



RESEARCH Showcase

Fall 2012

Managing Congestion Problems with Intelligent Transportation Systems





Fall 2012

The Florida Department of Transportation (FDOT) Research Showcase is published to provide information regarding the benefits of FDOT-funded research.

Managing Editor

Darryll Dockstader

Editor/Writer

Vicki Morrison
Charles Brown

Graphic Design

Vicki Morrison
Charles Brown

Printer

Gandy Printers

Front and Back Cover

Atkins North America

Governor

Rick Scott

Secretary of Transportation

Ananth Prasad, P.E.

Contact

FDOT Research Center
605 Suwannee Street, MS 30
Tallahassee, FL 32399-0450
Phone (850) 414-4615
<http://www.dot.state.fl.us/research-center/>

FDOT Research Showcase

In This Issue

We see myriad traffic control devices on our roadways: closed-circuit TVs that monitor and verify traffic conditions; sensors that collect traffic volume and speed data, and detect the presence of vehicles; dynamic message signs that display traffic information; and more. These Intelligent Transportation Systems (ITS) devices collect and transmit traffic information to Florida's transportation management centers, and ultimately back to the traveling public.

In the near future, we will experience another type of intelligent transportation technology — connected vehicles (CV). Statistics show that over 80 percent of avoidable collisions could be prevented with CV technology. In October 2011, the Florida Department of Transportation demonstrated CV capability at the 18th Annual ITS World Congress in Orlando, Florida. By 2013, the USDOT anticipates advancing CV technology to the mainstream, enabling traffic condition information to be communicated among vehicles, infrastructure, and personal communications devices.

Without research, however, these and other advanced transportation technologies would not exist. This issue of Research Showcase highlights ITS research in Florida that is helping to improve roadway safety, alleviate congestion, and protect the environment by reducing fuel consumption. Included is information about the evolution and implementation of SunGuide[®], software that manages Florida's ITS, and the Statewide Traffic Engineering Warehouse for Archived Regional Data (STEWARD), the central data warehouse where the vast amounts of data collected by ITS is stored.

This issue also highlights ramp metering technology, which was implemented on I-95 in South Florida to regulate the rate at which vehicles enter the interstate. Another technology, using sensors imbedded in pavement, seeks to match demand for truck parking spaces at interstate rest areas with existing supply.

I invite you to read about these technologies that are helping FDOT to manage congestion on Florida's roadways and improve transportation safety and mobility.

Darryll Dockstader, Manager

Contents

Managing Traffic Congestion with Intelligent Transportation Systems	4
STEWARD: FDOT's Central Data Warehouse for ITS Data	8
Truck Parking: ITS Detects Parking Availability, Improves Safety	10
Meet the Project Manager: Arun Krishnamurthy	12
Meet the Principal Investigator: Lily Elefteriadou	13
Ramp Signals Regulate Traffic Flow	14
For More Information	15

Managing Traffic Congestion with Intelligent Transportation Systems

Mobility is a basic need and essential to economic development. Mobility governs business location and makes it possible to share products and information with people around the world. However, a significant problem that results from increased traffic volume on roadways is congestion. Traffic congestion contributes to increased shipping costs, losses in productivity, wasted fuel, increased pollution, and vehicle crashes.

The Texas Transportation Institute (TTI) reports that in 2009, U.S. highway users wasted 4.8 billion hours a year stuck in congestion, nearly one full work week per traveler. The overall cost, based on wasted fuel and productivity, reached \$115 billion in 2009 – more than \$808 for every U.S. traveler. Delays in truck operations alone reached \$33 billion. The total amount of wasted fuel topped 3.9 billion gallons.

A recent FDOT-funded study of the economic cost of traffic congestion in Florida found that traffic congestion has been increasing in every county in Florida, as indicated by increases in average commute times and other measures.

The researchers also found that congestion is more than just an urban issue.



Advanced traffic management systems use a variety of intelligent transportation system technologies to manage traffic. A variety of equipment is mounted on this pole along the connected vehicle test bed in Orlando. From top: closed-circuit television camera; GPS antenna (small white object on the right side of the pole); road-side equipment, which transmits information from the vehicle to the regional transportation management center; microwave vehicle detector.



TTI's *2011 Urban Mobility Report* provides information on congestion in seven urban areas in Florida (in order from most to least congested): Miami, Tampa-St. Petersburg, Orlando, Jacksonville, Sarasota-Bradenton, Cape Coral, and Pensacola. The report states that in 2010, congestion cost Florida commuters in these areas \$5.6 billion. They experienced approximately 269 million hours in travel delay and wasted 116 million gallons of fuel. Commuters in Orlando and Miami experienced 38 hours of annual delay per highway user, the highest in Florida. Both cities ranked 15th nationally as the most congested – Miami for the very large population group, and Orlando for the large population group. Tampa-St. Petersburg, with an annual delay of 33 hours per highway user, ranked 27th nationally in the large population group.

Providing a safe, efficient, effective, and environmentally sound transportation system is becoming more difficult to achieve due to the exponentially increasing demand for mobility and the resulting congestion. Expanding existing roadways to increase capacity often is not practical or possible. An attractive and cost-effective approach for improving capacity is to optimize the efficiency of existing facilities using advanced traffic management systems (ATMS).

Advanced traffic management systems (ATMS) use a variety of intelligent transportation system (ITS) technologies to manage vehicles on existing roadways and to maximize the value derived from and capacity of our transportation system. Florida's ITS devices are connected to FDOT's fiber optic network and managed by SunGuide® software. ITS devices deployed in Florida include over 700 dynamic message signs that display real-time traffic information, over 1,900 closed-circuit television (CCTV) cameras that monitor

and verify traffic conditions, and about 3,200 sensors that collect traffic volume and speed data, and detect the presence of vehicles. Other ITS equipment includes ramp signals, highway advisory radios, and road weather information systems. These devices collect and transmit real-time traffic information to Florida's 10 regional transportation management centers (RTMCs). Located in major metropolitan areas, RTMCs are the nerve centers for managing traffic and disseminating information gathered with ITS devices to the traveling public and emergency workers.

