS/CFDW software for consolidating statewide traffic data and managing statewide traveler information as was used for the Orlando metropolitan area. These systems were used to support a statewide 511 system and a statewide traveler information Web site.

1.3. Traveler Information

A key part of the iFlorida Model Deployment was enabling traveler information service enhancements. These services included:

- *Dynamic message signs*. Most of the I-4 DMSs predated the *i*Florida deployment, though the VSL signs were added by *i*Florida. The network of DMSs along I-95 and trailblazer signs on nearby alternate routes was deployed in the same time frame of the *i*Florida deployment, but not as part of *i*Florida.
- *Central Florida and Statewide 511 services*. The Central Florida 511 service extended the pre-*i*Florida system, which provided information only for portions of I-4, to a system that provided traveler information on all of the roads highlighted in Figure 1 as well as I-95 east of Orlando and the

portions of I-4, SR 520, and SR 528 from Orlando to I-95. Before *i*Florida, no statewide 511 service existed in Florida. The statewide 511 system covered the roads highlighted in Figure 8.

- *Traveler Information Web site*. Before *i*Florida, information about travel times on I-4 was available via the Internet, though the service was not widely advertised or often used. One part of the *i*Florida deployment was the creation of a Central Florida and a Statewide traveler information Web site.

1.4. Other *i*Florida Activities

The *i*Florida Model Deployment also included a number of projects that did not fit easily into the above categories. These projects included:

- *Operation Center Connectivity*. Fiber connections were established between the D5 ITS network and other regional transportation agencies, including the City of Orlando Integrated Operations Center, the Brevard County Emergency Operations Center, and the LYNX transit operations center. These connections allowed these agencies to share information.
- *Use of Archived Transportation Data*. Several projects were included in the *i*Florida plans to make use of the transportation data that would be consolidated in the CFDW. FDOT planned to conduct a network reliability analysis for Orlando roads and to use *i*Florida traffic data to support traffic modeling to assess alternate routes in case of a bridge closure. METROPLAN, the Metropolitan Planning Organization for Orange, Osceola, and Seminole counties, was provided with funding to explore the usefulness of *i*Florida data to support regional planning activities. Because the CFDW did not operate as expected, FDOT delayed completion of these projects until a more reliable data warehouse was available.
- *Security Projects*. The *i*Florida plans included four projects related to transportation security. One project conducted a vulnerability assessment of the D5 RTMC, and another developed an evacuation plan for the Daytona International Speedway. A third project used a broadband wireless system deployed along a portion of I-4 to support a bus security video system for buses using that route. The last such project deployed a video security monitoring system at two Florida bridges.

2. The Deployment and Operating Experience

Two previous reports from this evaluation, the *iFlorida Model Deployment Design Review Evaluation Report* and the *iFlorida Model Deployment—Deployment Experience Study*, document FDOT's experience in designing and deploying the *i*Florida Model Deployment. These reports covered the period from May 2003, when the Model Deployment began, through May 2006. This report covers activities that occurred from May 2006 through November 2007. In particular, it focuses on the challenges FDOT faced in the development of the traffic management software for the RTMC because this effort was the focus of *i*Florida activities during this period. Details on other facets of the deployment can be found in other sections of this report.

2.1. Summary of Observations from Previous Reports

The *i*Florida Model Deployment began with FDOT D5 taking advantage of its already strong relationships with other transportation stakeholders in the Orlando area. One of the advantages of these relationships was that the plans for *i*Florida leveraged existing or planned capabilities from several of these stakeholders. For example, FDOT D5 planned to use toll tag readers to measure travel times on Orlando arterials, and OOCEA was already developing a system to use toll tag readers to measure travel times on the toll roads they operated. OOCEA agreed to use the travel time engine it was developing to compute arterial travel times from *i*Florida toll tag readings. FDOT planned to use an existing network of microwave communication towers to support a statewide network of traffic monitoring stations.

By January 2004, FDOT had completed the high-level design of the *i*Florida system. Operational plans for the deployment were not yet well-defined. The *i*Florida Design Review report noted that the lack of well-defined operation plans:

> *…introduced the risk that either operational plans would have to be tailored to the capabilities of the deployed system or that late changes would have to be made to the functional requirements to support operational plans, once they were developed. This risk was probably slight for the data collection procurements because the data collection requirements were relatively clear and FDOT had conducted pilot testing of the various data collection approaches being used for* i*Florida, further clarifying those requirements. The risk for the Conditions System, which will directly support iFlorida operations, is probably greater.*

The report noted that FDOT's strong "people themes" might overcome any difficulties that might arise because of uncertainties in the operational plans.

By April 2005, the deployment of most of the *i*Florida field equipment was complete, though there had been some delays due to the two major hurricanes that passed through the Orlando area in 2004. Signs of delays in developing the CRS were beginning to show and, despite the fact that the software was due to be complete in May 2005, the requirements for this software were still evolving.

These problems compounded over the summer of 2005. Additional delays occurred with the CRS development. As elements of the CRS came online, FDOT began noting problems with the deployed field equipment. The problems were particularly pronounced with the arterial toll tag reader network—almost half of the readers were not reporting tag reads in June 2005. The lack of data meant that FDOT could not adequately test the CRS software. When problems were detected, it was not clear if the problems were caused by poor data or software errors.

Without diagnostic tools to assess system performance, identifying the root cause of problems that were observed often required extensive manual work; sometimes it was not possible. For example, problems with the arterial toll tag readers were identified by daily, painstaking, manual reviews of the self-diagnostic screens for each reader and archives of the individual reads that were made. Problems with the weather data feed were not detected until the CRS software began accessing the data. Early development of stand-alone tools to access these data feeds and diagnose problems with them would have allowed FDOT to identify and correct problems with these interfaces before they impacted RTMC operations.

The design for TMC software should include stand-alone tools for diagnosing problems with the systems feeding data to it.

In November 2005, FDOT hosted a public unveiling of the *i*Florida system. The system was not perfect—only 70 to 80 percent of arterial toll tag readers were operational and the CRS had not been completely tested. However, the system did demonstrate the basic functionality expected of the *i*Florida deployment. Arterial and highway travel times were being computed, and this information was being used to generate DMS and 511 messages and populate traveler information web pages.

In the months that followed the unveiling, FDOT began to coordinate with other regional stakeholders concerning how best to use the *i*Florida infrastructure to support regional transportation management. Key to these plans was sharing transportation data through the CRS. At the same time, FDOT began to discover problems with the CRS. The CRS sometimes failed to correctly update DMS messages, and it sometimes miscomputed travel times from the raw travel time data it received. Incidents from the FHP CAD system were sometimes placed at the wrong map location.

Some problems also occurred with the less-used field equipment. The wireless network deployed along I-4 to support a bus security system was proving unreliable, and FDOT found it difficult to maintain the Statewide Monitoring System. The traffic monitoring equipment in the Orlando area, however, was becoming increasingly reliable. The arterial toll tag reader network and the I-4 loop detectors were operating reliably. FDOT had even deployed a series of detectors on I-95 and was beginning to integrate those into the *i*Florida systems.

FDOT was expending significant resources diagnosing problems with the CRS, and this software was slowly improving. The Deployment Experience Study report noted that, by May 2006, "*FDOT had finally overcome the most significant challenges and was beginning to rely on the CRS to manage its traffic management activities*."

2.2. The Failure of the CRS

By early May 2006, it appeared that FDOT may have turned the corner on the problems they had faced with *i*Florida deployment. The toll tag readers used on the arterials and the loop detectors used on I-4, I-95, and the toll roads to estimate travel times (see Section 3) were working reliably. The active bug list for the CRS was down to eight items and FDOT was regularly using the CRS at the RTMC. A test had recently been conducted, during which the CRS had successfully updated the message on each FDOT DMS. (Despite the success of this test, RTMC operators continued the practice of deactivating signs in the CRS so they could reliably control the sign messages.) The 511 system was operating reliably and processing more than 100,000 calls per month (see Section 10). The CRS contractor was preparing for FDOT to begin testing the CFDW. As FDOT continued to use these systems more extensively, the agency discovered that a number of problems were still unresolved.

The interface with the DMSs was unreliable, with sign messages sometimes not updating when requested. RTMC operators continued to report cases where a DMS message set through CRS did not appear on the sign or appeared only briefly before being replaced with another message. RTMC operators also reported that the signs sometimes seemed to "disappear," dropping off the user interface screen entirely.

In May 2006, FDOT discovered the cause of the disappearing signs: the CRS did not maintain an internal table of known signs. Instead, it downloaded the list of active signs once-per-minute from the Cameleon 360 software used to interface between CRS and the message signs. When the CRS had difficulty reading the file used to transmit this information (e.g., if the CRS tried to access the file while it was being updated), it deleted all of the signs from the CRS operator interface. The Evaluation Team felt that the best way to have prevented this error from occurring would have been for the requirements to specify what action was appropriate when the Cameleon 360 failed to provide information about a sign. (An appropriate response might be to alert the operator that contact with the signs had been lost rather than simply deleting the signs from the user interface.) When the problem was first reported, it was occurring several times per day. By July 2006, the frequency of these conflicts had been reduced to several times per week.

The TMC software requirements should address the actions that should be taken when different types of failures occur.

In September 2006, FDOT discovered that the CRS and Cameleon 360 software were applying opposite interpretations to priorities applied to messages: CRS interpreted higher numbers as having higher priority, while Cameleon 360 interpreted lower numbers as having higher priorities. This meant that messages sent by CRS as low priority messages often overwrote other, higher priority messages.

The travel time estimates for 511 and DMS travel time segments were sometimes miscalculated. This problem was first reported in January 2006 when OOCEA reported that messages signs were misreporting travel times on OOCEA toll roads. FDOT reviewed the configuration file, which was believed to be the source of the errors, and the CRS contractor made changes to these configuration files. However, spot checks by FDOT continued to identify additional travel time segments for which CRS was incorrectly computing travel times.

In September 2006, plans were made to perform "static tests" of the travel time calculations. The CRS contractor had stated that, because of the constantly fluctuating nature of the travel time information received by the CRS, it was difficult to test whether CRS was performing travel time calculations correctly. During a "static test," a set of constant travel times would be fed to the CRS so that the accuracy of the travel times computed by CRS could be more easily assessed. This testing was apparently the first time the CRS contractor had conducted an exhaustive test of the travel time calculations for every *i*Florida travel time segment. These tests were repeated periodically over the remaining nine months of CRS usage by FDOT, with each test revealing additional problems that would be addressed before the tests were repeated.

The travel time estimates for 511 and DMS travel time segments were sometimes missing. The original *i*Florida design called for the system to produce estimated travel times based on historical averages that could be used if equipment failures resulted in missing travel time data. The CRS/CFDW contractor had specified that the CFDW would produce these estimates, yet had not demonstrated this capability. In July 2006, FDOT identified this as one of their key concerns.

The locations of incidents from the FHP CAD system were sometimes misinterpreted. In early 2006, FDOT reported that the CRS was incorrectly geo-coding incident information received through the FHP CAD interface. (See Section 5 for more information.) In July 2006, an example of this error occurred while the CRS contractor was demonstrating CRS and CFDW and the contractor began trying to correct the problem. The problem continued until, in November 2006, FDOT requested that the CRS contractor turn off the geo-location feature because the incorrect geo-coding was causing incidents to show up at the wrong locations on *i*Florida traveler information Web sites and operator displays. With this feature turned off, RTMC operators were forced to review each FHP CAD incident and either delete it or identify the correct location for it manually. During peak travel periods, this required almost full-time attention from one RTMC operator. Although a number of attempts were made to correct this problem, FDOT never considered the CRS processing of FHP CAD data stable enough to use.

The CRS software was often unstable and crashed periodically. FDOT reported that the CRS would sometimes crash or begin working so slowly that a system restart was required. This problem recurred with less and less frequency as the CRS contractor applied fixes to the software.

The CRS filtering of weather data was sometime unavailable. In June 2006, FDOT discovered that the CRS contractor had, in January 2006, quit processing weather data received from Meteorlogix. (See Section 11.) When weather data processing was resumed, FDOT discovered that the CRS was no longer filtering weather events before displaying them on the operator's interface. The correction for this problem had apparently been lost during other CRS upgrades.

The CFDW was unable to pass acceptance testing. In late May 2006, FDOT cancelled acceptance testing after the CFDW failed to pass a large number of tests. In July 2006, the CRS contractor reported that the CFDW passed integration testing and requested that FDOT begin the 30-day acceptance test period. FDOT disagreed that the system requirements had been satisfactorily met. For example, repeated efforts by FDOT and the Evaluation Team to log into the CFDW resulted in errors. FDOT also noted that the CFDW was expected to produce travel time estimates based on historical data that could be used if real-time measurements were unavailable. This capability was never demonstrated to FDOT.

In August 2006, the Evaluation Team reviewed the CFDW capabilities and noted the following problems (some problems related to accessing current data in the CFDW):

- The "current situation" map included incidents that should have been closed.
- Attempting to access DMS information resulted in a system crash.
- Some discrepancies were noted between events listed in the CFDW and those in the CRS.
- The link-node travel time calculation feature failed when an attempt was made to use it.

Other problems related to accessing historical data included:

- The historical speed map appeared to display current rather than historical data.
- There were discrepancies in the historical incident lists.

FDOT testing also identified a number of additional problems with the CFDW reporting features.

This set of key problems remained the center of focus throughout the period from June 2006 through April 2007, with the CRS contractor fixing bugs and FDOT conducting further CRS/CFDW tests, which revealing that the same types of problems continued to plague the software. The CRS contractor insisted that the system was ready for final testing, and FDOT began acceptance testing on April 3, 2007. The testing was discontinued on April 4 after FDOT noted that several CRS/CFDW features were incomplete and did not function as intended. FDOT agreed to grant an extension to the period of performance of the CRS/CFDW contract, due to expire on April 30, 2007. The CRS contractor wanted additional funds to continue work on the project.

On May 1, 2007, the CRS/CFDW contractor quit supporting FDOT and the CRS/CFDW development. FDOT attempted to follow the instructions in the administrative guides to maintain the system, but the CRS and CFDW both failed within a week. The CRS/CFDW contractor refused to assist FDOT in restarting the software. FDOT managed to restart the CRS services, but could not restart the CFDW. Within a week of the first re-start, the CRS had failed again. The frequency of CRS failures increased throughout May, with the final failure occurring by the end of the month.

2.3. Transitioning to New Traffic Management Software

After the CRS failed, FDOT quickly developed a set of operational procedures that allowed it to continue to support transportation management operations at the D5 RTMC without the CRS. The following list describes FDOT's challenges and reactions following the final failure of the CRS:

- Data from loop detectors on I-4 was still available through the Cameleon 360 software, which interfaced directly with these detectors. RTMC operators could review current travel speeds in order to estimate travel times, though operators found that reviewing traffic conditions on the video wall often sufficed.
- The OOCEA travel time server continued to compute travel time estimates for arterials and toll roads, though FDOT had no way to access these estimates. Instead, FDOT reviewed historical data to estimate typical travel times on these roads.
- RTMC operators continued to use the FHP Web site to access incident information from the FHP CAD system. In addition, an FDOT contractor developed a new interface to the FHP CAD data that re-organized the data to better support *i*Florida traveler information systems. (See Section 5 for more details on this interface.)
- RTMC operators continued to update DMS messages directly through the Cameleon 360 software.
- The 511 system allowed FDOT to update 511 messages through a Web-based interface. RTMC operators began using this interface to manage 511 messages rather than recording messages through CRS. Because CRS had previously created the 511 travel time messages automatically, FDOT replaced the automatically generated messages with more generic ones based on typical travel times. When an incident occurred, operators overrode these messages with incident-specific ones.
- The *i*Florida traveler information Web site was unavailable during this period. In its stead, FDOT developed static Web content that provided access to other traveler information resources, such as the FHP incident information Web site.

Through these efforts, FDOT was able to continue to perform most of its traffic management activities with only somewhat reduced capacity. One reflection of the success of these efforts was the log of 511 calls made during this period. After the CRS failure, 511 users continued to access the 511 service at much the same rate as before the failure. (The increase in 511 usage in May is a seasonal increase that also occurred in 2006.)

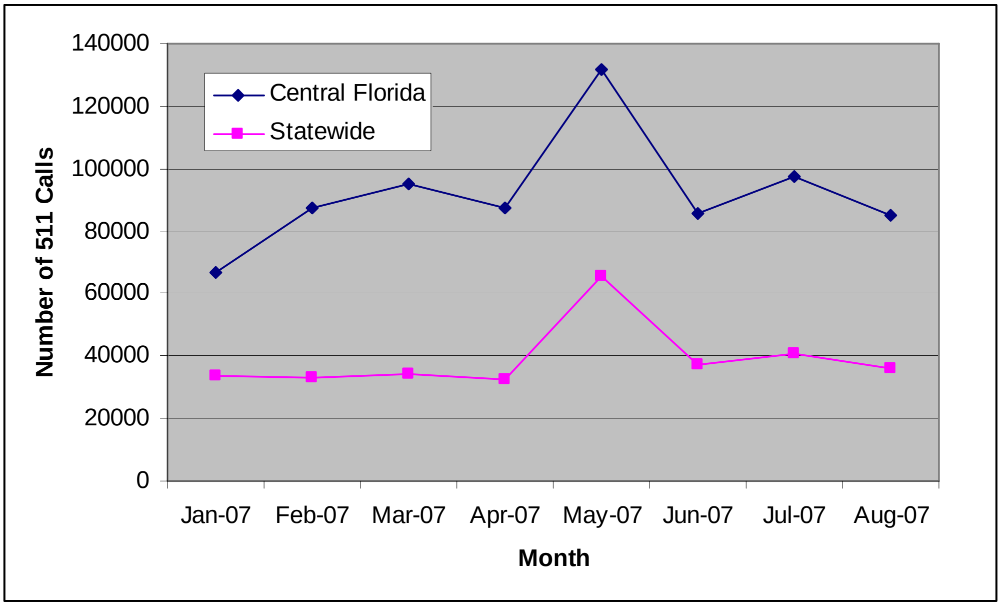


Figure 10. Number of *i*Florida 511 Calls Before and After the CRS Failure

2.4. Developing SunGuide

FDOT, aware of the problems with the CRS and anticipating the potential that it might fail, had begun testing SunGuide, a replacement for the CRS, in November 2006. FDOT began by installing an existing version of the SunGuide software and configuring it to manage recently deployed ITS equipment on and near I-95. This included a set of loop and radar detectors to measure volume, speed, and occupancy on I-95, DMS signs on I-95, and trailblazer signs on key intersections located near I-95. (See Section 6 for more information on these message signs.) They had used the period from November 2006 through April 2007 to work out problems with this system, such as interfacing correctly with the message signs, computing travel times from the speed data, and configuring the system to automatically post travel time messages on the message signs.

When the CRS failed in May 2007, FDOT began expediting a transition to this new software. The agency negotiated a new schedule with the SunGuide contractor to provide a new version of that software that included most of the transportation management features critical to operations at the D5 RTMC, including ingesting loop detector data and computing travel times, ingesting travel time data from the OOCEA travel time server, automatically updating DMSs and the 511 system with travel time messages, and managing ad hoc DMS and 511 messages. The schedule called for most of these features of the software to be available by August 2007.

By September 2007, FDOT was operating a Beta release of the SunGuide 3.0 software. This version implemented most of the above-mentioned features. Difficulties with the interface to the 511 system, however, meant that RTMC operators were still updating 511 messages through a Web-based interface. A final release of this version of the software was released in December 2007. The current version of this software (as of July 7, 2008) was released in June 2008. Because this occurred at the end of the evaluation period, the performance of the SunGuide software was not included in this report.

2.5. Lessons Learned—CRS versus SunGuide Development

One of the remarkable features of the SunGuide development process was how much more smoothly it went than the CRS development process. When asked about this, FDOT noted several differences that contributed to the improved process.

One item FDOT noted was that the SunGuide contractor spent much more time working with FDOT at the start of the project to understand FDOT's functional requirements than had the CRS contractor. With SunGuide, FDOT initially provided high-level functional requirements to the contractor, and the contractor mocked up screens to refine these requirements. Sometimes, the contractor would point FDOT to other Web sites as examples of what the contractor believed FDOT had requested. At other times, the SunGuide contractor would make "quick-and-dirty" changes to the version of SunGuide to demonstrate an understanding of FDOT's requirements.

> ***Devote time at the start of the project to ensure that the contractor shares an understanding of what is desired from the software.***

In contrast, the CRS contractor took FDOT's high-level requirements and attempted to build tools that complied with those requirements without much additional exploration. This was particularly problematic because FDOT had not developed detailed Concept of Operations for *i*Florida—having an *i*Florida Concept of Operations may have helped the CRS contractor better understand FDOT's expectations. Numerous examples of this occurred during a meeting held in January 2005 to review the CRS Software Design Document.

- It was unclear whether the CRS should post travel delay or travel time messages on DMSs. Most *i*Florida documentation indicated that signs would post travel times, though current FDOT D5 practice was to post travel delays. The CRS contractor had been developing the software under the assumption that travel delays would be used for most messages, but was uncertain of the type of information that would be provided for diversion messages (i.e., messages providing information about two or more alternate routes).
- There was disagreement on whether user-specific data access restrictions would exist. FDOT expected to provide versions of the CRS software to several *i*Florida stakeholders so that each could use the software to manage their roadside assets and yet share control. For example, a stakeholder with 24-7 operations might turn control of their roadside assets over to the D5 RTMC during off hours. FDOT expected that the CRS would include capabilities for managing which organization had "control" over those assets. The CRS contractor expected all users to have the same privileges for accessing and changing data and suggested that FDOT use MOUs between the agencies to describe under what conditions different agencies should change CRS data.
- There was disagreement on shared control for managing messages on DMS signs. OOCEA planned to deploy a number of DMSs along Orlando toll roads, and their operational plans called for using non-CRS software to manage content on those signs while allowing the RTMC to monitor and update those signs. The CRS design did not allow for this type of shared control.
- It was unclear whether weather data should be filtered to include only severe weather alerts before being received by the CRS. The CRS had been designed to treat all incoming weather data as an alert that should be displayed to RTMC operators. The weather data provider expected to provide all weather data to the CRS, with the CRS processing the received data to determine which conditions should generate an alert.

- The road speed index, a factor indicating the expected impact of weather conditions on traffic, was removed from the weather data to be provided to the CRS. The weather data provider had expected that this index would be key to identifying weather conditions that might impact traffic. It could be used to determine if weather conditions should generate an alert or to help determine appropriate travel speeds for variable speed limit signs. The CRS contractor indicated that the data would not be useful within the CRS and proposed instead to include weather information in its approach for forecasting travel times.

- There was disagreement about how 511 messages would be generated. The CRS contractor believed that all messages would be recorded by the operators, with most messages recorded live and some messages from a reusable message library. FDOT representatives at the review meeting wanted to generate 511 messages by splicing together message phrases while allowing operators to override the spliced messages. FDOT upper management had previously stated that no spliced messages should be used in the CRS.

Because the *i*Florida operational concepts where not clearly defined, key operational capabilities such as those listed above were still being debated as part of the review of the software design—only five months before the CRS was expected to be operational.

The lack of a well-defined Concept of Operations for *i*Florida might have had less impact if the CRS contractor had followed its initial plans for using a "spiral model" for developing the CRS software. This approach would have allowed FDOT and the CRS contractor to develop a shared understanding of *i*Florida operations through repeated opportunities for FDOT to provide feedback to the contractor based on incremental releases of the CRS software. This approach was not used.

Software projects are complex efforts that require skills that are not necessarily common to transportation agencies. Sustaining trained, certified, and knowledgeable staff is a key to success.

If FDOT D5 had more stringently followed a systems engineering process, some of these problems might have been avoided. In fact, the FDOT ITS Office had developed a systems engineering approach for ITS projects in Florida, and FDOT D5 chose not to apply that approach. FHWA had also agreed to provide to FDOT personnel responsible for *i*Florida software acquisition a course entitled ITS Software Acquisition.[1] FDOT D5 declined FHWA's offer.

FDOT also noted that the process of refining the functional requirements required great deal more upfront expense than the agency was accustomed to spending on non-software projects. In traditional FDOT projects, such as widening a road, the specifications are set by existing FDOT standards and there are few questions about the functional requirements of the resulting product. With software projects, there are no existing standards specifying requirements—many functional requirements will be unique to a particular organization, so significantly more time is required to develop a mutual understanding of those requirements.

The cost structure for a software project is significantly different than that for traditional DOT projects.

In the case of the CRS, FDOT relied on the CRS contractor to convert the functional requirements into detailed technical requirements. In many cases, the CRS contractor accepted the functional requirements provided by FDOT as the detailed requirements. This was particularly problematic because some FDOT functional requirements were ambiguous or otherwise flawed. This affected

[1] This course is offered by the US DOT Research and Innovative Technology Administration (RITA). Information on the course is available at www.pcb.its.dot.gov.

the development of the CRS software in that the CRS requirements continued to evolve throughout the development process. It also affected the testing of the software in that testing was performed against high-level, ambiguous functional requirements. As an example, one CFDW requirement was that the software would include "a data mining application to facilitate the retrieval of archived data." The test for this requirement was "Verify that the CFDW includes Crystal Reports or similar software." No more significantly detailed requirements or testing of the CFDW data mining capabilities was performed.

Another example of an ambiguous, high-level functional requirement was the FDOT specification that "Users shall be able to view/extract archived data via fifteen (15) standard reports." This requirement made its way into the CRS requirements specification, and the associated test was to "Confirm the existence of at least fifteen standard reports" with the acceptance criteria being "Pass if at least fifteen standard reports are available." The CRS contractor should have developed detailed requirements based on the high-level requirements provided by FDOT and developing tests based on the detailed requirements.

Because no detailed requirements were developed, it was difficult for FDOT to verify that detailed testing had been performed. For example, if a detailed requirement regarding the accuracy of the travel time calculations was present, system engineering practices would have required development of an approach for testing that accuracy and documentation of the results of those tests. This would have also provided a mechanism for FDOT to review the proposed testing process and test results. If detailed requirements were available and systems engineering practices were followed, errors in the travel time calculations might have been detected before the system was released and inaccurate travel time messages were broadcast to the public.

Requesting documentation of detailed testing performed by the contractor can help ensure that appropriate tests are performed.

Another problem FDOT faced with operating the CRS was that it was very difficult to administer. When FDOT specified the high-level functional requirements, it did require that the CRS include certain administrative capabilities, such as adding and deleting users and modifying the set of roads managed by the system. However, the CRS contractor did not provide any additional information to FDOT about how system administration would work and the CRS contractor performed the initial configuration. When problems with the travel time calculations were traced to inaccurate information in the configuration data, FDOT discovered that configuring the system required hand-modifying a large number of text files and that the approach for doing so was not well documented. This meant that many configuration activities could only be performed reliably by the CRS contractor. It also meant that the configuration process was error prone, which may have been one factor that led to the repeated cycles of performing static tests on the travel time calculations and correcting configuration problems that were discovered, only to have future tests reveal additional problems.

Being involved in the initial configuration of the system can help determine whether the configuration process is overly complex.

With the SunGuide software, the SunGuide contractor provided FDOT with the software and FDOT was responsible for configuring it as they wanted. (The SunGuide contractor did provide support during this process.) This approach simultaneously configured the system, trained FDOT in the administration process, and allowed FDOT to verify that the configuration process was easy to use.

Part of the reason for the difference in the administration processes might be related to a difference in how the two contractors intended the software to be used. In both cases, the software was based on tools that were being developed for use at multiple locations. With the CRS, the CRS contractor manages most of the deployments—they operate the servers and handle the configuration. With SunGuide, the SunGuide contractor provides software—software that is operated on DOT-owned servers and configured by the DOTs. The CRS contractor can afford more arcane configuration processes because the configuration is performed by CRS staff members expert in the process. The SunGuide contractor must have simpler, more robust configuration processes because the end-user will be performing those operations.

Contractual requirements can be used to ensure that software fixes can be implemented without disrupting operations.

FDOT also believed that the SunGuide architecture as a whole—not just the configuration process—was more robust than the CRS architecture. One example they noted was that the SunGuide contractor was able to modify the software without bringing down the entire system. With CRS, the contractor usually was required to shut down the entire system in order to install a patch. This meant that the CRS contractor tended to provide large patches less frequently, while the SunGuide contractor could provide smaller, more frequent patches. This allowed the SunGuide contractor to implement fixes for small bugs in the SunGuide software quickly. It also made it simpler for FDOT to test the patches, since each patch typically covered only a small number of problems.

Tools for testing of individual software components can help pinpoint the root cause of problems that may occur.

Finally, FDOT noted that it would have been useful to have had available tools to help monitor and test individual components of the software. When problems were detected with the CRS, FDOT and the CRS contractor often spent more time trying to locate where problems were occurring than fixing problems. FDOT could have obtained these tools by either including such tools in the CRS requirements or contracting for independent verification and validation effort on the CRS software.

The problem of testing individual software components was particularly severe when multiple organizations were involved in the problem. For example, the toll tag reader data was collected at field devices maintained by one FDOT contractor, transmitted through the FDOT network to a FDOT server, transmitted across the FDOT and OOCEA networks to the OOCEA travel time server, which was running software developed by a different contractor. The resulting travel times were pushed back across the OOCEA and FDOT networks to the CRS, which used the data to produce travel time estimates and published those travel times to message signs and the 511 system. When a problem occurred, it was difficult to identify at what point in this chain the problem first appeared, which sometimes resulted in more finger pointing than problem solving. It would have been useful to have had a tool that could sample each of the data streams involved in the travel time calculations so that the location at which an error occurred could be more easily identified.

2.6. Summary and Conclusions

FDOT experienced significant difficulties in reaching its objectives with the *i*Florida Model Deployment. Early in the deployment, the problems were centered on the deployed field equipment, with a large number of the arterial toll tag readers having failed by the time the software systems were in place to use that data. As FDOT brought the field equipment back online, problems with the CRS software became more apparent. From November 2005 through November 2007, FDOT's efforts were focused on eliminating the problems with the CRS software. Through this process, FDOT identified a number of lessons learned that might benefit others attempting to deploy a new (or upgrade an existing) traffic management system.

- *Following sound systems engineering practices is key for successfully deploying a complex software system like the CRS*. The CRS project began with inadequate requirements, and a process for refining those into detailed requirements was not followed. Systems engineering approaches that are less reliant on detailed requirements, such as a spiral model, were not employed.
- *Staff overseeing development of a complex software system like the CRS should be experienced in the software development process*. FDOT D5 had no ITS staff with that experience and declined FHWA's offer to provide a training course for the FDOT *i*Florida staff.
- *In a complex system, like the software system used to manage TMC operations, the system design should include tools for diagnosing problems that might occur in individual subsystems*.
  - When errors occurred with the arterial travel time system, it was difficult to identify whether the error was caused by the readers, the travel time server that computed travel times from the reader data, the CRS that used the computed travel times, or the interfaces and network connections between these systems.
  - When errors occurred with updating DMS messages, it was difficult to identify whether the CRS was sending incorrect data to the system that interfaced with the signs or the sign interface was not updating the signs correctly.
- *One of the biggest sources of problems in a complex system is the interfaces between subsystems*. With the CRS, long-standing problems occurred with the interfaces between the CRS and the FHP CAD system, the weather provider, the travel time server, and the DMS signs.
  - One approach for reducing the risk associated with these interfaces would be to adopt ITS standards that have been used effectively in other, similar applications.
  - Another approach for reducing the risk associated with these interfaces would be to develop the interfaces early in the development process and test the interfaces independently of the other parts of the system.
  - A third approach would be to include interface diagnostic tools that could sample data passing through the interface and assess whether the interface was operating correctly.
- *It is useful to have alternate methods for accessing data and updating signs and 511 messages in case the primary tools for doing so are not functioning correctly*.
  - The I-4 loop detector data was available through the Cameleon 360 software after the CRS failed, enabling RTMC operators to continue to estimate I-4 travel times.
  - The backup interface for updating DMS messages allowed FDOT to disable the signs in the CRS and manage the sign messages through the backup interface when the CRS interface for updating the sign messages proved unreliable.
  - The backup interface for updating 511 messages allowed FDOT to continue to provide 511 services when the CRS failed.
- *It is important to devote a significant amount of time at the start of a software development project to ensure that all parties share a mutual vision for how the resulting software should operate*.
  - With the CRS, FDOT had envisioned that the CRS would accept data from a variety of sources and filter that data before providing it to the RTMC operators. The CRS contractor

expected some of the data to be filtered to include only critical events before being provided to the CRS.

- With SunGuide, the contractor spent significant time with FDOT, ensuring that contractor staff understood FDOT's functional requirements and how those requirements would be implemented before beginning software development.

- *Testing is a critical part of a software development project.* While testing is primarily the responsibility of the contractor, the lead agency may want to review the test plans and documentation of test results during the development, including unit and integration testing. The testing should include both the software and configuration information used to initialize the system. To achieve this, the contractual process must include details related to the visibility of the testing process.
  - Errors in the CRS travel time calculations were not discovered until OOCEA reviewed the resulting travel times, and tools to test them (such as the static tests) were not available until more than 6 months after the problem was first discovered. Better testing for configuration data validity might have prevented errors from reaching the production software. For example, tools could have been developed to verify computed travel times independently. Tools that generated a map-based display of the configuration data would have provided an alternate means of testing that data.
  - More detailed tests of the component that related FHP CAD incidents to roadways should have identified the fact that the software sometimes miscalculated incident locations.
  - Tests of the CRS interface to the DMSs should have revealed some of the problems that FDOT experienced with this interface, such as the fact that the Cameleon 360 and CRS software had an opposite interpretation of the meaning of sign priorities.
- *The system requirements should include requirements related to configuration and administration of the system.*
  - With the CRS, the configuration was performed by the CRS contractor. When errors with the configuration were identified, FDOT discovered that the configuration was too complex to correct without assistance from the CRS contractor. Even the CRS contractor failed to eliminate all of the configuration errors in the CRS. Requirements that described the configuration process might have resulted in a simpler, less error prone configuration process.

The deployment experience also highlighted the challenges of taking a "top-down" approach rather than a "bottom-up" approach to development. FDOT wavered in its leadership over the contractors after expressing only a vision for the system operation. Guidance provided to contractors by lower level FDOT staff was often over-ridden by upper management, and lower-level staff had little or no voice in expressing concerns. FDOT also did not provide a well-developed document to describe the traffic and travel management operations the *i*Florida systems were expected to support. This meant that some *i*Florida contractors were provided with limited documentation regarding the requirements of the systems they were developing and received contradictory feedback from different FDOT staff. Many critical client-contractor relations suffered as a result, and the continued miscommunication magnified the errors of each successive phase of the development until it became too difficult to manage.

Despite these failures in developing the CRS, the existence of other methods of performing key operations, such as updating 511 and DMS messages, meant that FDOT did continue to perform these traffic management operations in spite of the failings of the CRS.

3. Maintaining a Network of Field Devices

Prior to starting the *i*Florida Model Deployment, most of the D5 traffic monitoring equipment was deployed along I-4. Data from loop detectors were used at times to estimate travel times, but operators were just as likely to base estimates on observations from the traffic cameras. Dynamic message signs (DMS) and 511 messages were only used on I-4, and Regional Traffic Management Center (RTMC) operators recorded these on the fly. Since most traffic management operations were done "by hand," the RTMC operators could adapt to any missing data from failed field devices.

With the start of *i*Florida, the situation changed. The roads managed at the RTMC increased from about 40 miles of I-4 through Orlando to more than 70 miles of I-4, an equal length of I-95, five toll roads near Orlando, seven key Orlando arterials, and a number of other roads across the state. More detailed operations were also required for each of these roads, including the need for real-time 511 and DMS travel time information. Because this additional workload could not be easily met using the previous "by hand" methods, *i*Florida included software to automate many traffic management activities. Travel time information would be automatically posted to message signs and the 511 system. Sign plans could be created to automate message sign postings if an incident occurred and to remind operators to remove sign messages when an incident cleared.

The increased reliance on automated methods brought about an increased reliance on the reliability of the field equipment. Prior to *i*Florida, an RTMC operator would find some other way to post information when equipment had failed; however, the automated systems were not so flexible, so equipment failures were more likely to result in missing messages in the traveler information systems.

The end result was a transition from a department with a moderate amount of non-critical equipment deployed in the field to a department with a large amount of critical equipment deployed in the field. This section of the report describes how the Florida Department of Transportation (FDOT) modified its maintenance practices to accommodate this transition.

3.1. FDOT D5 Field Devices

Prior to the *i*Florida deployment, field instrumentation maintained by FDOT District 5 (D5) consisted primarily of loop detectors, cameras, and DMSs along I-4 in Orlando, with a smaller set of similar devices deployed along I-95 east or Orlando. As the *i*Florida deployment proceeded, the complexity of the deployed field equipment increased in three different ways: the number of devices increased, the number of different types of devices deployed increased, and the size of the region throughout which those devices were deployed increased.

The number of deployed devices increased from about 240 in January 2004—the first date for which maintenance inventory records were available to the Evaluation Team—to more than 650 in June 2007 (see Figure 11).[1] This figure includes only traffic management devices and excludes equipment related to the FDOT networks used to connect to this equipment.

[1] The information on the number of traffic management devices comes from maintenance spreadsheets used by FDOT to track the operational status of their field equipment.

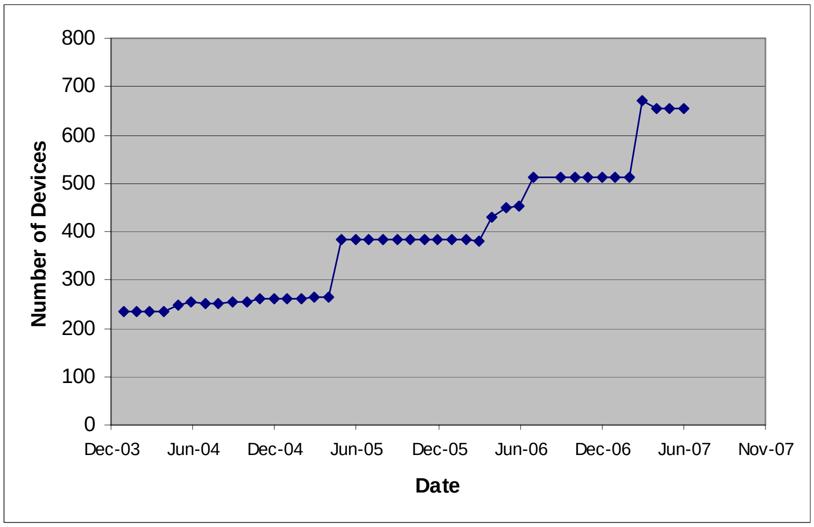


Figure 11. The Number of FDOT D5 Traffic Management Devices

The number of different types of devices also increased. In January 2004, the equipment included loop detectors, traffic cameras, and DMS. By 2007, FDOT had also deployed radar (in place of loop detectors), trailblazer signs, variable speed limit (VSL) signs, toll tag readers, and license plate readers (see Figure 12.)

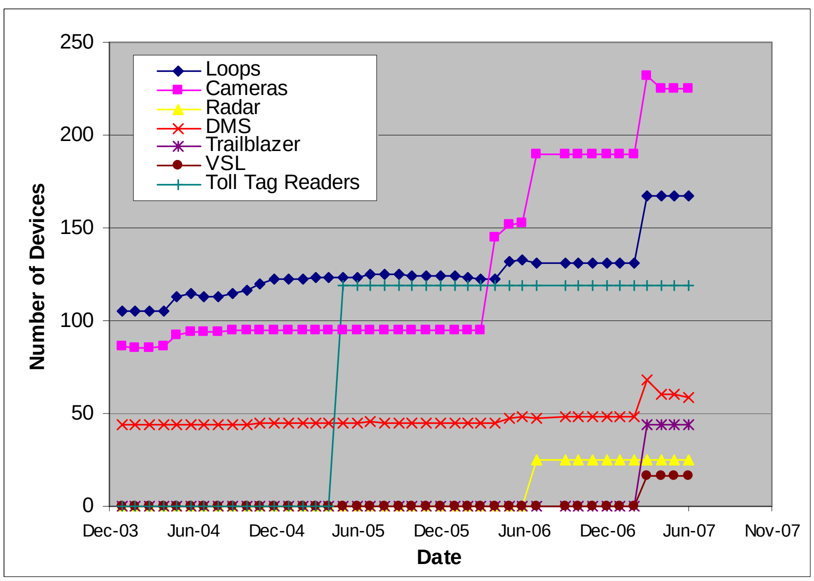


Figure 12. The Number of FDOT D5 Traffic Management Devices, By Type

The geographic distribution of the deployed equipment had increased. In January 2004, the majority of the deployed devices were located on I-4 (about 190 devices), with about 30 devices located on I-95 and 11 devices on SR 528. By 2007, additional devices had been deployed on these roads and other devices had been deployed across the state (e.g., 25 cameras and radar units to support the Statewide Monitoring System (see Section 0), and video surveillance cameras on two bridges).

Note that the devices listed above include only traffic management equipment and exclude switches and other network equipment required to operate the system. The list also includes only equipment that FDOT was helping maintain, so it excludes equipment that was being or had been deployed but was still being maintained by the deployment contractor.

3.2. FDOT D5 Maintenance Practices

Prior to the *i*Florida Model Deployment, FDOT monitored the deployed equipment and managed the maintenance process. Each day, an RTMC operator would review the loops, cameras, and signs and record in a spreadsheet whether the equipment was working. Loop failures were noted by scanning a list of current readings to ensure that data was available from each loop. Camera errors were noted by accessing the video feed from each camera to ensure that it was operational. Sign errors were noted by using the cameras to view each sign. When a new failure was noted, FDOT would either dispatch personnel to make the repair (for FDOT maintained equipment) or issue a work order for the repair (for contractor maintained equipment).

For the field equipment deployed as part of *i*Florida, a different approach was used. In most cases, the equipment deployment contracts included a warranty period covering the entire planned *i*Florida operational period through May 2007, during which the contractor would be responsible for maintaining the equipment. This was important to FDOT because the deployment of so much new equipment had the potential to overwhelm FDOT's ability to monitor and maintain it. FDOT expected that including a warranty period would put the responsibility for monitoring and maintaining the equipment on the contractor.

FDOT did discover a problem with the warranty approach. While the contracts included language requiring specified levels of availability for the equipment and maximum repair times when equipment failed, they did not include language specifying how the availability of the equipment would be monitored. Implicit in FDOT's plan was that the RTMC operators would be able to monitor the availability of the field equipment; when a piece of field equipment failed, an RTMC operator would note the failure because data he or she needed would be unavailable. When the Condition Reporting System (CRS) failed to work as expected (see Section 2), RTMC operators sometimes were unable to verify whether equipment was working because CRS failures prevented access to data from the equipment. If missing data were noted, it was not clear if the missing data was due to equipment failures, failures in the CRS, or failures elsewhere in the system.

This was particularly true with the arterial toll tag readers. Toll tag reads passed through several processing steps to generate travel time estimates before reaching the CRS, and FDOT had trouble tracking down the root cause of missing or inaccurate arterial travel times. Reader failures were first noted by FDOT when the CRS was ready to receive arterial travel times generated by the readers in the summer of 2005. When the travel time server failed to report travel times for most arterials, identifying the root cause of the failure required that FDOT personnel manually review a series of data processing and transmission steps.

In field equipment contracts, include requirements for tools to monitor the operational status of the deployed equipment and for helping with equipment monitoring once the deployment is complete.

In the case of the toll tag readers, this review was made more complicated because of limited documentation on how the reader network operated. FDOT eventually discovered that each reader included a self-diagnostic utility that could be accessed remotely via a web browser—the toll tag reader documentation did not describe this feature. Each reader also created a local archive of all tag reads it had made. To identify failed readers, FDOT staff would review the local diagnostics of each reader each day and review a sample of tag reads made, noting any diagnostic errors or fewer tag reads than expected in a spreadsheet. This process, when applied to the 119 *i*Florida toll tag readers, required about 4 hours per day to complete.[2] This research finally revealed the fact that almost half of the arterial toll tag readers had failed. (See Section 5 for more information.) If the requirements for the toll tag reader deployment had included a tool for monitoring and reporting on the operational status of each reader, then FDOT would not have needed to develop an ad hoc method for doing so and could have detected these failures more easily and corrected them as they occurred rather than having the number of failed devices accumulate while the system was unmonitored.

FDOT also noted that recurring failures sometimes occurred with some equipment at specific locations. FDOT suspected that high failure rates were sometimes related to a root cause (e.g., inadequate power conditioning or high cabinet temperature) that was not being addressed by repairing the failed part. However, the warranty contracts did not require root cause analysis or more extensive repairs if multiple failures occurred at a site. FDOT was considering whether to add such language to future warranty contracts.

3.3. Equipment Reliability

One part of FDOT's equipment maintenance process was the generation each day of a spreadsheet that documented whether equipment was working. While the primary purpose of these spreadsheets was to help generate work orders for repairing failed equipment, FDOT also archived each spreadsheet. FDOT provided the Evaluation Team with copies of these archived spreadsheets for the period from January 2, 2004 through July 2, 2007, and the Evaluation Team converted the information on these spreadsheets into a database so that the equipment failure data could be analyzed.[3] This allowed estimation of three measures of equipment reliability: availability, failure frequency, and repair time. Each of these measures was analyzed for the following groups of field equipment:

- Surveillance Motorist Information System (SMIS). This group includes equipment deployed along I-4. In early 2004, this consisted of about 87 loop detector stations, 68 cameras, and 36 message signs. In May 2007, this consisted of 128 loop detector stations, 77 cameras, and 56 message signs.
- Daytona Area Smart Highway (DASH). This group includes equipment deployed along I-95. In early 2004, this consisted of about 13 loop detector stations, 14 cameras, and 6 message signs. In May 2007, this consisted of 23 detector stations, 25 cameras, and 3 message signs.
- Bridge Security. This group includes cameras deployed to support the *i*Florida Bridge Security project—see Section 12. This consisted of 29 cameras deployed at two bridges.
- Statewide. This group includes cameras and radar units deployed as part of the Statewide Monitoring System—see Section 0. This consisted of 25 radar units and 25 cameras deployed at station locations across the State.
- Hurricane Evacuation System (HES). This group was deployed along SR 528 and SR 520 to support hurricane evacuations. In early 2004, this consisted of about 5 loop detector stations, 4 cameras, and 2 message signs. In May 2007, this consisted of 16 loop detector stations and 4 cameras.

[2] Several months after developing this process, FDOT simplified it by focusing on the number of tag reads that had been successfully transmitted to the toll tag server. This reduced the time required to review the readers to about one hour per day.

[3] The spreadsheets describe the operational status of the equipment at the time FDOT tested it—typically once per weekday in the morning with no tests on weekends. The spreadsheets also sometimes used a single spreadsheet cell to indicate whether any of several pieces of equipment had failed at a single location. These factors limit the accuracy of the reported reliability results.

- VSL. This group consists of 20 VSL signs deployed at 16 locations on a portion of I-4 in Orlando.
- Trailblazer. This group consists of 44 trailblazer message signs deployed at key intersections along I-95, intersections that might be used if traffic is diverted off of I-95 during an incident.
- Arterial. This group consists of 14 cameras deployed at key intersections in Orlando.

These measures were computed independently for each type of equipment (e.g., cameras, loop detector stations) within each group.

3.3.1. Field Device Availability

A measure of the availability of field devices was computed as the number of days during a specified period that FDOT reported that a piece of equipment was operational (i.e., no reported errors) divided by the number of days that FDOT reported on a piece of equipment. (Periods for which no reports were available were ignored.) Note that this may overstate the extent to which equipment was unavailable because any reported error was treated as if the equipment was unavailable. For example, if one of five loops at a detector location had failed, the detector location was treated as if data from that location were unavailable. Figure 13 depicts the availability of the loops, cameras, and signs that in the SMIS group.

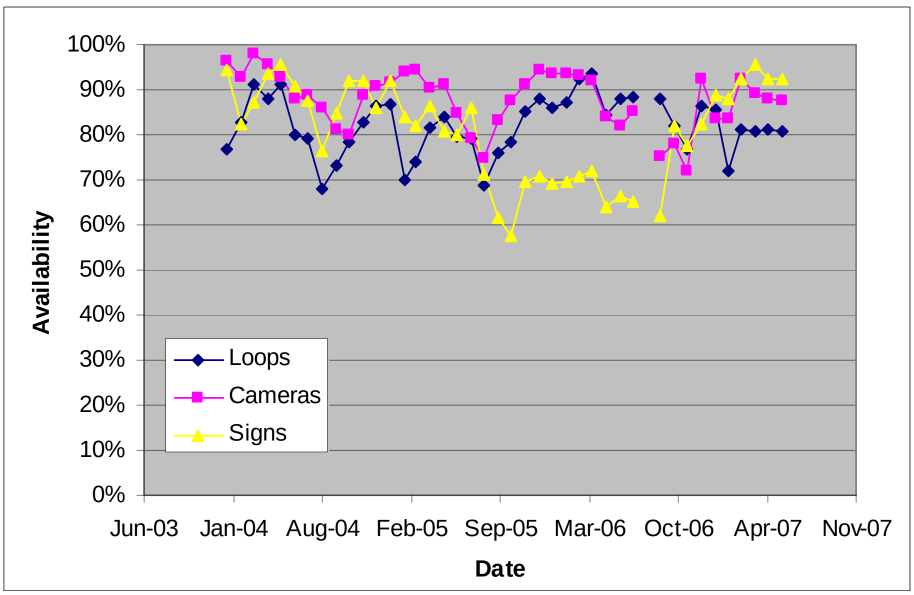


Figure 13. Availability of the SMIS Field Equipment

Note that, in general, the equipment was available 80 to 90 percent of the time, though lower levels of availability occurred during 2005. The lower levels of availability in 2005 correspond to a time when FDOT was simultaneously trying to manage repairs to the arterial toll tag reader network and go live with the CRS. With limited resources available, these new responsibilities appeared to impact FDOT's ability to maintain the existing SMIS network.

Figure 14 depicts the availability for the DASH field equipment. Note that this group showed lower levels of availability, which could be attributed to the fact that it was newer and FDOT had less experience maintaining it.

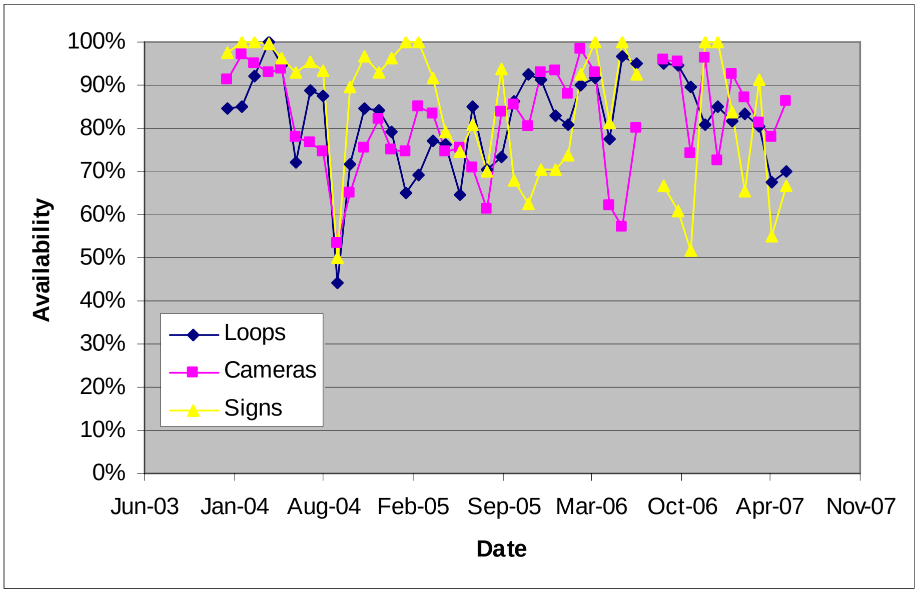


Figure 14. Availability of the DASH Field Equipment

The chart in Figure 15 shows the level of availability of the Bridge Security cameras. Because this system was secondary in importance to the systems that more directly supported traffic management operations, the lower levels of availability in this system were likely because FDOT placed less emphasis on maintaining it.

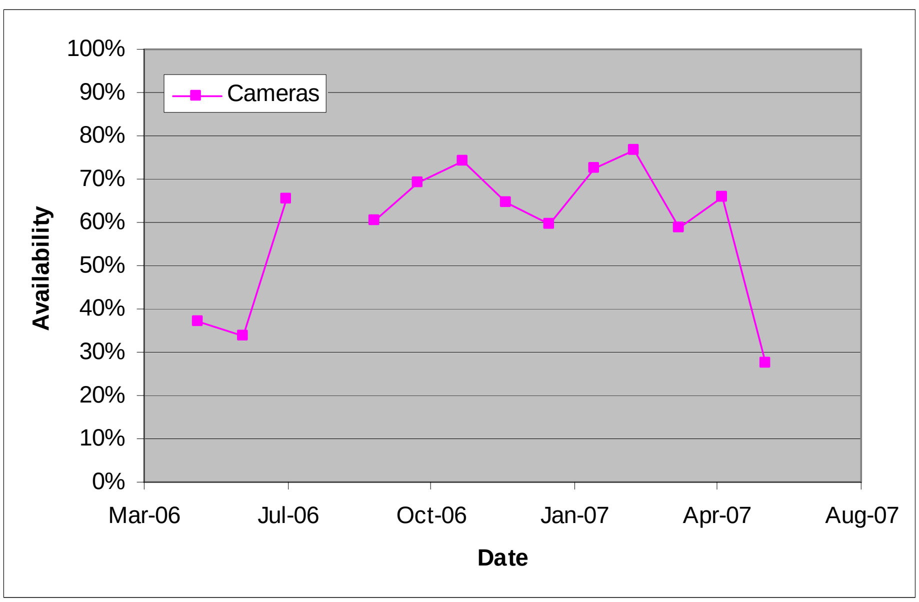


Figure 15. Availability of the Bridge Security Field Equipment

Figure 16 depicts the availability of the equipment in the Statewide Monitoring System. As FDOT discovered that this system was not very effective at providing statewide traveler information (see Section 10), the agency reduced the emphasis on maintaining it. This, and the fact that maintenance costs were high due to the cost of traveling to locations across the state to perform maintenance activities, likely resulted in the low levels of availability for this equipment.

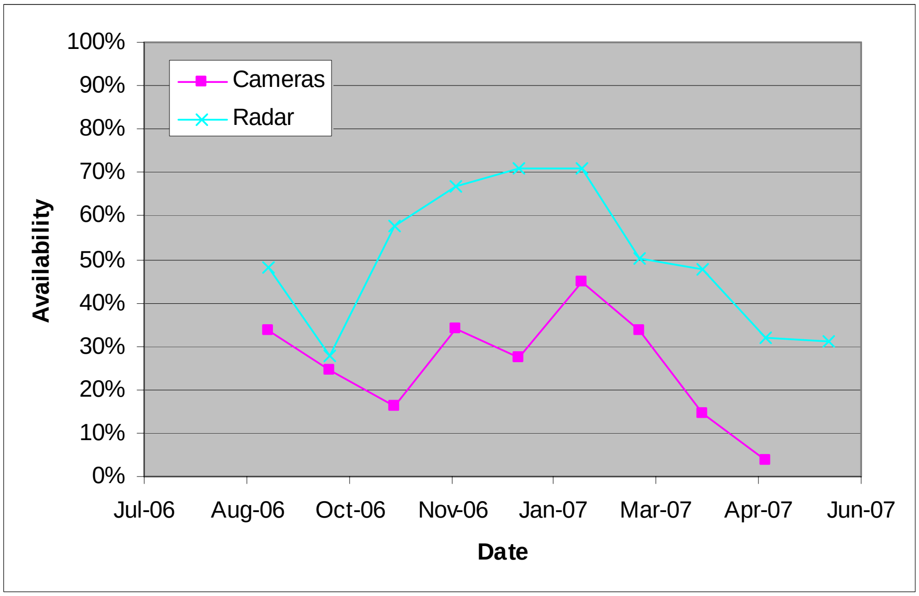


Figure 16. Availability of the Statewide Monitoring Field Equipment

The availability of the HES equipment is depicted in Figure 17. This equipment, which was used to support both hurricane evacuations and traveler information on SR 520 and SR 528, was less critical to FDOT than the instrumentation on I-4 and I-95 for day-to-day traffic management operations.

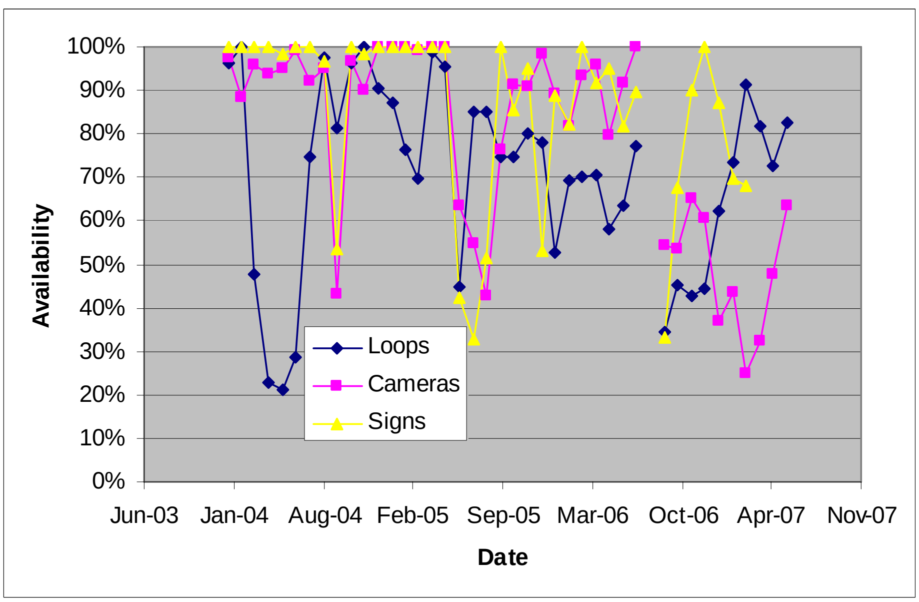


Figure 17. Availability of the HES Field Equipment

Figure 18 depicts the availability of the VSL signs deployed on I-4 in Orlando. Because VSL operations were not put in place in Orlando, lower levels of availability for these signs might be expected.

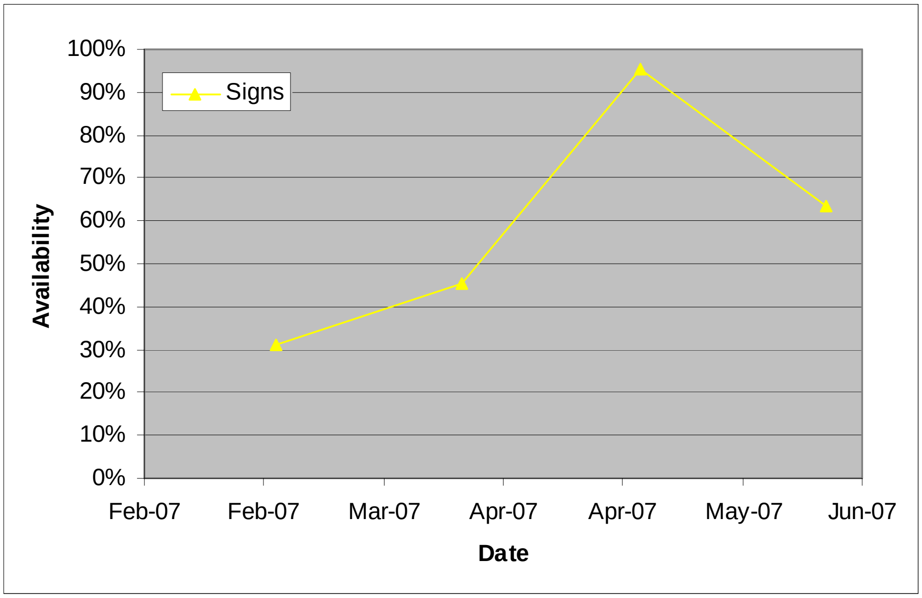


Figure 18. Availability of the VSL Field Equipment

Figure 19 depicts the availability of the trailblazer signs used at key intersections located near I-95.

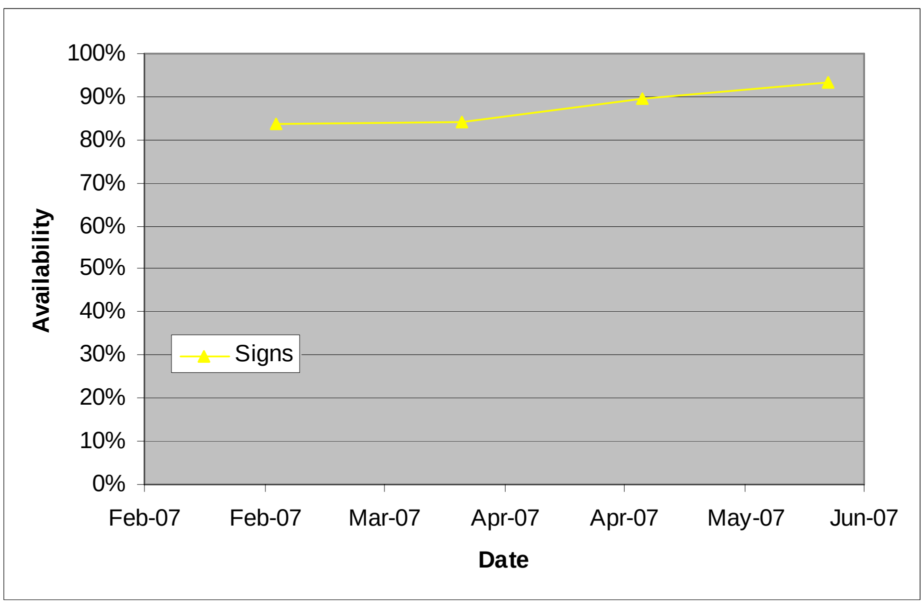


Figure 19. Availability of the Trailblazer Field Equipment

Finally, the availability of the traffic cameras deployed on Orlando arterials is depicted in Figure 20.

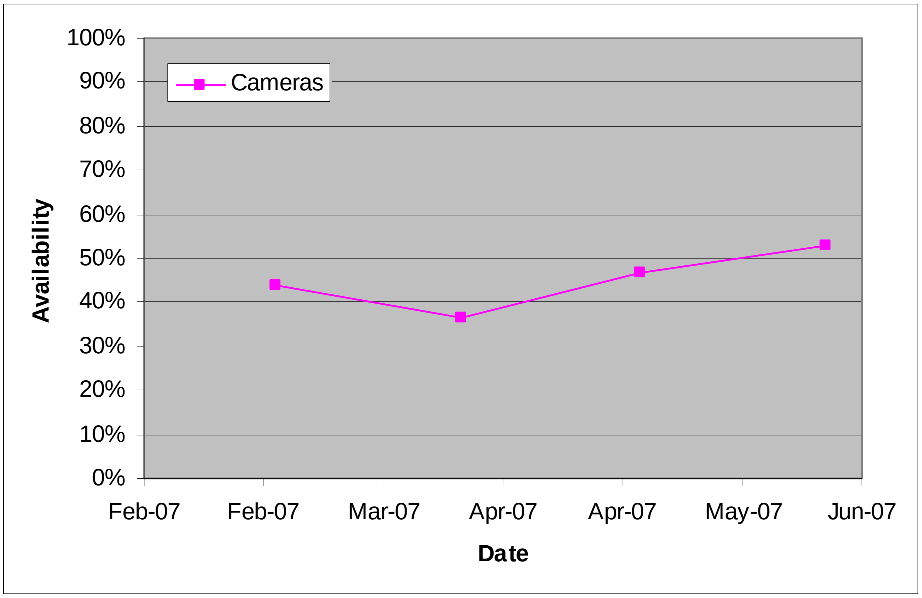


Figure 20. Availability of the Arterial Field Equipment

Figure 21 depicts the level of service for the arterial toll tag readers. (The definition for this measure of level of service is given in Appendix A.)

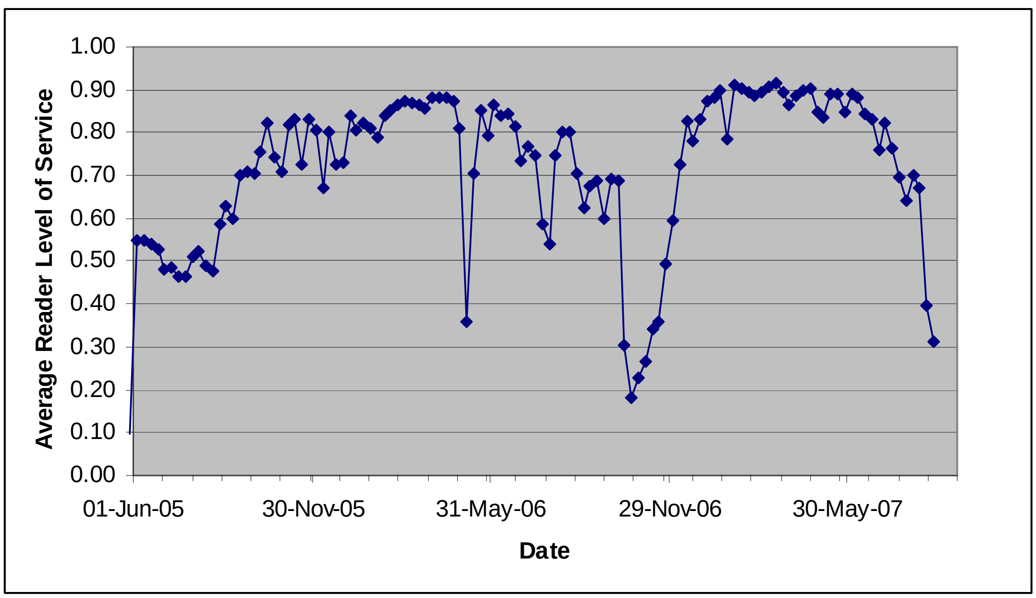


Figure 21. Availability of Arterial Toll Tag Readers

The availability of field equipment deployed by FDOT typically ranged between 80 and 90 percent in 2007. For the SMIS equipment, the 2007 average was about 80 percent for loop detectors, 87 percent for cameras, and 92 percent for signs. For the DASH field equipment, the corresponding averages were 77 percent, 82 percent, and 79 percent. For arterial toll tag readers (see Section 5), the availability was almost 90 percent. The availability of other equipment, which FDOT deemed less critical for its operations, had lower levels of availability.

One conclusion that can be drawn from these observations is that traffic management field equipment is going to be unavailable a significant fraction of the time, and systems that use data from that equipment must be designed to accommodate those failures. See Section 3.5 for suggestions on designing systems to accommodate device failures.

3.3.2. Time to Repair

Another measure related to the reliability of the field equipment is the repair time, measured as the number of successive days in which the maintenance logs reported an error for the equipment, averaged over the collection of equipment in each group. Figure 22 shows the average repair time for the SMIS equipment.

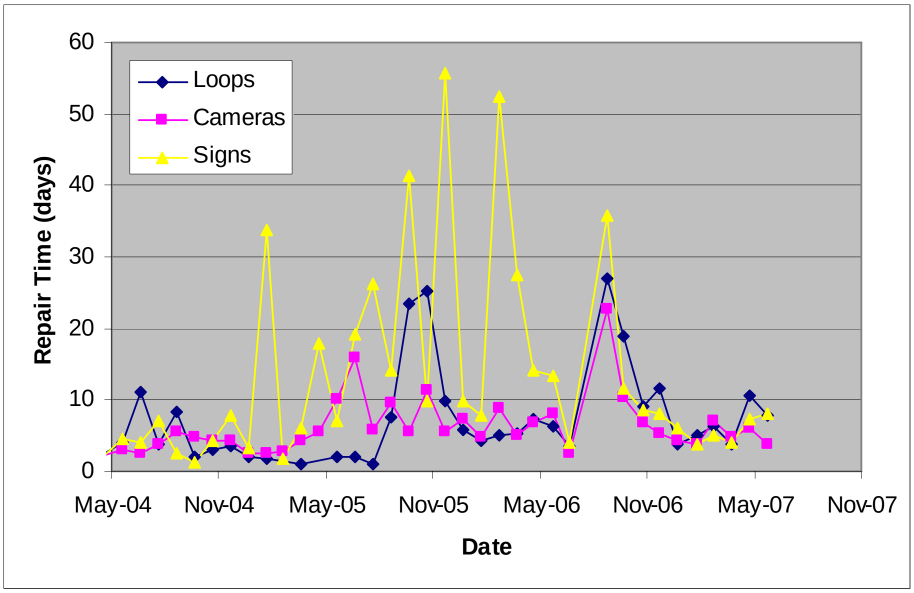


Figure 22. Average Repair Time for the SMIS Field Equipment

In 2007, the average repair time was about 6 days for SMIS loop detectors, about 5 days for cameras, and about 6 days for signs.

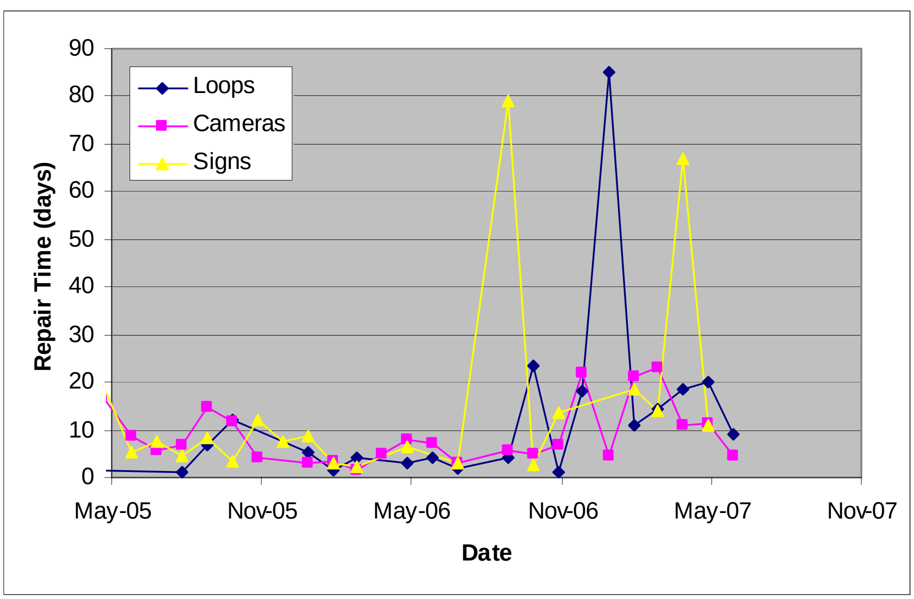


Figure 23. Average Repair Time for the DASH Field Equipment

The average repair time in 2007 was about 18 days for the DASH loop detector stations, about 9 days for DASH cameras, and 25 days for signs. For the HES field equipment, the 2007 average repair time was about 12 days for loop detector stations, 16 days for cameras, and 9 days for signs. For VSL signs, the average repair time was 16 days in 2007. For the Statewide Monitoring System, the average repair times were much longer, averaging about 29 days for detectors and 64 days for cameras in 2007.

3.3.3. Mean Time Between Failure

The mean time between failure (MTBF) was estimated by taking the average time that a piece of equipment was marked as being in service in the FDOT maintenance logs. Note that a piece of equipment could be marked as being out of service for a variety of reasons, including failure of the equipment, failure of equipment utilities, or failure of the network to provide connectivity to the equipment. So, the reported MTBFs are for the equipment as embedded in the FDOT network, not for the equipment itself. Figure 24 depicts the MTBF for the SMIS field equipment.

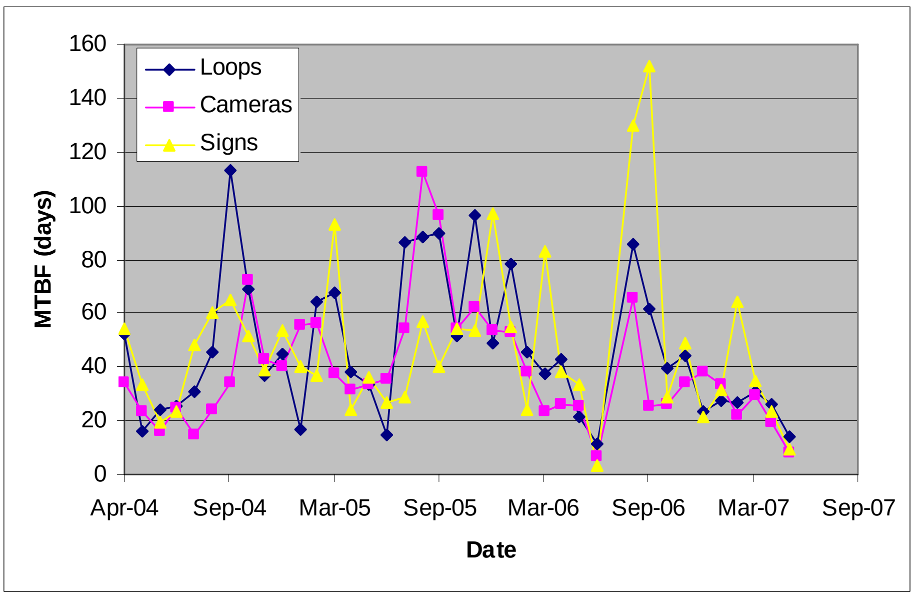


Figure 24. Mean Time Between Failures for SMIS Field Equipment

The MTBF, repair time, and availability for FDOT field equipment are summarized in Table 1.

Table 1. Average Mean Time Between Failures for FDOT Field Equipment, 2007

Equipment Group	Equipment Type	Count	MTBF (Days)	Repair Time (Days)	Availability	
					Obs	Est
SMIS	Loops	128	26	6	80%	81%
SMIS	Cameras	82	28	5	87%	85%
SMIS	Signs	59	36	6	92%	86%
DASH	Loops	23	39	19	77%	67%
DASH	Camera	25	37	9	82%	80%
DASH	Sign	6	58	25	79%	70%
HES	Loops	16	39	12	79%	76%
HES	Camera	4	11	16	40%	41%
Statewide	Camera	25	17	64	50%	21%
Statewide	Radar	25	24	29	21%	45%

Note that there is an approximate relationship between the MTBF, repair time, and availability: on average, each piece of equipment should work [MTBF] days before repairs are necessary, and the repairs require about [Repair Time] to complete. So,

$$[Availability] \cong \frac{[MTBF]}{[MTBF]+[repair\ time]}$$

The “Obs” column under “Availability” is the observed availability (see Section 3.3.1) and the “Est” column is the estimated availability using the formula above. Considering this formula leads to the following observation. Because the MTBF is usually significantly longer than the repair time, reducing the repair time by a given number of days will have a bigger impact on availability than increasing the MTBF by the same number of days.

3.4. Maintaining a Fiber Network

One of the common sources of device failures at FDOT was fiber cuts, which left field devices disconnected from the RTMC. The main cause of fiber cuts on the FDOT network was construction activities. One interchange project, for example, resulted in more than 90 fiber cuts during the course of the three-year project. In one instance, a contractor was onsite repairing the fiber when the fiber was literally jerked out of his hands as the result of a second cut occurring on the same fiber bundle.

Before 2007, the FDOT ITS Group had played a reactive role in the process of protecting and repairing their fiber. All contracts included clauses requiring the contractors to promptly repair any fiber that was damaged, but contractors often made little effort to avoid damaging fiber. FDOT believed that, in some cases, this was because the contractor may not have been aware of the exact location of the fiber. At other times, it appeared that the cost of repairing the fiber was less than the cost and inconvenience of trying to avoid it.

When a fiber cut did occur, the consequences were sometimes magnified because the ITS Group was not immediately notified so repairs could begin. Most contractors had few interactions with the ITS group, and were uncertain who to contact if a problem occurred. If a fiber cut occurred during off hours, the contractor, uncertain who to contact, might not report the cut immediately. Meanwhile, network monitors would note the loss of connectivity and began contacting FDOT employees by email, pager, and cell phone. FDOT employees would run tests to locate the problem and identify the source of the problem as being damaged fiber in a construction zone. In some cases, ongoing construction activities would have buried the damaged fiber by the time FDOT responded, and FDOT would have to run additional tests to determine the exact location of the cut and re-excavate the damaged fiber before repairs could be made.

In 2007, FDOT began taking a more pro-active stance in addressing the problem of fiber cuts. The goal was to reduce the number of fiber cuts and reduce the impact when a cut was made. As a first step, FDOT identified some of the root causes that led to fiber cuts, identifying the following:

- ITS fiber was often not included on construction plans. Until recently, the ITS Group was not integrated into the FDOT construction planning process. In some cases, ITS fiber was not included on construction plans and issues were often not identified until plans were nearly complete. At that point, the cost of modifying the plans was higher than if it had been done earlier in the planning process, and some approaches for avoiding damage to ITS fiber were no longer feasible. The ITS Group stated that their goal was to be fully integrated as part of the normal DOT process of identifying, designing, and building projects.

- The exact location of the ITS fiber was often not known. Sometimes, the actual deployment and as-built drawings differed too much to be useful guides for whether construction activities would damage the fiber. FDOT also found that using the toning wire to locate the fiber often was not accurate enough to avoid fiber cuts.

Integrate the ITS Group into the construction process to help ensure that consideration of the fiber network is included in construction plans.

- Contractors often were not certain how to contact FDOT to get further information if something in the field caused them to be concerned that they might damage some fiber. Not certain who to contact, contractors would often proceed with construction activities. If a fiber cut did occur, the contractor still might have been uncertain who to contact, and the damage would not be reported until FDOT detected it.

After reviewing these causes, FDOT identified several steps it could take to better protect its fiber. These steps were:

- The ITS Group began to develop a more accurate inventory of the location of their fiber. This GIS-based inventory would allow FDOT to provide more accurate information about the location of fiber to construction contractors before construction begins.
- The ITS Group should become better integrated into the construction planning process to ensure that construction activities include the appropriate steps to protect the FDOT ITS infrastructure.
    - Large projects pass through FDOT's consultant project management process. FDOT modified procedures for this process so that the ITS Group would be notified early in the planning process and could participate in early planning meetings between FDOT and the contractor. This helped ensure that the construction plans took into account the ITS infrastructure. It also gave FDOT the chance to take steps to reduce the amount of damage to the ITS infrastructure if damage did occur.
    - Smaller projects (local area projects and special projects) did not go through the FDOT consultant project management process. To ensure that protection of ITS resources was considered in these projects, FDOT began developing relationships with the various city and county government bodies that managed these projects. An ITS Group staff member began attending weekly project review meetings at these organizations at least once per month. This helped develop relationships between the ITS Group and those managing the local area projects and the local area project contractors.
- The ITS Group began considering changes they could make to its network before a project began to reduce the likelihood and impacts of fiber cuts.
    - Consider making fiber visible. In general, FDOT located fiber underground as a means of protecting it from damage. Making fiber difficult to see, however, has made it more prone to damage during construction activities. FDOT noted that contractors typically avoided damaging overhead fiber because it is visible to them. FDOT began repositioning the fiber above ground along the fence line during long-term construction projects on limited access roads. FDOT

Installing fiber in visible locations rather than underground can help contractors avoid damaging the fiber.

believed that making the fiber part of a visible obstruction (i.e., the fence) helped protect it from inadvertent damage.

- Consider locating fiber near features that contractors are likely to avoid during construction activities. FDOT noted that, with overhead fiber, the presence of nearby power lines made contractors more cautious. FDOT began considering the advantages of laying new fiber near other features that contractors were already prone to avoid, such as underground pipelines.
- Consider relocating the fiber before construction begins. In many cases, FDOT felt it was unrealistic to expect a contractor to avoid cutting fiber during prolonged construction activities. Multiple fiber cuts that might occur would result in costs for repairing the fiber, disruption of ITS services, and lower quality fiber connections (since the splices required to repair fiber reduce the overall quality of the fiber). Because most contractors included in their bid a reserve to pay for damages that may occur, the potential for fiber cuts actually results in increased construction costs for FDOT. FDOT began to consider moving the fiber away from the construction site in order to lower overall costs and better ITS service

  It can be more cost-effective to relocate fiber prior to construction to reduce the likelihood and impacts of fiber cuts than make repairs when cuts occur.

  - In one recent intersection reconstruction project (at SR 436 and SR 50), both ITS equipment and fiber were located at the site. FDOT decided that it would be more cost effective to re-route the fiber and move the ITS equipment than to maintain it during the construction. The ITS Group coordinated with the City of Orlando, Seminole County, and Orlando-Orange County Expressway Authority (OOCEA) to make use of nearby dark fiber that these organizations had available, enabling FDOT to reroute fiber around the SR 436/SR 50 intersection. The strong relationships between FDOT's ITS Group and these other agencies were key towards achieving this level of cooperation and sharing of resources. This approach was cost-effective because it required deploying only a small amount of new fiber.
- Consider increasing the amount of slack included in fiber deployments. FDOT has begun the practice of including large amounts of excess slack in areas where they expect to later deploy additional field equipment. This allowance can reduce the amount of rework required when the new equipment is deployed. FDOT recently had to rework several miles of infrastructure due to inadequate slack deployed in previous projects.

FDOT also noted that some contractors are more careful to avoid damaging ITS infrastructure than others.

Another cause of fiber cuts noted by FDOT was mowing activities. It was common for contractors working on fiber to not bolt down the covers on fiber hubs. If a mower passed over a hub cover that was not bolted down, it could either lift the cover and break it or, if the hub cover was not recessed, hit the cover directly and break it. Once the cover was broken, the suction from the mower could pull the fiber bundle up into the mower blades, cutting the fiber.

3.5. Designing Traffic Management Systems to Accommodate Equipment Failures

One of the lessons learned in considering the maintenance of the *i*Florida field devices is that failure of deployed field devices should be expected. At FDOT D5, it was common for between 10 and

20 percent of devices in key systems to be down at any one time. The TMC software should accommodate these failures when they occur. This section of the document describes an approach that could be used to accommodate device failures. The fundamental concepts behind the approach are:

- Missing data should be replaced with estimated data for all key data used in transportation decision making. In most cases, reasonable estimates of travel times and other data can be generated (e.g., from historical data, from operator review of traffic video). Basing transportation decisions on estimated data is likely more effective than basing them on no data.
  - FDOT's original specifications called for estimated travel times to be used whenever observed travel times were unavailable. When the CRS was first released and did not include this feature, a large number of 511 messages stated "Travel time on [name of road] from [location 1] to [location 2] is unavailable." The Evaluation Team felt that more time was spent creating an appropriate approach for addressing missing travel time data in the 511 system alone than would have been required to implement a method for replacing missing data across all systems with estimated values.
- Estimated data should be marked as such so that downstream decision support software can, if necessary, consider the fact that data has been estimated. In order for downstream data processing to differentiate between actual and observed data, the data must be marked accordingly.
- The estimated data should be produced as early in the data flow as possible. It is difficult to design software to accommodate missing data. Filling in missing data with estimated data early in the data flow will allow systems downstream from that point to assume data will always be available.
- All available data sources that can be used to estimate missing data, such as historical data generated by the detectors and traffic video that can be reviewed by TMC operators to assess the validity of estimated data, should be utilized and the most appropriate at that time used.
- The TMC software should provide tools to help TMC operators fill in missing data with estimated values. TMC operators, with access to many traffic data resources, are best equipped to help fill in missing data and review estimated values for correctness. The TMC software should inform operators of missing data and allow operators to specify parameters for controlling how the missing data should be estimated.

Figure 25 depicts an approach for replacing missing travel time observations with estimated values.

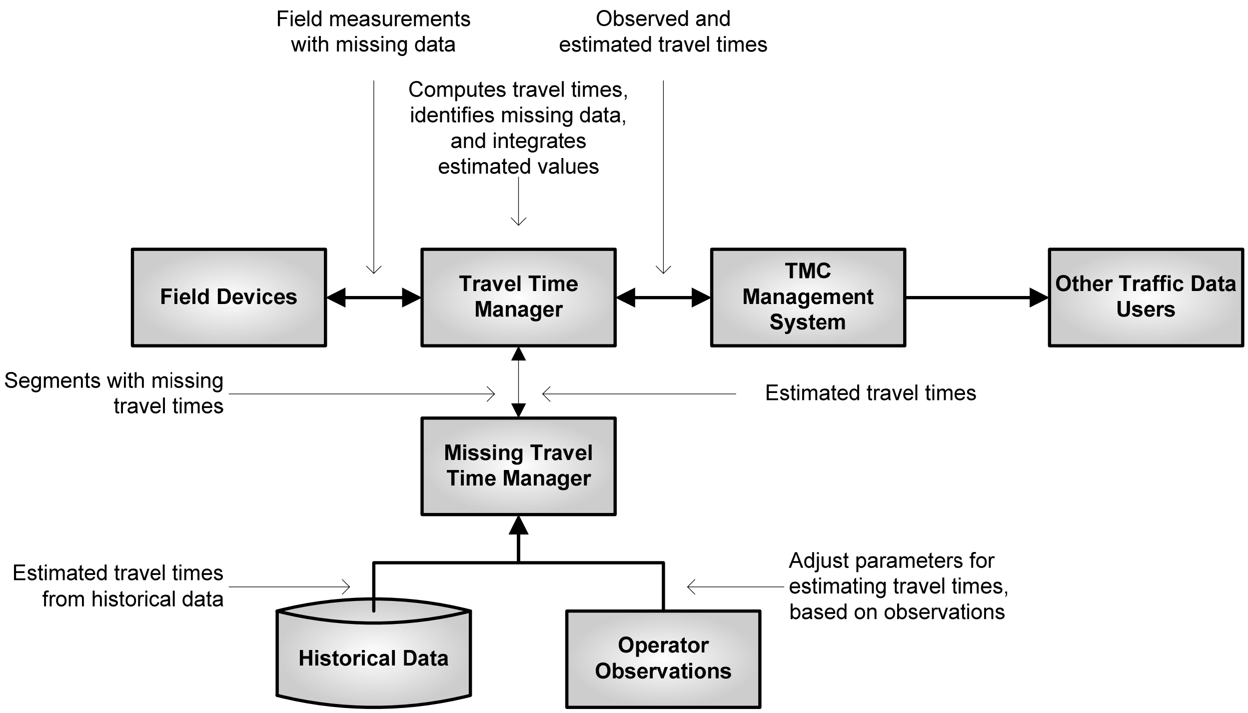


Figure 25. Process for Replacing Missing Travel Time Observations with Estimates

In the above process, field devices generate measurements that are processed by the Travel Time Manager to produce travel time estimates for road segments. This process also identifies segments for which missing observations from the field devices result in missing travel time estimates.

