ECONOMIC IMPACTS OF INTELLIGENT TRANSPORTATION SYSTEMS IN FLORIDA - AN ISSUE PAPER

FINAL REPORT

Prepared for
Florida Department of Transportation

As part of the requirement to fulfill Consultant Services
to Develop Intelligent Transportation Systems Strategic Plan for Florida

Prepared by

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The following is an excerpt from the Consultant Scope of Work:

> The paper shall be based on the information from Task 1 and any other current sources. The paper shall focus on how the deployment of ITS, consistent with the Department's vision and guiding principles, can enhance Florida's tourist, agriculture, manufacturing and international trade business in an expanding world economy. This shall include consideration of the affect and impact of current and proposed CVO applications. The paper shall also examine the potential of attracting high-tech ITS type industries through an aggressive ITS deployment strategy. The Consultant shall propose additional economic development issues for consideration to the Project Panel. Upon agreement to the economic development issues to be examined in the paper, the Department Project Co-managers will authorize the Consultant to begin developing this paper.

1. RELATIONSHIP OF FLORIDA'S TRANSPORTATION SYSTEM TO FLORIDA'S ECONOMY

Intelligent Transportation Systems (ITS) include a variety of technological applications that either individually, or in combination, generally provide information to support more efficient movement of goods and services. This paper attempts to examine the benefits derived from ITS applications implemented throughout the U.S., in order to predict the likely impacts to Florida's economy by type of application or strategy. This study then defines the latest findings in transportation efficiency gains by type of application or strategy. Finally, the study estimates the likely impact from aggressive ITS deployment on larger economic issues such as attracting high-tech industry to Florida. In summary, the objectives of this issue paper are:

- To examine the relationship between Florida's transportation system and its economy;
- To identify how ITS benefits the transportation system and its economy;
- To examine the benefits documented thus far from ITS deployment in Florida and nationwide;
- To examine the potential of an expanded ITS deployment on Florida's economy; and
- To examine the potential of aggressive ITS deployment on Florida's economy.

Florida's urban areas have grown rapidly over the last 30 years and are expected to continue growing at comparable growth rates, further congesting existing highway networks and other transportation systems. The Florida Department of Transportation (FDOT) has enacted a policy that limits the number of lanes on the State Highway System to be supported by federal and state transportation funding. This maximum lane policy, in conjunction with current congestion levels, projected growth, environmental impacts, and other considerations create a strong need to consider alternatives to highway construction for expanding system capacity. When combined, these factors support the implementation of ITS for purposes of increasing capacity and improving safety - without new construction.

Within the context of a larger FDOT project to develop an ITS strategic plan for implementation, this issue paper identifies the likely impacts to the vitality of Florida's economy from the application of ITS technologies that enhance the operation and safety of Florida's transportation system. The objective of this effort is to estimate the extent of direct benefits by type of application (in terms of transportation system efficiency gains), and to establish a conceptual framework that FDOT can use to explore options for promoting the most cost-effective ITS technologies.

In addition to the standard traffic management applications that affect the public at large, other ITS applications support specific freight shipment activities. This study examines both types of public- and private-sector system improvements, in an effort to provide a conceptual framework to support FDOT's decision-making process for considering ITS deployment.

1.1 What is ITS?

ITS embodies a collection of technologies that support transportation management systems for improving transportation network efficiency. ITS uses both existing and advanced technologies to improve transportation operations. These communication and information technologies are applied to traffic management; traveler information systems; emergency response systems; rail and bus transit operations; and commercial vehicle operations for trucking, air freight, and sea vessel shipment. For purposes of this study, a brief definition of the ITS technologies examined for this study is provided below.

<u>Cargo and equipment tracking technologies</u>

- Radio Frequency Technology is based on the use of passive backscatter for automated equipment identification (AEI), which relies on radio signals between passive tags and active interrogators. This technology was first marketed in the 1980s and is widely used in port and rail industries. This technology also has been used extensively in warehousing and manufacturing applications and, with improved reliability, durability, and effectiveness, has gained acceptance at terminals to manage traffic through gates and track yard equipment for improved cycle time and productivity.[1]
- Active Radio Frequency consists of battery-powered minicomputers that provide active monitoring of inventory and conditions during transport. The Department of Defense (DOD) is experimenting with alternate radio frequency technologies that use active read/write tags able to hold a complete container invoice for cargo and/or passengers.
- Cellular technologies have been used by companies, such as UPS, which has selected cellular phone communications systems rather than Global Positioning Satellites (GPS)

to maintain direct two-way contact with their drivers, allowing them to provide real-time information to customers

- Bar codes are printed, scanned, decoded, and transferred to a host computer. The technology relieves the user of the tedious and error-prone task of reading a label and manually transcribing information onto a form or by key-entry into a computer. Bar codes are mainly used to identify equipment.
- Smart cards are integrated circuit cards (the size and shape of credit cards) that contain an electronic chip allowing them to process as well as store information. Smart Cards can contain read-only memory, read/write memory or a combination. They are increasingly used in freight transportation as part of gate transactions to identify the driver and trucking company. Other applications include toll and gas payment and related transactions, and by extension, vehicle tracking.
- Satellite-based location determination and communication technologies are used for determining location. GPS is a DOD-owned constellation of 24 satellites that enable position determination. Geosynchronous Orbital Satellites (GOS) are used to relay positional data on cargo movement for inventory control and security. Low earth orbit satellites (LEO) promise to lower costs while providing the same services as GOS.