FDOT's SunGuide® Software

FDOT first deployed ITS devices in early 2000 on portions of limited access roadways in Jacksonville, Orlando, and Miami, and on the Florida Turnpike. Each roadway portion was managed by a different software system. To enable better coordination of the equipment, and to save money on software development and maintenance, FDOT and the Michigan Department of Transportation (MDOT) contracted with the Southwest Research Institute (SwRI) in 2001 to develop a unified software system to manage ITS devices statewide. SwRI researchers developed recommendations for integrating RTMC functions, toll collection, freeway incident management, traveler information, and vehicle information. The study helped FDOT to develop a long-term vision of ITS implementation and provided MDOT with a similar vision for implementing a traffic management system. The Federal Highway Administration (FHWA) monitored the study to ensure that the software system would follow national ITS standards. The study recommended that FDOT develop statewide ATMS software to reduce software development and maintenance costs, and to provide a uniform software platform that fosters collaboration among RTMCs.

In 2002, FDOT sought bidders to provide the statewide ATMS software and selected SwRI as the contractor. SwRI helped FDOT partner with Texas DOT, and FDOT used Texas DOT's

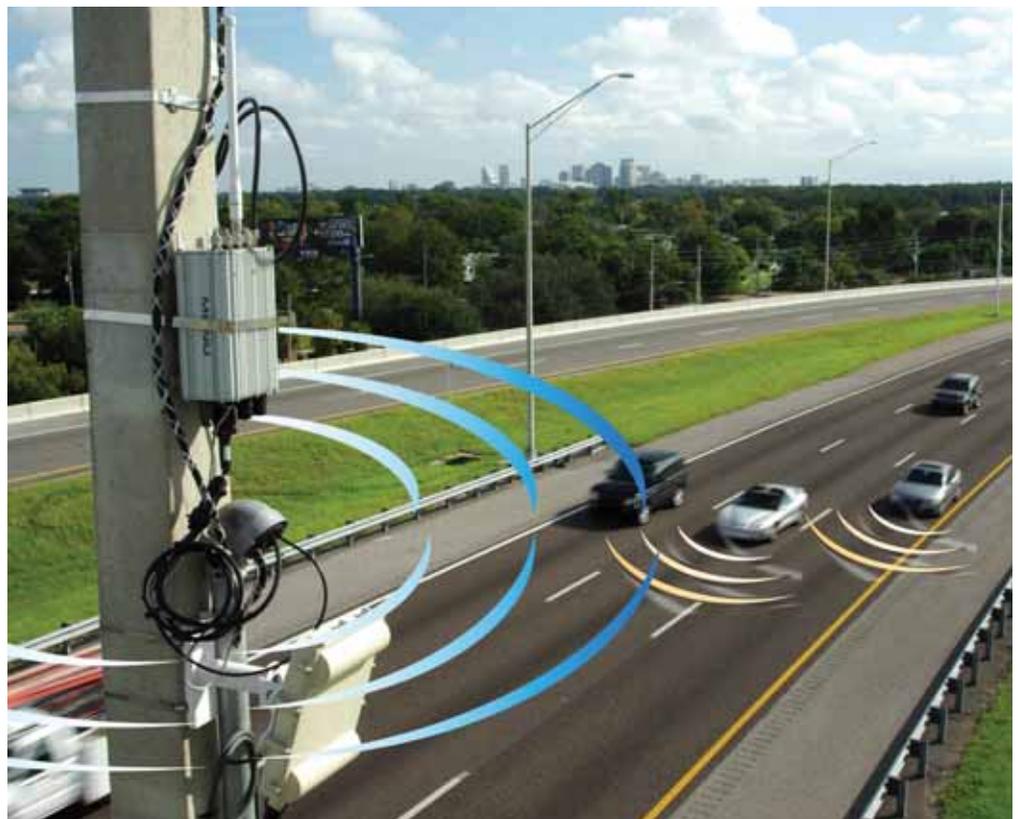
Orlando's Connected Vehicle (CV) test bed. CV technology enables wireless communication among vehicles, infrastructure, and personal communication devices. USDOT is targeting 2013 as the critical point at which CV technology will advance to the mainstream.



SunGuide®, FDOT's unified software system, enables all ITS devices to communicate with FDOT's regional traffic management centers.

ATMS software to develop and customize SunGuide® software to meet Florida's needs. FDOT deployed the first fully functional version of SunGuide® in 2005. SunGuide® is owned jointly by Texas DOT and FDOT.

SunGuide® was designed and implemented to facilitate the management of events and distribution of information to travelers, and to enable FDOT's ITS



devices to communicate with the RTMCs. SunGuide® allows RTMC operators to perform incident management tasks, obtain data from vehicle detection systems, display videos from roadside cameras, and direct advisory information to motorists by means of dynamic message signs and highway advisory radio or the Florida 511 advanced traveler information system. The software allows the RTMCs to integrate numerous hardware, software, and network applications, and to exchange data efficiently and effectively among the RTMCs. Currently, over 1,272 miles of FDOT's 2,000 miles of limited-access roadways, including the entire I-95 corridor, are managed by SunGuide®.

Connected Vehicle Technology

The U.S. Department of Transportation (USDOT) launched research on ITS in the mid-1990s, applying processes and technologies previously developed by the defense community, such as surveillance technologies and systems engineering. Research indicated by the early 2000s that technologies allowing vehicles to communicate with other vehicles (V2) and bidirectionally with infrastructure (V2I) held tremendous potential to manage congestion and address highway safety problems. These technologies were known collectively as the vehicle integration initiative (VII). Proof of concept test beds were designed and implemented in 2008 and 2009 in Oakland County, Michigan, and Palo Alto, California, to validate the technical feasibility of key components of VII. The USDOT renamed the VII program to Connected Vehicle (CV) in 2010.

The Virginia Department of Transportation (VDOT) is working with several federal, state, and local agencies, including FDOT, to establish a multi-phase program to facilitate the field demonstration and deployment of connected transportation infrastructure applications. This pooled fund study (TPF-5(206)) will aid transportation agencies to justify and promote the large-scale deployment of connected systems.

The CV research program is a multimodal initiative that uses networked wireless communications between vehicles, between vehicles and roadway infrastructure, and among vehicles, infrastructure, and personal communication devices. USDOT's vision for CV technologies is to create a roadway system where highway crashes are significantly reduced, transportation systems can be managed in real time for optimal performance, and travelers have access to

real-time information about roadway conditions, enabling them to make informed decisions about route and mode options. By taking advantage of the capabilities of wireless technology, USDOT believes the CV program will enhance the mobility and quality of life of roadway users while helping to reduce the environmental impact of surface transportation.