When it first occurs that travel time observations are not available for a segment, the Missing Travel Time Manager alerts an operator, who selects an approach for producing estimated travel times for that segment. (This also gives the operator the opportunity to alert maintenance personnel that a piece of equipment has failed.) Several approaches might be used to produce travel time estimates:

- The operator might specify the travel time to use. (When the CRS failed in 2007, TMC operators would use observations from traffic video and loop detector speeds to estimate travel times. See Section 2 for more information.)
- The system might use the historical average for similar types of travel days. The travel days might be categorized into a number of different categories, such as "Typical Weekday, Fall," "Typical Weekday, Summer," "Special Downtown Event, Weekday," "Typical Weekday, Strong Rain," and "Typical Weekday, Minor Incident." (When the CRS failed in 2007, FDOT did use historical travel time data for 511 travel time messages.)
- The operator might specify a relative congestion level (based on available traffic video) and the system would compute an appropriate travel time for the segment based on historical averages for the specified level of congestion.

The estimated travel times would be merged with the observed travel times, adding a flag to indicate if travel times were estimated, to produce a complete set of travel times for the monitored road segments. The operator would be periodically alerted to review the segments with estimated travel time times to verify that the estimates remain valid.

The TMC Management System would use the travel times—both observed and estimated—to help perform traffic management operations, such as creating DMS and 511 messages. Note that, because the travel time data received by the TMC Management System does not include missing data, this software does not need to include features to address the fact that some data may be missing. (The system can, if desired, adjust its responses when data is marked as being estimated instead of observed.) Since the TMC Management System likely consists of a number of modules performing different operations (e.g., a module for managing DMS messages, a module for managing 511 messages, a module for managing web-based traveler information), inserting travel time estimates before the data enters the TMC Management System simplifies the overall design of the system. (Travel time estimation occurs once and is used many times.) The savings are compounded when one considers that other traffic data users that receive data from the TMC Management System also benefit from the estimated travel times.

Another benefit of this approach is that it creates a mechanism for testing features in the TMC Management System independently of the field devices. One could disconnect the field devices from the Travel Time Manager and create a travel time estimation module that fed in pre-defined travel time values meant to simplify testing. (A similar approach was used to test the CRS, but required development of an ad hoc process for feeding static travel time data to the CRS. See Section 2 for more information.) The well-defined interface between the Travel Time Manager and the TMC Management System also provides a mechanism for testing these modules independently.

3.6. Approaches to Reduce Maintenance Costs

During the course of the *i*Florida evaluation, several ideas were discussed for reducing the overall costs of owning and operating traffic monitoring equipment. These ideas are discussed below.

- Consider total cost of ownership during the procurement process. The contract for the *i*Florida field devices included the cost for deploying the field devices and providing a maintenance warranty for two years after the deployment was complete. The expected cost of maintenance after this two-year warranty period would not be reflected in the procurement cost. Because of this, a system that has a lower procurement cost could have a higher life-cycle cost. In particular, a system that was less expensive to install but had higher maintenance costs could result in a low procurement cost (because only two years of maintenance costs are included), but a high life-cycle cost. A department may want to compare the full life-cycle cost of a deployment rather than the the procurement cost when evaluating deployment contracts.
- Consider participating in the FHWA ITS Benefits and Costs Databases. Considering the full life-cycle cost of a deployment requires estimating future failure rates for installed equipment and the costs of repairs. A good approach for doing so is to obtain information from other deployments of the technologies. FHWA established the ITS Costs database to help departments share information about the costs of deploying and maintaining ITS field equipment. Because of limited participation by agencies deploying ITS technologies, the information in this database is limited. Agencies should consider tracking costs and submitting their costs to this database so as to benefit others deploying similar technologies.
- Consider tracking the causes of equipment failures to help decrease maintenance costs. FDOT used a spreadsheet to track failed equipment and assign work orders for repairs. FDOT's maintenance contractor was expected to identify the root cause of failures that occurred. However, they did not provide this information to FDOT. This made it difficult for FDOT to identify common causes of failures so that they could take action to reduce the prevalancy of those causes. Even though FDOT was proactive in trying approaches to reduce failures, such as

adding surge protectors and lightening protection. The lack of ready access to detailed failure data made it difficult to determine if these approaches were successful.

3.7. Summary and Conclusions

The *i*Florida Model Deployment resulted in a significant increase in the number, types, and geographic distribution of field equipment that FDOT D5 was required to maintain. In January 2004, D5 was maintaining about 240 traffic monitoring stations. In 2007, this had increased to about 650 stations. This rapid increase in maintenance responsibility resulted in some problems with maintaining the equipment. The MTBF for most traffic monitoring stations was between 30 and 60 days. The availability of high priority equipment was typically available 80 to 90 percent of the time, with lower priority equipment having lower levels of availability.

One of the maintenance problems FDOT faced was that the contracts for deploying the field devices did not include requirements related to how the equipment would be monitored. This meant that FDOT had to rely on manual methods for monitoring whether field devices were operational. In the case of the arterial toll tag readers, almost half of the readers had failed before manual monitoring began. When monitoring did begin, it required a significant amount of FDOT staff time to poll each individual reader each day to identify readers that had failed. The same held true with the other deployed devices—FDOT staff was required each day to review the status of each field device and copy status information into spreadsheets used to monitor system status. Thus, even though FDOT had taken steps to reduce the demands on its maintenance staff by requiring warranties on much of the *i*Florida equipment, monitoring the equipment for failures still required a significant amount of FDOT staff time. The amount of time required was larger when systems were first brought online, as FDOT developed procedures to integrate the new equipment into its monitoring and maintenance programs.

During this process, FDOT did identify a number of lessons learned that might benefit other organizations planning on a significant expansion of their traffic monitoring field equipment:

- Establish a well-defined process for monitoring and maintaining field equipment before beginning a significant expansion in the amount of field equipment deployed.
  - Consider streamlining the existing monitoring and maintenance process before expanding the base of field equipment. A simple system that works well for a small amount of deployed equipment may be less effective as the amount of deployed equipment increases.
- Ensure that the requirements for new field equipment include steps to integrate the equipment into the monitoring and maintenance process.
  - These requirements should include tools and/or procedures for monitoring the equipment to identify failures that occur. In the case of the arterial toll tag readers, the deployment contractor provided no such tools and weak documentation. FDOT had to develop procedures for monitoring the equipment after it had been deployed, and it took several months before FDOT had developed an efficient process for doing so.
  - Newly deployed equipment should be integrated into the monitoring and maintenance process incrementally, as soon as each piece of equipment is deployed. The arterial toll tag readers were deployed and inspected over a period of four months in early 2005, but FDOT did not begin developing procedures to monitor that equipment until the deployment project was completed in May 2005. By the time FDOT began monitoring this equipment, almost half the devices had failed. Despite the fact that the deployment contractor was

responsible for the equipment during this period, it appeared that they did not monitor the equipment for failures.

- These requirements should include maintaining a sufficient inventory of spare parts so that repairs can be made quickly. When FDOT discovered the large number of failures in the arterial toll tag readers, it took many months before a sufficient number of replacement parts were available to conduct repairs. The contract placed requirements on the repair time for serviced parts, and the contractor failed to meet these requirements because insufficient replacement parts were available to make the necessary repairs.

- Plan for the increased demands on maintenance staff and contractors as new systems are brought online. If possible, avoid bringing several new systems online at the same time.
- Expect traffic monitoring equipment to be down part of the time. At FDOT, key equipment was available 80 to 90 percent of the time, with other equipment available less often.
    - Decreasing the time to repair equipment is an effective approach for increasing the percent of time that equipment is available.
    - Providing a mechanism to continue operations when equipment fails (e.g., redundant equipment, replacement of missing data from failed equipment with estimates based on historical data and/or operator observations) is needed.
- One important source of failure in a fiber network is fiber cuts and damaged network equipment. FDOT identified a number of ways to decrease the number of fiber cuts that occur or the time required to repair cuts when they do occur.
    - Ensure that the ITS Group is integrated in the construction planning process so that protection of fiber and network equipment is considered from the start in construction projects.
        - Becoming integrated in the construction process may require both working with transportation department construction contract management staff and nearby city and county governments, which may be responsible for managing some construction projects.
    - Consider installing fiber in visible, above ground locations (such as along fence lines) rather than underground. If installed underground, consider locating fiber near to existing underground utilities that construction contractors are accustomed to avoiding or near existing aboveground features (e.g., a fence line for a limited access highway) that serves as a visible marker that contractors will avoid.
    - When prolonged construction activities are planned, consider re-locating fiber and equipment so as to avoid the potential for damage during construction.
        - Because contractors will typically include a reserve for repairing damage to fiber in their bids, the cost of re-locating fiber and equipment may be offset by lower costs for the construction project.
- Because traffic monitoring equipment will fail, systems that rely on data from this equipment should be designed to work well when equipment fails.
    - Historical data can be used to estimate travel times during normal operating conditions.
    - Because TMC operators often have secondary sources of traffic data available to them (e.g., traffic video), they can estimate travel times or verify that estimated travel times based on historical data are accurate.

- Tools for replacing missing data with estimated values should be implemented early in the development process.
    - Time spent developing a single tool to replace missing data with estimated values is likely less than the time that required to develop processes to deal with missing data in every module that uses that data.
    - A tool to replace missing data with estimated values will allow the TMC software to be tested before field data is available.
    - A tool to replace missing data with estimated values will allow the TMC software to be tested independently of the field equipment.

FDOT did face significant challenges in maintaining its network of field devices, particularly when several new systems were brought online simultaneously in the summer of 2005. Noticeable drops in the availability of both new and existing field equipment occurred during that period. By the start of 2006, FDOT had reached relatively stable levels of availability for key field equipment and had developed a well-defined process for monitoring and maintaining that equipment. By 2007, the stability of FDOT's maintenance practices allowed the agency to spend more time focusing on ways to improve equipment availability. FDOT took a number of steps to reduce downtime in its fiber network. The agency also started experimenting with changes to equipment configurations that might improve reliability, such as removing lightning rods from some locations and improving grounding in others. FDOT was also transitioning to new software to manage TMC operations, and was including lessons learned with regard to how to handle missing data in the design of this software.

4. Using Toll Tag Readers for Traffic Monitoring

One of the innovative parts of the *i*Florida design was the extensive use of toll tag readers to collect vehicle probe data for estimating travel times and identifying incidents. (The system also used a limited number of license plate readers. The focus in this report will be on the toll tag reader network, though many of the observations would apply equally well to a network of license plate readers.) This section of the report describes the *i*Florida toll tag travel time system, the challenges faced by FDOT in deploying, operating, and maintaining this system, and the success of the system in producing travel times. A particular focus is given to the characteristics of the arterials on which the travel time system was deployed and the impact of those characteristics on the effectiveness of the travel time system.

4.1. Using Toll Tag Reads to Estimate Travel Times

Toll tag reads were used to estimate travel times for a segment of road by matching tag numbers read at the starting point of the segment of road with tag numbers read at the ending point and estimating the travel time as the difference between the times when two matching tag reads were made. In this sense, a travel time determined by matching toll tag readings was a direct measure of the travel time taken by a vehicle that actually traveled the segment in question. If the system identified every vehicle entering and exiting a segment and if each vehicle drove without diversion from the start to the end of the segment, then this approach would completely characterize the travels times experienced by vehicles on the segment.

In practice, the performance of the system will be much less for many reasons – not all vehicles will be equipped with toll tags, not all toll tags will be read, etc. The remainder of this section describes the process for computing travel times from toll tag reads and identifies different types of failures that might occur during this process. Later sections of the document give examples of these failures that occurred during the *i*Florida deployment and describes the effectiveness of the *i*Florida toll tag travel time system. Figure 26 depicts the process for estimating travel times from toll tag readings, calling out the factors that can reduce the effectiveness of the toll tag travel time estimation process.

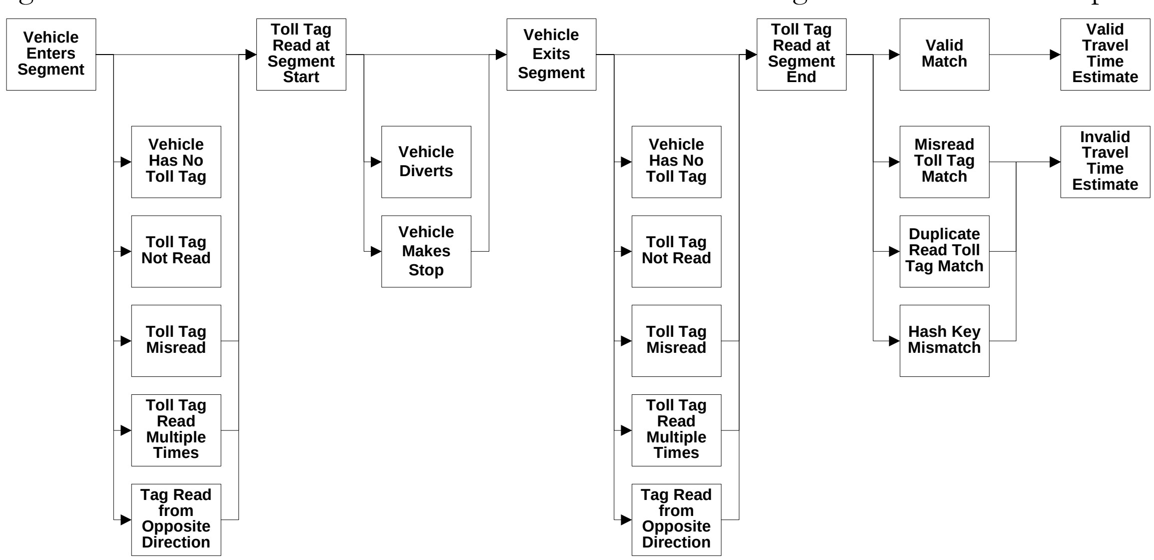


Figure 26. The Process for Estimating Travel Times from Toll Tag Readings

Each of these factors is described in the list below.

- Vehicle Has No Toll Tag. The fraction of vehicles with toll tags was a critical factor in whether toll tag readers were an efficient approach for estimating travel times. Field tests conducted by FDOT prior to deciding to use toll tag readers for travel time estimation indicated that about 20 percent of vehicles in the Orlando area, which has a large number of toll roads, were equipped with toll tags. The proportion of vehicles with toll tags was lower in other parts of the state with fewer toll roads. The primary effect of this factor would be to reduce the number of tag reads that were available for making travel time estimates. An approach for mitigating against negative impacts would be to only use toll tag travel time systems in areas where the toll tag market penetration was high.

> ***The effectiveness of a toll tag travel time system may be limited by a number of factors, including the fraction of vehicles equipped with toll tags, the effectiveness of the toll tag readers, duplicate reads, vehicle diversions and stops, and mis-matched tag reads.***

- Toll Tag Not Read. When optimally positioned, as at a toll booth, toll tag readers reliably read most tags. On Orlando arterials, the toll tag readers were placed roadside rather than directly overhead. This placed the readers further from the vehicles, reducing the efficiency with which they capture tag information. The readers were also aimed at a single lane of traffic and would read tags most effectively from that lane. Toll tags on vehicles in adjacent lanes would be read less efficiently. If a reader was not aimed correctly (e.g., was aimed between lanes, was aimed so that obstructions existed between the antenna and the vehicles), its read efficiency was lessened.
- Toll Tag Misread. It would be possible for a toll tag reader to misread a tag. Because of the error detection and correction capabilities built into toll tag readers, this type of error would be rare and should have little impact on toll tag travel time systems.
- Toll Tag Read Multiple Times. Most toll tag readers were designed for toll booth operations, where the sensors can be placed to detect toll tags in a limited area while a vehicle passess underneath the sensor. When deployed on *i*Florida arterials, the readers were placed further from the vehicles and had a broader detection footprint. This increased the chance that a toll tag would be read more than once while passing through the detection zone. This effect was exacerbated if vehicles stopped in the detection zone – say, because a preceding vehicle was making a turn. Because of this possibility, a toll tag travel time system should include steps to identify and discard duplicate reads. For the *i*Florida tag readers, duplicate reads accounted for between 5 and 10 percent of reads at most readers.
- Tag Read from Opposite Direction. Because *i*Florida roadside toll tag detectors were angled across the lanes of traffic, it was possible that toll tags from some vehicles traveling in lanes for the opposite direction of travel were detected. In general, such detections should have little effect on toll tag travel times since there would not be a matching toll tag read upstream. If a vehicle turned around after being falsely detected, it could result in a travel time estimate that included the time spent turning around. One could mitigate against tag reads from the opposite direction of travel by comparing reads from detectors for each direction of travel and filtering out those that matched. FDOT relied on methods for excluding outliers for removing travel times computed from such reads.
- Vehicle Diverts. A vehicle that entered a travel time segment might fail to exit the segment because it diverted onto another route. On limited access highways, diversion opportunities would be limited. On arterials, there would be many opportunities to turn off of the travel time

segment. The effect of vehicle diversions would be to reduce the fraction of vehicles entering a travel time segment that generated a travel time measurement by exiting the segment at its endpoint. One could reduce the opportunity for diversions to occur by using shorter travel time segments. With the *i*Florida deployment, the effect of vehicle diversions was indicated by the fact that, with long travel time segments, few of the vehicles that entered a segment later exited that segment.

- Vehicle Makes Stop. A vehicle that entered a travel time segment might exit the segment, but do so after making an intermediate stop or a side-trip. As with vehicle diversions, this would be much more likely to occur on arterials than on limited access highways. The effect of a vehicle making a stop would be to produce a travel time measurement that was too long because it included the time the vehicle spent stopped. A sign of this in the *i*Florida data was that the mean of all travel time measurements was typically much higher than the median. FDOT used algorithms to identify and remove outliers from the measured travel times.
- Duplicate Read Toll Tag Match. If duplicate tag reads were not filtered out when read, then the duplicates could result in associating multiple travel time measurements with the same trip – N duplicate reads at the starting point and M duplicate reads at the ending point could make a single trip appear as N times M travel time measurements. One potential effect if this occurred would be to bias the travel time estimates – slow moving vehicles would be more likely to generate multiple reads of longer travel times. One mitigation strategy would be to remove the duplicates before they enter the travel time calculation process.
- Hash Key Mismatch. In order to protect the privacy of the toll tag owners and the security of the toll tag IDs, the *i*Florida AVI readers did not transmit the toll tag ID directly to FDOT. Instead, the reader produces a hash key that is related to the toll tag ID. Because the same hash key could be generated from two different toll tag IDs, it is possible that the hash key value of a vehicle entering a travel time segment could match the hash key value of a different vehicle exiting the segment. In the *i*Florida deployment, the hash key values are six digit numbers, so that the frequency of hash key mismatches should be very low. If a mismatch did occur, the outlier removal process should prevent them from impacting the travel time estimates.

Other potential failure modes were associated with the specific process used in the *i*Florida deployment to estimate and make use of travel times from toll tag readings (see Figure 27).

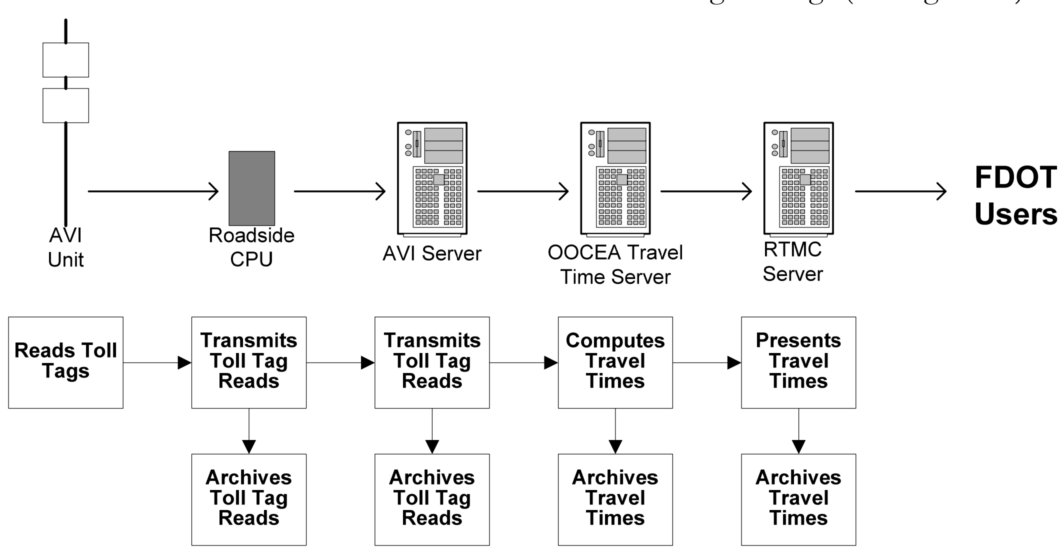


Figure 27. The *i*Florida Toll Tag Travel Time Process

This process worked as follows. A toll tag was read from a vehicle passing one of the *i*Florida toll tag readers and the data from that read was transmitted to a roadside central processing unit (CPU). This CPU accumulated readings from all readers deployed at a single site, archived those reads onto a local hard disk, and transmited each read to a central server. The roadside CPU also tracked transmissions that failed to reach the central server so that it ccould retransmit them at a future time. The central server batched all of the reads received during each one-minute interval, archived these one-minute batches, and transmited them to the travel time server. The travel time server combined each batch of data with other data previously received, matched toll tag reads across links to produce travel time measurements, excluded outliers from these measurements, and calculated the average travel time from the remaining measurements. The resulting travel time measurements were transmitted to the RTMC software, which used the travel times to support traffic management activities (e.g., produce automated 511 travel time messages) and archived the travel times in a data warehouse. The following list summarizes some failures that occurred as part of this specific toll tag travel time process.

> ***A toll tag travel time system should accommodate many different types of failures that might occur, including reader failures, clock mis-synchronization, incorrect reader location assignments, and network failures.***

- AVI Unit Failure. When the AVI unit failed, it produced fewer toll tag reads than expected, resulting in fewer travel time measurements. Early in the deployment, FDOT experienced significant problems with AVI unit failures (see section 3). Later, FDOT adopted an active monitoring program that included periodic comparison of the number of reads produced by each AVI unit with the expected number of reads to more quickly identify failed units. The presence of network addressable system diagnostics on the roadside CPU helped FDOT remotely check on the AVI status.
- Roadside CPU Failure. When the roadside CPU failed, then toll tag reads were not transmitted upstream in the travel time process and, depending on the type of failure, were not archived. In most cases, a CPU failure would prevent the roadside unit from operating. During *i*Florida operations, two other types of failures occurred that made it appear that the roadside unit was operating, though the tag reads from the unit were not useful for generating travel time estimates.
  - One type of roadside CPU failure that occurred in the *i*Florida system was that the clocks in the roadside CPUs did not remain synchronized. Since travel times were computed by comparing the timestamps between toll tag reads made by different readers, any discrepancy between the clocks on different roadside readers directly impacted the estimated travel times. One symptom of this type of failure was a discrepancy between the time stamps when a toll tag was read and when it was logged at the AVI server.
  - Another type of roadside CPU failure that occurred in the *i*Florida system was the incorrect assignment of AVI units to device IDs when connecting AVI units to the roadside CPU. In the *i*Florida system, the device ID was assigned by the roadside CPU according to the physical connection to which the AVI unit was connected. With up to four AVI units connecting to a roadside CPU, it sometimes happened that an AVI unit would be connected to the wrong physical connection on the CPU. This might mean that data for vehicles traveling northbound would be processed by the travel time server as if they were southbound vehicles, resulting in very low toll tag match rates and unusual travel times.

- Network Failure Between the Roadside CPU and the AVI Server. If the network failed between the roadside CPU and the AVI server, then the roadside CPU would continue to archive the toll tag reads, but the data would not be available to produce travel times. FDOT sometimes used the Ping command to determine they had network connectivity to field devices.
  - A secondary failure sometimes occurred in the *i*Florida system when a roadside CPU was reconnected to the network after an outage. During the outage period, the roadside CPU would continue to archive toll tag reads. When reconnected to the AVI server, the roadside CPU would attempt to transmit the archived toll tag reads to the server, creating high demands on the server that would sometimes interrupt real-time data from other roadside CPUs. While this characteristic was key to supporting a toll system – lost toll tag information would mean lost revenue – it was a detriment in a real-time travel time system. When designing a toll tag travel time system, one should weigh the advantages of obtaining a more complete archive of toll tag reads (e.g., for back-computing travel times from archived data to fill in travel time information in the data warehouse when real-time travel time calculations were interrupted) with the disadvantages of potentially disrupting real-time travel time calculations.
  - Another related problem occurred during *i*Florida operations, when some roadside CPUs re-transmitted toll tag reads to the AVI server several days after the initial transmission. This affected overall system performance by using up system resources transmitting redundant data, and also tainted the archives with the redundant data.
- AVI Server Failure. If the AVI server failed, then toll tag data was not transmitted to the travel time server and no real-time travel times were produced. Also, the toll tag data was not archived, though the data was often archived later when the AVI server became available and the roadside CPU's began transmitting their local archives of the toll tag data. With the *i*Florida design, an AVI server failure would result in the loss of toll tag travel time estimates. FDOT considered installing a hot-swappable backup server available in case the AVI server failed. An alternate approach would be to include in the design of the RTMC server alternate approaches for entering travel time data for failed services. For example, the RMTC server could default to historical averages if the AVI server failed and allow RTMC operators to adjust these values manually (or disable them) if current conditions were significantly different from historical averages (e.g., when an incident occurs). This approach would serve as mitigation for any failure that might occur in the AVI travel time system.
- Network Failure Between the AVI Server and the Travel Time Server. The symptoms of this failure would be toll tag readings archived at the AVI server, but the lack of toll tag readings at the travel time server. If this occurred, no real-time travel time estimates would be generated. Possible mitigation strategies would be those typically used to improve network reliability, such as loops that provide redundant network paths between equipment. In the case of the *i*Florida system, this network connection was made more complicated by the fact that the AVI server was part of the FDOT ITS network and the travel time server was on the OOCEA network.
- Travel Time Server Failure. A failure in the travel time server would prevent the generation of real-time travel time estimates. The possible mitigation strategies would be similar to those of the AVI server – a backup server and/or an alternate means of providing travel time data to the RTMC server.

- Network Failure Between the AVI Server and the Travel Time Server. A failure of this network connection would prevent the receipt by the RTMC server of the real-time travel time estimates produced by the travel time server.
- RTMC Server Failure. Because the RTMC server is the main software used to support RTMC activities, it was a critical system and included strongly protected against failure with power backup and a redundant, hot-swappable server. Failure of the RTMC server is outside the scope of a discussion of the toll tag travel time system.
    - The original *i*Florida RTMC software, the Condition Reporting System, did exhibit one failure mode that directly related to the toll tag travel time system. In some cases, travel times produced by the toll tag travel time system would be combined for presentation as traveler information. For example, travel time estimates for all of the segments on SR 417 were summed to provide travel time comparisons for driving through Orlando on the two alternate routes available, I-4 and SR 417. When the CRS contractor originally configured the system, they created the wrong relationship between the travel time segments and the traveler information – travel times on SR 417 were being computed by summing travel times on the wrong segments. A number of factors helped lead to this failure, including a complex configuration process that made introduction of errors more likely and inadequate testing of the configuration data before it was put into use.

4.2. The *i*Florida Toll Tag Travel Time Network

The development of the *i*Florida toll tag travel time network began with studies to test the feasibility of using toll tag reads to measure travel times on Florida roads. One study[1] reported on field tests conducted on Florida Interstate highways. Field tests were conducted on urban portions of I-4 and I-95 and on rural portions of I-10, I-75, and I-95. These tests indicated that toll tag penetration was high in urban areas with toll roads, but was much lower in other areas:

Field studies can help determine if toll tag market penetration is sufficient to support the use of a toll tag travel time system.

- In Orlando, with five major toll roads (SR 408, SR 417, SR 429, SR 528, and the Florida Turnpike), almost 20 percent of vehicle on I-4 had toll tags.
- In Fort Lauderdale, with two major toll roads (the Florida Turnpike and the Sawgrass Expressway), about 10 percent of vehicles on I-95 had toll tags.
- In Tampa, with two toll roads (Lee Roy Selmon Expressway and Veterans Expressway), about 10 percent of vehicles on I-75 has toll tags.
- In St. Lucie County, with one major toll road (the Florida Turnpike), about 8 percent of vehicles on I-95 had toll tags.
- Brevard County has no toll roads, but is connected to Orlando by SR 528, which is tolled in Orange County. More than 6 percent of vehicles on I-95 in Brevard County had toll tags.
- In Jacksonville and Tallahassee, which have no nearby toll roads, about 1 percent of vehicles had toll tags.

[1] See the report *Innovative Traffic Data Collection: Results of Field Test – Final Report* prepared for FDOT on February 12, 2003 for more information.

Additional tests were conducted on Orlando arterials.[2] These tests showed a similar level of toll tag penetration in vehicles on Orlando arterials as observed on I-4 – toll tag reads were made for 15 to 20 percent of vehicles at the eight observation sites considered in the study. This report also identified the following information about the percent of reads at a station for which a matching read was identified at a second station, so that a travel time estimate could be made.[3]

- For SR 50 from Clarke Road to Good Homes Road (0.95 miles), about 53 percent of toll tag reads resulted in a travel time estimate.
- SR 50 from Goldenrod Road to Old Cheney Highway (1.2 miles), about 54 percent of toll tag reads resulted in a travel time estimate.
- SR 436 from US 17/92 to Maitland Avenue (1.5 miles), about 48 percent of toll tag reads resulted in a travel time estimate.
- SR 436 from Curry Ford Road to Lee Vista Blvd (3.6 miles), about 30 percent of toll tag reads resulted in a travel time estimate.

For the segments considered in this study, the toll tag readers generated between 10 and 20 travel time estimates per hour. Based on this information about the feasibility of using toll tag readers to estimate travel times on Orlando arterials and limited access roads, FDOT developed a plan for doing so. The locations of the toll tag readers is depicted in Figure 3 on page 6, with the resulting travel time segments listed in Table 2.

[2] See the report *Field Test of the Potential for Using Probe Vehicles to Determine Arterial Travel Times in the Orlando Metropolitan Area - Final Report* prepared for FDOT on July 1, 2003 for more information.
[3] These figures include matches that resulted in very long travel time estimates, likely resulting from vehicles that made stops or other diversions between two toll tag readers used to make a travel time estimate. A production travel time calculation tool would filter out these outliers, resulting in lower percentage for matching toll tag reads.

Table 2. *i*Florida Arterial Travel Time Segments

Road	Segment	Length (miles)	Lanes	Major Intersections	Volume
SR 50 (Colonial Dr)	SR 91 to SR 429	4.9	2	7	28,500 to 50,000
	SR 429 to SR 408	2.4	2	4	56,000 to 44,500
	SR 408 to SR 423	6.5	3	17	33,500 to 47,500
	SR 423 to SR 441	1.1	3	3	47,500 to 36,500
	SR 441 to I-4	0.8	2	3	41,500 to 44,500
	I-4 to US 17/92	1.0	2	4	44,500 to 43,000
	US 17/92 to SR 436	3.4	3	12	48,000 to 65,000
	SR 436 to SR 417	3.0	3	4	45,500 to 44,500
	SR 417 to SR 408	4.5	3	8	53,500 to 45,500
SR 414 (Maitland Blvd)	SR 441 to I-4	4.3	3	2	31,000 to 66,500
	I-4 to US 17/92	2.0	2	7	56,000 to 31,500
SR 423 (John Young Parkway) (Lee Rd)	SR 417 to SR 528	2.8	3	3	(no data)
	SR 528 to I-4	6.1	3	3	(no data)
	I-4 to SR 408	3.0	3	3	(no data)
	SR 408 to SR 50	0.7	3	3	48,000 to 49,000
	SR 50 to SR 441	3.2	2	2	46,500 to 40,500
	SR 441 to I-4	2.1	3	3	38,500 to 44,500
	I-4 to US 17/92	1.3	2	2	40,500
SR 436 (Semoran Blvd)	SR 441 to SR 434	5.4	4	12	23,000 to 48,500
	SR 434 to I-4	1.8	4	7	48,500
	I-4 to US 17/92	3.1	4	12	63,000 to 62,000
	US 17/92 to SR 50	7.9	3	19	70,500 to 52,000
	SR 50 to SR 408	1.2	3	3	55,000 to 52,500
	SR 408 to SR 528	5.4	3	13	57,000 to 42,000
SR 441 (Orange Blossom Trail)	US 192 to SR 417	4.7	3	7	30,500 to 34,500
	SR 417 to SR 528	4.4	3	8	50,500 to 42,000
	SR 528 to I-4	4.7	3	13	61,500 to 66,500
	I-4 to SR 408	2.2	2	5	36,500
	SR 408 to SR 50	1.2	2	7	36,500 to 28,500
	SR 50 to SR 423	3.4	2	4	32,500 to 31,000
	SR 423 to SR 414	3.4	2	4	35,000 to 33,000
	SR 414 to SR 436	3.5	2	5	33,000 to 27,000
	SR 436 to SR 429	2.2	2	4	41,500 to 38,000
US 192 (West Coast Parkway)	I-4 to SR 441	9.8	3	18	54,000 to 37,000
	SR 441 to SR 91	3.6	3	9	35,500 to 36,000
US 17/92 (Orlando Ave)	SR 50 to SR 423	2.7	2	9	28,000 to 37,500
	SR 423 to SR 414	2.3	3	4	45,500 to 33,500
	SR 414 to SR 436	1.9	3	2	61,000 to 55,500
	SR 436 to SR 417	8.8	3	15	60,500 to 43,500

In this table, the Road column identifies the road on which each travel time segment lies with the segments, running either from East to West or from South to North, identified by the cross-streets bounding each segment. The length of the segment and the number of lanes was provided by FDOT. The number of intersections column lists the number of major intersections within each segment (i.e., excluding the intersections at the start and end of each segment), where each interchange and each intersection with a stop bar was identified as a major intersection. The volume information was obtained from FDOT statewide traffic count.[4]

Table 3 lists similar information for the FDOT toll tag travel time segments on limited access highways and on evacuation routes where travel time were monitored by either toll tag or license plate readers.

Table 3. *i*Florida Limited Access and Evacuation Travel Time Segments

Road	Segment	Length (miles)	Lanes	Major Intersections	Volume
SR 91 (The Florida Turnpike)	US 192 to SR 522	4.2	2	0	32,800
	SR 522 to SR 528	6.9	2	0	32,800 to 41,700
	SR 528 to I-4	4.1	2	0	41,700 to 44,700
	I-4 to SR 408	6.1	2	0	44,700
	SR 408 to SR 50	7.0	2	1	44,700 to 48,100
SR 417	I-4 to Boundary	5.1	2	2	10,200 to 16,300
	Boundary to SR 434	6.1	2	2	45,000 to 28,800
	SR 434 to US 17/92	6.6	2	1	24,100 to 14,500
	US 17/92 to I-4	4.8	2	2	(no data)
SR 520	SR 528 to I-95	13.9	1	2	(no data)
SR 528	I-4 to SR 91	4.3	2	3	60,600 to 54,400
	SR 91 to Boundary	4.6	2	0	54,400 to 49,800

4.3. The *i*Florida Toll Tag Travel Time Estimation Process

As each toll tag reader observed toll tag IDs on passing vehicles, it transmited an encrypted hash key representing that ID along with the time it was observed to a Travel Time Server. This server matched toll tag observations made at readers at the start and end of each travel time segment to generate travel time measurements. Anomalous measurements were discarded, and the remaining measurements were used to estimate the average travel time, using one of two possible approaches. In the first approach, a rolling average of recent observations over a fixed period of time was used. This approach was used when travel time observations were plentiful. In the second approach, a rolling average of the most recent fixed number of observations was used. This approach was used when fewer observations were available. Within this general framework, a number of configurable parameters were used to control the specific operations of the process.

- The Tag-Discard-Horizon parameter controled the time an unmatched tag read was kept "in the system" before discarding it. This parameter set a de facto upper bound on the maximum travel time that could be observed by the system.
- The Maximum-Speed-Threshold was used to prevent reporting of travel times indicating that current travel speeds were higher than the speed limit. If the travel speed associated with a travel time observation was greater than this amount, the travel time was adjusted upward so as to result in a travel speed equal to this parameter.
- The Speed-Threshold parameter was used to remove anomalous travel time observations. If the travel speed associated with a travel time observation differed from the last estimated average travel time by this amount or more, it was discarded.

[4] This data is available at http://www.dot.state.fl.us/planning/statistics/trafficdata/, last accessed March 10, 2009.

- The Link-Threshold parameter was used to remove anomalous travel time observations. If the percentage change in either the travel time observation or the associated travel speed relative to the last estimated average travel time / travel speed was greater than this amount, it was discarded.
- The Anomaly-Threshold parameter was used to remove anomalous travel time observations. If the travel speed associated with a travel time observation was greater than this amount, it was discarded. This parameter set a minimum for travel time observations.
- The Time-Window parameter specified the time interval over which travel times were averaged when the first averaging approach was used.
- The Sample-Size parameter specified the number of observations that were averaged when using the second averaging approach.
- The FM2-Timeout parameter specified the maximum time over which travel times were averaged when using the second averaging approach.
- The Time-Slice parameter specified the frequency with which the travel time calculations were performed.

This travel time process was originally designed for computing travel times for OOCEA on limited access toll highways, and the configuration parameters were set to the default values used on those highways. A number of adjustments were made to try to optimize the parameters for use on Orlando arterials.

4.4. An Example – Toll Tag Travel Time Estimates on Colonial Drive

This section exemplifies the performance of the toll tag travel time system by examining its performance on the eastbound section of Colonial Drive between US 17/92 (Mills Avenue) and SR 436 (Semoran Boulevard). This helps lay the groundwork for a more general analysis of the entire network by identifying performance characteristics that should be considered in the more general analysis.

Table 2 indicates that this section of road is 3.4 miles long, has 3 lanes in each direction of travel, includes 12 major intersections, and has a traffic volume ranging from 48,000 vehicles per day at the western portion of the section to 65,000 vehicles per day at the eastern portion of the section. The configuration of the intersection at the start of this travel time link is depicted in Figure 28.

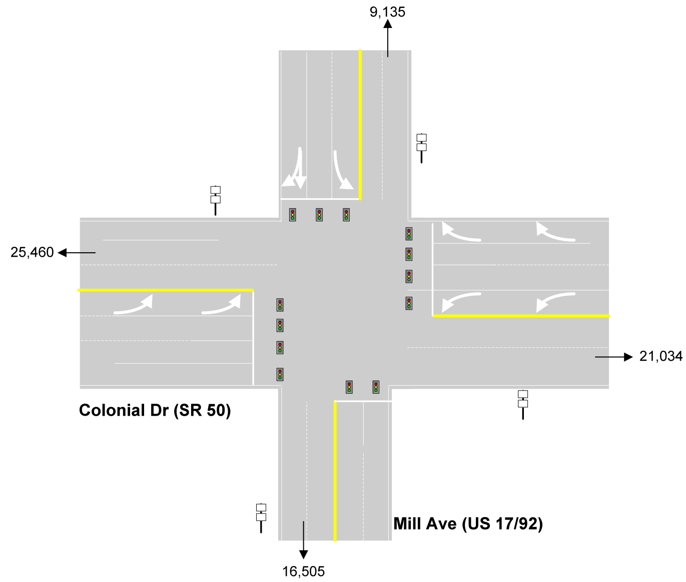


Figure 28. The Intersection of SR 50 and US 17/92

In this figure, the numbers are intersection traffic counts from City of Orlando traffic count program and the icons beside the roads represent the approximate location of the toll tag readers. Figure 29 depicts the configuration of the intersection at the end of this travel time link.

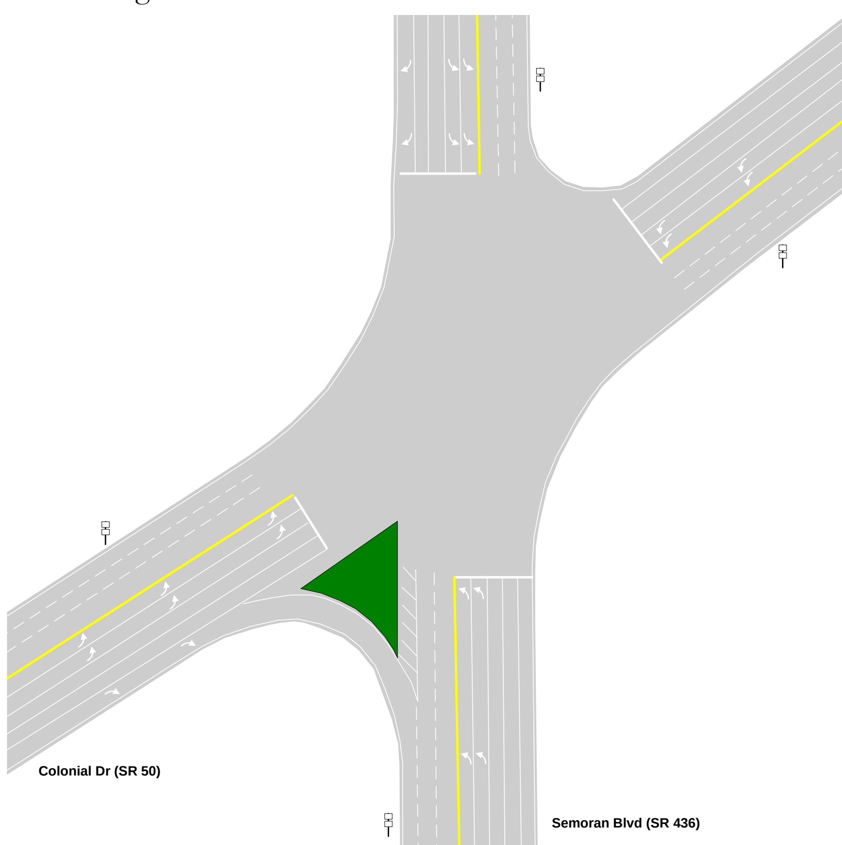


Figure 29. The Intersection of SR 50 and SR 436

Not shown in this figure is a road leading from SR 50 west of SR 436 to SR 436 southbound, which serves as a de facto turn lane for eastbound traffic on SR 50 wishing to turn right onto SR 436.

The *i*Florida travel time process for this travel time segment matched reads from the toll tag reader monitoring eastbound traffic on SR 50 east of the US 17/92 intersection with those from the reader monitoring eastbound traffic on SR 50 east of SR 436. (An alternate approach would be to include reads from the three readers at the SR 50 / SR 436 intersection monitoring eastbound traffic on SR 50 and north- and south-bound traffic on SR 436, though this approach would mix travel times that did and did not include the additional delay associated with making a left turn from SR 50 onto SR 436.) The number of tag reads at the SR 50 Eastbound, East of US 17/92 reader are depicted in Figure 30 (for weekdays) and Figure 31 (for weekends).

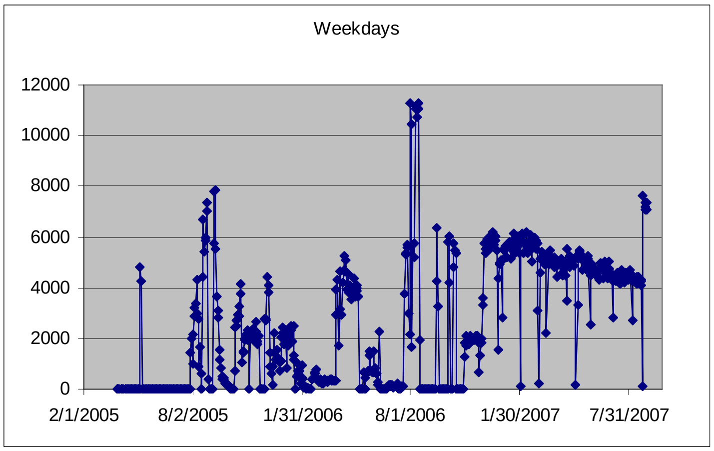


Figure 30. Weekday Tag Reads at the SR 50 Eastbound, East of US 17/92 Reader

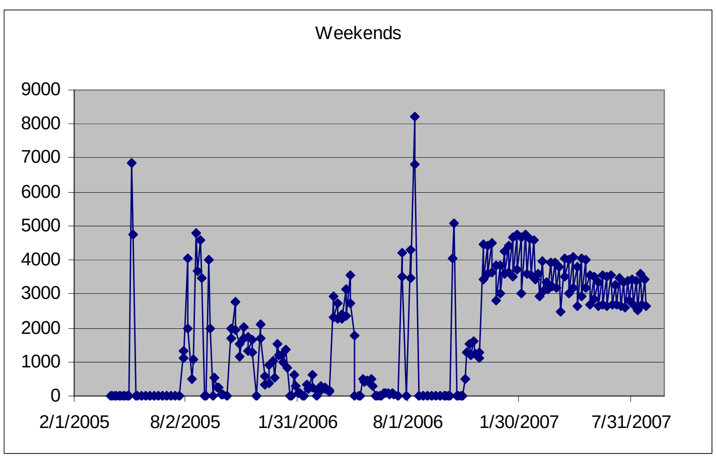


Figure 31. Weekend Tag Reads at the SR 50 Eastbound, East of US 17/92 Reader

Note that this reader first began operating stably in December 2006. Prior to that time, the reader often had no tag reads or fewer reads than should have been expected. Once it began operating stably, the number of reads per day remained between 4,000 and 6,300 on most weekdays and between 2,500 and 5,000 on most weekend days. The period in early August 2006 when more reads than usual were observed occurred when the reader re-transmitted the toll tag reads that occurred on August 1 and 2, 2006. After December 2006, the reader operated with only four days of very few reads and nine days with fewer reads than expected, but still sufficiently many to support travel time calculations.

Figure 32 is a frequency chart listing the number of days the reader at SR 50 Eastbound East of US 17/92 had a number of reads within a series of ranges for the period from 1/1/2007 through 8/26/2007. The lowest range category was 0 to 2,000 reads and the highest range category was more than 6,500 reads, with the size of each category in between being 250 reads.

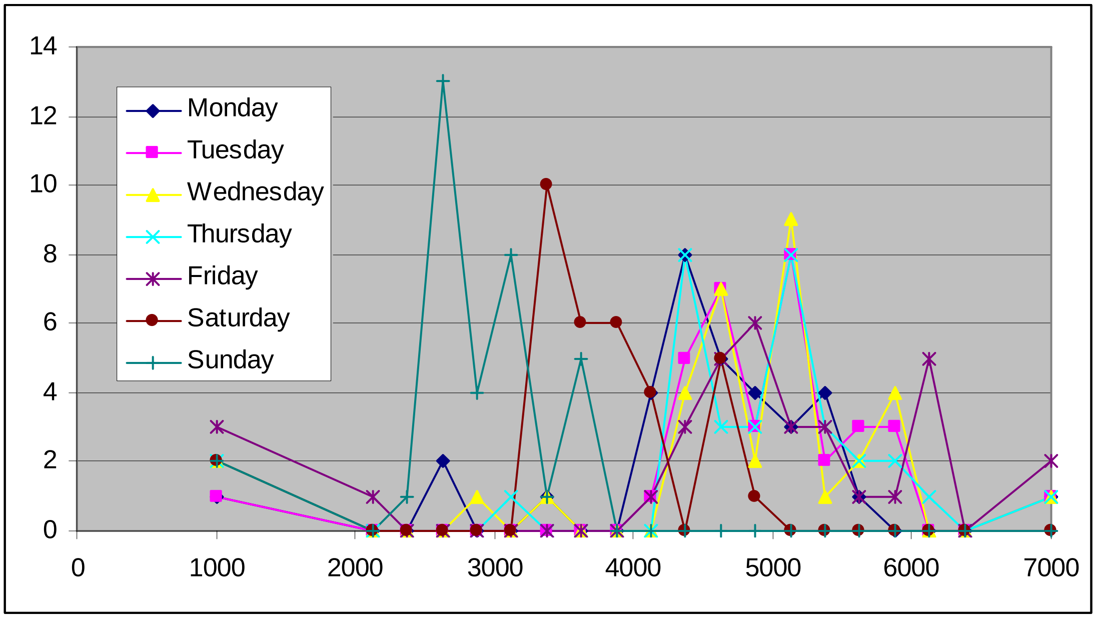


Figure 32. Toll Tag Reads at SR 50 Eastbound, East of US 17/92, by Day of Week

This indicates that the range for the number of reads per day was similar across weekdays, but different for Saturday and Sunday. Note that the average number of reads per day was about 4,500. Of these, about 500 reads per day were duplicate reads – multiple reads of the same tag at the same location within a five minute period – leaving about 4,000 vehicles read per day. Figure 28 indicates that the eastbound volume at the reader location was about 21,000 vehicles per day, indicating that the reader was identifying about 19 percent of the passing vehicles. This was consistent with the observations made by FDOT prior to the *i*Florida deployment.

Another measure of the operational status of a reader for supporting travel time calculations was the lag time between when a toll tag read was made and when it reached the toll tag server. Figure 33 depicts the measured lag time for the SR 50 Eastbound, East of US 17/92 reader.

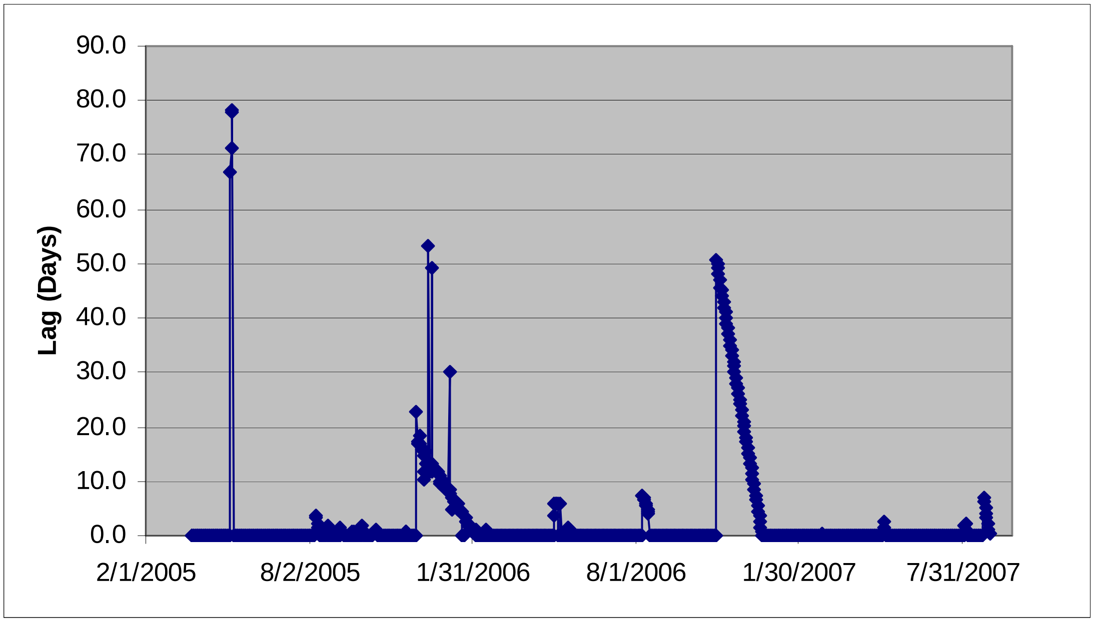


Figure 33. Lag Time for the SR 50 Eastbound, East of US 17/92 Reader

Because the lag time was measured as the difference between when a reading was timestamped by a roadside CPU and when it was logged at the AVI server, there were several possible causes for a lag:

- The clocks on the roadside CPU and the AVI server were different. In this case, the apparent lag should be relatively constant over time until the clocks were reset.
- The roadside CPU lost network connectivity to the AVI server for a time and, when connectivity was restored, uploaded the archived data that could not be sent to the server while connectivity was unavailable. In this case, the apparent lag should decrease over time at a rate of a bit less then one day of lag per day. The period in the above figure from October 31, 2006 through December 31, 2006 is an example.
- The roadside CPU could have re-transmitted data at a later date, duplicating data that had already been transmitted. In this case, the apparent lag should decrease over time at a rate of roughly half day of lag per day and the number of reads (see Figure 30) should be significantly higher than usual. The period in the above figure from August 1, 2006 through August 15, 2006 is an example.

Based on the number of reads and the lag time, a value representing the operational status of the reader was assigned to the reader for each day. The following codes were used:

- A value of “6” was used if a toll tag reader generated no reads. This probably indicates that the toll tag reading hardware was not operating correctly.
- A value of “5” was used if a toll tag reader generated data, but the lag time was high and decreasing at a rate of about one day of lag per day. This probably indicates that the reader had lost network connectivity to the AVI Server.
- A value of “4” was used if a toll tag reader generated data and the lag time was high, but did not following the pattern of decreasing one day of lag per day. This could indicate that the clocks on the roadside CPU and the AVI Server were not synchronized or that data was being re-transmitted.

- A value of "3" was used if a toll tag reader was generating fewer than 500 reads per day. This could indicate a problem with the toll tag reader, and meant that the reader was generating too few reads to be useful for supporting travel time calculations.
- A value of "2" was used if the reader was generating significantly fewer reads than usual, but still more than 500 reads per day. This could indicate a problem with the toll tag reader, or could just be a side effect of unusual traffic conditions for that day.
- A value of "1" was used if the reader generated significantly more reads then expected. This could be caused by a reader re-transmitting toll tag data, or by unusual traffic conditions.
- A value of "0" was used if none of the above deficiencies were noted.

The following four figures depict the operational status of each toll tag reader associated with the travel time segment on SR 50 from US 17/92 to SR 436. Note that a maximum value of 0 or 1 indicates that the reader was 100 percent operational from the standpoint of computing travel times, a value of 2 indicates that the reader was operating at lower effectiveness, and that higher values indicate that the reader could not be used to provide real-time travel times.

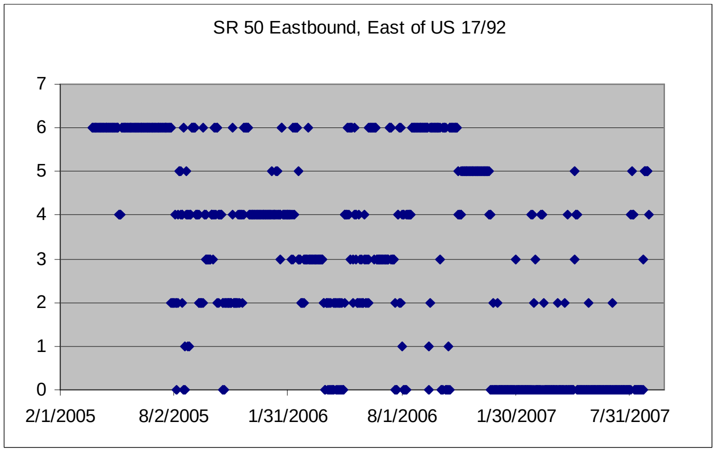


Figure 34. Errors at the SR 50 Eastbound, East of US 17/92 AVI Reader

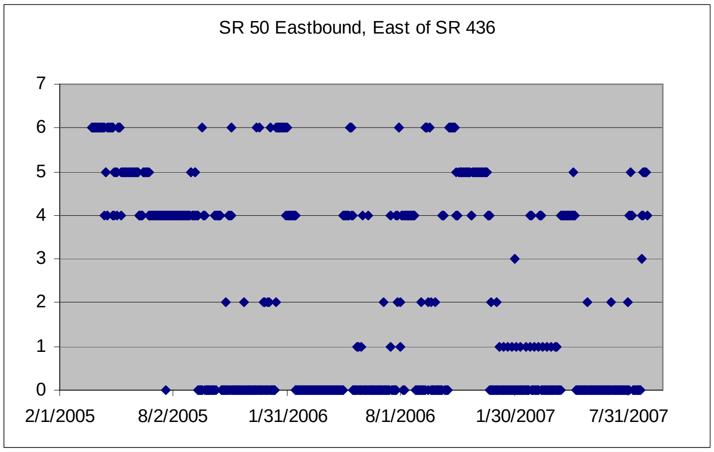


Figure 35. Errors at the SR 50 Eastbound, East of SR 436 AVI Reader

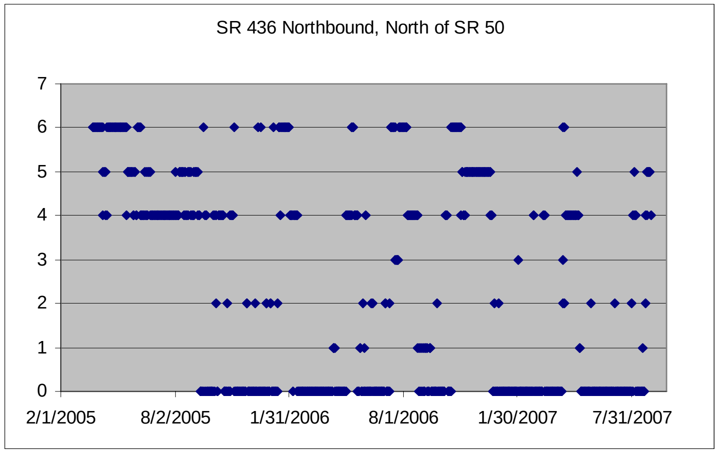


Figure 36. Errors at the SR 436 Northbound, North of SR 50 AVI Reader

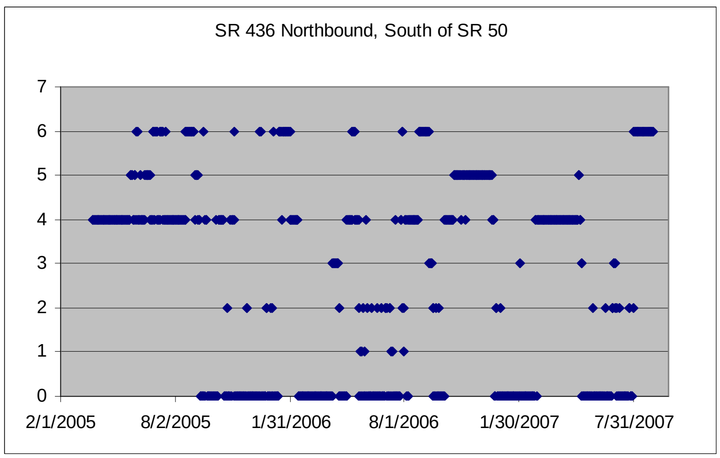


Figure 37. Errors at the SR 436 Southbound, South of SR 50 AVI Reader

Figure 38 combines the error information for the above four readers to identify the operational status of the travel time system for the travel time segment, with a value of 100 percent being used if the three readers used for the travel time calculation were all fully operational and lower percentages being used to represent degraded performance if one or more of the readers was exhibiting one or more deficiencies.

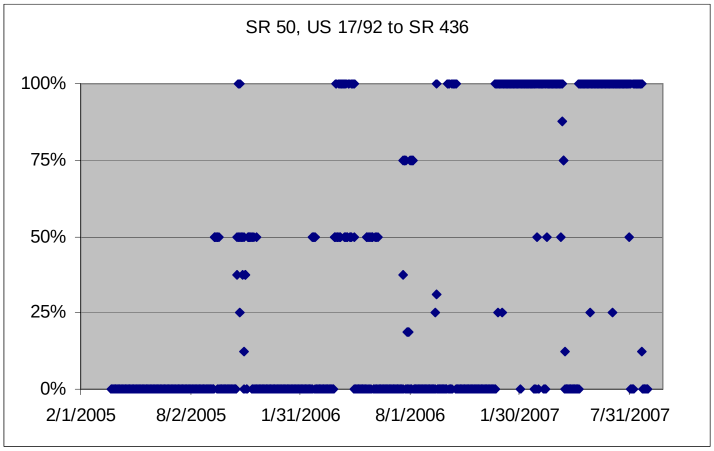


Figure 38. Status of the Travel Time System for SR 50 from US 17/92 to SR 436

Figure 39 summarizes this data by computing the average percent operational for each month.

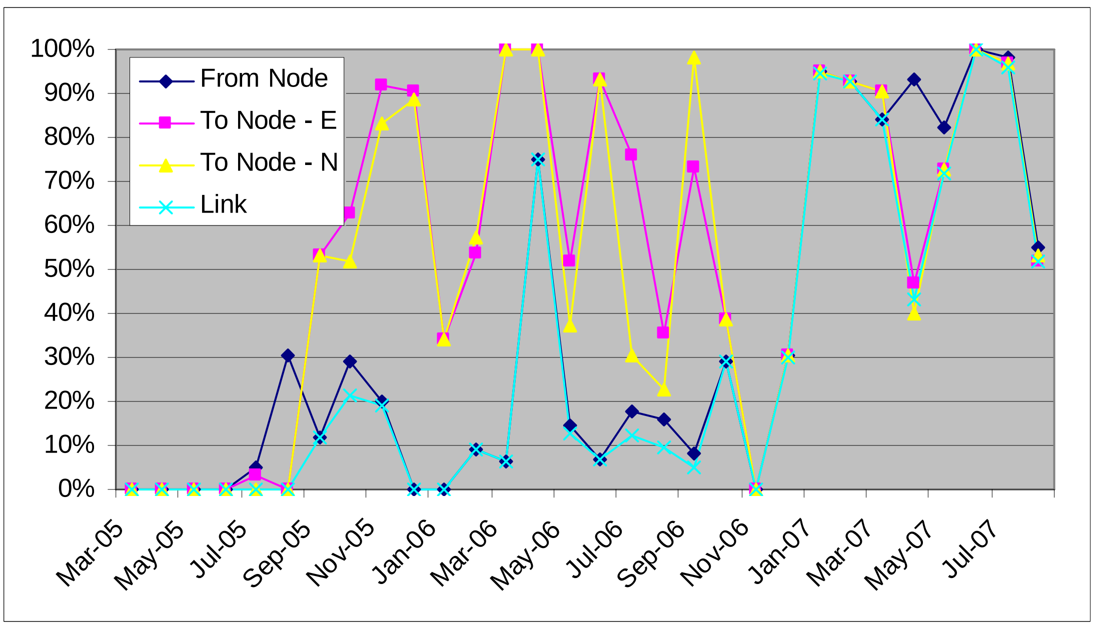


Figure 39. Monthly Status of the Travel Time System for SR 50 from US 17/92 to SR 436

Together, the above charts and figures provide measures for assessing the operational status of the portion of the toll tag reader network needed to support travel time estimates for the travel time segment on SR 50 from US 17/92 to SR 436. They indicate that, prior to 2007, the network was unreliable. Over the first eight months of 2007, the system was above 90 percent operational in four months, with lower levels of reliability in the other months.

But, the operational status of the toll tag reader only tells part of the story of a toll tag travel time network. Because the *i*Florida arterial travel time segments were long with many opportunities for travelers to divert, it was possible that many travelers entering the segment did not exit it at its endpoint. The percentage of (non-duplicated) toll tag reads for vehicles entering the travel time segment during the period from August 13, 2007 to August 19, 2007 are listed in Table 4. (That time period was chosen because the readers for this travel time segment did not exhibit any deficiencies on those days.)

Table 4. Matching Effectiveness for the SR 50 from US 17/92 to SR 436 Segment

Date	Duplicate Reads	Non-Matching Reads	Matching Reads	Matching Percent
8/13/2007	345	3165	612	16.2%
8/14/2007	319	3262	610	15.8%
8/15/2007	421	3265	692	17.5%
8/16/2007	373	3350	690	17.1%
8/17/2007	423	3350	598	15.1%
8/18/2007	286	2787	496	15.1%
8/19/2007	149	2321	440	15.9%

This table indicates that, for this travel time segment, about 16 percent of the toll tag reads made at the start of the segment would result in travel time measurements. However, some of these measurements may be invalid. For example, if a traveler makes a stop mid-segment, then later completes the segment, the result would be a travel time measurement that included the time the traveler spent stopped. This was more problematic for arterials than limited access highways because stops were more likely to occur and, if a stop occurred, it was more difficult to differentiate between a stop-induced delay and a delay induced by traffic signals encountered while traveling the segment. Figure 40 depicts the distribution for the travel times observed during the period from Monday August 13, 2007 through Friday August 17, 2007.

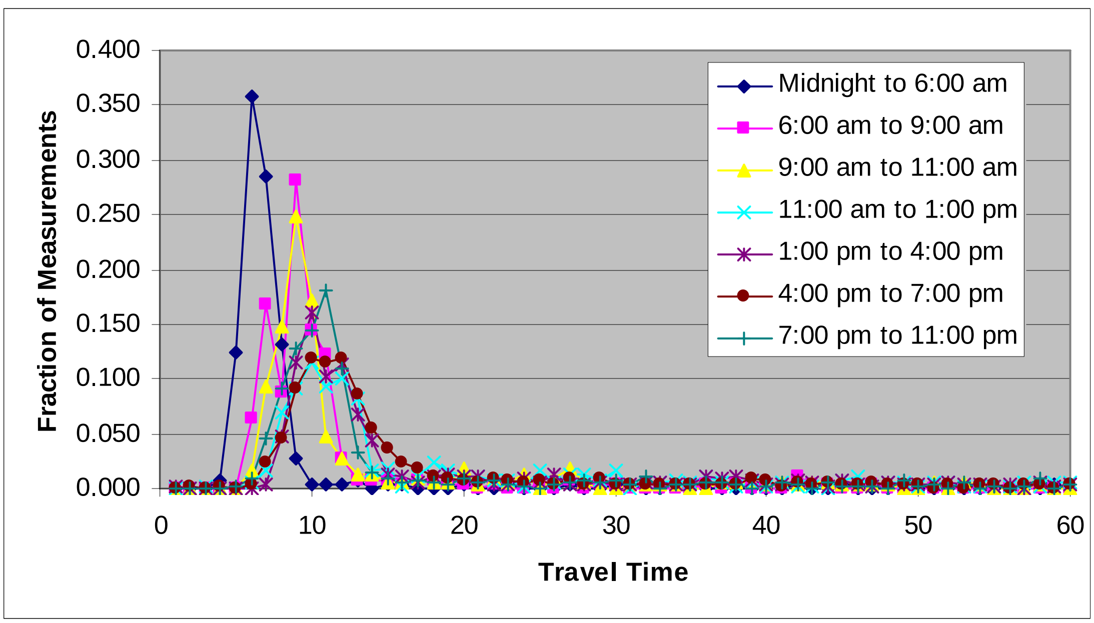


Figure 40. Travel Time Distribution for the SR 50 from US 17/92 to SR 436 Segment

> ***The effect of diverting traffic on arterials can introduce a high bias into the observed average travel time.***

The important thing to note about these distributions is the long tail of high travel times, indicative of travel times that include time spent stopped or diverting. The effect of these outliers on the mean travel time is shown in Table 5.

Table 5. Travel Time Statistics for the SR 50 from US 17/92 to SR 436 Segment

Time Period	Count	Median	Mean	Percent Outlier
Midnight to 6:00 am	257	6.1	7.4	5%
6:00 am to 9:00 am	263	8.8	10.3	5%
9:00 am to 11:00 am	319	9.0	14.0	18%
11:00 am to 1:00 pm	375	12.2	22.5	25%
1:00 pm to 4:00 pm	665	11.5	20.9	23%
4:00 pm to 7:00 pm	700	11.8	19.4	19%
7:00 pm to 11:00 pm	533	10.4	17.6	17%

In this table, the Percent Outlier column indicates the percentage of high travel time measurements that should be discarded as outliers in order for the corrected mean (i.e., mean for measurements after outliers are removed) to equal the median. Note that, without correcting for the outliers, the mean is a poor estimator of the travel time experienced by most travelers. Based on this example, it appears that the median may be a better choice for estimating the segment travel time based on arterial probe measurements than the mean. If the mean is used, a method for removing high travel time outliers resulting from intermediate stops and diversions must be used.

For limited access highways, diverting traffic is less likely to introduce a high bias into the observed average travel time.

For comparison, Figure 41 and Table 6 show corresponding travel times for a limited access section of highway, SR 417 from I-4 north of Orlando to US 17/92.

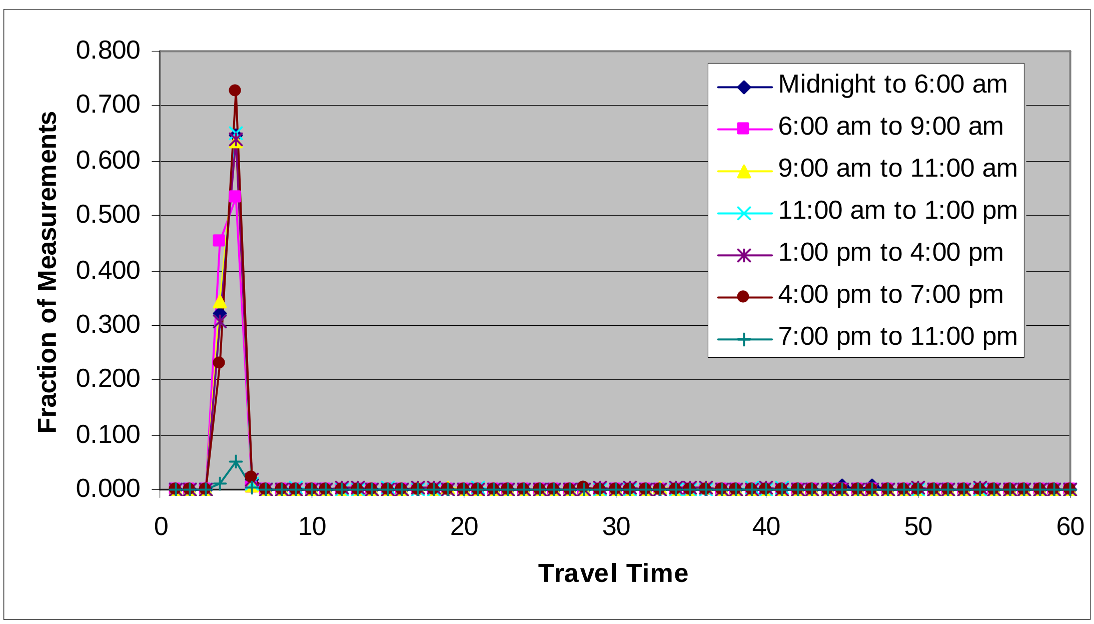


Figure 41. Travel Time Distribution for the SR 417 from I-4 to US 17/92 Segment

Table 6. Travel Time Statistics for the SR 417 from I-4 to US 17/92 Segment

Time Period	Count	Median	Mean
Midnight to 6:00 am	153	4.1	4.7
6:00 am to 9:00 am	869	4.0	4.3
9:00 am to 11:00 am	307	4.1	4.7
11:00 am to 1:00 pm	218	4.1	5.2
1:00 pm to 4:00 pm	441	4.1	5.3
4:00 pm to 7:00 pm	751	4.2	4.8
7:00 pm to 11:00 pm	298	4.1	4.7

Note that, for the limited access highway, outliers with travel time significantly above the median value were much less common and the mean and median were relatively close to each other in value.

Another question related to the effectiveness of a toll tag travel time system was whether it will generate enough toll tag matches to produce reliable travel times. Figure 42 depicts the average number of travel time reads per hour for the SR 417 from I-4 to US 17/92 segment during the period from August 13, 2007 to August 17, 2007.

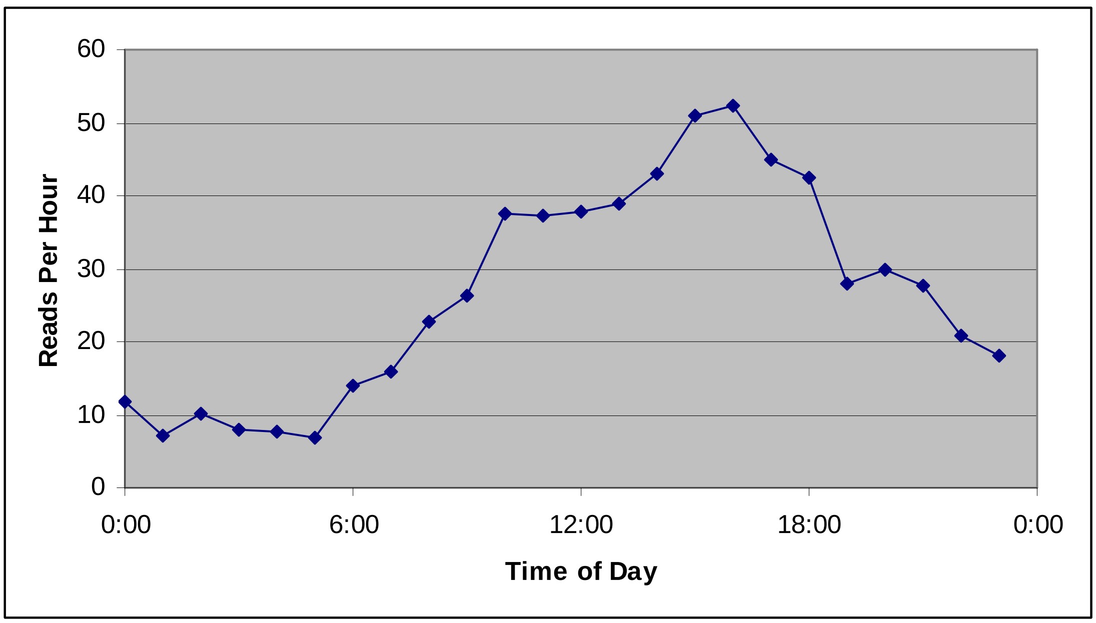


Figure 42. Travel Times Per Hour for the for the SR 417 from I-4 to US 17/92 Segment

The following approach can be used to generate a rough estimate of the number of travel time measurements needed to generate an accurate estimate for the average travel time. The curves in Figure 40 indicate that the width of the travel time distributions is roughly equal to the median, which is roughly equal to the mean after the top 25 percent of measurements are removed as outliers. Under these circumstances, a sample size of 25 (after removing outliers) would result in an estimate of the mean travel time that should be within 15 percent of the actual value about 90 percent of the time. A sample size of about 32 would provide enough measurements so that, after removing outliers, a sample size of 25 would remain. During peak hours, it required more than 30 minutes to accumulate 32 travel time measurements. During night time hours, it required about 3 hours to accumulate 32 travel time measurements. On weekends, when traffic volumes are lower, longer accumulation times would be needed.

These observations pointed to a tradeoff that must be considered when designing an arterial toll tag travel time system. If one assumes that the travel times do not change significantly over time, then averaging over a long time period will increase the number of observations over which the average is taken, which increases the statistical accuracy of the estimate for the mean travel time. If travel times do change over time, averaging over a long period of time would include in the average travel times that no longer represent current travel time conditions. This is exemplified in Figure 43, which depicts travel times on the SR 50 from US 17/92 to SR 436 travel time segment during the period from 6:00 pm to 7:00 pm on August 13, 2007, a time during which travel times were decreasing as rush hour ended. (Travel times greater than 20 minutes have been excluded from this chart.)

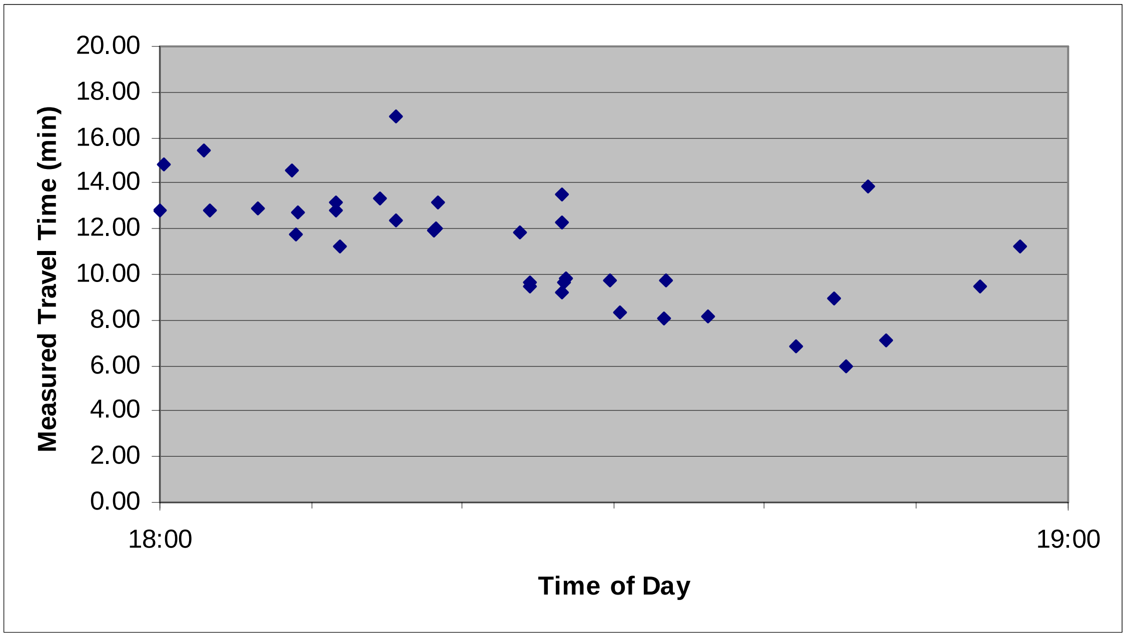


Figure 43. Travel Times for SR 50 from US 17/92 to SR 436 on 8/13/2007

Figure 44 shows the average travel times computed from the observed travel times on this day, using different values for the length of the interval (i.e., the lag time) over which the average was computed.

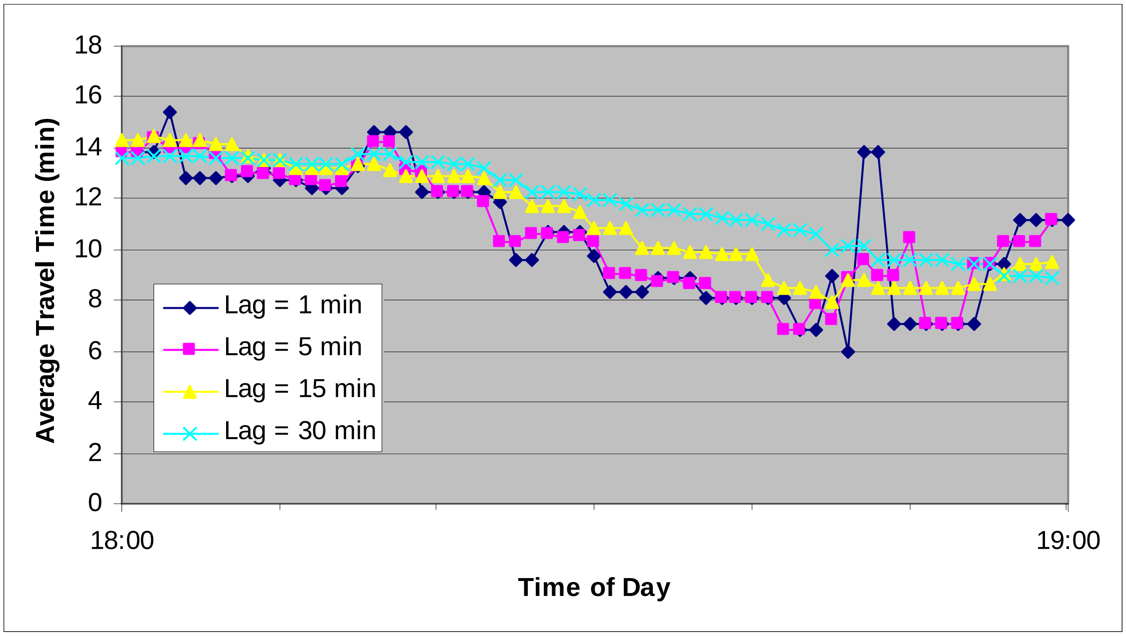


Figure 44. Average Travel Times for SR 50 from US 17/92 to SR 436 on 8/13/2007

Note that, as the lag time increased, the travel time curve was smoother, but the average travel time was larger than the recently observed travel times because the average included observed travel times from further in the past when congestion levels were higher. This is generally true. Averaging over short periods of time will result in highly variable estimates for the average travel time because the averages include few observations. The situation would be much worse if traffic conditions changed more abruptly, as might occur if a crash occurred on the travel time segment.

The main problem was that there are relatively few observations - averaging about one observation every two minutes for the period in question. Averaging over a short period of time, so that the estimated travel times responded quickly to changes in traffic conditions, meant that the estimated travel times were based on very few measurements and the variability in the estimated travel times was high. Averaging over a longer period of time to reduce this variability dampened the response to changes in traffic conditions.

One way to improve the performance of the travel time system would be to increase the number of observations by allowing multiple toll tag readers to supply measurements at the end point of a travel time segment. In the example at hand, all vehicles entering the segment pass by the toll tag reader on SR 50 eastbound, east of US 17/92. Vehicles that turn onto SR 436 at the end of the segment do not pass by the reader on SR 50 eastbound, east of SR 436 – left-turning vehicle pass by the reader on SR 436 northbound, north of SR 50 and most right-turning vehicles do not pass by a reader because the reader location is north of the entry point taken by most right-turning vehicles. The Travel Time Server used for *i*Florida only allows use of a single reader for the endpoint of a travel time segment. A tool developed by the Evaluation Team allowed multiple readers to be used at both the start and end point of a travel time segment. Table 7 summarizes results travel time results for the section of SR 50 from US 17/92 to SR 436 using different numbers of readers for the end node.

Table 7. Travel Time Statistics for the SR 50 from US 17/92 to SR 436 with Different End Node Configurations

	Raw Data			Corrected Data		
Time Period	**Match Count**	**Match Percent**	**Mean TT (min)**	**Match Count**	**Match Percent**	**Mean**
End Node: SR 50 Eastbound and SR 436 Northbound						
Midnight to 6:00 am	385	34%	8.3	273	24%	6.0
6:00 am to 9:00 am	394	19%	11.1	314	15%	8.4
9:00 am to 11:00 am	394	17%	12.8	329	14%	9.4
11:00 am to 1:00 pm	449	13%	16.9	345	10%	11.6
1:00 pm to 4:00 pm	831	16%	19.0	659	13%	11.6
4:00 pm to 7:00 pm	925	19%	17.1	763	16%	11.5
7:00 pm to 11:00 pm	710	21%	16.0	574	17%	10.3
End Node: SR 50 Eastbound Only						
Midnight to 6:00 am	265	24%	8.2	168	15%	5.8
6:00 am to 9:00 am	267	13%	10.8	209	10%	8.5
9:00 am to 11:00 am	284	12%	12.5	231	10%	9.2
11:00 am to 1:00 pm	326	9%	17.1	249	7%	11.5
1:00 pm to 4:00 pm	609	12%	18.2	481	10%	11.3
4:00 pm to 7:00 pm	646	13%	16.8	522	11%	11.5
7:00 pm to 11:00 pm	506	15%	16.1	398	12%	10.4
End Node: SR 436 Northbound Only						
Midnight to 6:00 am	151	13%	9.0	80	7%	6.2
6:00 am to 9:00 am	144	7%	12.3	101	5%	8.5
9:00 am to 11:00 am	122	5%	14.4	90	4%	10.0
11:00 am to 1:00 pm	149	4%	17.9	106	3%	12.8
1:00 pm to 4:00 pm	268	5%	21.8	199	4%	12.6
4:00 pm to 7:00 pm	333	7%	18.5	260	5%	11.5
7:00 pm to 11:00 pm	251	7%	16.4	179	5%	10.7

In this table, the corrected data was generated by excluding from the mean those travel time values that were more than 0.5 standard deviations above the mean. Note that including the northbound vehicles on SR 436 in the travel time calculation increased the number of travel time matches by almost 50 percent. This increase in the sample size could result in more reliable travel time estimates or allow for a shorter averaging period with the same level of reliability.

Including tag reads from turning vehicles increases the number of travel time observations generated.

It is interesting to note that the two travel time measurements, one for vehicles going straight through the SR 50 / SR 436 intersection and one for those turning left, provide a measure of the additional delay – about 36 seconds – for vehicles that turn left at that intersection relative to those that go straight.

In summary, the review of toll tag travel time operations for the SR 50 eastbound, from US 17/92 to SR 436, travel time segment identified the following observations regarding the use of toll tag readers for arterial travel times:

- The toll tag reader recorded toll tag readings from about 20 percent of the passing vehicles.
- Duplicate reads accounted for about 10 percent of the reads at each reader. The travel time system should include methods for excluding such duplicate reads.
- Maintaining toll tag readers was difficult. From May 2005 (when the reader deployment was complete) and December 2006, the readers on this segment were seldom operational. During the first eight months of 2007, the system was capable of producing travel times about 80 percent of the time.
- About 16 percent of the toll tag readings made at the start of the travel time segment matched with toll tags at the end of the travel time segment, resulting in a travel time measurement.
  - This percentage could be boosted to about 24 percent if the readers monitoring vehicles that turn at the end intersection are included in the travel time calculation.
  - About 25 percent of the travel time measurements were high travel time outliers, most likely associated with travelers who make a stop mid-trip or divert onto another route and just happen to drive by the end-point toll tag reader at a later time. These outliers must be excluded if the average observed travel time is to be a reliable estimator for the travel time experienced by most travelers on an arterial. The median observed travel time might be a more reliable estimator.
  - It did not appear that there were a significant number of low travel time outliers – the outliers are likely caused by stops and diversions, which always increase travel times. An asymmetric method focused on excluding long travel time outliers should be used.
- The system did not produce enough travel time matches to produce reliable travel time estimates without accumulating travel time observations over a relatively long period – about 30 minutes during peak hours and up to 3 hours after midnight.

In the following sections, these factors will be examined on a system-wide basis.

4.5. Toll Tag Reader Operations

This section reviews the operation of the toll tag reader system, with the primary objective being to assess the reliability of the *i*Florida toll tag reader network. The following list describes the primary measures were used to assess the level of service provided by the *i*Florida toll tag readers. (Appendix A describes these measures in more detail.)

- The Level of Service for Tag Reads (LOS_{Reads}) indicates whether a reader was producing fewer tag reads than expected, with 0 indicating it was producing few if any reads and 1 indicating it was producing at least as many as expected.
- The Level of Service for Latency ($LOS_{Latency}$) indicates if the read tags were correctly timestamped and reached the toll tag server in a timely manner. A value of 0 indicates that either the data did not reach the toll tag server quickly enough to be used for real-time travel time calculations or the timestamps were to inaccurate to be used for travel times.
- The Reader Level of Service (LOS_{Reader}), which is the product of LOS_{Reads} and $LOS_{Latency}$, indicates if the number of reads and latency are both within expected operational bounds.

These measures were assessed for each *i*Florida toll tag reader. Figure 45 summarizes this level of service information by presenting the weekly average for the level of service summed across all the *i*Florida toll tag readers. Table 19 in Appendix A provides a more detailed listing of these measures for the toll tag readers on SR 50.

