

Technical Memorandum No. 3.5

Florida's 2003 Intelligent Transportation System Strategic Plan Update –

Vehicle Probe Studies

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List of Acronyms

ADUS.....	Archived Data User Services
ALI.....	Automatic Location Identification
ATA.....	American Trucking Association
ATIS.....	Advanced Traveler Information System
ATMS.....	Advanced Traffic Management System
AVI.....	Automatic Vehicle Identification
AVL.....	Automatic Vehicle Location
CCTV.....	Closed-Circuit Television
CVO.....	Commercial Vehicle Operations
DOT.....	Department of Transportation
E-911.....	Emergency 911
ETC.....	Electronic Toll Collection
FCC.....	Federal Communications Commission
FDOT.....	Florida Department of Transportation
FIHS.....	Florida Intrastate Highway System
FTA.....	Florida Trucking Association
GPS.....	Global Positioning System
HELP.....	Heavy Vehicle Electronic License Plate
I-4.....	Interstate 4
I-75.....	Interstate 75
I-95.....	Interstate 95
I-95.....	Interstate 95
IAG.....	Interagency Group
ITS.....	Intelligent Transportation System
ITSA.....	Intelligent Transportation Society of America
JPO.....	U.S. Department of Transportation's Joint Program Office
LPR.....	License Plate Reader
OCTA.....	Orange County Transportation Authority
OOCEA.....	Orlando-Orange County Expressway Authority
PRR.....	Portable Roadside Reader
SwRI.....	Southwest Research Institute
TEOO.....	Traffic Engineering and Operations Office
USDOT.....	United States Department of Transportation
VID.....	Video Image Detector
VII.....	Vehicle Infrastructure Integration

1. Introduction and Purpose

This *Technical Memorandum* is one of a series of documents whose goal is to identify new intelligent transportation system (ITS) trends, technologies, and initiatives that implement and fulfill the vision, goals, and objectives identified in the original version of *Florida's Intelligent Transportation System Strategic Plan*.¹ These documents will research national and statewide efforts in the subject areas, and determine the feasibility of pursuing or implementing these efforts as part of the Florida Department of Transportation's (FDOT) ITS Program over the next three years.

In December 2001, an FDOT technical memorandum was developed entitled *Innovative Traffic Data Collection*.² This document provides an analysis of different, innovative methods for collecting traffic sensor data and their potential application in Florida. The main focus of the analysis is the application of various data collection methods for the Florida Intrastate Highway System (FIHS). This *Technical Memorandum* represents additional analysis and recommendations regarding that document.

Over the past two years, the FDOT Traffic Engineering and Operations Office (TEOO) has conducted research on a number of travel-time data collection techniques, including the use of toll transponders, license plate readers (LPRs), and commercial vehicle transponders as probes. However, with the advent of the Enhanced 911 (E-911) mandate, several new technologies are now available that utilize cellular telephones as probes to collect travel-time data. These include global positioning systems (GPS) and other cellular network-based applications. This *Technical Memorandum* considers these and other options to determine the feasibility of their application in Florida, and to recommend future strategies for implementation. These core actions will be incorporated in the update of *Florida's Intelligent Transportation System Strategic Plan*.

¹ Florida Department of Transportation, *Florida's Intelligent Transportation System Strategic Plan – Final Report* (August 1999). Available online at <http://www.dot.state.fl.us/IntelligentTransportationSystems/>.

² Ciccarelli, Armand (PBS&J), *Technical Memorandum No. 1 – Innovative Traffic Data Collection: An Analysis of Potential Uses in Florida, Version 1* (December 2001). FDOT Contract No. C-7772. Available online at <http://www.dot.state.fl.us/IntelligentTransportationSystems/> under the ITS Projects, Probe Vehicle Studies link.

2. Background

Due to the continually increasing demand for access to Florida's roadway system, traditional infrastructure management programs focusing on roadway expansion are becoming incapable of keeping congestion within tolerable levels. In its place, state, county, and local departments of transportation are being forced to examine alternative techniques for managing and operating their existing infrastructures. Among these alternative techniques are advanced traffic management systems (ATMS), advanced traveler information systems (ATIS), and archived data user services (ADUS). However, for these applications to have a noteworthy impact, they require access to traffic data that is superior to what is currently available with respect to both quality and geographic coverage.