<u>Information exchange and communication technologies</u>:

- In the last two decades, following the leadership of banking and financial institutions, transportation companies have recognized the benefits from electronic exchange of data. As companies re-engineer their business procedures, many internal procedures are outsourced, creating a greater need to exchange information and communicate electronically outside an individual company.
- Electronic data interchange (EDI) technology includes vehicle and cargo tracking, and electronic clearance for filing cargo manifests, bills of lading, vessel arrival times, “in-bond” movement, status notifications, and other information useful to shippers. U.S. Customs is committed to two main EDI platforms: ED1 and X12. Customs also automated its billing and cargo manifest systems. The Automated Broker Interface (ABI) has over 2,000 members, and the Automated Manifest System (AMS), which has been in place for 10 years and includes 131 ocean carriers, 37 data-processing service centers, 18 port authorities, 49 direct discharge ports, and 135 inland ports. Currently, the U.S. Department of Treasury is developing a beta system called the “International Trade Data System (ITDS)” that will be used to replace the Customs filing programs.

1.2 Economic Issues Associated With ITS Deployment

The deployment of ITS is a key issue for leveraging FDOT resources for improving the efficiency of its transportation system. Generally, direct economic benefits from ITS are expected to include:

- Enhanced public safety
- Reduced congestion
- Improved access to travel and transit information
- Reduced air pollution levels and other environmental enhancements; and
- Cost savings to motor carriers, transit operators, toll authorities, and government agencies in terms of time savings.

Aggressive ITS deployment can generate indirect benefits to an area's regional economy through the attraction of jobs depend on efficient transportation systems. Time-sensitive shipment schedules can place significant demands on the transportation network to provide both capacity and connectivity for maximum time savings for product shipments. An inadequate transportation network can hinder a manufacturer's ability to compete in a given market. As the volume of shipments increases, demands on the current infrastructure increase – requiring this economic activity to become a key consideration in the planning and programming of future transportation investments. ITS can improve a network's efficiency to move goods without major infrastructure costs.

ITS also can improve the efficiency of personal travel. ITS can support pre-trip decision-making activities. According to the U.S. DOT's Nationwide Personal Transportation Survey, the most prevalent reason for travel is family and personal business, which includes shopping, running errands, and dropping off and picking up others. Close to one-half the trips and slightly more than one of every three person-miles are traveled for family and personal business. The next most common purpose is social and recreational travel. Commuting to work is the third most frequent purpose, accounting for one of every six trips and more than one of every five miles traveled.[2] Advance access to information for making route and time-of-day choices can also improve a network's capacity without building new roadway infrastructure.

2. OVERVIEW OF FLORIDA'S ECONOMY

Since 1980 Florida's economy has grown at an average annual rate of more than 4 percent, outpacing the U.S. rate of 3 percent.[3] This rapid growth in the global marketplace has also marked Florida's evolution from an economy based primarily on agriculture, tourism, and retirement-living to that of a thriving urban economy supporting a prosperous mix of international and domestic industrial and commercial trade.[4] Florida's primary economic drivers include trade, agricultural and manufacturing, and tourism.

2.1 Economic Impacts of Trade

In recent years Florida has emerged as one of the world's fastest-growing trade markets, experiencing an explosion of international trade growth and serving as a major hub in the southeastern United States. Florida's transportation network supported exports and imports with a total value of $64 billion in 1997, representing a 13 percent increase in trade value over the previous year.[5] The network transported nearly 31 million tons of declared import/export cargo, excluding trans-shipments, in 1997.[6] From 1994 to 1997 trade value increased by 35 percent, whereas tonnage increased by 11 percent.[7]

Major commodities exported from Florida in 1995 (the most recent year for which commodity-specific data are available) included fertilizers ($1.9 billion, or 11 percent of total exports), automatic data processing machines ($1.7 billion, or 10 percent), parts for office machines ($1.4 billion, or 8 percent), and automobiles ($1.2 billion, or 7 percent). Apparel, medical/surgical equipment, and airplane equipment also were major commodities.[8]

Florida is the gateway for expanding U.S. trade with Latin America and the Caribbean.[9] Specifically:

- Florida captures 51 percent of all exports and 48 percent of imports to and from Central America. New Orleans is the state's closest competitor for Central American exports and imports, with 14 percent of exports and 11 percent of imports.[10]
- The state ships 42 percent of exports to South America but only 13 percent of imports. Houston (with 15 percent) is a major competitor for exports to South America, whereas New Orleans (with 18 percent) is a major competitor for imports.[11]
- Florida ships 54 percent of all exports to the Caribbean and 37 percent of imports. Houston, New Orleans, and Puerto Rico shared 29 percent of the export market, and all other states shared the remaining 17 percent. New Orleans, Houston, New York,

and Puerto Rico shared 44 percent of the import market, all other states shared the remaining 19 percent.[12]

Imports to Florida included automobiles ($4.8 billion, or 30 percent of total imports), men's and women's clothing ($1.5 billion, or 9 percent), and refined oil ($0.6 billion, or 4 percent).[13] The leading import markets included Japan, the Dominican Republic, Germany, and Colombia.[14]

As a percentage of Florida's gross state product (GSP), exports are comparable to the exports percent for U.S. gross domestic product (GDP). In 1996, U.S. export trade reached $612 billion, comprising 8 percent of the U.S. economy.[15] Florida's exports in the same year reached $24 billion, representing 6.8 percent of the state's economy.[16]

2.2 Economic Impacts of Agriculture and Manufacturing

Florida's agricultural and manufacturing gross state outputs (measured in current dollars) increased 67 percent and 76 percent respectively over a twenty-year time period (1977-1996). Agriculture showed an average annual increase of 6 percent, whereas manufacturing showed an 8 percent average increase. Continued transportation network efficiency is critical to these industries and their continued growth.