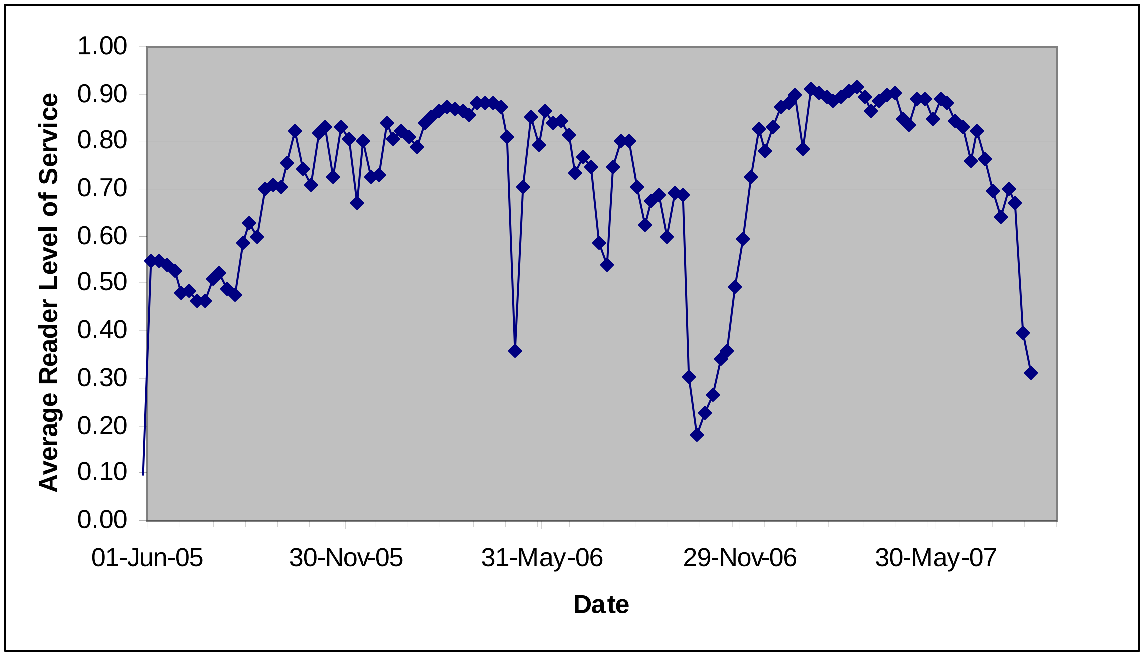


Figure 45. Weekly Average Level of Service for *i*Florida Toll Tag Readers

Note that the deployment of the toll tag reader system was completed May 31, 2005, a time when the level of service was just above 50 percent. The main cause for the low level of service at this time was that the readers were actually deployed and tested from February through May 2005, but there was no regular monitoring of the status of the already tested equipment until August 2005. Many devices failed during this period. With so many devices failed, the maintenance contractor had neither the man-power nor the spare parts available to quickly make all the necessary repairs. The need for so many spare parts at the same time also overwhelmed the manufacturer, who was unable to promptly replace failed equipment.

It is important that a system to monitor and maintain field equipment be in place by the time any field equipment is deployed.

The challenge of maintaining the network was made more difficult because FDOT did not have access to a simple way to monitor the equipment. The contractor provided neither a tool nor instructions for monitoring the status of the toll tag readers. The CRS software, which displayed travel times produced by the readers, was having reliability problems of its own, preventing FDOT from using the lack of travel times in the CRS as an indicator of a failed toll tag reader. FDOT resorted to a manual process of reviewing the log files at the toll tag server to determine if a reader was producing toll tag reads and providing them to the server. This process, which initially required almost half a day to complete, is still in use today, though it has been refined and now only requires about one hour each day.[5]

By January 2005, FDOT had achieved a fairly high level of service for the readers. FDOT attributed the drop in the number of functioning readers that occurred at times during that year to failures due to lightening strikes, though network cuts also caused some failures. The high number of failures resulted in a long turn-around time in getting replacement parts, extending the downtime when a

[5] More information on the challenges faced in deploying the toll tag reader network is contained in the report titled *iFlorida Model Deployment—Deployment Experience Study* completed in May 2006.

reader did fail. After noting the high number of lightening-induced failures, FDOT tested the use of power conditioners and new grounding methods to reduce these failures.

By January 2006, the level of service for the readers operated stably at about 90 percent for most of 2007 before the reliability dropped off again beginning in June 2007. When the warranty period for the readers ended in May 2007, FDOT did not receive adequate documentation or training on how to configure replacement parts. This delayed repairs, allowing failed units to accumulate while FDOT was conducting tests and developing repair procedures.

Despite considerable effort and expense devoted to maintaining the toll tag reader network, the network averaged almost 10 percent failed readers when working well. At times, the failure rates were much higher. Because the CRS software did not include a graceful way of coping with missing travel time data resulting from these failures, such as filling in missing data with historical averages and alerting operators that historical averages were being used so that they can more closely monitor the affected segments, a failed reader usually resulted in missing travel information.

Reader failures will occur. The systems that rely on the readers must be designed to work around those failures.

The reader level of service values provide an indication of how well each individual reader was operating. However, it requires reads fom two toll tag readers to generate a travel time estimate, so the level of service for a travel time segment should be a combination of the level of service values for the readers at the from and to nodes for that segment. The Segment Level of Service, $LOS_{Segment}$ provides a measure of whether the travel time system is producing as many travel time estimates as usual. (This measure is defined in Appendix A.) Figure 46 depicts the level of service for the *i*Florida toll tag travel time links.

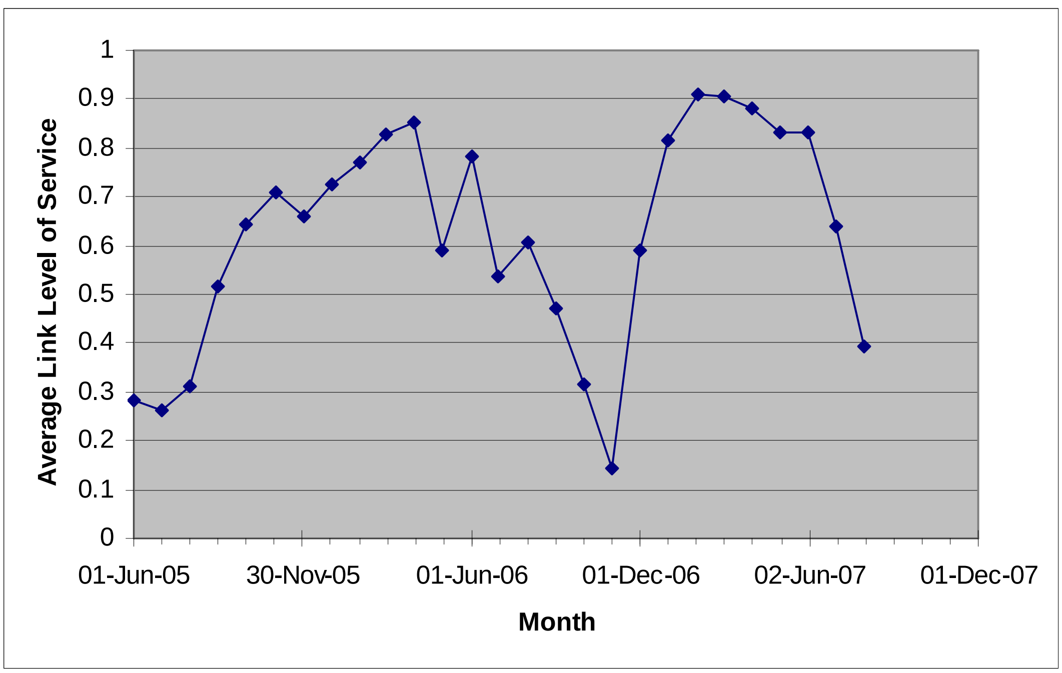


Figure 46. Monthly Average Level of Service for *i*Florida Toll Tag Travel Time Links

Note that it closely follows the level of service chart for the toll tag readers, except that the level of service is generally lower. This is because the level of service for the travel time segment is lowered whenever the level of service of the readers at either node of the segment drops.

4.6. Toll Tag Matching Efficiency

Another factor that impacts the effectiveness of toll tag readers for estimating travel times is the efficiency of the toll tag matching – what fraction of tag reads at the entrance to a travel time segment result in a travel time estimate when the vehicle exits the segment. The following list describes the main factors that affect this efficiency.

- The number of entering vehicles exiting the segment before reaching the end. If an entering vehicle exits the segment before reaching the segment end, no travel time estimate will be produced. A number of variables could impact the number of vehicles that exit the segment before reaching the end.
    - The length of the segment. If a segment is longer, it will typically have more exit points along it and more vehicles will exit along it.
    - The number of major intersections in the segment. More vehicles typically exit a segment at a major intersection than a minor intersection, so the presence of major intersections will usually lower toll tag matching efficiency.
    - Driving patterns on the segment. Some roads have a higher density of local trips and other roads have a higher density of longer trips. If most trips on a travel time segment are local, more vehicles will exit before reaching the end of the travel time segment.
    - Access control on the segment. Access control limits the number of chances for a vehicle to exit a segment. Also, roads with access control are more likely to be used by drivers taking longer trips. Both of these would tend to increase the fraction of entering vehicles that exit a segment.
- The number of lanes monitored and the total number of lanes. If only some of the lanes on a travel time segment are covered by toll tag readers, then the tags will not be read for vehicles in the other lanes. In particular, if a vehicle enters on a monitored lane but exits on an unmonitored lane, then a travel time estimate cannot be made for that vehicle.

This section of the report explores the impact of these factors on the toll tag matching efficiency. Two measures were used for the toll tag matching efficiency. The entering efficiency was the fraction of toll tag reads for vehicles entering the travel time segment that generated travel time estimate. The exiting efficiency was the fraction of toll tag reads for vehicles exiting the segment that resulted in travel time segments. The average toll tag matching efficiency for each arterial segment is reported in Table 8.

Table 8. *i*Florida Arterial Toll Tag Matching Efficiency

Road	Segment	Length (miles)	Lanes	Maj Int	Tag Matching Efficiency			
					East/North		West/South	
					Enter	Exit	Enter	Exit
SR 50	SR 91 to SR 429	4.9	2	7	15%	21%	22%	13%
	SR 429 to SR 408	2.4	2	4	22%	9%	26%	35%
	SR 408 to SR 423	6.5	3	17	6%	12%	11%	5%
	SR 423 to SR 441	1.1	3	3	35%	34%	54%	10%
	SR 441 to I-4	0.8	2	3	48%	26%	12%	45%
	I-4 to US 17/92	1.0	2	4	29%	43%	23%	48%
	US 17/92 to SR 436	3.4	3	12	16%	12%	21%	19%
	SR 436 to SR 417	3.0	3	4	11%	24%	14%	8%
	SR 417 to SR 408	4.5	3	8	10%	5%	26%	35%
SR 414	SR 441 to I-4	4.3	3	2	33%	14%	12%	5%
	I-4 to US 17/92	2.0	2	7	25%	42%	16%	38%
SR 423	SR 417 to SR 528	2.8	3	3	25%	49%	32%	27%
	SR 528 to I-4	6.1	3	3	11%	14%	13%	8%
	I-4 to SR 408	3.0	3	3	19%	11%	11%	18%
	SR 408 to SR 50	0.7	3	3	14%	54%	47%	34%
	SR 50 to SR 441	3.2	2	2	16%	7%	15%	14%
	SR 441 to I-4	2.1	3	3	34%	19%	20%	33%
	I-4 to US 17/92	1.3	2	2	27%	24%	34%	22%
SR 436	SR 441 to SR 434	5.4	4	12	8%	24%	27%	29%
	SR 434 to I-4	1.8	4	7	50%	20%	25%	30%
	I-4 to US 17/92	3.1	4	12	12%	12%	18%	14%
	US 17/92 to SR 50	7.9	3	19	4%	6%	4%	5%
	SR 50 to SR 408	1.2	3	3	35%	16%	23%	41%
	SR 408 to SR 528	5.4	3	13	10%	14%	18%	10%
SR 441	US 192 to SR 417	4.7	3	7	14%	12%	16%	22%
	SR 417 to SR 528	4.4	3	8	2%	8%	8%	16%
	SR 528 to I-4	4.7	3	13	15%	3%	15%	10%
	I-4 to SR 408	2.2	2	5	15%	21%	29%	17%
	SR 408 to SR 50	1.2	2	7	39%	31%	53%	21%
	SR 50 to SR 423	3.4	2	4	2%	4%	13%	31%
	SR 423 to SR 414	3.4	2	4	4%	2%	29%	28%
	SR 414 to SR 436	3.5	2	5	26%	56%	16%	39%
	SR 436 to SR 429	2.2	2	4	54%	15%	57%	57%
US 17/92	SR 50 to SR 423	2.7	2	9	8%	8%	12%	16%
	SR 423 to SR 414	2.3	3	4	23%	36%	18%	14%
	SR 414 to SR 436	1.9	3	2	10%	16%	65%	35%
	SR 436 to SR 417	8.8	3	15	5%	3%	2%	2%

In this table, the columns labeled East/North report the toll tag matching efficiency in the eastbound and northbound directions, while the columns labeled West/South are for the westbound and southbound directions. The Enter columns report the entering toll tag matching efficiency and the Exit columns report the exiting matching efficiency. Table 9 is an analogous table for limited access roads.

Table 9. *i*Florida Limited Access Toll Tag Matching Efficiency

Road	Segment	Length (miles)	Lanes	Maj Int	Tag Matching Efficiency			
					East/North		West/South	
					Enter	Exit	Enter	Exit
SR 91	US 192 to SR 522	4.2	2	0	78%	93%	52%	63%
	SR 522 to SR 528	6.9	2	0	37%	32%	19%	60%
	SR 528 to I-4	4.1	2	0	46%	71%	43%	47%
	I-4 to SR 408	6.1	2	0	84%	27%	78%	55%
	SR 408 to SR 50	7.0	2	1	17%	49%	29%	25%
SR 417	I-4 to Boundary	5.1	2	2	65%	52%	34%	70%
	Boundary to SR 434	6.1	2	2	33%	48%	52%	32%
	SR 434 to US 17/92	6.6	2	1	49%	72%	76%	53%
	US 17/92 to I-4	4.8	2	2	41%	73%	67%	45%

A number of observations can be made by examining the toll tag matching efficiencies listed in these tables.

- The toll tag matching efficiency is typically much higher for limited acess roads than for arterials. Even though the segment lengths were typically longer for the limited access roads than for arterials, the fact that few access points existed meant that the matching efficiencies were typically much higher for the limited access roads.

The tag matching efficiency is much higher for limited access roads than for arterials.

- For arterials, the matching efficiency was usually higher for shorter segments. For example, the average matching efficiency for the three longest segments, with lengths of 8.8, 7.9, and 6.5 miles, was about 6 percent. The average matching efficiency for the three shortest segments, with lengths of 0.7, 0.8, and 1.1 miles, was about 34 percent.

These observations are also demonstrated in Figure 47, with the trend line for limited access roads showing tag matching efficiency almost 40 percent higher than for arterials and the trend line for arterials dropping from about 40 percent for a 1-mile segment to less than 20 percent for a 5-mile segment.

The tag matching efficiency drops quickly as the segment length increases.

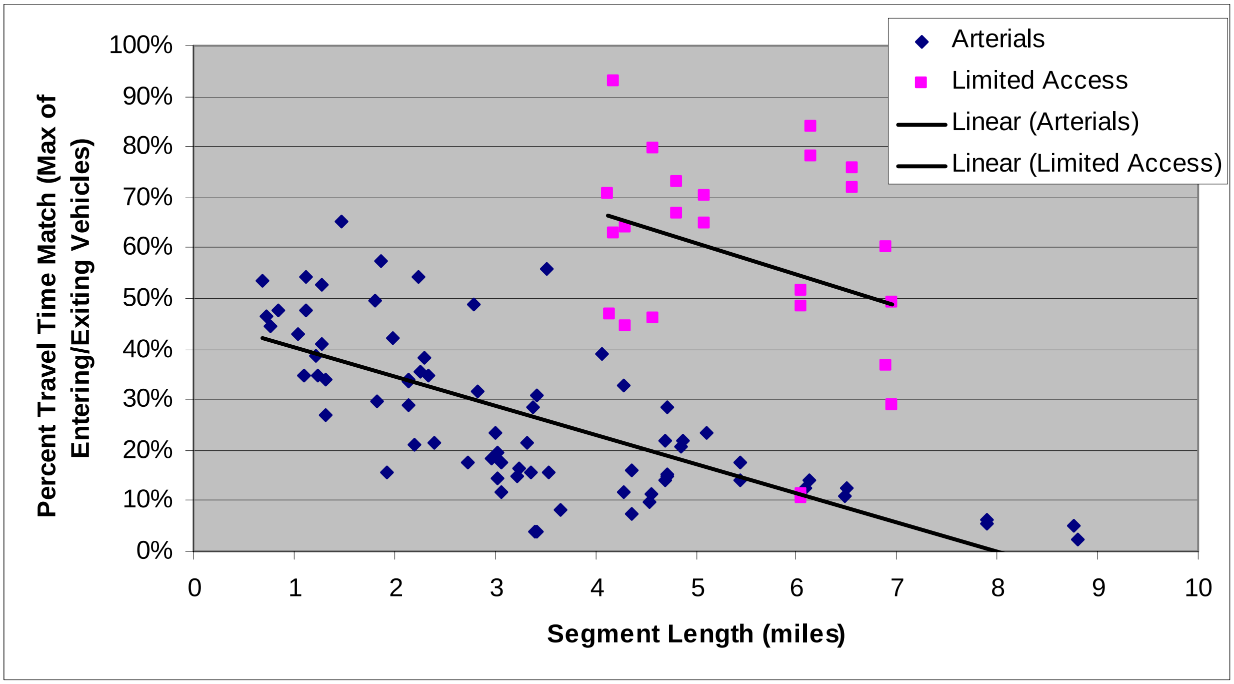


Figure 47. Tag Matching Efficiency versus Segment Length

4.7. Latency and Travel Time Estimation

The travel times experienced by actual travelers are different from those measured by either loop detectors or toll tag readers.

- For an actual traveler, the travel time experienced while traversing a segment is related to the travel speeds for the vehicle at different times as it traverses the segment.
- For loop detectors, travel time estimates are based on speed measurements made along the length of a segment at a particular point in time.
- For toll tag readers, the travel time estimates are based on the travel time experienced by travelers traversing a segment, but the measurement is delayed by the time required to complete the segment.

During times when travel times are relatively stable, all of these values will be similar. When travel times are changing, such as when congestion is building, these times can be different.

Consider what would occur for a segment where the usual travel time was 10 minutes after a crash occurred that instantly changed the travel time experienced by travelers to 30 minutes by introducing a 20-minute delay for those vehicle passing through the crash location. With loop detectors,[6] the observed speeds would quickly change from pre-crash to post-crash values, and the travel time estimated using loop detectors would change quickly from 10 minutes to 30 minutes.

For toll tag readers, the result would be different. During the first few minutes after the crash, vehicles already downstream of the crash location would continue to arrive at the end of the travel time segment and the system would continue to measure 10-minute travel times. After that, there

[6] The system response would depend on the location of the loop detectors relative to the congestion. If no loops were located in the congested area, then the system would not detect the additional delay. If loops were concentrated in the congested area, the system might over-estimate the delay. This statement assumes that loops were placed so as to accurately measure the crash-induced delay.

would be a period during which few vehicles arrived at the end of the travel time segment because the vehicles were caught in the delay caused by the crash. The system might note that fewer vehicles were arriving than expected, but would have no travel time data to indicate that travel times had increased. After 30 minutes had passed, those vehicles delayed by the crash would arrive at the end of the travel time segment and the system would report 30-minute travel times.

Thus, travel times estimates produced by loop detectors respond quickly to changes in travel times that may occur. Travel time estimates produced by toll tag readers are delayed by the time required for the vehicles that enter the travel time segment to completely traverse the segment – the estimates are delayed by a time equal to the travel time estimate. While this delay is modest for short travel time segments, it can be long for longer travel time segments. For example, the *i*Florida arterial toll tag reader deployment included a number of travel time segments that were 5 miles or more in length. Travel time along these segments during congested periods could exceed 30 minutes, which meant that the estimated travel times reflected travel times experienced by travelers entering the segment 30 minutes earlier rather than current traffic conditions. Thus, although toll tag readers produce accurate travel time estimates, in that they reflect travel times experienced by actual travelers, the delay in obtaining the estimate can limit the usefulness of the resulting estimates.

Toll tag readers introduce a delay in producing travel time estimates equal to the estimated travel time.

This latency inherent in toll tag based traffic monitoring systems can also impact the usefulness of toll tag reader networks for incident detection. In order for automated incident detection to be useful, an incident should be identified within minutes of when it occurred. Because the measurement delay in a toll tag based traffic monitoring system is equal to the travel time for the segment, this type of system would provide effective incident detection only if the toll tag readers were spaced sufficiently close so that the expected travel time was less than time delay allowed for effective incident detection.

The latency inherent in toll tag based traffic monitoring systems could limit its effectiveness for incident detection.

4.8. Summary and Conclusions

As part of the *i*Florida Model Deployment, FDOT deployed a network of toll tag readers that were used to estimate travel times on seven Orlando arterials and on portions of several limited access toll roads. Soon after the deployment of these readers was complete in May 2005, FDOT discovered that many of them had failed between the time they were deployed and FDOT began monitoring them. From that time until early in 2006, FDOT struggled to achieve reliable operations with these readers. The reader network operated reliably for the first six months of 2006, though configuration problems with the CRS software made it uncertain whether the travel times being produced by this network were being used correctly to provide 511 travel time messages. Beginning in May 2006, the operational reliability of the toll tag network dropped again. Stable operations were restored in January 2007 and continued through June 2007, when the reliability dropped again as FDOT transitioned from the warranty period, where the deployment vendor was responsible for most repair activities, to a period where FDOT was responsible for maintenance. The CRS software also failed in June 2007, and it was not until November 2007 that FDOT had procured new software that would ingest travel times from the toll tag network and automatically populate 511 messages with those travel times.

Throughout this process, lessons learned regarding the operation of a toll tag network for estimating travel times were documented. These lessons learned are summarized in the following list, with more details provided in the preceeding sections of this report.

- FDOT identified and/or experienced a number of factors that limited the effectiveness of the toll tag network for producing travel times. Those considering using toll tag based travel time networks should consider these factors in their designs. Some of the factors FDOT identified and problems they experienced included:
    - Limited market penetration for toll tag readers. Before deploying a toll tag network, FDOT conducted tests indicating that about 20 percent of vehicles on Orlando arterials had toll tag readers, indicating that toll tag readers would generate a large number of reads for the *i*Florida arterials.
    - Misaligned toll tag readers. After deployment, FDOT found that some toll tag readers did not produce as many reads as expected. FDOT discovered misaligned antennae and obstructions between the antennae and the roadway were often the root cause of this problem.
    - Duplicate tag reads. On arterials, vehicles often passed under the toll tag readers at low speeds or were stopped under the reader. This often resulted in duplicate reads of the same tag.
    - Vehicle diversions. FDOT found that many tags read at the start of a travel time segment did not match any tags read exiting the segment. This was likely caused by vehicles diverting onto other roads before exiting the segment. The fraction of vehicles diverting seemed to increase as the travel time segment length increased.
    - Vehicle stops. An analysis of travel time observations indicated that the mean observed travel time was typically significantly higher than the median observed travel time. This was likely because some vehicles made stops between the time they entered and exited a travel time segment, introducing a high bias into the travel time observations. Methods were needed to filter out these high travel time outliers.
    - Toll tag reader failures. FDOT experienced a large number of reader failures early in the deployment and struggled to maintain high availability of the readers throughout the project. At peak performance, about 90 percent of readers were operational, though the percent of operational readers could be much lower.
    - Clock mis-synchronization. When first deployed, the internal clocks on many of the toll tag readers were not synchronized with a standard clock, which prevented use of the toll tag reader data for computing travel times.
    - Transmission of archived tag reads. The FDOT toll tag reader system maintained an archive of toll tags read at each reader. If the transmission the tag information to the toll tag server failed, the reader would later re-transmit all of the tag reads that had previously failed to transmit. At times, this transmission required so much network bandwidth that the transmission of real-time toll tag reads from other readers was delayed, which prevented the use of the real-time data to generate real-time travel time esimates.
- Travel time estimation parameters. The algorithm that FDOT used to generate travel times from the toll tag reader data was originally developed for use on limited access highways. FDOT discovered that some of the parameter settings needed to be different to work well on arterials. For example, diverting traffic on arterials meant that the observed average travel time was

typically higher than the actual travel time, which was not the case on limited access highways. The algorithm for excluding outliers is, therefore, more important on arterials than for limited access highways.

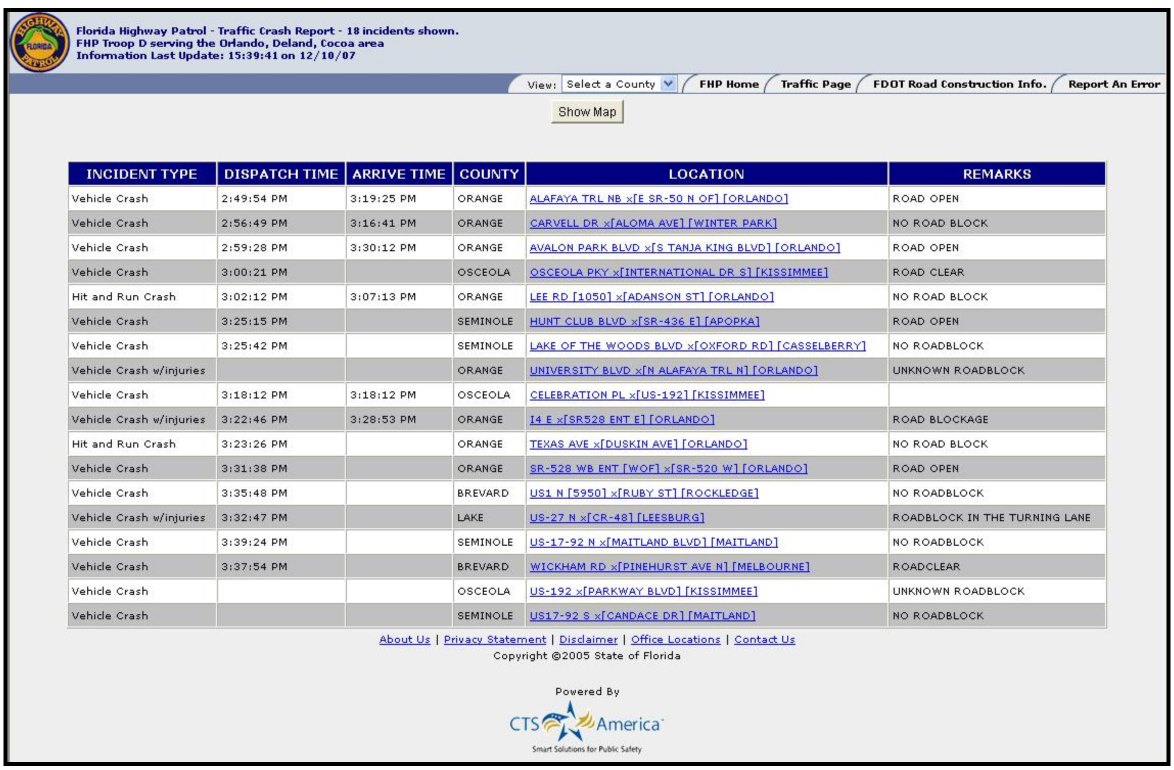
- Including tag reads from turning vehicles can increase the number of travel time observations generated. The FDOT algorithms used data from a single reader to supply tag reads for both the entrance into and exit from a travel time segment. Depending on the exact placement of the readers relative to the intersection, more matches can be obtained by allowing data from multiple readers to be used. (For example, if a reader supplying tag reads at the entrance of a travel time segment is placed upstream the starting intersection, then it will not record tag reads from turning vehicles that enter the segment. Including tag reads from readers monitoring the intersecting road can provide reads from these turning vehicles.) The evaluation team tested such an algorithm and found a significant increase in the number of travel time observations recorded.
- Toll tag reader monitoring should began as soon as deployment is complete. The *i*Florida toll tag readers were deployed over a four month period, and FDOT did not begin actively monitoring the reader status until the deployment was complete. In the intervening period, many readers had failed, which created a large demand for reader repairs that FDOT was not able to fulfill.
- Downstream systems should include methods to continue operations when reader failures occur. Even when operating well, about ten percent of *i*Florida toll tag readers were out of service. Yet, the CRS methods for handling missing data from toll tag readers were not very robust – in most cases, the data was simply treated as missing. An approach to fill in the missing data with estimates from historical data or operator observations would have helped FDOT continue to provide complete traveler information services even when toll tag readers failed.
- The toll tag matching efficiency was much higher for limited access roads than for arterials and much lower for long arterials than for short ones. For short aterial segments (about 1 mile in length), about 50 percent of entering vehicles were later observed exiting the segment. For long arterial segments (about 5 miles in length), this percentage dropped to less than 20 percent.
- Using toll tag readers to estimate travel times introduces a delay in generating observed travel times – if a travel time of T minutes is observed, then that travel time applies to a vehicle that entered the segment T minutes ago. During times of rapid change in the segment travel time, this delay can reduce the usefulness of the travel time data. In particular, this delay may mean that toll tag readers are ineffective tools for incident detection.

5. Interfacing with the FHP CAD System

One source of statewide traffic-related information developed by *i*Florida was an interface to the Florida Highway Patrol Computer Aided Dispatch (FHP CAD) system. Three different tools were used by the Florida Department of Transportation (FDOT) to interface with the FHP CAD system. The first tool "pushed" incident information to the Condition Reporting System (CRS). When the CRS failed, FDOT funded a project to develop a new interface to the FHP CAD data that would filter the data and make it available to FDOT Regional Traffic Management Center (RTMC) operators via a FHP CAD Data Viewer Web site. This was intended to be an interim solution until SunGuide, the replacement for the CRS software, could interface with the FHP CAD system. As this report was being written, the FHP CAD interface to SunGuide was being developed, based on the FHP CAD interface to the FHP CAD Data Viewer.

5.1. The FHP CAD System

The FHP operates seven installations of its FHP CAD, one for each of the seven FHP Dispatch Centers. These seven dispatch centers support the seven FDOT districts and the Florida Turnpike. FHP duty officers enter data into these CAD systems as incident information is received, and update the incident data as new information arrives. Each of these installations of the FHP CAD system submits data to a separate FHP server for inter-agency sharing and to support the FHP Traffic Crash Report Web site. Figure 48 is a screen shot taken from that Web site.


Florida Highway Patrol - Traffic Crash Report - 18 incidents shown.
FHP Troop D serving the Orlando, Deland, Cocoa area
Information Last Update: 15:39:41 on 12/10/07

View: Select a County | FHP Home | Traffic Page | FDOT Road Construction Info. | Report An Error

Show Map

INCIDENT TYPE	DISPATCH TIME	ARRIVE TIME	COUNTY	LOCATION	REMARKS
Vehicle Crash	2:49:54 PM	3:19:25 PM	ORANGE	ALAFAYA TRL NB x[E SR-50 N OF] [ORLANDO]	ROAD OPEN
Vehicle Crash	2:56:49 PM	3:16:41 PM	ORANGE	CARVELL DR x[ALOMA AVE] [WINTER PARK]	NO ROAD BLOCK
Vehicle Crash	2:59:28 PM	3:30:12 PM	ORANGE	AVALON PARK BLVD x[S TANJA KING BLVD] [ORLANDO]	ROAD OPEN
Vehicle Crash	3:00:21 PM		OSCEOLA	OSCEOLA PKY x[INTERNATIONAL DR S] [KISSIMMEE]	ROAD CLEAR
Hit and Run Crash	3:02:12 PM	3:07:13 PM	ORANGE	LEE RD [1050] x[ADANSON ST] [ORLANDO]	NO ROAD BLOCK
Vehicle Crash	3:25:15 PM		SEMINOLE	HUNT CLUB BLVD x[SR-436 E] [APOPKA]	ROAD OPEN
Vehicle Crash	3:25:42 PM		SEMINOLE	LAKE OF THE WOODS BLVD x[OXFORD RD] [CASSELBERRY]	NO ROADBLOCK
Vehicle Crash w/injuries			ORANGE	UNIVERSITY BLVD x[N ALAFAYA TRL N] [ORLANDO]	UNKNOWN ROADBLOCK
Vehicle Crash	3:18:12 PM	3:18:12 PM	OSCEOLA	CELEBRATION PL x[US-192] [KISSIMMEE]	
Vehicle Crash w/injuries	3:22:46 PM	3:28:53 PM	ORANGE	I4 E x[SR528 ENT E] [ORLANDO]	ROAD BLOCKAGE
Hit and Run Crash	3:23:26 PM		ORANGE	TEXAS AVE x[DUSKIN AVE] [ORLANDO]	NO ROAD BLOCK
Vehicle Crash	3:31:38 PM		ORANGE	SR-528 WB ENT [WOF] x[SR-520 W] [ORLANDO]	ROAD OPEN
Vehicle Crash	3:35:48 PM		BREVARD	US1 N [5950] x[RUBY ST] [ROCKLEDGE]	NO ROADBLOCK
Vehicle Crash w/injuries	3:32:47 PM		LAKE	US-27 N x[CR-48] [LEESBURG]	ROADBLOCK IN THE TURNING LANE
Vehicle Crash	3:39:24 PM		SEMINOLE	US-17-92 N x[MAITLAND BLVD] [MAITLAND]	NO ROADBLOCK
Vehicle Crash	3:37:54 PM		BREVARD	WICKHAM RD x[PINEHURST AVE N] [MELBOURNE]	ROADCLEAR
Vehicle Crash			OSCEOLA	US-192 x[PARKWAY BLVD] [KISSIMMEE]	UNKNOWN ROADBLOCK
Vehicle Crash			SEMINOLE	US17-92 S x[CANDACE DR] [MAITLAND]	NO ROADBLOCK

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Smart Solutions for Public Safety

Figure 48. The FHP Traffic Crash Report Web site

FDOT identified five types of data within the FHP CAD system that could be useful, and FHP provided insights into these types of data and their availability and reliability.

- Latitude and longitude. In Florida, the data is usually present and reliable. (FDOT reviewed one week of FHP-CAD data and verified that the latitude-longitude data was very reliable.)
- Incident type. This data is always present, though the incident type categories used by FHP are different than those used by FDOT. The FHP CAD side of the interface translates the FHP incident types into ones recognized by FDOT. Since FHP changes the incident types periodically, a process is needed to ensure that the translation tables are updated whenever FHP makes changes to the incident types.

> ***A process must be in place to update incident type translation tables whenever incident types are changed on the CAD side of a CAD-DOT interface.***

- Road location. When the FHP CAD interface was first used, this information was not always entered into the correct fields—it might be placed in a free text description field rather than in the road location fields. FHP sent out memos and took other steps to improve the consistency of how data was entered into the CAD system. Currently, this data is almost always present and in the correct field.

> ***The DOT should work with the Highway Patrol to ensure that practices are in place to enter key information in the correct fields within the CAD system.***

- The incident description is free text and includes many inconsistencies in the format and content of the data.
- County. The county field is not currently populated in the data received by FDOT. FHP will be updating FHP CAD to address this issue. In the updated version, county data will be added before warehousing the data, based on the latitude and longitude of the event.

5.2. The FHP CAD Interface to CRS

The CRS used FHP CAD data as one source of incident information, integrating it with incident information that could be directly entered by RTMC operators. Figure 49 depicts this CRS user interface for reviewing FHP CAD data.

The user interface displayed a list of incidents that the CRS had successfully received from FHP CAD and allowed users either to accept an incident (i.e., integrate the incident with other CRS incidents and continue to update it as new information arrived from the FHP CAD), take over an incident (i.e., integrate it with other CRS incidents and customize the information, but no longer update it if new information arrived), delete it, and place it on hold (i.e., decide later how to process the incident).

The FHP CAD interface to CRS was implemented as follows:

- FDOT hired the FHP CAD contractor (CTS America) to work with the CRS contractor to develop the interface between these two systems.
- The CRS contractor developed an interface specification based on the IEEE 1512 standards and provided that specification to the FHP CAD contractor.
- The FHP CAD contractor developed software to support its side of the interface to present data according to the specification provided by the CRS contractor, and the CRS contractor developed software to support the CRS side of this interface, along with CRS tools to manage incident information that was received.

The basic approach was to use Simple Object Access Protocol (SOAP) for transmitting incident information with the XML message formats based on the IEEE 1512 standards. Three types of messages were defined:

- New Incident. Information about a new incident is transmitted via the 1512 Incident Description (IDX) message with the Status Indicator indicating the information is for a new

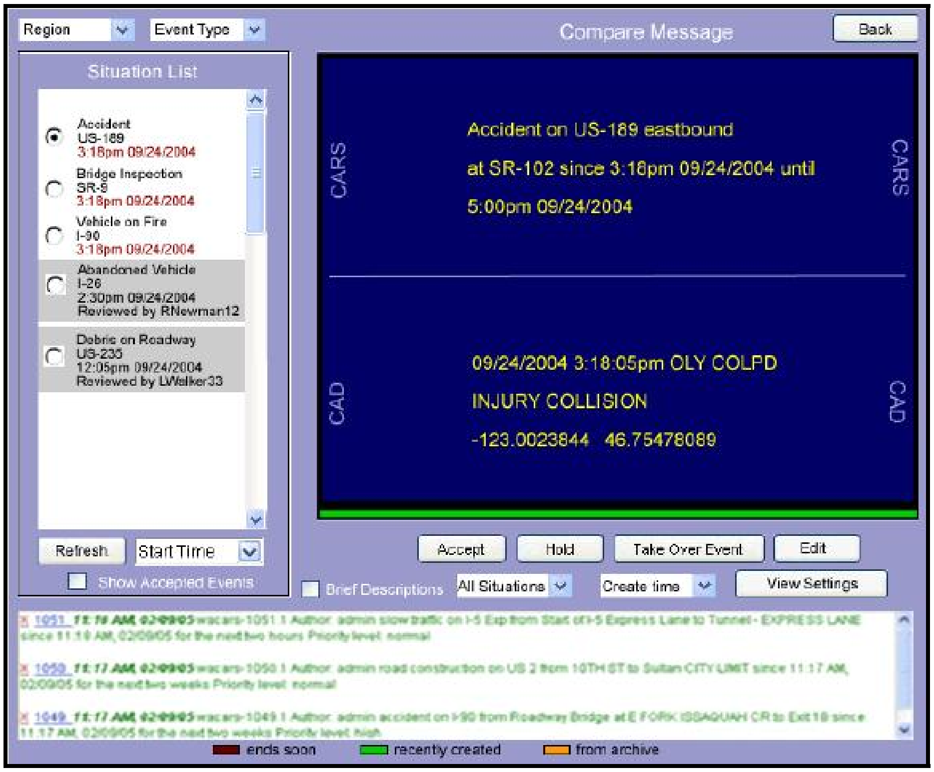

Figure 49. The CRS Interface to FHP CAD Data

  incident. This message defines an Event ID, which is a unique identifier that is used to identify an event in all additional messages related to that incident.

- Incident Update. Information about an already defined incident via the 1512 Incident Description (IDX) message with the Status Indicator communicating that the information is for an already defined incident (i.e., a New Incident message had already been sent).

- Close Incident. An incident is closed when the FHP CAD system transmits a "close incident event" message.

The CRS contractor took the message format itself directly from the IEEE 1512 standard in the form of a set of 13 ASN.1 statements, which the FHP CAD contractor was expected to convert to XML.

The messages would be transmitted from the FHP CAD system to the CRS via a SOAP push transfer. The CRS contractor referred to this as "event-driven SOAP" because each transfer was related to an event that occurred within the FHP CAD system: defining a new incident, updating an existing incident, or closing an existing incident. One consequence of using event-driven messaging is that the process must define methods for

The use of event-driven messages requires implementation of methods to identify and recover from dropped events.

identifying and recovering when a dropped event occurs. This could occur for any of several reasons, including failure of the FHP CAD server (i.e., a set of event messages due for transmission was not sent), network failure (i.e., so a sent message was not received) or failure of the CRS (i.e., a received message was not processed). If a message is dropped, a problem will occur with the CRS side of the data. If a New Incident or Incident Update message is dropped, incident data will be missing from the CRS. If a Close Incident message is dropped, a message will exist in CRS after it has been closed within the FHP CAD system.

The interface did include data for detecting when a message was dropped. The 1512 standard includes an Update Counter in the 1512 messages, and the CRS contractor required that the FHP CAD messages include this counter. This counter could be used to identify a dropped message by comparing the Update Counter with the last received Update Counter for an incident. This could detect dropped New Incident and Incident Update messages, but not a dropped Close Incident message.

The interface also did not include an approach for notifying the FHP CAD system that a message had been dropped and should be resent. In fact, the CRS design document does not indicate that the CRS will detect and recover from dropped FHP CAD messages, nor does it state how it will recover and restart if the CRS fails. There was evidence of these omissions in the data archived from the CRS, in that a query of recent incidents would often include older incidents that had never been closed.

Other problems occurred after the CRS received the data. First, the CRS often had difficulty correctly identifying the location at which an incident occurred. Within the CRS, the road and milepoint location were key to locating the incident. Within the FHP CAD system, this type of location information was not needed internal to the software. Consequently, a variety of road names might be used for the same road and, when the FHP CAD interface was first used, the road name might be entered as part of the free text description rather than in the correct field. This made it difficult for CRS to use the road name to locate incidents.

Identify the fields for which the CAD system does not perform strong quality control checks. Those fields may require extra effort to use them within a DOT system.

Since the latitude and longitude of FHP CAD incidents were present and reliable, the CRS used those values to identify the road location for an incident by "snapping" an incident to the point on the CRS road network that most closely matched the incident latitude and longitude. Incidents that were not located near any CRS road would be discarded. Unfortunately, the CRS incident snapping process did not work reliably, as incidents would sometimes snap to locations far removed from their actual locations. When incident snapping was turned off, a new problem occurred: the CRS could no longer filter out incidents that were not located on CRS roads, and RTMC operators had to delete a large number of extraneous FHP CAD incident data.

This combination of problems severely limited the usefulness of the CRS implementation of the FHP CAD interface.

5.3. The FHP CAD Interface to the FHP Data Viewer

The FHP Data Viewer Web site was designed to obtain incident information from the FHP CAD system, identify the road on which each incident occurred, and provide an interface that would allow RTMC operators to easily review incidents for each road that was covered by the Central Florida or

Statewide 511 systems. Organizing the data by road was intended to make it easier for RTMC operators to maintain the road-based 511 messages. The organization of the incident data in the FHP Data Viewer is shown in Figure 50.

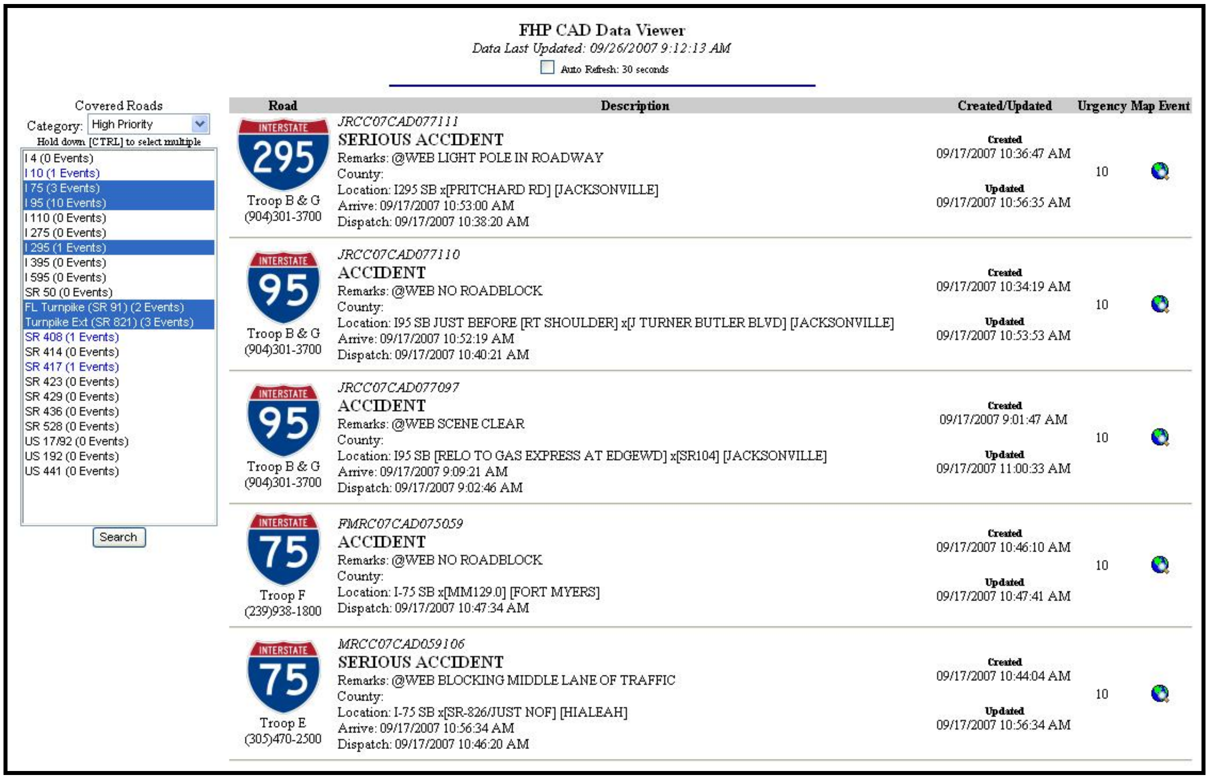

Figure 50. The FHP Data Viewer Web site

Rather than adopting the IEEE 1512 standard directly for the FHP CAD interface to the FHP Data Viewer, this standard was used as a starting point and was modified through a collaborative effort between CTS America (the FHP CAD vendor) and PBS&J (the FDOT contractor developing the FHP Data Viewer Web site). They first considered using the CRS 1512-based interface, but decided it was too complex. A simpler interface was designed that used file transfer protocol to push incident information from the FHP CAD system to a PBS&J server (rather than SOAP) and provided complete information from every active incident with each update (rather than using event-driven messages).

One advantage of this approach was that it was not subject to errors related to dropped messages. The main disadvantage was that the amount of information transmitted was larger. Since a typical FHP CAD incident message was less than 1 KB and the FHP CAD system typically was handling fewer then 200 incidents at a time, the size of the resulting XML file was small enough that the resending incident data would have a very minor impact on system performance.

Another advantage was the simplicity of the interface. Whereas the interface to the CRS was developed over a period of several months, the total time to design the interface and develop the software to support the FHP CAD side of the interface was about two weeks. It took about two weeks longer to finish the initial development of the FDOT side of the interface and the FHP Data Viewer.

To overcome the limitation experienced by the CRS with regard to road names, the developers of the FHP Data Viewer used a translation table to convert road names received by FHP into standard road names used by FDOT. For example, the Florida Turnpike is referred to by a number of names, including "SR 91" and the "Florida Turnpike." PBS&J reviewed archived FHP incident data to identify commonly occurring road names and translated them into the unique names used for roads within the FHP Data Viewer.

RTMC operators believed that the FHP Data Viewer Web site did provide a reliable source of incident data from the FHP CAD system, and many used it as their primary source of incident information. Some still preferred using the FHP Web site directly.

5.4. Summary and Conclusions

The primary objectives of the various FDOT interfaces to the FHP CAD system were to provide RTMC operators with an improved source of FHP incident information, which they could use to support the Central Florida and Statewide 511 systems. The first version of this interface was not very successful, and many operators preferred to refer to the incident information available via the FHP Traffic Crash Reporting Web site rather than rely on the CRS to provide incident information. The second version of this interface (the FHP Data Viewer), however, was successful.

While deploying and operating these systems, FDOT did identify a number of lessons learned that other locales may find useful.

- *The DOT should work with the Highway Patrol to ensure that practices are in place to enter key information needed by the DOT in the correct fields within the CAD system.* The data needs of FHP were different from those of FDOT, so some data fields that were key to FDOT but not key to FHP were not always entered consistently. One example was the road name, which was sometimes entered in the FHP CAD system as part of the free text description rather than in the road name field. FHP cooperated closely with FDOT by encouraging its dispatchers to follow more stringent data entry requirements with respect to these fields.
- *Transferring data from the FHP CAD system required translation of some coded values from FHP's values to those recognized by FDOT.* An example was the incident type. Because FHP sometimes revised the list of acceptable values for incident types and their meanings, FHP instituted procedures to ensure that the tables used to translate FHP incident type values to FDOT values would be updated whenever such changes occurred.
- *Event-driven messaging is subject to errors related to dropped messages.* A system that uses event-driven messaging should include methods for identifying and recovering from dropped messages.

6. Using Dynamic Message Signs for Traveler Information

To support their traveler information and traffic management objectives, FDOT deployed more than 100 DMSs. This section of the report describes FDOT's use of those signs.

6.1. The FDOT DMS Network

One collection of FDOT D5's DMSs was deployed along a 50-mile portion of I-4 running from SR 417 south of Orlando to I-95. Figure 51 depicts the locations of those signs in the Orlando area.

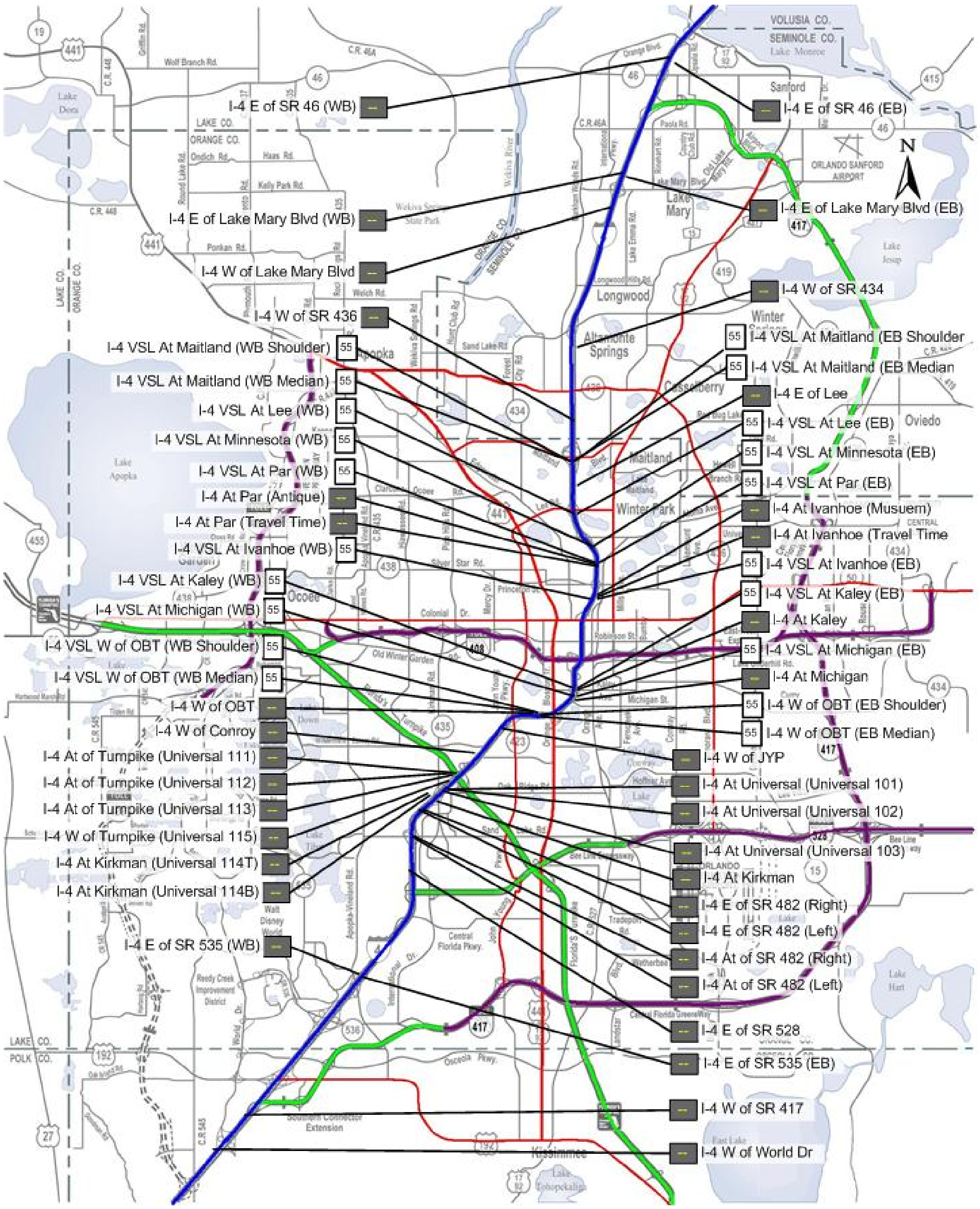

Figure 51. DMS on I-4 Near Orlando

Most of these signs were used for traffic information, displaying travel times by default and incident or congestion information when necessary. Two of this signs, one located south of the I-4 interchange with SR 417 south of Orlando (labeled “I-4 W of World Dr”) and one located north of the I-4 interchange with SR 417 north of Orlando (labeled “I-4 E of SR 46 (WB)”), displayed travel times along two possible routes through Orlando, one along I-4 and one along SR 417. Twenty VSL signs were located in a section of I-4 from just east of US 441 (Orange Blossom Trail) to SR 414 (Maitland Boulevard). Eleven signs were used primarily to provide information about nearby local attractions. Many of these signs were present before the *i*Florida deployment began, and the rest were in use by July 2005.

A second collection of DMSs were deployed along a 70-mile portion of I-95 from SR 509 in the south (near Belbourne Beach) to SR 40 in the north (about 5 miles north of Daytona Beach) and at a number of intersections on alternate routes near I-95 (see Figure 52).

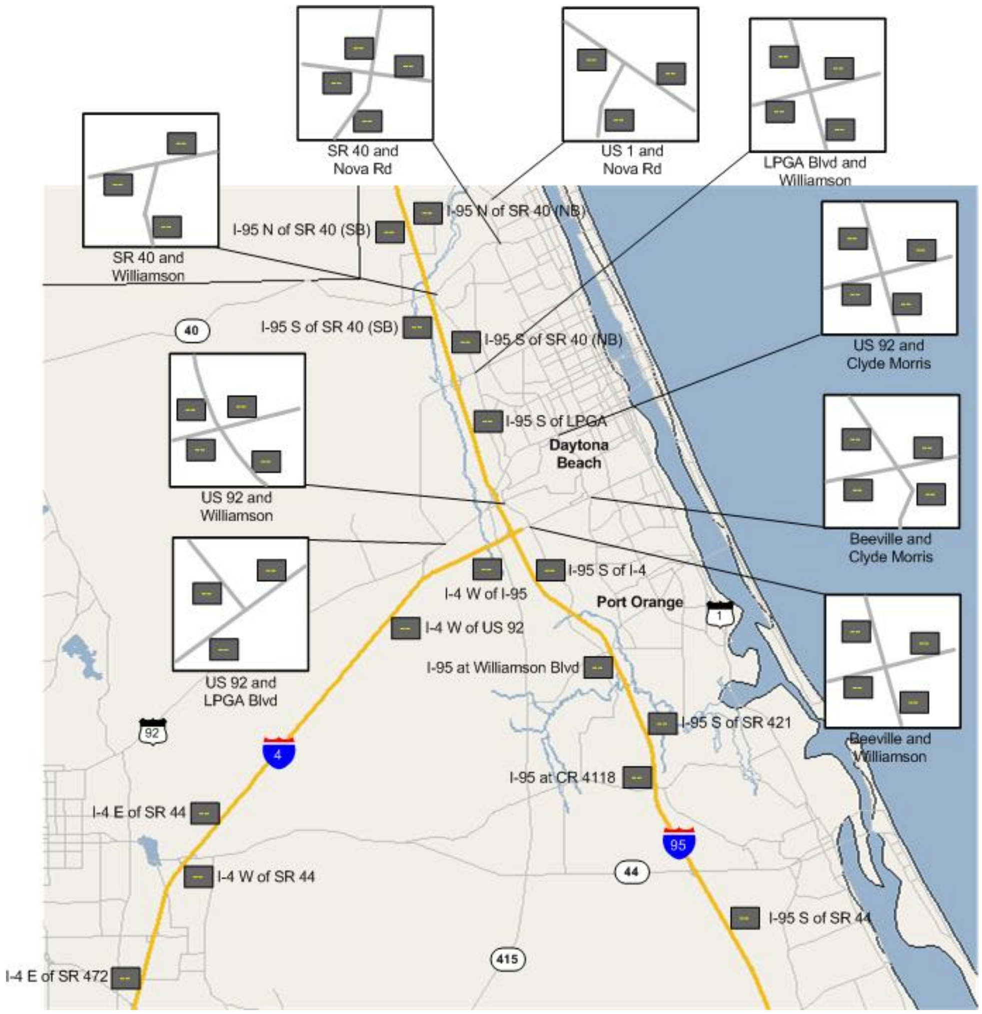

Figure 52. DMSs on I-95 Near Daytona Beach, Florida

The signs deployed along I-4 and I-95 were used primarily for traffic information. The signs on the nearby arterials were used to provide travel directions for travelers diverting off of I-4 and/or I-95 when a significant incident occurred on one of those highways. Additional signs were deployed at regular intervals along I-95 south of the area depicted in Figure 30. Few of these signs were available when the *i*Florida Model Deployment began in 2003. Many of the highway signs were in place by

2005, with deployment of signs along I-95 continuing through 2007. Most of the arterial signs were connected to the sign management system in May and June of 2006.

When the *i*Florida Model Deployment began, FDOT contracted to develop TMC management software called CRS, which included tools to help manage the messages on theses signs. (See section 2 for more information on this software.) For example, this software would ingest data from detectors on I-4, use that data to estimate I-4 travel times, and automatically post travel time messages to message signs. The system would also manage data about incidents and include tools for automatically generating messages when incidents occurred. The key features of this system were its ability to:

- Automatically generate travel time messages.
- Define manual messages with a pre-determined lifetime and alert the operator to retire or continue the message when the lifetime of the message ended.
- Define sign message plans that would be triggered when certain events occurred, automatically generate messages on appropriate signs during the lifetime of that event, and automatically retire messages when the event ended.
- Define default messages that would be displayed if no other message were available for a given sign.
- Prioritize messages, displaying the highest priority message at each point in time and, when the life of the highest priority message ended, automatically replace with the next priority message in the queue.

Unfortunately, the interface between the CRS and the message signs was not reliable. Operators reported that the CRS would sometimes fail to post a message when requested to do so, or would post it briefly before replacing it with a previously sent or lower priority message. At times, all of the message signs on the CRS operator interface would drop off the screen, only to reappear a few minutes later. When the signs disappeared from the interface, it sometimes affected the messages displayed on the signs.

When the first version of the CRS was released in November 2005, RTMC operators began using the basic sign management features of the CRS. They allowed it to automatically generate travel time messages and used it to manually post messages when an incident occurred. By the Spring of 2006, the above-mentioned problems forced FDOT to stop using CRS to post messages. Instead, FDOT disabled the signs within CRS and used a different software tool to manually post messages when an incident or significant congestion occurred. When there were no incident- or congestion-related messages to post, FDOT enabled the sign within the CRS and allowed the CRS to automatically post travel time messages.

In addition to the problems with updating sign messages, FDOT also noted that the CRS miscalculated travel times. In the field, travel times were measured over relatively short stretches of road. On I-4 and I-95, travel speeds were measured by detectors placed at roughly half-mile intervals. These detectors were used to estimate the travel time for each such interval. On toll roads, OOCEA reported travel times for segments that averaged about 1 mile in length. The travel times reported on DMSs were often 10 miles in length or longer. (See Table 11 on page 92.) So, a single travel time reported on a DMS was the sum of travel times

> ***Validating all travel time estimates before using them for traveler information can prevent dissemination of false data and possible loss of public confidence in the traveler information systems.***

measured for small segments of road, and the CRS configuration data had to include information about which observed travel times should be summed to generate a travel time displayed on a DMS. A review of the CRS configuration data by FDOT in February 2006 indicated that errors existed in about two-thirds of the travel time segment definitions, and repeated tests by FDOT continued to identify travel time calculation errors for as long as the CRS was operational. This led OOCEA to suggest that all travel time estimates should be validated before being used for traveler information. OOCEA was concerned that the loss of public trust that might accompany dissemination of inaccurate travel times could result in a loss of public confidence in the travel time information, which would reduce the impact of that information on traveler behavior.

Throughout the most of 2006, FDOT continued to use the CRS to automatically post travel times. RTMC operators periodically reviewed the posted travel times and disabled signs when the posted times were inaccurate. In September 2006, FDOT quit this practice and disabled all message signs within CRS. From that time until June 2007, FDOT managed all sign messages manually. FDOT posted standard travel time messages that reflected free-flow travel times when there was little congestion present, changing to other types of messages when an incident or congestion occurred.

In June 2007, FDOT began transitioning away from CRS to SunGuide. As signs were added to SunGuide system, FDOT allowed SunGuide to post travel times automatically. The transition between manual and automated posting of travel time messages is reflected in Figure 53, which depicts the average length of time that a travel time message remained posted.

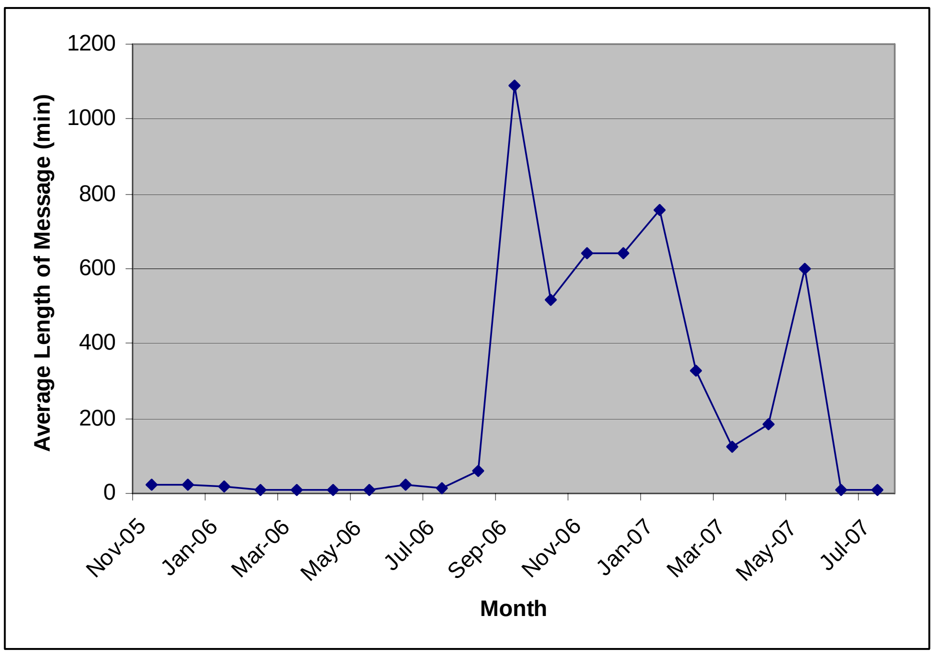

Figure 53. Average Length of *i*Florida Travel Time Message

Note that the periods of automated travel time messages are marked by relatively frequent changes in the travel time messages, while manually updated travel time messages changed infrequently.

The remainder of this section provides more details on FDOT's use of its network of message signs.

6.2. Uses for the FDOT D5 Message Sign Network

Most of the message signs used by FDOT could be organized into categories according to how they were typically used. Some signs were used primarily to provide travel time information, though the travel time messages would be replaced with other types of messages (e.g., incident information, Amber Alerts) when situations warranted it. Others were used primarily to provide information about local attractions or to provide detour information when traffic was diverted off the highway.

The following sections describe FDOT's usage of their message signs, organized by these categories. Many of the results presented rely on analysis of sign messages that FDOT archived from July 2005 to July 2007. This archive included most signs during this period, but excluded signs once they were fully integrated into SunGuide. For example, FDOT used the signs along I-95 and on nearby arterials for testing SunGuide well before it began officially using SunGuide in 2007. Information about those signs was excluded from this archive. Information about the archive and how the evaluation team analyzed it is presented in Appendix B.

6.2.1. Signs Used for Travel Time Messages

The largest category of message signs was for those signs used primarily for travel time messages. By default, these signs displayed travel time messages, which were replaced with higher priority messages when warranted (e.g., a crash occurred or congestion appeared downstream from the sign). Table 10 lists the message signs that were used primarily for travel time information, along with the first and last months for which the archived sign data indicated that a travel time message was posted on each sign.

Table 10. FDOT D5 Travel Time Signs on I-4

Road	MP	Name	Direction	Period
I-4	62.8	I-4 West of SR 417	Eastbound	05/06 to 07/07
I-4	69.0	I-4 East of SR 535 (Eastbound)	Eastbound	11/05 to 07/07
I-4	69.0	I-4 East of SR 535 (Westbound)	Westbound	11/05 to 07/07
I-4	72.6	I-4 East of SR 528	Eastbound	11/05 to 07/07
I-4	77.7	I-4 West of Conroy Road	Westbound	11/05 to 07/07
I-4	78.5	I-4 West of John Young Parkway	Eastbound	11/05 to 07/07
I-4	79.2	I-4 West of OBT	Westbound	09/06 to 07/07
I-4	81.0	I-4 At Michigan Ave	Eastbound	02/06 to 07/07
I-4	81.5	I-4 At Kaley Ave	Westbound	11/05 to 07/07
I-4	84.5	I-4 At Ivanhoe (Travel Time)	Eastbound	11/05 to 06/07
I-4	86.0	I-4 At Par Ave (Travel Time)	Westbound	11/05 to 07/07
I-4	89.0	I-4 East of Lee Rd	Eastbound	03/06 to 07/07
I-4	91.0	I-4 West of SR 436	Westbound	11/05 to 07/07
I-4	93.0	I-4 West of SR 434	Eastbound	08/05 to 06/07
I-4	97.0	I-4 West of Lake Mary Blvd	Westbound	03/06 to 07/07
I-4	99.2	I-4 East of Lake Mary Blvd (Westbound)	Westbound	10/05 to 07/07
I-4	99.3	I-4 East of Lake Mary Blvd (Eastbound)	Eastbound	11/05 to 07/07
I-4	104.3	I-4 East of SR 46 (Eastbound)	Eastbound	11/05 to 07/07
I-4	107.5	I-4 At The Causeway	Eastbound	11/05 to 07/07
I-4	109.9	I-4 At Enterprise Rd	Westbound	11/05 to 07/07
I-4	114.6	I-4 East of SR 472	Westbound	12/05 to 07/07

Two other signs on I-4 ("I-4 West of World Dr" and "I-4 East of SR 46 (Westbound)") were also used predominately for travel time information, but were classified as diversion signs because they were also used to provide diversion information (see section 6.2.2.). Four signs on I-95 were also used for travel time information (see Table 11), though travel times were only available on these signs part of the time because FDOT was still developing the I-95 travel time data collection system. Other signs on I-95 were used to display travel time information, but archives of the sign messages for those signs were not available.

Table 11. FDOT D5 Travel Time Signs on I-95

Road	MP	Name	Direction	Period
I-95	199.4	I-95 North of SR 519	Northbound	01/06 to 04/07
I-95	203.2	I-95 North of SR 524 (Southbound)	Southbound	01/06 to 04/07
I-95	203.9	I-95 North of SR 524 (Northbound)	Northbound	01/06 to 04/07
I-95	207.0	I-95 North of SR 528	Southbound	01/06 to 07/07

For each travel time sign, either one or two locations were selected and travel times were posted for the estimated time to drive from the location of the sign to each of those selected locations. Table 12 lists the locations used for the *i*Florida travel time signs and the distance to those locations.

Table 12. Locations Used for *i*Florida Travel Time Signs

Road	Sign Name	Location To (Distance To)
I-4	I-4 West of SR 417	SR 528 (10 miles) / SR 91 (15 miles)
I-4	I-4 East of SR 535 (Eastbound)	SR 91 (8 miles) / SR 50 (14 miles)
I-4	I-4 East of SR 535 (Westbound)	US 27 (13 miles)
I-4	I-4 East of SR 528	SR 50 (10 miles) / SR 436 (19 miles)
I-4	I-4 West of Conroy Road	SR 528 (5 miles) / US 192 (13 miles)
I-4	I-4 West of John Young Parkway	SR 50 (5 miles) / SR 423 (9 miles)
I-4	I-4 West of OBT	SR 91 (3 miles) / SR 528 (7 miles) SR 528 (8 miles) / US 192 (14 miles)
I-4	I-4 At Michigan Ave	SR 436 (10 miles) / Lake Mary Blvd (16 miles)
I-4	I-4 At Kaley Ave	SR 91 (4 miles) / SR 528 (7 miles)
I-4	I-4 At Ivanhoe (Travel Time)	SR 436 (7 miles) / Lake Mary (13 miles)
I-4	I-4 At Par Ave (Travel Time)	SR 91 (9 miles) / SR 528 (14 miles)
I-4	I-4 East of Lee Rd	Lake Mary (10 miles) / SJR Bridge (16 miles)
I-4	I-4 West of SR 436	SR 50 (6 miles) / SR 91 (13 miles)
I-4	I-4 West of SR 434	Lake Mary (5 miles) / SJR Bridge (11 miles)
I-4	I-4 West of Lake Mary Blvd	SR 50 (11 miles) / SR 91 (18 miles)
I-4	I-4 East of Lake Mary Blvd (WB)	SR 436 (7 miles) / SR 50 (15 miles)
I-4	I-4 East of Lake Mary Blvd (EB)	Saxon Blvd (12 miles) / I-95 (33 miles)
I-4	I-4 East of SR 46 (Eastbound)	Saxon Blvd (8 miles) / I-95 (32 miles)
I-4	I-4 At The Causeway	SR 44 (12 miles) / I-95 (26 miles)
I-4	I-4 At Enterprise Rd	SR 417 (7 miles) / SR 50 (24 miles)
I-4	I-4 East of SR 472	SR 417 (14 miles) / SR 50 (31 miles)

The travel time messages posted on these signs included three pieces of information: the location to which the travel time referred, the distance to that location, and the travel time to that location. (Prior to the start of the *i*Florida Model Deployment, FDOT reported travel times to the public in the form of travel delays, using messages with a format similar to "To SR 417, 15 Min Delay".)

Although 54 different formats for travel time messages were identified, most of the messages (about 97 percent of travel time messages) were minor variations of the following two formats.

- TO {Location To} / {Distance To} / {Travel Time From}{Next Phrase} / TO {Location To} / {Distance To} / {Travel Time From}
- TO {Location To} / {Distance To} / {Travel Time From}

While these signs were used primarily for travel time messages, other messages were used at times. When travel times were unavailable, the signs were either blank or contained a traffic-related advertisement (e.g., "For Travel Information Dial 511"). When an incident or significant congestion occurred, the travel time message was replaced by an incident or congestion message. Incident and congestion messages included much more variability in their content than did travel time messages.

More than 800 different formats were identified for congestion messages, with each message including some combination of the following types of information:

- A key phrase (e.g., "Congestion Ahead") indicating that the message was about congestion.
- Distance to the start of the congestion or, if the sign location was in the congested areas, distance to the end of the congestion.
- Name of location at which the congestion starts, if applicable, and name of the location at which the congestion ends.
- The expected delay caused by the congestion.

More than 1,100 different formats were identified for crashes, with another 122 formats for other types of incidents (e.g., heavy fog). These messages typically included some combination of the following types of information:

- A key phrase (e.g., "Crash Ahead") identifying the type of incident.
- Distance to the incident.
- Number of lanes blocked.
- A congestion message (see above) providing information about congestion induced by the incident.

Because the messages were entered manually by RTMC operators, variation existed in the messages that were used. For example, some operators tended to use the word "incident" to indicate a crash, while most used the word "accident". Other characteristics of the messages evolved over time. For example, congestion delay was usually expressed as a unique number of minutes in 2005, but almost always expressed as a range of possible minutes in 2007. Also, messages tended to include more details in 2007 than they did in 2005. Figure 54 depicts the fraction of time that these signs were displaying different types of messages.

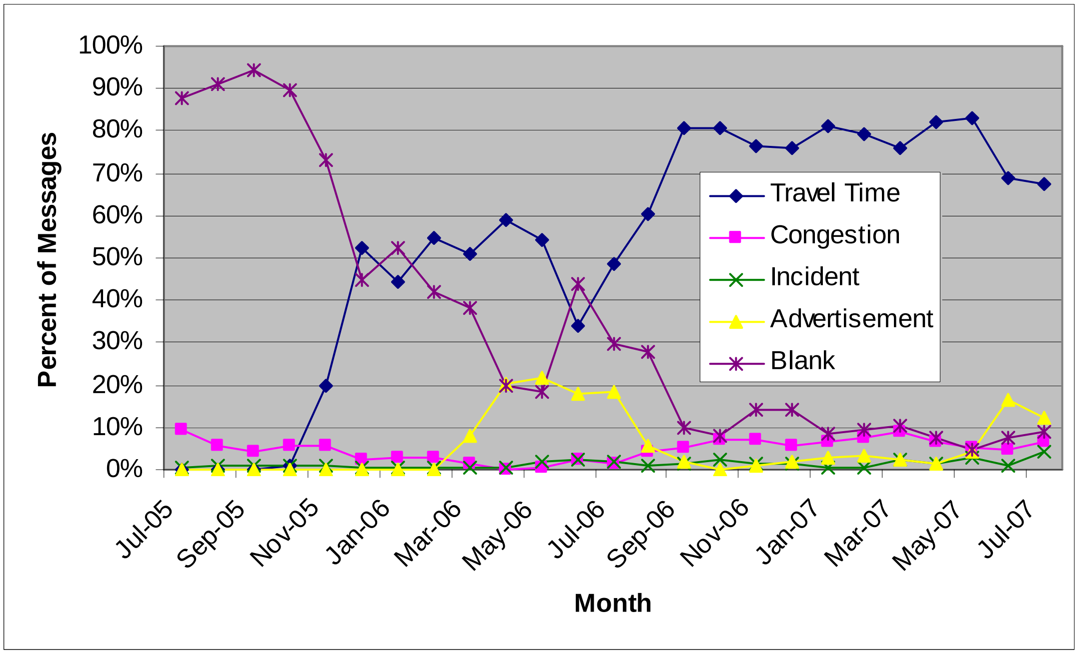

Figure 54. Type of Messages on *i*Florida Travel Time Signs

Consider, for example, the messages displayed on the I-4 west of the John Young Parkway sign on October 26, 2006. On this day, typical levels of congestion occurred during the morning and afternoon, as depicted in the congestion chart in Figure 55. (The I-4 west of the John Young Parkway sign is located near detector station 29 in this chart.)

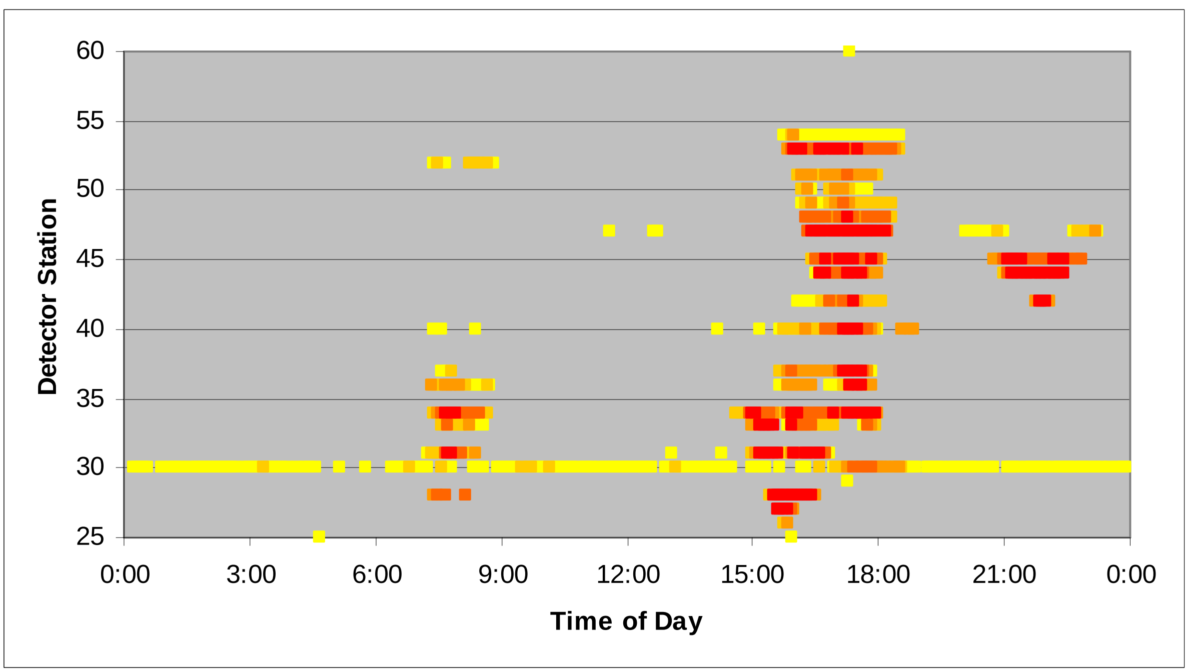

Figure 55. Congestion Chart for I-4 Eastbound Traffic on October 26, 2006

In addition, a crash occurred at about 3:15 p.m. near detector station 36. The following list describes the messages used on this sign on that day.

- While traffic was light, a standard travel time message was displayed. From midnight until 7:23 a.m., the message "To SR 50 / 5 Miles / 5 Min / To Lee Rd / 9 Miles / 10 Min" was displayed. (Because the CRS software was not working reliably, FDOT was manually posting standard travel time messages rather than using automated travel time messages.)
- When congestion began to build, operators began using congestion messages. From 7:23 a.m. until 8:25 a.m., the message "Congestion / Next 5 Miles / 15-20 Min / Congestion / Clears At / Anderson St" was displayed. From 8:25 a.m. until 8:36 a.m., the message "Congestion / Ahead 2 Miles / 10-15 Min / Congestion / John Young / To Anderson" was displayed. From 8:36 a.m. until 8:55 a.m., the message "Congestion / Ahead 3 Miles / 10-15 Min / Congestion / US 441/OBT / To Anderson" was displayed.
- At the end of the morning rush hour, the standard travel time message was used. From 8:55 a.m. until 3:13 p.m., the message "To SR 50 / 5 Miles / 5 Min / To Lee Rd / 9 Miles / 10 Min" was displayed.
- When a crash occurred, crash messages were displayed until the crash was cleared. From 3:13 p.m. until 3:36 p.m., three slight variations of the message "Accident / Ahead 3.5 Miles / Left Ln Blkd / Congestion / Ahead 3 Miles / 3-5 Min" were displayed.
- When the crash cleared, afternoon congestion was starting to build and congestion messages were displayed until 6:12 p.m., with the content of the message changing frequently as congestion built up and then dissipated.
  - At 3:36 p.m., the message "Congestion / Next 3 Miles / 5-10 Min / Congestion / Clears At / US441/OBT" was displayed.
  - From 3:37 p.m. until 3:54 p.m., the message "Congestion / Next 3 Miles / 10-15 Min / Congestion / Clears At / US441/OBT" was displayed.
  - From 3:54 p.m. until 4:14 p.m., the message "Congestion / Next 5 Miles / 10-15 Min / Congestion / Clears At / Anderson St" was displayed
  - From 4:14 p.m. until 4:17 p.m., the message "Congestion / Next 7.5 Miles / 15-20 Min / Congestion / Clears At / Ivanhoe Blvd" was displayed.
  - From 4:17 p.m. until 4:35 p.m., the message "Congestion / Next 13.5 Miles / 35-40 Min / Congestion / Clears / W of SR 436" was displayed.
  - From 4:35 p.m. until 4:42 p.m., the message "Congestion / Ahead 3 Miles / 35-40 Min / Congestion / OBT/US 441 To / W of SR 436" was displayed.
  - From 4:42 p.m. until 4:58 p.m., the message "Congestion / Ahead 1.5 Miles / 35-40 Min / Congestion / John Young Pkwy / To W of SR 436" was displayed.
  - From 4:58 p.m. until 6:12 p.m., the message "Congestion / Ahead 3 Miles / 35-40 Min / Congestion / OBT/US 441 To / W of SR 436" was displayed.
- From 6:12 p.m. until 6:41 p.m., the sign was blank.
- From 6:41 p.m. until 7:18 p.m., the standard travel time message "To SR 50 / 5 Miles / 5 Min / To Lee Rd / 9 Miles / 10 Min" was displayed.
- From 7:18 p.m. until 8:39 p.m., the sign was blank.
- From 8:39 p.m. until midnight, the standard travel time message "To SR 50 / 5 Miles / 5 Min / To Lee Rd / 9 Miles / 10 Min" was displayed.

The general approach exemplified by this sequence of messages was typical of how the travel time signs were used. Travel time messages were used by default, but were replaced with a congestion message when travel times increased. When an incident occurred, an incident message would be used instead.

It is worth noting that FDOT preferred to use congestion messages rather than travel time messages when travel times increased. The advantages of a congestion message are that it alerts travelers that traffic conditions worsen ahead and provides more detail than travel time messages about the exact location of the congestion. This meant that travel time messages were used during the times of day where travel times were most likely to be static, and congestion messages were used during the times of day when the messages were likely to change frequently. Because neither the CRS nor SunGuide requirements included specification for tools to automatically generate congestion messages, RTMC operators were required to generate and update these messages manually.

Ensure that the TMC software supports automated generation of common types of messages, such as congestion messages.

Thus, the CRS was designed to produce the types of messages (travel time messages) that were used predominately during the times of day when static messages would suffice. It was not designed to produce the types of messages (congestion messages) that were used during the times of day when the messages changed frequently. Designers of similar systems may want to clearly define DMS message policies and review those policies to identify which messages are used most often and change frequently before determining the types of messages that will be automated.

Design the TMC management software to automatically produce the types of messages that are used often and change frequently.

The biggest challenge FDOT faced with respect to the travel time signs was reliably producing travel time estimates. FDOT relied primarily on two types of technologies for producing travel time estimates. On I-4 and I-95, the agency used loop and radar detectors to collect speed data, and used the speed data to estimate travel times. On toll roads and arterials, FDOT primarily used toll tag readers and estimated travel times by comparing time stamps for vehicles that passed by two successive toll tag readers. In a few cases, they used license plate recognition rather than toll tag readers.

In the summer of 2005, the startup of the *i*Florida operational period was delayed because a large number of arterial toll tag readers were out of service, so that arterial travel times were unavailable. At that time, FDOT struggled to establish a process to quickly identify and repair failed readers. Even after 2 years of experience with these toll tag readers, failures were still common. For example, travel time estimates for arterial and toll travel time segments were available only about 60 percent of the time during the period from March 1, 2007, through May 21, 2007 (see Figure 56).

The software used to manage travel time messages on DMSs should include methods for managing sign messages when travel times are unavailable.

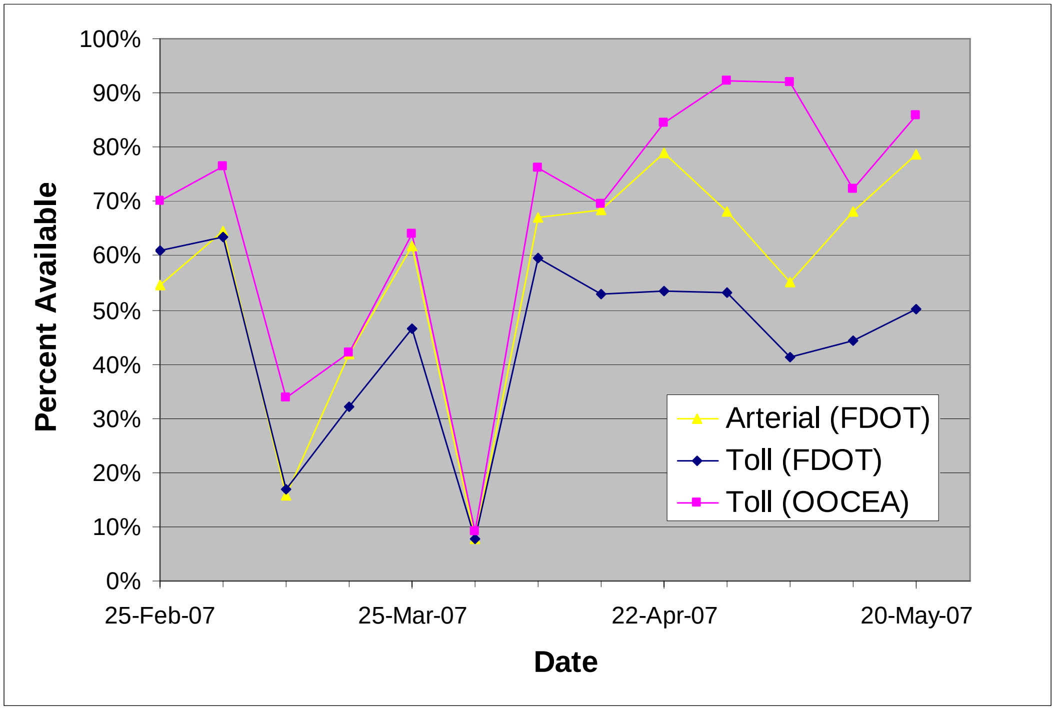

Figure 56. Reliability of Travel Time Estimates from Toll Tag Readers

The speed estimates from the I-4 and I-95 detectors were more often available than the travel time estimates from the toll tag readers, but still were unavailable a significant fraction of the time, as shown in Figure 57.