Traffic data collection is an activity that has traditionally been performed by public agencies responsible for managing traffic flows, responding to incidents, carrying out planning activities, and maintaining roadway surfaces. Technologies traditionally deployed for traffic data collection include inductive loop detectors, closed-circuit television (CCTV) cameras, and other point-oriented surveillance devices. Unfortunately, the high cost of deploying and maintaining this surveillance equipment has precluded most agencies from collecting real-time data on roads other than certain freeway portions and a few important arterials, thereby significantly limiting the equipment's usefulness for operations and management purposes.

Recently, there has been increasing interest in the many types of innovative data collection technology that potentially offers the opportunity to quickly and cost-effectively expand data collection coverage and quality. One technological area of particular interest utilizes location information collected from wireless telephone networks that include a large number of handsets combined with computerized street maps to measure the time it takes to travel from one area to another.

2.1 Concept of Using Cell Phones to Collect Traffic Data

In the United States, the deployment of technologies for gathering data on wireless telephone locations was initially driven by regulatory mandates related to E-911. On June 12, 1996, the Federal Communications Commission (FCC) established a timetable within which mobile telephone companies were required to locate wireless callers' physical locations when the callers dial 911.

Timing for implementation of the E-911 requirements was divided into two phases. Phase I requires wireless carriers to deliver the telephone number of a wireless handset originating a 911 call to the emergency dispatcher, as along with the location of the cell site or base station receiving the 911 call, which provides a rough indication of the caller's location. This phase was largely implemented by the end of 1998.

Phase II required carriers to deliver more specific latitude and longitude information, known as automatic location identification (ALI), to the dispatcher. A number of interim milestones were identified for full Phase II implementation, beginning in March 2001 and ending with complete implementation by the end of 2004.

Several vendors developing location solutions to satisfy the FCC's E-911 mandate have indicated that, aside from providing latitude and longitude information for individual telephones, their technologies can also provide velocity and direction information for significant numbers of telephone users traveling on nearby roads. Consequently, these vendors believe that working E-911 geolocation systems might also be utilized as platforms for supporting other location-based applications, including the provision of traffic information.

3. Review and Update of the Findings from the December 2001 Technical Memorandum

For the purpose of the December 2001 *Technical Memorandum* referenced previously, innovative data collection methods were defined as those that facilitate the direct measurement of segment (i.e., “link”) travel times or average speeds along a roadway. This approach was in contrast to “point” sensors such as loop detectors, video image detectors (VIDs), or infrared and acoustic detectors that characterize traffic flow at a specific location along a roadway. This analysis was not intended as an “either/or” assessment of traditional data collection versus innovative data collection. Rather, the analysis was intended to characterize the relative attractiveness of these methods for use in Florida and to provide recommendations for further activities as appropriate.

The analysis focused on the following innovative data collection methods:

- In-Vehicle transponders
- License plate readers
- Cellular telephones as probes
- Transit automatic vehicle location (AVL) technologies
- Private fleet AVL technologies

3.1 In-Vehicle Transponders

As stated in the original *Technical Memorandum*, a number of public agencies from across the country are using transponder-based technology to determine travel times and speeds on roadways within their jurisdictions. Transponders are in-vehicle devices that transmit radio signals to roadside sensors at toll plazas for the purpose of automated electronic toll payment. Additional hardware and software are required to turn an existing electronic toll collection (ETC) system into an accurate travel-time data collection system, such as the need for additional antennas and readers that may need to be deployed between toll collection plazas to facilitate the collection of supplemental data, and additional processing equipment and software that will need to be set up at a centralized processing facility. However, with such modifications, ETC systems have the potential to become an abundant source of travel-time and speed data.

At present, the Orlando-Orange County Expressway Authority (OOCEA) is in the process of deploying a travel-time data collection system using supplemental tag readers deployed at sites between toll collection plazas. As part of this effort, the OOCEA has contracted with Southwest Research Institute (SwRI) to develop a “data server” capable of turning raw license plate data collected by its supplemental sensors into “fused” data that indicates travel times along discrete segments of roadway. The OOCEA is also exploring the use of fused data for incident management and performance monitoring purposes.