2.3 Economic Impacts of Tourism

The state of Florida generated $40.9 billion in taxable sales from tourism and recreation during 1997 and reported year-to-date tourism revenues of $25.9 billion through July 1998. Florida has consistently produced over $30 billion in annual taxable revenues from tourism and recreation throughout the 1990s, and in 1997 the taxes from tourism and recreational spending (i.e., hotels, gift shops, liquor stores, etc.) generated $41 billion.[17]

Florida's tourist traffic can be analyzed based on transportation modes. The number of tourists relying on air travel to reach Florida has grown annually since 1991. Florida reported that during 1997, 26.5 million tourists flew into the state, representing growth of 4.8 percent over 1996 (25.3 million). From 1995 to 1996 visitors flying to Florida increased 17.4 percent, from 21.5 to 25.3 million tourists using Florida's airports.

Tourists using automobiles (measured by car-rental sales) in Florida also grew between 1991 and 1997. The year ending 1997 reported 20.5 million tourists who used automobiles, representing a growth of 5 percent over the prior year. Although 1994 and

1996 reported declines in automobile use, automobile tourist traffic reported positive growth for the entire seven-year period.

The number of cruise tourists both embarking and disembarking in Florida in FY95/96 was 7,272,361 and grew to 8,303,640 in FY96/97, producing an annual growth of 14.1 percent.[18] Although the percentage of cruise-based tourism is still low, this rapidly growing industry requires special consideration with regard to the transportation system and to Florida's economy.

Total tourist traffic increased over the seven-year period. Florida's combined 1997 figure for automobile and airline tourist traffic came to 46.9 million, representing a growth of 5 percent over 1996, which reported 44.8 million visitors. Characteristic of the auto sector, the number of tourists using air transportation declined in 1991 and 1994. The years 1996 and 1997 reported the highest growth rates for air and auto tourist traffic.[19] Continued economic growth nationwide is likely to support these trends, placing increasing demands on the transportation network to support the transportation needs of Florida's visitors.

3. OVERVIEW OF FLORIDA'S TRANSPORTATION SYSTEMS

Florida's transportation system has a fundamental role in supporting Florida's economy. The network accommodates tourist travel and commuter travel, as well as intrastate and interstate goods shipment and shipments entering or leaving the U.S. via Florida. Florida's seaports, airports, railroads, and highways are linked by intermodal facilities. The following subsections summarize the extent to which Florida's transportation network supports the movement of people and goods, defining their impacts on the state economy.

3.1 Economic Impacts of Seaports

Florida has 14 major seaports. In terms of containerized cargo, Florida ranks first in the Southeast and fourth in the nation for both imports and exports. Four of the nation's top 25 container ports are located in Florida. These seaports handled a total of 108.6 million tons of domestic and international cargo in FY1997, representing a 9 percent growth since 1991.[20] Customs declarations indicated that the value of import/export shipments totaled $39 billion in 1997.[21] Last year a total of 2.4 million twenty-foot equivalent units (TEUs) moved through Florida's seaports, representing an increase of 148 percent since FY-90.[22] Significant TEU growth indicates a shift from bulk cargo to containerized, lighter-weight goods. Both rail and highways provide landside access to Florida's major ports. Cruise-ship services brought in 8,303,640 passengers in FY-96/97. Total GSP for waterborne transportation (as identified by Standard Industrial Code 62440) in 1996 was 11.47 million.[23]

3.2 Economic Impacts of Airports

Florida has 22 major airports, more than half of which provide international services. Miami International is ranked the number one airport in the nation in international air cargo shipments.[24] In 1997 Customs reports showed that just 3 percent of Florida's total import and export merchandise tonnage moved by air, but it represented 37 percent (or $23 billion) of the total international trade value.[25] The value of airport shipments has increased at an average annual rate of 17 percent since 1994.[26] The highest-value commodities shipped through Miami include computers and peripherals, telecommunications equipment, aircraft, spacecraft, and medicines. Tampa primarily exports computer/electrical equipment, eyeglasses, and tropical fish. Orlando ships perishable horticultural products, electronics and computer parts, and medical supplies.[27] Ft. Lauderdale serves as a hub for overnight airfreight companies – on average, approximately $260,000 worth of small packages are shipped through Ft. Lauderdale Airport each night.[28] Total gross state product (GSP) for air travel (SIC 62450) reached $3.8 million in 1996; for that same year, 25,265,499 passengers traveled to Florida.[29]

3.3 Economic Impacts of Rail

Florida has 2,900 route-miles of rail that connect the state's 14 freight railroads to major business centers and distribution nodes. There are two Class I, one Class II, with the remaining Class III railroads.[30] All but one of Florida's deep-water seaports are served by rail.

Prior to the CSX-NS acquisition of Conrail, CSX, a Class I railroad, operated approximately 19,000 route miles in 20 states, the District of Columbia and one Canadian province. Still Florida's largest railroad, prior to the acquisition CSX operated 1,752 route miles in Florida, covering virtually every area of the state. Major commodities shipped by CSX include nonmetallic minerals, chemicals and allied products, and coal.

Also prior to the Conrail acquisition, NS, the east coast's other major Class I, operated a total of 14,500 route miles in 20 states and Canada. Prior to the acquisition, NS operated 96 route miles within Florida, comprised of the lines of two former subsidiaries and track rights over CSX from Jacksonville to Palatka. The NS-owned mileage is comprised of two lines – one running from Georgia into Jacksonville, the other from Georgia to Navair. Major commodities transported over the NS lines in Florida are nonmetallic minerals; food and related products; pulp, paper, and allied products; and various commodities moved by containers on flat cars and trailers on flat cars.