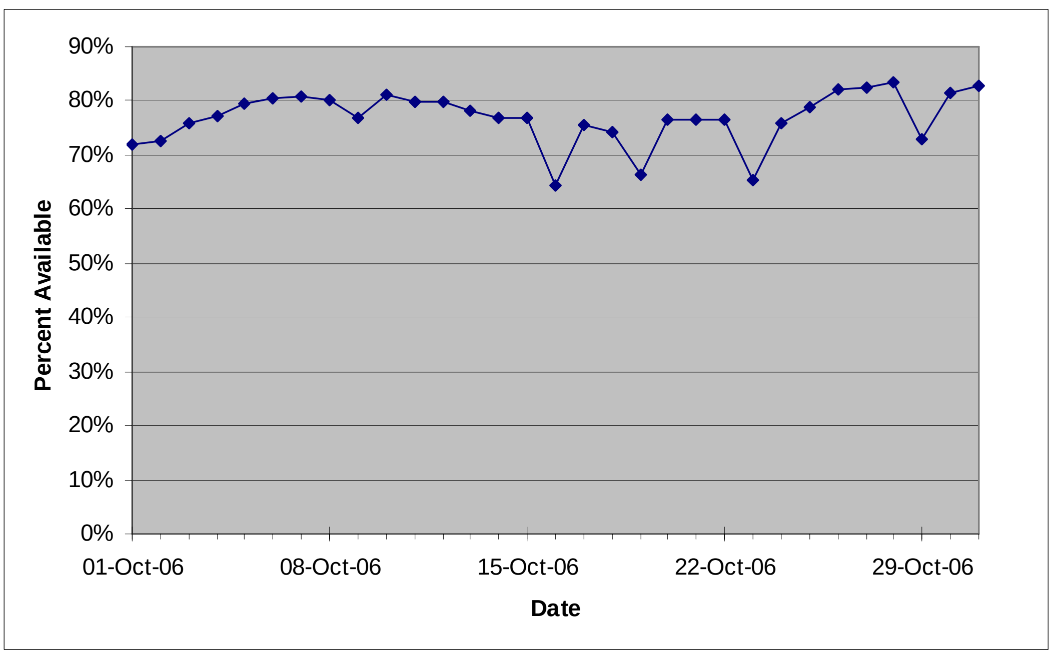

Figure 57. Reliability of Speed Estimates from Loop and Radar Detectors

With the CRS, FDOT was able to manually post travel time messages manually if observations were not available. However, the CRS did not alert RTMC operators to the fact that data was missing, so signs could remain blank for some time before operators detected that fact. It is interesting to note that both prior to the CRS becoming operational in November 2005 and after FDOT abandoned using it to maintain sign messages in September 2006, RTMC operators regularly maintained congestion information on these signs during peak travel periods without the help of automated tools for doing so. The RTMC operators were also skilled at estimating travel times based on traffic surveillance video and often used this approach rather than considering loop speed measurements when automated travel time estimates were unavailable.

6.2.2. Signs Used for Diversion Messages

Two signs were used to display travel time information for two alternate routes, one along I-4 through downtown Orlando and one along the SR 417 toll road that bypasses downtown Orlando. The route along I-4 was shorter—about 42 miles long—but was often congested and could have longer travel times. The route along SR 417 was longer—about 57 miles long—but was seldom congested and could have shorter travel times when I-4 was congested.

The system was intended to display a diversion message only when the travel time on I-4 was larger than that on SR 417 by at least 10 minutes, indicating that diverting onto SR 417 would save time. The I-4 west of World Dr. sign, located west of the I-4 / SR 417 interchange west of Orlando, was used for diversion information for travelers heading east on I-4. The I-4 east of SR 46 (westbound) sign, located east of the I-4 / SR 417 interchange east of Orlando, was used for diversion information for travelers heading west on I-4.

Figure 58 depicts the fraction of time these signs were devoted to different types of messages, including diversion messages.

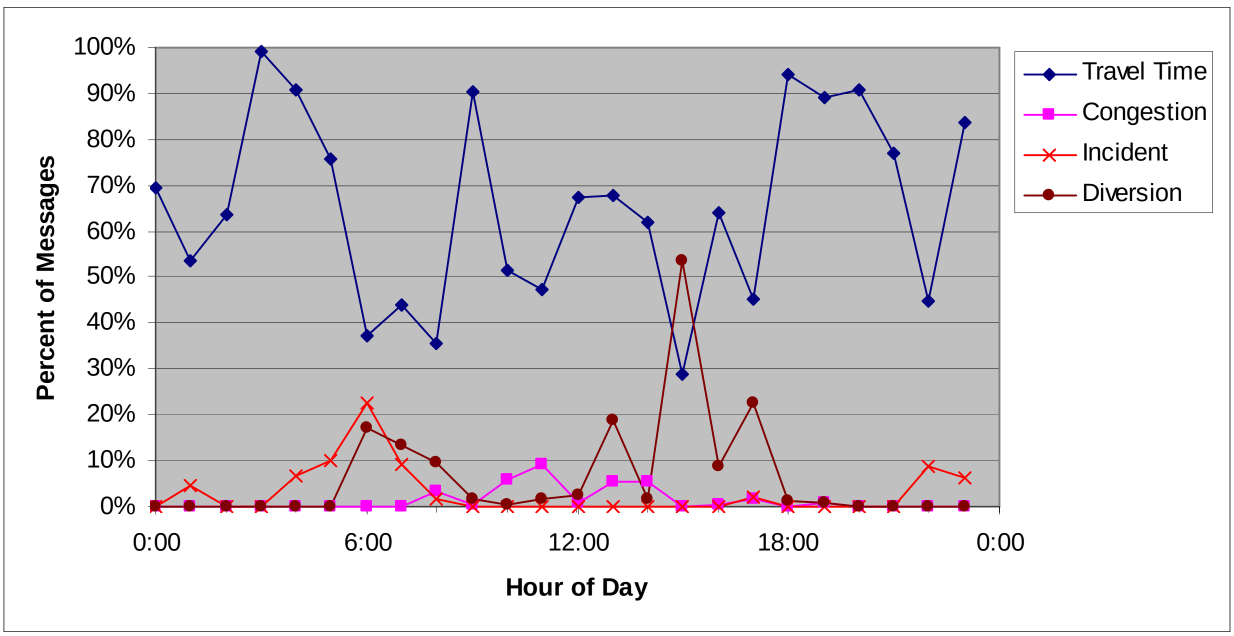

Figure 58. Messages of *i*Florida Diversion Signs

As would be expected, the diversion messages occurred primarily during the morning and evening rush hours. Figure 59 depicts the percent of diversion entries with different travel times on the I-4 west of the World Dr. sign.

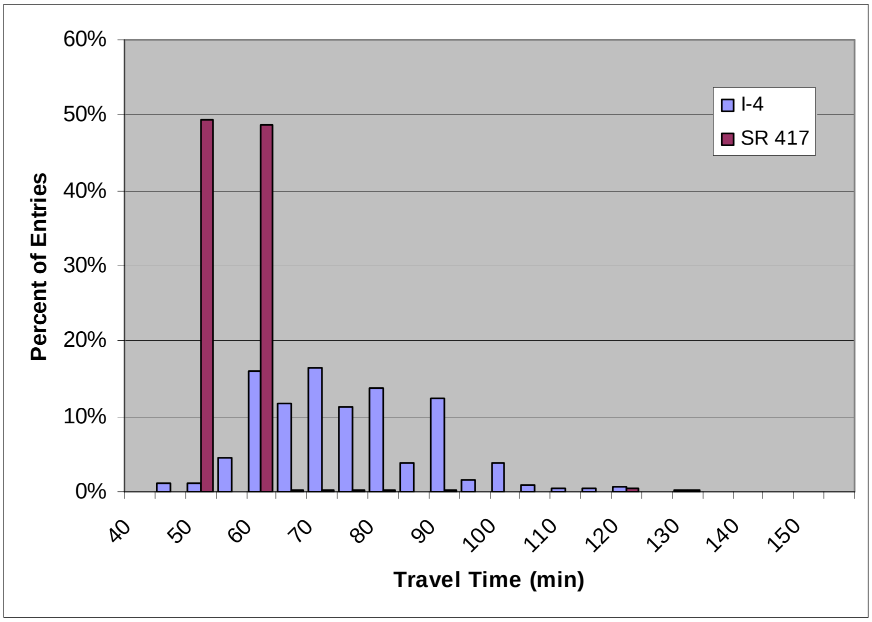

Figure 59. Average Diversion Travel Times on the I-4 West of World Dr. Sign

Note that almost all of the travel times along SR 417 were either 50 or 60 minutes, whereas the I-4 travel time ranges from 45 to 120 minutes. Figure 60 is a similar chart for the I-4 east of SR 46 (westbound) sign.

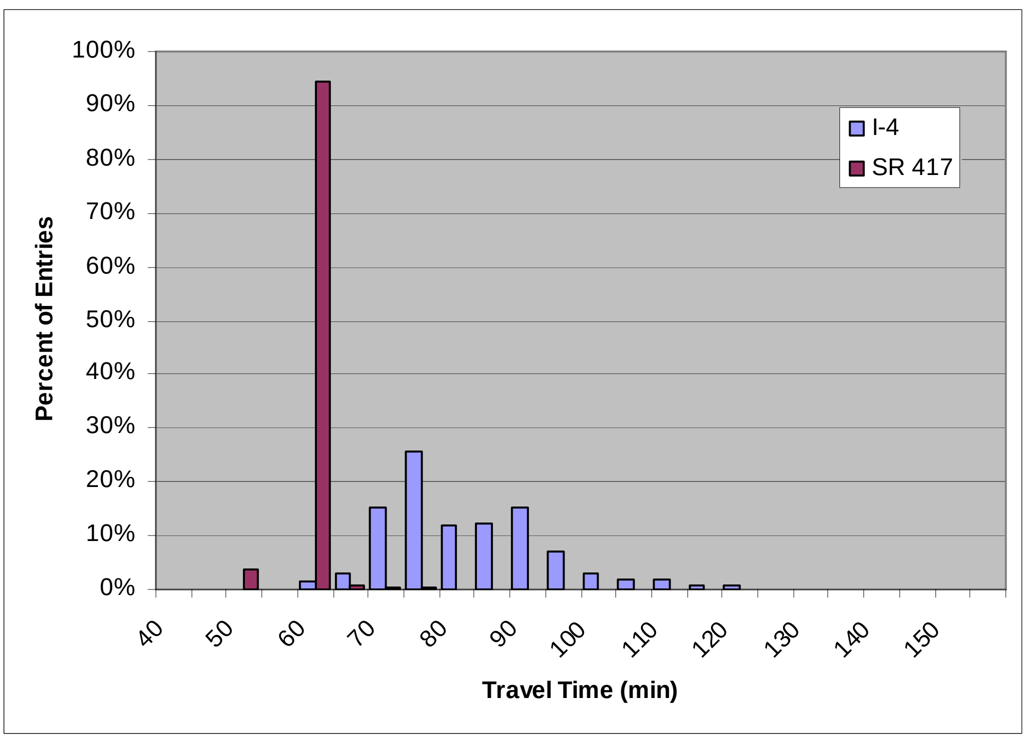

Figure 60. Average Diversion Travel Times on the I-4 East of SR 46 (Westbound) Sign

As with the I-4 west of World Dr. sign, the SR 417 travel times showed little variation while the I-4 travel times showed broad variation.

6.2.3. Signs Used at Arterial Intersections

One of the unusual features of the network of FDOT D5 message signs was the extensive collection of trailblazer signs deployed at key arterial intersections located along I-4 and I-95 near the I-4 / I-95 interchange. These signs were used primarily to direct traffic that either had detoured off one of the nearby Interstate highways due to an incident or was traveling to or from the Daytona International Speedway during a race weekend.

An example of the usefulness of these signs occurred on February 19, 2007. A man was shot and killed at about 9:30 p.m. on I-4 westbound as people were leaving the Daytona 500 race at the Daytona International Speedway. During the investigation, traffic in both directions on I-4 was blocked, eliminating the primary exit route westbound from the Speedway. The presence of these signs allowed FDOT to identify diversion routes and post information on the arterial signs to redirect travelers along the diversion routes. After the event, the Daytona International Speedway reported to FDOT that they received numerous compliments on the usefulness of these signs from race attendees.

Further support for the value of diversion signs came from a survey of Central Florida freeways users conducted in March 2005.[1] When asked to specify two types of new traveler information they would like to receive, 68 percent of respondents listed "information about alternate routes" as one of their two choices. The next most frequently listed item, "travel information Web site," was listed by only 12 percent of respondents.

6.2.4. Other Types of Signs

FDOT managed messages on several other types of signs in the Orlando area. One set of five signs was used to suggest an appropriate exit number to take to reach the Universal theme parks. These signs included variable content that could be changed to different exit numbers and static content indicating that the listed exit number should be taken to reach the theme parks. FDOT had the ability to change the exit numbers on these signs in response to traffic on the nearby arterials, although these exit numbers were seldom changed in practice.

Another two signs identified nearby attractions, such as the Mennello Museum of American Art, the Antique District, Leu Gardens, the Shakespeare Center, etc. Twenty-two signs were designated for displaying variable speed limits, though these signs displayed static speed limits throughout the *i*Florida evaluation period. (See Section 7 for more information on the variable speed limit signs.)

6.3. The Reliability of the FDOT Sign Network

In general, the FDOT roadside signs proved fairly reliable, as depicted in Figure 61. In this figure, sign reliability is reported as the average percent of days during each month that a sign was listed in FDOT's maintenance logs as requiring maintenance. Prior to the *i*Florida deployment, about 90 percent of the forty-four FDOT DMSs were operational. Throughout most of 2005 and 2006, when FDOT was experiencing significant problems with other aspects of the *i*Florida deployment, this percentage dropped down to about 70 percent. By early 2007, after FDOT abandoned the use of the CRS to manage sign messages, the reliability of these signs returned to pre-*i*Florida levels, even as the number of signs increased from 44 to 60.

[1] *i*Florida Evaluation Telephone Survey, prepared for FDOT in March 2005.

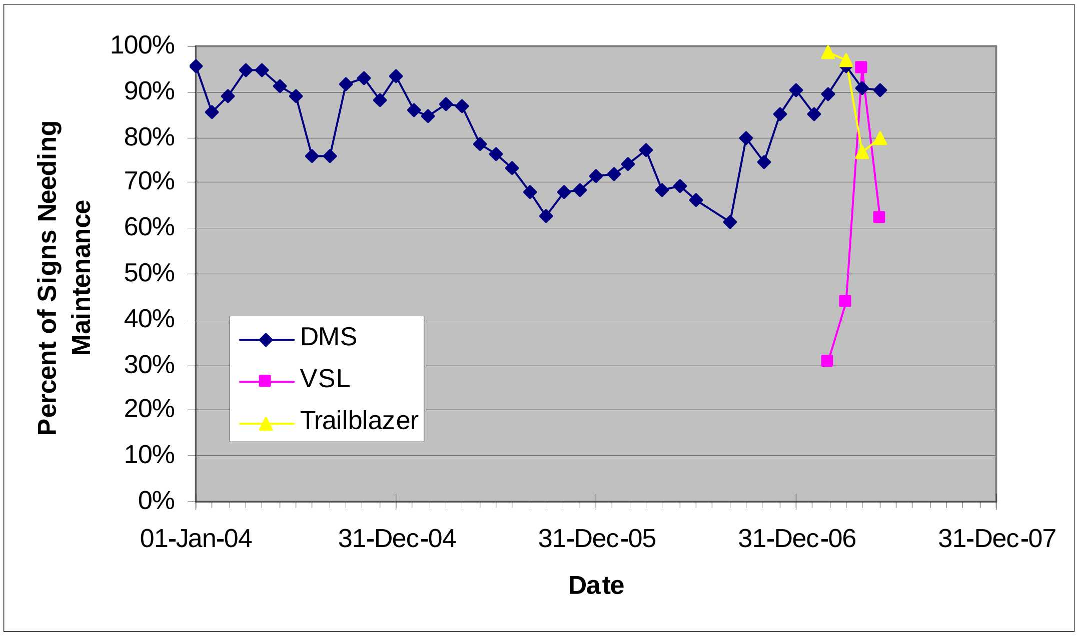

Figure 61. Percent of FDOT Signs Requiring Maintenance

Too little data is available to make statements regarding the reliability of the VSL and trailblazer signs.

6.4. Summary and Conclusions

At the start of the *i*Florida Model Deployment, FDOT managed about 45 DMSs deployed along I-4 and used for several different purposes. Most signs were used to display delay and incident information, with a small number of sign used to display information about local attractions. During the *i*Florida deployment and operational period, the number of these signs increased to 60. In addition, 20 VSL signs were deployed as part of *i*Florida and a number of trailblazer signs were deployed at arterial intersections near the I-4 and I-95 interchange. These signs operated reliably, with about 90 percent of the signs operational, on average. This percentage was significantly lower during the midst of the *i*Florida deployment when the CRS software was experiencing difficulties interfacing with the signs and FDOT resources were focused on correcting other problems with the *i*Florida deployment.

A number of lessons learned were identified by observing sign operations during the evaluation. These lessons are contained in the following list:

- *Travel time estimates should be validated before being used for traveler information.* The CRS software miscalculated travel times that were used for DMS messages, resulting in inaccurate travel times being displayed to the public. One *i*Florida stakeholder suggested that the process used to produce travel times for DMS messages should be thoroughly validated before being used in the field.
- *Software for automating DMS messages should focus on the types of messages that are used often and change frequently.* The CRS software included tools to generate travel time DMS messages automatically. FDOT operational policies for these signs meant that congestion messages were used most often during high traffic periods—exactly the time when sign messages changed frequently (because of changes in travel times). This required RTMC operators to manage congestion sign

messages manually during rush hour periods while travel time messages, used when congestion was not present, were generated automatically. The workload on RTMC operators might have been reduced if congestion messages were automated rather than travel time messages.

- *Tools for automatically generating travel times should include methods for managing sign messages when automated travel times are unavailable*. FDOT experienced significant reliability problems with their travel time network, so that travel time estimates were often unavailable. Although the CRS software was intended to include tools to estimate travel times based on historical values, these tools were not used. When the CRS failed, FDOT discovered that (a) static historical travel times worked well for most of the day and (b) RTMC operators could update signs manually to reflect current travel conditions when congestion occurred, although they made these updates by circumventing the CRS software.

7. Implementing Variable Speed Limits

The initial plans for iFlorida called for the implementation of Variable Speed Limits (VSLs) on a 9-mile stretch of I-4 in central Orlando running from just west of Orange Blossom Trail to Maitland Boulevard. These plans called for the CRS to process weather and traffic data in order to recommend appropriate speed limits to RTMC operators, who would then select the speed limits to apply. These plans were not implemented due to inability of the CRS software to update sign messages reliably. FDOT did deploy VSL signs, however, and prepared plans for implementing VSL once the transition to the new TMC software was completed. This section of the report describes FDOT's experiences in preparing to implement VSL and its plans for doing so in the future.

7.1. Florida Speed Limit Statutory Requirements

At the time of the iFlorida Model Deployment, Florida statutes placed the following requirements[1] on speed limits on Florida Interstate highways:

Identify statutory and regulatory speed limit requirements before considering the use of variable speed limits.

- FDOT could increase or decrease speed limits if an engineering and traffic investigation indicated that the existing speed limit was "greater or less than is reasonable or safe under the conditions found to exist." In that case, FDOT could declare a new speed limit that became effective as soon as appropriate signs were "erected" notifying drivers of the new speed limit.
- For limited access highways, the maximum allowable speed limit was 70 miles per hour.
- For non-limited access divided highways with at least four lanes outside of urban areas, the maximum allowable speed limit was 65 miles per hour.
- For other roads under FDOT's authority, the maximum allowable speed limit was 60 miles per hour.
- For "all highways that comprise a part of the National System of Interstate and Defense Highways and have not fewer than four lanes," the minimum speed limit is 40 mph, or 50 mph if the posted speed limit is 70 mph.

The key requirement among these statutes relative to variable speed limits was that an engineering and traffic investigation was required before speed limits could be changed. To satisfy this requirement, FDOT conducted an engineering and traffic investigation that identified reasonable and safe speeds under different weather and traffic conditions. This investigation provided RTMC operators with the authority to change speed limits after verifying that the appropriate conditions existed without requiring a new engineering and traffic investigation for each event. Through the engineering investigation, FDOT noted that speeds on the portion of I-4 covered by the VSL signs regularly fell below the 40 mph minimum speed limit (see Figure 63 in section 7.4) and determined the speed limits as low as 30 mph should be applied under some conditions.

[1] Requirements listed are detailed in Title XXIII, Chapter 316, Section 316.187 of the 2007 Florida Statutes

7.2. The iFlorida VSL System

The *i*Florida VSL signs were deployed along a 9 mile portion of I-4 in Orlando, as shown in Figure 62. In this figure, the boxes on the left indicate the locations of loop detectors used to monitor traffic on this portion of I-4. These detectors report speed, volume, and occupancy for each travel lane at 30-second intervals. The boxes on the right indicate the location of the VSL signs, with the values in those boxes being the normal speed limit displayed by that sign.

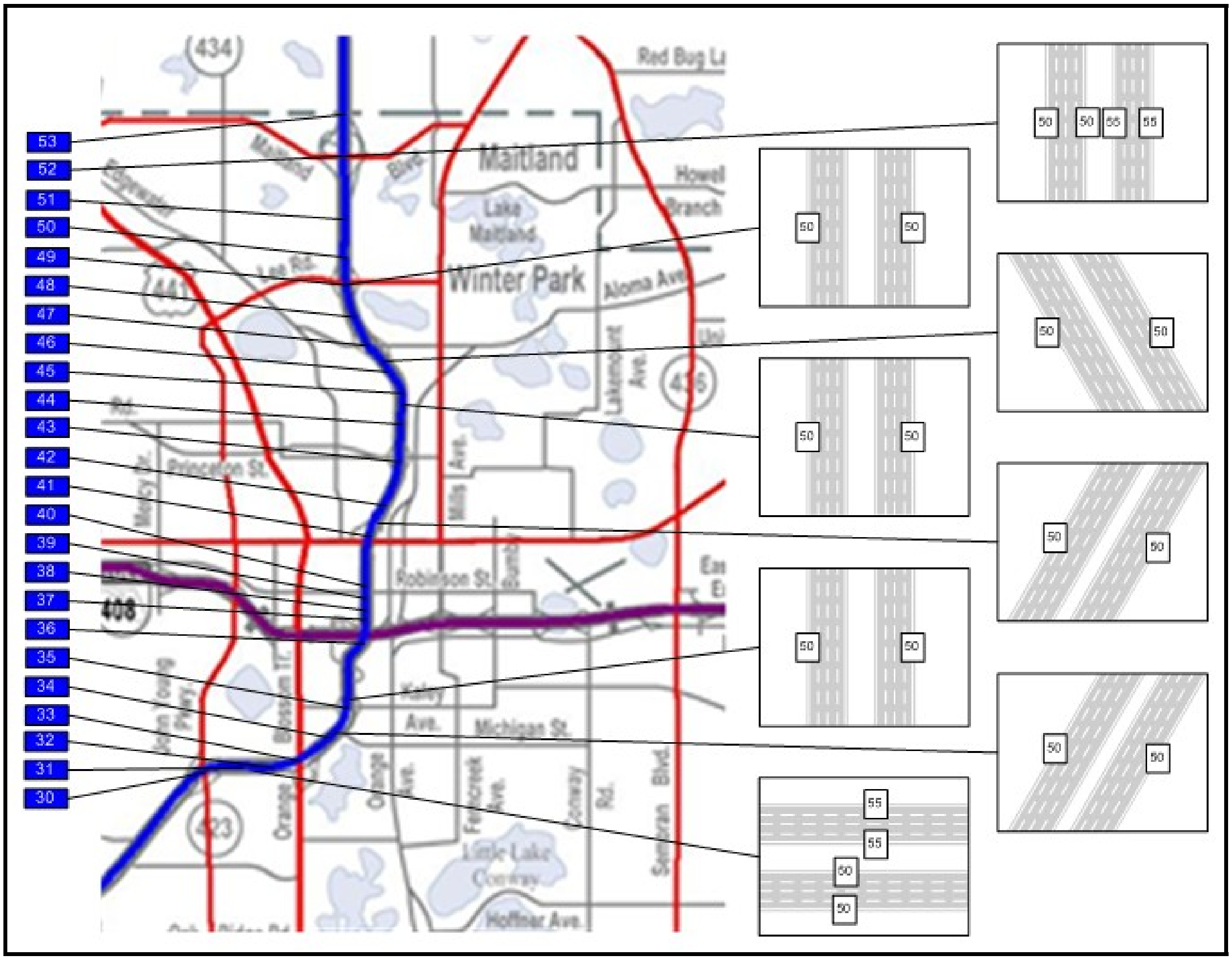

Figure 62. *i*Florida VSL Signs

Two signs were deployed in each direction of travel at the beginning and end of the portion of I-4 covered by VSLs, with one sign in each direction in the interior portion of the trial segment. The normal speed limit in this region is 50 mph, with 55 mph speed limits beginning for eastbound traffic as it exits the area at Maitland Boulevard and for westbound traffic as it exits the area west of Orange Blossom Trail. FDOT noted that the exact location of the VSL signs should be identified after considering the patterns of recurring congestion in the area. FDOT suggested deploying signs before an interchange where congestion often begins so that speed limits can be lowered prior to vehicles entering the congested area. They also suggested deploying signs after an interchanges that serve as congestion relief points so that the speed limit can be increased immediately downstream of where the congestion typically ends.

7.3. *i*Florida VSL Plans

During discussions with the evaluation team, FDOT noted that several reasons and circumstances exist for using variable speed limits:

- VSL might be used when prevailing conditions make the usual speed limit unsafe.
  - VSL might be used when weather conditions, such as "Florida ice"[2] or fog, make driving conditions hazardous. Normal speed limits are set to be safe under usual driving conditions, although safe speeds may be lower than the normal speed limit during adverse weather conditions. Using VSL to reduce speed limits during adverse weather conditions could reduce the number of crashes that occur at those times.
  - VSL might be used when high levels of congestion result in prevailing speeds that are lower than the normal speed limit. Prevailing speeds in a congested area are lower than the normal speed limit and drivers cannot safely drive the speed limit. Using VSL to reduce speed limits in congested areas would result in speed limits that were more consistent with current travel speeds and could result in less variability in vehicle speeds in congested areas.
  - VSL might be used upstream from congested areas. Vehicles upstream from a congested area must reduce speed when they reach the congested area. Reducing speed limits upstream of the congested area will both warn drivers that traffic ahead is moving more slowly and help them make the transition to the lower speeds ahead. Using VSL to reduce speed limits upstream of congestion could reduce the number of crashes that occur as vehicles enter congestion-related queues.
  - VSL might be used in work zones. Construction activities can make driving hazardous, and high speed traffic in a work zone can be a risk to workers. Reducing speed limits in work zones could reduce vehicle speeds in work zones, which could result in fewer work zone-related crashes and injuries.
- VSL might be used upstream of a congested area to reduce the number of vehicles entering the area, which could help clear congestion more quickly. FDOT determined that the 9-mile length of the planned VSL area was too short to provide any effective reduction in the number of vehicles entering the congested area. Also, Florida statute allowed changing speed limits due to safety concerns, not for traffic management.
- VSL might be used in a commonly congested area to encourage travelers to find alternate routes or alternate travel times. FDOT determined that the lower speeds already present in the VSL area during congested periods provided encouragement for travelers to find alternate routes. As noted above, Florida statute allowed changing speed limits due to safety concerns, not for traffic management.

In 2005, FDOT prepared a concept of operations document for using variable speed limits on I-4. This document noted that "The purpose of the VSL sign system is to facilitate the maintenance of safe driving conditions along the I-4 corridor (in both directions of travel) through the Orlando metropolitan area." This would be accomplished by reducing speed limits by 10 mph when any of the following five types of conditions occurred:

- *Traffic incidents and work zone conditions*. Traffic incidents and work zones often result in traffic queues, and crashes could occur as drivers approach the back of the queue. FDOT planned to reduce speed limits for the portion of I-4 upstream from an incident or work zone. FDOT

[2] "Florida ice" occurs in the first minutes of rain when rain mixes with oil and other residues on the road to produce slick conditions.

defined three levels of response, depending on the severity of the road blockage resulting from the incident or work zone:

- The lowest level of response would modify speed limits on the two closest VSL signs upstream from the incident and post a speed reduction message on the first upstream DMS. (If the incident was within ¼ mile of the first upstream VSL sign, modified speed limits would be posted on three upstream signs.) This response would apply to incidents that affected only one lane of travel.
- The next level of response would modify speed limits on the three closest VSL signs upstream from the incident and post a speed reduction message on the first two upstream DMSs. (If the incident was within ¼ mile of the first upstream VSL sign, modified speed limits would be posted on four upstream signs.) This response would apply to incidents that affected two lanes of travel.
- The highest level of response would modify speed limits on the four closest VSL signs upstream from the incident and post a speed reduction message on the first four upstream dynamic message signs. (If the incident was within ¼ mile of the first upstream VSL sign, modified speed limits would be posted on five upstream signs.) This response would apply to incidents that affected three lanes of travel.

Operators would begin to return speed limits to their normal values once the prevailing vehicle speed for a segment of road had returned to within 5 mph of the normal speed limit for at least 15 minutes.[3]

- *Non-incident recurring congestion*. Congestion can result in reduced traffic speeds and queuing that could be a risk for vehicles approaching the congestion. During non-recurring congestion, FDOT planned on reducing speed limits upstream from the location of the congestion based on the average speed in the congested area.
  - If the average speed in the congested area was less than, but within 10 mph of, the normal speed limit, the speed limit would be reduced within the congested area and at the two VSL signs upstream of the congestion.
  - If the average speed in the congested area was between 10 and 20 mph below the normal speed limit, the speed limit would be reduced within the congested area and at the three VSL signs upstream of the congestion. The nearest DMS upstream would post information about the congestion.
  - If the average speed in the congested area was more than 20 mph below the normal speed limit, the speed limit would be reduced within the congested area and at the four VSL signs upstream of the congestion. The nearest two DMSs upstream would post information about the congestion.

  Once speeds returned to within 5 mph below the speed limit for at least 15 minutes, the posted speed limits on the VSL signs would be returned to the normal speed limit.
- *Work zone-related recurring congestion*. The same process would be used as described above for traffic incidents and work zone conditions.
- *Extreme weather conditions*. Extreme weather conditions can mean that the usual speed limit is unsafe. It can also result in slower traffic, which can be a hazard for vehicles approaching the

[3] The evaluation team recognizes that there is a potential contradiction in these plans. If speed limits are reduced by 10 mph, they can only return to within 5 mph of the normal speed limit if vehicles are exceeding the speed limit set by the VSL signs.

portion of road affected by the extreme weather. During extreme weather conditions, FDOT planned on reducing speed limits within and upstream from the location of the extreme weather.

- If there was moderate rainfall, windy conditions (25 to 35 mph), or visibility of about ½ mile, speed limits would be reduced within the affected area and at two signs upstream from that area. A notice of the reduced speed limits would be posted on one sign upstream from where the reduced speed limit takes affect.
- If there was heavy rainfall, windy conditions (35 to 50 mph), or visibility of between ¼ and ½ mile, speed limits would be reduced within the affected area and at three signs upstream from that area. A notice of the reduced speed limits would be posted on at least one sign upstream from where the reduced speed limit takes affect.
- If there are squall-like conditions, very windy conditions (more than 50 mph), or visibility of less than ¼ mile, speed limits would be reduced within the affected area and at five signs upstream from that area. A notice of the reduced speed limits would be posted on at least two signs upstream from where the reduced speed limit takes affect.

Once the weather condition had cleared and traffic speed returned to within 5 mph below the normal speed limit for at least 15 minutes, the normal speed limits would again be posted on the VSL signs.

- *Other nonrecurring traffic events*. The same process would be used as described above for non-incident recurring congestion.

FDOT's plans called for the CRS, the traffic management software used at the RTMC, to ingest speed, weather, and incident data, analyze that data, and make recommendations regarding variable speed limits to RTMC operators. When the CRS made a recommendation to lower speed limits, the RTMC operator was to verify that the appropriate conditions existed for changing speed limits. After verifying the conditions, the operator was required to request supervisor approval to lower speed limits and, if approval was granted, the operator would post the lower speed limit.

During the period that speed limits were lowered, RTMC operators were required to periodically check that the VSL signs were displaying the correct speed limit and review traffic and weather conditions to determine whether the speed limits should be returned to normal. Supervisor approval was required before returning the speed limits to their normal values.

7.4. Assessing the Potential for VSL

Variable speed limits were considered appropriate for this section of I-4 because congestion often developed in this area and vehicle speeds were often below the posted speed limits. The typical congestion levels in this area are depicted in the figures below. Figure 63 depicts the average vehicle speeds measured at the detector stations in this area for the weekdays in October 2006, with averages calculated every 15 minutes. This figure indicates that vehicle speeds regularly dropped below the normal speed limit during both the morning and afternoon rush hour, particularly for eastbound traffic.

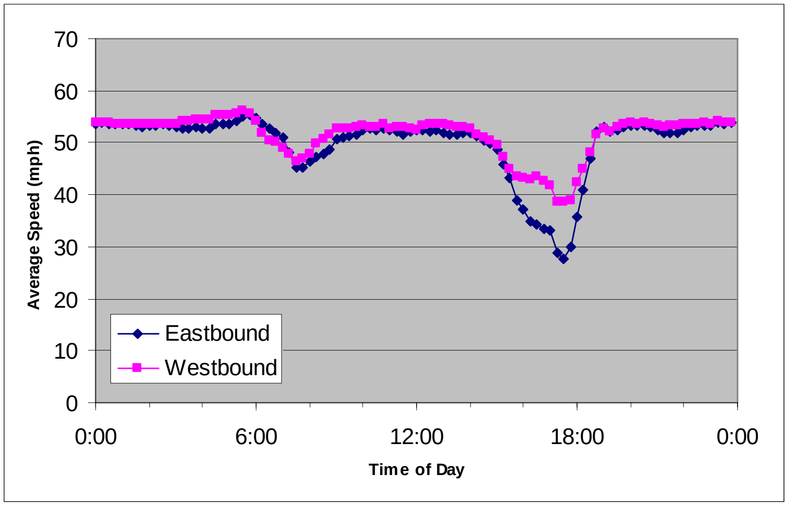

Figure 63. Average Speeds by Time of Day in the VSL Area, Weekdays in October 2006

Figure 64 depicts similar vehicle speed data for weekend days. Note that there was little indication of congestion on weekends.

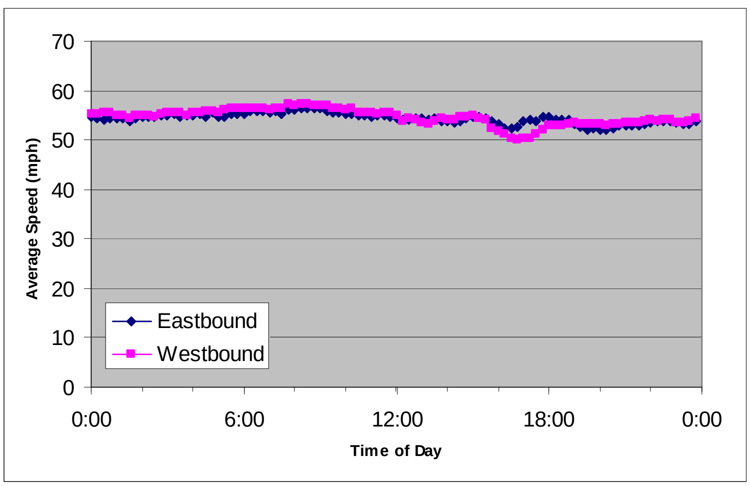

Figure 64. Average Speeds by Time of Day in the VSL Area, Weekends in October 2006

The following congestion charts provide a more detailed view of I-4 congestion. Each chart depicts the degree of congestion at different times of day for a single direction of travel. The x-axis of each chart shows the time of day and the y-axis shows the detector station number. Because the detectors are arranged in milepoint order and are spaced at roughly half-mile intervals, the y-axis can be thought of as representing I-4 with the lowest numbered station representing a point west of Orlando near US 192 and the highest numbered station representing a point east of Orlando near SR 472. The VSL signs were deployed in the area between stations 31 and 52. For each station and each 5-minute period, a dot is placed if the average speed at the indicated station and time period was less than or equal to 40 mph. The shading of the dot is determined by the average speed with darker dots representing lower average speeds. A black dot indicates the average speed was below 20 mph, and a white dot with black outline indicates the average speed was between 35 and 40 mph, and shades of gray were used when the average speed was between these two ranges. No dot indicates either that the average speed was above 40 mph or that a detector was either not reporting data or was reporting data that was deemed unreliable (e.g., detectors 37 and 38 in Figure 65). Thus, an area where congestion occurred is represented in the chart by a cluster of dots, with darker dots indicating an area with more extensive congestion. Figure 65 below is a congestion chart for I-4 eastbound on Wednesday, October 4, 2006, and Figure 66 is a congestion chart for westbound traffic on the same day.

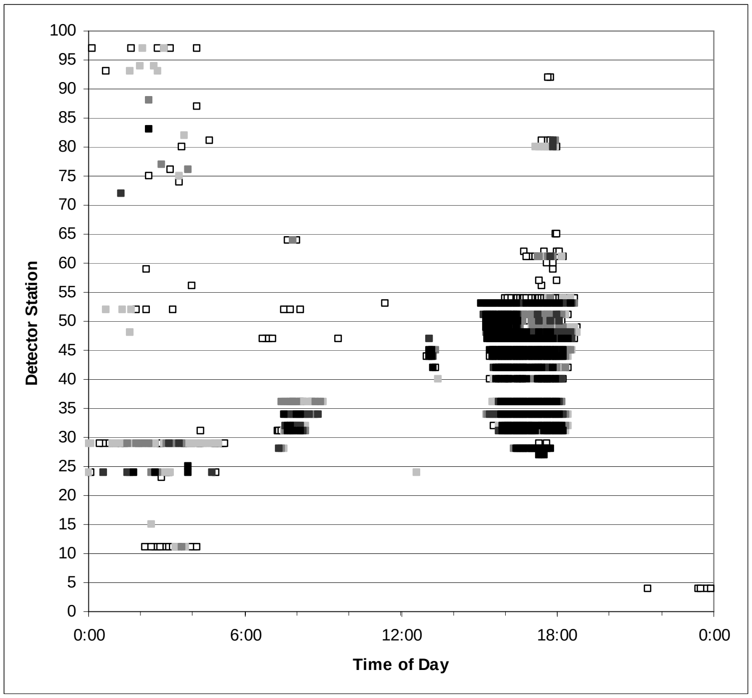

Figure 65. Congestion Chart for I-4 Eastbound on Wednesday, October 4, 2006

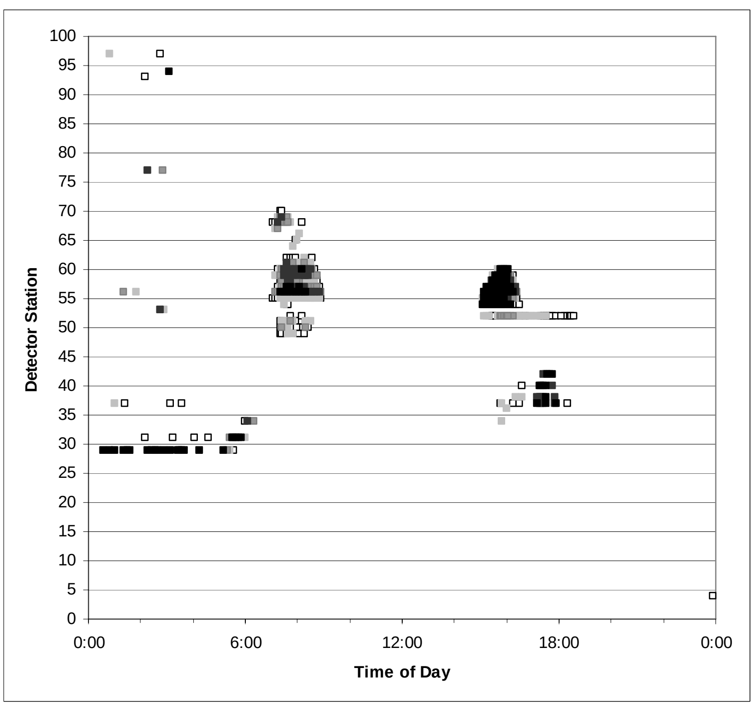

Figure 66. Congestion Chart for I-4 Westbound on Wednesday, October 4, 2006

These charts, while representing traffic for only a single day, are consistent with the average weekday traffic depicted in the earlier charts. Some localized congestion occurs in the eastbound direction in the morning, with more significant congestion occurring across the VSL area in the afternoon. Some mild congestion in the westbound congestion occurs in the morning, though this congestion occurs east of the VSL area. Consideration of these congestion charts led to several other observations related to the application of VSL in Orlando.

Note that these charts indicate the dynamics of recurring congestion on I-4. In the eastbound direction, congestion first appears in the afternoon for eastbound traffic around detector 34 (near Kaley Ave) and around detector 50 (east of Lee Road). (The left-most congestion indicators in the afternoon block of congestion are at these detectors.) From these two points, the congestion begins to migrate westward. FDOT felt that advanced speed limit signing would be most important during the transition from free flow to congestion. VSL signs were located upstream from these two locations to accommodate that. As the congestion grows, it may extend west beyond the point where VSL signs were deployed, in which case speed limits could not be lowered in advance of the congested area. These signs could be used to lower speed limits in the congested area so that the posted speed limits reflect current speeds.

The concept of operations for VSL should be validated against historical data. The algorithms for recommending speed limit changes should be able to detect and correct for low vehicle speed observations that are not related to congestion.

The westbound congestion actually occurred east of the location of the VSL signs, so the area in which congestion was most likely to occur in the westbound direction was not covered by the VSL signs. The reason for this was not clear. The evaluation team did note that the VSL concept of operations was developed after the VSL sign locations were already determined and did not include an analysis of traffic patterns that result in the use of the VSL system.

Another observation is related to the occurrence of low travel speeds in the 5-minute averages depicted in these charts that do not appear to be related to congestion. Examples are detector 29 (low speeds prior to 6:00 a.m. in both directions of travel), detector 30 (observations omitted from charts because low speeds were recorded all day in both directions of travel), and detector 37 (low speeds sporadically throughout the day in the westbound direction). These low values could be due to faulty detectors or vehicles occasionally driving at low speeds. In either case, the system must include methods to prevent such anomalous readings from resulting in recommendations to lower speed limits. It might be appropriate to test the algorithms against historical data to fine-tune them before using them in a production system.

A key element of FDOT's approach to ensuring that speed limits would not be lowered inappropriately was to require operator approval of all speed limit changes before they were implemented. This approval process would allow RTMC operators to disregard suggested changes to speed limits that were not supported by their observations of traffic conditions. Thus, failures of the algorithms used to recommend speed limit changes would result in false recommendations that operators would disregard.

Operator approval should be required for all speed limit changes.

7.5. *i*Florida VSL Activities

Because of problems with the CRS, *i*Florida did not implement its VSL plans during the period of the national evaluation of *i*Florida activities. The main problem that prevented implementation was that the CRS could not reliably update sign messages. The CRS also demonstrated problems with analyzing traffic and weather data that may have impacted its VSL recommendations. (See Section 2 for more information.) With FDOT focused on getting the CRS to reliably support basic traffic management capabilities, it chose to delay lower priority activities, such as VSL. This resulted in wasted resources—the costs of deploying the signs could have been delayed and the cost of maintaining them while displaying static speed limits could have been avoided. It also resulted in some negative press when a local newspaper noted that the signs were not being used and included an article in the newspaper titled *Stuck on I-4? High-tech signs aren't doing their job*.[4]

> ***A VSL system should not be deployed until the other systems required to support it are operating reliably.***

In the case of the *i*Florida Model Deployment, FDOT scheduled the deployment of the VSL signs so they would be ready for use at the start of the planned *i*Florida operational period—the schedule for the *i*Florida Model Deployment provided 2 years for deployment and 2 years for operations. In order to meet this constraint, FDOT accepted the risk that problems with other parts of the deployment would prevent the use of the VSL signs. Other sites considering VSL, without similar constraints, should consider ensuring that all the support systems needed to support VSL operations (e.g., traffic measurement, sign management software, software tools to make speed limit recommendations) are working reliably before deploying VSL signs.

After the CRS failed in May 2007, FDOT began the process of replacing it with SunGuide software. By November 2007, SunGuide was able to access and analyze traffic data, including loop data on the section of I-4 covered by the VSL trial, and reliably update DMS messages. SunGuide also included tools for analyzing traffic conditions and, based on that analysis, recommending sign messages. As FDOT grew more confident in the reliability of SunGuide, it re-started the delayed VSL project.

In December 2007, FDOT began testing the ability of SunGuide to update VSL speed limit messages. FDOT also began testing whether the SunGuide tools could implement the logic required to automatically recommend speed limits to operators based on the criteria established in the engineering and traffic investigation conducted to support the VSL on I-4. Because the version of SunGuide in use at that time did not include weather data, it would not be able to implement the weather-related speed limit recommendations. Initial tests did indicate that it would be able to make appropriate speed limit recommendations to RTMC operators based on current traffic speeds and incidents.

In early 2008, FDOT began testing specific VSL algorithms. The first step was to examine the variability in observed occupancy and speed data to determine which would produce more reliable speed limit recommendations. FDOT also considered the period over which observations should be averaged. . (A very short averaging period could result in frequent changes to speed limit recommendations, particularly during the periods when congestion is building or dissipating. A very long averaging period could make the system slow to respond to changes in the level of congestion present.) Once this general review was performed, an algorithm as selected for making VSL recommendations and the VSL recommendations were compared against detector data and visual observations of traffic to determine the responsiveness and reasonableness of the recommendations.

[4] *Orlando Sentinel*, January 12, 2007.

During this evaluation period, the VSL signs were covered so a full execution of the VSL system could be accomplished without displaying messages to the I-4 motorists.

7.6. Future Plans for Using VSL

At the time of this report, FDOT had completed initial testing with good results and was working on issues that needed to be resolved before full implementation. The following list describes the basic approach FDOT is taking:

- The area covered by the VSL signs will be divided into four sub-areas: eastbound south, eastbound north, westbound north, and westbound south.
- The SunGuide software will monitor the occupancy level and classify traffic conditions within each area as either free flow, light congestion, or heavy congestion.
- The SunGuide software will make speed limit recommendations for signs within each area based on these traffic condition classifications. Current plans call for recommending speed limits of 30 mph for heavy congestion, 40 mph for light congestion, and the normal speed limit (i.e., 50 or 55 mph) for free flow.
- The SunGuide software will also recommend lower speed limits when necessary to ensure that the posted speed limit does not change by more than 10 mph between two adjacent sets of VSL signs. (For example, the nearest signs upstream of an area with a posted speed limit of 30 mph due to heavy congestion would have a 40 mph posted speed limit, even if conditions there were free flow.)

FDOT will be able to adjust the operation of the system by adjusting a number of parameters in SunGuide. One set of parameters identifies the detector stations assigned to each sub-area, allowing FDOT to remove problematic detectors from the VSL calculations. Other parameters specify the threshold values used to assign traffic condition categories to each sub-area based on the observed occupancies and the number of seconds of detector data to use when making these assignments. A last set of parameters specifies the value of the posted speed limit that corresponds to each traffic condition category.

FDOT also identified a list of items needing resolution or completion before full implementation:

- If communication with the sign fails, then the sign should default to the posted speed limit. Some of the signs currently have this capability, but others need to be updated to provide this function. This function is necessary to prevent a reduced speed limit to continue to be posted after the congestion condition has passed if communication was lost during the period that the reduced speed limit was being implemented.
- Operator procedures need to be developed and training provided to operators to allow the operators to train on the full process of managing the VSL subsystem before the signs are uncovered. These procedures include a daily check of data quality from the detectors assigned to the VSL subsystem and the process for removing failed detectors from the VSL recommendation process.
- Brief the Florida Highway Patrol on the proposed operations of the signs and advise them that the signs will be posting a speed limit that best matches the flow of congested traffic. The intended purpose of the signs is to improve safety along I-4 through more steady flow during congested periods and to provide advance warning to drivers of slowing traffic ahead.

- Implement a public information plan just prior to full implementation of sign operation that explains that the VSL signs have the ability to both improve safety and reduce congestion.
- Add features to draw attention to VSL signs when speed limits are reduced. When FDOT first announced plans for VSL in Orlando, the initial response of the public was that the system was intended to be a speed trap, catching drivers speeding who were unaware of the lowered speed limit. FDOT combated this perception through a public relations campaign and also added flashing lights above the VSL signs that flash to indicate when speed limits are lowered.

In September 2008, FDOT completed these steps and began operating their VSL system. FDOT has begun gathering data on driver response to the variable speed limits and their impacts on safety and mobility and will prepare a report to FHWA on these impacts.

7.7. Summary and Conclusions

As part of the *i*Florida Model Deployment, FDOT deployed the field hardware needed to support variable speed limits on a portion of I-4 and maintained a network of loop detectors on I-4 that could support determination of when reduced speed limits should be implemented. The agency developed a concept of operations for using VSL and included requirements for CRS, the District 5 (D5) RTMC software, to support VSL operations. When this software failed to operate as expected, FDOT delayed its VSL plans while it worked with the CRS contractor to repair that software. In May 2007, after 2 years of additional work, the CRS software still did not operate reliably and FDOT abandoned it. Thus, the *i*Florida operational period ended without FDOT gaining direct experience operating a VSL system.

Even though FDOT's experiences did not result in an operational VSL system prior to the completion of this evaluation, they did bring to light a number of lessons learned that might benefit others considering VSL:

- *Identify statutory and regulatory speed limit requirements before considering the use of variable speed limits.* Statutory restrictions limit the applicability of VSL on I-4. The minimum speed limit of 40 mph, combined with the normal speed limits of 50 and 55 mph on I-4 in Orlando, meant that speed limits could be varied only over a small range. The requirement for an engineering and traffic investigation before speed limits could be changed was also problematic. FDOT determined that it could perform this type of investigation once to identify the types of traffic conditions that would warrant lower speed limits, and RTMC staff could then change speed limits after verifying that the specified conditions for lowering speed limits had been met.
- *Develop the concept of operations for VSL before designing the VSL system and validate it against historical data.* Because of the long lead time for deploying the iFlorida field equipment, FDOT contracted to deploy the VSL signs before completing the VSL concept of operations, specifying that the signs be deployed in the area where congestion most often occurred. The VSL concept of operations emphasized the benefits of lowering speed limits upstream from a congested area. A comparison of the VSL sign locations to historical patterns of recurring congestion indicated that the signs were located to cover the area upstream of the points where eastbound congestion typically began, though not the area upstream of the full extent of the congestion at its peak. The VSL signs appeared to be west of the area congestion typically occurred in the westbound direction. FDOT noted that the agency had discussed each of these issues prior to selecting the site for deploying the VSL signs; however, because these issues were not addressed in the concept of operations document, the basis for the VSL design was not documented.

- *Ensure that the algorithms for recommending speed limit changes can detect and correct for low vehicle speed observations that are not related to congestion.* A review of historical speed data identified a number of cases where low speed measurements did not appear to be related to congested conditions. In some cases, this appeared to be caused by a faulty detector (e.g., the detector consistently reported low speeds). In others, a single low value would be embedded in a series of otherwise normal values. In either case, the algorithms for recommending lower speed limits should include methods to detect and disregard low vehicle speed measurements that are not related to congestion. (In the case of *i*Florida, the problems with the CRS made this very difficult or impossible to do.) Problematic detectors might also be taken offline until repaired, in which case the algorithms must be able to adapt to the fact that detectors may be taken offline. The robustness of those algorithms could be verified by applying them to historical data.
- *Require operator approval of all speed limit changes*. FDOT's design of the VSL system called for an automated system to monitor traffic and weather conditions and recommend lower speed limits when conditions appeared to warrant them. RTMC operators would be required to investigate traffic conditions and approve the recommendation only when warranted by current traffic conditions. Since any algorithm for recommending speed limits is likely to fail on occasion, this approach will prevent those failures from resulting in changing speed limits at inappropriate times.
- *Deploy a VSL system only after the systems required to support it are mature and reliable*. Because of its participation in the Model Deployment and the required milestones, FDOT had to deploy infrastructure and develop the operating system concurrently. This resulted in the deployment of VSL signs before the CRS software for supporting those signs had proven reliable. These signs remained set at the fixed speed limits when the initial version of the CRS software did not operate reliably and 2 years of additional work by the CRS contractor did not remedy the problems. Thus, FDOT had to bear the cost of deploying VSL signs without obtaining the benefit of using variable speed limits.

After the CRS software was abandoned, FDOT began working with a new contractor to migrate to a different traffic management application, SunGuide, for the RTMC. By August 2007, FDOT was using SunGuide at the RTMC. By November 2007, SunGuide supported most of FDOT's basic traffic management needs and FDOT's confidence in the system was growing. At about that time, FDOT elected to restart its delayed VSL project. In December 2007, FDOT reviewed the VSL concept of operations and began to develop a new approach for triggering speed limit changes. The agency also began testing the SunGuide capabilities to support VSL operations. As the national evaluation was ending, it appeared that FDOT's experience with VSL on I-4 was ready to begin.

8. Statewide Operations

Before *i*Florida, statewide traffic management activities were mostly limited to support for hurricane evacuations. During a hurricane, the Florida Department of Transportation (FDOT) Transportation Statistics Office would activate real-time data collection for its Telemetered Traffic Monitoring Site (TTMS) network, which would provide volume and speed information from a subset of 54 stations scattered across the state. Most other traffic management activities were handled regionally by the seven FDOT districts and by FDOT staff stationed at the State Emergency Operations Center (SEOC).

The main objective of *i*Florida statewide operations was to establish statewide traffic management by deploying new traffic monitoring devices and consolidating those devices with existing sources of statewide traffic data, then disseminating this data to the public as traveler information and to decision makers in need of statewide traffic information—primarily those involved in hurricane evacuation decision making.

8.1. *i*Florida Statewide Activities

The *i*Florida statewide activities established methods for monitoring traffic conditions statewide, a 511 system, and a Web site for disseminating this traffic information. Specifically, the *i*Florida statewide operations included the following activities:

Statewide Monitoring. Twenty-five traffic monitoring stations, including radar for traffic detection and video, were deployed at existing microwave communication towers. These stations used available bandwidth in the microwave network to transmit these data back to the District 5 Regional Traffic Management Center (D5 RTMC). The locations of these stations are depicted in Figure 67 below.

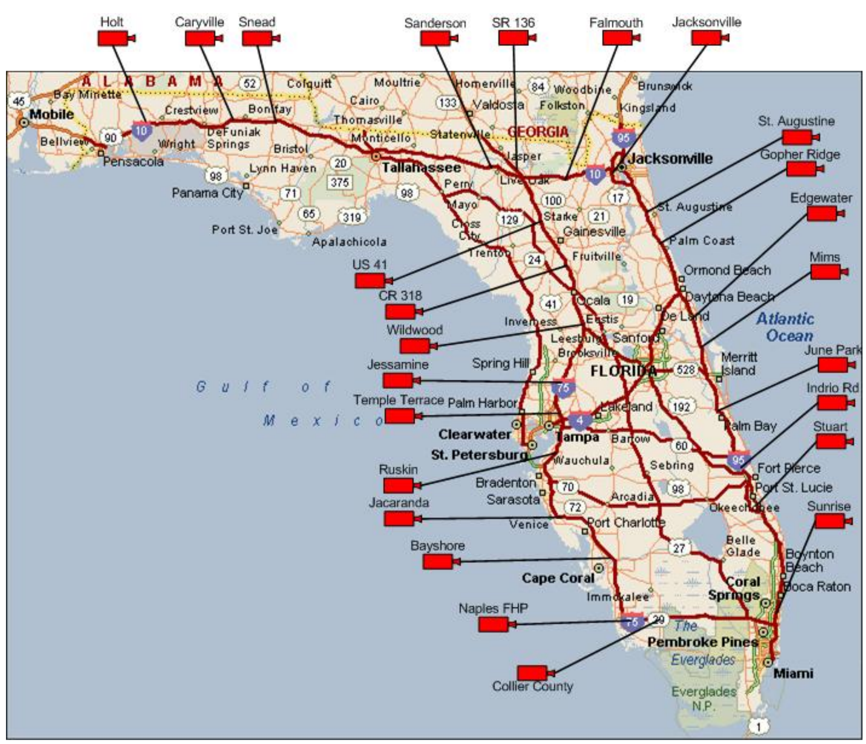

Figure 67. Locations of *i*Florida Statewide Traffic Monitoring Stations

Florida Highway Patrol (FHP) Incident Data. An interface was established between the FHP Computer-Aided Dispatch (CAD) system and FDOT to transmit FHP CAD data to the D5 RTMC. These data included information about incidents that occurred across the State.

Weather data. FDOT contracted out for weather data and forecasts for each Florida Interstate road segment. The supplier used software to fuse weather data from multiple sources and generate weather forecasts for each road segment at various time intervals, and then providing these data and forecasts to the D5 RTMC. The weather data provider also provided severe weather alerts that covered entire counties and individual roads. FDOT received additional data from a network of Road Weather Information System (RWIS) stations that were deployed at locations across the State.

Statewide Traveler Information. As part of the *i*Florida deployment, FDOT established a statewide 511 system. The traveler information provided by the system was managed by the D5 RTMC, based on the statewide data sources listed above. A Web site also provided travelers with access to statewide traveler information.

***i*Florida Condition Reporting System.** The *i*Florida Condition Reporting System (CRS) is a software system that was intended to consolidate the traffic, incident, and weather information and help the D5 RTMC staff manage the traveler information resources and other tools used to manage traffic. Different versions of the CRS were applied to the Orlando and statewide road networks. This system did not work as intended and was eventually abandoned and replaced with software developed by a different vendor.

8.2. Using Microwave Communications to Transmit Statewide Monitoring Data

The Statewide Microwave System (SMS) was originally deployed in the 1980s to support emergency call boxes that are available at regular intervals on Florida Interstate Highways. The combination of Road Rangers (motorist assistance patrols), cameras monitoring roads, and the availability of E911 service and cell phones have made the call boxes less important in helping travelers report incidents that do occur. Consequently, FDOT is in the process of removing call boxes from many FIHS roads.

Starting in 2002, the SMS was upgraded from an analog, non-integrated system to a digital backbone to create a seamless and homogenous statewide network. The SMS upgrade was performed in three phases. The first phase involved the construction of towers and shelters at various locations. The second phase involved changes to the microwave radios, re-channelization of the system, reconfiguration of the motorist aid call box system, and installation of a statewide network management system. The third, and final phase, involved a data network overlay to facilitate data and video transport across the state.

The network consists of a set of hub sites with fiber connection and remote sites using microwave to communicate with the hub sites. The remote sites are daisy-chained, so that bandwidth usage at the remote site nearest the hub is the sum of the bandwidth required for that site and for all other remote sites directly or indirectly connected to it. This network is capable of transmitting up to 33 megabits per second (Mbps) between hub sites and up to 3 Mbps from remote sites to hub sites. The SMS can also support the transmission of multiple streams of IP-based traffic information from remote field devices to Regional Traffic Management Centers (RTMC) that are connected to the microwave system data network.

Designing Around Limited Bandwidth. One of the challenges faced in designing the Statewide Monitoring System to use the SMS was the limited bandwidth available and the relatively high bandwidth requirements of traffic video. Table 13 lists the approximate bandwidth required for different types of video using different types of compression.[1]

Table 13. Approximate Bandwidth Requirements for Traffic Video

Resolution	MPEG-2			MPEG-4		
	Low	Medium	High	Low	Medium	High
QCIF	0.34 Mbps	0.24 Mbps	0.14 Mbps	0.17 Mbps	0.12 Mbps	0.07 Mbps
CIF	1.01 Mbps	0.62 Mbps	0.38 Mbps	0.50 Mbps	0.31 Mbps	0.19 Mbps
4CIF	2.88 Mbps	1.92 Mbps	1.10 Mbps	1.44 Mbps	0.96 Mbps	0.55 Mbps
QCIF = Quarter Common Intermediate Format (176 pixels by 144 lines, 30 frames per second; 1.22:1). CIF = Common Intermediate Format (352 pixels by 288 lines, 30 frames per second; 1.22:1). 4CIF = 4 times Common Intermediate Format (704x576 pixels).						

Given that the bandwidth available from remote sites to hub sites was limited to 3 Mbps and part of this bandwidth was reserved for other applications, FDOT determined that it could deploy, at most, three monitoring sites along a single "spoke" of remote microwave towers. The first step taken by FDOT in designing this system was to review the network topology for the microwave network to identify the remote towers that shared a single spoke. This allowed FDOT to select Statewide Monitoring System sites so that no more than three sites lay along the same spoke before reaching a hub site.

A key to making use of a microwave network is accommodating its bandwidth limitations.

FDOT also required that each site include video compression hardware that was remotely configurable. This allowed FDOT to easily vary the video type and compression after the system was deployed in order to find the combination that worked best with the limited bandwidth available through the SMS. At the time of this report, FDOT was using MPEG-4 with CIF resolution and low compression for an expected bandwidth usage of about 500 kilobits per second per camera. The resulting video appears slightly grainy on a full screen and slightly choppy. FDOT felt that the video was definitely of high enough quality to support traffic management decision making, though the quality was noticeably lower than most other video that FDOT D5 has available.

Impact on Site Selection. The original plans for the Statewide Monitoring System called for an upgrade to existing TTMS stations to support real-time communications. The remote location of these sites made it difficult to establish the high-bandwidth communications needed to support transmission of traffic and traffic video data in a cost-effective manner. As a solution to this communication problem, FDOT decided to deploy Statewide Monitoring System stations at existing microwave tower locations. This choice significantly reduced costs by allowing FDOT to take advantage of existing buildings and enclosures, existing utility connections, and existing communications.

The downside of this approach was that it restricted the choice of sites to the locations of microwave towers. Since these sites did not coincide with existing TTMS locations, the data from the Statewide Monitoring System was not integrated with pre-existing statewide traffic data collection activities of the FDOT Transportation Statistics Office. This resulted in two independent systems for monitoring statewide traffic, with separate costs for maintaining each. Since these sites did not necessarily coincide with the best locations for monitoring traffic, the resulting stations were sometimes located at less than ideal positions.

[1] Actual bandwidth requirements will vary, depending on the characteristics of the traffic video and the compression technology used.

As an explicit example, FDOT pointed out that the I-10/I-75 interchange was often a key junction during a hurricane evacuation, and that a camera positioned to view that interchange would be helpful for evacuation decision-making. Because no microwave towers were located at that interchange, a Statewide Monitoring System station was not deployed there. Instead, a station was deployed a few miles west of the interchange, with another deployed a few miles north of it (Figure 67). In effect, FDOT designed its Statewide Monitoring network around the locations of microwave towers. This resulted in significant cost savings that allowed FDOT to deploy more stations for the same cost compared to deploying stations at other locations that could not take advantage of the microwave communications. In retrospect, FDOT suggested that it would have been better to select locations for statewide traffic monitoring stations based primarily on their ability to support traffic management activities, using microwave tower infrastructure to reduce costs, when possible.

SMS Performance. Information on the performance of the microwave system is limited by the fact that FDOT experienced difficulties in maintaining the Statewide Monitoring System field equipment (see Section 8.3). FDOT reported that the microwave network itself was quite reliable, though it did note that communications were sometimes disrupted during severe thunderstorms.

Microwave tower locations should not be the primary factor in selecting locations for traffic monitoring stations.

8.3. Maintaining a Statewide Traffic Monitoring System

One challenge faced by designers of the Statewide Monitoring System was related to the maintenance of field devices distributed across the state—some of the stations were located more than 400 miles from the FDOT D5 offices in Deland. The cost of traveling to each site from Orlando made maintenance visits expensive. FDOT took this into consideration in the system design, deploying network-addressable Uninterruptible Power Supply (UPS) at each station so that equipment could be rebooted remotely. It was hoped that being able to reboot equipment remotely would reduce the need for expensive onsite maintenance.

Travel costs can make the costs of maintaining a statewide traffic monitoring System high.

After it was deployed, the system did not develop a regular set of users. FDOT had anticipated that the data from this system would be useful for traveler information and to support hurricane evacuation decision making. RTMC operators found that the stations were too widely spaced to consistently provide statewide traveler information (see Section 8.6 for more information). While the SEOC was very interested in using video from the Statewide Monitoring System during hurricane evacuations (see Section 8.5), SEOC's actual use of the video was irregular, only occurring during hurricane evacuations. The combination of high maintenance costs and no regular users meant that FDOT D5 placed a lower priority on maintaining this field equipment than the equipment that was less costly to maintain and used more frequently. The result was low availability of the Statewide Monitoring System, as reflected in FDOT's maintenance logs. Figure 68 depicts the average daily number of Statewide Monitoring System cameras and detectors working each week. The average length of time a device was inoperable was almost 50 days, much longer than for devices FDOT D5 maintained within its district.

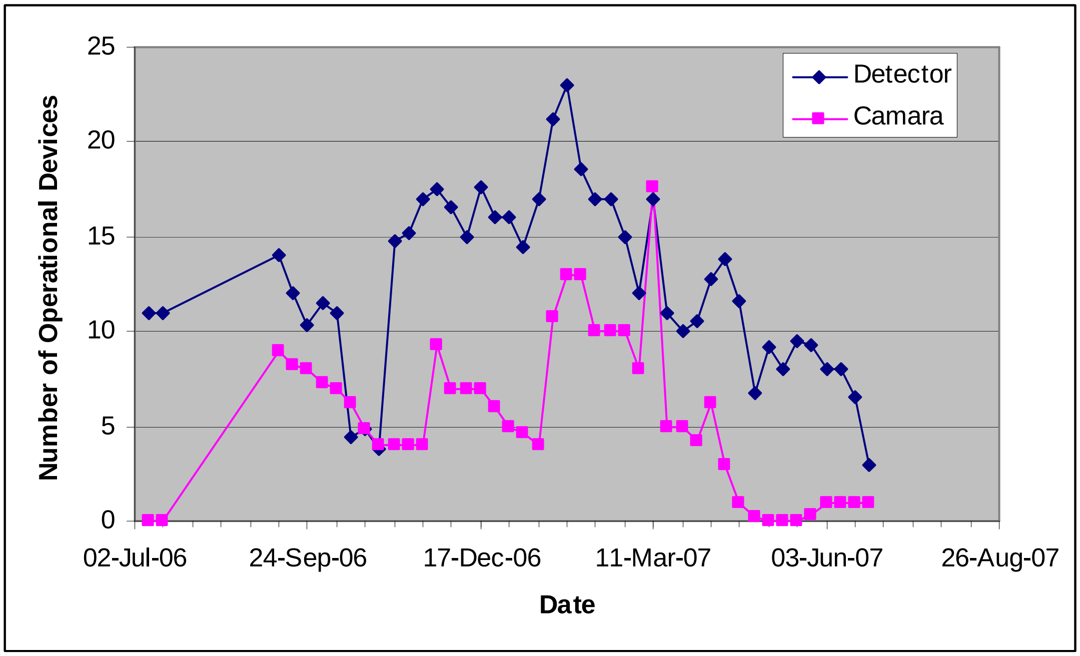

Figure 68. Statewide Monitoring System Operational Devices

FDOT believed that one cause of maintenance problems was the power supplies, noting that the power transformer was deployed in the equipment room and a 25 V line made a long run to the field equipment. FDOT also noted that the software it used to interface with the Statewide Monitoring System field equipment caused some of the problems it observed. At times, FDOT personnel could view video if they accessed the video controller directly, but could not view the video through the software the agency used to manage the video at the RMTC.

FDOT D5 also anticipated that the districts in which the Statewide Monitoring System equipment was located would take over responsibility for maintaining the equipment (each district was already responsible for maintaining the microwave tower equipment in its boundary). This did not occur during the *i*Florida operational period. This may have been caused, in part, by the fact that the other FDOT districts were not involved in the design of the Statewide Monitoring System. FDOT D5 received push-back from some districts when deploying the Statewide Monitoring System equipment because the districts had not been given the opportunity to verify that the new equipment was compatible with existing equipment.

Involving all other DOT districts in the design of a Statewide Monitoring System may make it easier to distribute maintenance responsibility for these stations across the districts.

In August 2007, FDOT D5 took over maintenance responsibility for the Statewide Monitoring System (prior to that, the equipment was under warranty with maintenance performed by the vendor, who was contracted to deploy the equipment). At that time, FDOT D5 requested that the other FDOT districts take over maintenance of the equipment in their district. Districts that had an active ITS program were willing to take over this responsibility. Some districts had little or no ITS equipment deployed and no staff or maintenance contracts for maintaining ITS equipment. These districts were not interested in maintaining this equipment.

8.4. Interfacing Between the FHP CAD System and the D5 RTMC

A second source of statewide traffic-related information developed by *i*Florida was an interface to the FHP CAD system. Prior to *i*Florida, the FHP maintained a Web site that included selected incident information extracted from its CAD systems across the state.[2] Because D5 RTMC activities prior to *i*Florida were focused on I-4 and restricted to the Orlando area, this Web site was rarely used by RTMC operators. If an RTMC operator wanted information about an incident on I-4, the operator could request it from the co-located FHP CAD Troop D dispatchers.

With the advent of *i*Florida and its statewide traveler information systems, the D5 RTMC had a need for statewide incident information and the *i*Florida plans included developing an interface between the FHP CAD systems and CRS. (Section 5 provides a more complete description of this interface and FDOT's use of FHP CAD data.) The CRS presentation of data from this interface did not operate as expected: it did not effectively restrict incidents to those on roads included in the *i*Florida statewide system and it sometimes placed on incident at an incorrect location. When the CRS failed to operate as expected, RTMC operators referred to the FHP Web site for statewide incident information, and used that information to populate the statewide 511 system and the statewide Web site with incident information.

Despite this limitation, FHP CAD incident information was the primary source of data used for statewide traveler information. The primary limitation noted by FDOT with regard to this incident information was that it was not complete—local police rather than FHP responded to incidents at some locations that were included in the *i*Florida statewide traveler information system. This meant that FDOT might not be aware of incidents at some locations, so that the statewide traveler information was sometimes incomplete. FDOT did take steps to remedy this limitation. One creative step was to make 511 user feedback on unreported incidents available to RTMC operators. FDOT also began considering ways to work with other police jurisdictions to obtain incident information.

Interfacing with local police organizations to obtain more complete incident information may be a better source of statewide traveler information than a statewide monitoring system.

More information about the statewide traveler information system and data supporting it are in Section 10.

8.5. Using Statewide Data to Support Hurricane Evacuations

Emergency management in Florida, and evacuation management in particular, is managed primarily at the county (or regional) level, with the SEOC monitoring evacuation traffic and providing support as needed. For example, the emergency manager for each county makes the decision for issuing evacuation orders, the areas covered by the order, and when it takes effect (the Governor can override these decisions, if necessary). Because most evacuation decisions are made by local emergency management personnel, the main use of statewide traffic data at the SEOC is for general situational awareness and for monitoring traffic conditions on evacuation routes.

Prior to *i*Florida, the SEOC relied on three sources of information on statewide traffic conditions: reports from the FHP, reports from the individual counties during periodic statewide conference calls, and information from the TTMS network. The TTMS network, which did not provide real-time data during normal operations, could be activated to provide hourly traffic data from a limited

[2] This system is accessible to the public at http://www.fhp.state.fl.us/traffic/.

number of sites during a hurricane evacuation. This data was made available via a public Web site, and the SEOC regularly consulted this Web site to assess traffic conditions on key evacuation routes.

The original design for the Statewide Monitoring System was to improve a number of TTMS stations by providing connectivity for real-time data and adding traffic video. Because *i*Florida Statewide Monitoring stations were deployed at microwave tower locations, which did not coincide with TTMS station locations, the system was supplemental to the existing TTMS network. This meant that the traffic data from the Statewide Monitoring System was not integrated into the TTMS Web site, so was not used at the SEOC. The traffic video, on the other hand, was enthusiastically received at the SEOC. Paul Clark, the Traffic Incident Management Program Manager then TTMS video first became available at the SEOC, stated, "We believe (the iFlorida cameras) will be invaluable for this coming hurricane season." Network connectivity was provided to the SEOC in January 2006 so that staff could view video from any of the 25 *i*Florida Statewide Monitoring cameras. The SEOC requested an upgrade to the bandwidth of this network connection to provide improved access to this video.

Because no significant hurricane evacuations occurred during the *i*Florida operational period, direct observations of the impacts of the *i*Florida statewide data on evacuation operations is unavailable. Section 9 of this report does provide more information on Florida evacuation operations and the expected impacts of *i*Florida on those operations.

8.6. Using Statewide Data to Support Traveler Information

The original *i*Florida plans called for statewide traveler information services to cover roads on the Florida Intrastate Highway System (FIHS), which includes about 4,000 miles of Florida Interstate highways, the Florida Turnpike, selected urban expressways, and major interregional and intercity arterial highways. Early in the *i*Florida project, FDOT realized that the amount of traffic and incident information that would be available for many of these roads was extremely limited. FDOT decided to limit the statewide traveler information to ten major roads: I-4, I-10, I-75, I-95, the Florida Turnpike, SR-60, SR-70, SR-528, US-19, and US-27.

The main source of data to support the statewide traveler information was information from the FHP CAD system obtained from the FHP CAD Web site. FDOT also established processes in which the various FDOT districts would submit information about construction activities on roads that were covered by the statewide traveler information systems.

The Statewide Monitoring System provided video and traffic data from the monitoring stations that were deployed. While the video from these stations was occasionally useful to confirm information about incidents that occurred within range of the video cameras, most incidents were not within camera range. The wide spacing between Statewide Monitoring System stations meant that the system was not very useful at supporting statewide traveler information services.

A Statewide Monitoring System may be too sparse to consistently provide useful traveler information.

The FHP-CAD interface provided incident data from the FHP CAD system. The FHP-CAD data was the primary source of statewide traveler information. However, the CRS presentation of FHP-CAD data was not reliable, so was seldom used. Most operators chose to review FHP incident information through the public Web site interface provided by FHP. Because the FHP-CAD information was the main source of statewide traveler information, FDOT contracted in the summer of 2007 for the development of a new interface to the FHP-CAD data. This tool received data from the FHP-CAD system and provided a Web site that listed incidents associated with the roads included in FDOT's Statewide traveler information systems. It could also use Google maps to display the maps of the incident locations. D5 RTMC operators found that interface to the FHP data to be both reliable and useful, though some still preferred to access the FHP Web site directly (see Section 5 for more information on this interface).

FDOT staff suggested that, for the purpose of supporting statewide traveler information, some of the resources spent on the Statewide Monitoring System might have been better spent on developing interfaces to additional police CAD systems across the State.

The FHP CAD was the primary source of statewide traveler information.

8.7. Uses of Statewide Weather Data

The *i*Florida system did provide weather data to RTMC operators. The operators did not find this weather data useful for supporting traveler information. More information on *i*Florida weather data is available in Section 12.

8.8. The Condition Reporting System and Statewide Operations

The purpose of the CRS for supporting statewide operations was to manage incident information and assist with creating 511 messages that reflected these incidents. The primary sources of incident information for the CRS were the FHP CAD system and RTMC operator input. RTMC operators found the CRS manner of handling FHP CAD incident information difficult to use. The CRS did not effectively filter the FHP CAD incidents to only those that occurred on *i*Florida roads. At one point, an RTMC operator was required to spend most of his time deleting FHP CAD incident information that was for incidents that did not occur on *i*Florida roads. FDOT had expected the CRS to filter out these incidents automatically (see sections 2, 5, and 8.4 for more information). Thus, the CRS incident management features were not very useful with regard to statewide data. The CRS did provide tools that FDOT used to manage 511 messages. In May 2007, the CRS contractor discontinued development of the CRS and the CRS software failed. After the failure of the CRS, FDOT began migrating to SunGuide as its traffic management center software. By November 2007, FDOT was using SunGuide to manage 511 messages for the Statewide 511 system. See section 2 for more information on the CRS software and the migration to SunGuide.

8.9. Statewide Traveler Information

Despite the difficulties of obtaining information to populate the statewide 511 system and the limitations of the CRS in supporting statewide operations, FDOT D5 did create a successful statewide 511 system. When the CRS failed to successfully automate capabilities for maintaining statewide traveler information, RTMC operators used more manual methods to ensure that support for statewide traveler information continued. When available source of incident information sometimes left holes in coverage, FDOT used creative methods to fill those holes, such as providing 511 user comments to RTMC operators so they can correct 511 messages that may be in error. Over the period from November 2005 through August 2007, the statewide 511 system typically logged about 35,000 calls per month (see Figure 69).

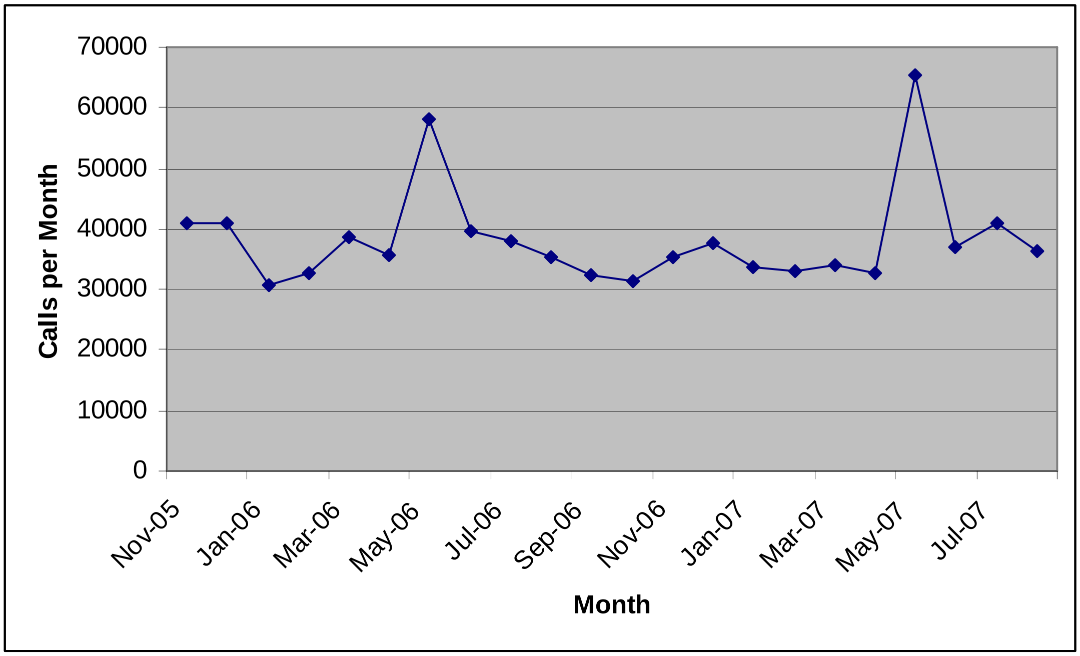

Figure 69. Statewide 511 Calls Per Month

More information on statewide traveler information can be found in Section 10.

8.10. Summary and Conclusions

The primary objectives of *i*Florida Statewide Operations were to support statewide traveler information and hurricane evacuations, objectives that FDOT met despite having to overcome significant challenges to do so. When the CRS failed to meet expectations for managing incident information from the FHP CAD interface, FDOT worked around those limitations. With this support, the statewide 511 system serviced about 35,000 calls per month throughout the operational period. FDOT also provided access to Statewide Monitoring System traffic video to the SEOC, though this system was not used extensively because no significant hurricane evacuations occurred during the operational period.

While deploying and operating these statewide systems, FDOT did identify a number of lessons learned that it might use to improve future operations and that other locales may find useful. The following list summarizes these lessons learned.

- The Statewide Monitoring System demonstrated that using the pre-existing microwave communication network was a cost-effective approach for providing communications to remote traffic monitoring stations.
  - One challenge was designing around the bandwidth limitations of the microwave network.
  - FDOT noted that the network was reliable, except for some disruptions during bad weather.
  - FDOT noted that using the locations of microwave towers as the primary factor in selecting sites for the Statewide Monitoring System may have been a mistake. A better system may have resulted from selecting sites primarily on the basis of the usefulness of the sites for supporting transportation decision making, and only taking advantage of microwave tower locations when consistent with those site selections.

- The cost of maintaining the Statewide Monitoring System was high, and the demand for data generated by the Statewide Monitoring System was low.
  - Because of this, FDOT focused its limited maintenance budget on field equipment that produced data for which demand was higher.
- The SEOC was very interested in using the traffic video provided by the Statewide Monitoring System during hurricane evacuations.
- FDOT found that the FHP CAD interface provided more useful data for supporting statewide traveler information than that obtained from the Statewide Monitoring System.
  - FDOT suggested that, for the purpose of supporting statewide traveler information, the resources spent on the Statewide Monitoring System may have been better spent on interfacing with additional police CAD systems across the State.

9. Evacuation Operations

Before *i*Florida, access to real-time traffic data to support evacuation decision making was limited. On a statewide level, Florida Department of Transportation (FDOT) supported a network of 54 traffic monitoring stations that, during a hurricane evacuation, uploaded hourly data and made that data available via the Web. Staff at the State Emergency Operations Center (SEOC) monitored this information and alerted evacuation managers at the SEOC when observed volumes significantly exceeded historical values. The Florida Highway Patrol (FHP) also reported on congestion observed by its personnel in the field. Individual counties would sometimes report on traffic problems during regularly scheduled conference calls between the SEOC and all FDOT counties.

The *i*Florida Model Deployment improved evacuation operations in several ways. It deployed 25 traffic monitoring stations across the State, stations that provided both real-time traffic measurements and traffic video. It deployed traffic monitoring devices on SR 520 and SR 528, key evacuation routes between the east coast and Orlando. Additional traffic monitoring was deployed on I-4 and I-95. The Central Florida 511 system was expanded and a new statewide 511 system was deployed. It also established network connectivity between a number of Transportation Management Centers (TMC) and Emergency Operations Centers (EOC) in the Orlando area as well as the SEOC. Taken together, these modifications had the potential to change evacuation operations by providing evacuation decision makers with new sources of real-time traffic information to guide their decision making processes.

This section of the report describes the *i*Florida systems that were expected to impact evacuation operations, the types of impacts that occurred, and observations made during Florida hurricane evacuations.

9.1. Florida Evacuation Operations

Emergency management in Florida, and evacuation management in particular, is performed at the county (or regional) level, with State activities designed primarily to support county needs and to ensure coordination between counties and between Florida and neighboring States. Chapter 252 of the Florida statutes identifies the following key elements of Florida emergency management:

- The Florida Division of Emergency Management (FDEM) oversees regional emergency management organizations and authorizes cooperation with the Federal government and other states.
- FDEM prepares a State comprehensive emergency management plan that includes an evacuation component ensuring coordination for evacuees crossing county lines.
- The Governor specifies routes, modes of transportation, and destinations for evacuations and controls ingress and egress to and from an emergency area, and executes plans and rules for traffic control during evacuations. However, the Governor is expected to “utilize the services and facilities of existing officers and agencies of the State and of the political subdivisions thereof … as the primary emergency management forces of the state.”
- Each county develops a county emergency management plan. Two or more adjoining counties may, instead, develop a joint emergency management plan.
- Municipalities create municipal emergency management programs.

- All emergency management orders and rules are expected to take into consideration the orders, rules, actions, recommendations, and the requests of Federal authorities.

The result of this statutory background is an emergency management process in which most of the transportation-related issues are managed locally, with local officials appealing to State officials for support, when needed.[1] For example, each county is responsible for determining when and if a county evacuation is required, though the State may encourage counties to do so. Similarly, evacuating counties work directly with surrounding counties to coordinate evacuation times and help ensure that sufficient shelters will be available to accommodate evacuees.

During an evacuation, State officials at the SEOC gather information about evacuation activities in each county, monitor statewide traffic patterns, and organize statewide conference calls to share emergency response information between the counties. For example, State officials monitor traffic on key evacuation routes and work with local transportation organizations, FDOT, and FHP to address transportation problems that arise. State officials also, at the request of local emergency response officials, address certain evacuation-related issues, such as organizing fuel shipments to counties running short on fuel, removing tolls on toll roads, and authorizing contraflow on evacuation routes. State officials also host conference calls with adjacent States to help the adjacent States prepare for an influx of Florida evacuees.

In summary, county (or regional) emergency response officials are the primary decision-makers regarding emergency evacuations in Florida, while State personnel at the SEOC are responsible for helping to coordinate the county emergency response decisions, providing requested support to the counties and regions, monitoring and responding to statewide issues, and coordinating with nearby States.

9.2. *i*Florida Activities to Support Evacuations

As a result of *i*Florida and other projects that occurred in parallel, FDOT's ability to monitor evacuation traffic and the resources available for distributing traveler information during an evacuation increased significantly. The following list describes the most important of these changes:

- *Deployment of loop detectors and video surveillance on SR 528 and SR 520.* SR 528 is a key evacuation route between the east coast and Orlando, and SR 520 is an alternate route from the coast. A dense network of loop detectors was deployed on SR 528, and a limited number of detectors were also placed on SR 520.
- *Traffic monitoring on Orlando toll roads.* The Orlando-Orange County Expressway Authority (OOCEA) deployed a network of toll tag readers and software to estimate travel times on OOCEA toll roads and provided this data to the *i*Florida systems. As part of *i*Florida, FDOT D5 deployed additional devices to monitor traffic on Orlando toll roads not managed by OOCEA. Closed Circuit Television (CCTV) and Dynamic Message Signs (DMS) were also deployed on these toll roads.
- *Traffic monitoring on Orlando arterials.* As part of *i*Florida, FDOT D5 deployed toll tag readers on Orlando arterials to estimate travel times and CCTV to monitor traffic.
- *Traffic monitoring on I-4 and I-95.* As part of other projects, the loop detector and CCTV network on I-4 was extended east of Orlando to I-95. A similar network was deployed on I-95. This

[1] State emergency management officials do have the authority to overrule local officials on some issues, though this authority is seldom exercised.

traffic monitoring data was integrated into *i*Florida systems. DMS were also deployed in these areas.

- *Weather monitoring.* A set of Road Weather Information System (RWIS) stations were deployed, including wind speed monitoring stations on bridges. A contractor also provided road-specific weather data and forecasts.
- *Statewide traffic monitoring.* A collection of 25 traffic monitoring stations with CCTV and radar-based traffic monitoring were deployed across the State.
- *Traveler information.* A statewide 511 system was deployed, and the I-4 511 system was extended to include all of the roads for which traffic monitoring was available (i.e., I-4, I-95, Orlando toll roads, and key Orlando arterials).

The combination of these changes enhanced FDOT's ability to monitor evacuation traffic in the Orlando area and to provide traveler information to the public. The changes also somewhat enhanced evacuation traffic monitoring capabilities across the state and created a statewide 511 system that could be used to provide traveler information during an evacuation.

9.3. Impacts of *i*Florida Activities on Florida Evacuations

Several factors limited the impacts that *i*Florida had on Florida evacuations. First and foremost were the problems experienced with the Condition Reporting System (CRS). This software was designed to support operations at the Regional Traffic Management Center (RTMC) by gathering data from the traffic monitoring devices on roads near Orlando and statewide, presenting the data to RTMC operators to support traffic management decision making, and managing traveler information resources. The CRS was also a key part of the plans for sharing traffic data with regional transportation agencies, including those responsible for evacuation decision making. The intention was for agencies interested in accessing *i*Florida or other FDOT traffic data to install a copy of the CRS and use it to view the data.