Additionally, and due in large part to research conducted by the FDOT and described in *Section 4* of this *Technical Memorandum*, one of the iFlorida model deployment’s subprojects involves the deployment of automatic vehicle identification (AVI) transponder readers and a small number of LPRs at 35 sensor sites along arterial roadways, and 15 sensor sites on roadways operated by Florida’s Turnpike Enterprise in the Orlando metropolitan area.³ Rather than developing a stand-alone software package to manage the processing of this data, the FDOT is working with the OOCEA to leverage the data server software being developed by SwRI. Thus, the OOCEA data server will facilitate the processing of these 50 additional sensor sites.

Travel-time data collected from these systems will be used to supplement the Orlando regional 511 telephone service and traveler information Web site, which is currently under development.

3.2 License Plate Readers

As stated in the December 2001 *Technical Memorandum*, LPR technology has been gaining acceptance:

*Applied extensively in the United Kingdom and undergoing testing in Oregon, the use of license plate readers to determine travel times is a data collection method that should be given careful consideration in Florida. This method uses optical character recognition technology to identify license plate numbers and convert them to electronic identifiers. This method has essentially the same functionality as transponder-based systems, but does not require the transponder. As a result, it has the potential to operate successfully even in areas where transponder penetration is low.*⁴

³ More information regarding the FDOT’s iFlorida Surface Transportation Security and Reliability Information System Model Deployment Project is available online at <http://www.iflorida.net/>.

⁴ Ciccarelli, *Executive Summary*, iii.

Based on research the FDOT has conducted, LPRs appear to be a viable means for facilitating the data collection needed to calculate roadway-oriented travel times. However, a small number of LPRs are being deployed by the design-build vendor as part of the *iFlorida Model Deployment*, but no large-scale deployments of this technology have yet occurred in Florida.

3.3 Cellular Telephones as Probes

In the December 2001 *Technical Memorandum*, it was determined that the FDOT should proceed cautiously in the further investigation and implementation of the concept of using cellular telephones as probes for the following key reasons:

- Implementation of E-911 is occurring slowly. On October 1, 2001, the deadline for technology selection and implementation passed with each wireless carrier seeking at least a partial waiver on full implementation of the FCC ruling. Although all wireless carriers are working to deploy E-911, the rate of progress is varied and unpredictable.
- Technology is uncertain. Since all carriers have not selected or fully tested the technologies they will use to meet the FCC's E-911 mandate, it is not yet clear whether any or all of the carriers' systems will lend themselves to use in monitoring traffic conditions.
- Business and implementation coordination issues need to be resolved. It was believed that it would be cost-prohibitive and otherwise very difficult to implement cellular probe systems without the cooperation of one or more of the wireless carriers. As was learned during interviews at that time, only one carrier indicated an existing interest in using their system to monitor traffic. Furthermore, use of cellular probe systems has incited the largest outcry of all the methods investigated in terms of potential privacy invasion. Finally, it is unclear what the impact will be from the increasing number of legislative initiatives limiting a motorist's cellular telephone use while driving.

During the intervening two years, however, other vendors and technology solutions have come on the scene that seek to utilize other types of cell/telephone network data (i.e., not gathering data concerning individual phones) to determine real-time travel times and speeds. By amassing and analyzing data from large numbers of wireless telephones, these vendors seek to provide real-time travel times and speeds for a variety of roads, both urban and rural. In contrast with E-911 oriented data collection technologies that require additional equipment, either in the handset itself or attached to existing cell tower equipment, this data collection paradigm is touted as requiring very little, if any, additional infrastructure to implement. Consequently, it is envisaged that such systems could be widely deployed both quickly and cost effectively.

With ever-increasing numbers of Americans utilizing wireless phones, the number of potential probes on our roads increases on a daily basis. This fact, combined with the development of new technologies/algorithms for analyzing such probe data, increases the likelihood that cellular telephone-based travel-time data collection has the potential to soon become a disruptive technology that seriously alters the manner in which public agencies collect travel-time data. Such information could be immensely valuable, particularly as more and more traveler information systems come online.

3.4 Transit Automatic Vehicle Location

Research conducted as part of the initial *Technical Memorandum* completed in December 2001 indicated that a test conducted by the Orange County Transportation Authority (OCTA) found little correlation between speed estimates determined by a transit probe algorithm developed for testing purposes and recorded automobile speeds. Problems with project data analysis concerned the fact that the algorithm failed to distinguish between actual congestion and normal stopping delays, especially when buses ran ahead of schedule. Consequently, the *Technical Memorandum* recommended that the FDOT simply monitor whether any new research or applications emerge that are capable of overcoming the inherent complexity of using transit vehicles as probes. At this time, no significant changes have been observed in this technology. As a result, it is recommended that the FDOT continue to monitor events in this industry.