Florida East Coast Railway company (FEC), a Class II, serves the east coast of Florida, with its main line running from Jacksonville to Miami. The carrier's 442 route miles, making it the second largest railroad in Florida, are contained completely within the state. In addition to its main line, FEC operates a branch from Ft. Pierce to Lake Harbor. The major commodities handled by the FEC are nonmetallic minerals and various commodities moved in containers and trailers. There are 11 Class III short-line rail companies operating in Florida.

3.4 Economic Impacts of Highway/Interstate Systems

Four major interstate highways, a 12,000-mile state highway system, including Florida's Turnpike, and more than 100,000 miles of local roads provide all areas of the state access to Florida's airports, seaports, and rail lines, as well as to regional and national markets. Nearly 60 percent of the U.S. population is within reach of overnight truck shipments from a Florida location. Interstate-95 provides shippers with north-south access along Florida's Atlantic coast. Interstate-75 passes through the center of Florida and provides access to the central United States and to Canadian markets. Interstate-10 provides market access to the West Coast, whereas Interstate-4 provides east-west access within central Florida.

Trucking is the primary mode for freight shipment in the state in terms of overall tonnage.[31] 1992 trucking statistics indicate that 70 percent of all manufactured goods were hauled by trucks. This represents more than twice the tonnage hauled by all other modes of transport. The most prevalent use of truck hauling was for trade and construction. Trucks carried 325 million tons of goods, an increase of 35 percent from a decade before. During the same time, 1982-1992, gross state output increased 44 percent.[32]

3.4.1 Vehicle-miles traveled

The vehicle miles of travel (VMT) throughout the state of Florida increased 52.7 percent from 1986 to 1997.[33] In 1993 Florida urban areas, by functional area, comprised a greater percentage of vehicle miles traveled than the corresponding national average. The urban miles traveled in Florida were 72 percent of the total miles traveled, whereas the national urban percentage was 61 percent of all travel. Corresdonding average rural Florida VMT in 1993 was slightly lower than the national, 28 percent, whereas the national average for rural vehicle miles traveled was 39 percent.[34]

The average daily auto traffic entering and leaving Florida and the closest respective bordering major urban areas of Tampa, St. Petersburg, and Orlando substantiate consideration for tourist-related advanced traveler information systems (ATIS). The combined monthly average of the “border crossing” and crossings into select major urban areas (listed above) is 291,845 vehicles per month. For 1994 average monthly out-of-state traffic was 95,509 vehicles, peaking during the spring break and summer vacation months; the monthly average crossings into the urban areas closest to the border was 196,335 vehicles, peaking during spring break and continuing throughout the summer months. These vehicles were recorded commuting between Georgia and Alabama and Florida, I-275 through Tampa and St. Petersburg, I-4 through Orlando, and the Florida Turnpike’s first exit, Wildwood.[35]

3.4.2 Traffic statistics – nonfatal and fatal injuries from motor vehicles

Florida’s roadway fatalities are best understood by comparison with the nationwide statistics. Although the state of Florida experienced a 7 percent decrease in nonfatal injuries from 1985 to 1995, there was only a 1 percent decrease in fatal injuries during the same time period.[36] Florida recorded 2,847 fatalities, 8 percent of the 37,241 national roadway fatalities; by contrast, similar state traffic fatalities averaged 3.75 percent.[37]

3.4.3 Trucking industry impacts on the Florida economy

Employment, taxes, and accessibility statistics indicate the extent of highway-based freight shipment impacts to Florida’s economy.

- Employment. Florida ranks fourth for trucking employment in the nation, following New York, Texas, and California. Florida’s trucking industry is one of the largest employment sectors in the state, employing 435,500 people. One of every 12 workers in Florida is involved with the Florida trucking industry. These workers collect $12.5

billion in wages, an average of $28,801 per worker, a significantly higher wage than Florida's per capita income.[38]

- Taxes. In 1992 Florida's trucking industry paid $710 million in state and federal highway user taxes. Of this, $388 million was paid directly to the state.[39] Other costs such as diesel fuel taxes, registration fees, and taxes on parts and service, cause each truck to pay nearly $11,000 a year to the state.
- Access. Every county in Florida uses trucking services to some extent. Over 84 percent of the communities in Florida depend exclusively on trucking for the shipment of their goods. In 1995 truck travel in Florida accounted for 17.6 percent of the 134 billion vehicle miles traveled statewide.[40]

3.5 Economic Impacts of Intermodal Facilities

Most intermodal connections are at trailer-on-flat-car (TOFC) and container-on-flat-car (COFC) facilities. There are 10 TOFC/COFC facilities located across the state, along with the major seaports equipped to handle these operations. Florida's 15 bulk transfer facilities are used by railroads for transferring bulk materials between rail and truck for businesses without access to direct rail service.[41] The railroads provide another type of intermodal facility, known as team tracks. These public tracks, varying in length, are used to transfer freight between rail cars and trucks, and are located throughout the state.[42]

3.6 Economic Impacts of Population Growth

The current population of the U.S. is 271 million, which is expected to grow 18 percent between the years 2000 and 2025. The current population of Florida is approximately 14.8 million, which is expected to grow 27 percent between the years 2000 and 2025, 9 percent above that of the U.S. The number and proportion of Florida's population aged 18 and over is expected to increase from 11.7 million (or 77 percent) in 2000 to 16.7 million (or 80.8 percent) in 2025. The proportion of Florida's population classified as elderly is expected to increase from 18.6 percent in 1995 to 26.3 percent in 2025.[43] Without considering migration to the state, these statistics indicate that the current population eligible to drive in Florida can be expected to increase significantly over the next 20 years.