Initially, a number of agencies expressed an interest in installing copies of the CRS from FDOT. Most were hoping to use the CRS both to access *i*Florida data and manage their own ITS resources. When the CRS did not perform as expected (see section 2 for more information), these agencies chose not to install copies of the CRS, limiting access to *i*Florida data to FDOT. Thus, most evacuation decision makers in the Orlando area did not have direct access to the *i*Florida data on evacuation routes. One important exception was the video from the Statewide Monitoring System, which was available at the SEOC in the 2006 and 2007 hurricane seasons.

Difficulties with the iFlorida deployment limited the impacts on Florida evacuations that occurred.

A second limitation had to do with the reliability of the traffic monitoring equipment on evacuation routes. One result of the large increase in the amount of field equipment deployed and maintained by FDOT D5 that occurred from 2003 to 2005 was that FDOT had trouble achieving high levels of reliability with this equipment. Figure 70 depicts the availability[2] of the Statewide Monitoring System field equipment, indicating that camera video was available from less than half the cameras on most days. (Section 5 provides more information on the challenges FDOT faced in maintaining the *i*Florida field equipment.)

[2] The availability refers to the percentage of the equipment reported by FDOT as being in-service each day, averaged over each month.

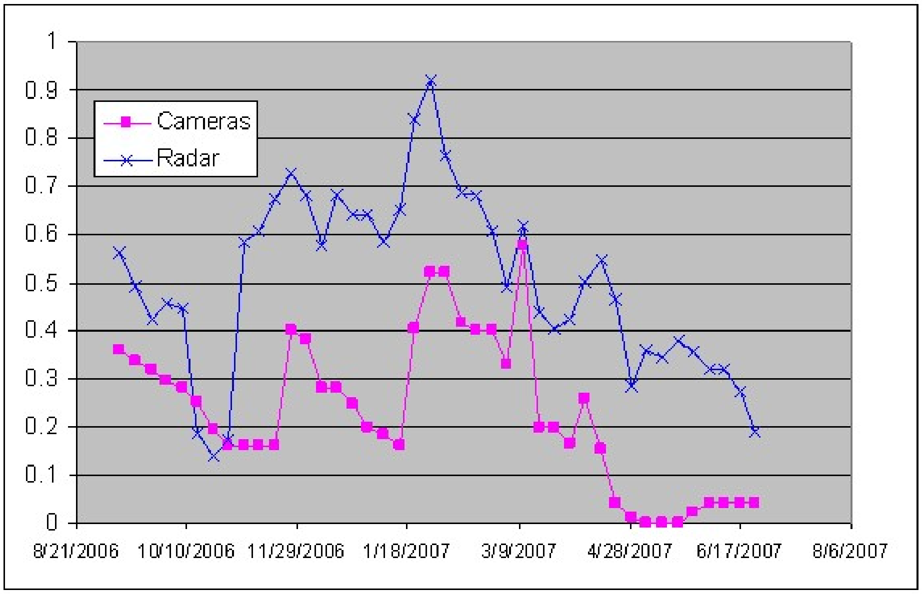

Figure 70. Availability of the Statewide Monitoring Field Equipment

Figure 71 depicts the availability of the Hurricane Evacuation System (HES) field equipment.

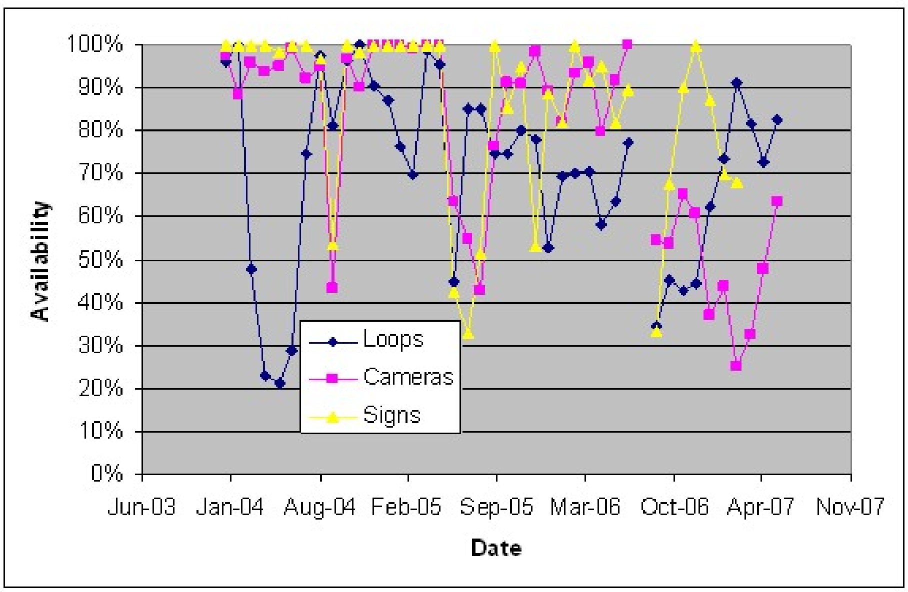

Figure 71. Availability of the HES Field Equipment

The last limitation was simply that no significant hurricane evacuations occurred in Florida during the 2006 and 2007 hurricane seasons, the time when the *i*Florida equipment and systems were available.

9.4. Evacuation Observations during Florida Hurricanes

Despite the fact that no significant hurricane evacuations occurred while the *i*Florida systems were operational, observations by the Evaluation Team during hurricanes that occurred in the 2005 hurricane season did lead to some lessons learned with regard to hurricane evacuations.

9.4.1. Hurricane Charley

Hurricane Charley began as Tropical Depression Three on August 9, 2004. By August 11, it had been upgraded to a hurricane. Before making landfall near Charlotte Harbor on August 13, Charley strengthened rapidly from category 2 to category 4 and gusts of up to 180 mph were reported. From there, Charley swept quickly through the State of Florida, passing directly through Orlando, and crossed over a small section of the Atlantic before making a second landfall in South Carolina. The storm track through Florida for Hurricane Charley is depicted in Figure 72 below, along with the counties that issued evacuation orders in response to the hurricane. The 17 counties that issued mandatory evacuation orders are highlighted in red. The 16 that suggested voluntary evacuations are highlighted in yellow.

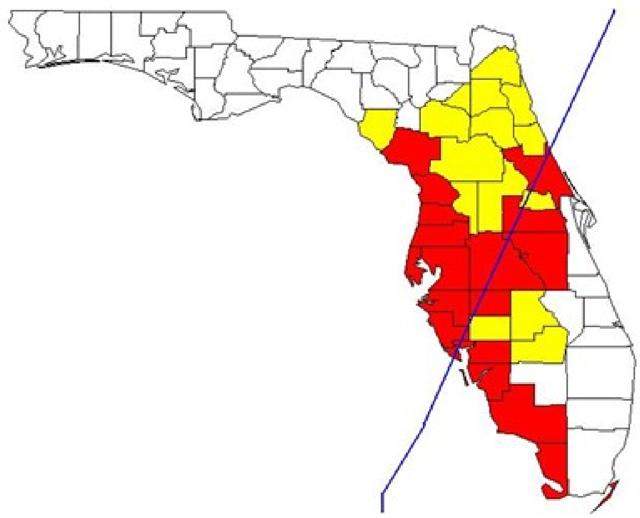

Figure 72. Storm Track and Evacuating Counties for Hurricane Charley

Estimates were that more than 1 million Floridians evacuated due to Hurricane Charley, resulting in significant increases in traffic volumes on some Florida roads (see Figure 73).

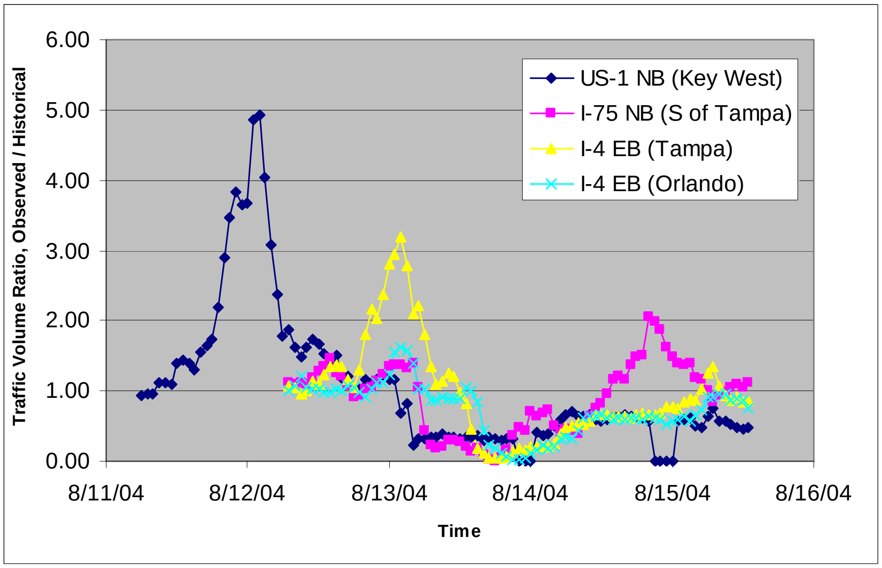

Figure 73. Traffic Volumes During the Hurricane Charley Evacuation, South and Central Florida

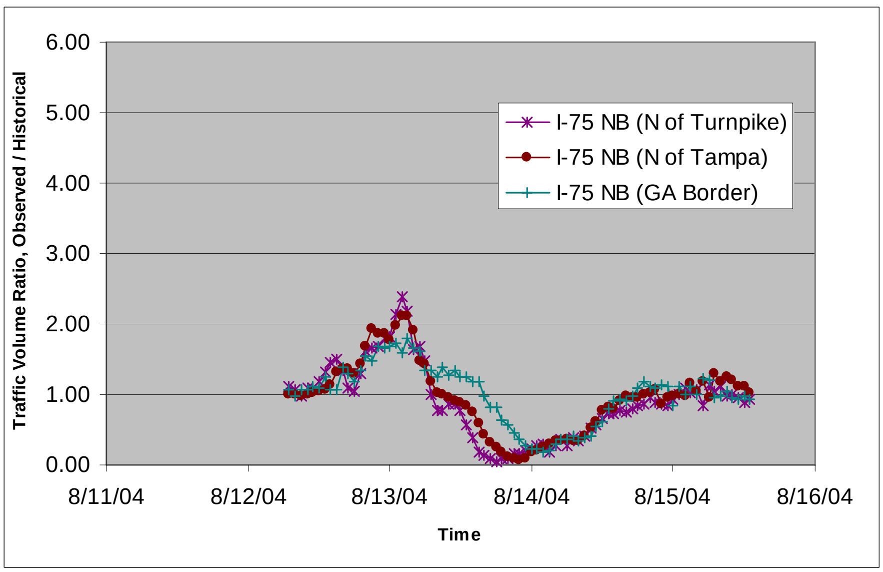

Figure 74. Traffic Volumes During the Hurricane Charley Evacuation, Central and North Florida

In Figure 73, the charted values are the ratio of the observed hourly traffic volumes to the historical hourly traffic volumes for that day and hour taken from FDOT's Telemetered Traffic Monitoring Site (TTMS) system.

$$[Traffic\ Volume\ Ratio] = \frac{[Observed\ \ Hourly\ Volume]}{[Historical\ \ Hourly\ Volume]}$$

A value above 1 indicates more traffic than the historical average would suggest for that day and time, likely due to evacuating vehicles. The largest values tended to occur during the late-night or early-morning hours, when the historical volumes were low. The date values on the x-axis indicate midnight at the start of the particular day. The flows are listed in the approximate order in which the hurricane traffic impacted the indicated roads, starting with US 1 in Key West, then proceeding to roads north of the landfall point and south of Tampa and following traffic flows north and east.

Note that very little evacuation traffic flowed north from Charlotte Harbor on I-75 northbound, South of Tampa. This is likely because news reports at the time emphasized the potential for Hurricane Charley to make landfall near Tampa. The traffic peaks were localized, with only a small increase in traffic crossing the Georgia border. A separate review of traffic speeds indicated few prolonged drops in traffic speeds during this evacuation.

During Hurricane Charley, the Evacuation Team observed operations at the D5 RTMC. These observations indicated that the primary role of the RTMC at that time was to monitor and respond to traffic conditions on I-4. The RTMC operators recorded 511 messages, set DMS messages, managed Road Ranger activities on I-4, and coordinated with FHP. The main tool used to monitor I-4 traffic was the traffic video. Speed and volume data from the I-4 loop detectors were rarely consulted. The RTMC did not have access to traffic data from across the state, so had trouble anticipating whether future traffic conditions would worsen because of incoming evacuation traffic. On one occasion, a D5 RTMC operator phoned the RTMC in Tampa to obtain information on the traffic volumes leaving Tampa heading towards Orlando.

The *i*Florida Model Deployment changed many of these characteristics. After *i*Florida, the D5 RTMC was able to monitor traffic on all limited access roads in the Orlando area, including all key evacuation routes. The RTMC also had access to traffic conditions at locations across the state. Automated traffic monitoring systems produced travel time estimates for these roads. The RTMC was responsible for managing both the Central Florida and Statewide 511 systems.

9.4.2. Hurricane Frances

Hurricane Frances (see Figure 75) began as Tropical Depression Six on August 24, 2004. On August 26, Frances was classified as a hurricane and continued intensification was forecast. By September 3, Frances had begun to weaken and had slowed to 6 mph. The National Hurricane Center (NHC) expressed concerns that a large, slow Frances could bring torrential rains and flooding to Florida. NHC reports on the evening of September 4 indicated that Frances was "nearly stationary." Frances made landfall around 10:00 a.m. on September 5 near Sewall's Point, and passed slowly across central Florida into the Gulf of Mexico. Frances later turned north and hit the Florida panhandle on the afternoon of September 6. In response to this storm, 28 counties issued mandatory evacuation orders and 17 counties suggested voluntary evacuations.

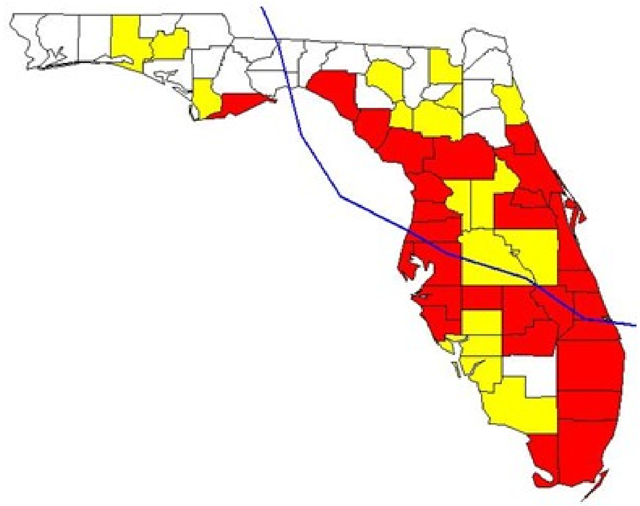

Figure 75. Storm Track and Evacuating Counties for Hurricane Frances

The traffic peaks (see Figure 76) resulting from Hurricane Frances were significantly larger than for Hurricane Charley and extended over a larger area, with significant traffic flows reaching all the way to the Florida-Georgia border.

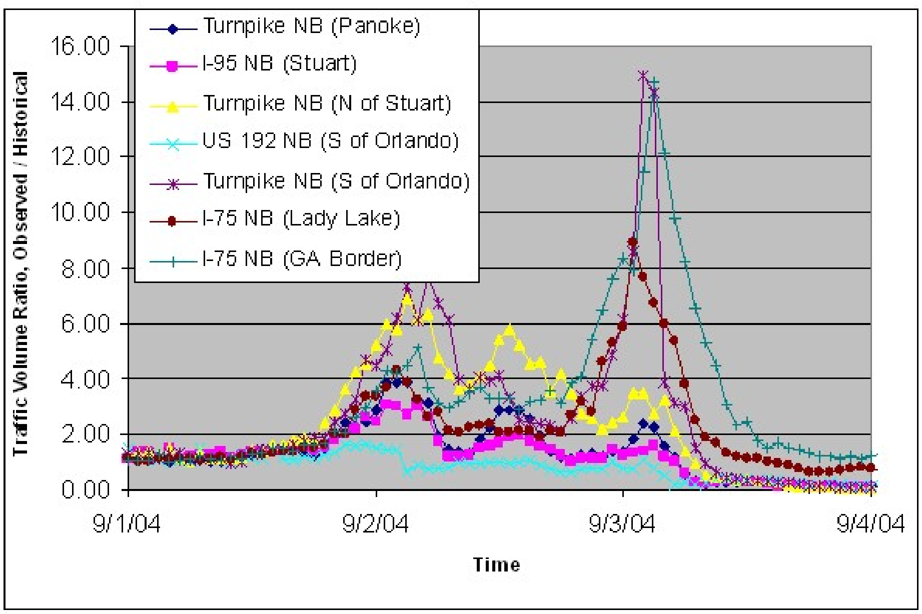

Figure 76. Traffic Volumes During the Hurricane Frances Evacuation

The extreme peaks shown on September 3 reflect the fact that high traffic volumes occurred in the early morning hours when historical volumes were small. This was indicative of high demand that continued throughout the night, which was likely caused by bottlenecks on I-75. A number of reports from the SEOC identified traffic problems around the state. FHP reported significant congestion on the Florida Turnpike. Calls to local TMCs indicated that traffic was at a crawl on I-95 north of Daytona, on I-75 in Ocala, and on I-4 in Marion County. Georgia reported that a 20-mile backup existed on I-75 in Georgia. It is interesting to note that speed data from the TTMS sites (see Figure 77) did not reveal the extent of the congestion across the State.

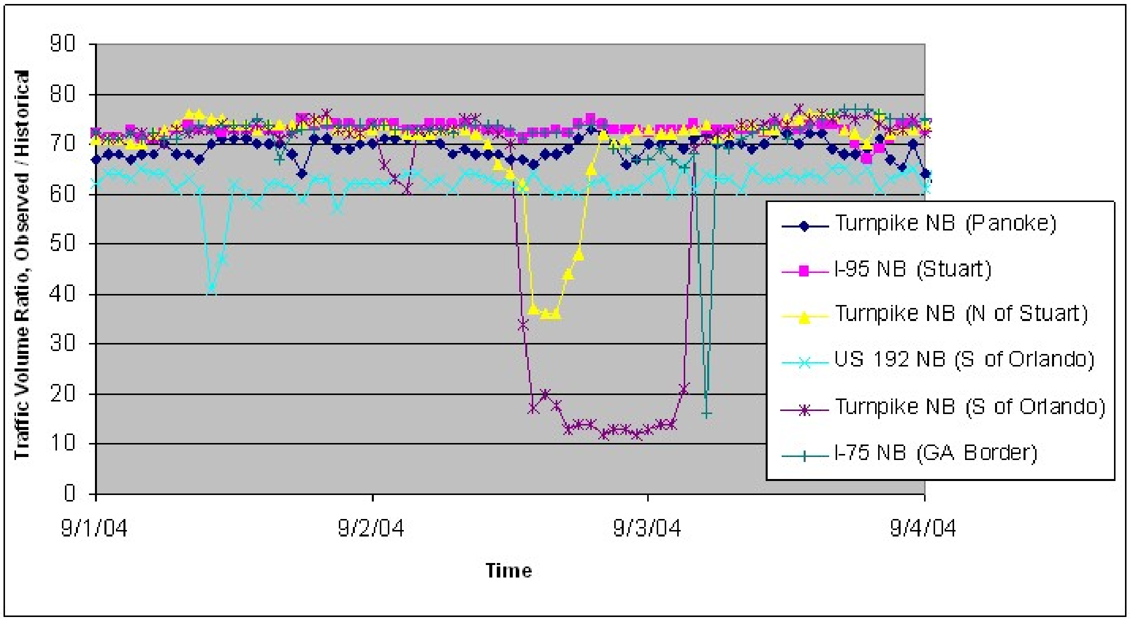

Figure 77. Traffic Speeds During the Hurricane Frances Evacuation

The TTMS data identified significantly reduced speeds on the Florida Turnpike, but indicated that traffic was flowing at normal speed on other roads across the state. This was likely because the TTMS sites happened to be at points away from the bottlenecks where congestion was occurring on I-75. The high traffic volumes shown in Figure 76 made it clear that a large number of evacuating vehicles were on the road, so congestion was likely. But, confirmation of that came from the local TMCs and the FHP rather than from the TTMS data.

Point speed measurements did not produce an accurate picture of the amount of congestion across the State.

During Hurricane Frances, the evaluation team observed traffic management operations at the SEOC in Tallahassee. The following list describes the main activities that were observed:

- *Monitoring traffic conditions at the TTMS sites.* One person stationed at the SEOC spent most of his time reviewing the TTMS Web site and reporting any unusually high traffic volumes to evacuation decision makers.
- *Hosting evacuation status report meetings with all Florida counties.* The SEOC hosted conference calls twice per day that were attended by representatives from each Florida county. These meetings allowed the SEOC to help coordinate evacuation activities, such as ensuring that receiving counties had opened sufficient shelters to handle the number of evacuees expected from evacuating counties. They also allowed counties to report any problems that they wanted the SEOC to address, such as arranging for gasoline shipments to arrive in counties where shortages were expected.
- *Hosting evacuation coordination meetings with regional emergency managers of the regions directly impacted by the hurricane.* These calls addressed concerns specific to evacuating counties, such as the need for shelters and the potential for contraflow operations.
- *Hosting evacuation coordination meetings with adjacent states.* These calls helped ensure that adjacent states were prepared to receive people evacuating from Florida.

- *Addressing issues identified during the status and coordination meetings.* One issue that was addressed was gasoline shortages. The evacuation increased the demand for gasoline as people prepared to evacuate just as ports closed and fuel shippers moved transport vehicles out of the area to avoid the hurricane. Because gasoline supply lines were likely to remain disrupted for several days after the hurricane passed, counties in the hurricane's path also wanted to establish gasoline reserves so they could operate response vehicles after the hurricane. The SEOC staff worked with the ports and gasoline suppliers to arrange for gasoline shipments to counties where shortages were reported.

Twice during Hurricane Frances, the SEOC was involved in contraflow decision making. The first occurred on September 2, when the Governor granted approval to use contraflow on SR 528, if it was needed. A conference call was held with the FDEM Region Coordinator for Region 5, which includes Orlando and SR 528. The Region 5 Coordinator reported that evacuees were being encouraged to go to nearby shelters and that contraflow on SR 528 was not expected to be necessary. The coordinator also noted that several cruise ships were docked in Port Canaveral and that up to 10,000 people might be making the trip from Orlando to Port Canaveral on SR 528 to board those ships. The coordinator warned that instituting contraflow on SR 528 would prevent those passengers from reaching the port, stranding them in the path of the hurricane. After considering these factors, the plan for contraflow was abandoned. The observed traffic flows on SR 528, shown in Figure 78, seem to support this decision.

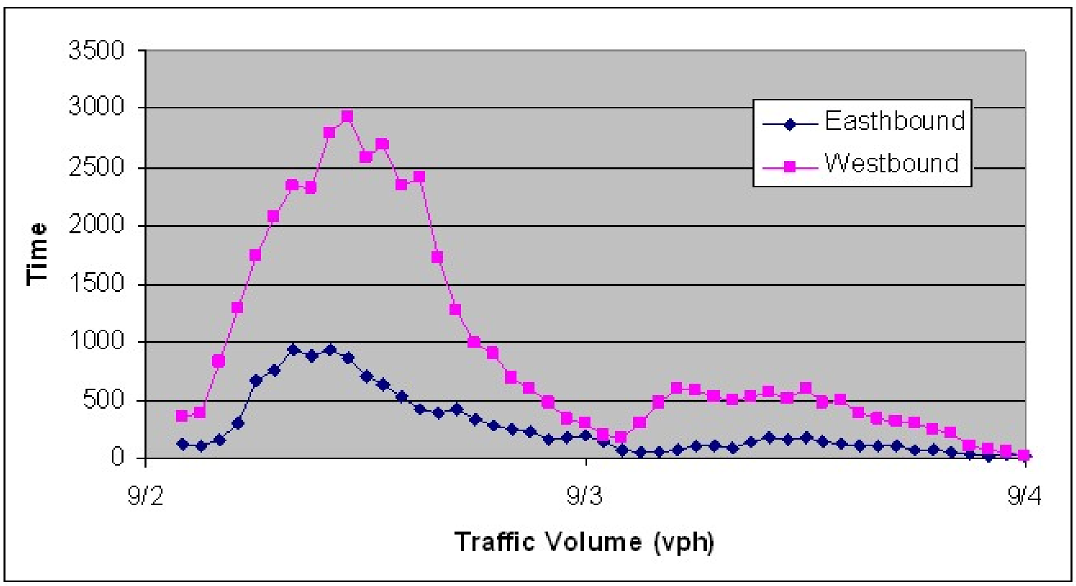

Figure 78. Traffic Volumes on SR 528 Near Titusville During Hurricane Frances

The second contraflow decision related to reports that the State of Georgia was considering instituting contraflow on I-75 at the Florida-Georgia border. As shown in Figure 79, high traffic volumes occurred on I-75 northbound through most of the day on September 2 carrying over through the night into the morning of September 3. Georgia also reported that significant delays were occurring on I-75 in south Georgia. The State of Georgia was concerned that, if higher demand occurred on September 3, then a significant bottleneck might develop and evacuees could be trapped on the highway.

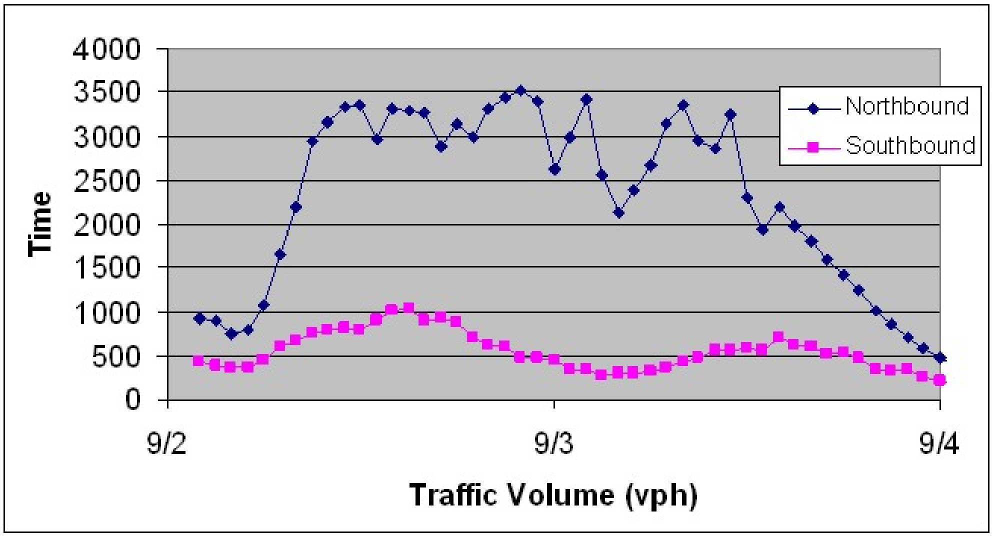

Figure 79. Traffic Volumes on I-75 Near the Georgia Border During Hurricane Frances

The SEOC responded by consulting the TTMS Web site to estimate demand that was likely to occur on I-75 entering Georgia. Although traffic levels were high, demand on most roads was lower than the previous day and was leveling off or dropping. This seemed to indicate that demand at the Georgia line was probably peaking. FDOT also deployed signs at the I-75 / I-10 interchange encouraging evacuees to take I-10 rather than I-75. The State of Georgia was briefed on these results and on other traffic observations from around Florida and chose not to use contraflow on I-75.

In these two instances, the determination of whether to use contraflow depended primarily on estimates of future demand. (This was because of the long preparation time required to set up contraflow operations.) In the case of SR 528, the estimates of future demand depended primarily on local knowledge of the regional emergency managers, who were encouraging evacuees to use local shelters and knew of future demand in the eastbound direction. In the case of I-75, the estimates of future demand relied on comparisons of current and previous-day demand to determine if demand was likely to be greater or less than the previous day.

The determination of whether to use contraflow depends on estimates of future demand. Real-time traffic data is of limited use in making this estimate.

The evaluation team noted that in neither case were current traffic conditions key in the decision-making process. In the case of SR 528, current traffic conditions were not discussed during the decision-making process. In the case of I-75, current traffic conditions were used only to verify that volumes were lower than during the previous day. It is also worth noting that, during the Hurricane Charley and Hurricane Frances evacuations, the period of high demand only lasted about 24 hours. Given the length of time required to set up contraflow operations, it might have been too late to do so if decision makers had waited for real-time traffic volumes to indicate that a need was developing.

A tool that integrated current traffic condition data would be a valuable tool for supporting SEOC traffic management decision making.

Even though current traffic condition data was not key in the contraflow decision making process, an understanding of current traffic conditions was important for other decisions. SEOC staff felt that this data was important enough that one person spent a majority of his time monitoring the traffic data on the TTMS Web site and summarizing the information that was contained there. As already indicated above, the TTMS data gave an incomplete view of traffic conditions across the State, and reports from local TMCs and FHP were necessary to provide more detail. Yet, the SEOC had no tools available to integrate the traffic data from these different sources to create a consolidated view of statewide traffic conditions. The evaluation team felt that a tool that automatically integrated available data and used it to estimate potential problem points would save time and, potentially, improve evacuation decision making.

The evaluation team also noted that Florida's basic approach to emergency management in the areas observed by this evaluation team was to distribute the decision-making responsibility to the county (or regional) emergency managers. The primary responsibilities of the State were to provide support requested by the counties and regions and to coordinate with other States and the Federal government. For example, each county (or region) developed its own emergency management plan, determined its emergency activation level, and decided whether and when to declare an evacuation. The State addressed issues that extended beyond the jurisdiction of the counties and regions, such as coordinating with the Federal Emergency Management Agency (FEMA), arranging for shipments of fuel and other key goods, lifting tolls on toll roads, and managing contraflow operations.

The State also provided oversight of county and regional activities, ensuring that local officials took appropriate steps to safeguard their citizens and support surrounding counties. For example, the Governor had the authority to declare an evacuation if county officials did not do so. Although this authority was not used, the existence of this dual authority helped ensure that county and State officials consulted with each other and reached a consensus on key emergency management decisions.

This division of responsibility appeared to work very well. The State ensured that the counties had access to up-to-date information on the hurricane and statewide traffic conditions. The counties, then, had necessary information to make decisions on whether and when to evacuate. By organizing coordination conference calls, the State helped ensure that these decisions were coordinated between the counties. Many of the evacuating Counties coordinated directly with neighboring Counties to ensure that their evacuees could find shelter, while the State gathered statewide information about the number of expected evacuees and the available sheltering capacity to look for discrepancies. This combination of local control of the emergency response for each county and State support for and oversight of emergency response activities proved very effective.

The distributed model for emergency management used in Florida worked very well.

As the evacuation was ending and traffic flows began to drop around the state, the SEOC staff began to discuss problems related to re-entry after the hurricane had passed. A number of challenges and potential concerns for future evacuations were noted during these discussions:

- Disseminating information to returning evacuees. SEOC staff identified information needs of returning evacuees, including advising evacuees of the availability of food, water, and gas along return routes and the accessibility of electricity, food, and water at their homes when the evacuees return. Experience has shown that it is difficult for most evacuees to gain access to this type of information before deciding to return.
    - It was difficult to communicate with Floridians who had evacuated the State. Mechanisms existed for communicating with Floridians before the evacuation—information provided to Florida commercial media went out on Florida TV, radio, and newspapers, FDOT could

provide information via 511 systems, message signs, and highway advisory radio, etc. Most of these methods could not reach evacuees outside of the State.

- Managing the return of evacuees before services are restored. Many evacuees, concerned about the security of their possessions and anxious to repair damages that may have occurred may be tempted to return before vital services, such as water or electricity, are restored in their areas.
- Preparing for possible congestion during re-entry. During the evacuation, Florida counties spread out evacuation orders over time to help reduce the peak traffic demand. During re-entry, no mechanism existed to directly impact the time at which evacuees choose to return. If most evacuees chose to return at or about the same time, the peak demand during re-entry would be higher than the peak demand during the evacuation.

These discussions made it clear that managing the outgoing evacuation traffic was only half of the evacuation traffic management challenge.

9.4.3. Hurricane Jeanne

Hurricane Jeanne began as Tropical Depression Eleven on September 13, 2004, reaching hurricane strength on September 16. Jeanne made landfall as a category 3 hurricane on September 25 near Stuart, Florida, very close to the place Hurricane Frances came ashore. Jeanne turned north near Lake Okeechobee and passed through the Florida peninsula. The storm track through Florida for Hurricane Jeanne is depicted in Figure 80, with the 28 counties that issued mandatory evacuation orders highlighted.

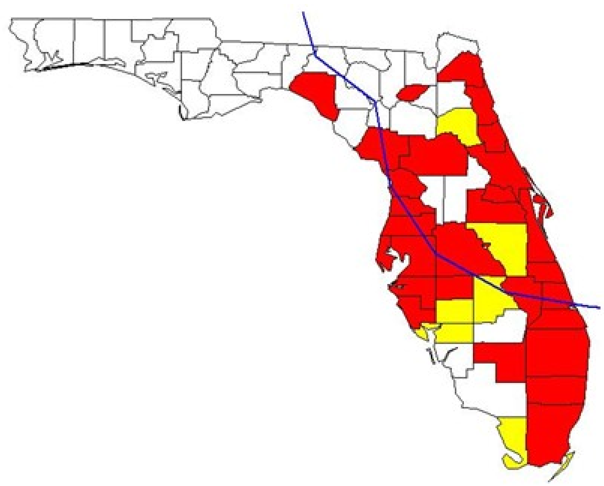

Figure 80. Storm Track and Evacuating Counties for Hurricane Jeanne

The traffic volumes that occurred during the Hurricane Jeanne evacuation are depicted in Figure 81.

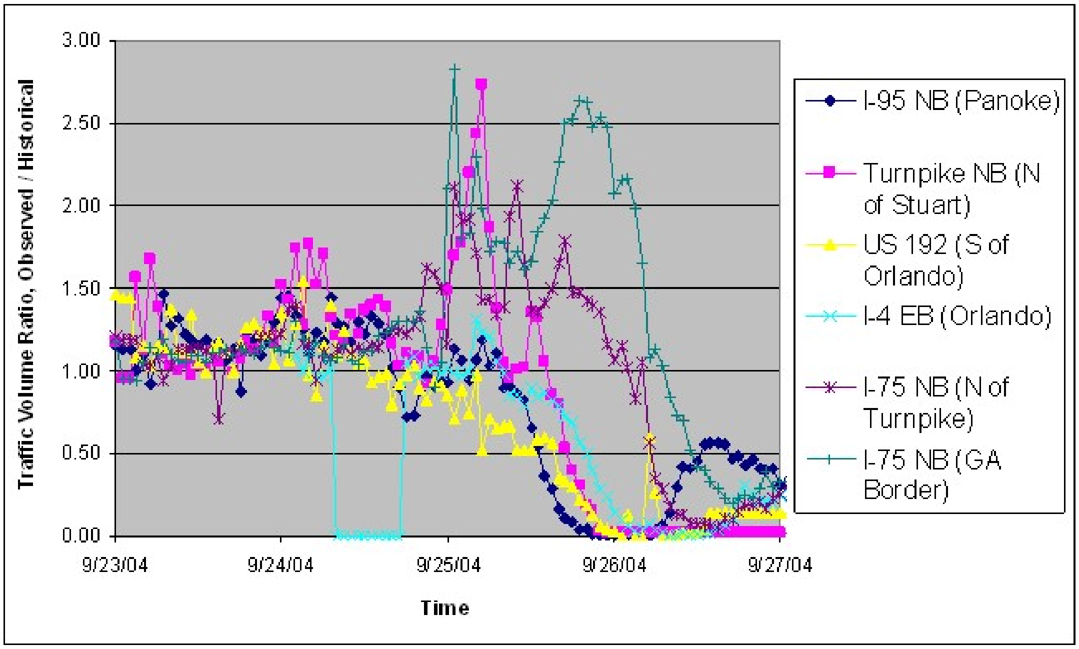

Figure 81. Traffic Volumes during the Hurricane Jeanne Evacuation

The evacuating traffic showed similar patterns to those observed during Hurricane Frances, but with lower overall demand.

9.5. Summary and Conclusions

The observed impact of the *i*Florida Model Deployment on Florida evacuations was small. One cause for this was that the problems experienced with the CRS prevented its use at locations other than FDOT, limiting evacuation decision makers' access to *i*Florida data. There were also problems with maintaining the field equipment that monitored evacuation routes. The fact that no significant hurricane evacuations occurred in Florida limited the possibility of observing any changes in evacuation operations that might have occurred.

Observations of evacuation operations that occurred while the *i*Florida systems were being deployed did point to some of the potential impacts *i*Florida might have on evacuation operations as well as some potential limitations. These observations also identified successful evacuation management practices other States might consider. The following list summarizes the potential impacts, limitations, and lessons learned:

- *Access to statewide traffic data is important.* SEOC staff spent a considerable amount of time gathering information about statewide traffic conditions: consulting the TTMS Web site, calling local TMCs, and holding discussions with FHP officers. One SEOC staff member specifically noted that having access to video from the *i*Florida traffic cameras would "be invaluable for this coming hurricane season." The operations center staff's understanding of traffic conditions was important in making a number of evacuation decisions, such as setting up signs to encourage evacuees to use less congested routes and whether to use contraflow.
  - *The data from the sparse network of TTMS sites did not accurately represent traffic conditions on some roads.* During Hurricane Frances, reports from local TMCs and the FHP indicated that significant congestion was occurring on a number of roads across the State. The TTMS data

identified high traffic volumes on these roads, but did not indicate low travel speeds on most of them. The *i*Florida Statewide Monitoring System may have similar limitations.

- *The D5 RTMC did not have ready access to information about evacuating traffic that might be entering the district.* During Hurricane Charley, the D5 RTMC did not have access to data indicating how much evacuation traffic to expect on I-4 from Tampa. This made it difficult for the agency to decide whether it needed to take actions to prepare for high traffic volumes. A call to the Tampa TMC provided FDOT D5 with the information it needed.
- *A tool to consolidate statewide traffic data might be beneficial.* The SEOC relied on traffic information from numerous sources, including the TTMS Web site and reports from local TMCs and the FHP, to provide them with an understanding of traffic conditions across the state. But, it did not have a tool to consolidate all of this information. Charts from the TTMS Web site were printed and hand written notes were taken for other traffic reports. A tool that consolidated this information might simplify the process of collecting the traffic data and improve the overall understanding of statewide traffic conditions.

- *Estimates of future traffic demand were needed to support contraflow decision-making.* During Hurricane Frances, it was estimated that it would require 3 hours to set up contraflow on SR 528. The long setup time and the fact that contraflow operations are not allowed at night in Florida effectively requires that a contraflow decision be made a day before contraflow is implemented. So, the contraflow decision must be based on estimates of traffic demand for the following day.
  - *For coastal areas, knowledge of the number of people expected to evacuate and their expected destinations was key to estimating future traffic demand.* When contraflow was considered on SR 528 during Hurricane Frances, regional emergency management personnel were encouraging people to use local shelters and believed that this would prevent excess traffic demand on SR 528.
  - *For inland areas, knowledge of the amount of upstream evacuation traffic was key to estimating future traffic demand.* When contraflow was considered on I-75 in south Georgia during Hurricane Frances, the SEOC reviewed traffic counts from across the state to estimate whether this traffic was likely to create excess demand on I-75 as the evacuating traffic continued its migration northwards. Indications that traffic demand was decreasing throughout much of the state provided evidence that traffic demand on I-75 would soon be decreasing.
- *A distributed approach to evacuation management is very effective.* In Florida, many of the responsibilities for evacuation management are delegated to the counties, with the State arranging coordination between the counties, responding to requests from them, and coordinating with adjacent States. This approach was very effective.
  - *Coordination is key.* One of the most important roles of the SEOC during the evacuation was to arrange conference calls that helped improve coordination. SEOC hosted conferences calls attended by all Florida counties twice per day, with additional calls with the Regional Emergency Managers for areas directly impacted by the hurricane. The counties also had access to a software application that allowed them to submit requests to the SEOC. To coordinate with adjacent States, the SEOC hosted daily conference calls with them.
  - *Co-location of personnel in the SEOC improved coordination.* It often required a number of different people with knowledge and expertise in many different areas to address the problems that arose during an evacuation. For example, providing gasoline to counties with shortages required the Port of Tampa to postpone closing to allow gasoline shipments to arrive, gasoline tankers off shore to head to port, and gasoline shippers within the state to deliver the fuel to the counties with shortages. The co-location at the SEOC of staff spanning these

different functional areas allowed for quickly locating people with the proper knowledge and expertise to address the problems that arose.

While the impacts of the *i*Florida Model Deployment on evacuation operations during the 2006 and 2007 hurricane seasons were limited, there are reasons to believe the impacts may be larger in the future. First, the CRS software was replaced with SunGuide software, and this software appeared to be providing more reliable access to traffic monitoring data and more flexible tools for using that data for traffic management and traveler information. A number of traffic and emergency management organizations in the Orlando area had expressed an interest in obtaining licenses to install the SunGuide software, which will provide them with access to *i*Florida data. Once evacuation managers have access to the *i*Florida data, they may begin to integrate it into their evacuation decision-making processes.

FDOT D5 had also begun negotiating with other FDOT district offices to take over responsibility for maintaining Statewide Monitoring System equipment located in their districts. While FDOT D5 was maintaining this equipment, the high cost of traveling to those locations limited the amount of maintenance that was performed. With the local FDOT districts performing the maintenance, the equipment reliability will likely increase.

With more reliable equipment and wider access to the traffic monitoring data generated by this equipment, the next several years may provide more insights into the potential for enhanced traffic management capabilities to improve evacuation management.

10. Traveler Information Operations

A key part of the *i*Florida Model Deployment was a significant increase in the amount of traveler information that was available both in Central Florida and statewide. In Central Florida, the previous 511 system, which provided traveler information only for I-4, was expanded to include all other limited access roads in Central Florida and several key arterials in the Orlando area. A traveler information Web site was developed, and the number of DMSs displaying traveler information was increased. Statewide, a new 511 system was established and a traveler information Web site was developed. Outside organizations also used traffic information gathered by FDOT to augment their traveler information—local television and radio broadcasts included more detailed traffic information and Internet content providers included Orlando traffic information on their maps.

This section of the report focuses on the Central Florida and Statewide 511 system and traveler information Web sites. It also briefly discusses uses of FDOT traffic information to support traveler information services provided by other organizations. Information about the use of DMSs for traveler information is discussed in Section 6 of this report.

10.1. *i*Florida Traffic Monitoring and Traveler Information Services

The foundation of the *i*Florida traveler information operations was the traffic data collection that provided the data used as traveler information. Before *i*Florida, this data collection consisted primarily of loop detectors and cameras on I-4 in the Orlando area. FDOT used this data to provide 511 service for I-4. A Web site also provided access to the loop detector data, though the availability of this Web site was not well publicized and demand for the Web site was low.

As part of the *i*Florida Model Deployment, FDOT deployed an extensive network of traffic monitoring devices in the Orlando area. This included an extension of the loop detector network on I-4 to I-95 east of Orlando, transponder-based travel time monitoring on the Florida Turnpike, the western end of SR 528, the northern and southern ends of SR 417 and seven high priority arterials, LPR-based travel time monitoring on US 192 and SR 520, micro-loop detectors on SR 528 from SR 520, and CCTVs at 12 key arterial intersections. FDOT also deployed a series of loop detectors and cameras on I-95 along the coast east of Orlando. OOCEA deployed a transponder-based travel time monitoring system on the four toll roads (SR 408, SR 417, SR 429, and SR 528) it managed in the Orlando area. Taken together, these deployments resulted in a comprehensive metropolitan traffic monitoring system. Figure 82 highlights the roads in the Orlando area for which traffic monitoring was in place after the *i*Florida deployment was completed. (See section 1 for a more detailed summary of the *i*Florida infrastructure and section 3 for information on the transponder-based travel time monitoring.)

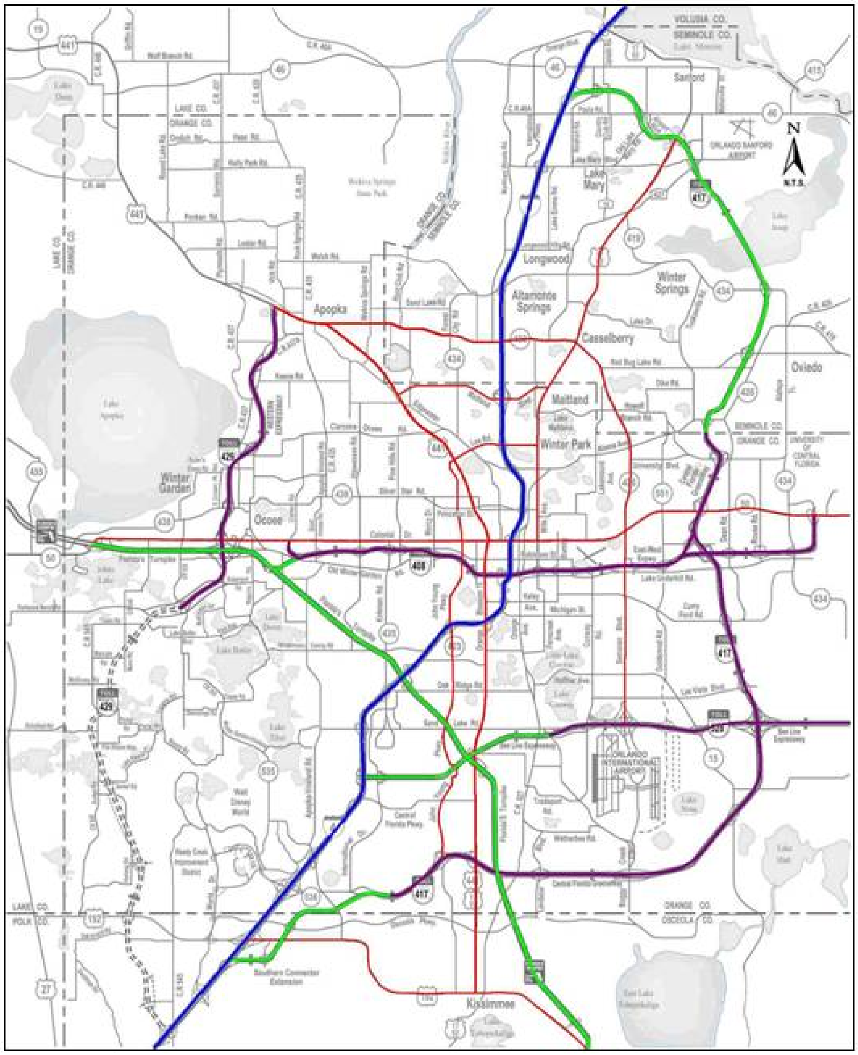

Figure 82. Orlando Metropolitan Area Traffic Monitoring

FDOT complemented these traffic monitoring capabilities with information about incidents obtained through an interface to the FHP CAD system (see section 5) and weather through an interface to a weather data provider (see section 11).

FDOT took advantage of this new information by expanding its Central Florida 511 system to cover all of the roads for which traffic data was available and creating a new Central Florida traveler information Web site. FDOT also posted travel time, congestion, and incident information on DMSs available along I-4 and I-95. In addition, outside organizations used traffic information gathered by FDOT to augment their traveler information—local television and radio broadcasts included more detailed traffic information and Internet content providers (e.g., Google™, MapQuest®, Traffic.com) included Orlando traffic information on their maps.

For statewide traffic information, FDOT relied primarily on incident information received through the FHP CAD interface. However, the agency did deploy a network of 25 traffic monitoring stations at locations scattered across the state. (See section 0 for information about statewide traffic monitoring.) FDOT used this information to support a statewide 511 system and a statewide traveler information Web site.

10.2. Central Florida Freeway Users

In February 2005, FDOT conducted a survey of 400 Central Florida drivers who used Central Florida freeways at least three times per week.[1] This survey provided information about how the public used Central Florida freeways and the traveler information resources available to them. This section of the report summarizes results of that survey.

About three-fourths of the drivers surveyed typically used the freeway during either the morning or evening rush hour. As indicated in Figure 83, most of this freeway usage was work-related during the day, but not work-related at night.

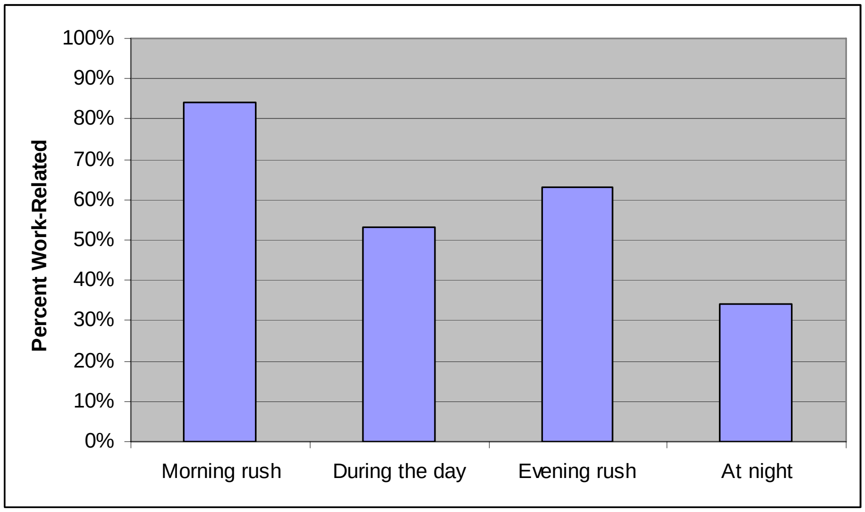

Figure 83. Percent of Freeway Users Whose Travel is Work Related

Almost all of these drivers (about 90 percent) used some source of traffic information, with most relying on radio and television—about 50 percent and 40 percent, respectively.[2] (See Figure 84 for more details.) Only 3 percent indicated that they used 511 for traffic information, with another 2 percent indicating that they used a phone-based subscription service.

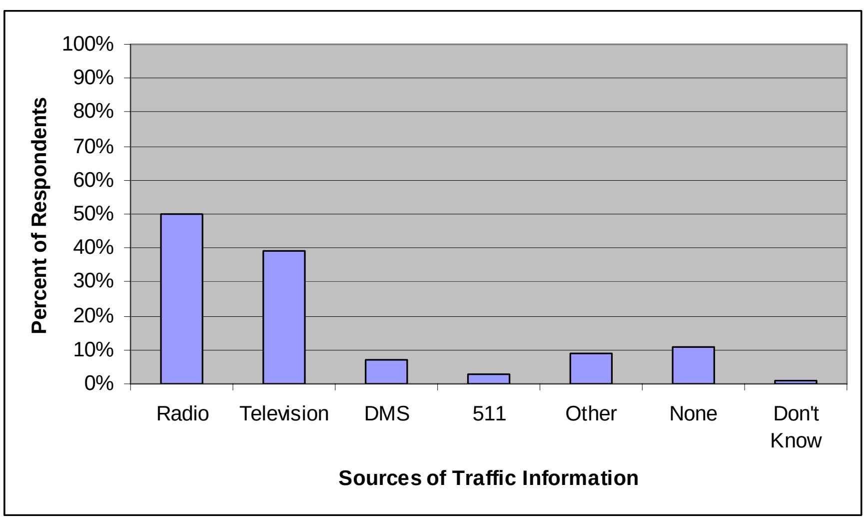

Figure 84. Sources of Traffic Information

[1] *i*Florida Evaluation Telephone Survey, prepared for FDOT in March 2005.
[2] Respondents were allowed to indicate more than one source of traffic information, so the percentages do not sum to 100 percent.

While 50 percent of respondents indicated that they used the radio for traffic information, an even higher percentage (69 percent) indicated that they listen to radio traffic reports often (47 percent) or occasionally (22 percent). Almost all of those who had heard radio traffic reports (87 percent) found them either somewhat or very useful.

Of the drivers surveyed, most (82 percent) have a phone available while driving, though only 25 percent of these would be likely to use their phone to obtain traffic information. About one-fourth of the drivers surveyed were aware of the 511 service. Of those aware of the service, only 36 percent indicated that they had used the service (see Figure 85). Of those that used the service, about one-fourth classified themselves as frequent users. So, about 10 percent of all drivers surveyed reported having used 511, and about 3 percent classified themselves as frequent 511 users.[3]

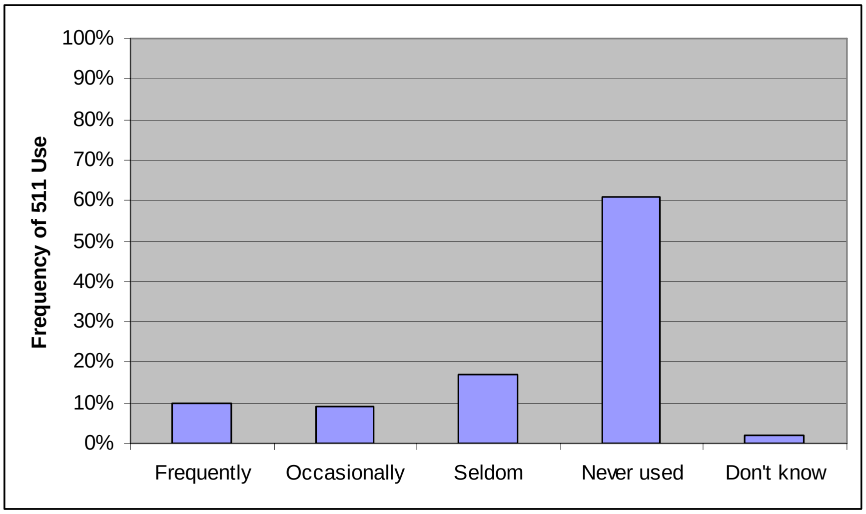

Figure 85. Frequency of 511 Usage for Those Aware of the 511 Service

Because the number of those surveyed who indicated that they had used the 511 service was small (only 40), no quantitative results on their usage preferences were produced. Some qualitative statements on usage patterns were noted:

- Most of the 511 users surveyed indicated that they called the service while on the road.
- Most of the 511 users surveyed indicated that they found the service useful and based travel plans on it.
- Few of the 511 users surveyed indicated that they use 511 to obtain more information about DMS postings.

Though only 18 percent of respondents indicated that they used Web sites for traffic information, an additional 30 percent indicated that they would use such a system if they knew that one was available.

When asked what additional traveler information they would like FDOT to provide to them, a large majority (68 percent) indicated they would like more information about alternate routes (see Figure 86). The preference for more information about alternate routes greatly outweighed the preference for the other options presented to the respondents.

[3] Section 10.4.4 contains results on frequent users gathered from 511 call logs that indicated few 511 callers were frequent 511 users. This likely resulted from a difference in how the term "frequent user" was interpreted. In section 10.4.4, a frequent user was defined as one that called the 511 system several days per week. These two results can be reconciled if those surveyed considered frequent usage to refer to lower levels of 511 usage.

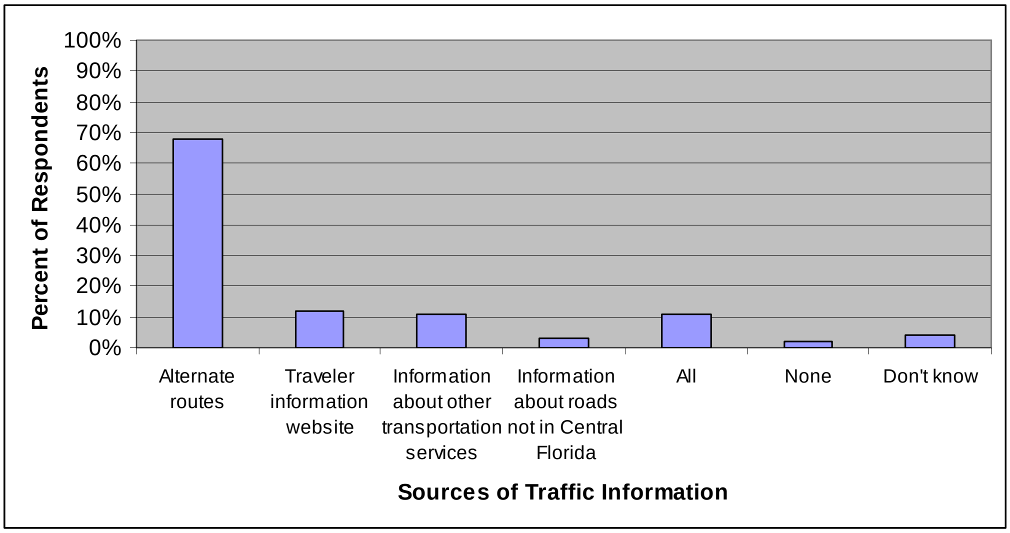

Figure 86. Most Preferred New Traveler Information Resources

10.3. The Central Florida 511 System

The Central Florida 511 system used speech recognition technology to interpret user commands and provide requested traveler information on 13 roads in the Orlando area. In general, the Central Florida 511 system provided travel times for pre-defined segments of road, though the travel time messages were replaced with other messages when incidents occurred. The system supported various types of summary messages that provided callers with alternate formats for traffic information and other features that could be used in special circumstances, such as a hurricane. FDOT monitored caller feedback on the system and continued to refine the 511 system based on the feedback it received.

Section 10.3.1 describes the features of the 511 system in more detail, and section 10.4 describes results related to the usage of this system.

10.3.1. The Characteristics of the Central Florida 511 System

The description of the Central Florida 511 system can be divided into three parts:

- The 511 road segments, which describes the roads covered by the 511 system,
- The 511 architecture, which describes how other parts of the *i*Florida deployment supported 511 operations, and
- The 511 call tree, which describes the menu structure used in the 511 system.

Each of these is addressed below.

10.3.1.1. The Central Florida 511 Road Segments

The Central Florida 511 system included all roads for which FDOT had traffic monitoring equipment deployed. The roads were divided up into sub-segments that were deemed an appropriate size for use in a 511 system. Dividing up the road into sub-segments was an important step for achieving a useful 511 system. FDOT noted that this division would result in a menu structure for the 511 system that was difficult to navigate;

Limited the number of 511 segments for each road simplified the menu structure for choosing a segment.

however, using a small number of long segments would result in traveler information with too little detail to be useful.

FDOT eventually selected a compromise approach between these two extremes. It used relatively long segments in the 511 menu structure—with some segments being more than 20 miles in length—but increased the level of detail by dividing most of these 511 segments into two sub-segments for the purpose of presenting the 511 information. Figure 87 depicts these 511 segments and sub-segments. Each box represents a 511 sub-segment, and the number in each box identifying the associated segment and sub-segment number.

Dividing 511 segments into sub-segments for reporting travel times allowed more detailed travel time information to be presented.

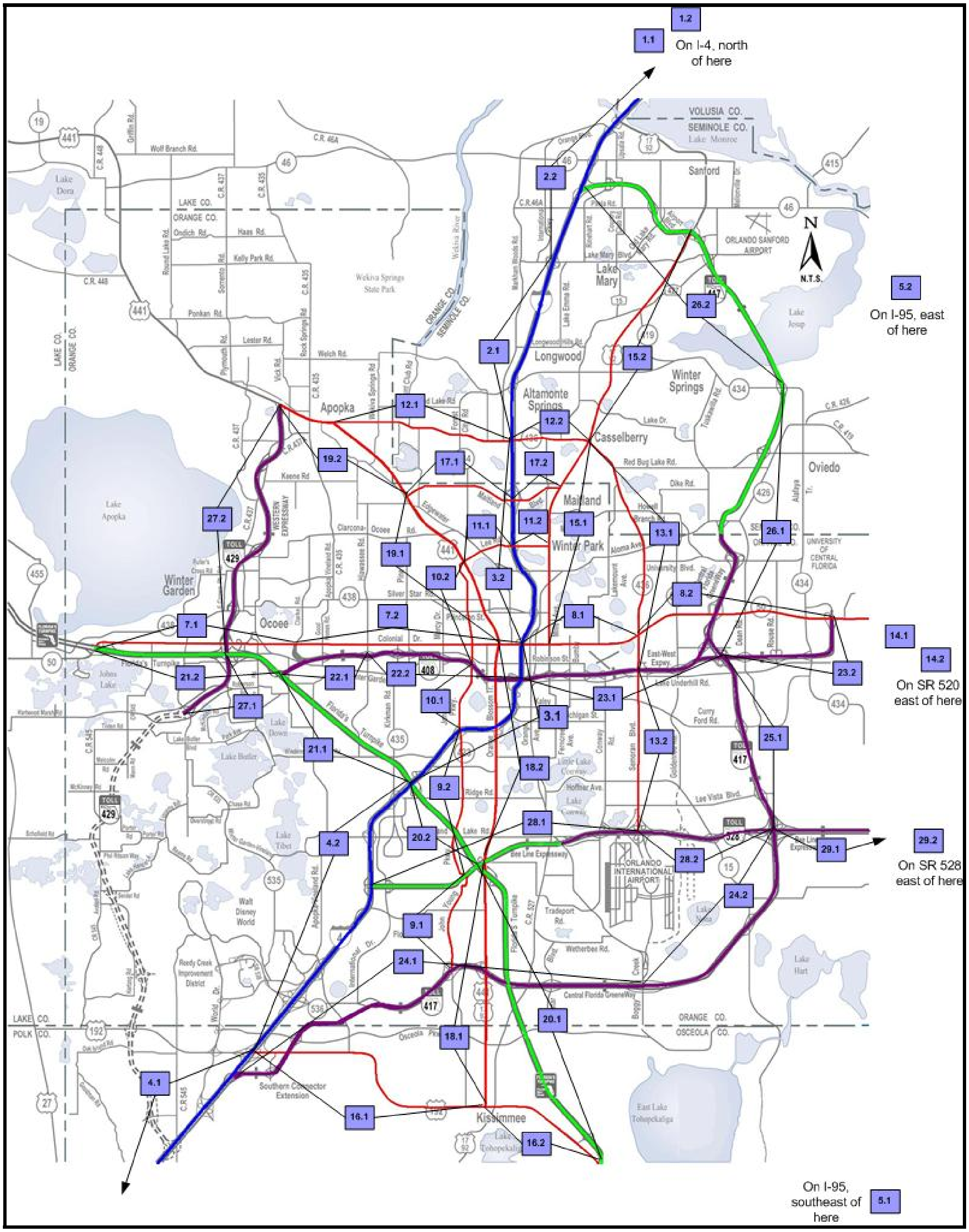

Figure 87. Central Florida 511 System Road Segments

For example, I-4 was divided into four 511 segments, with each segment divided into two sub-segments:

- Segment 4, I-4 from US 27 to the Turnpike, consisted of sub-segment 4.1 (I-4 from US 27 to US 192) and sub-segment 4.2 (I-4 from US 192 to the Turnpike).

- Segment 3, I-4 from the Turnpike to SR 436, consisted of sub-segment 3.1 (I-4 from the Turnpike to SR 50) and sub-segment 3.2 (I-4 from SR 50 to SR 436).
- Segment 2, I-4 from SR 436 to the St. John's River Bridge, consisted of sub-segment 2.1 (I-4 from SR 436 to Lake Mary Blvd.) and sub-segment 2.2 (I-4 from Lake Mary Blvd. to the St. John's River Bridge).
- Segment 1, I-4 from the St. John's River Bridge to I-95, consisted of sub-segment 1.1 (I-4 from the St. John's River Bridge to SR 44) and sub-segment 1.2 (I-4 from SR 44 to I-95).

When a segment was selected from the 511 menu, the 511 system provided traffic information separately for each sub-segment and direction of travel. For example, a caller that selected the I-4 from US 27 to the Turnpike segment might receive a message such as the following:

> ***Travel times on I-4 eastbound. From US 27 to US 192, 15 minutes. From US 192 to the Turnpike, 15 minutes. On I-4 westbound, from the Turnpike to US 192, 10 minutes. From US 192 to US 27, 15 minutes.***

10.3.1.2. The Central Florida 511 Architecture

Support for the Central Florida 511 system was divided into two parts: (1) generating and maintaining 511 messages, which was performed by the CRS, and (2) managing 511 calls and disseminating 511 messages. A schematic of this architecture is contained in Figure 88.

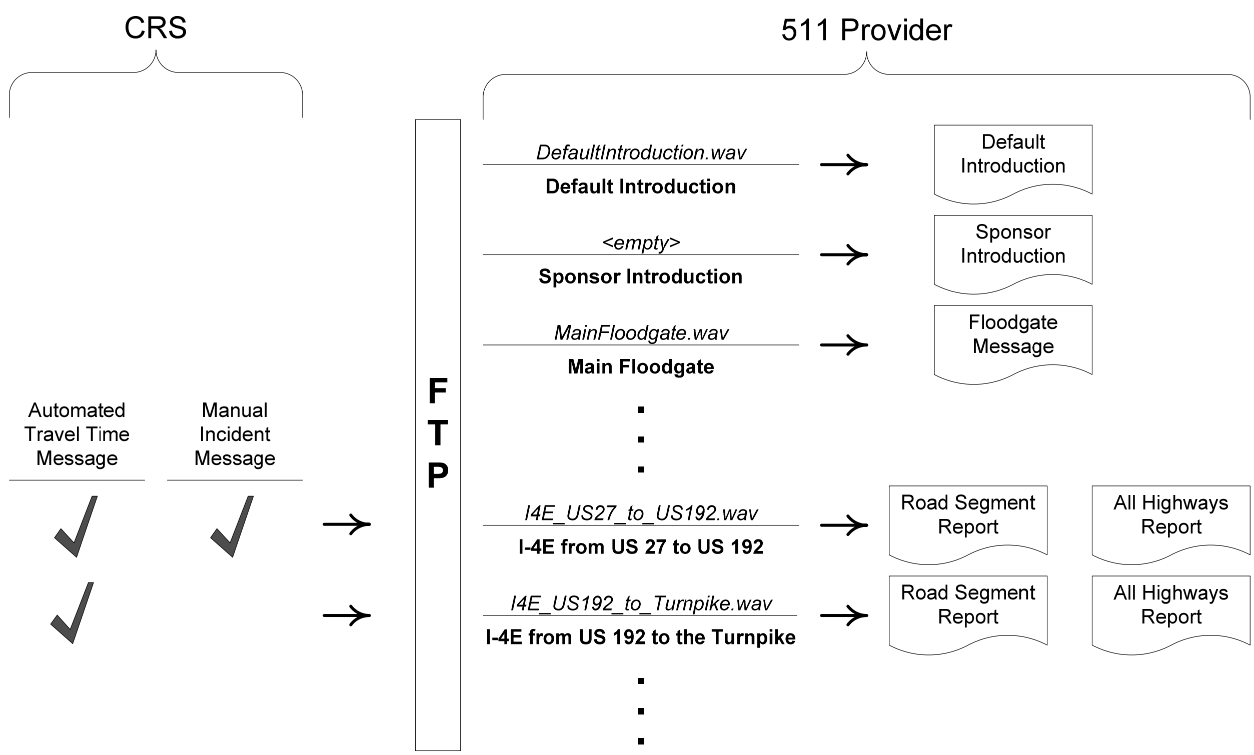

Figure 88. The Central Florida 511 Architecture

The functionality on the right-hand side of this figure was provided by the *i*Florida 511 provider. A menu structure, known as a call tree, was defined, and a 511 user accessed 511 services by navigating through the call tree. (See the next section for more information on the Central Florida 511 call tree.) At certain points in the call tree, the 511 provider played messages to the 511 user, with each message being stored within the system in a Waveform audio format (WAV) file. FDOT could change the messages in the 511 system by replacing these WAV files. For example, changing the file I4E_US192_to_Turnpike.wav changed the message that was played when a 511 user requested the road segment report for I-4 from US 192 to the Turnpike.

The WAV files were changed by using a secure File Transfer Protocol (FTP) to transmit new WAV files to the 511 provider. Transferring a new WAV file I4E_US192_to_Turnpike.wav to the 511 provider would overwrite the previous file with the same name so that future requests to hear the road segment report for I-4 from US 192 to the Turnpike would play the new WAV file.

The CRS software (represented by the left-hand side in the figure above) was responsible for managing and updating these WAV files. This software allowed RTMC operators to record 511 messages manually and associate those messages with specific road segments. When a manual message was recorded, it was sent to the 511 system as a WAV file and played when requested by the user. When no manual message was available for a road segment, the CRS software computed the travel time for that segment and submitted a pre-recorded travel time message to the 511 provider that was specific for that travel time. (FDOT considered pre-recording names for each road segment and numbers for possible travel times and splicing these pre-recorded phrases together to create a 511 travel time phrase. The agency chose to pre-record all combinations of road segments and travel times in order to avoid any loss in audio quality that might result from splicing together road segment names and travel times.)

Pre-recorded travel time messages for all road segments reduced message splicing and increased audio quality.

Although FDOT used the above approach for providing 511 service during part of the *i*Florida operation period, problems with the CRS sometimes forced the agency to use more manual methods. Because the CRS miscalculated travel times for some road segments, FDOT disabled the feature to automatically produce travel times for these segments. In those cases, FDOT prepared WAV files and transmitted them manually via FTP to the 511 service provider for use in the 511 system. The same approach was used during CRS failures, including the final failure in May 2007, when FDOT stopped using the CRS. The availability of this alternate means of maintaining their 511 messages allowed the 511 system to operate reliably even when the CRS did not.

The use of FTP to update 511 messages allowed for continued 511 service even when the TMC management software failed.

10.3.1.3. The Central Florida 511 Call Tree

The operation of the Central Florida 511 system was defined using a call tree, which is essentially a flow chart depicting the possible interactions with 511 users and the response taken by the system for each possible user selection. Figure 89 depicts a summary of the initial call tree proposed for the Central Florida 511 system in May 2005. (This figure depicts only the general structure of the 511 menu system. The actual call tree included many more details, such as features for verifying verbal requests from a user and resolving ambiguities when the system was uncertain how to interpret something said by the user.)

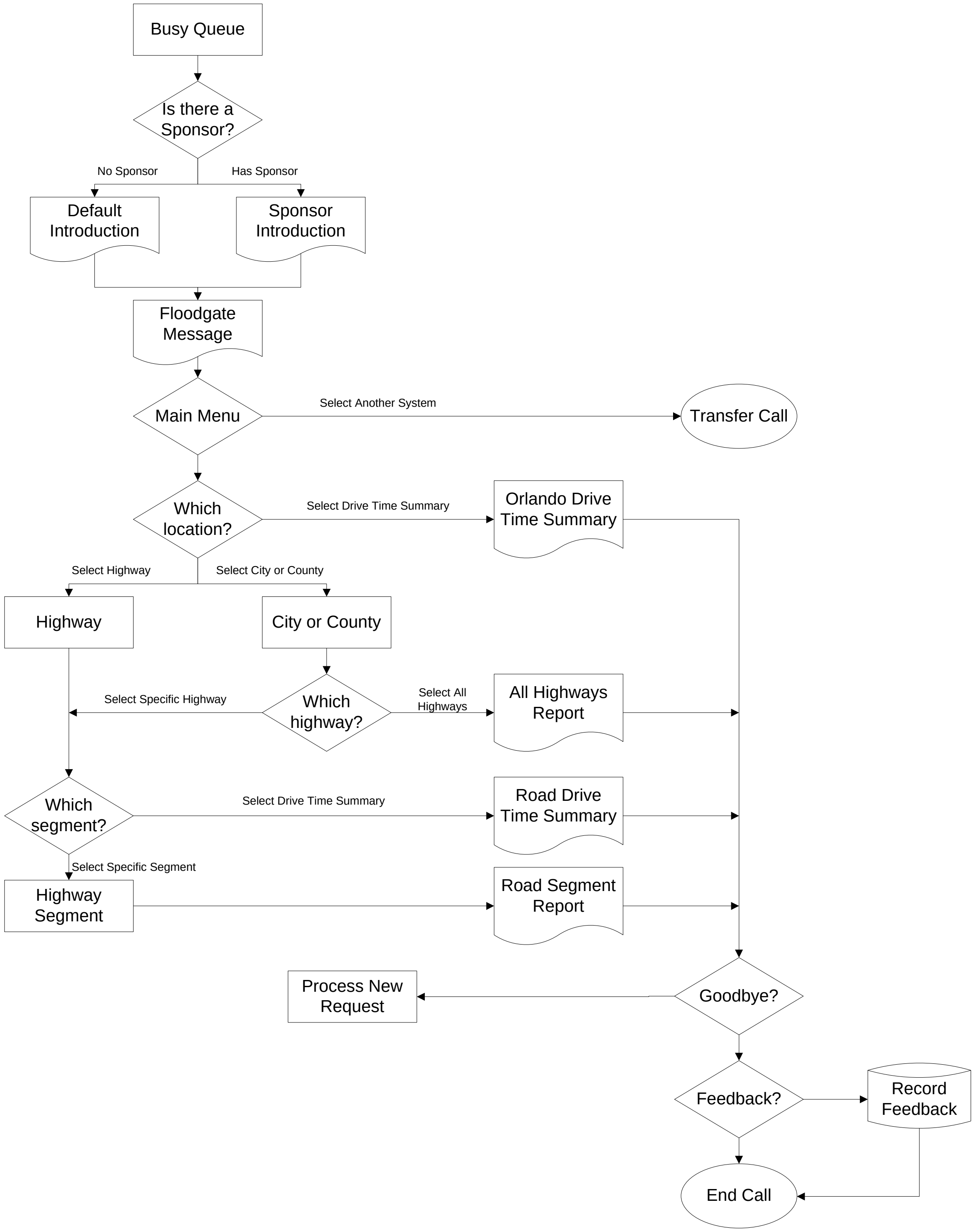

Figure 89. Central Florida 511 Call Flow Summary, May 2005

The following list describes some of the key features of this call tree:

Busy Queue. The Central Florida 511 system was designed to handle up to 255 simultaneous callers. Additional callers heard a message indicating that the system was busy and they should wait for the next available line. Users could also transfer from the Busy Queue to a different 511 system.

Introduction. The system played either a standard introduction or, if available, a sponsored introduction. The sponsored introduction feature gave FDOT the capability of crediting private sector sponsors that helped support the 511 system. This feature was not used during the iFlorida Model Deployment.

Main Menu. The main menu allowed the user to transfer to another system or to request traffic information. The other systems included other 511 systems in the area, as well as phone information systems for other nearby transportation organizations, such as LYNX, Port Canaveral, the Orlando International Airport, and the Orlando Sanford International Airport.

Orlando Drive Time Summary. This feature provided a brief summary of traffic conditions in Orlando. During the morning rush hour, it focused on inbound traffic coming into Orlando. At other times of day, it focused on outbound traffic.

Selecting a Highway. This menu option allowed a 511 user to select a highway for which they wanted to receive traffic information. FDOT supplied the 511 provider with a list of highways to use in the system, including a number of pseudonyms used for each highway and pronunciation guides for difficult-to-pronounce names.

Selecting a City or County. This menu option allowed a 511 user to select a city or county by name. FDOT provided the 511 provider with a list of county and city names. (All counties in the Orlando area were included, and all cities with a population above 6,000 residents.) When a city or county was selected, the user could either request information for all roads or select a single highway in that city or county.

Road Drive Time Summary. This feature provided a brief summary of traffic conditions on a particular road.

Road Segment Report. This feature provided traffic condition information for a segment of road. In general, this was the current travel time for that segment of road, though a custom message might be used if an incident or congestion occurred.

All Highways Report. This feature provided the road segment reports for all segments on the selected highway.

User Feedback. The user could leave feedback for FDOT's review.

Other general features of the system were that it ended a call (after giving the user an opportunity to leave feedback) if the system did not understand four successive user requests, ended a call (after informing the user) if a call exceeded 10 minutes in length, and restarted a call where it left off if a user called back within 2 minutes of being disconnected.

As soon as the Central Florida 511 system went live in November 2005, FDOT began monitoring the user feedback daily. This allowed FDOT to identify ways to improve the system. For example, users began complaining about the complexity of the menu structure soon after the system went live. (The previous 511 system provided traveler information only for I-4, so a much simpler menu system was used.) In early 2006, FDOT simplified the call tree to make it easier for callers to access traffic information quickly. Over the following two years, FDOT made a number of additional improvements to the Central Florida 511 system:

Monitoring feedback helped adapt the call tree to better meet user expectations.

- The content of several key menus (e.g., the main menu, the menu for selecting a city, county, or highway) was shortened significantly.

- The number of synonyms used to identify locations in the 511 system was increased. FDOT regularly monitored the 511 system to identify user statements that were not understood by the 511 system. When common synonyms were identified, FDOT would add them to the list of key words understood by the 511 system. In some cases, the 511 system was updated to better interpret local pronunciations of some words.

Monitoring user requests that could not be interpreted by the system allowed new phrases and pronunciations that should interpreted by the 511 system to be identified.

- The capability was added to state a flood gate message before providing traffic information. This message could be used when a significant incident existed that affected many roads in the Orlando area.
- The 511 system was updated to provide more sophisticated transfers to other systems, including better management of calls that could not be immediately transferred because the line to the receiving system was busy.
- The methods for processing a request to hear information about all highways in a city or county were modified to present different menu structures, depending on the number of highways in the selected city or county.
- The menu structure that clarified which of two highways a user mentioned when two interpretations were similar was removed from the system. Instead, the system suggested the highest rated option and asked the user to confirm it. If the user did not confirm the presented option, the system tried again, remembering that the presented highway was not the one of interest to the user.
- The menu structure for presenting traffic information when multiple segments were selected was changed to present, by default, drive time summaries. The user could also elect to hear the detailed segment-by-segment reports.

In August 2007, FDOT modified the menu structure so that a user could more easily request either travel times or drive time summaries. The "which location" decision point shown in Figure 89 was changed so that a user could specify either "summary" for a drive time summary or "travel time" for more detailed travel times.

Beginning in early 2008, FDOT introduced a new feature to the Central Florida 511 system, called Travel Time Summaries, which provided travel time information along two or more alternate routes between locations in the Orlando area. First, FDOT identified six key locations that were common origins and destinations for trips and for which more than one route existed between the locations (see Figure 90). A user specified an origin and destination location, and the 511 system presented travel times for all of the alternate routes between the specified locations. For example, a user selecting Southside as the origin and Downtown as a destination was presented with travel times on two alternate routes between these locations, one via I-4 and the other via SR 417 to SR 408. The intention was to provide 511 users with information specifically tailored to help with trip planning by indicating which of the alternate routes available would provide the fastest travel time.

Travel time summaries were used in the 511 system to provide travel times for alternate routes between pre-defined locations.

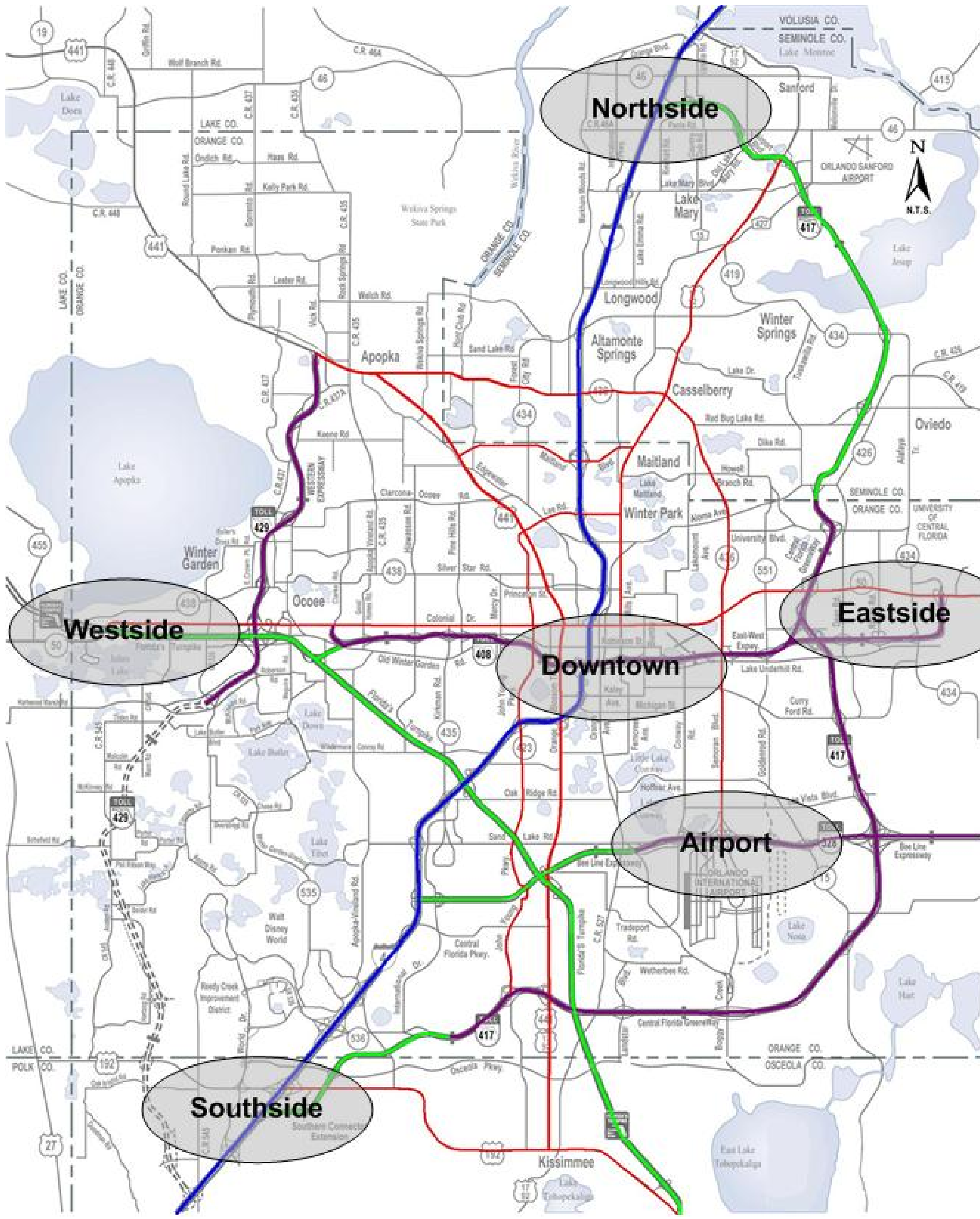

Figure 90. Locations Used for Central Florida 511 Travel Time Summaries

Throughout the period from November 2005, when the Central Florida 511 system went live, to early 2008, FDOT continued to work to find ways to make the system more useful.

10.4. Usage of the Central Florida 511 System

This section of the report presents results from the analysis of usage statistics for the Central Florida 511 system.

10.4.1. Overall Usage of the Central Florida 511 System

Prior to the start of *i*Florida, the Orlando 511 system was already receiving nearly 5,000 calls per day, making it the third most frequently called 511 system in the United States behind the San Francisco and Southeast Florida 511 systems. The changeover from the previous 511 system in Orlando, which provided travel times only for I-4, to the more expansive Central Florida 511 system resulted in an apparent drop in the number of 511 calls received by the system, as depicted in Figure 91.

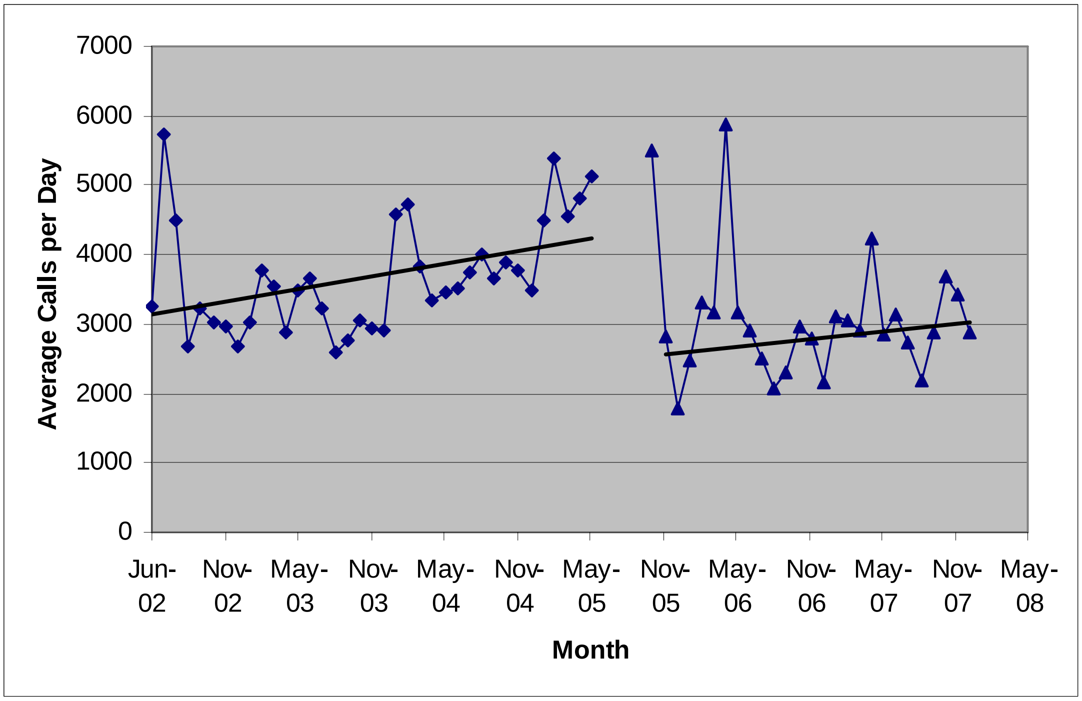

Figure 91. Average Number of Central Florida 511 Calls Per Day by Month

This chart indicates a steep drop in call volumes, from about 5,000 calls per day in June 2005 to 3,000 calls per day in December 2005, though the trend lines indicate that a similar growth rate applied before and after the transition to *i*Florida. (The trend line for the after *i*Florida period excludes the data points for November 2005 and May 2005. The first was excluded because the transition to the new system and media coverage surrounding that transition resulted in increased usage. The second was excluded because widespread fires resulted in anomalously high usage that month.)

Transitioning to a new 511 system may alienate existing users accustomed to the former system.

One cannot be certain that this drop was a direct result of the transition to the new system. It is possible that the approach used to tally the number of calls received changed because a new vendor implemented the new system. The publicity surrounding the unveiling of the 511 system in November 2005 could have resulted in a greater demand at the time of the event. A plot of the average number of calls per day by week (see Figure 92) during the first six months of operation of the new 511 system supports the conclusion that this drop was real.