The USDOT's goal of zero fatalities is one of the driving forces behind the CV research effort. Statistics show that over 80 percent of avoidable collisions could be prevented with the implementation of CV technology. USDOT is targeting 2013 as the point at which CV technology will advance to the mainstream with the anticipated ruling by the National Highway Traffic Safety Administration

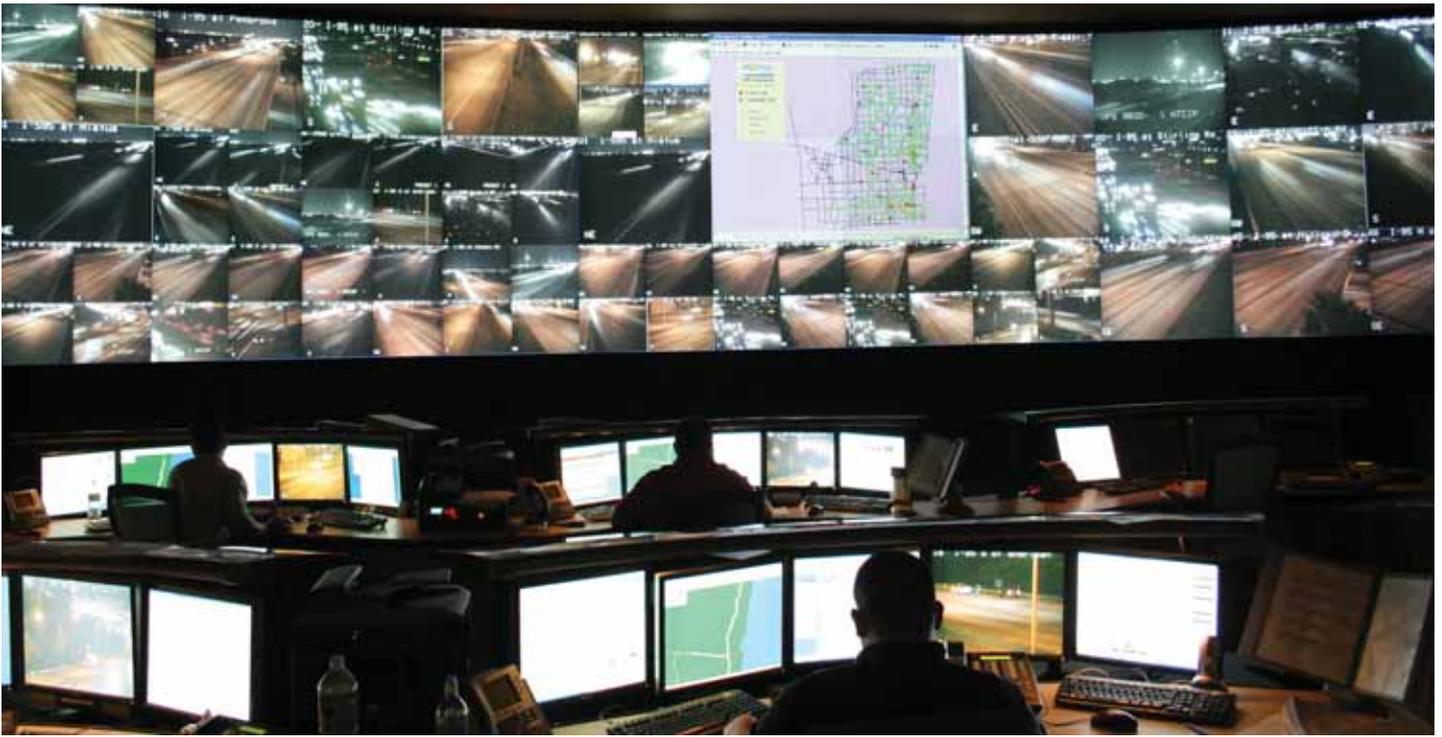
(NHTSA) requiring new vehicles to be equipped with dedicated short-range communication (DSRC) radios. In anticipation of the ruling, USDOT has upgraded its California and Michigan test beds enabling manufacturers and agencies to test applications, services, and components using the latest technology and architecture, and enabling researchers to find the best way to communicate information between roadway infrastructure and vehicles.

CV Demonstration at the 18th Annual ITS World Congress

In addition to upgrading the California and Michigan test beds, USDOT assisted FDOT to establish a CV test bed in Orlando, Florida, and provided FDOT with 29 roadside equipment (RSE) units and 42 vehicle



The Connected Vehicle (CV) test bed route in Orlando, Florida, is the only RTMC-based operational test bed in the U.S.



Florida's Regional Transportation Management Centers (RTMCs), located in major metropolitan areas, are the nerve centers for disseminating information about traffic conditions gathered with ITS devices to the traveling public and emergency workers. Pictured above, the Broward County/District 4 RTMC located in Fort Lauderdale, Florida, is staffed 24-hours per day, seven days per week, 365 days per year. Pictured above: RTMC operators in Broward County monitor closed-circuit television (CCTV) cameras deployed along I-95, I-595, and I-75 and post messages to dynamic message signs. When operators detect an incident, such as stopped or slowed traffic, operators dispatch road rangers and the severe incident response vehicle, in coordination with the Florida Highway Patrol (FHP), to determine specific incident and congestion locations.

awareness devices. In October 2011, FDOT used the test bed to demonstrate the capability of CV technology when Orlando hosted the 18th Annual World Congress on Intelligent Transportation Systems. The Congress is the ITS industry's most anticipated event and serves as the premier venue where industry leaders from around the world showcase their latest products and future innovations. The test bed consisted of 25 miles of limited access and arterial facilities (Interstate 4, International Drive, and John Young Parkway; see map, page 6) in the urban area around the conference site. Because SunGuide® software allows new modules to be developed quickly to meet user needs, FDOT was able to modify SunGuide® and showcase CV functionality at the Congress. Vendors and demonstrators provided probe vehicles equipped with vehicle awareness devices. FDOT installed vehicle awareness units on LYNX buses, I-RIDE trolleys, and FDOT maintenance vehicles. During the demonstration, conference participants observed how the RSE transmitters sent safety messages to the probe vehicles via DSRC radios while collecting information from the vehicles about location and speed.