4. BENEFITS OF ITS

Based on estimates from 1996, increasing highway capacity in the U.S. by one-third (34 percent) would require $15 billion per year in new roadway capacity over the next ten years.[44] Although Florida would spend only a fraction of the $15 billion for new road capacity, ITS would permit more efficient use of roads already in use and reduce overall spending for equivalent capacity. The U.S. DOT estimates that a combination of ITS and new physical capacity could cut the cost of needed infrastructure expansion by half nationwide.

Florida's economy is improved by any efficiency gains to its transportation systems The benefits are described from case study evidence and provide a qualitative overview of the documented gains in efficiency from the most common ITS applications. Intelligent transportation systems have already been deployed in Florida. Florida's ITS facilitates commuter and tourist travel and supports shipping access between landside shipments and ports, linking several of the country's largest international ports with both domestic manufacturing and distribution centers.

ITS deployment outside of Florida provides proxies of expected economic benefits from similar applications in Florida. Case study evidence from specific projects operating in Florida or elsewhere in the U.S. has shown that ITS can improve transportation efficiency and, at a macroeconomic scale, generate a multiplier effect in returns on investment. The following sections describe real-world applications of ITS and the demonstrated or expected benefits to an area's economy in terms of time savings, operating-cost savings, accident reduction (injuries and fatalities), throughput, and customer satisfaction. Other important transportation system efficiencies include lower emissions and fuel consumption.

The potential impacts of a Florida statewide ITS program on the state's economy fall into various categories. These categories require a variety of specific ITS applications and, in certain cases, are focused on benefitting specific classes of transportation users. Categories of ITS applications and brief descriptions are listed below:

- Support of highway pricing initiatives/electronic toll collection;
- Improved regional data collection and dissemination for transportation planning;
- Improved inter-jurisdictional transportation planning, traffic operations, and incident management;
- Opportunities for new service and product innovations;
- Hurricane/flood/fire;
- Restoration of capacity after disasters/major incidents;
- Tourist travel information;

- Resident travel information/reliability of employee arrival;
- Traffic operations for draw bridges;
- Reliability of goods movement/impact on just-in-time delivery;
- Management of traffic/travel information/electronic clearance at intermodal terminals/access to ports and airports;
- More efficient allocation of existing highway capacity;
- Incident management/special events traffic management; and
- Management of traffic under construction.

ITS supports a number of interrelated transportation management strategies. These broad-based strategies provide the basis for specific categorical ITS applications.

4.1 Support of Highway Pricing Initiatives/Electronic Toll Collection/Improved User Fee Transportation Financing

Electronic toll collection technology allows vehicles to go through toll plazas without stopping to hand a toll payment to a toll booth operator, instead, tolls are collected electronically. A computer in the toll plaza identifies a transponder in the vehicle and bills or deducts from the owner's account electronically. Several variable pricing initiatives have generated direct benefits in terms of time savings, customer satisfaction, and operating-cost savings (at both vehicle and administrative levels). The most prominent examples are California's *91 Express Lanes* connecting Riverside and Orange Counties, and the I-15 project in San Diego. The *91 Express Lanes* produced considerable time savings to both toll lane users and freeway users - a typical PM peak trip delay on the freeway fell from 30-40 minutes to less than 10 minutes per trip.[45] The *91 Express Lanes* also produced a shift to HOV+3, traffic observations on all lanes of the highway showed a greater than 40 percent jump in the number of peak period HOV+3 vehicles, which travel on the facility free of toll charges.[46] The I-15 project has proven that the sale of excess capacity (unlike *the 91 Express Lanes* project which added new lanes) produces sufficient revenues to fund operations and ancillary transit services. Other benefits from I-15 include better utilization of the I-15 Express Lanes (HOV lanes), a significant increase of HOV users, and a slight reduction in overall traffic volumes (combining both the toll lanes and freeway lanes).[47]

4.2 Improved Regional Data Collection/Dissemination for Transportation Planning

Intelligent transportation systems offer improved data processing tools that enhance transportation planning activities. ITS provide daily, weekly, seasonal, or annual summaries of selected transportation conditions, and they help to enhance the reliability of long term planning forecasts by reducing the timing gap associated with travel surveys or census reports. ITS also offers imaging techniques that capture traffic patterns and events as they occur. Planners can use this specialization to plan for and capture the wide variations in congestion conditions and other travel patterns in their models.[48]

4.3 Improved Interjurisdictional Transportation Planning and Traffic Operations

The recent advances in ITS have impacted both transportation planning and traffic operations at the regional level. As local traffic patterns become more complex, so do the demands for better traffic control methods. The ability of ITS to monitor and record traffic volume and congestion patterns improves traffic operations management and enhances modeling techniques. For example, data on past traffic conditions can lead to better control of traffic signal systems, whereas data on past volume and congestion patterns help set freeway ramp-metering rates. With surveillance equipment, ITS can collect accurate traffic observations and eliminate the need for labor-intensive highway counts. Furthermore, by using ITS state and local agencies can better track the causes of congestion or manage local traffic incidents. Surveillance will also provide continuous information on traffic mix, speeds, and volume.

4.4 Opportunities for New Service and Product Innovations

Freeway travelers tend to make travel and route decisions spontaneously, using information from a variety of sources, including radio broadcasts, weather conditions, and the length of a line of cars waiting to enter a freeway system. In an effort to solve this problem, queue detectors have been installed on blind ramps in the Twin Cities area under Orion, a $38.9 million initiative. This equipment counts the number of vehicles waiting at a specific location and computes the length of the wait from the meter cycle time. These data are transmitted to the traffic management center every 30 seconds. The data will help create an algorithm that will calculate the approximate length of time travelers can expect to wait in a ramp queue. The estimated wait time will be displayed on variable message signs located before a ramp entrance, giving travelers time to make route choices.