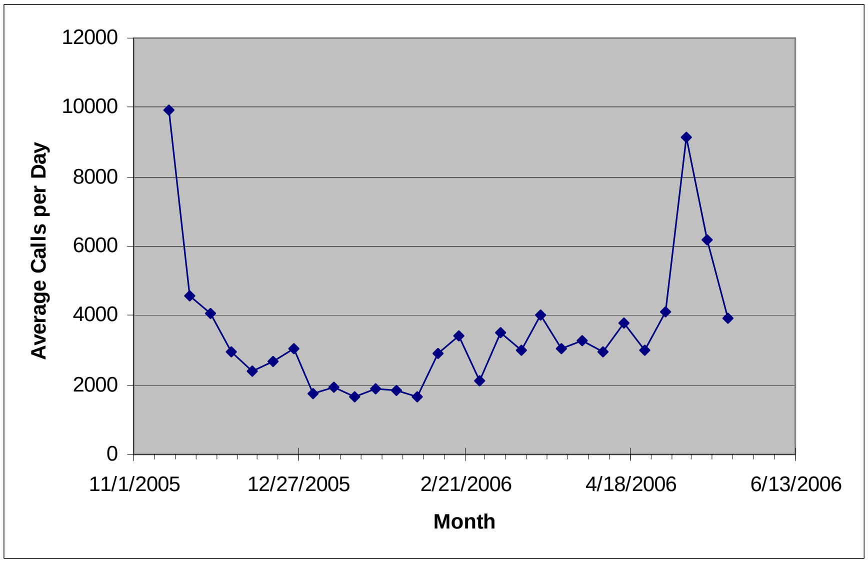

Figure 92. Average Number of Central Florida 511 Calls Per Day, 11/2005 Thru 5/2006

The number of calls per day in the first week of operation (i.e., while publicity was ongoing) was very high, but quickly dropped down to levels comparable to pre-*i*Florida levels. The number of calls per day then consistently dropped during the first 12 weeks of operation before beginning to rise again in February 2006.[4] At the same time, FDOT received a large number of complaints from previous users that indicated they were unhappy with the new system. Many of these complaints were related to the difficulties former users found in navigating the new menu structures and using the speech recognition features. It appears that the transition to the new 511 system resulted in a significant loss of former users of the 511 system.

Another period of particular interest was the period from May 2007 through September 2007. In May 2007, the CRS failed and FDOT could no longer automatically populate the Central Florida 511 system with travel time information. (See section 2 for more information on the failure of the CRS.) From that time until September 2007, when the SunGuide software that replaced CRS was capable of automatically populating 511 messages, FDOT set 511 messages manually. For I-4, FDOT continued to have access to raw loop detector data and traffic video, and RTMC operators used this information to set travel time messages. FDOT's access to traffic data for other roads was limited, and 511 messages for those roads were based primarily on historical travel times. One might have expected to see a significant drop in the number of 511 users because of the reduced quality of the travel time information available on the 511 system. This did not occur, as shown in Figure 93.

[4] The usage spike in May 2006 was related to a series of large fires that resulted in many road closures. This topic will be addressed later in this report.

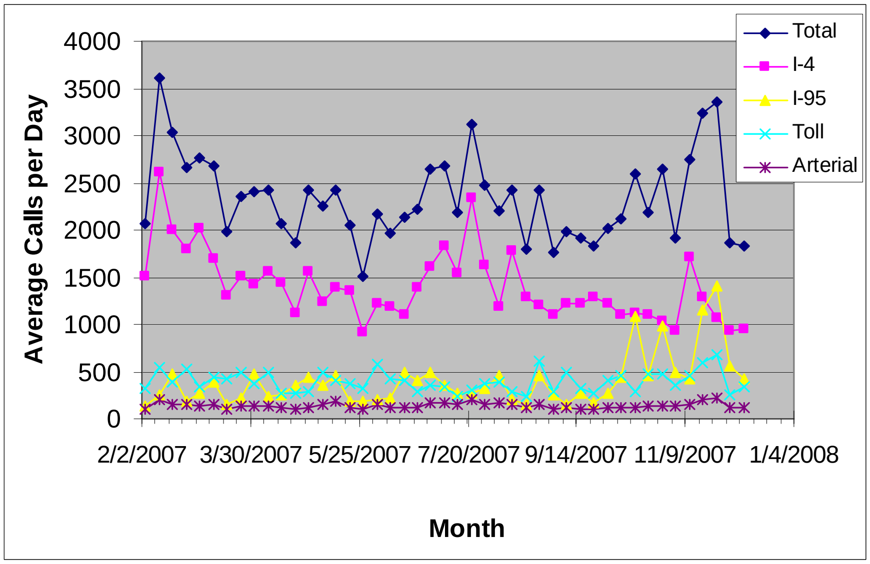

Figure 93. Average Number of Central Florida 511 Calls Per Day, 3/2007 Thru 12/2007

It is interesting to note the difference between the response of 511 users to the changes in November 2005 and those in May 2007. In November 2005, when FDOT made significant modifications to the menu structure and increased the quantity of available data, a large drop in the number of 511 calls occurred. In May 2007, when FDOT was forced to reduce the quality of the 511 data that was available, no such drop occurred.

Another factor related to 511 usage was the source and timing of the 511 calls. Do travelers call 511 before departing or while on the road? One indirect measure of this was the proportion of 511 calls that were made from a wireless phone, as depicted in Figure 94. This figure indicates that between 60 and 70 percent of 511 calls originated from cell phones. (Note that this chart and the one that follows includes callers to both the Central Florida and Statewide 511 systems. The available data did not allow separate analysis for the two systems.)

Most 511 calls are made while users are on the road.

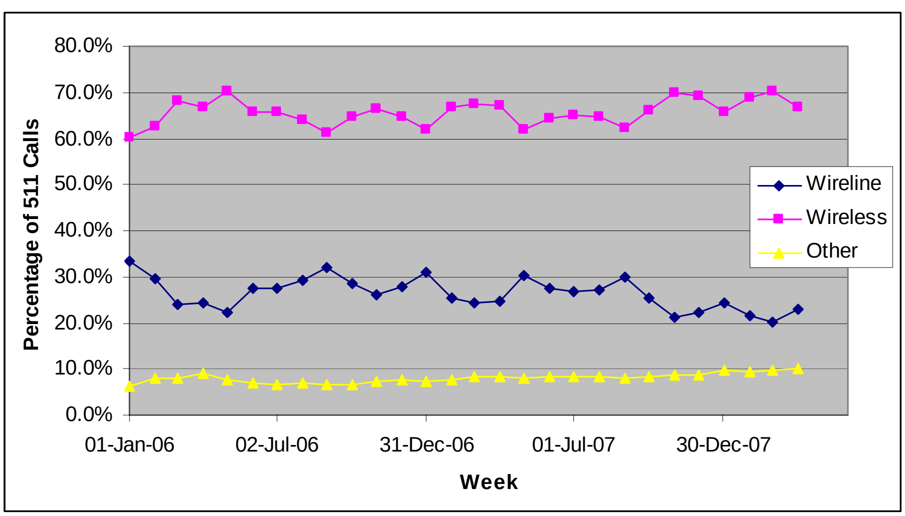

Figure 94. Percentage of *i*Florida 511 Calls from Wireless Phones

While it is possible that these cell phone users are calling 511 before starting to drive, a survey of 400 Central Florida freeway drivers[5] indicated that most 511 users call the service while on the road. Since 90 percent of 511 users make two or fewer call per week (see section 10.4.4), the conclusion regarding the number of users making calls was likely applicable to the number of calls, as well. The combination of observations, while not conclusive, strongly implied that most 511 calls were made while drivers were already on the road.

While the percentage of 511 calls that were made from cell phones was typically between 60 and 70 percent, the percentage was much higher on days when 511 usage was high, as shown in Figure 95.

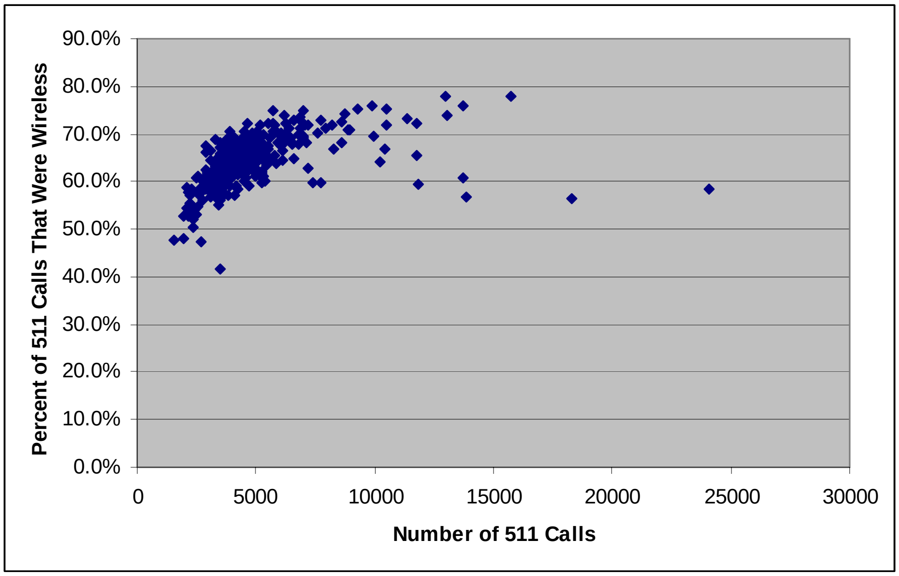

Figure 95. Percentage of 511 Calls from Cell Phones by the Number of Calls Per Day

The implication is that, on most days where 511 usage was high, drivers in cars were using cell phones to call 511 in order to obtain additional information about unusual traffic conditions of which they were already aware. The six anomalous points, points with usage above 10,000 calls per day and percent of calls that were wireless below 65 percent, all occurred in May 2007 when large brush fires caused road closures in the Orlando area. During that period, travelers were apparently calling the 511 service to obtain information on road closures before departing.

While the above results depict the general trends in usage of the Central Florida 511 usage, there were also important variations by day of the week and from day to day. Figure 96 depicts the average number of calls by day of the week for the Central Florida 511 system for the period from January 1, 2006, through February 2, 2008. This chart indicates that, in Orlando, 511 usage was much higher on Fridays than on other days of the week.

[5] *i*Florida Evaluation Telephone Survey, March 2005.

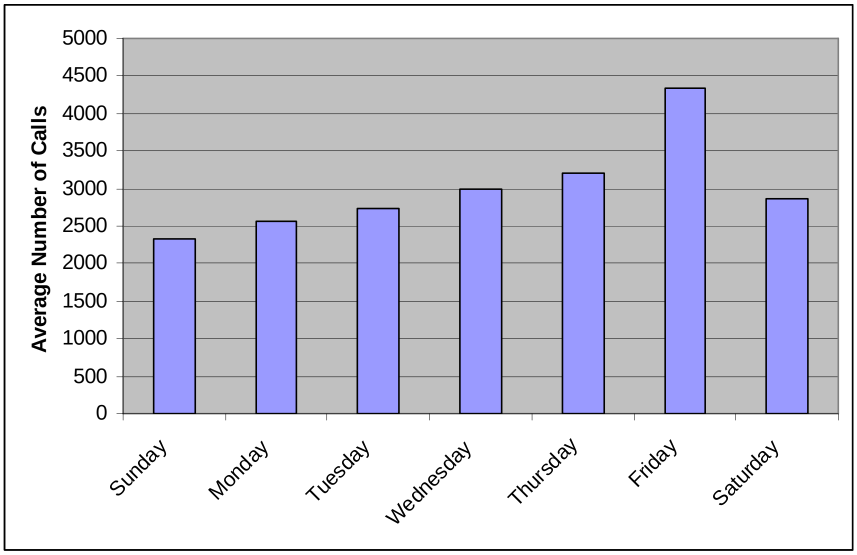

Figure 96. Average Number of Central Florida 511 Calls by Day of the Week

Usage also differed by time of day, as shown in Figure 97. Weekday call volumes showed a strong peak from about 4:00 p.m. until 6:00 p.m., corresponding to the afternoon rush hour. Saturday and Sunday call volumes were spread more evenly throughout the day.

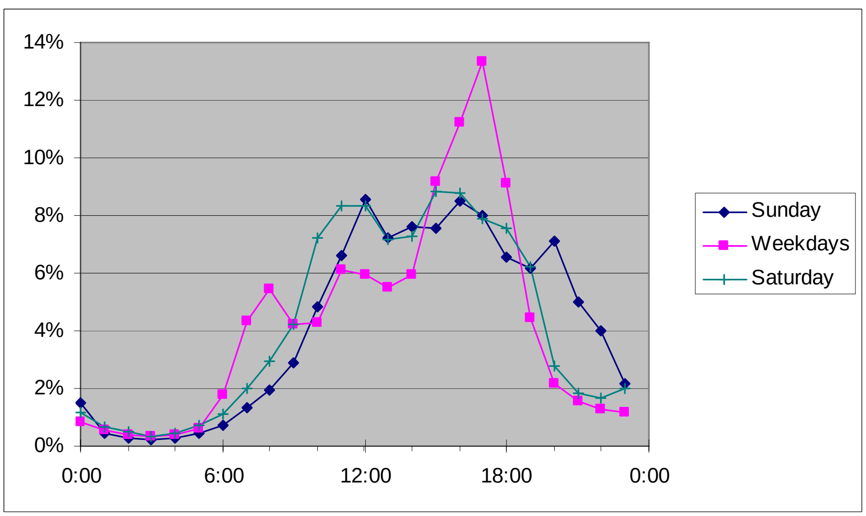

Figure 97. Percentage of *i*Florida 511 Calls by Time of Day

Usage also varied from day-to-day, even on the same day of the week, as shown in Figure 98. This figure shows the percentage of days (Tuesday, Wednesday, and Thursday only) during the period from January 1, 2006, through February 23, 2008, for which different daily call volumes were achieved.

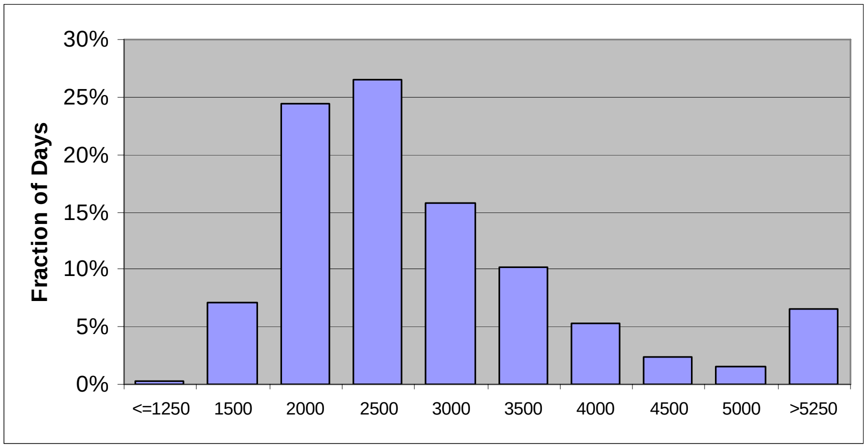

Figure 98. Fraction of Days by Number of Calls; Tuesday, Wednesday, and Thursday

This chart implies that the Central Florida daily 511 usage could be divided into two groups, one comprising about 94 percent of the days, which followed a unimodal distribution,[6] and the other group comprising the remaining 6 percent of the days, which were high usage outliers. These outliers are often associated with an event that results in higher-than-average usage. It was suspected that these days of high usage were related to specific events that occurred on those days. Partial support for that hypothesis comes from an examination of these high usage days.

About 5 percent of days had much higher than usual 511 call volumes, and those days often occurred in conjunction with unusual traffic incidents.

For example, 10 of the 15 days in this category in Figure 98 occurred in May and early June 2006, when brush fires were causing closures of roads in Central Florida, including I-95, SR 520, and SR 528. The demand for information about these road closures was apparent in the types of information requested by 511 callers, as shown in Table 14.

Table 14. Central 511 Requests on Days of High 511 Usage

511 Request	April 2006	4/20/2006	5/3/2006	5/4/2006
I-4	2,077	4,457	2,587	2,245
I-95	129	102	1,216	722
SR-408	119	109	110	78
SR-528	49	72	730	795
Florida's Turnpike	86	81	112	71
SR-50	25	39	94	149
US-17/92 (Mills)	30	42	45	36
OBT (US-441 / US-17 / US-92)	32	53	35	27
SR-417	43	86	63	30
US-192	26	34	38	28
SR-520	16	22	280	234
SR-436	17	28	16	34
SR-423	9	23	7	8
Maitland Blvd. (SR-414)	7	23	6	8
SR-429	8	13	6	9

[6] A Gamma distribution fit to this data had a mean of 2,579 and a standard deviation of 742.

In this table, the first column indicates a highway for which the Central Florida 511 system could provide traffic information. The April 2006 column is the average number of daily requests for the Tuesdays, Wednesdays, and Thursdays in April 2006. The other columns list the number of requests on the day indicated. Note that on May 3 and 4, 2006, most of the additional requests for information were concentrated on the roads that were subject to closure because of smoke from the fires. Similar usage patterns existed for the other days in May and early June when usage was high and road closures due to brush fires were a threat.

A different event explained the high usage on April 20, 2006, where the additional 511 requests were concentrated on I-4. A review of the time of those requests (see Figure 99) indicates that a large increase in requests began to occur between 9:00 a.m. and 10:00 am. A review of the DMS message logs indicated that a crash occurred at about 9:30 a.m. on I-4 westbound near Lee Road. Messages were posted on two DMSs, one located at SR 436 and one located west of Lake Mary Boulevard. The sign at Lake Mary Boulevard continued to display information about this crash until 11:20 am. A review of travel speeds on I-4 westbound shows speeds of less than 20 mph over an approximate 1.5 mile portion of I-4 lasting from about 9:30 a.m. until nearly noon. Traffic volumes in the westbound direction also dropped dramatically, from more than 1,800 vehicles per lane per hour to about 350 vehicles per lane per hour. The location and time extent of the increased 511 usage seemed to correspond with travelers seeking information about this crash and the resulting congestion.

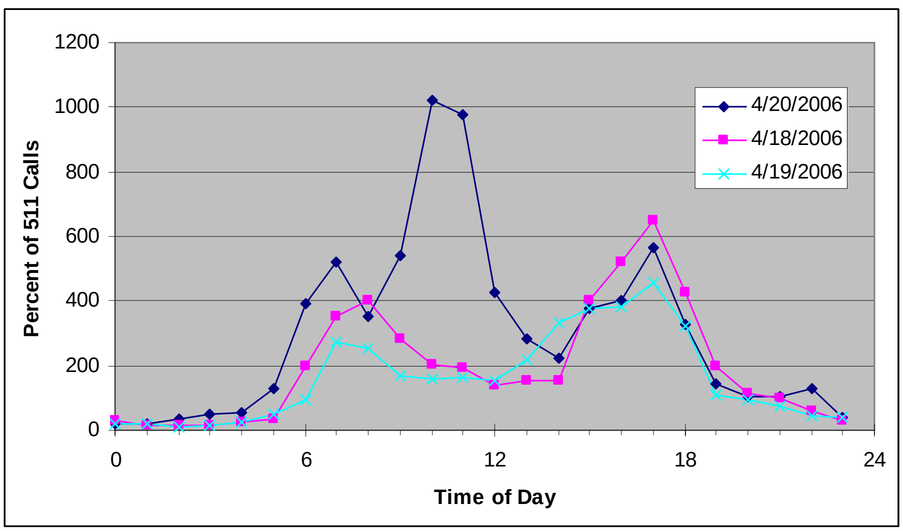

Figure 99. Central Florida 511 Usage by Time of Day for 4/20/2006

Comparing the number of 511 calls that occurred on April 20 with the average number of calls on April 18 and 19 indicated that, during the 3 hour period from 9:00 a.m. until noon, this crash generated an additional 2,235 calls over normal call volumes. The normal traffic volume for the westbound section of I-4 during this period would be about 14,000 vehicles. These 2,235 calls to 511 represented about 16 percent of the vehicles that were likely directly impacted by the delays caused by this crash.

A significant percentage of the drivers of vehicles impacted by an incident appeared to call the 511 system.

A review of other days with much larger than average 511 call volumes revealed a similar pattern. On March 9, 2006, about 3,000 more calls came in to the 511 system than on previous days, with the highest call volumes occurring between 8:00 a.m. and 4:00 p.m. and between 7:00 p.m. and 9:00 p.m.

On that day, DMSs reported crashes on I-4 in Orlando from 9:24 a.m. until 11:43 a.m. (eastbound near SR 408), from 10:56 a.m. until 11:32 a.m. (eastbound near Orange Blossom Trail), and from 8:08 p.m. until 8:52 p.m. (eastbound near Fairbanks Avenue). A review of congestion on I-4 indicated unusually severe congestion between about 9:00 a.m. and 3:00 p.m. and between about 7:00 p.m. and 9:00 p.m., correlating well with the increased 511 usage pattern. These 3,000 calls represent about 19 percent of the vehicles that were likely directly impacted by the delays caused by these crashes.

One interpretation of this result is that about 15 percent of drivers who observed unusual congestion related to the incident called 511 for additional information about traffic conditions.

10.4.2. The Duration of Central Florida 511 Calls

The duration of the 511 calls was another useful metric for assessing the performance of the system. This metric is important in two ways. First, the value of this metric impacts the number of simultaneous call that will occur during operations—for the same number of calls, longer calls will generate more simultaneous calls. This metric also measures the quality of the service provided to the caller, in that a caller is better served if they receive more traffic information in less time. Figure 100 depicts the average duration of Central Florida 511 calls for each month from November 2005 through April 2008. (In computing this average, calls of length less than 15 seconds were excluded from the average as these calls were too short for the caller to receive traveler information. These calls averaged between 6 and 8 percent of all calls throughout this period. Calls of length greater than 5 minutes were also excluded because FDOT periodically made very long calls to test system operations. These calls were rare, at about 0.1 percent of all calls.)

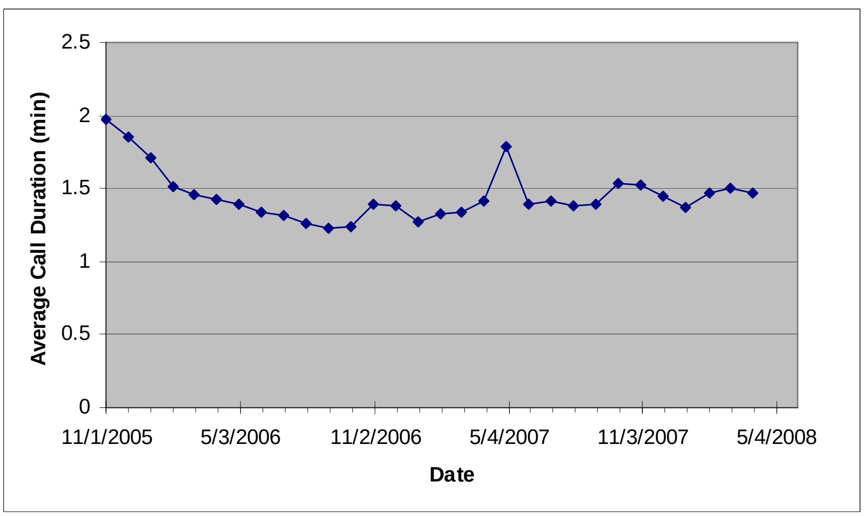

Figure 100. The Average Duration of Central Florida 511 Calls

The evolution of the call durations is depicted in Figure 101. Soon after the deployment, the calls showed a wide range of durations, perhaps because callers were spending more time experimenting with the new 511 features. By March 2006, the call durations began to cluster around the median of about 70 seconds.

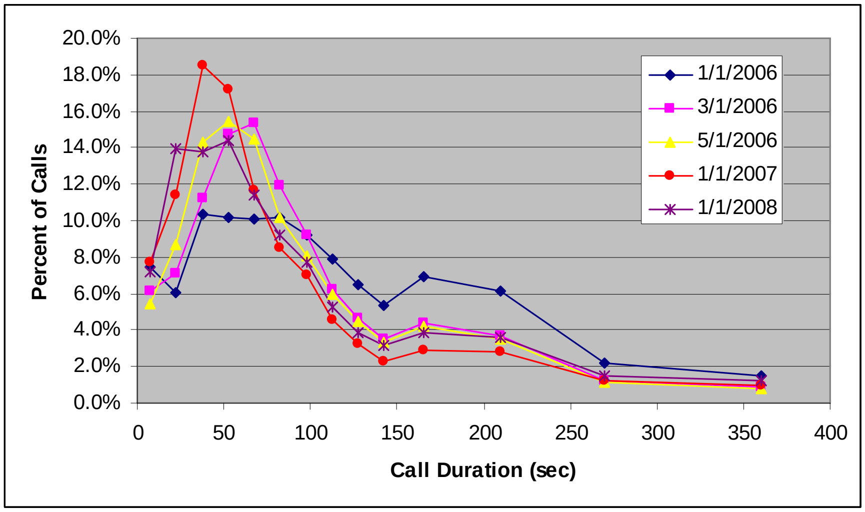

Figure 101. Distribution of 511 Call Durations

This median is, in part, explained by the results of Figure 102, which depicts the distribution of call durations on March 26, 2008, according to the number of traffic information messages received by the caller. The average call duration of Figure 101 is between the distributions for callers receiving one and two traffic information messages.

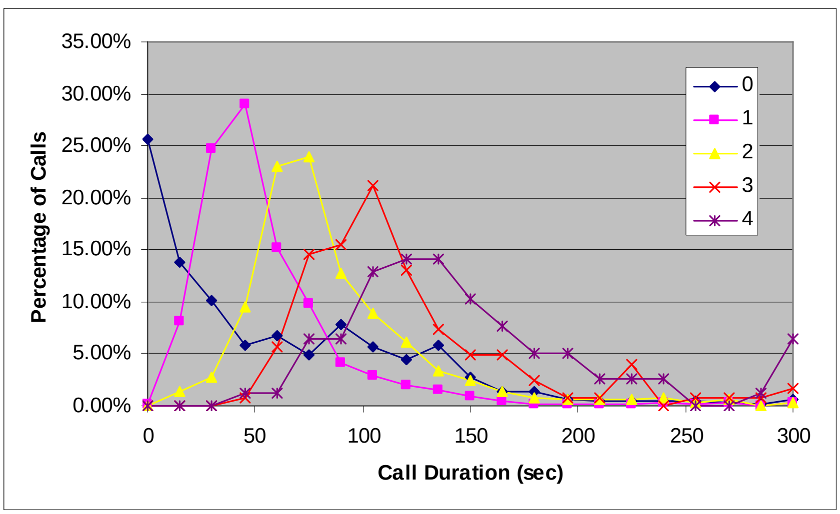

Figure 102. Call Duration by Number of Traffic Information Messages Received

This figure also provides information about the time required for users to obtain traffic information from the Central Florida 511 system—it took about 50 seconds to receive the first traffic information message from the system and about 30 seconds for each additional traffic information message.

10.4.3. Information Requested from the Central Florida 511 System

One of the new features of the Central Florida 511 system was the inclusion of many additional roads in the system. Figure 103 depicts the average number of Central Florida 511 requests per day by the type of road for which the request was made for each month from December 2005 through March 2008.

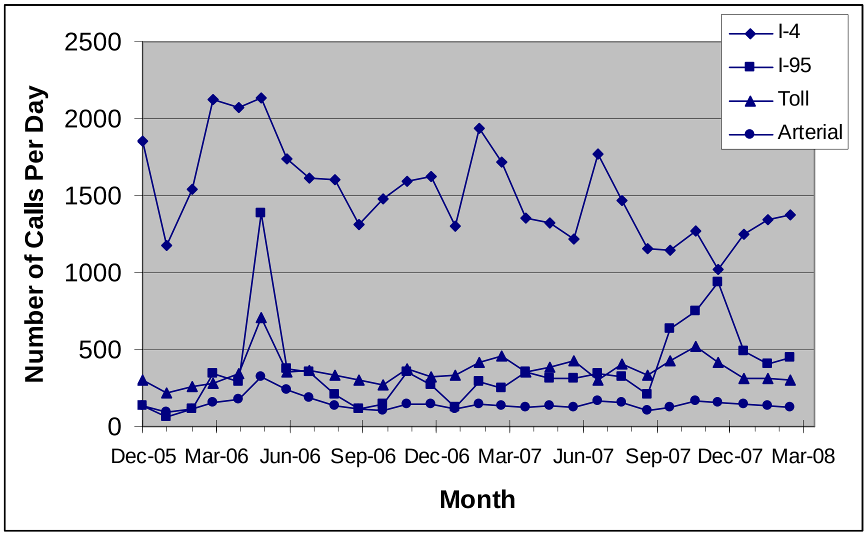

Figure 103. Number of Central Florida 511 Requests by Type of Road

Figure 104 depicts the same data, but presented as a stacked area chart showing the percentage of the requests for each type of road.

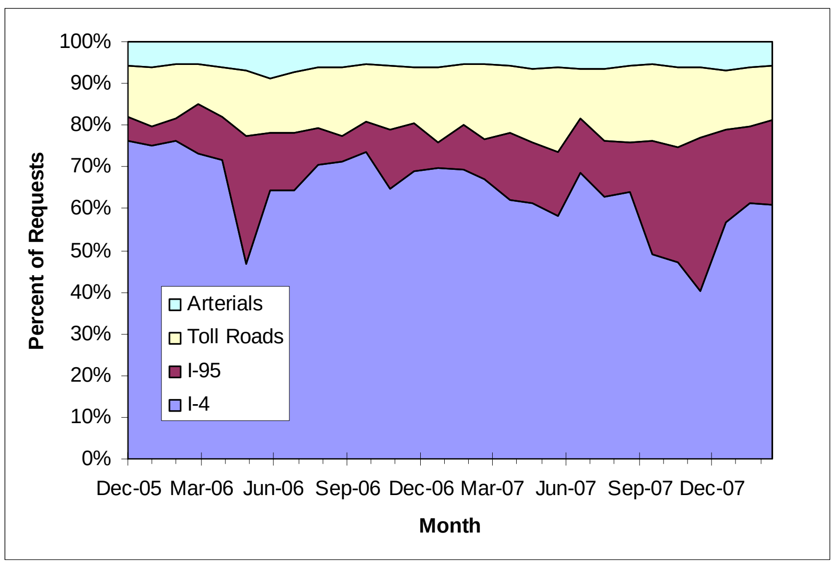

Figure 104. Percentage of Central Florida 511 Requests by Type of Road

Note that few requests were made for information on arterial traffic conditions, averaging less than 150 requests per day, and the number of these requests did not seem to increase over time. There was apparently little demand for this type of traveler information. Requests for traffic information on limited access roads was more frequent, averaging a combined total of 300 requests per day for the 5 toll roads, over 400 requests per day for I-95, and around 1,300 requests per day for I-4. The number of requests for I-4 information decreased with time, while the number of requests for information about I-95 and the toll roads increased over time. The requests for arterial traveler information showed little change over this period.

511 users made few traffic information requests for arterials.

The number of requests for traffic information also varied from segment to segment within these roads. Table 15 lists this variation for the 511 calls made during three days in early 2008. As might be expected, the most requested segments were those near central Orlando (e.g., the portion of I-4 from the Florida Turnpike to SR 426, the portion of SR 408 from I-4 to SR 50).

Table 15. Percentage of Central Florida 511 Requests by Segment Within a Road

Road	Percentage of 511 Requests			
	Segment 1	Segment 2	Segment 3	Segment 4
I-4	13%	65%	13%	9%
I-95	76%	18%	5%	0%
Turnpike	30%	61%		
SR 408	24%	76%		
SR 417	25%	30%	45%	
SR 528	36%	64%		
US 17/92	98%	2%		

To put these numbers in perspective, a recent estimate put the number of daily trips taken on I-4 as 1.53 million.[7] Assuming that each request for traffic information on I-4 is made in conjunction for preparing for a trip that might include I-4, the fraction of total trips on I-4 for which 511 is used to help plan the trip was less than 0.1 percent. While the Central Florida 511 system may have helped users of the system avoid using I-4 when traffic conditions on I-4 are poor, it did little to relieve congestion on I-4—there simply were not enough users of the system to have a significant impact on congestion.

> ***The percent of I-4 travelers using the 511 system for information on I-4 traffic is very small—too small to have a measurable impact on traffic conditions and congestion.***

Over the course of the evaluation, FDOT also introduced several different ways to access 511 information. Initially, the system used two types of informational messages: floodgates were used to provide information to all callers (e.g., during a hurricane) and segment reports were used to provide information about selected segments of road (e.g., a portion of I-4). If a user requested information about an entire road, the information was provided by concatenating together a series of segment reports. Later, FDOT added other formats for this data. Drive time summaries provided summary information about traffic conditions for vehicles traveling towards Orlando in the morning and away from Orlando in the afternoon. Link summaries provided a summary of traffic conditions for an entire road. Road floodgates were used to provide information to all users that requested information about a particular road. Table 16 lists the number of 511 requests fulfilled by the Central Florida 511 system on the last Wednesday of each month, beginning in January 2007. These results indicated that most Central Florida 511 users received segment reports when they called the 511 system.

[7] Central Florida Commuter Rail Transit Environmental Assessment, March 2007. Analysis of FDOT data performed for this evaluation estimated about 7.5 million average daily vehicle miles traveled for the portion of I-4 covered by the Central Florida 511 system. If the average trip length were about 4.9 miles, the two estimates would agree exactly. The vehicle miles traveled data indicates 1.53 million is a reasonable estimate for the daily number of trips.

Table 16. Number of 511 Requests Fulfilled by Type of Request, Central Florida 511

Date	Floodgate	Link Floodgate	Segment Report	Link Summary	Drive Time Summary
1/31/2007	0	0	2,140	1,008	26
2/28/2007	0	0	2,747	1,032	17
3/28/2007	5	0	2,110	783	14
4/25/2007	0	0	2,502	753	26
5/30/2007	0	0	2,380	742	24
6/27/2007	0	0	5,203	715	118
7/25/2007	2,734	0	3,610	519	0
8/29/2007	2,650	5	3,439	596	0
9/26/2007	2,245	0	2,562	0	0
10/31/2007	4,702	0	5,339	0	0
11/28/2007	2,980	31	2,769	0	0
12/26/2007	402	21	9,679	0	0
1/30/2008	0	0	2,005	0	0
2/27/2008	0	0	1,640	0	0
3/26/2008	0	3	2,412	0	0
4/30/2008	35	0	2,033	56	0

Another new feature of the Central Florida 511 system was the ability to transfer the call to other traveler information systems, such as the Statewide 511 system, other regional 511 systems, and information systems for local transit agencies and airport authorities. Figure 105 depicts the percentage of Central Florida 511 calls that were transferred to one of these other systems during the call. Transfers from the Central Florida 511 system were relatively uncommon—only about 6 percent of calls into the Central Florida 511 system later transferred into another system.

Caller requests to regional 511 systems may focus on traveler information, with few callers requesting transfers to other 511 systems.

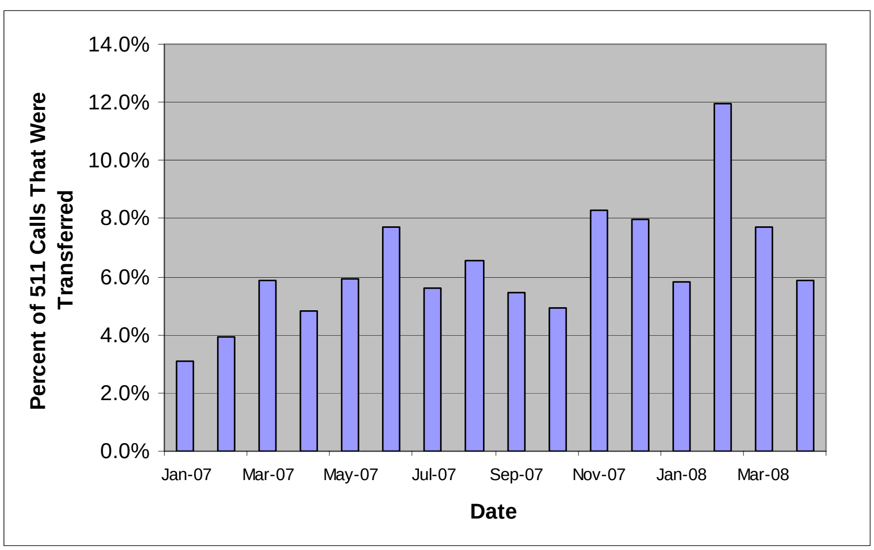

Figure 105. Percent of Central Florida 511 Calls that Were Transferred

Another feature of the Central Florida 511 system was to allow users to register their phone number with the system so that the 511 system could present traveler information specifically tailored to that individual user. The users could select from several pre-defined types of trips (called profiles), such as "To School" or "From Work." For each profile, the user defined the specific segments for which he or she would want traffic information. If the user defined a single profile, then the system would automatically play the traffic reports associated with that profile if the user called. If multiple profiles were defined, the user stated the profile name to select among the defined profiles.

The My Florida 511 approach had the potential to improve 511 service in two different ways. First, it could allow 511 users to reach their desired traffic information more quickly by reducing the number of menu selections that were required. Second, it could result in fewer errors in interpreting voice input by the users, since the user would be selecting from a small set of profiles rather than a larger set of roads, cities, or counties.

The My Florida 511 system, a personalized 511 sytem, required fewer commands to access traffic information and provided callers with traffic information more quickly.

A few examples of My Florida 511and non- My Florida 511 calls will exemplify these potential advantages. First, consider a My Florida 511 call with a single profile from March 26, 2008. This call followed the sequence of events:

- (0 sec into call) 511 system announced the default introduction and stated "I see that you saved a profile: 'To Home.' "
- (3 sec into call) 511 system stated "Report 1," then read then the traffic report for the portion of I-4 identified as part of the "To Home" profile.
- (37 sec into call) The 511 user hung up and the call ended.

Note that the user began to receive traffic information within 3 seconds of making the call without having to make a single menu selection. Less than 10 percent of the call time was spent providing introductory information, with more than 90 percent of the time spent providing traffic information. An example of a My Florida 511call with more than one profile from March 26, 2008, followed this sequence of events:

- (0 sec into call) 511 system announced the default introduction and stated "OK. I see that you have saved profiles. Do you want to hear about: 'From Work' or 'To Home'?" and waited for input from the user.
- (16 sec into call) The user stated his or her preference, and the 511 system began stating the traffic reports associated with the selected profile. The system stated "Report 1," then read the traffic report for one segment of I-4.
- (46 sec into call) The system stated "Report 2," then read the traffic report for another segment of I-4.
- (71 sec into call) The user hung up and the call ended.

In this case, the user made a single menu choice and received traffic information for two road segments. The first 16 seconds of the call (about 22 percent of the call time) were spent making that menu choice, with the remaining 55 seconds (about 78 percent of the call time) spent providing traffic information.

For comparison, a call made on the same day by a non-My Florida 511user followed this sequence of events:

- (0 sec into call) 511 system announced the default introduction and main menu, then waited for input from the user.
- (9 sec into call) The user stated "Highways." Then, the 511 system asked, "Which city, county or highway would you like information for? To hear a summary report, say 'summary report,' or, if you want to know your travel time, say 'travel time.' If you want to hear a driving time summary, say 'summary.' You can say 'help' or press the star key to hear the list of highways we cover." The system then waited for input from the user.
- (16 sec into call) The user stated, "I-4," and the 511 system responded, "Say 'south' for 27 to the Turnpike. Say 'Orlando' for the Turnpike to 436. Say 'north' for 436 to the St Johns River Bridge. Say 'Volusia' for the St Johns River Bridge to I-95. Or say 'All' to hear them all." The system then waited for input from the user.
- (24 sec into call) The user stated "Orlando." Then, the 511 system stated the segment report for that portion of I-4 and waited for input from the user.
- (39 sec into call) The user hung up and the call ended.

Note that it required 24 seconds before the user began to receive traffic information for a single segment of road, and about 62 percent of the call was spent making menu choices with only 38 percent of the call spent receiving traffic information. The average time for all calls made on February 27, 2008, to receive the first traffic information was 9.3 seconds for My Florida 511 callers and 28.6 seconds for all other callers.

The percent of calls made by by My Florida 511 users, a personalized 511 service offered by FDOT, did not increase over time.

Although more than 4,000 users have signed up for the My Florida 511, only about 2 percent of Central Florida 511 calls are currently made by My Florida 511 users, as shown in Figure 106.

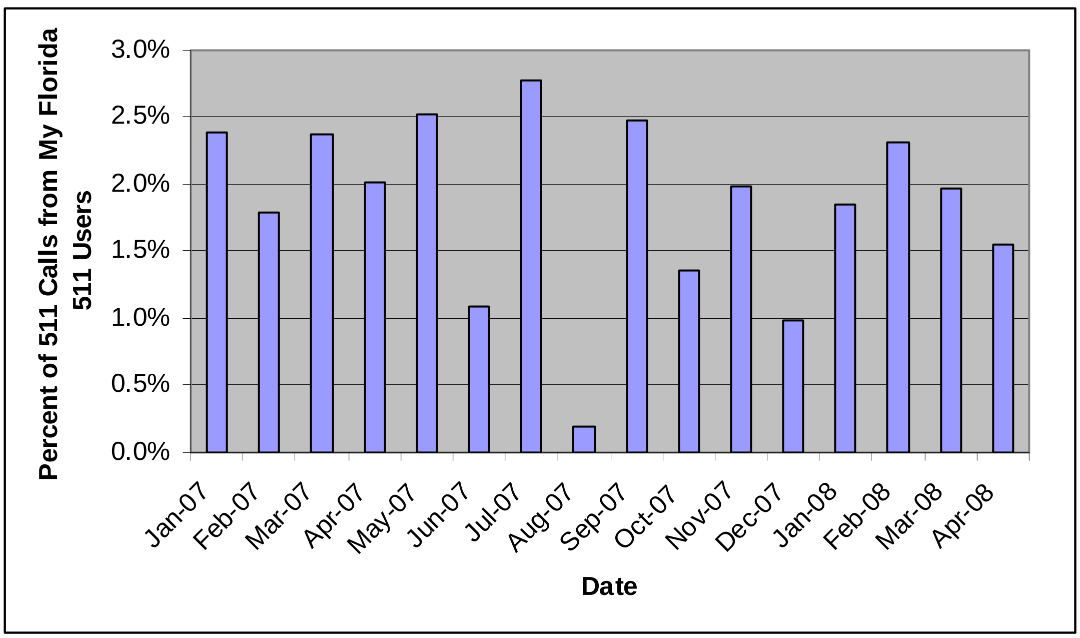

Figure 106. Percent of Central Florida 511 Users that are My Florida 511 Users

It is interesting to note that, despite the increasing number of people who registered for the My Florida 511 service, the percentage of calls made by My Florida 511 users did not increase over time. This implied that existing My Florida 511 users discontinued using the service at about the same rate as other users newly signed up for the My Florida 511 service.

10.4.4. Usage Patterns of 511 Users

The data archived by FDOT also allowed the evaluation team to explore the 511 usage patterns of individual 511 users. The 511 system archived detailed information from each 511 call received, assigning a unique identifier to each caller based on the phone number from which the call was made.[8] This data was used to explore how 511 callers used the system.

The first analysis focused on the question of how often 511 users called the system: did users call the system frequently (i.e., as might be done if a user called the 511 system every day on their way to work) or infrequently (i.e., as might be done if a user called the 511 system only after becoming aware of unusual traffic conditions)? Figure 107 depicts the number of Central Florida 511 calls made per 511 user for those users that called the week of March 9, 2008. (This analysis was restricted to calls lasting at least 20 seconds.) During this week, about 74 percent of the 511 calls were from users that made only one 511 call that week, with an additional 16 percent making two calls during the week. Only 10 percent of 511 users—1,134 users—made more than 2 calls per week. Only 268 users made 5 or more calls per week, as might be expected for a traveler using 511 every day during their work commute. The average number of calls during the week per 511 user was 1.5.

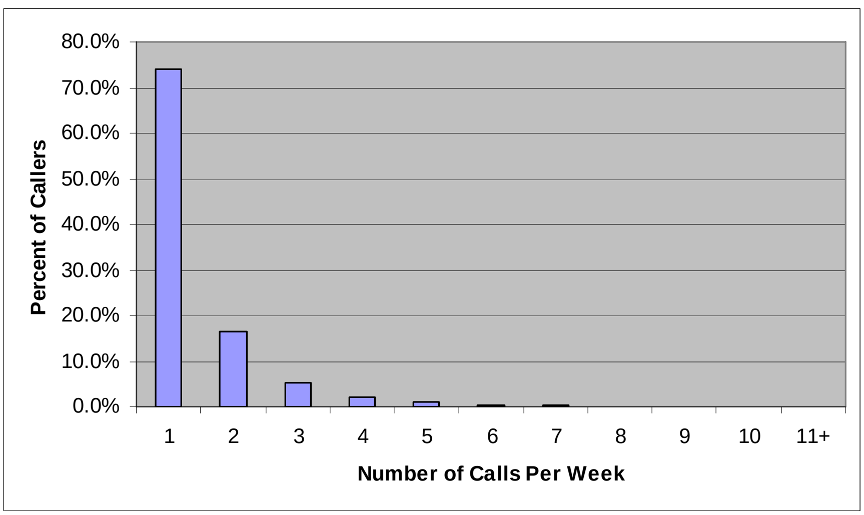

Figure 107. Number of Calls Per Week by Central Florida 511 Users, 3/9/2008 thru 3/15/2008

This pattern of infrequent use is also supported by Figure 108, which depicts the number of callers according to the number of days called during the week of March 9, 2008. Almost 90 percent of callers called on only a single day that week, with 795 callers making calls on two different days and 433 callers making calls on three or more different days. This result provided further indication that few Central Florida 511 callers used the system as part of their daily trip planning process.

[8] Because this identifier was based on the caller's phone number, it did not in all cases uniquely identify a caller. If a single caller makes 511 calls from several different phones, the analysis that follows will treat the calls from each phone as a different caller. If multiple callers make calls through a private branch exchange (PBX), all of the calls may appear to originate from a single phone number and will be treated as a single caller in the analysis that follows.

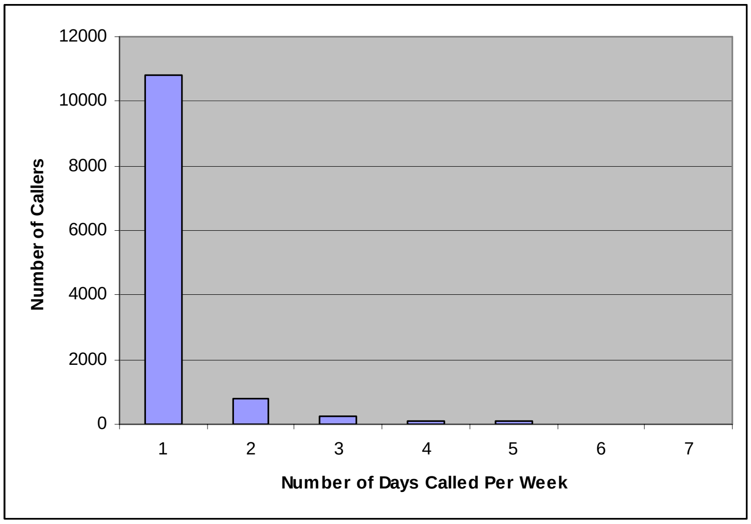

Figure 108. Number of Days Called per Week for Central Florida 511 Users

The following two charts, Figure 109 and Figure 110, provide more detailed information about the 511 users that did use the system frequently. Both of these charts depict the number of frequent Central Florida 511 users each week (labeled "Callers" in the charts), using two different definitions for a frequent user. In Figure 109, a frequent user is one that called the 511 system at least three times in a week and called on at least two different days. In Figure 110, a frequent user called at least 4 times on at least three different days. In these charts, the "added" line represents 511 callers that called frequently in a given week, but did not call frequently in the preceding week. The "dropped" line represents those that had called frequently in the preceding week, but did not call frequently in the given week. The "new" line represents the number of frequent users in the indicated week that had not previously been frequent users – it was the first time that caller had used the 511 system frequently. The "continued" line represents the number of frequent users in the indicated week that were frequent users in the previous week.

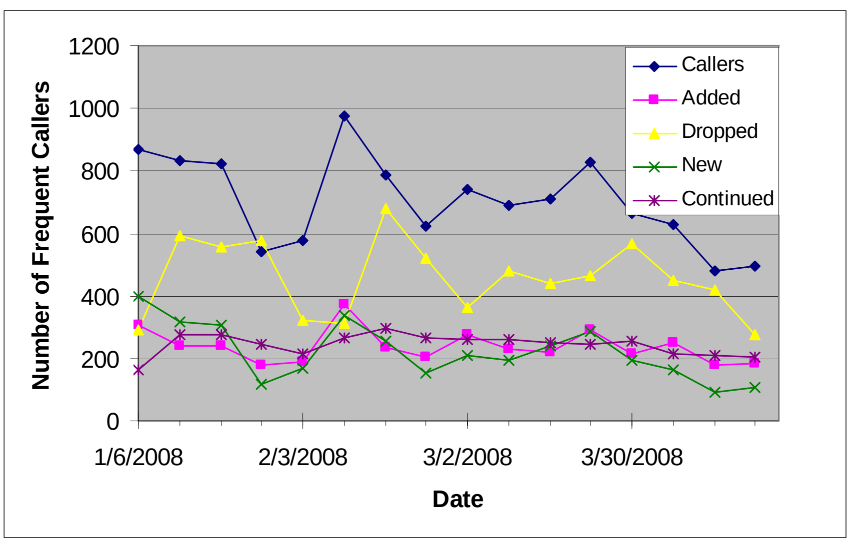

Figure 109. Frequent Central Florida 511 Callers, Those Making 3 Calls Per Week on 2 Different Days

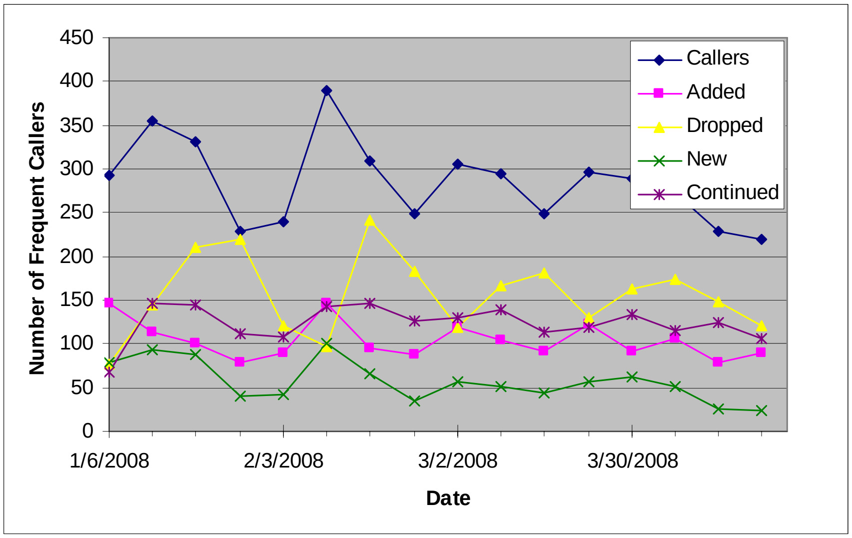

Figure 110. Frequent Central Florida 511 Callers, Those Making 4 Calls Per Week on 3 Different Days

These charts show not only the number of frequent callers —between 600 and 800 using the former definition and around 300 using the latter—they also show the changeover in frequent users from week-to-week. If the 511 system was attracting callers to use the system frequently each week and consistently from week-to-week, one would expect the "callers" line to increase over time, the "continued" line to be nearly as large as the "callers" line, and the "dropped" line to be small. The fact that this was not the case indicated that the *i*Florida system was not good at retaining frequent callers. Using the looser definition of a frequent user (Figure 109), about 65 percent of frequent users during one week were not frequent users the following week. Using the more stringent definition of frequent users, an average of 57 percent of frequent users during one week were not the next. In other words, most of those classified as frequent users in these figures were not consistently so. Taken together, this information suggested that very few Central Florida 511 users make regular use of the system as part of their daily trip planning.

> ***Very few 511 users appeared to regularly use the system as part of their daily commute planning.***

10.4.5. Phone Lines Required to Support the 511 Service

One of the key design objectives for the Central Florida 511 system was ensuring the system could handle the number of calls that it might receive. The system was designed with a number of features intended to ensure this objective would be met:

- The system could handle a large number of simultaneous calls. The number of 511 calls that the system could handle simultaneously was specified by the number of ports available to the system. Initially the system was configured with 255 ports, although this number was modified as operations continued.
- If the number of simultaneous calls exceeded the number of ports, the excess calls were placed in a queue. While in the queue, the callers received a message indicating that their call would be processed as soon as a line was available.
- FDOT could quickly reconfigure the system to play only a floodgate message to callers, which would reduce the length of calls and free space for new calls more frequently. For example, this

feature might be used during a hurricane evacuation when a very large number of callers might be expected.

Because the 511 call volume did not exceed the number of ports available to FDOT, the features for handling excess calls were not used. Figure 111 depicts the maximum number of ports required each day versus the daily call volume for that day. The middle line shown is a curve fit for the mean peak number of lines used, with the bottom and top lines being curve fits for the 5th and 95th percentiles around these means.

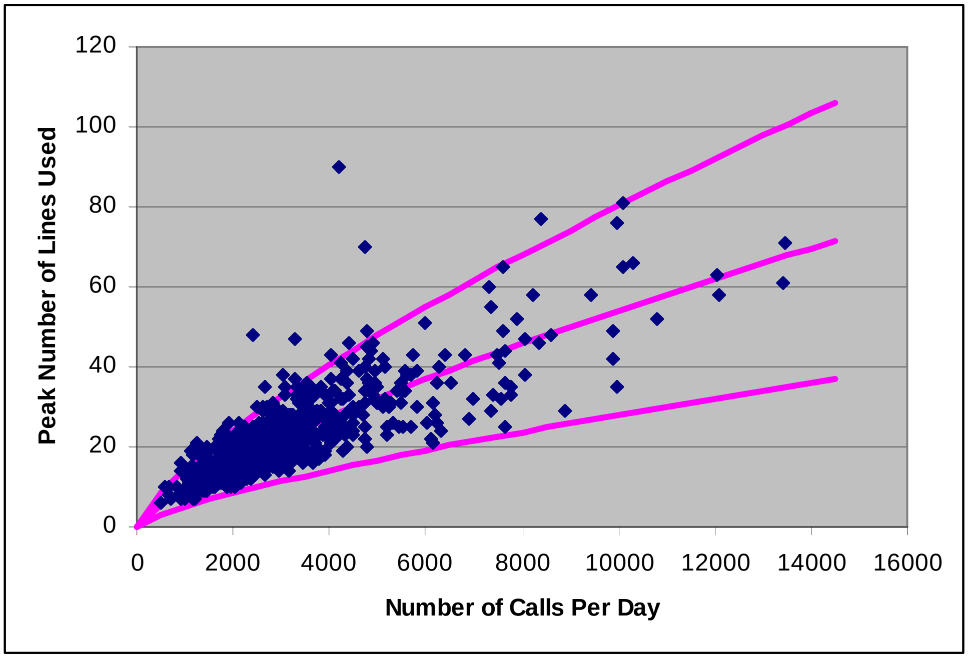

Figure 111. Peak Number of Lines Used Versus Number of Calls Per Day

Note that one of the challenges FDOT faced in designing the 511 system was anticipating the number of ports necessary to handle the expected 511 call volume. This chart provides some guidance in doing so. For example, one would expect 19 ports to handle a day with 2,500 calls about half the time. Increasing the number of ports to 28 would handle a day with 2,500 calls about 95 percent of the time. However, Figure 98 on page 159 indicates that, if the average number of calls per day is expected to be about 2,500, call volumes may exceed twice that value on about 5 percent of days, with even larger call volumes on some days. Designing the system to handle these peak days would require a larger number of ports.

10.4.6. The Performance of the Speech Recognition System

One of the features of the *i*Florida 511 system was the use of voice recognition to process menu selections by 511 users. (The system supported both voice recognition and touch tone entries, though most menu texts emphasized the use of spoken word for selecting menu options.) This section of this report explores the effectiveness of the speech recognition.

Soon after starting Central Florida 511 operations, comments FDOT received on the 511 system indicated that users were frustrated with the effectiveness of the speech recognition system. Many callers complained that the system frequently could not interpret or misinterpreted them when they provided spoken input to the system.

FDOT responded by manually reviewing call archives to identify enhancements that could be made to the 511 system. This resulted in FDOT improving the system by simplifying the menu structure and increasing the number of words recognized by the 511 system to include commonly used synonyms for roads and locations.[9] Later, FDOT established the My Florida 511 program, which could provide traffic information to some callers without requiring any input at all. Despite these efforts, the frequency with which caller inputs could not be interpreted by the 511 system remained high, as shown in Figure 112. In this figure, the "rejected" line refers to the percentage of calls for which the 511 system rejected user input at least one time and the "aborted" line refers to the percentage of calls for which the 511 system stopped waiting for user input at least one time. (Some of these aborts occurred after the system finished providing traffic information and were expected.) The "either" line refers to the percentage of calls for which either of these events occurred.

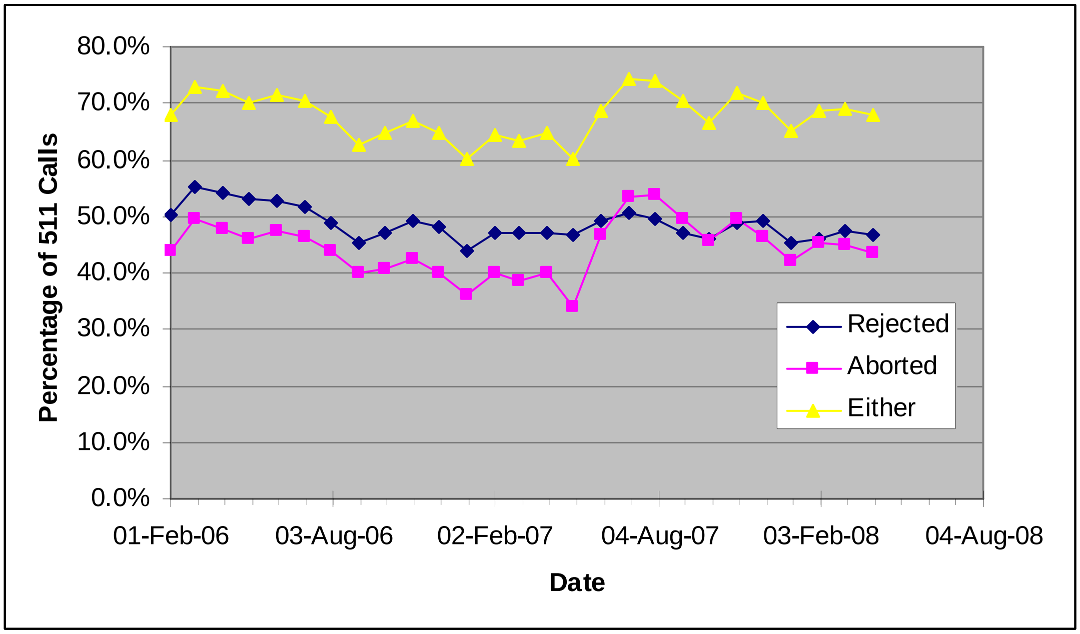

Figure 112. Effectiveness of the *i*Florida 511 System Speech Recognition

Early in the deployment, more than 50 percent of calls included at least one case of rejected input during the call. As FDOT refined the 511 system, this percentage dropped slightly, reaching about 46 percent in 2008. A more detailed analysis of all calls from selected days indicated that the ratio of user input that was accepted by the system to user input rejected by the system was about 6-to-1. In other words, about one out of seven efforts by the user to provide input to the system was rejected. Since the average call required several user inputs to complete, the failure rate of one in seven resulted in the high percentage of calls that included rejected user input. Despite efforts in this area, a large number of *i*Florida 511 callers continued to experience problems with the system rejecting their spoken inputs to the system.

511 implementers should consider establishing and monitoring metrics on the effectiveness of the speech recognition used in their 511 system.

The difficulty with navigating the menu structure could explain the large percentage of calls during which the caller did not receive detailed traffic information, as shown in Figure 113.

[9] The evaluation team noted that the addition of a large number of synonyms could have both positive and negative impacts on the effectiveness of 511 speech recognition. Positive impacts would come about because the system might understand a wider variety of phrases used by callers to identify locations for which traffic information is desired. Negative impacts would come about because of the increased potential for a spoken phrase to match more than one phrase within the 511 system.

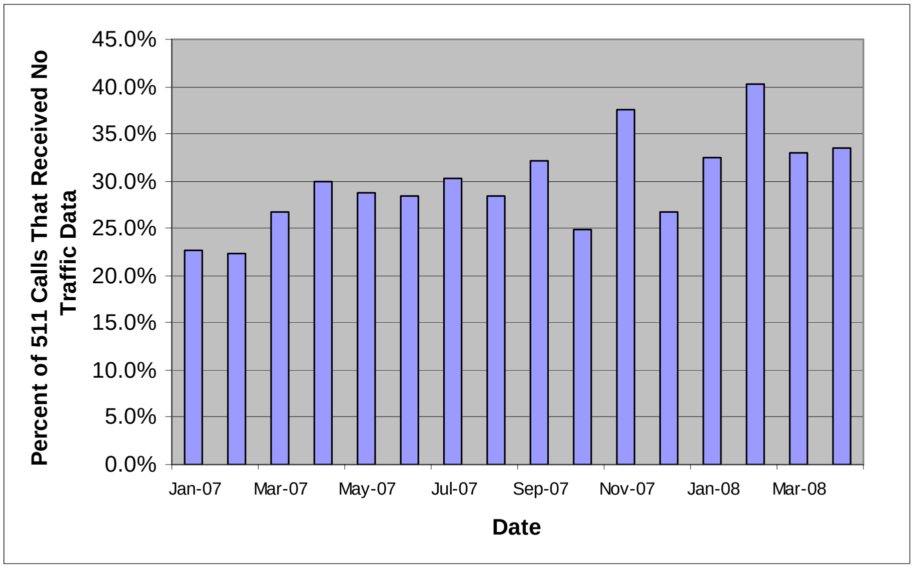

Figure 113. Percent of 511 Calls Without Traffic Information

Over the period shown, about 29 percent of Central Florida 511 calls did not result in the caller receiving any traffic information. In about one-third of these calls, the 511 system did not process any requests from the users—either the caller did not make any requests, or background noise was such that the system did not recognize that the caller had made a request. That leaves about 18 percent of the calls for which the 511 system attempted to interpret input from the caller, but did not end up providing the caller with traffic information.

Having input rejected by the 511 system had a negative impact on whether a caller succeeded in obtaining traffic information. This is demonstrated in Table 17. In this table, the columns indicate the number of caller inputs accepted by the system and the rows indicate the number of caller inputs rejected. The values indicate the percentage of the calls with the indicated number of accepted and rejected inputs that resulted in the caller receiving traffic information. Note that when the number of accepted inputs was less than three, few callers received traffic information. This is because most calls required at least two inputs to access traffic information. (My Florida 511 calls can obtain traffic information with no inputs.) Once the number of accepted inputs reached three, most callers received traffic information, though the fraction of callers that received traffic information dropped as the number of rejected inputs increased.

Table 17. Percentage of Calls with Traffic Information, by Inputs Accepted and Rejected

Inputs Rejected	Inputs Accepted					
	0	1	2	3	4	5+
0	5%	34%	87%	94%	78%	89%
1	0%	10%	41%	86%	85%	92%
2	0%	5%	24%	83%	75%	85%
3	0%	0%	13%	56%	81%	83%
4	0%	0%	0%	71%	71%	81%
5+	13%	0%	0%	27%	73%	86%

Cognizant of the impact that rejected caller inputs had on the ability of the 511 system to provide callers with traffic information, FDOT continuously searched for ways to tweak the menu structure or supplement the dictionary of words understood by the system so as to increase the system's ability to understand caller requests. As shown in Figure 112 on page 172, these steps had only a small positive impact on the system performance.

However, one enhancement made by FDOT that did result in fewer rejections of user input was the My Florida 511 program. (See section 10.4.3 for more information on this program.) In many cases, My Florida 511 users could receive traffic information without making any user inputs. If inputs were required, the inputs were restricted to the names of a small number of "profiles" previously defined by the caller. A review of 511 calls made by My Florida 511 users indicated a higher percentage of calls in which the system provided traffic information though no input was required and a lower rate of rejection when input was required.

For example, of the 46 My Florida 511 calls made to the Central Florida 511 system on March 26, 2008, callers received traffic information during 43 of those calls. Table 18 shows the number of Central Florida 511 calls during which callers received traffic information for My Florida 511 users according to the number of caller inputs accepted and rejected.

Table 18. Number of My Florida 511 Calls with Traffic Information, by Inputs Accepted and Rejected

Inputs Rejected	Inputs Accepted					
	0	**1**	**2**	**3**	**4**	**5+**
0	12 of 12	9 of 9	4 of 4	1 of 1	2 of 2	0 of 1
1	0 of 0	2 of 2	2 of 2	1 of 1	0 of 0	2 of 2
2	0 of 0	1 of 1	1 of 1	0 of 0	0 of 0	2 of 3
3	0 of 0	0 of 0	0 of 0	1 of 1	0 of 0	0 of 0
4	0 of 0	0 of 0	0 of 0	0 of 0	0 of 0	1 of 1
5+	1 of 1	0 of 0	0 of 0	0 of 1	0 of 0	1 of 1

Although many My Florida 511 callers experienced problems with the 511 system rejecting their input, almost all callers did receive traffic information during their calls. Because the percentage of 511 calls made by My Florida 511 users was only a small fraction of the total 511 calls received, better system performance for these users resulted in only small improvements in overall system performance.

10.5. The Statewide 511 System

The Statewide 511 system was operated by the same vendor that supported the Central Florida 511 system, and shared many if its characteristics. The roads covered by the Statewide 511 system are those highlighted in Figure 114 and included all Interstate highways in the state as well as other key toll roads and state highways.

Figure 114. Statewide 511 System Roads

As with the Central Florida 511 system, these roads were divided into segments, so that a caller selected a road segment of interest by first specifying a road, then specifying a specific segment of that road. (A caller could also select a city or county and a road, in which case the segments of the road within or near the selected city or county would be selected.) The same architecture as for the Central Florida 511 system was used to update the messages for the Statewide 511 system (see Section 10.3.1.2). A similar call tree structure was also used (see Section 10.3.1.3), though some of the changes made after the initial system was deployed (e.g., travel time summaries, drive time summaries) did not apply to the Statewide 511 system.

There was one important difference between the two systems: the traffic information available for the segments in the Statewide 511 system was limited. The original concept for the Statewide 511 system identified three primary sources of statewide traffic information:

- A statewide collection of traffic monitoring stations, called the Statewide Monitoring System, provided access to real-time speed, volume, and occupancy data and traffic video. (See Section 0 for more information).
- An interface with the FHP-CAD system provided access to incident information. (See Section 5 for more information).

- Construction reports provided access to information on construction activities. (FDOT organized a method for districts and counties across the state to submit reports on construction activities to FDOT D5 for inclusion in statewide traveler information.)

These plans also called for the Statewide 511 system to cover all the roads that were part of the Florida Intrastate Highway System (FIHS), a total of almost 4,000 miles that included all Florida Interstate highways, the Florida Turnpike, a number of urban expressways, and major interregional and intercity arterial highways.

As FDOT explored the information available to support statewide traveler information services, the agency realized that it could not ensure that they had reliable traffic information on many of the roads that constituted the FIHS. The Statewide Monitoring System provided traffic information at 25 points across the state along Interstate highways. FHP was not responsible for responding to incidents on all parts of all the roads on the FIHS, and the FHP-CAD system would not contain information on incidents to which FHP did not respond. Because of these concerns, FDOT reduced the scope of the Statewide 511 system to those roads shown in Figure 114.

Populating the Statewide 511 system with high quality traffic information was challenging.

Even when limited to these roads, it was difficult for FDOT to ensure that the Statewide 511 system contained complete and up-to-date traffic information. In the Orlando area, FDOT D5 had an extensive network of traffic monitoring devices and traffic video surveillance in place, as well as close working relationships with all of the organizations in the area responsible for responding to incidents that might occur. When an incident occurred in the Orlando area, FDOT could often directly observe it and, if not, knew who to contact to get more information about the incident. This gave FDOT access to detailed information needed to populate the Central Florida 511 system with up-to-date traffic information. This level of detail was not available to FDOT D5 for incidents that occurred in other locations.

10.6. Usage of the Statewide 511 System

This section of the report presents results from the analysis of usage statistics for the Statewide 511 system.

10.6.1. Overall Usage of the Statewide 511 System

The Statewide 511 system was newly deployed as part of the *i*Florida Model Deployment, so did not have a previous history of usage. The usage rates for this system after it went live in November 2005 are depicted in Figure 115. As with the Central Florida 511 usage rates, usage rates for the Statewide 511 system were initially high but quickly dropped to much lower levels. The high initial usage was likely due to the publicity associated with the *i*Florida unveiling. These high usage levels quickly dropped off after the unveiling and continued to drop throughout the evaluation period. (The linear trend line shown in this figure was computed using data beginning in January 2006 so as to omit the effects of the unveiling.)

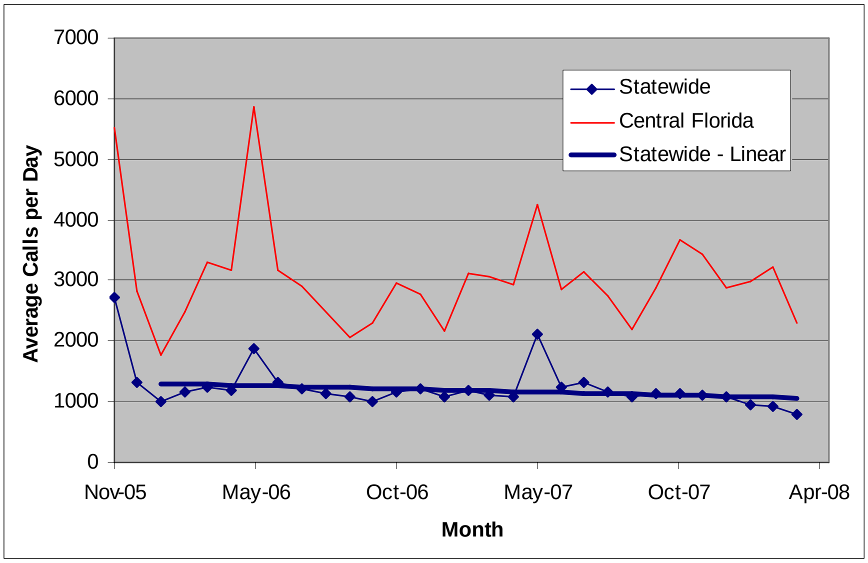

Figure 115. Average Number of Statewide 511 Calls Per Day by Month

The exceptions to this trend occurred in May 2006 and May 2007, when brush fires resulted in many road closures. In May 2006, fires in Central Florida resulted in closures of I-95, and 511 requests for information on I-95 resulted in the increased 511 usage for that month. In May 2007, fires occurred near the Georgia border and resulted in closures of I-10 and I-75, resulting in increased 511 requests for those roads during that month.

Figure 116 depicts how the number of calls varied by the day of the week. As with Central Florida 511, usage was higher on Fridays than on other days of the week.

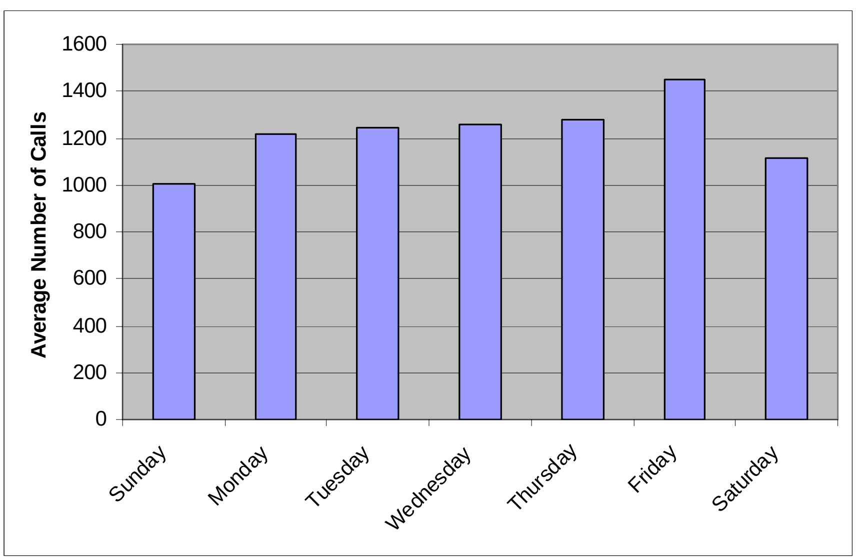

Figure 116. Average Number of Statewide 511 Calls by Day of the Week

The variation by time of day for Statewide 511 calls is shown in Figure 117. The weekday peak occurred during afternoon rush hour, with the weekend peak being more spread throughout the day.

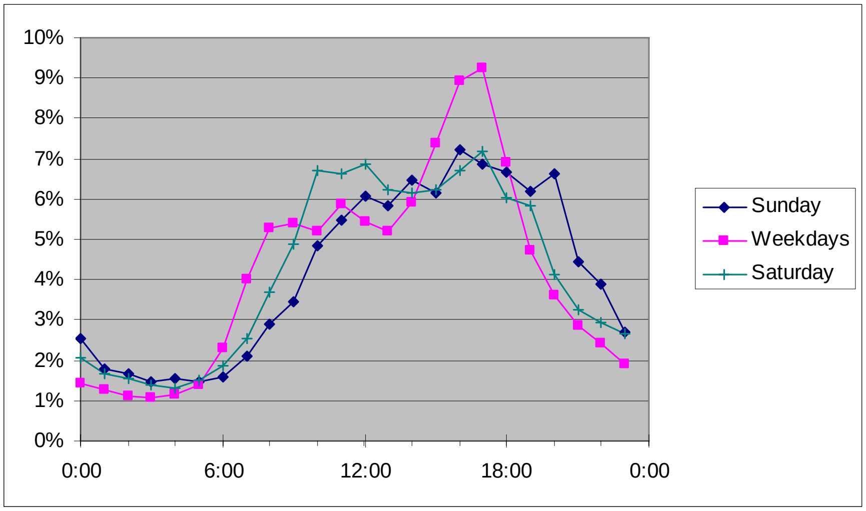

Figure 117. Percentage of Statewide 511 Calls by Time of Day

Usage also varied from day-to-day, even on the same day of the week, as shown in Figure 118. This figure shows the percentage of days (Tuesday, Wednesday, and Thursday only) during the period from January 1, 2006, through April 26, 2008, for which different daily call volumes were experienced. Comparing this chart with Figure 98 on page 159 shows that the Statewide 511 system showed less day-to-day variation in call volume than was exhibited by the Central Florida 511 system.

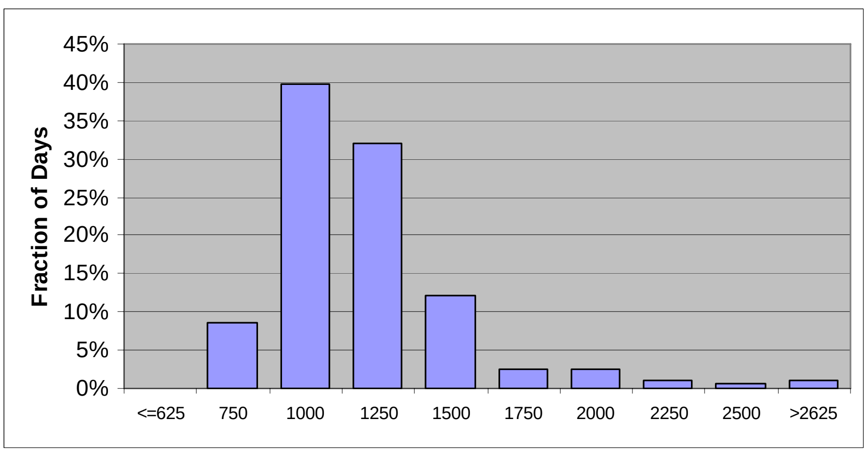

Figure 118. Fraction of Days by Number of Calls: Tuesday, Wednesday, and Thursday

10.6.2. The Duration of Statewide 511 Calls

The average duration of Statewide 511 calls was about 1.5 minutes long throughout much of the operation period, as indicated in Figure 119. (Calls of duration less than 15 seconds were excluded from the average as these calls were too short for the caller to receive traveler information. A large fraction of Statewide 511 calls, ranging from 30 to 40 percent of all calls for most months, fell into this category. Calls of duration greater than 5 minutes were also excluded because FDOT periodically made very long calls to test system operations. These calls were rare, typically less then 0.1 percent of all calls.) The average call duration was about 1.5 minutes in most months. The longer average duration in May 2007 appeared to be related to callers requesting information about brush fire-related road closures in North Florida.

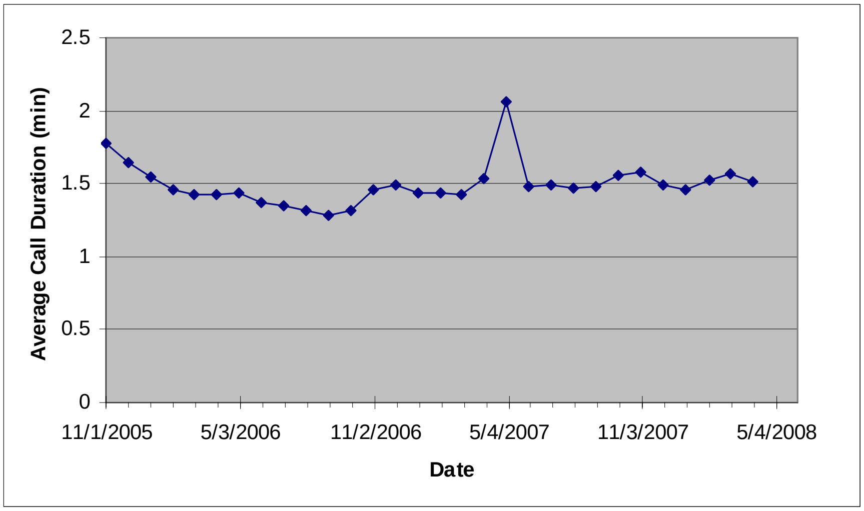

Figure 119. The Average Duration of Statewide 511 Calls

The evolution of the call duration profiles is depicted in Figure 120.

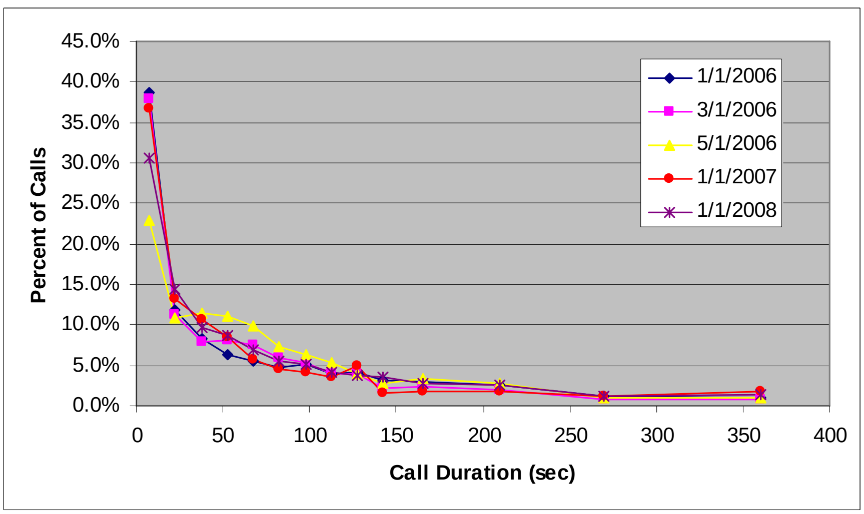

Figure 120. Distribution of Statewide 511 Call Durations

The large number of calls with short duration was likely related to ways callers made use of the Statewide 511 system, as explored in the next section.

10.6.3. Information Requested from the Statewide 511 System

The Statewide 511 system, like the Central Florida 511 systems, could provide traveler information for many different roads across the State. Figure 121 depicts the average number of Statewide 511 requests per day by the type of road for which the request was made for each month from January 2006 through April 2008. As with the Central Florida 511 system, most requests were concentrated on the Interstate Highways, particularly I-75 and I-95. In most months, requests for information on these two Interstate Highways accounted for more than 70 percent of Statewide 511 requests. The two primary exceptions occurred in May 2007 and January 2008 when brush fires caused closures of other state roads.

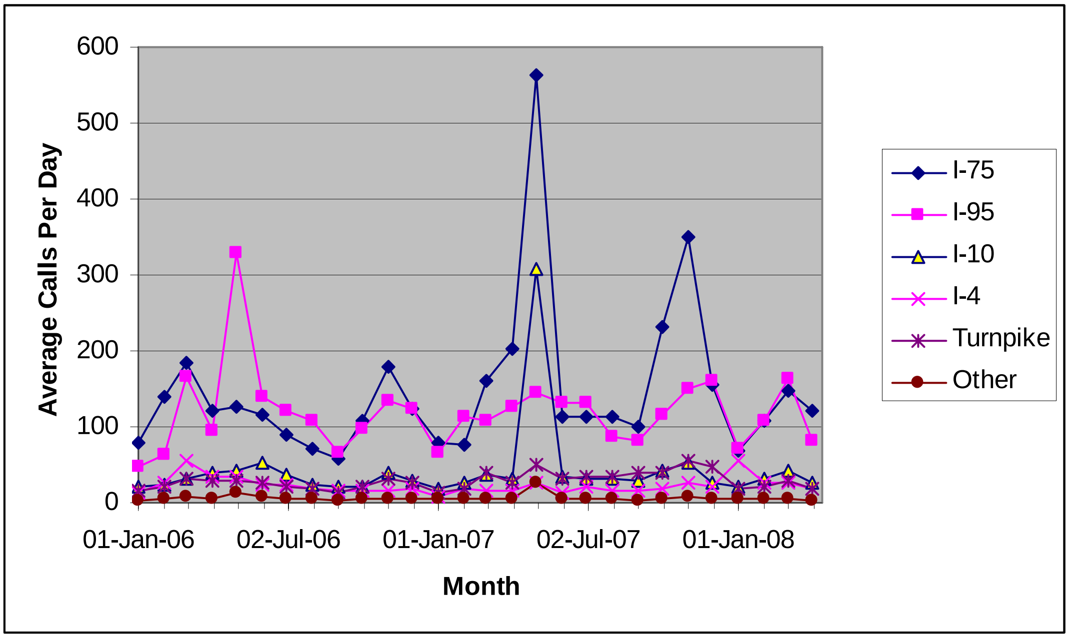

Figure 121. Average Number of Statewide 511 Requests Per Day by Type of Road

All in all, there were few requests for traveler information from the Statewide 511 system. In part, this was because fewer calls were made to the Statewide 511 system relative to the Central Florida 511 system; the former system averaged about 1,000 calls per day while the latter averaged more than 3,000 calls per day. Other reasons were that many Statewide 511 callers did not request any information from the system when they called and other callers used the Statewide 511 system primarily as a gateway to other 511 systems (see Figure 122).

> ***In most months, relatively few callers requested traffic information from the Statewide 511 system.***

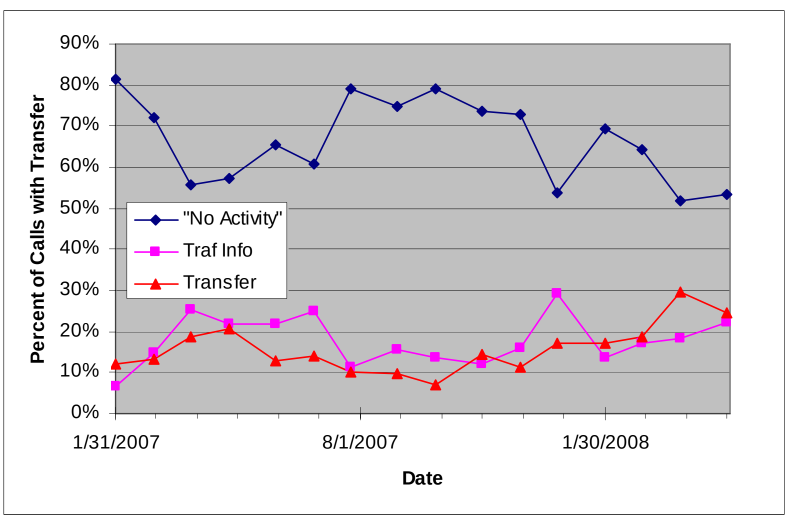

Figure 122. Caller Activity for Statewide 511 Calls

As indicated, most Statewide 511 callers did not receive any information from the system, either because they hung up without requesting any information or the system could not interpret the requests made by the callers. Among the remaining callers, about as many requested transfers to another traveler information system as requested traveler information from the Statewide 511 system. (For comparison, nearly two-thirds of Central Florida 511 callers obtained traveler information and only about 8 percent requested transfers to another traveler information system.)

10.6.4. Usage Patterns of Statewide 511 Users

As shown in Figure 123, which considers calls made during the week of March 9, 2008, most users (77 percent) called the Statewide 511 system only once per week. As with the Central Florida 511 system, about 10 percent of users (251 users) made more than two calls per week. The average number of calls per user during the week was 1.5.

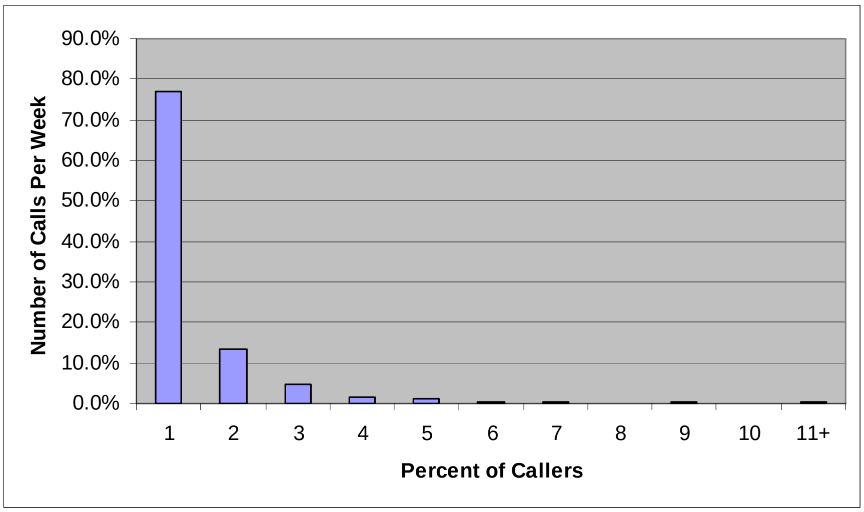

Figure 123. Number of Calls Per Week for Statewide 511 Users, 3/9/2008 to 3/15/2008

This pattern of infrequent use is also supported by Figure 124, which depicts the number of callers according to the number of days called during the week (for the week of March 9, 2008). Just over 90 percent of callers called on only a single day that week, with 215 callers (almost 6 percent) making calls on two or more different days. The usage frequency for users of the Statewide 511 system was very similar to that of Central Florida 511 users.