3.5 Private Fleet Automatic Vehicle Location

During the development of the original *Technical Memorandum*, it was believed that with the widespread deployment of fleet management systems for commercial vehicles, it may be possible to employ vehicle location and speed data from these systems for use in developing aggregate representations of traffic conditions on roads nationwide. However, when contacted to discuss this option in late 2001, Qualcomm, Inc., one of the largest suppliers of long-haul fleet tracking services including more than 300,000 units deployed nationally, was not interested in utilizing their data for traffic monitoring purposes for the following two key reasons:

- According to Qualcomm's contracts with their customers, all data collected for fleet management purposes belongs to the customer rather than Qualcomm.
- Their core business competency is fleet management, not traffic data collection. Consequently, for such an application to be attractive to Qualcomm, it would have to be an obvious revenue generator, something that traffic data collection has not yet demonstrated.

Private fleet AVL continues to be a significant, untapped data collection resource. The following recommendations should be considered for future ITS Program strategies:

- Report on the issue to the Intelligent Transportation Society of America's (ITSA) Commercial Vehicle Operations (CVO) Committee, the United States Department of Transportation's (USDOT) ITS Joint Program Office (JPO), and the American Trucking Association (ATA) to determine whether there is any interest in pursuing the issue with Qualcomm.
- Contact the Florida Trucking Association (FTA) to see whether one or more carriers would be interested in conducting a pilot test on the movement of their vehicles using data received from Qualcomm or another fleet management service provider.

4. Details on Recent Research Conducted by the Florida Department of Transportation

Over the past two years, the FDOT has conducted a significant amount of research on the potential for utilizing in-vehicle transponders and LPRs as the foundation for a probe-oriented data collection system to enhance the accuracy, timeliness, and reliability of real-time traffic data. Two sets of field tests were conducted to assess the feasibility of deploying these technologies on limited-access and arterial roadways across Florida. Overall, the primary goals of these field tests were to:

- Assess the penetration of toll transponder-equipped vehicles along nontolled, limited-access and arterial roadways to determine whether sufficient numbers of those vehicles exist to assist with travel-time data collection.
- Conduct a proof-of-concept test concerning the feasibility of utilizing LPR technology to collect travel-time data along arterial roadways around the Orlando metropolitan area.
- Initiate the development of rules for reader spacing and the determination of optimal link size (e.g., smaller segments result in an increased number of matched links [reduced leakage] and reduced latency of data, but lead to increased costs).

Results of these field tests yielded the conclusions detailed in the following sections.

4.1 Portable Roadside Readers

The following conclusions were reached regarding portable roadside readers (PRRs):

- Adequate penetrations of toll transponder-equipped vehicles exist on all of the arterial roadways tested in the Orlando metropolitan area, as well as along Interstate 4 (I-4) in Orlando and Interstate 95 (I-95) in Broward County. This suggests that suitable penetrations are likely to exist in Miami and, potentially, West Palm Beach due to their proximity to a large network of toll roads.
- Placing the PRR readers too far apart has the potential to affect data quality (e.g., increased numbers of outliers).
- It is likely that a full system deployment will require greater lane coverage to ensure that a sufficient number of matched links become available for analysis. Failure to provide sufficient lane coverage results in an unacceptable loss of data between reader sites.

4.2 License Plate Readers

The following conclusions were reached regarding LPRs:

- Results indicate that LPRs have the potential to monitor at least 80 percent – and likely more – of the vehicles in any lane under observation.
- As with the PRR test, placing LPRs too far apart has the potential to affect data quality (e.g., increased numbers of outliers).
- Due to its ability to collect data on most of the vehicles traveling past an LPR, this technology has the potential to operate successfully along roadways with a limited monitoring infrastructure.

The results of these field tests suggest that both transponder/reader and LPR-based technologies offer viable methods for collecting travel-time data on key arterials in Florida. License plate readers seem to offer the potential for higher penetrations and larger numbers of matched links, but a further determination of each technology's relative cost effectiveness needs to be conducted.