4.5 Hurricane/Flood/Fire

ITS has been proven to help with traffic management during system-wide crises. Central Florida experienced wide-spread wildfires in the summer of 1998. Several fires, located along I-95 in Volusia County became so severe that authorities decided to evacuate several areas of the county and to close I-95 to all but emergency vehicle traffic between the Beeline Expressway, near Titusville, and St. Augustine - a distance of over 90 miles. The traffic management centers for Districts 2 and 5 coordinated the use of variable message signs (VMS) in Orlando, Daytona Beach and Jacksonville to alert travelers on I-95 and I-4 of the closure. A diversion route was established that routed I-95 traffic along I-10 to I-75 and then to the Florida Turnpike and the Beeline Expressway. Variable message signs north of Jacksonville were used to alert traffic southbound on I-95. Variable message signs on I-95 and I-4 in Daytona Beach were used during the initial stages of the evacuation and road closure. Interstate 4 was also closed from Lake Helen to Daytona Beach and the VMS in Orlando were used to notify travelers. These ITS were extremely valuable in managing this unusual interstate closure and evacuation. The economic impact of the use of these systems during the fire emergency was indirect - improved safety, reduced delay due to diversion, etc. - however there is no doubt is was a positive impact.

The Central Florida area is designated a “host shelter” area for hurricane evacuation from coastal areas. With one of the largest concentrations of hotel rooms in the country and over 40 miles from either coast, it provides a natural refuge. In the fall of 1998, Hurricane George passed through the Florida Keys and threatened the southwest coast from Tampa to Naples. Evacuation warnings were issued to several communities along the coast. All evacuees were directed to the Orlando area. The VMS on I-4 in Orlando were used to provide guidance to both public shelters (high schools, armories, etc.) and to hotel information centers operated by the convention and visitor’s bureau. In this case the ITS provide positive economic impacts in terms of improved safety and public welfare and also in terms of hotel occupancy.

In other states, the Yonkers (New York) Bridge fire on October 9th 1997, is one of the most recent documented examples of ITS deployment to manage traffic during a disaster. A gasoline tank was struck at midnight by a car, causing 8,800 gallons of fuel to explode beneath this major New York artery. The ITS systems alerted travelers within a 100-plus mile radius of the tri-state area: New York, New Jersey and Connecticut, with linkage to variable message signs (VMS) located as far south as Delaware. A 911 call alerted the Operations Center in Albany, New York. Technicians alerted TRANSCOM, an agency responsible for coordinating traffic information and relaying this information to the Highway Advisory Radio (HAR) and other radio and television sources, and the NY DOT Maintenance Division to adjust VMS to indicate the bridge’s closure. Portable VMS detoured traffic away from the unstable bridge. TRANSCOM also alerted the I-95 Corridor Coalition, a group of traffic management officials from 12 Northeast states, who also posted messages on VMS and HAR in surrounding states. As a result of this ITS application, the NY DOT was able to avert significant traffic congestion from both commuters and long-haul truckers. Use of ITS enable traffic management agencies to restore capacity after an incident more quickly because the incident is detected and responded to more quickly. When tied into ramp metering operations and VMS, the normal flow rates can resume more quickly.

4.6 Restoration of Capacity After Disasters/Major Incidents

Select cities with transportation kiosks report extremely high usage of the kiosks during times of disaster. Kiosks as well as dial-up computer services that provide real-time info regarding traffic conditions give residents possible options regarding availability of alternate roadways and public transportation that would meet their traveling needs.

One example of ITS restoring capacity after a major disaster was kiosk use after the Northridge earthquake. The 1994 Northridge, California, earthquake left many roadways either destroyed or closed, and commuters were forced to take alternate routes and alternate modes of transportation. Plans for three audiotex and videotex kiosks burgeoned to 80 to accommodate the sudden information demand. Kiosks located in shopping malls, public buildings, and business parks allowed travelers to plan transit trips, find car pools, and view traffic conditions. One year after the quake kiosk use remained high, averaging 60,000 inquiries per month [49] Caltrans and the California Highway Patrol also increased coordination with the media. Along with a good proportion of ITS infrastructure already in place, Caltrans fast-tracked the additional installation of HARs and CMSs.

4.7 Tourist Travel Information

ITS applications have been deployed to support special events and tourism. ATIS and Advanced Parking Information Systems (APIS), among other systems, provide information to the occasional traveler regarding location, parking, and traffic conditions. ITS applications for the occasional traveler can improve time savings, improve customer satisfaction, and, of key importance to a visitor to a new city, promote perceptions of safety.