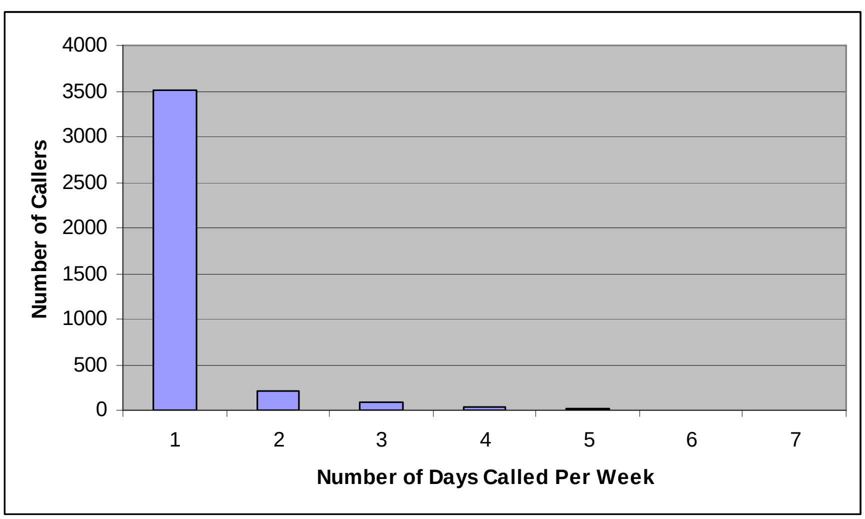

Figure 124. Number of Days Called per Week for Statewide 511 Users

Of those who were frequent users during any week, most were not frequent users in the following week. The next two charts provide information about users that frequently called the Statewide 511 system. For this analysis, two definitions of frequent callers were used. In Figure 125, a frequent caller was defined as a user that called the 511 system at least three times in a week and called it on at least two different days. In Figure 126, a frequent caller called at least 4 times on at least three different days. (Section 10.4.4 includes a description of how to interpret this type of chart.)

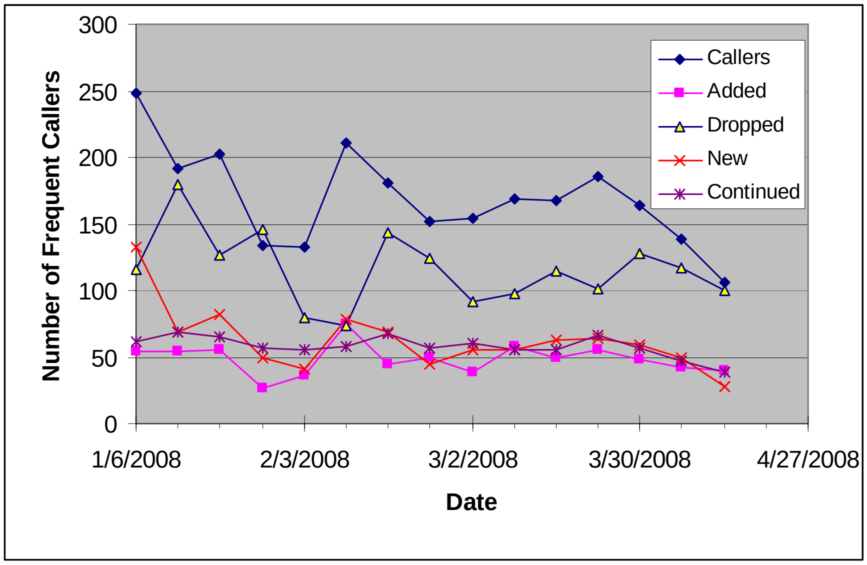

Figure 125. Frequent Statewide 511 Callers, Those Making 3 Calls Per Week on 2 Different Days

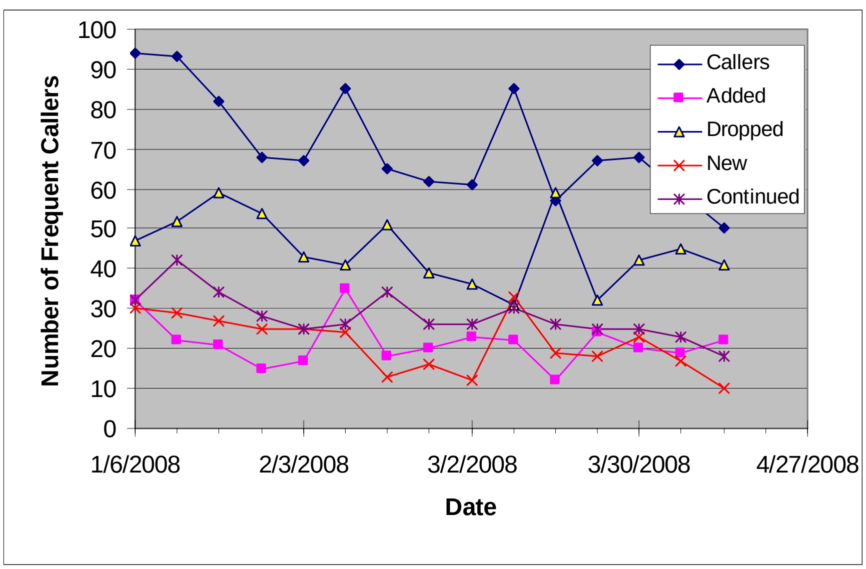

Figure 126. Frequent Statewide 511 Callers, Those Making 4 Calls Per Week on 3 Different Days

If the 511 system was attracting callers to use the system frequently and consistently, one would expect the "callers" line to increase over time, the "continued" line to be nearly as large as the "callers" line, and the "dropped" line to be small. The fact that this is not the case indicates that the *i*Florida 511 system was not good at retaining frequent callers. For the Statewide 511 system, only about 150 users called at least three times per week on two different days. (About 70 users called at least four times per week on three different days.) As with the Central Florida 511 system, the number of frequent callers was relatively small and few of these were frequent callers week after week.

10.7. The *i*Florida Traveler Information Web site

The *i*Florida traveler information Web site (http://www.fl511.com) was a new capability introduced by the *i*Florida. (A Web site was previously available that provided travel time information for a portion of I-4, though the availability of this Web site was not advertised and it was little used.) This Web site provided six types of functionality to users:

- Statewide and Central Florida maps displayed traffic information for the roads covered by *i*Florida.
  - The roads were color-coded (red, yellow, or green) to indicate current traffic conditions on the road.
  - Icons were placed to indicate the position of incidents (e.g., crashes, severe weather, road construction) on those roads.
- A travel time calculator estimated travel times between key intersections on the *i*Florida network in Orlando.
- A web page provided links to other Web sites that provided access to still images and video from traffic cameras.
- A web page listed the messages currently displayed on DMSs managed by the CRS.
- A web paged listed information about construction activities on *i*Florida roads.
- A web page provided links to other traveler information Web sites.

The look and feel of the maps in this system is depicted in Figure 127 (the statewide traveler information map) and Figure 128 (the travel time calculator map).

Figure 127. CRS Statewide Traveler Information Map

Soon after the Web component of the CRS software was released, FDOT expressed dissatisfaction with the quality of the interface. FDOT felt that the maps contained too little detail and did not allow the users enough flexibility in moving around the maps. (The maps did not allow panning and supported only two zoom levels.) FDOT staff, like many others, had come to expect map quality similar to what was available from map servers available over the Internet. The limited flexibility of these maps also caused some functional problems. For example, incident icons for closely spaced incidents could overlap, making it difficult to click on them in order to obtain additional information.

Reviewing mock ups of highly graphical user interfaces, such as map interfaces, before starting development of the interface can help ensure that the resulting interface is esthetically pleasing.

Figure 128. CRS Central Florida Travel Time Calculator Map

When FDOT replaced the CRS, the agency opted to take advantage of Google™ mapping services to support its traveler information maps. This meant that the FDOT traveler information maps included all of the same detail and capabilities as were included in Google™ map. The updated traveler information maps are depicted in Figure 129 and Figure 130. There were two benefits of leveraging these internet map server capabilities. First, the cost was low because map management features were provided at no cost by the internet map server. Second, the features and capabilities were high because they took advantage of the features of these map servers.

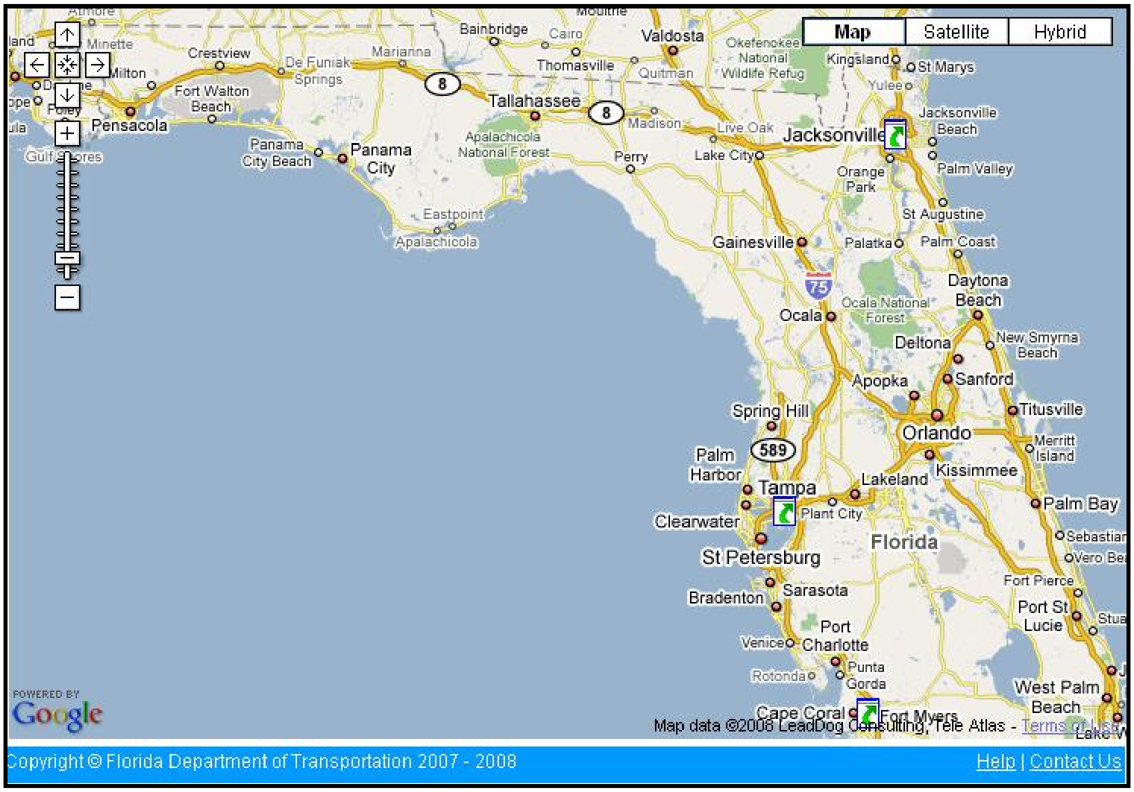

Figure 129. SunGuide Statewide Traveler Information Map

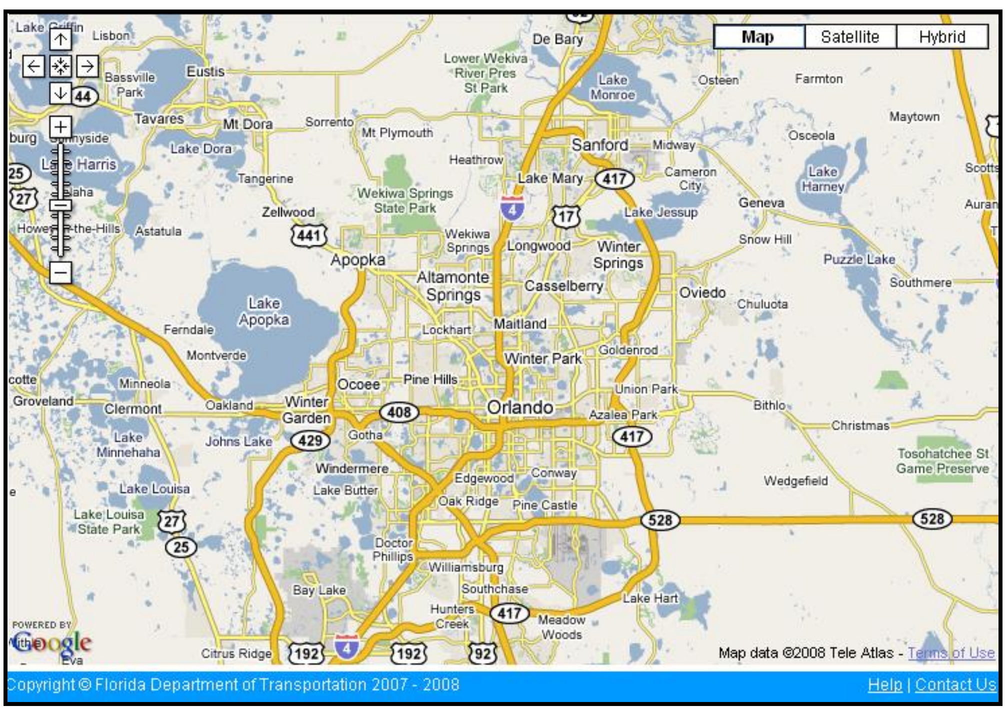

Figure 130. SunGuide Central Florida Traveler Information Map

The challenges FDOT faced with the CRS and the arterial travel time network also impacted the traveler information Web site. For example, roads on the traveler information maps were often color-coded gray because no travel time data was available and the travel time calculator sometimes suggested circuitous routes between nodes when no travel time data was available.

10.7.1. Usage of the Traveler Information Web site

The CRS requirements specified that a "usage monitoring system will provide information on CRS-Web usage patterns for different parts of the Internet Web site" and that "parameters to be tracked shall be proposed at the design stage." The CRS design document specified that Windows® Internet Information Services (IIS) would be used to provide this functionality. This decision limited the amount of information that was available about Web site usage.

The Web site requirements should include details about the types of tracking information that should be maintained about Web site users.

For example, IIS does not record information about individual sessions of individual users. Instead, it records information about each Web request made by the user's Web browser, and each Web page typically consists of numerous Web requests. Downloading the main *i*Florida map pages involved more than 30 such requests—a main page request, 2 Java® script pages, a style sheet, 5 graphic files related to page headers and footers, 6 graphic files related to the box around the map, the map image, 6 graphic images related to tabs, and 10 icon files. In the IIS logs, the user is identified only by IP address. The same IP address may apply to multiple users, and a user during multiple sessions will likely have the same IP address. All of these factors together limit the information that can be gleaned from IIS logs regarding Web site usage.

The evaluation team used the following approach to estimate from the IIS logs information about the number of users and the number of times users accessed the Web site. Each IP address that accessed the Web site was treated as a separate user. Once a user accessed the Web site, all additional requests from the same IP address were treated as a single session until ten minutes had elapsed between requests from this IP address. The next request, if any, from the same IP address was treated as a new session from the same user.

Figure 131 depicts the average number of users and sessions per day (averaged over 1-month periods), where users and sessions were defined via the methods above. For the year 2006, this indicates that around 620 users per day generated about 1,500 visits per day to the *i*Florida traveler information Web site, for about 2.4 visits per day per user. For comparison, users of the Central Florida and Statewide 511 systems called about 4,000 times per day. More people used the 511 systems, though users of the traveler information Web site visited it more often each day. The peak usage occurred during the brush fires in May 2006.

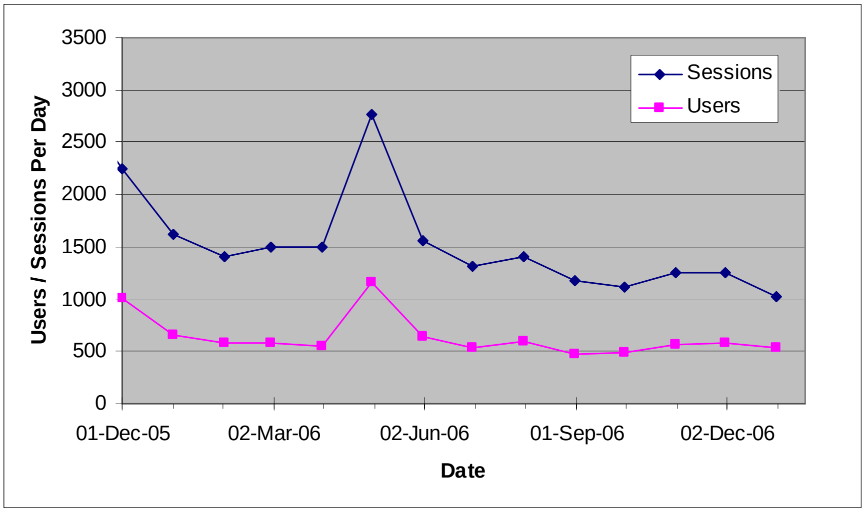

Figure 131. Average Number of *i*Florida Web site Users and Sessions per Day

Most of these users had only one session per week, as shown in Figure 132, though a small number of users had a very large number of sessions per week.

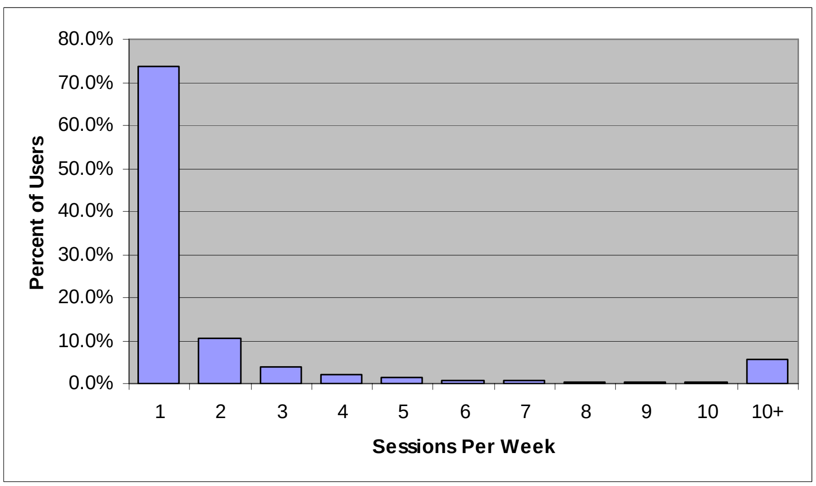

Figure 132. Number of Sessions per Week for *i*Florida Web site Users

The number Web site sessions varied little from day to day (see Figure 133).

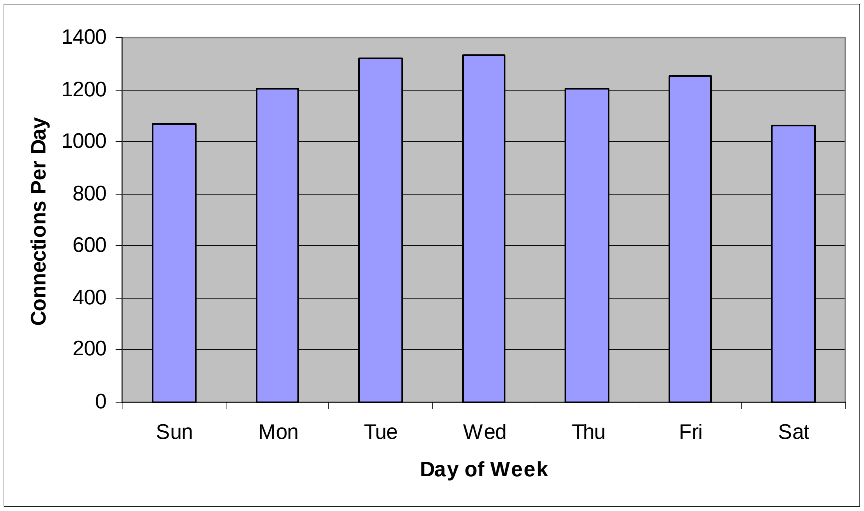

Figure 133. Average Number of *i*Florida Web site Sessions by Day of the Week

The Web site usage throughout the day, as shown in Figure 134, was more evenly distributed than 511 usage (compare to Figure 97).

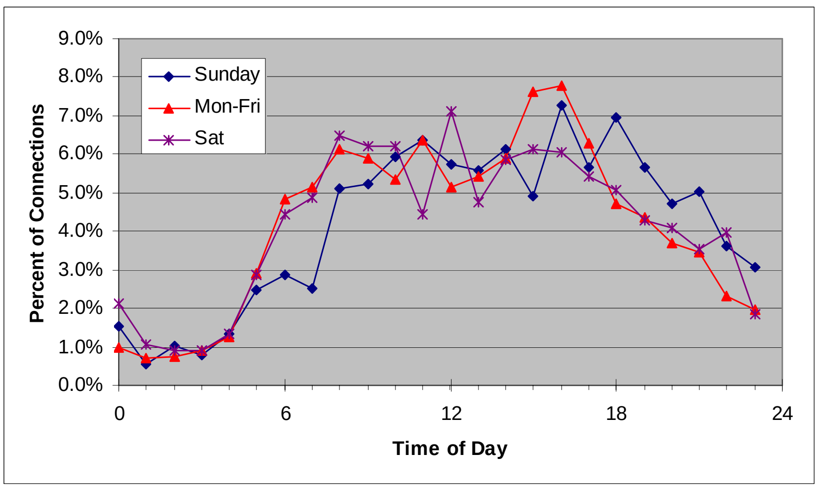

Figure 134. Percentage of *i*Florida Web site Sessions by Time of Day

Figure 135 shows that the number of sessions per day varied from day to day, with the number of sessions on most days clustering about the mean of 1,500 per day, but with a cluster of high-usage days. This is similar to the distribution observed for 511 calls.

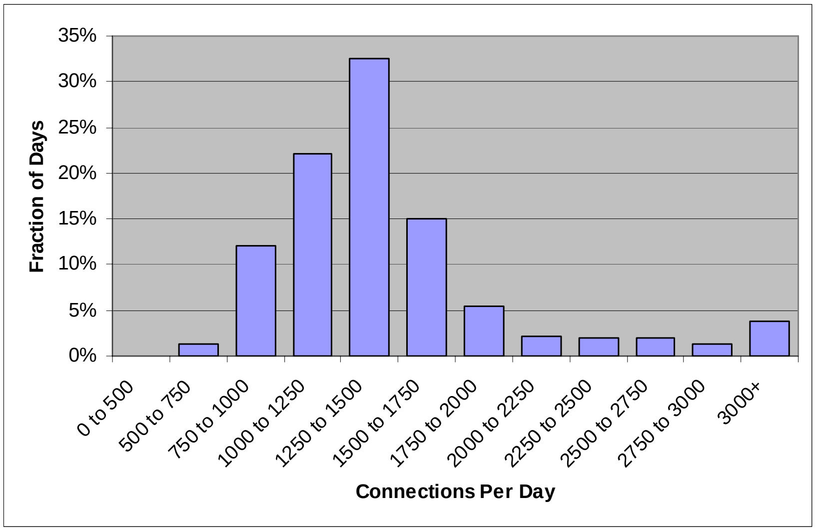

Figure 135. Fraction of Days by Number of Sessions

10.8. Other Sources of Traveler Information

The traffic data gathered by FDOT to support its own traveler information services also found its way to other organizations that provided traffic information to the public. Local television stations used FDOT traffic video in their news reports, and local radio stations began to broadcast more detailed traffic reports. One television station began to offer automated email or text message alerts to registered users so they could obtain customized traffic information along a specified route at a specific time of day. National providers of traffic information, such as Traffic.com, Google™, MSN™, and others, obtained FDOT traffic information and made that data available to their users. Thus, *i*Florida traffic information was available to the public through a number of services outside of those specifically provided by FDOT.

Traffic data collected by FDOT was the basis for traveler information services provided by both regional and national traffic information providers.

10.9. Summary and Conclusions

By one measure, the *i*Florida traveler information operations were a significant success. An extensive network of traffic monitoring equipment was deployed and used to provide traveler information via 511, the Internet, and electronic signs. Taken together, the Central Florida and Statewide 511 systems received about 4,000 calls per day, and the Web site received more than 1,000 visits per day. That represented nearly 2 million visits to the *i*Florida 511 and Internet traveler information services per year. This data was also picked up by both local media and national distributors of traffic information, so traveler information reached the public through both public-sector (i.e., 511 and the *i*Florida Web site) and private-sector channels.

Other measures pointed out some of the limitations of the *i*Florida traveler information operations. A sharp decline in the number of Central Florida 511 calls occurred soon after FDOT made the transition to the new 511 system, and the growth rate in the number of callers for the new system appeared to be lower than the growth rate before *i*Florida was deployed. In fact, the number of 511 requests for traffic information on I-4 continued to decline throughout the observation period, with this decline offset by additional requests for information on I-95 as traffic monitoring systems for I-95 was brought online. Only about 20 percent of the traffic information requests were for toll roads or arterials, the two other types of roads for which traffic information was available after *i*Florida. Because of the large increase in the scope of roads covered by the 511 system, an increase in 511 usage was expected. This did not occur.

A more detailed analysis indicated that there were few 511 callers who regularly used the system for pre-trip planning. During a typical week, less than 300 users of the Central Florida 511 system made at least 4 calls during the week on at least three different days—a frequency that might indicate they were regularly using the system for trip planning. Of these 300 frequent 511 users, most did not qualify as frequent users during the following week. Instead of proactively using the 511 system for trip planning, it appeared that the system was being used reactively to obtain information about unusual traffic conditions that were observed once a traveler was on the road. This supposition was further supported by the observation that high 511 call volumes tended to occur in conjunction with incidents that occurred and that the fraction of calls made from cell phones increased when 511 call volumes were high.

One counter example to this general pattern occurred in May 2006 when brush fires caused numerous road closures in Central Florida. In that case, high call volumes occurred without a corresponding increase in the fraction of calls that were from cell phones, suggesting that travelers were using 511 to determine if roads were closed before departing. Even in this case, callers were using 511 in a reactive manner—already aware that brush fires were causing road closures, travelers were apparently calling 511 to determine if specific roads were closed to help them plan their trips.

This observation may be important in two ways. First, it could impact the type of information that will be most beneficial to 511 callers. If most callers were using the system proactively to determine the best route to take before departing, the system messages should focus on route travel times. If most callers were using the system reactively to obtain more information about known problems and determine how to respond to them, the system messages should provide more detailed information about specific problems and, perhaps, suggest alternate routes around them.

Second, it could impact how the expected benefits of a 511 system should be estimated. One approach that has been used to estimate 511 benefits is to estimate travel time savings that a caller might experience if he or she regularly used the system to determine the best departure time for a trip and/or the best route to take. An underlying assumption of this approach is that travelers would call the 511 system regularly as part of their trip planning process. Observations during this evaluation identified few such 511 users. If most 511 users call only after becoming aware of—and possibly enter a queue related to—a traffic problem, then the benefits of the 511 system will be related to how well the system allows users to circumvent traffic problems once on the road rather than how well it helps them plan trips ahead of time. Perhaps the 511 system should even be tailored more towards such users, providing more information specifically designed to help travelers approaching incident-induced congestion. For example, the system could provide information about the location of the incident, where congestion ends, the expected time-extent of the congestion, suggested detour routes, etc.

Other observations made in evaluating the *i*Florida traveler information operations are summarized in the following list:

- Few callers took advantage of traveler information available for Orlando arterials and toll roads. About 80 percent of the requests for traffic information from the Central Florida 511 system were for I-4 and I-95, with requests for information on toll roads and arterials composing about 15 and 5 percent of calls, respectively.

- The voice recognition system was not very effective. The 511 system rejected about one in seven times the system believed a caller had uttered a command, the system rejected the command. Because most calls required the user to make several commands to reach the desired information, almost 50 percent of calls included at least one case where the system rejected a user utterance.
- Very few Central Florida 511 users could be classified as frequent users of the system. In a typical week, less than 300 users called the system at least four times during the week on at least three different days. Of the users that called frequently in a given week, less than half called frequently in the following week.
- Obtaining accurate traffic information for the Statewide 511 system was challenging. FDOT found that the Statewide Monitoring System, a system of 25 traffic monitoring sites deployed around the state, was too sparse to support Statewide 511 traffic information needs. The interface with the FHP CAD system provided useful information about incidents across the state, though this data did not always include as much information as desired for 511 (e.g., expected delay). Also, jurisdiction for responding to incidents on some parts of *i*Florida roads were with other organizations, in which case information about incidents on those parts of roads might not be included in the FHP CAD system. FDOT did find that 511 users would sometimes leave comments reporting on incidents that were not included in the 511 system.
- FDOT was dissatisfied with the traveler information Web site map interface provided by the CRS contractor. When a new contractor was hired to replace the failed CRS, this contractor used Google™ mapping services to support the *i*Florida traveler information Web site. (Similar capabilities are available from other internet map servers.) This meant that the *i*Florida Web site traveler information maps included all of the capabilities of Google maps.

Based on FDOT's observed experiences with traveler information operations during the *i*Florida deployment, the following lessons can be derived for the benefit of other users who wish to implement or modify a 511 system:

- *Plan for maintaining the 511 system when other equipment fails*. Early in the *i*Florida deployment, equipment failures meant that travel time measurements were often unavailable for arterials, in which case the system explicitly stated that fact. At times, a caller was presented with up to four successive "The travel time from A to B is unavailable" messages. Later, FDOT modified the system so that it would simply omit segments for which travel times were unavailable.
- *Plan for maintaining the 511 system when other systems fail*. When the CRS failed, it eliminated FDOT's tool for maintaining 511 messages. Because File Transfer Protocol (FTP) was used to transmit those messages to the 511 service provider, FDOT could manually use FTP to manage the 511 messages. This allowed the agency to continue to provide the 511 service while replacement software for the CRS was being developed
- *Consider the needs of existing users when changing the 511 menu structure*. FDOT received a number of complaints from existing 511 users about the new menu structure when it first released the new 511 system. These complaints might have been avoided if FDOT had continued to support the old menu structure while providing access to new features via new menus.
- *Monitor user feedback for suggestions on how to improve the 511 service*. Early feedback on the *i*Florida 511 system indicated callers were dissatisfied with the complexity of the menu structure. Callers also sometimes reported on specific commands that were not understood by the system. Monitoring

this feedback helped FDOT identify the need to simplify the menu structure and to add additional words to the lexicon of commands understood by the system.

- *Allowing callers to customize their 511 requests resulted in more efficient 511 calls.* My Florida 511 users required fewer commands to access traffic information and obtained traffic information more quickly than other 511 users.
- *Document specific requirements for the types of tracking information that should be maintained about Web site users.* The requirements for the *i*Florida Web site included very general requirements for tracking Web site usage. The approach used by the CRS contractor for tracking Web site usage, IIS log files, limited the level of detail with which this Web site usage could be tracked.

In addition to identifying these lessons, the evaluation team developed a number of metrics for assessing *i*Florida traveler information operations. This metrics, listed below, may be useful for other organizations in monitoring the performance of their 511 systems.

- Number of 511 calls and Web site sessions per day.
- Peak number of simultaneous calls and Web site sessions.
- Number of requests for specific types of traveler information, including transfers to other traveler information service providers.
- Average duration of 511 calls, the time require to reach desired traveler information, the percent of users that receive traveler information, and the percent of call time during which a caller is receiving traveler information, along with analogous measures for Web site usage.
- The number of frequent callers and the percentage of calls they generate.
- The number of incident-related calls.
- The percentage of user utterances that are rejected by the system and the percentage of calls that include rejected utterances. (The evaluation team noted several other measures related to the effectiveness of the speech recognition system, but did not compute them for this evaluation. Among those measures were the percentage of user utterances that are misunderstood by the system and the percentage of user utterances rejected or misunderstood broken out by the user's position in the call tree.)

11. Weather Data

One of the features of the *i*Florida deployment was the integration of weather data into the traffic management system at the District 5 Regional Transportation Management Center (D5 RTMC). This weather data was provided in several forms. FDOT deployed a number of Road Weather Information System (RWIS) stations to collect new weather data. FDOT also contracted with a third party provider to supply the RTMC with weather data, including current and forecast weather data specific to *i*Florida road segments and severe weather alerts tied to specific locations. FDOT planned to use this data in a number of ways, including identifying appropriate speed limits for setting variable speed limits (VSL) and warning travelers of adverse weather conditions. This section of the evaluation report documents the *i*Florida use of weather data.

11.1. The *i*Florida Weather Systems

The first element of the *i*Florida weather systems were the RWIS stations deployed by FDOT. The locations of these stations are depicted in Figure 136.

Figure 136. The Locations of *i*Florida RWIS Stations

Seven of these stations were deployed at Motorist Aid System Microwave Towers and used the microwave network to transmit their data back to a central server. (See Section 9 for more information on this microwave network.) Each of these stations included an anemometer, a visibility sensor, a rain gauge, a barometer, and a temperature and relative humidity sensor. A data server at the microwave tower collected data from the sensors and transmitted it through the microwave tower network to the University of North Florida. (This data was available to FDOT, though FDOT did not have software installed to decode the data.)

Three additional stations were deployed on poles within District 5. These stations included an anemometer, a visibility sensor, a rain gauge, and a temperature and relative humidity sensor. A data server at the pole collected data from the sensors and transmitted it through an existing fiber network to the University of Northern Florida.

Four stations, measuring only wind speed and direction, were deployed on bridges. The data from the anemometer was transmitted via a wireless system to a nearby station with an existing connection to the FDOT network. A portable weather station was also developed that could be positioned near to locations with connectivity to the FDOT network. See Section 11.2 below for more information on Road Weather Information System performance.

The original design of this system called for the data from these RWIS stations to be transmitted to a weather data processor at the D5 RTMC. This data was accessible at the RTMC, but was in a format that was incompatible with the interface requirements for the CRS and was not used directly. Instead, the University of Northern Florida collected and redistributed the data to the National Weather Service Meteorological Assimilation Data Ingest System (MADIS). FDOT obtained the data through MADIS. The requirements also called for a web-based interface for accessing real-time and historical weather data.

The second element of the *i*Florida weather system was a contract with Meteorlogix, a company that supplies customized weather data. This company ingested data from five sources of real-time weather data: a Next Generation Weather Radar (NEXRAD) data feed that provides information about precipitation rates and severe weather conditions, county-based National Weather Service (NWS) weather warnings and watches, information about tropical storms from the National Hurricane Center, and surface observations from MADIS. The system also ingested regional weather forecasts and performed additional processing on this data to generate enhanced precision local weather forecasts with a resolution of 5 km.[1]

Spatial analyses were performed to relate this weather data to specific geographic objects to generate weather condition and forecasts for those objects. In the case of *i*Florida, the geographic objects were road segments, so the system provided weather condition and forecast data for specific road segments.

The third part of the iFlorida weather system involved the CRS, the transportation management software used at the D5 RTMC. High expectations were placed on the CRS software system in terms of its anticipated capability to apply weather data toward facilitating transportation operations decisions. For example, the system was to consider weather conditions when providing recommendations for speed limits to use on VSL signs. The CRS was to provide forecasts of future travel times on iFlorida segments and alert RTMC operators if current or forecast weather conditions would result in an "abnormal road condition" so that the operator could post appropriate 511 and DMS messages. The CRS was also to consider weather conditions when generating traffic condition maps for web-based traveler information, color-coding roads when severe weather conditions existed. These expectations, however, were never realized. The causal factors for this are explored later in this section.

[1] The National Weather Service National Digital Forecast Database offers free access to weather forecasts on a 5-km grid covering the continental United States. This could be a viable alternative as a source for digital weather data.

11.2. The Performance of the *i*Florida RWIS Stations

In Florida, the weather conditions most likely to impact traveler safety are low visibility from fog, smoke, and heavy rain as well as hazards presented by strong winds, wet pavement, and freezing temperatures. Because most of these conditions are local in nature, data on weather conditions at individual RWIS stations provided little guidance in assessing when and where such conditions existed on Florida roads. FDOT D5 recognized this, and did not intend to use data from individual RWIS stations as part of its decision-making process in responding to road weather conditions. Instead, the data from the RWIS stations was to be integrated with other data in the weather models used by Meteorlogix to generate weather condition and forecast data for individual road segments. The data would also be posted to the MADIS mesonet, so it would be available to weather modelers to improve general forecasts.

The exception to this was the wind-speed monitors placed on bridges. In that case, the risks were at specific locations (i.e., bridges) rather than distributed along roads, and FDOT deployed RWIS stations at the specific locations where the risk existed. The intention was for data from those stations to be ingested by the CRS, which would generate alerts whenever high wind speeds were detected. These alerts would prompt review of conditions at the bridge so that a bridge closure decision could be made.

In practice, the effectiveness of the RWIS stations was limited by disputes between the contractors responsible for developing the CRS and RWIS over how the RWIS stations would interface with the CRS. The project for deploying the RWIS stations was let before the CRS vendor was selected, and the specifications for the interface to this system were vague:

> *Design a web-based interface to the road weather data collected by the RWIS that shall make this information available in real-time, in a user-friendly and useful format to public and private users (processors) of the data.*
>
> *Conduct a workshop to determine the requirements of FDOT, and other potential stakeholders, and to get feedback about successive versions. The design of the site shall be done in cooperation with FDOT-District 5 and the ITS Office, UNF and NWS meteorologists.*

To meet this requirement, UNF developed a web server that could be used to access real-time data from the RWIS stations. It also fed the data to NWS MADIS, which archived the data and made it available to the meteorological community. National Oceanic & Atmospheric Administration (NOAA) staff indicated that the National Centers for Environmental Prediction, which run the operational weather models for the United States, uses data from the MADIS mesonet in these models. Thus, the *i*Florida RWIS data was available to improve weather forecasting, though it is not clear how strong the impact of this additional data is on the forecasts.[2]

> ***Providing RWIS data to the MADIS mesonet or to the Clarus system will make the data available to the meteorological community.***

[2] From email exchanges with Mike Barth of the National Oceanic and Atmospheric Administration.

The CRS contractor, on the other hand, expected to receive this data through an interface that was based on the IEEE 1512 standard and used Simple Object Access Protocol (SOAP) push to deliver the data. This was the same interface the contractor used to receive most of its data. UNF refused to develop an interface consistent with the one specified by CRS, stating that it was not familiar with the SOAP technology that CRS required it use and did not have sufficient software development resources available to develop an interface based on an unfamiliar technology. CRS refused to develop an interface to available UNF data sources, including a Web site and FTP site through which real-time data was available.

When systems that must interact are being developed by different contractors, the contractual language for those contractors should specify how the systems will interface and who is responsible for developing each part of the interface.

Faced with this impasse, FDOT elected to have the CRS receive the RWIS data through MADIS. Meteorlogix, the contractor providing the *i*Florida weather condition and forecast data, had already developed an interface to the MADIS data and was in the process of developing an interface to transmit weather data to CRS. The data would go from UNF to MADIS, from MADIS to Meteorlogix, then from Meteorlogix to CRS. The disadvantage of this approach was that it introduced an approximate 15-minute lag between when measurements were made and when the CRS received the data.

The FDOT RWIS data was first delivered to MADIS on February 28, 2005, and the data feed stopped on June 6, 2006, when the contract with UNF to push this data to MADIS ended. The data from these stations during this period is available from MADIS. As of September 2007, FDOT was considering upgrading all FDOT RWIS stations so as to be NTCIP compliant. If this were done, then the agency's new traffic management software (see Section 2) would be able to ingest the RWIS data directly.

11.3. Deploying the Meteorlogix Weather Data System

The contract with Meteorlogix to provide weather data to the *i*Florida systems was signed in January 2004, about the same time as the contract to begin development of the CRS was signed. It described the following basic approach for providing Meteorlogix weather data to FDOT:

The contract with a data provider should clearly describe the data that will be provided and its format.

- Meteorlogix would ingest weather data from a variety of sources and produce high-resolution estimates for current and forecast weather conditions for a wide variety of forecast parameters.
- Meteorlogix would ingest NWS Doppler Weather radar data and compute projected storm tracks for individual storm cells.
- Meteorlogix would ingest NWS thunderstorm and tornado warnings and associate those warnings to Florida counties.
- Meteorlogix would use the high-resolution current and forecast weather condition data to compute current and forecast values for a Road Speed Index. (The Road Speed Index would be a number estimating the extent of the impact of weather conditions on traffic.)
- Meteorlogix would compute the intersection of the Road Speed Index values with pre-defined road segments and transmit the current and 3-day forecast values of the Road Speed Index for

each road segment. The data would be transmitted as a Geographic Information System (GIS) shape file and as a text file.

- Meteorlogix would compute a Road Speed Summary for each road segment, where the Road Speed Summary is a classification of the Road Speed Index into several categories. The data would be transmitted as a GIS shape file and as a text file.
- Meteorlogix would compute the intersection of projected storm tracks and NWS thunderstorm and tornado warnings and provide current and forecast road alerts based on that data.
- Meteorlogix would provide a text narrative for each road segment that summarizes expected weather conditions for the next three hours and would be appropriate for use in a 511 message.

The basic concept was that Meteorlogix would pre-process the weather data and provide to FDOT information tailored to support specific traffic management activities. The Road Speed Index could be used to estimate the impact of current and forecast weather conditions on traffic flow. The alerts could warn operators of severe weather conditions that could impact traffic. The text narratives could be used to generate 511 messages or populate a traveler information Web site.

As the design proceeded for the CRS, which was to receive and make use of the Meteorlogix weather data, considerable change to this approach occurred. Some of the key changes were:

- Meteorlogix would neither compute the Road Speed Index nor provide it to FDOT.
- Meteorlogix would provide weather data for each Florida county, including:
  - Current and forecast weather conditions for each Florida county, including a general descriptor of weather conditions, wind speed and direction, and current, minimum, and maximum temperatures;
  - Severe weather alerts.
- Meteorlogix would provide weather data for each *i*Florida road segment.
  - This data would take the form of one or more descriptors indicating when rain, thunderstorms, hail, high winds, snow, or mixed precipitation were expected to affect or were affecting a road segment.
  - The data would only be provided when one or more weather conditions exceeded reporting thresholds. The weather conditions that would trigger a data submission were light rain, thunderstorms, hail, high winds, fog, snow, and mixed precipitation.
  - The data would be transmitted in the form of TMDD FEU messages, a much more complex format than the use of text files and shape files.
- Meteorlogix would not provide a text narrative for each road segment.

In other words, the role of Meteorlogix changed from providing weather information that was pre-processed specifically to support traffic management activities to providing simpler weather data. The responsibility for estimating the impact of weather conditions on traffic had migrated from Meteorlogix to the CRS contractor. However, the format that Meteorlogix was to use for transmitting the data had changed from a simple transmission of shape and text files to a more complicated

The design of the system that uses provided data should be complete before a contract with a data provider is put in place.

transmission of XML files in which a time-series of transmissions were organized into events and event updates. These changes meant that the requirements of the Meteorlogix contract were no longer consistent with the actual requirements for participating in the *i*Florida deployment.

A second difficulty caused by this evolution of the requirements was that it impacted Meteorlogix's part of the *i*Florida deployment. The original schedule called for the meteorological portion of the CRS to be completed in January 2005, making that software available to test the Meteorlogix data feed before Meteorlogix entered the operational phase on May 1, 2005. However, the evolution of the Meteorlogix-CRS interface continued to evolve throughout 2004 and the first part of 2005. The last significant change occurred in March 2005, when CRS documentation first indicated that Meteorlogix would not provide the Road Speed Index to the CRS. The continual evolution of the CRS design prevented Meteorlogix from completing the development of the system that would provide data to the CRS.

A coordinated master schedule should be maintained that reflects the dependencies between the projects.

The delays in the CRS development also affected the Meteorlogix deployment in indirect ways. First, FDOT could not test the Meteorlogix data feed until the CRS meteorological component was available. The Meteorlogix system first began providing weather data to FDOT in June 2005, though the CRS interface for receiving that data was not available until July 2005. With no system available to receive the Meteorlogix data, the development of the Meteorlogix side of the Meteorlogix-CRS interface was accepted without complete testing and the contract entered the operational phase. Second, FDOT had no need of Meteorlogix weather data before the CRS development was far enough along to make use of that data. Because FDOT struggled to get the CRS to provide basic traffic management functionality, such as automatically computing travel times and populating DMS with travel time messages, it never moved on to secondary features, such as integrating weather data into its traffic management process. If FDOT had developed a detailed master schedule for the *i*Florida deployment that included all of the dependencies for using weather data, it might have avoided paying for a weather data feed that it could not use.

11.4. The Performance of the Meteorlogix Weather Data System

A number of problems were reported with this interface between June 2005, when Meteorlogix first began providing data to FDOT, and November 2005, when FDOT first began regularly using the CRS at the D5 RTMC. Soon afterwards, RTMC operators complained about the presence of extraneous weather data in their CRS displays—the system would post messages indicating that weather conditions were good on every road segment. The root cause of this seemed to be a misunderstanding regarding the type of weather data that would be passed through the Meteorlogix-CRS interface. Meteorlogix provided current weather data for every road segment, while CRS believed that it would only receive weather data for road segments when certain weather conditions existed. FDOT believed that it would be able to tailor the weather conditions that resulted in the display of weather alerts on the operator consoles. The interface control document specified the format that should be used for transmitting the data, but did not specify the data that should be transmitted or the triggers for transmitting it. This information was in the CRS and Meteorlogix design documents. Because comprehensive testing of this data feed was not performed, the discrepancy was not noted until RTMC operators began using the CRS.

Interface documentation should clearly describe the data that is passed through the interface.

Sometime in January 2006, the CRS contractor turned off the CRS process that received data from Meteorlogix. This eliminated the appearance of extraneous weather data on the RTMC CRS displays, but also removed weather data from the CRS. The CRS weather data processing was restarted in June 2006, but little use was made of this data at the RTMC. Because this data feed was not often used at the RTMC, little is known about the reliability of the feed.

11.5. The Performance of the CRS Weather Data Systems

FDOT's original requirements for the CRS specified that the CRS would:[3]

- Incorporate roadway weather conditions, alerts and forecasts and accept data feeds from Meteorlogix's weather information;
- Exhibit an abnormal road condition in the operator interface when adverse weather conditions presently exist or are forecasted within the next 60 minutes that will affect throughput capacity or safety along the roadway link;
- Color-code roads on the statewide Web site to indicate if severe weather conditions exist on each road;
- Prompt operators to record a regional 511 message if a significant weather condition exists on a Central Florida or Statewide 511 route;
- Consider weather conditions when estimating future travel times on *i*Florida road segments; and
- Archive weather data received.

Of these capabilities, only the first (incorporating weather data) and last (archiving weather data) were successfully demonstrated while the CRS was in operation. CRS did accept data feeds from Meteorlogix, and archived data that it received. The extent to which the CRS met the other requirements is summarized in the following list:

- The CRS did display weather events on the operator interface, but did not initially differentiate between adverse and normal weather conditions, displaying both types of conditions. The CRS was updated to filter the weather data and only display severe weather conditions. But, this filtering capability was frequently "lost" when the CRS software was updated.
- Roads on the statewide Web site were not color-coded based on weather data.
- RTMC operators did not indicate that the CRS prompted them to produce 511 messages based on severe weather conditions.
- FDOT reported that the CRS did not appear to produce travel time forecasts, regardless of whether those forecasts made use of weather data.

11.6. Summary and Conclusions

As part of the *i*Florida Model Deployment, FDOT D5 successfully deployed a set of RWIS stations and established a method (through the MADIS mesonet) for providing that data to the D5 RTMC and to the meteorological community. This method of providing the data to the D5 RTMC introduced a 15-minute lag between the time the data was measured and when it reached the RTMC, which could have reduced its effectiveness in supporting real-time decision making. FDOT also

[3] Source: CRS baseline requirements database.

successfully contracted with a third-party provider of weather data to supply road-specific weather condition and forecast data to FDOT.

However, the CRS software that was to help integrate this weather data into FDOT's transportation management decision making process did not perform as expected. Thus, the weather data was little used during the period considered in this report. In large part, this was due to limitations in the CRS, such as not including appropriate filtering of the weather data so that FDOT could select the types of weather conditions that generated alerts for the operators. These limitations were likely compounded by the fact that FDOT was focused on correcting other problems with the CRS, problems that included incorrect computations of travel times and failure to update DMS messages (see Section 2 for more information), rather than correcting problems with CRS use of weather data. With problems existing with the primary types of information needed to support traffic management (e.g., travel times), there was little advantage to improving sources of secondary information, like weather data. In retrospect, it might have been better to introduce weather data into the transportation management process at FDOT after the primary transportation management tools (e.g., travel time measurements, travel time forecasts, traveler information) were more stable.

While deploying and operating these weather systems, FDOT did identify a number of lessons learned that it might use to improve future operations and that other locales may find useful. The following list summarizes these lessons learned.

- Use of the microwave tower sites was a cost-effective approach for deploying RWIS stations at remote sites. Deployment costs were reduced because utilities were already available at those sites and the microwave network could be used to transmit the collected data.
  - NWS indicated that locating some weather observation equipment on a microwave tower could violate NWS equipment, siting, and exposure standards. For example, a temperature sensor should be at least 100 feet from any paved or concrete surface and precipitation gauges should not be located close to isolated obstructions such as trees and buildings.[4]
- The interface between the software that compiled and disseminated data from the RWIS stations and the CRS software, which was to use this data, was a problem, and the contractual language between the two contractors involved did not make it clear who was responsible for fixing the problem. When systems developed by different contractors must interact, the contract should clearly define the interface that will be used and the responsibilities of the contractors in developing that interface.
- The MADIS mesonet can be used as an interface between RWIS stations and traffic management software.
  - If DOT RWIS data is provided to the MADIS mesonet, it will be available to the meteorological community, including the National Centers for Environmental Prediction, which runs the operational weather models for the United States.
  - If a DOT accesses its RWIS data through the MADIS mesonet, it may also be able to access other real-time surface weather data collected by other organizations.
  - Accessing data through the MADIS mesonet may introduce a latency in the availability of the data. For the FDOT RWIS stations, there was an approximate 15-minute lag between when RWIS data was collected and when it was available through the MADIS mesonet.

[4] Source: http://www.weather.gov/om/coop/standard.htm (accessed on December 19, 2007). These standards are recommendations rather than requirements. Not following the standards does not preclude NWS from making use of the resulting weather data.

- Simultaneously introducing new traffic data collection methods, transportation management software, and weather data into the transportation management process is difficult. One may want to wait until the primary transportation management tools and practices are stable before introducing weather data into the process.

Despite the difficulties FDOT faced, it is still hoping to integrate weather data into its transportation decision-making process, but at a slower pace. The agency has replaced the problematic CRS software with software from a different vendor. FDOT is currently focusing its efforts on primary transportation management tools, such as collecting accurate travel time and incident data and facilitating the use of this data to manage its incident response and traveler information capabilities. FDOT has been considering other sources of weather data, and hope in the future to re-introduce weather data into their transportation management practices.

12. Security Projects

The plans for the *i*Florida deployment included five projects related to transportation security. Four of these projects were completed during the period from May 2003 through October 2007:

- A bridge security monitoring system was deployed at two high-priority bridges in Florida.
- A broadband wireless system was deployed on parts of I-4, providing network connectivity to vehicles there, and the LYNX transit system deployed video surveillance equipment that used that broadband wireless system to transmit bus security video to the LYNX operations center and the District 5 Regional Transportation Management Center (D5 RTMC).
- A vulnerability assessment of the D5 RTMC was conducted.
- An emergency evacuation plan for the Daytona International Speedway was developed.

The fifth project, using traffic modeling applications to test the effectiveness of alternate routes in case a bridge was destroyed or disabled, was delayed because the *i*Florida data warehouse did not archive sufficient data to support those activities. FDOT plans on completing that activity once a new data warehouse, under development at the time of this writing, is in place. The remainder of this section describes each of the four completed *i*Florida security projects and the lessons learned in implementing them.

12.1. Bridge Security Monitoring

FDOT viewed the Bridge Security Monitoring project as a technical proof of concept that would indicate the feasibility and cost of deploying a system to monitor the location around a bridge in order to identify and respond to potential threats to the bridge. This part of the evaluation report describes FDOT's experience in designing, deploying, and using the Bridge Security System.

12.1.1. Assessing the Need for a Bridge Security Monitoring System

FDOT believed that, before deciding to deploy a Bridge Security Monitoring System, a DOT should perform a comprehensive review of the security risks across the whole DOT infrastructure to identify the highest priority risks that could be addressed most cost effectively. One approach for doing this is to use the Homeland Security Comprehensive Assessment Model (HLS-CAM), developed by the National Domestic Preparedness Coalition.[1] Although the full HLS-CAM process was not necessary for this project—FDOT was committed to deploying a Bridge Security Monitoring System in order to gather information on the costs and effectiveness of such a system—FDOT elected to follow applicable parts of the HLS-CAM process. Following this process involved the following five steps:

1. *Threat Assessment*. The purpose of the threat assessment was to list the critical infrastructure and key resources that might be threatened and identify the types of threats that might exist for those items. Because the three bridges considered for the *i*Florida Bridge Security project were pre-selected, this step was only used to identify the types of threats that might exist for the bridges.
2. *Criticality Assessment*. The purpose of the criticality assessment was to estimate the overall impact of a terrorist attack on a given target. This information would have helped FDOT select the infrastructure that should receive highest priority in conducting the security

[1] Information about the HLS-CAM is available at http://www.ndpci.us/.

assessment (attacks that result in more severe impacts receive priority over attacks that result in less severe impacts). However, because the three bridges were pre-selected, this step was not necessary for this project.

3. *Mission, Demography, Symbolism, History, Accessibility, Recognizability, Population, and Proximity (M/D-SHARPP) Matrix*. The M/D-SHARPP matrix included a rating for each of the eight M/D SHARPP characteristics assigned to each method of attack for each infrastructure element. These ratings were combined to help identify the most likely methods of attack, with the most likely methods receiving focus in the remaining two HLS-CAM steps.
4. *Community Priority Assessment Plan*. The community priority assessment plan considered the results of the Criticality Assessment and the M/D-SHARPP matrix to identify the high-impact targets (from the criticality assessment) that also have high vulnerability (from the M/D-SHARPP Matrix). This helped identify the infrastructure items and modes of attack that should be emphasized in the vulnerability assessments. In this project, three types of threats were identified for inclusion in the bridge vulnerability assessment: (1) an explosion on the bridge surface, (2) an explosion under the part of the bridge over land, and (3) an explosion under the part of the bridge over water.
5. *Vulnerability Assessment*. The vulnerability assessment identified the vulnerabilities of infrastructure elements to the types of attacks identified in the community priority assessment plan. In the *i*Florida Bridge Security project, vulnerability assessments were conducted for all three bridges. These vulnerability assessments identified specific threat scenarios related to the three general explosion scenarios, such as where and how a bomb might be placed.

The end result was a series of threat scenarios that identified specific vulnerabilities that could be addressed and mitigated. In general, the HLS-CAM process might identify a number of different mitigation approaches, such as limiting access to the bridge (e.g., by installing fencing), identifying and responding to a threat before damage occurs (e.g., by deploying a monitoring system), hardening the bridge against damage if an attack occurs (e.g., by reinforcing key structural elements), or reducing impacts if a bridge is damaged (e.g., by identifying and signing alternate routes). Each mitigation approach would be considered and the most cost-effective ones selected for deployment.

For the *i*Florida Bridge Security Monitoring project, the mitigation strategy was selected ahead of time. In this case, the HLS-CAM process defined the details of potential threat scenarios that were used to help design the Bridge Security Systems by identifying locations at which surveillance was needed in order to detect a threat before damage could occur.

12.1.2. Designing the Bridge Security Monitoring System

The *i*Florida Bridge Security Monitoring System was a software system that automatically monitored video images and activated an alarm whenever it detected image characteristics indicating that suspicious activities might be occurring near the bridges. When an alarm was raised, the system would allow operators to review real-time and archived video footage to identify the source of the alarm and monitor response activities, if a response was required.

Based on the threat scenarios identified during the HLS-CAM vulnerability assessment, the first step in the design process was to identify the locations for the video surveillance cameras. The threat scenarios identified the most likely locations where explosives might be placed to damage the bridges. Cameras were positioned to monitor access to those locations. This analysis identified the need for 15 cameras at 1 bridge and 16 at the other, providing surveillance both on the surface of the bridge and underneath it.

The next step was to design the hardware needed to support the video surveillance equipment, the video archiving, the video monitoring software, and the operator interface to the surveillance video and alarms, as well as the network connecting this equipment together. The *i*Florida Bridge Monitoring System design called for deployment of digital video recorders and video analysis processors in the field near the bridge and the use of the existing FDOT fiber network to transmit the video and alarm data to the Bridge Security Monitoring workstations.

The last step in the design was to specify the type of monitoring that the video monitoring software would apply to the bridge security video. This software provided a number of different tests that can be applied to a video stream in order to generate alarms. In general, one could specify an area in a video image that should be monitored and specify the type of test that should be applied. For example, one test looks for motion in an area while another is designed to detect static objects. A motion test might be used to identify objects entering an area in which access was limited, while a static test might be used to detect a vehicle that stops on a road. While the design documentation for the Bridge Security Monitoring System included all the details related to the hardware required to operate the system, it did not include details on the video monitoring tests that would be applied. Instead, tests were defined after the system was installed. More information on this part of the design is covered in the next two sections.

> ***The system design should include design of the video monitoring tests that will be applied.***

12.1.3. Deploying the Bridge Security Monitoring System

The Bridge Security Monitoring System project was first delayed because the contractor withdrew. A new contractor was selected and the project began in October 2004. The design and deployment proceeded on schedule until the summer of 2005, when several hurricanes resulted in extensive flooding that left several planned pole locations underwater. Construction at one bridge was also halted during the Super Bowl. In September 2005, testing was completed and the Bridge Security System was operational. However, network problems prevented FDOT D5 from accessing bridge security monitoring data from one location until July 2006. (The data was assessable from a different FDOT TMC.) By July 2006, network connectivity had been restored and D5 had full access to the Bridge Security Monitoring system.

12.1.4. Using the Bridge Security Monitoring System

The first step in using the Bridge Security Monitoring System was to set up the tests that would be applied to the video surveillance images and trigger alarms. The contractor assisted FDOT with setting up the initial set of tests that would be used. FDOT tested the system, and it successfully detected vehicles entering monitored areas. FDOT did not test the system to determine if the number of false alarms generated was acceptable. Observations by the Evaluation Team indicated that the number of false alarms was high, and RTMC operators responded to the high number of false alarms by turning off the alarm speakers.

> ***System testing should include verifying that the number of false alarms is not excessive.***

One major source of false alarms appeared to be the highly variable environment in which the system operated. The environment included locations often shadowed by the bridge, and lighting varied dramatically throughout the day. Headlights from vehicles entering the area could put lights and shadows at different locations as the vehicles passed. The automated video analysis often generated alarms that, when reviewed, had no apparent cause. An example is shown in Figure 137 below.

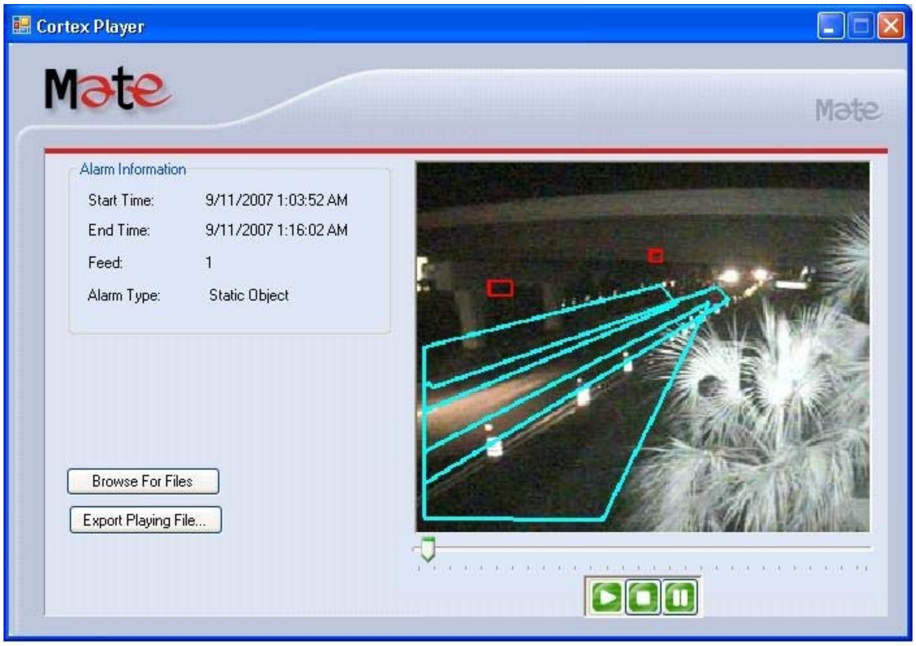

Figure 137. Example of a Bridge Security System False Alarm at Night

In this figure, the large, blue highlighted regions indicate areas in which special tests have been defined and the smaller, red highlighted boxes indicate locations that generated alarms. Another example is shown in Figure 138.

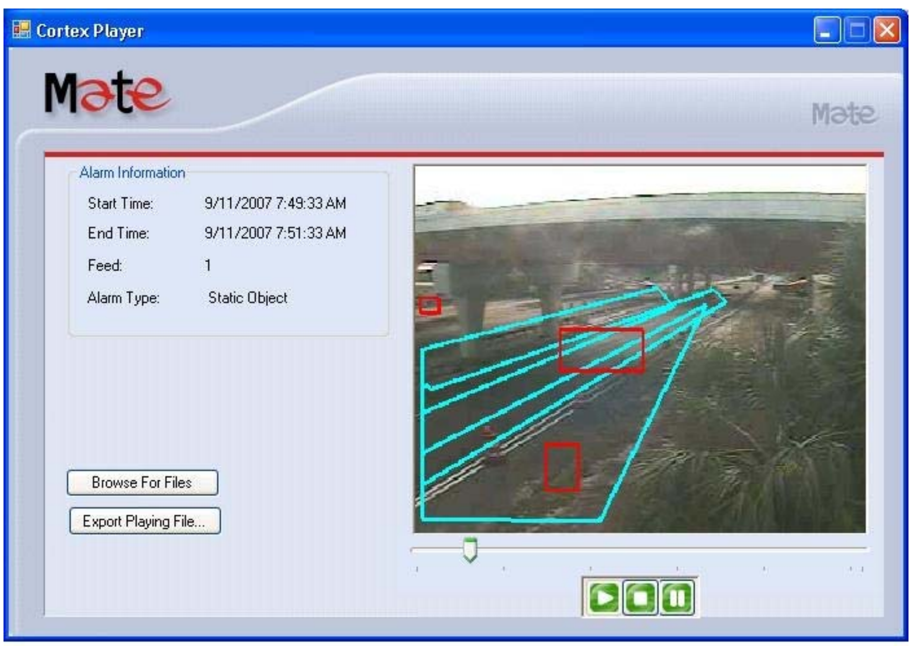

Figure 138. Example of a Bridge Security System False Alarm During the Day

In each of these examples, there was no readily apparent cause for the alarm. A review of the alarms logs during one twenty-four hour period showed that 559 alarms had occurred. (This high number of alarms occurred shortly after FDOT installed a software upgrade and reconfigured the system. Lower—but still high—alarm rates had occurred previously.)

False alarms also often occurred during construction activities around the bridge, as the system would detect parked vehicles or construction workers entering and exiting monitored areas. Because the Bridge Monitoring System did not include alternate alarm parameters for use during construction activities, RTMC operators usually muted alarms during these times.

The system design should include alarm plans for normal operations and other alarms plans that might be used during construction activities.

FDOT also experienced challenges in maintaining the cameras needed to support the Bridge Monitoring System. Figure 139 depicts the average percent of Bridge Security Monitoring cameras that were operational each month.

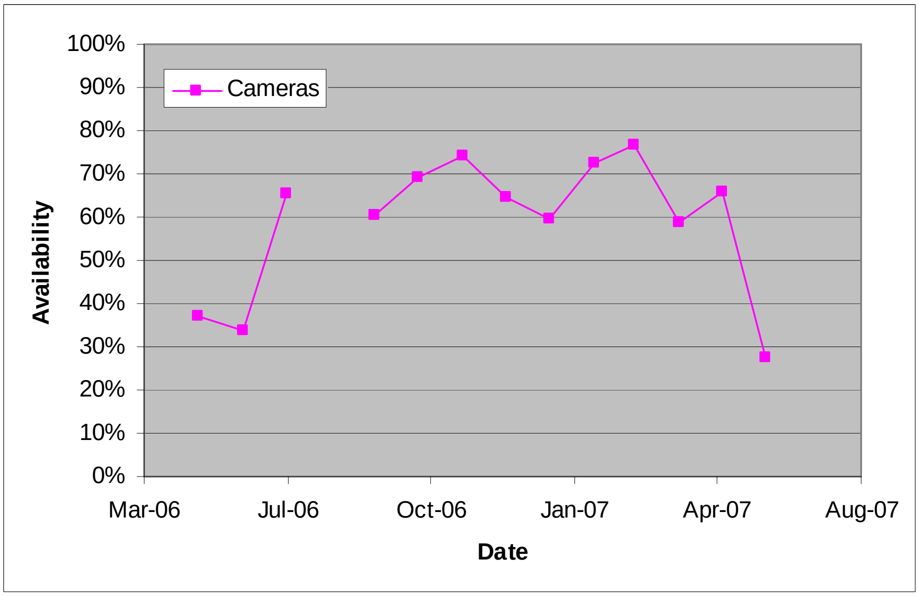

Figure 139. Availability of the Bridge Security Field Equipment

These camera failures decreased the effectiveness of the system by leaving some areas un-monitored. A camera failure could also increase the number of false alarms, if the failure resulted in a distorted image rather than a failed video feed.

12.1.5. Future Plans for the Bridge Security Monitoring System

When the planned operational period for the Bridge Security Monitoring System ended in May 2007, FDOT considered whether it would continue to operate the systems. If the agency continued to operate the Bridge Security Monitoring System, it identified two changes to the hardware configuration they would make to improve the system reliability and performance. First, FDOT planned to replace the digital video recorders located at the bridges with a video server. The agency felt that these devices were a frequent source of failure, and migrating to a video server would increase reliability. It would also allow FDOT to include the video data in its standard backup process. Second, FDOT planned on relocating much of the hardware (i.e., the video server and the video analysis hardware) from the field to the Deland office. This change would simplify maintenance, since the equipment would no longer be exposed to environmental stresses and site visits would not be required to perform repairs. This change would also protect the archived video images in case a bridge failure did occur—locating this equipment in the field meant that damage to the bridge would likely damage the equipment that archived the surveillance video.

12.1.6. Summary and Conclusions

FDOT demonstrated that a video monitoring system could be used to identify potential threats to a bridge. However, the cost of protecting the two bridges—more than $860,000 for design, deployment, and 2 years of operation—was high. Since the likelihood of attack at these specific bridges was relatively low, a complete HLS-CAM review would likely have identified more cost-effective ways to increase transportation security.

In addition, the effectiveness of the system was compromised by the high number of false alarms that occurred. In a security operations center with operators devoting full-time attention to video surveillance, such false alarms could be easily dismissed by operators and might be a minor nuisance. At the D5 RTMC, however, operators were primarily concerned with traffic operations and could not review and dismiss frequent bridge security alarms. In this type of environment, the acceptable number of false alarms is low. Given the uncontrolled environment around most bridges, it was not clear whether existing video analysis systems could provide a low enough level of false alarms to make the system useful without having full-time operators available to discount false alarms.

The Evaluation Team was also concerned with whether the system would provide an alert in sufficient time for steps to be taken to mitigate the effects of an attempt to damage the bridge. The explosion scenarios the system was designed to detect involved a rapid series of events, leaving little time to detect and respond to the threat. To reduce impacts of an attack, a warning must occur sufficiently in advance of an incident to allow responders to arrive at the scene, clear the area, and/or neutralize the threat. The Evaluation Team suspected that this would not be the case for the *i*Florida Bridge Security Monitoring System.

In the process of deploying and using the Bridge Security Monitoring System, FDOT did identify several lessons learned that might benefit others wishing to deploy similar systems:

- *The system design should include design of the video monitoring tests that will be applied.* Many different types of tests were available for FDOT to use to detect threats and sound alarms. While the software made these tests easy to define, it was difficult to define them in such a way to reduce the number of false alarms.
- *System testing should verify that the number of false alarms is not excessive.* The high number of false alarms in the *i*Florida Bridge Security Monitoring System meant that alarms were often ignored. Testing the number of false alarms, and adjusting the system until an acceptable number was generated, might have made the RTMC operators more responsive to alarms that did occur.
- *The system design should include alarm plans for normal operations and other alarms plans that might be used during special circumstances, such as construction activities.* RTMC operators noted that a number of common events, such as construction activities or a disabled vehicle on the bridge, would sometimes generate a large number of false alarms. The system did not include a convenient way to temporarily adjust the operating parameters when such situations occurred.
- *The video processing and archiving equipment should be located away from the asset being protected, preferably in a climate-controlled environment.* FDOT noted that, with the video archiving hardware deployed in the field, a catastrophe at the bridge would likely destroy the archived video. Archiving the video at a location separate from the monitored asset would protect the archived video from damage, so that it could be used to support post-catastrophe analyses. FDOT also believed that the equipment deployed in the field would have operated more reliably if deployed at the climate controlled environment of the Deland office.

12.2. LYNX Bus Security

FDOT viewed the LYNX Bus Security project as a technical proof of concept that would indicate the feasibility and cost of using a broadband wireless network to support transmission of surveillance video on mobile assets, such as a bus. This part of the evaluation report describes FDOT's experience in designing, deploying, and using the LYNX Bus Security system.

12.2.1. The LYNX Bus Security System

LYNX—the business name for the Central Florida Regional Transportation Authority—operates a public transportation system in Orlando. One part of the *i*Florida Model Deployment established network connectivity between the FDOT ITS network and the LYNX Command Center. This provided LYNX with network connectivity to roadside locations in many areas in which it operated buses. The LYNX Bus Security project took advantage of this connectivity by deploying a wireless network along a 14-mile stretch of I-4 between Orlando and the Disney World attractions. This wireless network bridged the gap between LYNX buses and this roadside network. Buses that used this portion of I-4 were then equipped with security cameras and wireless equipment for transmitting video from these cameras to FDOT and LYNX.

12.2.2. Deploying and Using the LYNX Bus Security System

The deployment of this system occurred with few surprises and was completed in the fall of 2005. RTMC operators reported receiving high-quality video images from buses while on the instrumented portion of I-4. However, they found it difficult to consistently verify that the system was operating correctly. Buses were on the instrumented portion of I-4 at regular but infrequent intervals. RTMC operators periodically checked the system to see if video was present as a method for gauging whether the system was working. Without knowledge of when the buses were present, the lack of video could be caused by either the system working incorrectly or the fact that no buses were present on the instrumented portion of I-4.

As time went on, it became apparent that the system was not working reliably, and FDOT reported in May 2006 that the system had been out-of-service for several months. A planned demonstration in July 2006 was cancelled because of network errors, though it was not clear whether the errors were in the FDOT fiber or in the wireless network. Because the system did not include any diagnostic routines for monitoring system performance, the contractor used a series of network pings to identify where the loss of connectivity occurred. Even then, there was disagreement between FDOT and the contractor over whether the root cause was problems with the FDOT fiber or within the wireless network.

From that time forward, FDOT reported that the system failed to operate reliably. Without specific diagnostic tools or test procedures, no quantitative measures of the system reliability were available to the Evaluation Team. RTMC operators indicated that they had witnessed the system in operation and that it delivered high-quality video. Despite several attempts to do so, the Evaluation Team did not witness the system delivering LYNX Bus Security video.

12.2.3. Summary and Conclusions

At the time the LYNX Bus Security System was deployed, few extensive broadband wireless networks had been deployed and it was not clear that a wireless network could successfully transmit video from a mobile vehicle. The system successfully demonstrated that such a network could be created and that it could be used to transmit real-time video from mobile vehicles. FDOT also reported that the video transmission worked well, when the system was operational.

However, the system was rarely operational. Because the system did not include any diagnostic tools for monitoring system performance, quantitative data on the reliability of the system was not available. Several planned demonstrations of the system were cancelled when problems occurred, and FDOT often reported that the system was out of service. Also, the cost of the system was relatively high—about $640,000 for the initial deployment and for maintaining the system from its deployment date through May 2007. The result was a high-cost approach for providing network connectivity to a small number of buses.

Also, the rapid advance of technology has meant that this project, which was a cutting-edge application in 2003 when it was first considered, is no longer cutting-edge. A number of cities are now considering deploying broadband wireless networks on a much more extensive scale than that deployed in Orlando. Other approaches, such as cell modems, are being used to provide network connectivity to buses, and some of these approaches also provide sufficient bandwidth to support security video.

12.3. D5 RTMC Vulnerability Assessments

As part of the *i*Florida Model Deployment, FDOT conducted a vulnerability assessment of the D5 RTMC. This section of the report describes the process used and lessons learned in conducting this assessment.

12.3.1. The Vulnerability Assessment Approach

The vulnerability assessment was performed to determine the potential weaknesses at the FDOT D5 RTMC and to suggest measures that would either eliminate the vulnerabilities or lessen the impact if vulnerabilities that cannot be eliminated are in fact exploited. An effort was made to identify vulnerabilities that might be common to TMCs so that results from the D5 RTMC VA could be used to reduce vulnerabilities at other TMCs.

The vulnerability assessment approach was centered on estimating the three risk factors listed in the following risk estimation equation:

[Risk] = [Threat] * [Consequence] * [Vulnerability]

The following four-step process was used to conduct the vulnerability assessment.

- *Step 1 – Threat Characterization.* The threat characterization determined the *Threat* value of the above equation. This step also provided an inventory of generalized threats/scenarios most likely to affect a TMC, such as use of explosives or a cyber-attack. The *Threat* value was obtained by determining the target attractiveness and the threat condition of the nation. The *Threat* value is a static value, meaning that a countermeasure will not reduce the value. Seven types of threat scenarios were considered: car bomb; large vehicle bomb; chemical, biological, or radiological attack; package bomb; armed attack; collateral damage; and cyber attack.
- *Step 2 – Consequence Assessment.* Based on the threat scenarios that were developed in step 1, potential consequences were estimated based on current conditions. These potential consequences were used to estimate the *Consequence* factor in the above formula. Five types of potential consequences were considered: fatalities and casualties, mission downtime or degradation, economic impact, downstream effects, and emergency management.
- *Step 3 – Vulnerability Analysis*. For each threat scenario, a set of predetermined vulnerability factors were used to generate the *Vulnerability* value of the equation.

- *Step 4 – Countermeasure Analysis*. This step involved the development of countermeasure packages and an assessment of the impact on the risk if a package were deployed. Each countermeasure package was considered and the *Consequence* and *Vulnerability* factors re-estimated, assuming that the countermeasure package was implemented.

The end result of the vulnerability assessment process was a list of vulnerabilities identified, a list of countermeasures that could be used to reduce those vulnerabilities, estimated costs of these countermeasures, and estimates of the impact on risk if each countermeasure were implemented. This allowed FDOT to identify for implementation those countermeasures that could decrease risk most cost effectively.

12.3.2. The Vulnerability Assessment

The main vulnerabilities observed during the vulnerability assessment were related to the inability to maintain a clear space around the building. Parking was adjacent to the building, including spaces adjacent to the external walls of the RTMC area of the building. Private property was close to the building on one side and separated from the facility by only a chain link fence. These factors are difficult to correct for an existing facility, and it was not feasible to correct them at the D5 RTMC.

The design for a TMC should include standoff distances that help maintain a clear space around the building.

Other observed vulnerabilities related to the failure for some staff to follow existing security procedures. For example, people sometimes entered the TMC by tailgating authorized personnel and people without an appropriate badge displayed were seldom challenged. The vulnerability assessment suggested that staff be trained in the security procedures for the facility and that FDOT take steps to emphasize the importance of following these procedures.

Three common problems were also discovered during the cyber-security review. A number of servers were identified that did not have the most recent security patches installed. Several servers were identified as running unnecessary services. (Since each service running on a server provides a potential entry point for cyber-attack, the fewer services running the better.) Some software systems were installed using the default password, and the password had not been updated. (Since default passwords are well known, they should be changed to prevent unauthorized users from accessing a system.) A second cyber-security review indicated that FDOT had corrected most of the vulnerabilities discovered during the initial cyber-security review.

12.3.3. Summary and Conclusions

The RTMC vulnerability assessment improved the security at the RTMC in several ways. The most obvious was that it identified several vulnerabilities that FDOT addressed. Several of these were believed likely to apply to many other TMCs:

- TMCs should be designed with sufficient standoff distances, making it more difficult for a potential attacker to approach the building.
- The importance of security and following security procedures should be emphasized to all TMC staff.
- Processes should be in place to ensure that security patches are applied to all servers and appropriate passwords are used.

At the D5 RTMC, the act of performing the vulnerability assessment increased awareness of security issues among FDOT and FHP staff. For example, the Evaluation Team noted that FDOT staff was more careful to ask to see IDs before visitors were allowed to enter the building and were more careful to ensure that background checks were performed.

A secondary benefit of the FDOT vulnerability assessment was that it helped satisfy FHP security requirements. In Florida, FHP was required to conduct vulnerability assessments at each FHP dispatch center. Because the FHP dispatch center is located at the RTMC, and the RTMC vulnerability assessment followed accepted guidelines for performing vulnerability assessments, FDOT expected that the its RTMC vulnerability assessment would satisfy the FHP vulnerability assessment requirements.

12.4. Daytona International Speedway Emergency Evacuation Plan

Another activity funded as part of the *i*Florida Model Deployment was the development of an emergency evacuation plan for the Daytona International Speedway. This section of the report summarizes the results of that activity.

12.4.1. Background Information

The Daytona International Speedway committed to work with FDOT D5 and the transportation agencies of Volusia County to coordinate transportation activities necessary to support an emergency evacuation of the Speedway, both in terms of getting spectators out of the Speedway and public safety and law enforcement personnel in.

Each year, about 500,000 visitors come to the Daytona Beach area during Speedweek, 2 weeks of racing in February that culminates in the Daytona 500. In addition, the Pepsi 400, hosted on July 4th weekend, attracts over 200,000 visitors. Many of the visitors during these events stay in the Speedway's infield in motor homes, trailers, and tents. With so many people attending Speedway events, concerns existed about whether the Speedway could be efficiently evacuated if an event occurred. These concerns were increased because, in 2004, the Speedway was in the process of a significant remodeling of the Speedway infield area. These changes necessitated an updated evacuation plan for the Speedway.

The ITS infrastructure near the Speedway that supported traffic leaving the Speedway during an evacuation was also changing. Prior to the 2003, there was already close coordination between the Speedway and nearby transportation agencies—particularly, FDOT D5, Volusia County, the City of Daytona Beach, and the FHP—to manage traffic entering and exiting the Speedway. Volusia County and the City of Daytona Beach would modify signal timings to accommodate higher traffic flows towards the Speedway before a race and away from it afterwards. FDOT staff would stay at the Daytona Beach TMC to coordinate between the City of Daytona Beach, local law enforcement, FHP, and Road Rangers, and D5 would use its traffic management resources (e.g., 511, DMS) to help monitor and improve traffic flow.

During the period when the *i*Florida infrastructure was being deployed, a significant expansion in ITS infrastructure near the Speedway was taking place. Traffic monitoring devices and DMSs were being installed on both I-4 and I-95 near the Speedway, and trailblazer signs were being deployed at a number of key intersections on arterials that might carry traffic during a Speedway evacuation or when an incident occurred on I-4 or I-95 near the Speedway. Figure 140 shows the locations of the dynamic message and trailblazer signs in the area around the Speedway. The development of the new Speedway evacuation plan provided an opportunity for the nearby transportation agencies to update their plans on how to use available resources to best manage Speedway traffic.

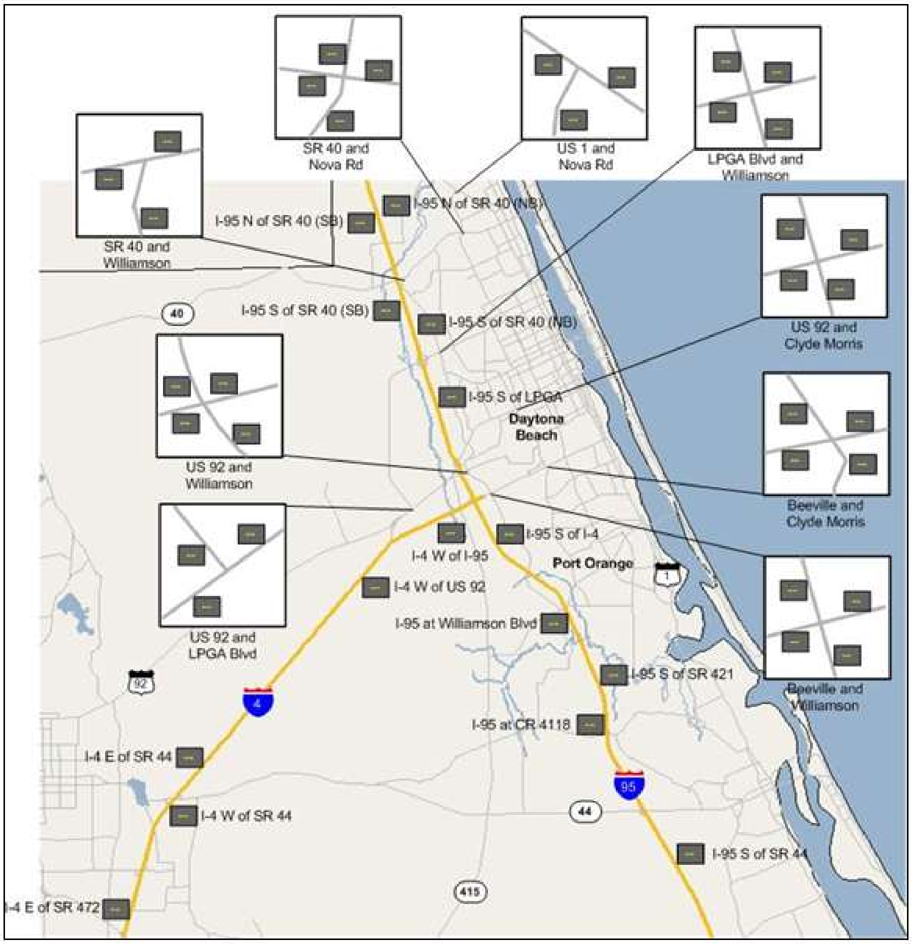

Figure 140. Dynamic Message Signs Near the Daytona International Speedway

12.4.2. The Evacuation Plan

The project began with a kick-off meeting on June 15, 2004, involving representatives from the Speedway corporation, FDOT, NASCAR, city and county police and fire, Daytona Beach Airport Authority, Embry-Riddle Aeronautical University, Florida State Troopers, and city and county Emergency Management agencies. The contractor developing the evacuation plan began by reviewing the planned changes and observing activities during the Pepsi 400. Based on this information, the contractor developed an emergency evacuation plan that focused primarily on evacuating spectators off the property and onto the roads. This plan included the following components:

- A concept of operations that described the organizations involved in an evacuation and their responsibilities as well as the relationship of the Speedway evacuation plan to other emergency plans and facilities.
- Pre-planned pedestrian evacuation routes for all sections of the facility, with assignment of responsibility to uniformed public safety personnel and vested event staff as necessary to direct evacuees to safety.
- Recommended public information and emergency instructions regarding the evacuation process.

A review of the plan identified the following key elements within it:

- *Establish a joint command center*. In order to evacuate attendees, a number of jurisdictions and organizations would need to be involved. The Speedway would need to direct attendees to their vehicles and manage traffic exiting parking facilities. The City of Daytona Beach and Volusia County would need to modify signal timings and police the evacuating traffic. FDOT and FHP would need to manage traffic on I-4 and I-95. Coordination of these activities would be simplified from a joint command center.
- *Identify a route for ingress and egress of emergency response personnel*. The Speedway evacuation plan designated a route linking the Speedway with the nearby Halifax Medical Center. This emergency ingress/egress route could be used for entry by emergency response personnel and for evacuation of injured to the medical center. It did not cross any pre-planned evacuation route to avoid conflicts between pedestrian evacuees and emergency service vehicles.
- *Identify an off-site staging area for emergency response personnel*. The plan identified a strategic off-site location to which supplemental response personnel would initially respond, and located this area on the emergency ingress/egress route.
- *Establish pedestrian evacuation routes and procedures for managing pedestrian traffic on these routes*. The plan established pedestrian evacuation routes, so that attendees could make it to their vehicles. Attendees would be expected to walk to their vehicles in a direction away from or around the evacuated area. Once in their vehicles, evacuees would be directed to drive out of the area, away from or around the evacuated area.
- *Establish evacuation routes and procedures for managing vehicular traffic on local and state routes evacuating the Speedway area*. Once vehicles departed from the available parking areas, traffic management services would be provided by the city, county and State, using currently established procedures and facilities.
- *Review and update the evacuation plans annually*. To accommodate changes that might occur either at the Speedway or in the local transportation network, the evacuation plans should be reviewed on an annual basis. It was recommended that a table top exercise be conducted biannually to help determine if modifications or enhancements are needed.

Although no Speedway evacuations occurred during the evaluation period, one event did occur that emulated some of the traffic disruption that might take place during a Speedway evacuation. On February 18, 2007, following a race at the Speedway, a motorist on I-4 was shot and killed and I-4 was closed for several hours during the investigation. The shooting occurred about one half mile east of the SR 44 exit on I-4, preventing all traffic from using I-4 to exit the Speedway. FDOT responded by changing DMS and trailblazer messages to establish detours on nearby arterials. The extensive signing helped drivers find and follow these alternate routes. FDOT also used its 511 system to provide information to travelers. The Speedway reported to FDOT that it had received numerous comments from Speedway attendees regarding the usefulness of the roadside signs in helping them find their way during this event.

12.4.3. Summary and Conclusions

The evacuation plan identified a number of features that should be established to facilitate evacuation of traffic from a venue site. The following list contains five of the key features:

- Identify a route for ingress and egress of emergency response personnel.
- Identify an off-site staging area for emergency response personnel.

- Establish pedestrian evacuation routes and procedures for managing pedestrian traffic on these routes.
- Establish evacuation routes and procedures for managing vehicular traffic on local and state routes evacuating the Speedway area.
- Review and update the evacuation plans annually.