The deployment of CV technology into the SunGuide® ATMS environment is unique because it is the only RTMC-based operational test bed in the U.S. Following the ITS World Congress, FDOT left the infrastructure in place to use in future research. The vehicles cur-

rently equipped with vehicle awareness devices continue to broadcast basic safety messages and collect and transmit data to the RTMC.

Data collected on Orlando's test bed is a valuable resource to USDOT in support of its real-time Data Capture and Management (DCM) program. The program aims to acquire and provide integrated, multi-modal data from connected vehicles, devices, and infrastructure and develop environments that enable integration of high-quality data from multiple sources for transportation management. The program provides USDOT with the opportunity to explore uses of real-time data provided by FDOT to increase safety and operational efficiencies through various applications of the data. FDOT and USDOT anticipate that the information developed from the DCM program will reveal opportunities for achieving greater efficiencies within our transportation systems.

FDOT continues to enhance the capabilities of SunGuide® software. It is available to other states free of charge. For more information, contact Arun Krishnamurthy, P.E., FDOT Traffic Engineering and Operations, at (850) 410-5615, or email arun.krishnamurthy@dot.state.fl.us. ●

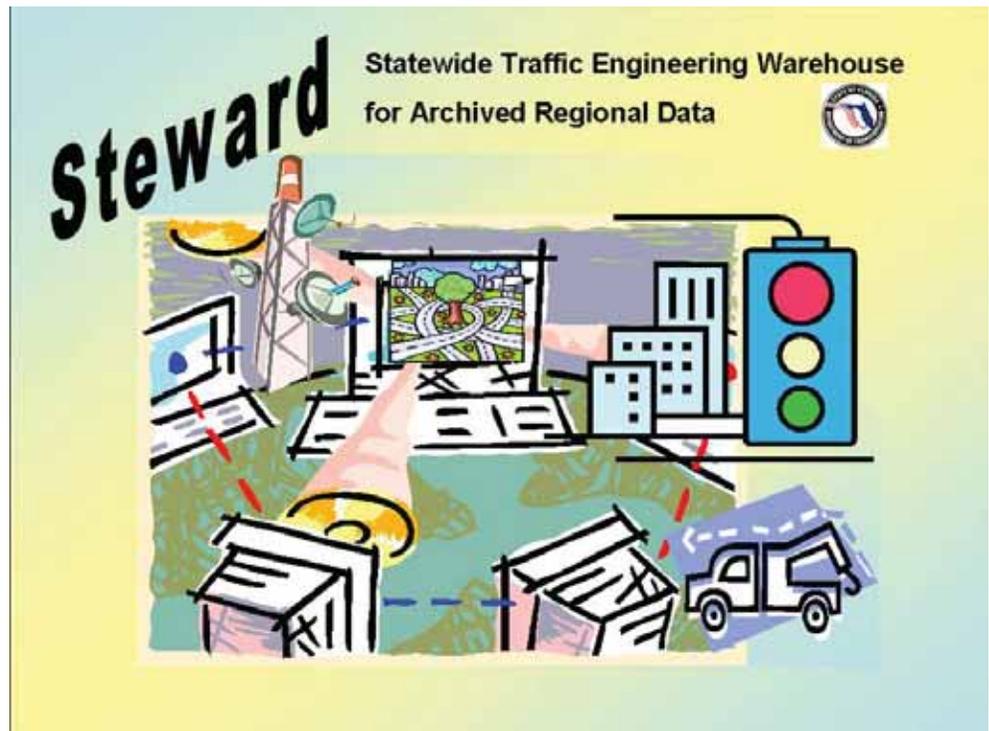
STEWARD: FDOT's Central Data Warehouse for ITS Data

SunGuide® software allows FDOT's 10 regional traffic management centers (RTMC) to monitor and control roadside equipment and incident management vehicles. Each RTMC collects and archives a wealth of real-time information on traffic conditions obtained from Intelligent Transportation System (ITS) devices located on limited access roadways in urban areas.

As originally designed, SunGuide® contained a rudimentary archiving function that created a daily summary of basic data produced by each ITS sensor during each reporting interval (usually 20 seconds). The generated data included traffic volumes, speeds, vehicle occupancies, and travel times. While the generated data were numerically accurate, the information was not useful until it could be organized geographically, stored in a database, and systematically arranged in the form of useful reports.

In a 2008 study, researchers at the University of Florida's (UF) Transportation Research Center designed and implemented a traffic data archive system called the Statewide Transportation Engineering Warehouse for Archived Regional Data (STEWARD). STEWARD serves as a central data warehouse for SunGuide® data collected by RTMCs. STEWARD allows transportation practitioners to query archived data and produce a variety of reports. The data is a valuable resource to transportation practitioners who study freeway operations. The ability to retrieve and analyze freeway data allows them to develop performance measures and conduct research concerning traffic flow and congestion management.

UF researchers also developed a website to support users in retrieving data and creating reports. The website allows users to choose the source RTMC, request specific information, and download the report. The website also includes a systems resources page that provides access to project reports, example results, training materials, and software utilities that are used for processing data files.



STEWARD gives RTMC managers, district ITS program managers, and transportation engineers the ability to identify malfunctioning roadway equipment, calibrate instructions for the equipment, perform quality assessment and data reliability tests, develop daily performance measures, extract traffic counts and crash data, and analyze traffic volume trends. STEWARD also allows transportation practitioners to analyze specific traffic conditions, such as the performance of managed lanes; travel time reliability; speed, flow and density relationships; and the effects of incidents.

Since its implementation, UF researchers have used STEWARD data in three subsequent FDOT-funded research projects to study travel time reliability. Researchers used STEWARD data to identify congested areas in and around Jacksonville and to extract speed, flow, and travel time information from those areas. They used STEWARD data to assess the capacity of Florida freeways and analyzed speed and flow data from Jacksonville, Miami, Ft. Lauderdale, Orlando, and Tampa to develop speed-flow relationships and capacity distributions for a variety of basic freeway segments. The researchers have also used STEWARD data to model the location of crashes within work zones and to study ramp management.

Researchers at the Lehman Center for Transportation Research, Florida International University (FIU), used STEWARD data in three recent FDOT-funded research projects. In one study, *Traffic Management Simulation Development*, researchers developed tools that interface with SunGuide® software and allow system testing using a technique called microscopic simulation, which simulates traffic in unique ways. Archived STEWARD data provided researchers with cost-effective and detailed information for the development and calibration of simulation modeling applications.