In 1993 over 4,000 drivers, mostly tourists, participated in an operational test of TravTek in Orlando, Florida. The TravTek test was run with approximately 100 rental cars equipped with electronic guidance systems. The guidance systems contained databases featuring navigational maps for five Florida counties, an AAA Florida Tourbook and tourist information on Orlando hotels, attractions, restaurants and special events. Touch tone screens in the automobiles gave the motorist the ability to search the database and pull up a detailed map and an estimated travel time. Verbal instructions were also available to drivers, as well as cellular phones for emergency help. By using satellite technology, magnetic compasses and sensors located in the car's wheels, TravTek was able to keep all vehicles on their established courses. TravTek users who were unfamiliar with the area reduced their travel planning time and their actual travel time.[50] When compared to control tests in which drivers used standard printed maps, TravTek was shown to reduce tourist travel time and decrease the amount of accidents caused by lost drivers.[51]

4.8 Resident Travel Information/Reliability of Employee Arrival

Commuters generally benefit from ITS applications that help manage traffic congestion. Typical applications include: ATIS, VMS, traffic signal control systems, electronic toll collection, ramp metering and incident management. Commuter applications can be divided in two categories: traveler information systems and traffic control systems. Traveler information systems provide real-time travel information to the public, allowing them to predict trip times accurately and make route and mode choices. Traveler information systems include pre-trip and en-route. En-route decisions are supported by VMS and kiosks for transit, providing bus schedules and arrival times. Pre-trip real-time information is available on the Internet and, at selected times, via radio and TV. Traffic is controlled using ramp meters, VMS, and advanced traffic signal control systems. Benefits from these applications include time savings (through traffic reduction on the major arteries) and safety.

4.9 Traffic Operations for Drawbridges

Real-time coordination of bridge and water traffic can ameliorate congestion in areas where bridge openings create commuter delays. Draw bridges are a major source of delay in Florida, where every urbanized area along Florida's coast must deal with intra-coastal water traffic and drawbridges. Each of Florida's urban communities have studied ways to reduce the impact of a bridge opening on roadway traffic.

Two factors compound the problem associated with drawbridges: (1) Marine traffic normally has the right-of-way and (2) There is little or no coordination between marine traffic and highway traffic. In South Florida, a landmark agreement was reached between the boating and highway communities that switched the right-of-way from the waterway to the highway. Boaters can no longer demand a bridge opening at any time of day.

The second problem still has not seen a ready answer. Coastal communities, such as Ft. Lauderdale, are studying ways that ITS can help with this coordination problem. Highway traffic would be alerted to bridge openings using variable message signs that identify alternate travel routes. If congestion already exists, bridge openings could be delayed. This scenario is more suited to urban areas that incur severe congestion from bridge openings.[52]

4.10 Reliability of Goods Movement/Impact on Just-in-Time Delivery

Commercial vehicle operations (CVO) continue to be viewed as a potential early winner for the ITS program. Use of advanced vehicle monitoring and communication technologies by motor carriers have demonstrated considerable time savings.[53] Examples include:

- Trans-Western Ltd., which reported that its fleet management system improved driver relations; this allowed drivers to increase daily mileage by 50 to 100 miles.
- Frederick Transport of Ontario, Canada, estimated an increase of 20 percent in loaded miles, a reduction of $30 to $150 per month in telephone charges, and a 0.7 percent greater load factor.[54]

4.11 Management of Traffic/Travel Information/Electronic Clearance at Intermodal Terminals/Port Access

Freeway management systems collect information on current traffic conditions and respond to problems by managing traffic flow. This system uses ramp meters that adjust to accommodate increases and decreases in traffic flow, signal systems on arterials that adjust to divert or slow traffic coming onto the freeway, and variable message signs that warn of upcoming traffic problems and suggest alternate routes.

4.12 More Efficient Allocation of Existing Highway Capacity

Florida has several advanced traffic management ITS applications that help promote more efficient allocation of highway capacity. One key example is Orlando, Florida's I-4 Surveillance and Motorist Information System, which includes loop detectors, closed circuit television (CCTV) cameras, and changeable message signs (CMS). The system covers 64 km of I-4, from Disney World on the south to Lake Monroe in the north. The system includes "smart guide signs" that direct traffic bound for Universal Studios to exit at one of two possible exits based on real-time volumes detected at the ramps.[55]

The Daytona Area Smart Highways (DASH) project is another example of using ITS for relieving congestion. To alleviate extreme traffic peaks in the Daytona Beach area, DASH manages local traffic control using CCTV cameras, CMS, and detectors on I-4, I-95, and on several arterials leading from the interstates to the beaches. The City of Daytona manages the operation of this system in cooperation with the FDOT.[56]

Dallas was able to increase rush hour capacity without any new construction, despite continued population growth. In order to avoid construction of major freeways servicing the Dallas area, the city alleviated a traffic congestion crisis by utilizing “smart” signs that reverse directions of lanes to accommodate traffic flow at peak periods.[57]

4.13 Incident Management/Special Events Traffic Management

ITS has been a critical tool for incident management. Some of the same applications used for CVO operations can be employed for incident management. Technologies that allow transportation managers to respond quickly to incidents on highways include video systems and loop detectors, which identify slowdowns and then allow traffic managers to view the cause of the slowdown and divert traffic away from the congestion caused by an incident.

Call-in systems provide travelers and transit operators the opportunity to report incidents on the highway to a central dispatching center. These systems include a digital map display at the emergency dispatch location that shows the exact location of a 911 call. Vehicles can use GPS with MAYDAY systems to alert emergency personnel to an accident and help them quickly locate the vehicle. This process facilitates quicker emergency response and traffic management.

More advanced than incident management, advanced collision avoidance systems (ACAS) facilitate safety by enhancing driver performance. Reducing the number of crashes results in fewer injuries and fatalities, and in lower societal costs. Roadside and in-vehicle devices are used to facilitate safety by providing drivers with a better awareness of their surroundings, warning drivers of hazardous situations, or, eventually, compensating for driver error.[58] This type of technology has not been widely deployed; consequently, benefits are not well documented.

Traffic signal technologies can also respond to real-time traffic conditions to give vehicles (or direction) priority status. This is possible by utilizing emergency vehicles equipped with devices that hold through-street lights green (also known as emgergency vehicle preemption), as well as signal coordination systems that respond to conditions at special event centers (e.g., a sports arena), allowing the smooth flow of traffic entering and exiting event locations, also known as daptive signal control (e.g., RT-TRACS, SCATS, and SCOOT)[1].