An event that occurred on February 18, 2007, following a Speedway race resulted in significant congestion that tested the ability of FDOT to respond to the types of conditions that might exist during a Speedway evacuation. During this event, the availability of trailblazer signs on key routes leading from the Speedway allowed FDOT to establish alternate routes that helped Speedway attendees find their way despite the closure of I-4, the primary route taken by most westbound traffic after a Speedway event.

13. Summary and Conclusions

The *i*Florida Model Deployment began in May 2003 with ambitious goals and high hopes for what could be accomplished. Problems faced along the way prevented FDOT from achieving many of these goals. FDOT did, however, continue to support key traffic management capabilities while these problems were occurring, though many operations that were expected to be automated had to be conducted manually. This ensured that the traveling public continued to benefit from the *i*Florida capabilities and allowed identification of some lessons learned related to these operations. The next section summarizes the history of the *i*Florida Model Deployment. Section 13.2 summarizes the lessons learned.

13.1. Summary of the *i*Florida Model Deployment

*i*Florida plans called for FDOT to complete the design, build, and integration of the infrastructure required to support *i*Florida operations in 2 years. The required infrastructure was extensive, spanned numerous stakeholders, and included many technologies that were new to FDOT D5, such as sophisticated TMC operations software, a wireless network deployed along I-4, an interface to FHP CAD data, statewide traffic monitoring, and many others. The *i*Florida plans also called for deployment of these technologies in ways that required coordination among more than 20 stakeholders. It was an ambitious plan that would result in dramatically different traffic management operations for FDOT D5 and other transportation stakeholders in the Orlando area.

Unfortunately, the Model Deployment faced numerous barriers to achieving its full potential. Maintaining all of the newly deployed field hardware proved difficult. Significant failures occurred with the arterial toll tag readers, the Statewide Monitoring System, the wireless broadband network, and the bridge security system. But, the most significant challenge concerned the integration of all the components through the CRS software. The CRS was the traffic management software that was intended to combine data from the *i*Florida field equipment and provide tools to manipulate this data and control FDOT traffic management assets, such DMSs, 511 messages, the traveler information Web site, and road ranger services. Some of the shortcomings of the CRS software included:

- Difficulties interfacing with the FHP CAD system. The CRS software was expected to receive incident data from the FHP CAD system and provide tools to integrate that data into the incident data entered directly into the CRS by RTMC operators. However, the CRS software had difficulty interpreting the location information received from the FHP CAD system and sometimes placed an incident at an incorrect location. RTMC operators overcame this barrier by entering all incident data by hand.
- Limited capability for handling missing travel time data. The original specifications for *i*Florida called for missing travel time data to be filled in by estimates from either historical data or operator observations. This requirement was later classified as non-critical and wasn't implemented when the CRS was first activated. This meant that many DMS signs were blank and many 511 messages stated that data was unavailable. The CRS requirements called for the CRS to include tools to estimate travel times based on historical data when observations were unavailable. These tools never functioned as expected in the CRS.
- Miscalculating travel times. After the CRS had been in operation for several months, RTMC operators and other *i*Florida stakeholders began reporting that some of the travel times displayed

on DMSs and included in 511 messages were incorrect. Although these errors decreased in frequency over time, they persisted for the entire period that FDOT used the CRS software.

- Improper processing of weather data. When FDOT first began using the CRS software in the RTMC, the CRS operator interface included a large number of alerts related to good weather conditions. The CRS contractor had expected the weather data provider to filter the weather data so that CRS received information about severe weather conditions only. The CRS software itself did no such filtering. The CRS software was also supposed to consider weather conditions when estimating current travel speeds based on historical data, a feature that never functioned.
- Difficulties interfacing with DMSs. Soon after FDOT began using the CRS, RTMC operators noticed that it did not always update DMS messages as expected. Sometimes the CRS was unable to manage messages for a DMS, and sometimes a DMS message set by an operator would appear for a brief time, then be replaced by another message. Other times all of the DMS icons would disappear from the RTMC operator user interface. Eventually, FDOT abandoned the use of the CRS for managing DMS messages.
- Difficulties with recording 511 messages. Soon after FDOT began using the CRS software, RTMC operators reported that the 511 messages they recorded sometimes skipped. RTMC operators were sometimes forced to record a message several times before the quality of the audio was sufficient to use in the 511 system.
- Instability of the CRS software. Throughout the time FDOT used the CRS software, it was prone to instabilities and crashes, with early versions crashing numerous times each week. Later versions of the software proved more stable, though it commonly crashed one or more times each week. After the CRS contractor quit the project in April 2007, instabilities in the software increased dramatically. Within a month, FDOT could not restart the software when it crashed, after which FDOT stopped using the CRS.

Many factors contributed to these failures. First among them was that FDOT did not follow a rigorous systems engineering process in managing the development of the CRS software. At the start of that project, it was noted that no clear statement of the concept of operations for *i*Florida existed and that many of the requirements for the CRS software, the software that would support those operations, were vague and incomplete.

A second contributing factor to the failure for integration was the ambiguous relationship between FDOT and the CRS contractor. Early in the project, most client-contractor interactions with the CRS contractor occurred between CRS contractor management staff and FDOT project management. Contractor employees who would be developing the CRS software and regional traffic management center (RTMC) operators who would be using it were seldom directly involved in the discussions. The CRS contractor had pre-existing software that it hoped to use to meet most FDOT requirements, and the CRS contractor sometimes seemed more intent on convincing FDOT that the capabilities of its pre-existing software were best for FDOT rather than on understanding FDOT's intentions for the CRS software. It was hoped that close collaboration between FDOT and the CRS contractor would result in a shared vision for iFlorida operations that the CRS software would support. This did not occur, and fundamental questions related to *i*Florida operations were still being discussed as the scheduled completion date for the CRS software approached.

A third contributing factor was the lack of a rigorous systems engineering approach to software development. The CRS contractor had originally proposed using a "spiral model" for developing the CRS, which would have provided FDOT with many opportunities to provide feedback to the CRS contractor and refine the CRS requirements. FDOT chose not to use this approach. System engineering practices suggest that CRS contractor develop detailed requirements based on the high-level functional requirements provided by FDOT. These detailed requirements would completely define the funcational capabilities of the CRS in unambiguous and testable terms. Instead, the CRS contractor adopted the high-level functional requirements as the detailed requirements for the CRS. The FDOT staff member overseeing the CRS development was not experienced in software procurements, and accepted these requirements as the basis for the CRS design and testing.

A fourth contributing factor was a confusing program management structure for the iFlorida program. On FDOT's side, top-level management sometimes superseded decisions made by FDOT CRS project management during meetings with the CRS contractor. This made it difficult for final decisions to be made during meetings between the CRS contractor and FDOT CRS project management, because it was uncertain who had the final authority for making a decision. One example was the use of spliced speech for generating 511 messages. FDOT top-level management had decided early in the project that they did not want spliced speech used in the 511 system. During discussions with the CRS contractor, FDOT CRS project management was convinced that spliced speech should be used. Later, FDOT top-level management intervened and the decision to use spliced speech was reversed. The fact that decisions made by FDOT staff working directly with the CRS contractor were often later reversed by higher level FDOT staff led to many miscommunications and damaged client-contractor relations. The continued miscommunications and client-contractor mistrust magnified the ramifications of errors that occurred until the entire CRS software project became too difficult to manage and was abandoned.

Because the CRS software and some of the field hardware did not work as expected, it made it difficult for FDOT to support all of the *i*Florida activities it had hoped to pursue. In some cases, planned activities were abandoned or postponed, while other *i*Florida activities were completed, though completing them often required FDOT personnel to do things manually that they expected to be automated. The following list summarizes the extent to which FDOT completed the activities that were part of the initial *i*Florida plans.

- Deploying new field hardware. FDOT did deploy most of the field hardware needed to support *i*Florida operations. Problems with maintaining the hardware sometimes limited its effectiveness. More details are provided below.
  - Network extensions. The FDOT fiber network was extended along a number of roads in order to provide communication to *i*Florida field devices. Network connectivity was also established between FDOT and other area transportation stakeholders, including OOCEA, the Brevard County EOC, LYNX, and the City of Orlando IOC.
  - Toll tag and license plate readers. FDOT deployed toll tag and license plate readers on some stretches of toll road managed by the Turnpike Authority, on seven key Orlando arterials, and on evacuation routes between the east coast and Orlando. At the time *i*Florida was expected to become operational, many of these readers had failed and FDOT struggled to repair them. During some periods, about 90 percent of these readers would be operational. At other times, this percentage would be much lower.
  - Microloop detectors. Eighteen microloop detectors were deployed on SR 528, a key evacuation route from the east coast to Orlando. Four additional detectors were deployed on a parallel section of SR 520. This data was used to collect travel time data on SR 528, though no hurricane evacuation occurred between the time the loops were available and the time that the *i*Florida evaluation ended.

- Arterial CCTV. Cameras were deployed at a number of key arterial intersections in Orlando, The reliability of these cameras was low, perhaps because their loss did not strongly impact planned *i*Florida operations.
- RWIS stations. FDOT deployed ten RWIS stations in Central Florida, but had a disagreement with the contractor over who was responsible for developing the software to push that data to the CRS. The data was pushed to MADIS, pulled from MADIS by FDOT's weather data provider contractor, and pushed to CRS. This introduced a time lag between the collection of the data and receipt of the data by CRS, which diminished its usefulness. After about one year of operations, the data feed to MADIS was stopped.
- Statewide monitoring. FDOT initially proposed upgrading 54 existing TTMS stations to provide real-time data, with 48 of the upgrades also providing traffic video. FDOT later decided to deploy 25 new traffic monitoring stations at existing microwave tower sites, primarily to reduce the communication costs. FDOT found that these sites were not very effective at providing information useful to support statewide traveler information and that the cost of maintaining them was high. The SEOC expected that video from those devices would be very useful during a hurricane evacuation, though no evacuation occurred between the time the devices were deployed and when the evaluation ended. As FDOT became aware of the high cost and limited usefulness of these devices, its level of effort in maintaining the equipment dropped. The equipment was often out-of-service and little used.
- Variable speed limit signs. FDOT deployed variable speed limit signs, but did not use them, principally because of a lack of confidence in the ability of the CRS software to properly manage the VSL messages. After FDOT began using SunGuide, it conducted tests of the VSL signs and determined problems with the signs that prevented their use. As of July 2008, FDOT planned on purchasing new VSL signs to support VSL operations.
- Bridge security. A bridge security system was deployed that included cameras to monitor the environment around two selected bridges and software to monitor the resulting video. Tests indicated that the system could detect intrusions. However, video failures were common and a high rate of false alarms meant that system alarms were often muted and ignored.
- Bus security. A wireless broadband network was deployed along a section of I-4 to provide communications for security video and panic buttons that were placed on some LYNX buses. FDOT personnel indicated they had witnessed the system working. However, failures of the communication network foiled several official demonstrations of the system, and persistent failures meant that the system was never used operationally.
- Laptops for FHP patrol cars. FDOT planned on helping FHP take advantage of the I-4 wireless broadband network by purchasing laptops for FHP patrol cars, giving patrol officers access to *i*Florida traffic information. These laptops were not purchased.

- Other Data Collection. In addition to data from the field devices, *i*Florida plans called for four other sources of data to support *i*Florida traffic management operations.
  - OOCEA travel time server. Independent of *i*Florida, OOCEA deployed a network of toll tag readers to measure travel times on the toll roads they managed. FDOT provided the toll tag and license plate readers from its network of readers to this server so that it could compute travel times for FDOT. These travel times were then pushed from the OOCEA server to the CRS software. Although there were some initial problems with the server software (such as determining the best parameters to use on arterials), it worked reliably throughout most of the *i*Florida operational period.

  - FHP CAD integration. FHP and the FHP CAD contractor worked with the CRS contractor to develop an interface allowing export of FHP CAD incident data to the CRS. This interface did not work properly, and FDOT did not often use this data for traffic management. Eventually, FDOT quit using this interface entirely and hired another contractor to develop a new, web-based interface that would give RTMC operators access to FHP CAD data.
  - LYNX and GOAA traveler information. The initial plans called for LYNX and GOAA to enter event data (such as bus service disruptions or airport delays) into the CRS, and the CRS would make this information available through the Central Florida 511 system and the traveler information Web site. Instead, LYNX and GOAA developed their own automated phone information system, and the Central Florida 511 system allowed callers to transfer to these other systems.
  - Road weather data. FDOT contracted with a weather data provider to provide current and predicted weather data to the CRS, which was to use it for traveler information, to estimate travel times when measurements were unavailable, and to estimate future travel times. No use was made of this weather data for traffic management. It was not clear whether the expected CRS capabilities were not available or whether other problems with the CRS prevented FDOT from focusing on the use of the *i*Florida weather data.
- Traffic Management. The purpose for collecting and obtaining the data listed above was to better support traffic management operations. The following four items describe the status of the *i*Florida traffic management activities.
  - The CRS software. The CRS software was expected to consolidate data from all the sources listed above and provide tools that used this data to facilitate traffic management operations. The list below describes the status of the CRS traffic management features.
    - Travel time estimation. The CRS software was expected to estimate I-4 travel times based on speed measurements from I-4 loop detectors. This capability seemed to work most of the time. The CRS software was also supposed to combine travel time estimates to produce travel times appropriate for use on DMSs, in the 511 systems, and on the traveler information Web site. Errors in the CRS software meant that many of these travel times were miscalculated. The CRS was also expected to fill in missing travel time data with historical data and to predict future travel times. These capabilities were not demonstrated during the evaluation period.
    - Incident data management. The CRS software was expected to obtain incident information from the FHP CAD system, allow RTMC operators to enter additional incident information, use that information to help manage DMS and 511 messages, and make incident data available on the traveler information Web site. The software did manage incident information, though problems with the interface to the FHP CAD system meant that RTMC operators had to enter all incident data manually.
    - DMS message management. The CRS software was expected to automatically generate travel time messages for DMSs and to allow RTMC operators to override those with manual messages when appropriate. It was also to allow FDOT to design "sign plans" that could automatically populate signs with appropriate messages when certain triggering events occurred. For example, a crash on I-4 closing a lane could activate a sign plan that posted crash messages on signs near the crash location. When the crash and related congestion ended, the crash messages would automatically be removed.

Problems with the travel time estimation process limited FDOT's use of automated travel times. Problems with the interface between the CRS and the signs limited FDOT's use of all the other CRS DMS message management features.

- 511 message management. The CRS software was expected to automatically generate travel time messages for 511 and allow RTMC operators to override those with manual messages if an incident occurred. These messages were pushed to a 511 service provider, who used them to populate the *i*Florida 511 systems. Concerns over the accuracy of the travel times computed by the CRS limited the extent that FDOT used the CRS travel time message generation features. FDOT did regularly use the CRS to manage manual 511 messages.
- Traveler information Web site management. The CRS software was expected to make traveler information available to the public via a traveler information Web site. The CRS did make traveler information available to the public via a Web site.

- The CFDW software. The CFDW was expected to archive the data provided to the CRS and generated by the CRS or CRS operators during traffic management operations. It was expected to provide data mining tools to help FDOT use this data to explore its traffic management operations. It was also intended to provide non-FDOT users with access to the data. The CFDW never compiled a useful archive of CRS data. The data mining tools often ran so slowly against the collected data that the tools were never used by FDOT.
- Central Florida and Statewide 511. The 511 service, which was supported by a 511 service provider, appeared to work well, though voice recognition service often failed to understand spoken commands given by 511 callers.
- Traveler information Web site. This Web site was available most of the time, though missing data and problems with the CRS often limited the availability and accuracy of the data on the site. FDOT also was very dissatisfied with the look-and-feel of the Web site, as the traffic maps available there were of lower quality than those available from other Internet map providers.

- Auxiliary *i*Florida Activities. The *i*Florida plans included several activities that were not directly related to day-to-day traffic management. These activities are described below.
  - Network reliability. FDOT had developed a method for determining a quantitative measure of network reliability called the Florida Reliability Method, which reflected the fraction of time that travel time is significantly longer than usual. FDOT planned on using the travel time data collected for *i*Florida to conduct a network reliability analysis of Orlando roads. Problems with the CFDW prevented them from completing the network reliability analysis during the evaluation period. FDOT began preparing to conduct this analysis in May 2008 based on data archived by SunGuide.
  - Metropolitan planning. FDOT provided funds to the region's Metropolitan Planning Organization to explore how archived *i*Florida data might be used to improve regional planning activities. Problems with the CFDW prevented this activity from occurring. Plans were cancelled in May 2008 after the contractor hired to perform this work reviewed the available data.
  - Probe vehicle test bed. The initial *i*Florida plans called for deploying a probe vehicle test bed, which would test the effectiveness of using probe vehicles for collecting traffic data. These

plans were abandoned early in the deployment, by mutual agreement between USDOT and FDOT.

- Traffic modeling for emergency response. FDOT planned to explore the use of traffic modeling applications to test the effectiveness of alternate routes in case a bridge was destroyed or disabled. These plans were delayed because problems with the CFDW limited access to *i*Florida data. Work on this project resumed in the spring of 2008 based on data compiled by SunGuide.
- RTMC vulnerability assessment. FDOT planned to conduct a vulnerability assessment of the D5 RTMC and develop general security guidelines that could be applied at other FDOT RTMCs. This activity was completed as planned.
- Daytona International Speedway evacuation plan. FDOT planned to work with the Daytona International Speedway to develop an emergency evacuation plan for the speedway and to work with other venue operators in the region in order to identify the role ITS can play in supporting emergency evacuations from large venues. This plan was developed and shared with other venue operators.

Despite the challenges that FDOT faced, it can be readily claimed that the overall *i*Florida Model Deployment was successful. When limitations of the automated systems were discovered, FDOT developed ways to continue to support key traffic management capabilities. When the reliability of the arterial toll tag readers was lower than expected, FDOT modified the way messages were presented in the 511 system to reduce the impact of the missing data on 511 messages. When the CRS travel time estimation process proved inaccurate, FDOT deactivated messages that were known to be flawed. Later, it developed standard messages that could be used during uncongested periods and had operators manually create messages when congestion occurred. When the FHP CAD interface failed, a new interface was developed so that RTMC operators could continue to receive data about FHP CAD incidents. After problems with the CRS's ability to manage sign messages were observed, FDOT had RTMC operators periodically review sign messages to ensure that the correct message was being displayed and, later, had RTMC operators manage all sign messages manually. When the CFDW failed to create useful archives of CRS data, FDOT archived copies of many of the raw data streams that were being provided to the CRS.

In this way, FDOT ensured continued traffic management operations through all of the technical and operational barriers it faced. The challenges associated with the *i*Florida Model Deployment also provided many opportunities to identify lessons learned from the experiences the agency had—lessons that are scattered throughout this report and summarized in the following section.

13.2. Lessons Learned

This section of the report summarizes the lessons learned during the *i*Florida Model Deployment. The key lessons listed are taken from the body of the report and organized according to the chapters in this report. Each lesson is listed, and a reference is made to the page in the report on which the lesson is called out.

Deployment and Operating Experience

- The design for TMC software should include stand-alone tools for diagnosing problems with the systems feeding data to it. (See page 17.)
- The TMC software requirements should address the actions that should be taken when different types of failures occur. (See page 18.)

- Devote time at the start of the project to ensure that the contractor shares an understanding of what is desired from the software. (See page 22.)
- Software projects are complex efforts that require skills that are not necessarily common to transportation agencies. Sustaining trained, certified, and knowledgeable staff is a key to success. (See page 23.)
- The cost structure for a software project is significantly different than that for traditional DOT projects. (See page 23.)
- Requesting documentation of detailed testing performed by the contractor can help ensure that appropriate tests are performed. (See page 24.)
- Being involved in the initial configuration of the system can help determine whether the configuration process is overly complex. (See page 24.)
- Contractual requirements can be used to ensure that software fixes can be implemented without disrupting operations. (See page 25.)
- Tools for testing of individual software components can help pinpoint the root cause of problems that may occur. (See page 25.)

Maintaining a Network of Field Devices

- In field equipment contracts, include requirements for tools to monitor the operational status of the deployed equipment and for helping with equipment monitoring once the deployment is complete. (See page 30.)
- Integrate the ITS Group into the construction process to help ensure that consideration of the fiber network is included in construction plans. (See page 40.)
- Installing fiber in visible locations rather than underground can help contractors avoid damaging the fiber. (See page 40.)
- It can be more cost-effective to relocate fiber prior to construction to reduce the likelihood and impacts of fiber cuts than make repairs when cuts occur. (See page 40.)

Using Toll Tag Readers for Traffic Monitoring

- The system design should include design of the video monitoring tests that will be applied. (See page 49.)
- A toll tag travel time system should accommodate many different types of failures that might occur, including reader failures, clock mis-synchronization, incorrect reader location assignments, and network failures. (See page 51.)
- Field studies can help determine if toll tag market penetration is sufficient to support the use of a toll tag travel time system. (See page 53.)
- The effect of diverting traffic on arterials can introduce a high bias into the observed average travel time. (See page 65.)
- For limited access highways, diverting traffic is less likely to introduce a high bias into the observed average travel time. (See page 66.)
- Including tag reads from turning vehicles increases the number of travel time observations generated. (See page 70.)

- It is important that a system to monitor and maintain field equipment be in place by the time any field equipment is deployed. (See page 72.)
- Reader failures will occur. The systems that rely on the readers must be designed to work around those failures. (See page 73.)
- The tag matching efficiency is much higher for limited access roads than for arterials. (See page 76.)
- The tag matching efficiency is much higher for limited access roads than for arterials. (See page 76.)
- The tag matching efficiency drops quickly as the segment length increases. (See page 76.)
- Toll tag readers introduce a delay in producing travel time estimates equal to the estimated travel time. (See page 78.)
- The latency inherent in toll tag based traffic monitoring systems could limit its effectiveness for incident detection. (See page 78.)

Interfacing with the FHP CAD System

- A process must be in place to update incident type translation tables whenever incident types are changed on the CAD side of a CAD-DOT interface. (See page 82.)
- The DOT should work with the Highway Patrol to ensure that practices are in place to enter key information in the correct fields within the CAD system. (See page 82.)
- The use of event-driven messages requires implementation of methods to identify and recover from dropped events. (See page 83.)
- Identify the fields for which the CAD system does not perform strong quality control checks. Those fields may require extra effort to use them within a DOT system. (See page 84.)

Using DMSs for Traveler Information

- Validating all travel time estimates before using them for traveler information can prevent dissemination of false data and possible loss of public confidence in the traveler information systems. (See page 89.)
- Ensure that the TMC software supports automated generation of common types of messages, such as congestion messages. (See page 96.)
- Design the TMC management software to automatically produce the types of messages that are used often and change frequently. (See page 96.)
- The software used to manage travel time messages on DMSs should include methods for managing sign messages when travel times are unavailable. (See page 96.)

Implementing Variable Speed Limits

- Identify statutory and regulatory speed limit requirements before considering the use of variable speed limits. (See page 103.)
- The concept of operations for VSL should be validated against historical data. (See page 110.)
- The algorithms for recommending speed limit changes should be able to detect and correct for low vehicle speed observations that are not related to congestion. (See page 110.)

- Operator approval should be required for all speed limit changes (See page 110.)
- A VSL system should not be deployed until the other systems required to support it are operating reliably. (See page 111.)

Statewide Operations

- A key to making use of a microwave network is accommodating its bandwidth limitations. (See page 117.)
- Microwave tower locations should not be the primary factor in selecting locations for traffic monitoring stations. (See page 118.)
- Travel costs can make the costs of maintaining a statewide traffic monitoring System high. (See page 118.)
- Involving all other DOT districts in the design of a Statewide Monitoring System may make it easier to distribute maintenance responsibility for these stations across the districts. (See page 119.)
- Interfacing with local police organizations to obtain more complete incident information may be a better source of statewide traveler information than a statewide monitoring system. (See page 120.)
- A Statewide Monitoring System may be too sparse to consistently provide useful traveler information. (See page 121.)
- The FHP CAD was the primary source of statewide traveler information. (See page 122.)

Evacuation Operations

- Difficulties with the iFlorida deployment limited the impacts on Florida evacuations that occurred. (See page 127.)
- The determination of whether to use contraflow depends on estimates of future demand. Real-time traffic data is of limited use in making this estimate. (See page 135.)
- A tool that integrated current traffic condition data would be a valuable tool for supporting SEOC traffic management decision making. (See page 135.)
- The distributed model for emergency management used in Florida worked very well. (See page 136.)

Traveler Information Operations

- Limit the number of Limited the number of 511 segments for each road simplified the menu structure for choosing a segment. (See page 145.)
- Divide Dividing 511 segments into sub-segments for reporting travel times allowed more detailed travel time information to be presented. (See page 146.)
- Pre-recorded travel time messages for all road segments reduced message splicing and increased audio quality. (See page 149.)
- The use of FTP to update 511 messages allowed for continued 511 service even when the TMC management software failed. (See page 149.)
- Monitoring feedback helped adapt the call tree to better meet user expectations. (See page 151.)

- Monitoring user requests that could not be interpreted by the system allowed new phrases and pronunciations that should interpreted by the 511 system to be identified. (See page 152.)
- Travel time summaries were used in the 511 system to provide travel times for alternate routes between pre-defined locations. (See page 152.)
- Transitioning to a new 511 system may alienate existing users accustomed to the former system. (See page 154.)
- Most 511 calls are made while users are on the road. (See page 156.)
- About 5 percent of days had much higher than usual 511 call volumes, and those days often occurred in conjunction with unusual traffic incidents. (See page 159.)
- A significant percentage of the drivers of vehicles impacted by an incident appeared to call the 511 system. (See page 160.)
- 511 users made few traffic information requests for arterials. (See page 163.)
- The percent of I-4 travelers using the 511 system for information on I-4 traffic is very small—too small to have a measurable impact on traffic conditions and congestion. (See page 164.)
- Caller requests to regional 511 systems may focus on traveler information, with few callers requesting transfers to other 511 systems. (See page 165.)
- The My Florida 511 system, a personalized 511 sytem, required fewer commands to access traffic information and provided callers with traffic information more quickly. (See page 166.)
- The percent of calls made by by My Florida 511 users, a personalized 511 service offered by FDOT, did not increase over time. (See page 167.)
- Very few 511 users appeared to regularly use the system as part of their daily commute planning. (See page 170.)
- 511 implementers should consider establishing and monitoring metrics on the effectiveness of the speech recognition used in their 511 system. (See page 172.)
- Populating the Statewide 511 system with high quality traffic information was challenging. (See page 176.)
- In most months, relatively few callers requested traffic information from the Statewide 511 system. (See page 180.)
- Reviewing mock ups of highly graphical user interfaces, such as map interfaces, before starting development of the interface can help ensure that the resulting interface is esthetically pleasing. (See page 184.)
- The Web site requirements should include details about the types of tracking information that should be maintained about Web site users. (See page 186.)
- Traffic data collected by FDOT was the basis for traveler information services provided by both regional and national traffic information providers. (See page 189.)

<u>Weather Data</u>

- Providing RWIS data to the MADIS mesonet or to the Clarus system will make the data available to the meteorological community. (See page 195.)

- When systems that must interact are being developed by different contractors, the contractual language for those contractors should specify how the systems will interface and who is responsible for developing each part of the interface. (See page 196.)
- The contract with a data provider should clearly describe the data that will be provided and its format. (See page 196.)
- The design of the system that uses provided data should be complete before a contract with a data provider is put in place. (See page 197.)
- A coordinated master schedule should be maintained that reflects the dependencies between the projects. (See page 198.)
- Interface documentation should clearly describe the data that is passed through the interface. (See page 198.)

Security Projects

- The system design should include design of the video monitoring tests that will be applied. (See page 204.)
- System testing should include verifying that the number of false alarms is not excessive. (See page 204.)
- The system design should include alarm plans for normal operations and other alarms plans that might be used during construction activities. (See page 206.)
- The design for a TMC should include standoff distances that help maintain a clear space around the building. (See page 210.)

13.3. Conclusions Related to *i*Florida Evaluation Hypotheses

One of the first steps taken in conducting the *i*Florida evaluation was development of the Evaluation Plan, a document that described specific hypotheses that would be explored during the *i*Florida Model Deployment. Many of these hypotheses were explored, while some were not because of the various problems that occurred during the evaluation. This section of the report lists the original evaluation hypotheses and identifies any conclusions that were drawn related to each hypothesis or, when no conlusions could be drawn from the model deployment, describes why that occurred. The hypothese are arranged in the order they appeared in the *iFlorida Model Deployment Evaluation Plan*, as published in April 2005.

13.3.1. The Design Review Hypotheses

The Design Review was a crosscutting study that focused on documenting the experiences of the *i*Florida Deployment Team during the design process. There were no hypotheses, per se, for the design review. Instead, different activities were defined that would gather information for the evaluation. The planned evaluation activities are described in the following list, with more information available in two previously published reports, *iFlorida Model Deployment Design Review Evaluation Report* and *iFlorida Model Deployment—Deployment Experience Study*, and in section 2 of this report.

- Document the iFlorida system engineering process. FDOT did not strictly follow standard systems engineering practices for the CRS software. FDOT provided high-level functional requirements to the CRS contractor at the start of the project. The CRS contractor adopted these as detailed requirements without further refinement, and modifications and refinements of these requirements occurred throughout the CRS development. In the end, the CRS software was abandoned and replaced with SunGuide software.

- Document the *i*Florida design. The *i*Florida design is documented in parts throughout this report. For example, *i*Florida traffic operations are described in section 1.1.1.
- Document the basis for key *i*Florida design decisions. Key *i*Florida design decisions were documented during the evaluation.
- Document the use of data quality and message set standards. Previous reports addressed about data quality and message set standards. Information about the use of IEEE 1512 standards for FHP-CAD is described in section 5 of this report.
- Document methods for ensuring data quality. Inadequate methods were implemented to ensure data quality, and FDOT experienced significant problems with data quality, both in terms of data availability and accuracy of data that was available. These issues are addressed in section 2 of this report.
- Document privacy and security issues regarding *i*Florida data and methods used to address those issues. Because the data warehousing features of the *i*Florida deployment did not function correctly, FDOT did not address privacy and security issues regarding the data.
- Document integration challenges regarding the *i*Florida data and methods used to overcome them. FDOT experienced a number of challenges in integrating data from different sources. These challenges are described in section 2 of this report.
- Document the business and data management practices planned for the *i*Florida data. One of the weakness of the *i*Florida Model Deployment was the lack of a clear concept of operations, so that neither their business practices for how to best take advantage of the *i*Florida data were nor their practices for managing the data were well defined.

13.3.2. The Deployment Experience Study Hypotheses

The Deployment Experience Study was a crosscutting study that documented the experiences of the *i*Florida Deployment Team while deploying the *i*Florida infrastructure. The planned evaluation activities are described in the following list, with more information available in two previously published reports, *iFlorida Model Deployment Design Review Evaluation Report* and *iFlorida Model Deployment—Deployment Experience Study*, and in section 2 of this report.

- Document the effectiveness of the iFlorida system engineering process and lessons learned in applying it. FDOT experienced significant problems with developing the CRS software, and the root cause of many of those problems can be traced to a failure to follow standard systems engineering practices.
- Document the actual deployment costs and schedule and the reasons for changes that occurred. The deployment costs of the deployment activities are scattered throughout this report.
- Document data quality challenges that were faced and how those challenges were overcome, and document the results of data quality tests. FDOT did not perform adequate tests of data quality and suffered from data quality issues throughout much of the model deployment. Data quality problems were related to both failures of field devices and software mismanagement of data received from those devices. Sections 2 and 3 of this report describe data quality challenges that FDOT faced.

- Document privacy and security challenges that were faced and how those challenges were overcome. Problems with the operation of the CRS and CFDW software meant that there was little usage of the *i*Florida data outside of FDOT, limiting the extent to which FDOT was faced with privacy and security challenges regarding that data.

13.3.3. Metropolitan Operations Hypotheses

The primary objective of the *i*Florida metropolitan operations was to collect traffic data, use that data to support operational and programming decisions, and provide metropolitan services such as Orlando 511, roadway diversion information, and variable speed limits. This element of the evaluation examined the impact of the *i*Florida deployment on transportation system operations in the Orlando metropolitan area by documenting the ways *i*Florida changed operating practices and evaluating the impact of those changes. For the purpose of the evaluation, the metropolitan operations were divided into groups of related activities. These groups and the evaluation hypotheses related to each are described in the following lists.

Transponder and license plate readers travel time measurements

FDOT deployed an extensive collection of transponder readers to measure travel times on arterial roads and a small number of license plate readers. The license plate readers saw little use. The transponder readers were used extensively to generate travel time information. Information about these readers

- The travel time data will be reliable. Early in the deployment and at different times throughout, FDOT experienced significant problems with maintaining their network of toll tag readers. At its best in February 2007, toll tag based travel times were available about 90 percent of the time, though this percentage was often below 70 percent.
- The travel time data will be accurate. The travel time data produced by the toll tag readers appeared to be accurate, though achieving this accuracy required algorithms for excluding travel time observations for vehicles that made stops. Some segments produced too few travel time observations for accurate travel time estimation, and most produced too few observations during periods of low usage, such as late at night.
- The approach will be cost effective. The approach was effective for producing arterial travel time information, information that is difficult to obtain through other types of measurement. However, the maintenance cost of the toll tag reader system was higher than expected and the 511 demand for arterial travel time information was low.

More information about these readers can be found in sections 3 and 4 of this report.

Variable speed limit trial

The *i*Florida VSL capabilities were not utilized during the deployment. As the evaluation period ended, FDOT was preparing to enable their VSL signs.

- Document how VSL is used (e.g., to reduce speeds in response to weather conditions, to reduce speeds prior to an incident-induced queue). VSL was not used.
- The infostructure will provide the data needed to trigger variable speed limits. One of the reasons VSL was not implemented was a lack of confidence in the CRS capabilities to support VSL operations.
- Travelers will comply with the variable speed limits.VSL was not used.

- VSL will increase safety (if VSL is used in that manner). VSL was not used.
- VSL will decrease congestion when an incident occurs on I-4 (if VSL is used in that manner). VSL was not used.

More information on the *i*Florida VSL system is available in section 7 of this report.

Roadway Diversion Study

FDOT used two DMS's along I-4 to provide information to travelers about the travel times on two alternate routes to and around Orlando. The shorter route was along I-4, but was prone to congestion, and the longer route was along a toll road, SR 417. FDOT also sometimes displayed incident-related detour information on other DMS's.

- Document how roadway diversion is used (e.g., during normal operations, during incidents, types of messages used). FDOT displayed travel times for both routes only when the travel time along SR 417 was shorter (i.e., when I-4 was congested).
- The infostructure will provide the data needed to trigger roadway diversion messages. The loop data was sufficient to support diversion messages, though early in the deployment the CRS software sometimes displayed travel times that were computed incorrectly.
- Travelers will change routes based on roadway diversion messages. Traveler route changes were difficult to assess from available data.
- Roadway diversion will decrease congestion and increase network reliability. The data indicated increasing congestion on I-4 throughout the *i*Florida operational period.

More information about the roadway diversion messages is available in section 6.2.2 of this report.

Laptop usage by FHP patrol cars and Road Rangers

FDOT planned to provide laptops to FHP patrols and Road Rangers that would take advantage of the wireless broadband deployed along a portion of I-4 to support the LYNX Bus Security project. These laptops were not purchased.

- Laptops will be useful to FHP patrols and Road Rangers. The laptops were not purchased.

Evaluate the use of the iFlorida infrastructure for traveler information

FDOT used *i*Florida data to support many modes of traveler information, including 511, a traveler information website, and DMS's.

- Document the effectiveness of the metropolitan traveler information system. The Central Florida 511 system handled a large number of 511 calls each day, though the number of calls did not increase significantly over pre-*i*Florida levels. The traveler information website saw little usage. DMS's were used throughout *i*Florida operations, though limitations of the CRS prevented the use of automated sign message generation capabilities.

More information on *i*Florida traveler information capabilities is in sections 6 and 10 of this report.

Evaluate the use of the iFlorida infrastructure to manage recurring congestion

FDOT took advantage of the new *i*Florida traffic monitoring and traveler information capabilities to improve their traffic management processes. However, problems with the CRS software prevented them from implementing some features (e.g., VSL, automated sign message plans). Also, recurring congestion in the Orlando area is concentrated on I-4 and many traffic monitoring and traveler information capabilities along I-4 were in place before *i*Florida began. Early in the evaluation, it was expected that coordination might occur between FDOT and other Orlando traffic operation centers to improve response to congestion. For example, sign messages could encourage detours onto nearby arterials when I-4 was congested, and signal timings on those arterials could be modified to better accommodate the diverting traffic. FDOT expected the CRS software to provide the data sharing capabilities key to supporting this type of coordination. When the limitations of this software became apparent, this type of coordination effort ceased. Greater coordination began to emerge once FDOT began using the SunGuide software.

- Document how the iFlorida infrastructure is used at traffic operation centers (e.g., the D5 RTMC, the Orlando IOC, the OOCEA operations center) to manage recurring congestion. FDOT's relied primarily on the dissemination of traveler information to help manage recurring congestion.
- Document organizational challenges that were faced in coordinating congestion management practices among the Orlando traffic operation centers. The failures of the CRS software prevented coordinated congestion management practices from developing.
- *i*Florida will decrease traffic congestion. Congestion management practices changed little during *i*Florida operations, so impacts on congestion were not expected and detailed analyses were not performed. Reports on the use of Trailblazer signs to provide detour information to travelers leaving the Daytona International Speedway after an incident closed all lanes on I-4 indicated that these signs reduced congestion by helping travelers follow detour routes.
- *i*Florida will increase traffic safety. Congestion management practices changed little during *i*Florida operations, so impacts on congestion were not expected and detailed analyses were not performed.

Evaluate the use of the iFlorida infrastructure to manage incident response

It was anticipated that the *i*Florida infrastructure would change incident response activities on Orlando arterials by providing improved traffic monitoring capabilities on those roads. The problems with the CRS software meant that *i*Florida traffic monitoring capabilities were not shared with other Orlando traffic operation centers, so the impact of the deployment on incident response for those roads was limited. Because I-4 was already closely monitored before *i*Florida, the *i*Florida deployment did little to change incident response on those roads.

- Document how the *i*Florida infrastructure is used at traffic operation centers (e.g., the D5 RTMC, the Orlando IOC, the OOCEA operations center) to manage incident response. FDOT used traffic monitoring cameras to identify incidents that occurred on I-4 and shared that video with FHP dispatchers co-located at the D5 RTMC. When an incident involved a lane closure, FDOT would post incident-related messages on DMS's upstream from the incident and on the 511 system. *i*Florida data was not used at other traffic operation centers.
- Document organizational challenges that were faced in coordinating incident response practices among the Orlando traffic operation centers. Little new coordination occurred as a result of the *i*Florida deployment.
- iFlorida will decrease incident-induced congestion. Because incident response practices changed little because of the *i*Florida deployment, no significant impact was expected.
- iFlorida will decrease secondary accidents. Because incident response practices changed little because of the *i*Florida deployment, no significant impact was expected.

<u>Document the use of the iFlorida infrastructure to manage transit operations</u>

It was anticipated that *i*Florida data would be available to LYNX and LYNX might use that data to better manage their transit operations. Problems with the CRS software meant that the *i*Florida data was not shared with LYNX.

- Document how the iFlorida infrastructure is used at the LYNX transit operations center. *i*Florida data was not available at the LYNX transit operations center.

<u>Other evaluation activities</u>

- Document how the iFlorida infrastructure is used at transportation management centers in Orlando. It was anticipated that several transportation management centers in the Orlando area would adopt the use of the CRS software, and that the shared software and data would help improve operations at these centers and coordination between them. Several organizations began making plans with FDOT to do just that early in the deployment, but those plans were halted when the inadequacies of the CRS software became apparent. Those talks resumed when the SunGuide software proved more reliable.
- Document lessons learned in operating a metropolitan infostructure. The difficulties FDOT faced in reaching full operational performance from *i*Florida prevented the type of coordination required for a metropolitan infrastructure to form.
- iFlorida will result in improved system performance. The type of area-wide coordination that was expected to increase performance did not occur.

13.3.4. Statewide Operations Hypotheses

The primary objective of the *i*Florida statewide operations was to collect traffic data from across the state to support statewide traveler information services and hurricane evacuation activities. This element of the evaluation focused on the effectiveness of those activities, with the following lists describing the specific evaluation hypotheses that were planned. Section 0 of this report provides more details on the evaluation of statewide operations.

<u>Using Microwave Communications to Transmit TTMS Data</u>

FDOT deployed a collection of 26 traffic monitoring stations across the state and used an existing microwave communications network to provide connectivity between those stations and D5.

- The TTMS data will be reliable. The microwave communication system proved itself to be a reliable way to provide connectivity to remote field devices. However, FDOT found that the field devices were costly to maintain and that the data produced had limited value. As FDOT focused maintenance efforts on other equipment, these devices fell into disrepair.
- The TTMS data will be accurate. The data provided by the TTMS appeared to be accurate.
- The approach will be cost effective. The use of the microwave communication system was a low cost approach for connecting remote devices. However, utilizing the network required placing devices near the towers, which sometimes meant they were not placed at the optimal locations for traffic monitoring. This reduced the usefulness of the resulting traffic monitoring. FDOT found that the resulting data was not very useful for supporting statewide traveler information systems and noted that the money spent on TTMS might have been better spent on developing interfaces to additional CAD systems throughout the state.

Hurricane Operations

The main impact of statewide operations on hurricane evacuations was expected to be the availability of additional data through the TTMS. A video feed was established from D5 to the SEOC to carry TTMS video. Traffic data from the TTMS was not available to the SEOC.

- Document the effectiveness of the statewide data in supporting hurricane evacuations. Several hurricanes struck Florida while *i*Florida was being deployed, but none struck once the deployment was complete. Observations during the hurricane evacuations that occurred prior to the *i*Florida deployment provided some insights into the potential impacts of the deployment on hurricane evacuations. Interviews with SEOC staff indicated that the availability of statewide traffic video from the TTMS was expected to greatly increase situational awareness of statewide traffic conditions during a hurricane evacuation.

Section 9 of this report focuses on the impact of *i*Florida on evacuation operations.

Evaluate the use of statewide data for traveler information

The *i*Florida deployment established the first statewide traveler information services in Florida – a statewide 511 system and a traveler information website.

- Document the effectiveness of the statewide traveler information system. The statewide traveler information services saw limited use except during specific events, such as wildfires that caused road closures. Many statewide 511 callers used the system as a gateway to reach regional 511 systems.

Section 10 focuses on *i*Florida traveler information services.

Other evaluation activities

- Document the uses of iFlorida statewide data. The CFDW software, which was to be create a data archive of *i*Florida data and provide interfaces for real-time access to that data, did not function as expected. There was little opportunity for users to access *i*Florida statewide data.
- Document lessons learned in operating a statewide infostructure. Many lessons learned were documented related to the collection and use of statewide traffic information. However, the failure of the CFDW software meant that a statewide infostructure was never established.

13.3.5. Evacuation Operations Hypotheses

The main impact of statewide operations on evacuation evacuations was expected to be the availability of additional data to support evacuation decision making and increased coordination among regional traffic management centers during an evacuation. The limitations of the CRS software limited the availability of the *i*Florida data to evacuation decision makers in the Orlando area and the extent to which additional coordination could occur. The fact that no hurricane evacuations occurred after *i*Florida became operational also limited the ability to assess the impacts of the deployment on evacuation operations. Section 9 of this report focuses on the impacts of *i*Florida on evacuation operations. The following lists summarize the results related to the original evaluation hypotheses that were proposed for this element of the evaluation.

Contraflow operations on SR 528

One of the planned contraflow routes in Florida runs along SR 528 from the east coast of Florida to Orlando. The *i*Florida deployment increased traffic monitoring along this route by deploying micro-loop detectors, license plate readers, and CCTV monitoring.

- Document how the evacuation route monitoring data will be used to support contraflow decision making and monitoring. The evaluation team witnessed contraflow decision making during Hurricane Frances while the *i*Florida deployment was underway. Because the decision to implement contraflow was made a day ahead of implementation, the value of real-time traffic data to support this decision seemed limited. The decision was based more on expected traffic volumes for the following day. Because the State did not consider implementing contraflow on SR 528 after *i*Florida became operational, it was unclear if the availability of real-time data would change the contraflow decision-making process.
- The evacuation monitoring data will be reliable. The evacuation monitoring equipment tended to be out of service more often than other equipment that was more key to FDOT D5's day-to-day operations, but still showed a relatively how level of service. More information is available in Section 3.3 of this report.
- The evacuation monitoring data will be accurate. The data appeared to be accurate.
- The available data will support contraflow decision making processes. Because no hurricane evacuations occurred in Florida while the evaluation was active, the evacuation monitoring data was not used to support contraflow decision making. Observations of the contraflow decision-making process while *i*Florida was being deployed indicated that real-time traffic monitoring data might provide little help in contraflow decision making.

Monitoring high wind conditions on the SR 528 Causeway Bridge

FDOT deployed wind speed monitors on the SR 528 Causeway Bridge with the expectation that this data would help with the determination of when to close the bridge because of unsafe conditions created by high wind speeds. Because this data reached FDOT through MADIS, the data arrived after a 15-minute delay, reducing its usefulness for real-time decision making. The bridge closure decision was also typically made based on observations by personnel stationed at the bridge rather than on observed wind speeds.

- Document how the RWIS data will be used to support monitor wind conditions on the bridge. Both the planned and actual usage of this data was documented.
- The RWIS wind speed data will be reliable. The wind speed data appeared to be reliable, though the network path through which FDOT received the data introduced significant delays.
- The RWIS wind speed data will be accurate. No specific tests of the accuracy of this data were conducted.
- The available data will support bridge closure decision making processes. The data had limited impact on bridge closure decision making. The 15-minute delay between data collection and receipt of that data by FDOT limited the usefulness of the data for bridge closure decision making. Also, the FHP bridge closure process emphasized the observations of personnel stationed at the bridge rather than wind speed measurements.

More information on the bridge wind speed monitors is included in section 11 of this report.

Brevard County EOC, SEOC, D5 RTMC, and Orlando IOC Evacuation Operations

When the *i*Florida deployment began, it was expected that many of the regional operation centers would have access to the CRS software, which would give them access to the software and facilitate more coordinated decision making. Problems with that software meant that it was not adopted by other operation centers, which limited the impact of *i*Florida on both traffic management and evacuation operations.

- Document how the iFlorida infrastructure will be used to support evacuation decision making and monitoring at these operation centers. The *i*Florida data was not available at centers other than the D5 RTMC.
- iFlorida will improve emergency operations at these operation centers. *i*Florida had little impact on emergency operations at these centers.

<u>HEADSUP</u>

HEASUP is a software tool that we being developed by FDEM to support hurricane evacuation decision making. At the start of the *i*Florida deployment, it was anticipated that *i*Florida data would provide real-time information about statewide traffic conditions to HEADSUP. Difficulties with maintaining the statewide traffic monitoring stations and problems with the CFDW software, which was to include interfaces allowing access to the *i*Florida data, discouraged FDOT from pursuing this activity.

- Document how the iFlorida data will be used in FDEM's HEADSUP software. *i*Florida data was not provided to FDEM.

<u>Evacuation Exercises and Simulations</u>

Limitations in the data archives created by the CFDW software prevented FDOT from performing these exercises and simulations while the CRS and CFDW were in use. FDOT began these activities once the SunGuide data archiving services became available and a reasonable store of archived data was available.

- Document how evacuation exercises and simulations were used to improve evacuation planning and if these activities led to greater use of iFlorida data. These activities were not completed during the evaluation period. FDOT began them in 2008.

<u>Using traveler information to support evacuations</u>

No hurricane evacuations occurred after the *i*Florida systems were operational. FDOT did use the pre-existing 511 system to provide traveler information during Hurricane Charley and Hurricane Frances and activated the statewide 511 system during Hurricane Wilma.

- Document how the iFlorida traveler information capabilities will be used to support evacuations. FDOT did not develop a concept of operations describing how their traveler information resources would be used during a hurricane evacuation and no hurricane evacuations occurred so that observations would reveal how these resources were used. Observations during hurricane evacuations that occurred before the *i*Florida systems were operational provided some insight into how the *i*Florida traveler information resources would likely be used.
- iFlorida traveler information will be an effective means of providing information to evacuees. No hurricane evacuations occurred after *i*Florida systems became operational.

<u>Other evaluation activities</u>

- Document lessons learned in using an infostructure to support hurricane evacuations. The lack of an effective infostructure and hurricanes that caused evacuations in Florida limited the opportunities to identify lessons learned.

- iFlorida will result in improved evacuation management. Many of the anticipated improvements were related to improved access to *i*Florida data and coordination among regional operation centers. The problems with the CRS software limited both of these factors, so few changes in evacuation management occurred.

13.3.6. Weather Data Hypotheses

FDOT contracted for a vendor to provide real-time weather data to the *i*Florida systems. This data included current and forecast weather conditions for *i*Florida roads and alerts for severe weather conditions. FDOT also deployed a number of RWIS stations in Central Florida. The weather data provider consolidated this data with the data they were providing and pushed it to the CRS software for processing. It was expected that the CRS software would use this data for a variety of purposes, such as predicting future traffic conditions, suggesting lower variable speed limits when weather conditions were severe, and posting weather-related traveler information messages. Because of the problems with the primary functionality of the CRS software (e.g., calculating travel times, posting DMS messages), little attention was paid to the use of weather data. FDOT is considering re-introducing weather data to their traffic management processes after they gain more experience with the use of SunGuide. More information on the *i*Florida weather data is in section 11 of this report.

<u>Providing weather data to an infostructure</u>

- The weather data will be reliable. Anecdotal reports indicated that the weather data was reliable. However, the CRS software disable weather data processing for long periods of time and the CFDW did not correctly archive the data, so it was not possible to verify this.
- The weather data will be accurate. The confirmation of the accuracy of the weather data was deemed outside the scope of this evaluation.
- The weather data will be useful. Little or no use was made of the *i*Florida weather data.

<u>Using weather data for variable speed limits</u>

- Document the effectiveness of using weather data to determine appropriate speed limits. Variable speed limits were not used during the *i*Florida operational period. Future plans for variable speed limits will base speed limit suggestions on existing traffic conditions, not on weather conditions.

<u>Using weather data for bridge closures</u>

- Document the effectiveness of using weather data to determine when to close bridges because of high wind conditions. Latencies between wind speed observations and the arrival of those observations at the D5 RTMC limited the usefulness of the wind speed data for bridge closure decision making.

<u>Using weather data for traveler information</u>

- Document the effectiveness of using weather data for traveler information. Little use was made of weather data for traveler information. FDOT did sometimes post DMS messages related to heavy fog, though the available weather data was not used as a source of that information.

<u>Other evaluation activities</u>

- Document the uses of iFlorida weather data. Little use was made of the weather data.

- Document lessons learned in using weather data in an infostructure. Some lessons learned were noted related to weather data.

13.3.7. Traveler Information Operations Hypotheses

Before *i*Florida, FDOT operated a 511 system that provided traveler information for a portion of I-4 near Orlando. A website was available that listed I-4 travel times, though the availability of this website was not advertised and it was little used. An extensive collection of DMS signs was also deployed along I-4. *i*Florida extended the 511 system to include all limited access roads and several key arterials in the Orlando area, created a much more sophisticated traveler information website, and was intended to provide more sophisticated tools for managing DMS message. (The DMS message management tools in the CRS software did not work well.) It also established a statewide 511 system and included statewide data on the traveler information website.

Detailed information on the *i*Florida 511 systems and traveler information website is in section 10 of this report. Section 6 provides information on FDOT's management of DMS messages.

Central Florida 511

The Central Florida 511 system experienced a large drop in calls soon after the *i*Florida system became operational in November 2005, and call volumes never reached pre-*i*Florida volumes. This, despite the fact that the Central Florida 511 system included many additional roads not covered by the previous 511 system, which was limited to I-4. Most callers were interested in information on I-4 and I-95. Some callers interested in information on Orlando toll roads, and the fewest number of callers requested information on Orlando arterials. Few callers could be classified as frequent callers. It appeared that most callers called infrequently in response to observed traffic conditions rather than frequently for trip planning purposes.

- The increase in the quantity and quality of information available will increase 511 usage. The quantity of 511 information increased, though 511 usage decreased. There were concerns that the CRS was miscomputing some travel times, which would have reduced 511 data quality. But, data archives were not sufficient to test this.
- 511 advertising will be an effective way to encourage 511 use. A jump in 511 usage occurred when local media covered the start of *i*Florida operations in November 2005, though usage dropped quickly afterwards.
- Customers will value the characteristics of the 511 system (e.g., the menu structure, the quality of voice recognition). FDOT received many complaints about the new menu structure and the capabilities of the voice recognition system soon after the new 511 system began operation. Analysis of call logs indicated that problems with the voice recognition continued throughout the deployment.
- The 511 system will improve traveler mobility. No direct measures of the impact of the 511 system on traveler mobility were computed. However, aalysis indicated that few 511 users called the system was part of their regularly trip planning process, where travel time information would be most effective at improving mobility. Most calls seemed to originate from travelers already on the road after observing unexpected traffic conditions. For those callers, information on travel times would be of limited value for increasing mobility, and information on possible alternate routes might have been more useful.

Central Florida traveler information Website

The CRS software provided a traveler information Website that included statewide and regional maps that displayed information about incidents and congestion, a travel time calculator for the Orlando area, a list of currently displayed DMS messages, a list of current construction activities, a link to images from traffic surveillance cameras, and a link to other traffic information Websites.

- The increase in the quantity and quality of information available will increase Website usage. Website usage remained low throughout the *i*Florida operational period.
- Website advertising will be an effective way to encourage Website use. Most advertising concentrated on 511 instead of Website usage.
- Customers will value the characteristics of the Website user interface. FDOT received few comments regarding the Website user interface. However, FDOT was not satisfied with the Website user interface provided by the CRS software.
- The Website system will improve traveler mobility. No measures of the impact of Website usage on traveler mobility were computed. Low usage rates for the Website meant that the site had little overall impact.

Statewide 511

The Statewide 511 system was new to Florida. Although it covered a much broader area than the Central Florida 511 system, it received only about one-third as many calls each day and many of these calls ended with a request to access a regional 511 system.

- The increase in the quantity and quality of information available will increase 511 usage. The Statewide 511 system did not generate a large number of calls and call usage increased little during the *i*Florida operational period.
- 511 advertising will be an effective way to encourage 511 use. The media campaign accompanying the start of *i*Florida operations in November 2005 resulted in a large number of calls to the Statewide 511 system during the first several weeks of operation. This usage quickly dropped to about 1,000 calls per day and remained at about that level throughout the remainder of the *i*Florida operational period.
- Customers will value the characteristics of the 511 system (e.g., the menu structure, the quality of voice recognition). The problems with the voice recognition system already noted for the Central Florida 511 system also applied to the Statewide 511 system. Because a user based did not already exist when the Statewide 511 system began operation, it did not generate as many complaints about the menu structure as did the Central Florida 511 system.
- The 511 system will improve traveler mobility. No direct measures of the impact of the 511 system on traveler mobility were computed.

Statewide traveler information Website

A single application supported both the Central Florida and Statewide Traveler Information Websites, and the observations related to the Central Florida Traveler Information Website noted above apply to both.

Other evaluation activities

- Document lessons learned in operating the iFlorida traveler information systems in an infostructure. The original plans for the *i*Florida traveler information systems called for coordinated control of some *i*Florida traveler information. For example, the 511 system was going to include information related to the Orlando International Airport, and GOAA was going to have access to *i*Florida systems for maintaining this information. Shared control of traveler information capabilities with other organizations was expected. In the final system, GOAA developed its own phone information system, and the *i*Florida 511 system provided a linkage to that system. There was no coordinated control of *i*Florida traveler information.

13.3.8. Security Project Hypotheses

The *i*Florida Model Deployment included five projects related to transportation security. Evaluation hypotheses related to these five projects are discussed in the lists below. More details are provided in section 12 of this report.

Bridge security

FDOT deployed a video surveillance system at two bridges in Florida. The intention of these systems was to automatically monitor the locale around each bridge and generate alarms if the monitoring software detected suspicious activity near a bridge. FDOT and/or FHP staff, warned by the alarm, could access the security video to determine if a response was necessary. These systems generated a large number of false alarms, so that staff regularly muted the alarms.

- The bridge security system will be an effective tool for automatically identifying threats. Tests indicated that the system could identify threats, though the number of false alarms generated was high.

Traffic modeling to assess alternate routes

FDOT planned on using archived *i*Florida data to support traffic modeling to assess alternate routes that could be used in case a bridge is damaged and can not be used. The problems with CFDW software limited the data available in the *i*Florida data archives, so FDOT postponed this project until the SunGuide data archives were available.

- Traffic modeling will be an effective tool for assessing the viability of alternate routes in case of a bridge failure. The modeling had not been completed when the evaluation period ended.

On-board video surveillance on LYNX buses

FDOT deployed a wireless broadband network along a portion of I-4 and LYNX equipped buses that used that portion of I-4 with video surveillance equipment and equipment to use that wireless network to transmit the bus video back to FDOT and LYNX. The system worked sporadically, although it failed to work during several planned demonstrations.

- The system will decrease the time required to identify, characterize, and verify an emergency event. The system did not work consistently and these capabilites were not tested.
- The system will be effective at preventing and mitigating security incidents on LYNX buses. The system did not work consistently.

The D5 RTMC vulnerability assessment

A vulnerability assessment of the D5 RTMC was conducted, and a follow up assessment was performed.

- The vulnerability assessment will help to decrease the vulnerabilities at Florida RTMCs. The vulnerability assessment identified a number of vulnerabilities, and the follo up assessment indicated that many of the vulnerabilities had been addressed.

The Daytona International Speedway emergency evacuation plan

A study generated an emergency evacuation plan for the Daytona International Speedway and identified some general features that could be considered to improve evacuations at many venues.

- Improvements at the speedway will facilitate faster and more reliable evacuations. Because the evacuation plan was developed in conjunction with a project to refurbish the speedway infield, a before and after comparison of evacuation capabilites could not be performed.
- Improvements at the speedway will facilitate faster and more reliable access for emergency services. The evacuation plan identified specific access routes for use by emergency services.
- Document lessons learned in preparing the emergency evacuation plan and applying it to other venues. Several lessons learned were identified by reviewing evacuation plan documentation.

13.3.9. Data Availability Hypotheses

One of the objectives of the *i*Florida deployment was to create a central repository of traffic information that included methods that different organizations could use to access *i*Florida data. This would include access to archived, historical data as well as access to real-time data. The CFDW software, which was to create this data archive, did not work as intended. It did not create a useful archive of historical data and it did not provide good tools for accessing either historical or real-time data.

FDOT remedied this, to some extent, by saving archives of much of the *i*Florida raw data. For example, they saved logs that listed the DMS messages that were displayed and text files that listed the loop detector readings from I-4 and I-95. Because these data were saved in a variety of formats (e.g., Access databases, text files, XML files), the data was difficult to access and use. Also, the data did not include any information about the quality of the data – data from loop detectors producing erratic data was archived in the same way as loop detectors that produced reliable data. Appropriate use of the data required required analysts to test for data quality problems before making use of the data.

Operating the CRS / CFDW

- Document the costs, benefits, and lessons learned in operating the CRS / CFDW. The CRS / CFDW did not operate as expected.

Data quality

- The iFlorida data will be accurate. The raw data appeared to be accurate, though the CRS sometimes miscalculated travel times and archived the miscalculated travel times in the data archives.
- The iFlorida data will be reliable. The CFDW data was not reliable because the CFDW software was unreliable. FDOT did archive a significant amount of raw *i*Florida data, and these archives were reliable.
- The quality of the iFlorida data will be high. The data quality was not high because the CFDW software did not consistently archive the data – there were large gaps in the available data. The

FDOT archives of the data did not include any information about data quality (e.g., marking data as suspect if from a detector that was producing erratic results).

Data accessibility

- Good interfaces will exist for accessing iFlorida data. No interface existed for accessing real-time data and the interface for accessing data from the CFDW was slow and difficult to use. FDOT data archives were in a variety of formats, making them difficult to use.
- Broadband wireless Internet access will be a useful tool. The broadband wireless system on I-4 did not work reliably.
- Business and data management practices will encourage use of iFlorida data. The problems with the CFDW software made *i*Florida data inaccessible, and no users (other than the evaluation team) emerged. FDOT did not develop business and data management practices related to the *i*Florida data.
- iFlorida data will be widely used. The data was difficult to access and little used.
- iFlorida data will be an effective aid to those who use the data. The data was difficult to access and little used.

Impact of iFlorida on traffic and congestion

- iFlorida will reduce congestion. The fact that the *i*Florida deployment did not result in an increased coordinated traffic management activities meant that its ability to reduce congestion was limited.
- iFlorida will improve network reliability. The *i*Florida project was to include a network reliability analysis, but this project was postponed because of limitations in the archived data.
- iFlorida will reduce incident-induced delays. The fact that the *i*Florida deployment did not result in an increased coordinated traffic management activities meant that its ability to reduce incident-induced delay was limited.

Impact of iFlorida on safety

- iFlorida will reduce accident rates. The fact that the *i*Florida deployment did not result in an increased coordinated traffic management activities meant that its ability to reduce accident rates was limited.

Appendix A. Toll Tag Reader Level of Service

This appendix presents information about the level of service of the toll tag readers. During *i*Florida operations, three types of failures affected toll tag reader operations: (1) a reader produced fewer toll tag reads than expected, (2) a reader did not provide the toll tag information to the toll tag server in a timely manner, and (3) the clock on the reader was not synchronized with the clock on the toll tag server. The first type of failure can be measured by comparing the number of reads in archived data to the expected number of reads. Because the *i*Florida system did not include processes to monitor whether the toll tag reader clock was synchronized, it is difficult to differentiate between the second and third types of failure based on the archived data – both types of failure result in a discrepancy between the time when a toll tag was read and the time stamp when the toll tag server received the data. The second two types of failure can be measured together by computing the latency, which is the difference between the time when the toll tall tag server received a toll tag reading and when that reading was made. Specifically, the archived toll tag data was evaluated to compute the following two measures:

- The number of reads generated by each reader was reviewed and a normal range established for each day of the week. A Level of Service for Tag Reads (LOS_{Reads}) was assigned as follows. If the number of reads is above the minimum of the normal range, then LOS_{Reads} was set to 1. Otherwise, the following formula was applied.

  $$LOS_{Reads} = \frac{N_{Reads} - 200}{N_{Reads;Min} - 200}$$

  In this formula, N_{Reads} is the number of reads at the reader and $N_{Reads;Min}$ is the minimum of the normal range. This formula provides a measure of whether the reader was generating as many reads as usual and enough to support travel time operations. A value of 0 indicated that the reader was generating less than 200 reads per day – deemed insufficient for real-time travel time estimation. A value of 1 indicated that the reader was operating normally and generating as many reads per day as usual. Values in between indicated that the reader was generating fewer than the usual number of reads per day.

- The latency of the reads was examined and a Level of Service for Latency ($LOS_{Latency}$) was assigned as follows. If the average latency was less than 2 minutes or the number of reads with a latency of less then 2 minutes was greater than the minimum of the normal range for the number of reads, then $LOS_{Latency}$ was set to 1. If the average latency (L_{avg}) was greater than 20 minutes, then $LOS_{Latency}$ was set to 0. Otherwise, the following formula was used:

  $$LOS_{Latency} = 1 - \frac{L_{avg} - 2}{18}$$

  A value of 0 indicated that the reader lag time 12 greater than 20 minutes – deemed insufficient for real-time travel time estimation. A value of 1 indicated that the reader was operating with a lag of less than 2 minutes. Values in between indicted that the reader lag was between 2 and 20 minutes, with smaller numbers indicating a longer lag.

A Reader Level of Service (LOS_{Reader}) measure was computed as the product of these two measures. If LOS_{Reader} is 1, it indicates that the number of reads is operating at least as well as expected. (For example, the number of reads is within the expected range and the average latency is less than 2 minutes.) Lower levels of service occur if the reader is not producing as many reads as expected (i.e., LOS is less than 1) or the reads do not arrive at the toll tag server in a timely manner, so are not useful for computing real-time travel times.

The above definitions define daily measures of the level of service of a toll tag reader. The level of service over a period of time is computed as the average level of service for the days in that period. The level of service for a collection of readers is defined as the average level of service across those readers.

Another factor that affected the performance of the system was the number of duplicate reads that occurred at a toll tag reader. (For the purpose of this assessment, a duplicate read is defined as one where the toll tag read matches another tag read at the same reader in the previous five minutes.) The percent of duplicate reads (i.e., the number of duplicate reads divided by the total number of reads) was also computed.

The fact that the number of toll tag reads varies throughout the day can also impact the effectiveness of a toll tag reader in supporting travel time operations. For example, a reader that produces a large number of reads per hour during peak hours may produce very few reads during off-peak hours. Two measures of this factor were produced. The peaking minimum ($Peak_{Min}$) was the ratio of the number of reads that occurred during the hour when the fewest reads were made to the average hourly reads per day. The peaking maximum ($Peak_{Max}$) was the ratio of the number of reads that occurred during the hour when the most reads were made to the average hourly reads per day.

The following measures were used to summarize the operational performance of each toll tag reader.

- The normal range of reads per day for weekdays, Saturdays, and Sundays.
- The average number of reads per day for weekdays, Saturdays, and Sundays, with the average taken over all days for which the number of reads per day was in the normal range.
- The percentage of reads that were duplicates, with the percentage computed over all days for which the number of reads per day was in the normal range.
- The average values for $Peak_{Min}$ and $Peak_{Max}$, where the average was taken over all days for which the number of reads per day was in the normal range.
- The average LOS_{Reads} and the percentage of days for which the LOS_{Reads} was above 0.8, 0.9, and 0.95.
- The average $LOS_{Latency}$ and the percentage of days for which the $LOS_{Latency}$ was above 0.8, 0.9, and 0.95.
- The average LOS_{Reader} and the percentage of days for which the LOS_{Reader} was above 0.8, 0.9, and 0.95.
- The number and percentage of months for which LOS_{Reader} is above 0.8, 0.9, and 0.95 and the average level of service.

Because of the strong difference in the level of service before and after the readers studied in the previous section began operating reliably in January 2007, two different sets of these measures were used to differentiate between the average level of service that was found for a reader and the level of service that was found once the reader began reliable operations. To do this, the first month for which the average level of service was above 0.9 was identified and called the First Month of Reliable Service. Each of the measures listed above was computed for the first eight months of 2007 and for the entire time after the First Month of Reliable Service (FMORS).

The following tables list the level of service measures for each of the *i*Florida toll tag readers, with each table listing values for readers on a specific road. The first column of the table identifies the reader location, the first month of reliable service for that reader, and the peaking minimum and maximum. The next two columns list the normal range for the number of reads per day for Sundays only, Weekdays only, and Saturdays only, as well as the percent of the reads that were duplicates. The last seven columns list information about the reader level of service, with the first of these columns indicating the type of data on each row, the next three columns listing level of service information for the period from 1/1/2007 to 8/31/2007, and the final three columns listing level of service information for the period from the first month of reliable service to 8/31/2007. The first row in these columns lists the average level of service for these periods, with the other three rows listing the percentage of days for which the level of service was equal to or above 0.5, 0.9, and 1.0, respectively.

Table 19. Level of Service for *i*Florida Toll Tag Readers on SR 50

Reader (FMORS) ($Peak_{Min}$ / $Peak_{Max}$)	Normal Range of Operations		Level of Service						
			Category	1/1/2007 to 8/31/2007			Since Reliable		
	Category	Tag Reads		LOS_{Reads}	$LOS_{Latency}$	LOS_{Reader}	LOS_{Reads}	$LOS_{Latency}$	LOS_{Reader}
SR 50 @ SR 91 East (February) (0.05 / 2.17)	Sunday	7,900 to 10,900	Average	0.95	0.97	0.95	0.89	0.93	0.89
	Weekdays	7,900 to 10,900	>0.5	96%	97%	96%	90%	93%	90%
	Saturday	7,900 to 10,900	>0.9	94%	97%	94%	86%	93%	86%
	Duplicates	4.5%	=1.0	94%	97%	94%	83%	93%	83%
SR 50 @ SR 429 East (January 2006) (0.07 / 2.63)	Sunday	500 to 3,500	Average	0.97	1.00	0.97	0.84	0.86	0.84
	Weekdays	500 to 4,400	>0.5	97%	100%	97%	84%	86%	84%
	Saturday	500 to 4,500	>0.9	93%	100%	93%	83%	86%	83%
	Duplicates	14.4%	=1.0	92%	100%	92%	82%	86%	82%
SR 50 @ SR 408 Exit 1 East (January 2006) (0.05 / 2.17)	Sunday	7,900 to 10,900	Average	0.70	0.71	0.70	0.81	0.84	0.81
	Weekdays	7,900 to 10,900	>0.5	70%	71%	70%	80%	84%	80%
	Saturday	7,900 to 10,900	>0.9	69%	71%	69%	78%	84%	78%
	Duplicates	8.2%	=1.0	69%	71%	69%	78%	84%	78%
SR 50 @ SR 423 East (January 2006) (0.07 / 2.27)	Sunday	1,000 to 3,000	Average	0.95	0.97	0.95	0.94	0.98	0.94
	Weekdays	2,300 to 3,900	>0.5	95%	97%	95%	94%	98%	94%
	Saturday	1,500 to 4,500	>0.9	94%	97%	94%	90%	98%	90%
	Duplicates	7.2%	=1.0	94%	97%	94%	90%	98%	90%
SR 50 @ US 441 East (January 2006) (0.10 / 1.95)	Sunday	1,000 to 2,500	Average	0.95	0.97	0.95	0.78	0.87	0.78
	Weekdays	4,300 to 5,900	>0.5	95%	97%	95%	78%	87%	78%
	Saturday	2,000 to 3,000	>0.9	94%	97%	94%	71%	87%	71%
	Duplicates	12.4%	=1.0	82%	97%	82%	64%	87%	64%
SR 50 @ I-4 East (January 2006) (0.14 / 1.87)	Sunday	2,000 to 4,000	Average	0.95	0.97	0.95	0.79	0.84	0.79
	Weekdays	5,400 to 7,400	>0.5	96%	97%	96%	79%	84%	79%
	Saturday	3,500 to 5,500	>0.9	94%	97%	94%	75%	84%	75%
	Duplicates	5.5%	=1.0	94%	97%	94%	68%	84%	68%
SR 50 @ US 17/92 East (April 2006) (0.12 / 1.98)	Sunday	4,800 to 6,500	Average	0.92	0.95	0.92	0.65	0.81	0.65
	Weekdays	4,800 to 6,500	>0.5	93%	95%	93%	64%	81%	64%
	Saturday	4,800 to 6,500	>0.9	90%	95%	90%	59%	81%	59%
	Duplicates	11.7%	=1.0	80%	95%	80%	52%	81%	52%
SR 50 @ SR 436 East (February 2006) (0.09 / 2.07)	Sunday	7,900 to 10,900	Average	0.98	1.00	0.98	0.90	0.94	0.90
	Weekdays	7,900 to 10,900	>0.5	98%	100%	98%	89%	94%	89%
	Saturday	7,900 to 10,900	>0.9	97%	100%	97%	86%	94%	86%
	Duplicates	5.5%	=1.0	95%	100%	95%	80%	94%	80%

Reader (FMORS) ($Peak_{Min}$ / $Peak_{Max}$)	Normal Range of Operations		Level of Service						
			Category	1/1/2007 to 8/31/2007			Since Reliable		
	Category	Tag Reads		LOS_{Reads}	$LOS_{Latency}$	LOS_{Reader}	LOS_{Reads}	$LOS_{Latency}$	LOS_{Reader}
SR 50 @ SR 417 East	Sunday	1,500 to 3,000	Average	0.97	1.00	0.97	0.94	0.99	0.93
(March 2006)	Weekdays	2,000 to 6,000	>0.5	98%	100%	98%	96%	99%	96%
(0.09 / 2.06)	Saturday	3,000 to 5,500	>0.9	93%	100%	93%	85%	99%	84%
	Duplicates	5.4%	=1.0	93%	100%	93%	80%	99%	80%
SR 50 @ SR 408 (Exit 23) East	Sunday	2,000 to 5,000	Average	0.96	0.98	0.96	0.95	0.97	0.95
(January 2006)	Weekdays	2,200 to 6,000	>0.5	95%	98%	95%	96%	97%	95%
(0.10 / 2.17)	Saturday	2,000 to 5,500	>0.9	95%	98%	95%	93%	97%	93%
	Duplicates	2.0%	=1.0	95%	98%	95%	92%	97%	92%
SR 50 @ SR 408 (Exit 23) West	Sunday	8,000 to 10,000	Average	0.98	0.99	0.98	0.87	0.91	0.87
(February 2006)	Weekdays	11,100 to 13,700	>0.5	98%	99%	98%	88%	91%	88%
(0.09 / 2.26)	Saturday	10,000 to 12,500	>0.9	96%	99%	96%	83%	91%	83%
	Duplicates	2.6%	=1.0	94%	99%	94%	58%	91%	58%
SR 50 @ SR 417 West	Sunday	2,500 to 4,000	Average	0.77	0.88	0.77	0.75	0.87	0.75
(September 2006)	Weekdays	2,600 to 5,500	>0.5	77%	88%	77%	78%	87%	78%
(0.07 / 2.25)	Saturday	3,000 to 5,000	>0.9	72%	88%	72%	63%	87%	63%
	Duplicates	0.8%	=1.0	72%	88%	72%	61%	87%	61%
SR 50 @ SR 436 West	Sunday	2,000 to 3,500	Average	0.73	0.97	0.73	0.81	0.93	0.81
(February 2006)	Weekdays	3,800 to 5,700	>0.5	62%	97%	62%	77%	93%	77%
(0.06 / 2.44)	Saturday	3,000 to 5,000	>0.9	61%	97%	61%	73%	93%	73%
	Duplicates	0.2%	=1.0	61%	97%	61%	67%	93%	67%
SR 50 @ US 17/92 West	Sunday	2,500 to 5,000	Average	0.94	0.96	0.94	0.83	0.91	0.83
(March 2006)	Weekdays	5,200 to 7,500	>0.5	94%	96%	94%	84%	91%	84%
(0.11 / 2.19)	Saturday	3,500 to 6,000	>0.9	92%	96%	92%	74%	91%	74%
	Duplicates	9.2%	=1.0	91%	96%	91%	66%	91%	66%
SR 50 @ I-4 West	Sunday	1,000 to 3,000	Average	0.89	0.92	0.89	0.85	0.88	0.85
(January 2006)	Weekdays	2,000 to 3,500	>0.5	89%	92%	89%	85%	88%	85%
(0.13 / 1.91)	Saturday	1,500 to 3,000	>0.9	89%	92%	89%	82%	88%	82%
	Duplicates	8.7%	=1.0	89%	92%	89%	81%	88%	81%
SR 50 @ US 441 West	Sunday	4,300 to 5,900	Average	0.90	0.96	0.90	0.82	0.94	0.82
(January 2006)	Weekdays	500 to 1,100	>0.5	90%	96%	90%	81%	94%	81%
(0.09 / 2.25)	Saturday	4,300 to 5,900	>0.9	88%	96%	88%	80%	94%	80%
	Duplicates	0.4%	=1.0	88%	96%	88%	80%	94%	80%
SR 50 @ SR 423 West	Sunday	1,000 to 3,500	Average	0.94	0.97	0.94	0.94	0.96	0.94
(January 2006)	Weekdays	1,800 to 4,700	>0.5	95%	97%	95%	96%	96%	95%
(0.10 / 2.21)	Saturday	1,500 to 3,500	>0.9	88%	97%	88%	90%	96%	89%
	Duplicates	7.5%	=1.0	87%	97%	87%	89%	96%	88%

Reader (FMORS) ($Peak_{Min}$ / $Peak_{Max}$)	Normal Range of Operations		Level of Service						
			Category	1/1/2007 to 8/31/2007			Since Reliable		
	Category	Tag Reads		LOS_{Reads}	$LOS_{Latency}$	LOS_{Reader}	LOS_{Reads}	$LOS_{Latency}$	LOS_{Reader}
SR 50 @ SR 408 Exit 1 West	Sunday	7,900 to 10,900	Average	0.52	0.70	0.52	0.69	0.77	0.69
#N/A	Weekdays	7,900 to 10,900	>0.5	51%	70%	51%	69%	77%	69%
(0.06 / 2.12)	Saturday	7,900 to 10,900	>0.9	44%	70%	44%	64%	77%	64%
	Duplicates	1.2%	=1.0	44%	70%	44%	60%	77%	60%
SR 50 @ SR 429 West	Sunday	4,000 to 5,500	Average	0.94	1.00	0.94	0.71	0.91	0.71
(January 2006)	Weekdays	6,900 to 9,400	>0.5	95%	100%	95%	67%	91%	67%
(0.08 / 2.12)	Saturday	5,000 to 7,000	>0.9	87%	100%	87%	60%	91%	60%
	Duplicates	12.1%	=1.0	72%	100%	72%	41%	91%	41%
SR 50 @ SR 91 West	Sunday	7,900 to 10,900	Average	0.99	1.00	0.99	0.87	0.89	0.87
(January 2006)	Weekdays	7,900 to 10,900	>0.5	100%	100%	100%	88%	89%	88%
(0.09 / 2.59)	Saturday	7,900 to 10,900	>0.9	98%	100%	98%	85%	89%	85%
	Duplicates	1.5%	=1.0	96%	100%	96%	81%	89%	81%

The previous table provided values for the level of service of the individual toll tag readers positioned along Colonial Drive (SR 50). The following formula uses those measures to estimate a measure for the level of service of a toll tag travel time segment.

$$LOS_{Segment} = \left(\sum_{i \in From\ Readers} \frac{N_{Reader\ i}}{\sum_{k \in From\ Readers} N_{Reader\ k}} LOS_{Reader\ i} \right) \cdot \left(\sum_{j \in To\ Reader} \frac{N_{Reader\ j}}{\sum_{k \in To\ Readers} N_{Reader\ k}} LOS_{Reader\ j} \right)$$

In this formula, $N_{Reader\ i}$ is the average number of reads per day for Reader i, one of the readers at the from or to node for the travel time segment, and $LOS_{Reader\ i}$ is the level of service for that reader, as previously defined. This formula will return a value of 1 if all of the readers associated with the segment have level of service equal to 1, a 0 if all of the readers at either the from or to node have level of service equal to 0, and otherwise return a value in between these two extremes.

The following measures of the level of service of the toll tag segments were derived from this measure:

- The average value of $LOS_{Segment}$ over a specified period of time. This gave an indication of the general level of operation of a segment over that period of time.
- The percentage of days for which $LOS_{Segment}$ was at least 0.5 over a specified period of time. This gave an indication of the fraction of time that travel times were being produced for the segment, though at a significantly reduced level of service.
- The percentage of days for which $LOS_{Segment}$ was at least 0.9 over a specified period of time. This gave an indication of the fraction of time that the travel time system was operating effectively for the indicated segment.
- The percentage of days for which $LOS_{Segment}$ was at least 1.0 over a specified period of time. This gave an indication of the fraction of time that the travel time system was operating as expected for the indicated segment.

These measures are tallied in Table 20 for two different periods of time. The period from January 1, 2007 through August 31, 2007 covers the latest period for which complete tag reader information was available to the evaluation team. During the early part of that year, the system was operating effectively, though the performance dropped of dramatically later in the year. The period from March 1, 2007 through March 31, 2007 is a period of time during which the toll tag reader was operating well.

Table 20. Level of Service for *i*Florida Toll Tag Segments on SR 50

Travel Time Segment	January 1, 2007 thorugh August 31, 2007				March 2007			
	Average	Percent >0.5	Percent >0.9	Percent = 1.0	Average	Percent >0.5	Percent >0.9	Percent = 1.0
SR 50 East from SR 91 to SR 429	0.93	93%	89%	88%	1.00	100%	100%	100%
SR 50 East from SR 429 to SR 408	0.70	70%	68%	68%	1.00	100%	100%	100%
SR 50 East from SR 408 to SR 423	0.69	69%	68%	68%	1.00	100%	100%	100%
SR 50 East from SR 423 to SR 441	0.95	94%	94%	94%	1.00	100%	100%	100%
SR 50 East from SR 441 to I-4	0.95	95%	94%	94%	1.00	100%	100%	100%
SR 50 East from I-4 to US 17/92	0.95	94%	94%	87%	1.00	100%	100%	100%
SR 50 East from US 17/92 to SR 436	0.91	91%	89%	79%	0.87	87%	84%	81%
SR 50 East from SR 436 to SR 417	0.96	97%	90%	88%	0.98	100%	90%	90%
SR 50 East from SR 417 to SR 408	0.94	95%	90%	90%	0.98	100%	90%	90%
SR 50 West from SR 408 to SR 417	0.75	75%	70%	68%	0.85	84%	74%	71%
SR 50 West from SR 417 to SR 436	0.55	46%	44%	44%	0.30	10%	10%	10%
SR 50 West from SR 436 to US 17/92	0.69	58%	57%	55%	0.37	13%	13%	13%
SR 50 West from US 17/92 to I-4	0.89	88%	88%	85%	1.00	100%	100%	97%
SR 50 West from I-4 to SR 441	0.87	87%	83%	83%	1.00	100%	100%	100%
SR 50 West from SR 441 to SR 423	0.90	93%	81%	79%	0.99	100%	97%	90%
SR 50 West from SR 423 to SR 408	0.51	50%	42%	40%	0.63	52%	35%	32%
SR 50 West from SR 408 to SR 429	0.52	50%	44%	41%	0.63	52%	35%	35%
SR 50 West from SR 429 to SR 91	0.93	93%	87%	71%	1.00	100%	100%	94%

Appendix B. Analyzing Sign Data

FDOT archived the activity logs from the software it uses to manage messages on roadside signs for the period from July 29, 2005 through July 24, 2007. This software polled the signs at roughly 2-minute intervals, and the signs were expected to respond with the message currently displayed on the sign. The Evaluation Team analyzed these logs to assess FDOT's usage of the message sign network.

For each sign, the logs were reviewed and one of three status codes to each sign for each period of time:

- A status code of Message indicated that the sign reported back the currently displayed message.
- A status code of Connection Error indicated the sign management software reported an error connecting to the sign.
- A status code of Unknown indicates that the sign did not report status information for a period of 12-minutes or longer.

When a sign message was present, the Evaluation Team went on to review each message, identify the type of message that was displayed, and parse the content of the message to identify key characteristics of the message. The messages were parsed by compiling a list of formats that were used on FDOT signs. Each format included both text that must be included in a sign message and parameters that could be set within the message. For example, the message format

"CONGESTION / AHEAD <DistanceTo> / EXPECT DELAYS / CONGESTION / <LocationFrom> TO / <LocationTo>"

would match any sign message that began with the words "congestion / ahead ", followed by any text that represented a distance (e.g., "3 miles"), followed by the words " / expect delays / congestion / ", followed by any text recognized as a location (e.g., "SR 436"), etc.

Associated with each message format would be one of the following message types:

- Blank, indicating that the sign was blank.
- Test, indicating that a test message was being displayed.
- Advertisement, indicating that a traffic-related "advertisement", such as "For Traveler Information Call 511" or "Buckle Up", was being displayed.
- Information, indicating that information about a local event or attraction was being displayed.
- Exit Information, indicating that an exit number was being displayed. (This message type was used for custom signs used to suggest the best exit to take to reach specific local attractions.)
- Travel Time, indicating that travel time information from the sign's location to a location ahead was being displayed.
- Diversion, indicating that travel time information for two alternate routes to the same location was being displayed.
- Congestion, indicating that a warning of congestion ahead was being displayed.
- Crash, indicating that information about a crash ahead was being displayed.
- Road Construction, indicating that information about upcoming road construction was being displayed.

- Other Incident, indicating that the information about some other type of incident (i.e., not a crash, road construction, or congestion) was being displayed.
- Future Incident, indicating that information about a future incident, typically planned road construction, was being displayed.
- Road Closure, indicating information about a road closure ahead was being displayed.
- Detour, indicating information about a detour ahead was being displayed.
- Speed Limit, indicating that a speed limit was being displayed on a VSL sign.
- Amber Alert, indicating that an Amber Alert message was being displayed.
- Law Enforcement, indicating that a message related to law enforcement efforts (e.g., "Look for car / Tag #### / Call 911") was being displayed.

Matching a sign message to its format allowed assigning that sign message to one of these message types. It also allowed for the key parameters in the sign message to be parsed out of the message. In the above example, three parameters would be parsed out:

- The DistanceTo value, which would be converted into a numeric value indicating the distance from the sign to the position where the congestion began.
- The LocationFrom, which would be converted into an integer that identified which item in a list of recognized locations was the location where the congestion began.
- The LocationTo, which would be converted into an integer that identified which item in a list of recognized locations was the location where the congestion ended.

The following list is describes the parameters that could be included in a sign message:

- Distance From, which was the distance to the start of the incident being described by the phrase.
- Distance To, which was the distance to the end of the incident being described by the phrase.
- Location From, which was a cross-street name indicating the location for the start of the incident being described by the phrase.
- Location To, which was a cross-street name indicating the location for the end of the incident being described by the phrase.
- Delay From, which was the minimum travel delay associated with the incident being described by the phrase.
- Delay To, which was the maximum travel delay associated with the incident being described by the phrase.
- Travel Time From, which was the minimum travel time associated with the incident being described by the phrase.
- Travel Time To, which was the maximum travel time associated with the incident being described by the phrase.
- Road Blockage, which was information about a road or lane blockage caused by the incident being described by the phrase.
- Speed, which was a speed limit for a VSL sign.
- On Road, which was the road on which the incident being described by the phrase occurred.

The above approach worked for many sign messages. However, some sign messages contained multiple types of information (e.g., a message about a crash may also contain information about congestion caused by the crash). In these cases, each message format was divided into a series of phrases with a phrase type and parameters identified for each phrase.

For example, the message:

"SR 528 / 4 Miles / 5 Min / SR 50 / 16 Miles / 22 Min"

would be assigned the Travel Time message type and parsed into two Travel Time phrases. Each phrase was parsed to identify the Location To (e.g., "SR 528), the Distance To (e.g., "4 Miles"), and the Travel Time From (e.g., "5 Min").

Each of these pieces of information was coded and saved in a database for further analysis, along with an identifier for the sign that held the message and the date and time at which the indicated message was first displayed and when it was replaced with a different message. The result was a database that had converted the text message on each sign into a set of numeric values that could be analyzed to gather information about how FDOT used its signs.

*i*Florida Model Deployment Final Evaluation Report

U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Ave., SE
Washington, DC 20590
Toll-Free "Help Line" 866-367-7487
FHWA-HOP-08-050