In another FIU study, *Decision Support Tools to Support the Operations of Traffic Management Centers*, the researchers estimated the accuracy of congestion and incident conditions by combining current SunGuide® estimation methods with other methods. They developed a method to estimate the time from the occurrence of an incident to the time it is recorded in the SunGuide® database based on a combination of detailed historical traffic detector and incident management databases. They also developed methods to measure other incident-related measures and estimated secondary freeway crashes and contributing factors. The researchers also developed models and

methods to estimate incident impacts, including the number of lanes blocked; predicted incident duration; and estimated queue length, average delay, and secondary incident probability. The research resulted in improved tools to manage incidents and to optimize future incident response.

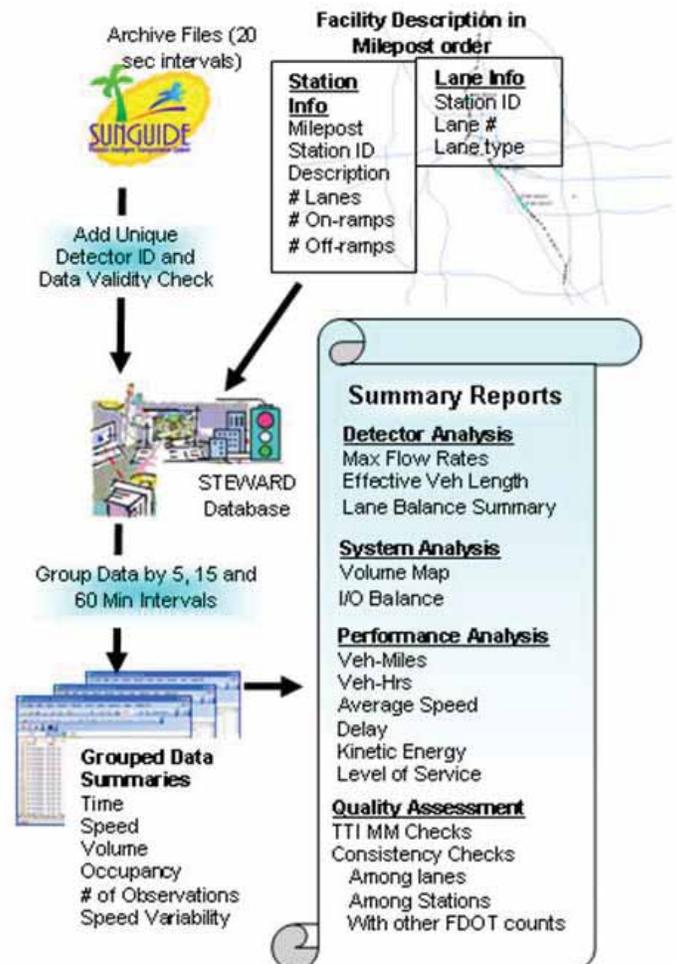
A third FIU study, *Using Advanced Analysis Tools to Support Freeway Corridor Freight Management*, investigated methods and tools for assessing combinations of corridor freight management and pricing strategies as part of the corridor freight planning process. The researchers acquired incident data, traffic detector data, and travel time data from STEWARD to support the calibration of a traffic flow model for I-95 and I-295 in the Jacksonville, Florida, area. The model was developed to assist transportation planners to better manage freight traffic on congested roadways.

STEWARD is an important resource for a wide variety of users who need freeway operational data to determine traffic trends and conditions. Transportation practitioners may access the data free of charge at <http://cdwserver.ce.ufl.edu/steward/index>. ●

How does STEWARD work?

There are six separate processes involved in the operation of STEWARD:

1. Configuring detector systems in each RTMC. Each detector is assigned a unique identification, location (milepost, coordinates, etc.), direction, lane number, and operating parameters.
2. Daily transmission and assimilation of archived data. An automated process at each RTMC transmits daily data to STEWARD. Configuration data are combined with archived data to transform the data into the required format.
3. Daily generation of diagnostic reports. The reports assist RTMC operators to identify detectors that require maintenance.
4. Application of a quality assurance test to identify invalid data. Data that do not pass the quality assurance test are rejected.
5. Posting of valid data to the STEWARD website for public access.
6. Downloading and use of data by stakeholders.



Truck Parking: ITS Detects Parking Availability, Improves Safety

Studies conducted by USDOT have found that truck driver fatigue contributes to traffic accidents. To ensure that drivers do not operate their trucks when tired, the Federal Motor Carrier Safety Administration (FMCSA), a branch of the U.S. Department of Transportation, administers laws regarding the trucking industry and regulates the number of hours truck drivers may operate their vehicles before taking a mandatory rest period. Federal law requires that drivers may not drive more than 11 hours per day without taking a rest period, and may not work for more than 14 hours, including driving and non-driving duties, in any 24-hour period. Drivers also must take a mandatory rest period during every 24-hour time frame. These requirements are meant to prevent drivers from becoming drowsy and to ensure the safety of all highway users.



Parked trucks at an interstate rest area near Orlando.