5. National Initiatives

5.1 Vehicle Infrastructure Integration Initiative

Leaders in the USDOT's ITS JPO are spearheading an effort in conjunction with automotive manufacturers and other public/private partners to implement the Vehicle Infrastructure Integration (VII) Initiative.⁵ As envisioned, the VII Initiative will be composed of a nationwide system in which vehicles will routinely communicate with transportation infrastructure in real time to improve vehicle and roadway safety, and support a wide range of commercial activities.

Such a system would theoretically enable all vehicles that have self-geolocation capabilities to act as probes within that system, thereby resulting in near ubiquitous data collection capability wherever a communications infrastructure has been installed. At this time, details on the rollout of this initiative are under development.

⁵ More information regarding the VII Initiative is available online at <http://www.its.dot.gov/initiatives/>.

6. Recommendations

To move beyond the research stage, it will be necessary to develop a concept plan for the development and use of travel-time data collection systems in Florida. This concept plan should:

- Establish a vision and purpose for travel-time data collection, including how it will support operations, planning, and traveler information (e.g., 511) applications.
- Determine the facilities for which travel-time data will be collected, the density of coverage, and the required quality parameters of the data.
- Utilize existing corridor plans the FDOT has developed to assist in selecting the technology or technologies to be used to collect travel-time data along the corridors involved for each facility and determine the communication method to be used to get data to the appropriate location(s) for real-time aggregation and analysis. Technology selection should be based on the extent to which the corridor concept is supported, the technology's cost-effectiveness, and the results of the implementation of risk analysis.
- Utilize a project architecture and concept of operations to ensure that the data collected is properly computed, stored, shared, and used. Identify the modifications to the regional architecture and systems that are needed so travel-time data can be incorporated in local operations as desired.

Furthermore, to support the development of a well-founded concept plan, additional research activities have been identified and are detailed in the sections below.

6.1 Using Cellular Telephones for Probe Concept Testing

As the technology underlying the “cell-phones-as-probes” data collection concept becomes increasingly mature, the FDOT should consider conducting concept testing with one or more of the vendors that have demonstrated an ability to make their technology work. Any vendor that is selected should have preexisting agreements in place with at least one of the larger wireless carriers, such as Sprint®,⁶ AT&T®,⁷ Verizon®,⁸ Cingular®,⁹ etc. As mentioned earlier, this technology has the potential to be highly disruptive in nature, having a significant impact on the way traffic data is collected in the future. Getting involved in the testing of this technology now will make the FDOT one of only a handful of state departments of transportation (DOTs) taking a leadership role in the development of this field.

6.2 Using Other Transponder Types for Travel-Time Data Collection in Florida

More than 200,000 commercial vehicles use Heavy Vehicle Electronic License Plate (HELP)/PrePass® transponders for electronic clearance throughout Florida and the United States.¹⁰ Over 7 million vehicles nationally are equipped with the Interagency Group (IAG) E-ZPassSM ETC transponders.¹¹ With a vendor that indicates a willingness to provide PRRs that can read both Pre-Pass and E-Z-Pass transponders at no cost to the FDOT, a low-cost test could be conducted on Interstate 75 (I-75) and I-95 near the Georgia border; Interstate 10 (I-10) at the Alabama border; and near Jacksonville to determine the volume of vehicles that enter the State equipped with either or both of these transponders. Results of such testing will assist the FDOT in clarifying whether these groups of AVI transponders can be used as a reliable source of probe data.

⁶ Sprint is a registered trademark of Sprint Communications Company, L.P.

⁷ AT&T is a registered trademark of American Telephone and Telegraph Company.

⁸ Verizon is a registered trademark of Verizon Communications.

⁹ Cingular is a registered trademark of Cingular Wireless, L.L.C.

¹⁰ PrePass is a service mark of Lockheed Martin IMS Corporation.

¹¹ E-ZPass is a service mark of the Port Authority of New York and New Jersey.

6.3 Testing License Plate Readers in North Florida

In conjunction with research to assess the penetration of HELP/PrePass and IAG E-ZPass transponder-equipped vehicles in northern Florida as described above, it is recommended that the FDOT conduct a follow-up test of LPRs in North Florida, primarily in Tallahassee, with the test emphasizing:

- Determination of the ability of current LPR technology to read the many different types of license plates used in Florida;
- Whether single-lane deployments that cost less than the deployment of a reader in each lane, will yield accurate data
- How side-fire mounting versus look-down mounting affects the system's data collection capability