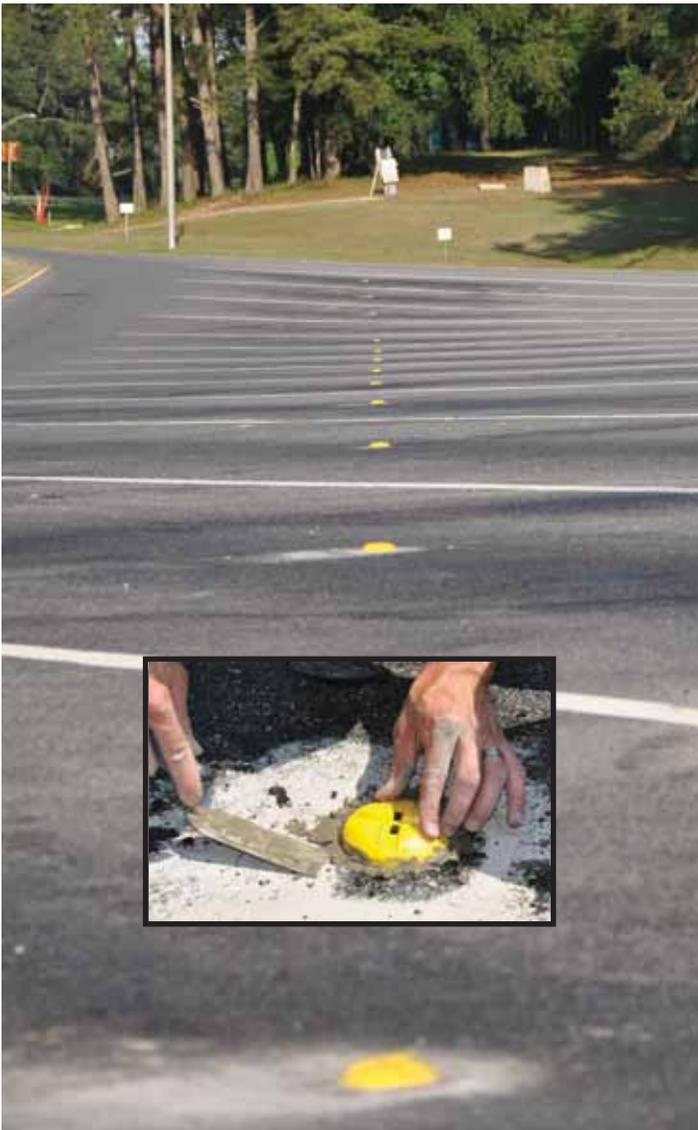
Truck drivers typically park either in publicly owned roadside rest areas or at privately owned truck stops. In the absence of a reservation system at publicly owned rest areas, when it is time for a driver to rest, he or she stops at a rest area to see if parking space is available. If parking space is not available, the driver has two choices: park illegally along the roadside or continue driving in violation of hours-of-service rules.

In 2005, FMCSA began studying the truck parking problem and identified two possible solutions to parking shortages: increase the supply of spaces, and better match supply and demand in areas where parking shortages exist. The study found that increasing the supply of parking spaces is a direct but capital-intensive solution, whereas better matching supply and demand is a more practical and cost-effective solution that could more evenly distribute

parking along highway corridors. To better match demand with existing supply, FMCSA recommended Intelligent Transportation System (ITS) deployments to provide commercial motor vehicle drivers with real-time information on the location and availability of parking spaces.

In 2007, FMCSA began the SmartPark initiative to demonstrate whether ITS technology for providing real-time parking availability information to truck drivers would effectively divert them from filled to unfilled parking areas. Researchers conducted field tests to determine the feasibility of using magnetometry technology, which detects the presence of magnetic metals, to determine parking availability. The technology deployed wireless, battery-powered sensors embedded in the pavement to measure the presence of trucks and relayed this information to a centralized server where a





Above: Wireless occupancy detection sensors installed in truck parking spaces at the test rest area on I-10 in Leon County, Florida. Insert: A technician installs a detection sensor in the pavement.

Top right: Contractors with IPSens, LLC, install a data collector on a lightpole at the test rest area on I-10.

Right: A relay node mounted on a lightpole receives occupancy information from the detection sensors and transmits information to the data collector.

detection/classification processor determined parking availability. Researchers determined that the vehicle detection system performed accurately approximately 96 percent of the time, but that more work was needed to improve accuracy.

In 2011, FDOT funded a study to understand the truck parking problem in Florida, determine supply and demand characteristics for truck parking, assess technology that can be used to improve parking management, and deploy test locations for a smart parking system. The goals of the study were to increase operational efficiency of commercial drivers and to reduce illegal parking on shoulders, crashes due to

driver fatigue, and diesel emissions due to unnecessary driving. Another goal was to develop a method to predict the availability of parking based on travel time by combining parking trend data with real-time data.

Researchers at Florida International University (FIU), led by Dr. M. Emre Bayraktar, visited each of Florida's 53 rest areas along the I-10, I-75, and I-95 corridors to collect data on the adequacy of truck parking space capacity and the extent of illegal parking.

The researchers identified facilities that reach or exceed capacity during the busiest hours of a 24-hour period (usually nighttime hours). Over the course of four months, the researchers visited each rest area over a three- to four-day period during daytime and nighttime hours to collect data regarding truck parking space supply and demand characteristics.

The researchers counted the number of spaces at each location and the number of trucks parked both legally in the parking spaces and illegally elsewhere at the facility. They also interviewed truck drivers and on-site security officers, state troopers, county sheriffs, and FDOT staff to obtain their observations about truck parking practices.

The researchers summarized truck count and interview data for each rest area. They categorized each facility based on the level of the truck parking capacity problem and depicted the facilities on a color-coded map. The data enabled the researchers to identify the rest areas with recurring truck parking problems due to an inadequate supply of parking spaces available to meet demand.



Continued on page 15

Meet the Project Manager

Arun Krishnamurthy, P.E., ITS Software and Architecture Coordinator
FDOT Traffic Engineering and Operations Office

Arun Krishnamurthy began managing FDOT's SunGuide® software program in 2009 and is considered the point person for all things related to SunGuide® software. SunGuide® is an advanced transportation management system (ATMS) software used by Florida's 10 regional transportation management centers (RTMC). It enables FDOT's Intelligent Transportation System (ITS) devices located on Florida's interstates and turnpike to communicate with the RTMCs.

As ITS devices evolve, so must the capabilities of SunGuide® software. Krishnamurthy oversees the development and management of new SunGuide® software applications in several ways.

Krishnamurthy is an active member of FDOT's change management board (CMB). The CMB ensures that proposed changes to FDOT transportation management initiatives are consistent with FDOT's long-term goals and user needs. The CMB provides a forum for FDOT ITS engineers to evaluate, investigate, and discuss issues that help with decisions requiring technical input from SunGuide® users and administrators. The CMB meets quarterly to discuss items that need CMB approval prior to implementation and deployment, examines each proposed change, and votes. If the majority of members favor the change, the project moves forward.

Krishnamurthy also is a member of the SunGuide® software user's group (SSUG), a subgroup of the CMB. While the CMB makes decisions on changes to the SunGuide® software, the SSUG provides a forum to discuss complex issues that may need significant input from multiple parties prior to making decisions.

Periodic SunGuide® software updates add new functions that need to be communicated to users. Krishnamurthy manages the SunGuide® training program that provides training resources to TMC operators, equipping them to operate and configure SunGuide® software.

In 2009, Krishnamurthy managed a research project that developed the Statewide Traffic Engineering Warehouse for Archived Regional Data (STEWARD), a central data warehouse that stores FDOT's ITS and



other transportation data. Researchers at the University of Florida developed a repository for ITS data collected at RTMCs and a method to analyze it. STEWARD gives transportation practitioners the ability to produce various reports and products from centrally archived data, and enables FDOT to model traffic congestion, produce performance measures, and improve transportation management.

More recently, Krishnamurthy managed a project that developed traffic management simulation tools using STEWARD. The tools, developed by researchers at Florida International

University, interface with SunGuide® and simulate traffic conditions. The tools collect data from ITS archives, manipulate and aggregate the data, and automatically modify input files. Users can define the traffic environment by designating the number of ITS devices on a roadway segment, determine the effectiveness of message signs, and estimate how many drivers will respond to advisory alerts. The tools can use ITS data archives to estimate traffic parameters for planning, travel demand forecasting, and traffic analysis purposes. "These are complex problems because both the traffic system and how people make decisions are complex," says Krishnamurthy. "Trying to simulate how people make decisions is tricky. Although these methods are not an exact science, we get as close as possible to predicting driver behavior through the simulation of traffic environments and people's reactions to them."

Currently, Krishnamurthy is managing the third phase of an FDOT-funded project that will implement previously developed simulation tools in a traffic management center environment and determine the usefulness of the tools to TMC operations.

Krishnamurthy looks forward to working on future FDOT-funded ITS research. "My colleagues and I anticipate devising innovative tools and solutions to problems that can be applied at the RTMCs to manage traffic efficiently and effectively," says Krishnamurthy. "We strive for the right balance of research, planning, deployment, and maintenance and hope FDOT can be a resource for other states." ●

Meet the Principal Investigator

Lily Elefteriadou, Transportation Research Center
University of Florida

FDOT's Strategic Intermodal System (SIS) comprises a network of high-priority transportation facilities across all large-scale transportation modes, ranging from the spaceport, airports, seaports, and rail systems, to buses and highways. The goal of the SIS is to provide a transportation system that efficiently serves Florida's citizens, businesses, and visitors; helps Florida become a worldwide economic leader; enhances economic prosperity and competitiveness; enriches quality of life, and reflects responsible environmental stewardship. One way to measure the efficiency and usefulness of the SIS



is to measure travel time reliability (TTR), which is the likelihood that travelers will arrive at their destinations on time. Understanding TTR involves developing computer models that can accurately predict the expected travel time in and across transportation modes. Such predictions give transportation planners a means to measure congestion. However, measuring and quantifying TTR had been difficult due to the lack of data specific to Florida conditions.

Lily Elefteriadou, Director of the University of Florida's Transportation Research Center and principal investigator for numerous FDOT-funded research projects, began studying methods to measure TTR on Florida's freeways in 2006. She and her research team developed a preliminary model to measure, report, and predict travel time on freeways using data from Philadelphia, Pennsylvania. This model provided a framework for estimating TTR based on field data and travel time estimation for various conditions, including the presence of work zones, congestion, incidents, and rain.

With the deployment in the late 2000s of Intelligent Transportation Systems (ITS) on SIS facilities in urban areas, SunGuide® software to manage ITS data, and the STEWARD central data warehouse to store the data, Elefteriadou has been able to apply data specific to Florida's freeways to subsequent TTR congestion modeling projects. Elefteriadou and her research team have validated the reliability of the models, compared scenarios and reliability estimates, and adjusted the models based on comparisons to the field data.

The models also can be used to estimate travel time on arterial streets. "As more ITS technology is deployed to arterials, researchers will be able to apply models and obtain TTR on arterials as well," says Elefteriadou. "I anticipate that in the near future, FDOT also will be able to incorporate arterial data into STEWARD."

The computer tools she has developed as part of the TTR efforts can be used to evaluate the impact of various ITS strategies, incident identification and removal policies, high-occupancy vehicle lanes, and work zone policies. Her research

also has studied the definition of TTR across different modes of transportation, such as cars, trucks, and trains.

Elefteriadou has been the Co-Principal Investigator on the study of adjusted time-of-day lane pricing on the 95 Express in Miami. In another recent project, she studied driver behavior and perceptions of the Variable Speed Lane (VSL) system, as well as alternative VSL algorithms on a 10-mile section of the I-4 corridor.

Currently, Elefteriadou is conducting research on TTR implementation for the entire SIS, including both freeways and arterials. She also is researching the relationship between traffic signal control and work zones on arterials, and developing guidelines to help contractors devise a signal control plan based on the location of the work zone to better accommodate traffic through arterial work zones.

Elefteriadou anticipates that she will continue to study ITS strategies and their impact on traffic flow. "Advanced traffic management technologies, such as ramp metering, variable speed limits, and congestion pricing, are receiving a lot of attention at both the federal and state levels as methods to relieve congestion," says Elefteriadou. ●

Ramp Signals Regulate Traffic Flow

Ramp signals installed along I-95 in Miami-Dade County make merging onto the interstate easier and safer. FDOT's District 6 began operating ramp signals in 2009. Currently, there are 22 entrances on I-95 with ramp signals.

Ramp signals use red and green lights to regulate the rate at which vehicles enter the interstate. Controlling the rate of entrance reduces the disruptions caused by merging traffic and helps motorists enter the interstate more safely and efficiently. Ramp signals are proving to be an effective traffic management technique and a low-cost alternative to widening roadways to increase capacity.

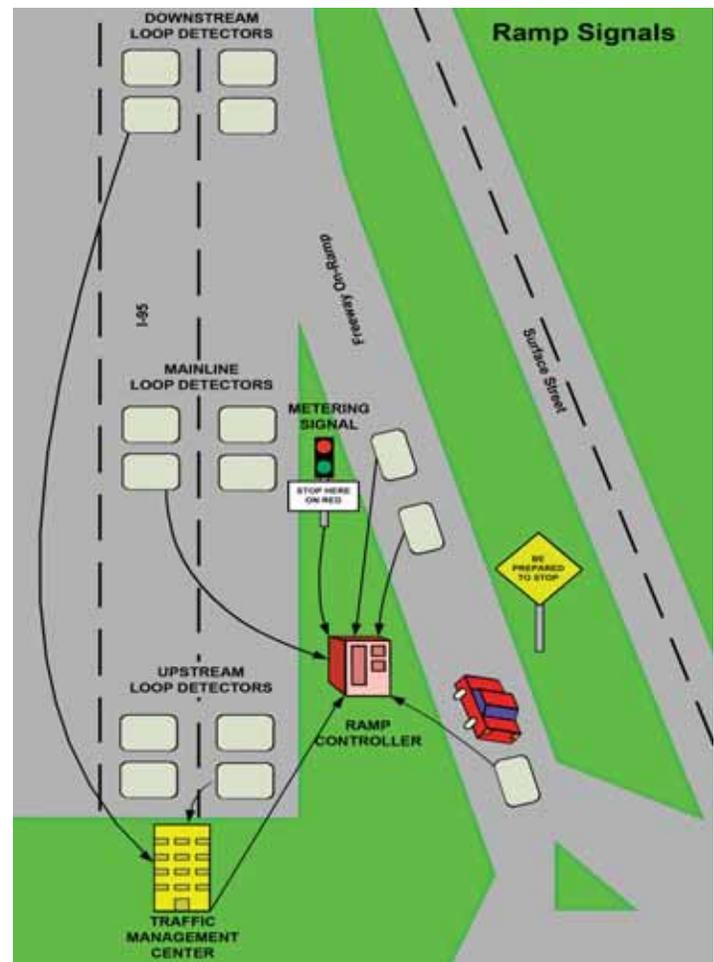
When many cars try to merge onto the interstate at once, drivers are forced to slow down to let the cars enter. These slower speeds quickly cause backups. However, if cars enter the highway in a spaced, controlled manner, they merge more easily and with less disruption to traffic. By regulating the flow of traffic entering the interstate, the overall flow of interstate traffic is smoother, and the interstate's existing capacity is able to accommodate more vehicles per hour, which improves commute times and safety.

FDOT District 6 has determined that ramp signals have resulted in average vehicle speeds increasing by six mph during afternoon rush hour. This speed increase provides motorists with real-time improvements and helps them save time and money on their commute. Further, by reducing the amount of stop-and-go traffic caused by merging vehicles at congested interstate entrance points, fuel consumption and adverse impacts to air quality are reduced.

Ramp meters are managed with SunGuide® software.



Typically, traffic management center (TMC) operators activate ramp signals during the weekday rush-hour periods to ease congestion during heavy freeway use. Operators may also activate ramp signals at different hours according to real-time traffic conditions to mitigate other congestion-causing events, such as crashes. District 6 engineers have observed that activating ramp signals during high levels of congestion helps the interstate recover faster. Although the ramp signaling system on I-95 has not been operating long enough to collect significant crash



information, studies conducted in other parts of the country have shown that highway crashes often result from the combination of stop-and-go conditions and inattentive drivers. Ramp signals provide a smoother flow of traffic, which should improve safety.

Not all freeway locations are suitable for ramp signals. In 2011, researchers at Florida International University developed guidelines to help FDOT transportation planners and engineers determine the suitability of ramp signals for specific freeway locations. Researchers also developed a method to analyze and link a variety of data sets maintained in various FDOT offices and make them accessible to users as the Florida Highway Information System (FHIS). The availability of FHIS data greatly reduces the data acquisition effort, which is often the most time-consuming part of the evaluation process.

Now, transportation planners and engineers can access the data necessary to evaluate the suitability of new signal locations. Although FHIS was developed specifically to evaluate ramp signals, it has potential applications in many planning and design tasks. ●

During the second phase of the project, researchers installed a smart parking management system at two rest areas on the east- and west-bound sides of I-10 in Leon County, Florida. The system has the capability to monitor real-time occupancy information of individual parking spaces and transmit that information to truck drivers on the highway.

The system consists of wireless occupancy detection sensors embedded in the parking spaces to determine availability; relay nodes mounted on light poles to receive and transmit sensor data to the collector; and the collector, which is a central unit that receives the raw data and transmits it to a remote server, e.g., the server of a regional traffic management center.

The smart parking system also includes an archival function so that a historical record of parking avail-

ability can be developed and used in estimating parking availability. Researchers propose that by collecting and archiving parking space occupancy data, FDOT will be able to predict parking availability, including peak parking hours, parking space usage, and parking duration, and deploy parking availability information to roadside dynamic message signs.

FDOT anticipates incorporating data collected during this research project into SunGuide®. Once the smart-parking system is implemented, RTMCs will be able to deploy parking availability information to truck drivers based on real-time and predictive data. Better information about the supply and availability of parking will help truck drivers make informed decisions about when and where to park. ●

For More Information

Intelligent Transportation Systems

BDK75 977-19, The Economic Cost of Traffic Congestion in Florida

Darryll Dockstader, Project Manager
A. G. Blanco, Principal Investigator

BDK80 977-02, Decision Support Tools to Support the Operations of Traffic Management Centers

Dong Chen, Project Manager
Mohammed Hadi, Principal Investigator

BDK80 977-03, Traffic Management Simulation Development

Trey Tillander, Project Manager
Mohammed Hadi, Principal Investigator

BDK80 977-24, Demonstration of the Applications of Traffic Management Center Decision Support Tools

Arun Krishnamurthy, Project Manager
Mohammed Hadi, Principal Investigator

TPF-5(206), Program to Support the Research, Development, and Deployment of System Operations Applications of Vehicle Infrastructure Integration
<http://www.pooledfund.org/Details/Study/431>

Central Data Warehouse

BC354-61, Feasibility Study for an Integrated Network of Data Sources, Phase I

Liang Hsia, Project Manager
Charles Wallace, Principal Investigator

BD545-37, Development of a Central Data Warehouse for Statewide ITS and Transportation Data in Florida, Phase II: Proof of Concept

Liang Hsia, Project Manager
Kenneth Courage, Principal Investigator

BD545-93, Development of a Central Data Warehouse for Statewide ITS and Transportation Data in Florida, Phase III: Final Report

Arun Krishnamurthy, Project Manager
Scott Washburn, Principal Investigator

Truck Parking

BDK80 977-14, Commercial Motor Vehicle Parking Trends at Rest Areas and Weigh Stations

Paul Clark, Project Manager
M. Emre Bayraktar, Principal Investigator

Ramp Signals

BDK80 977-08, Integrated Database and Analysis System for the Evaluation of Freeway Corridors for Potential Ramp Signaling

Javier Rodriguez, Project Manager
Albert Gan, Principal Investigator