4.14 Management of Traffic Under Construction

The I-95 Corridor Coalition (a partnership of major public and private transportation agencies, toll authorities, and industry associations that serves the northeastern corridor

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[1]RT-TRACS: Real Time Traffic Adaptive Control System (USA), SCATS: Sydney Coordinated Adpative Traffic System (Australia), SCOOT: Split, Cycle and Offset optimization Technique (England).

from Maine to Virginia) posts construction advisories on their Information Exchange Network, which facilitates real-time construction information so that regional diversions can be implemented.[59] Benefits can be assumed from the reduction of annual cost of construction-related delays in the corridor, estimated to exceed several hundred million dollars.[60] Minnesota uses a portable Traffic Management System, fully deployable and operational in four hours, to address work zone management. The system uses traffic detection cameras and a series of CMS in and around work zone areas. The benefits include time savings from relatively rapid traffic diversion from construction areas, and possibly accident reduction savings.[61]

5. ITS IMPACTS ON FLORIDA'S ECONOMY

Overall gains from basic ITS deployment in urban areas can provide significant, direct benefits to Florida's transportation systems in terms of efficiency gains, such as time savings and accident reduction. As stated previously, generally, the economic benefits from ITS are expected to include:

- Enhanced public safety
- Reduced congestion
- Improved access to travel and transit information
- Reduced air pollution levels and other environmental enhancements; and
- Cost savings to motor carriers, transit operators, toll authorities, and government agencies in terms of time savings.

Although a key study undertaken at the national level found that most existing ITS project analysis and benefits estimation focused on corridor- or project-level findings, which resulted in limited information on benefits at the state, regional, or national level, the study findings can be extrapolated to a certain extent to help predict the broader impacts of ITS on Florida.[62]

The *ITS National Investment and Market Analysis* study findings were estimated from models, consultation with researchers and stakeholders, and a review of existing studies. The findings concluded that the breadth and diversity of benefits – and the factors that drive these benefits – are highly dependent on local circumstances. The study's nationwide estimation of direct benefits is based on basic ITS deployment in 75 major cities and over 200 MPOs, basic deployment is defined as including grade crossings, traffic signal control, freeway management, electronic toll collection (ETC), incident response, emergency management, ATIS, and electronic fare payment (for transit). It is important to recognize that the *Market Analysis* estimation of nationwide benefits does not include transportation system efficiency gains from rural applications and CVO applications, nor does this issue paper attempt to define broader macroeconomic effects (such as employment, or increased competitiveness, etc.) from ITS deployment.

Nationwide direct benefits from **transportation system efficiency gains** (as measured by time savings, operating costs, incidents, emissions/fuel efficiency) were expected to reach $252 billion over a 20-year period (based on the assumption that 5 percent of basic deployment was already in place). The majority of the direct benefits is attributed equally between accident savings and time savings (41 percent each, respectively). Using the proxy of the ratio of 1996 values for U.S. GDP to Florida GSP, 4.7 percent, Florida's portion of direct ITS benefits ($252 billion) could reach $12 billion. Using the proxy of 1996 U.S. VMT to Florida VMT, 5.2 percent, direct benefits could reach $13 billion. Florida's expected gains would be significantly higher with rural and CVO benefits.

Table 1. Estimated Direct Economic Benefits to Florida from Basic ITS Metropolitan Deployment

	VMT (1997)	FL % of US	FL Benefits (VMT proxy)	GDP/GSP (1996)	FL % of US	FL Benefits (GDP/GSP proxy)
US	2,560 billion	–	–	$7,662 billion	–	–
FL	134 billion	5.23 %	$13.2 billion	$360 billion	4.71 %	$11.9 billion

The potential benefits of ITS to Florida, if anywhere near the order of magnitude of the estimates above, are substantial. Capturing these benefits is especially important for maintaining Florida's economic competitiveness and quality of life.

Whereas estimates of gross benefits may be apportioned to Florida and are possible to produce, it is not possible to estimate potential benefits from strategies that target specific categories of benefits. What follows are examples of ITS applications focused on achieving specific categories of benefits. The examples represent specific applications that cannot be extended to the state. However, the examples do suggest applications that hold promise for deployment in Florida.

5.1 Reduced Travel Delay

Many types of ITS applications help reduce travel delay; however, the biggest gains can be derived from applications that improve CVO operations and commuter travel. Electronic clearance reduces travel delay but is only of significance to the private sector if a driver is paid by the hour. Florida, in addition to Georgia, Kentucky, Tennessee, Ohio, and Michigan, is currently participating in an electronic clearance project, Advantage-75, which reduces travel delay (i.e., delay from waiting to be processed at weigh stations), improves fuel economy, and reduces exhaust emissions.

Other facility-based applications to reduce travel delay include incident management, ramp metering, traffic signals/signal control, and VMS. The most significant travel delay impacts affecting both CVO and commuter travel are likely to be derived from ramp metering and incident management. Time savings from *incident management* case study evidence ranges from 10 to 45 percent.[63]

Ramp meters along Seattle, Washington's, I-5 have increased rush-hour capacity by 10 to 100 percent while increasing highway speeds.[64] Other cities with ramp metering have reported handling 8 to 22 percent more traffic while increasing or maintaining travel speeds.[65] Case studies of facility-based applications indicate the percent reduction in travel time from ramp metering ranged from 7.4 percent (in Denver and Detroit) to 47.7 percent (in Minneapolis/St. Paul).[66] Ramp metering also reduces accidents, which in effect reduces travel delay. Case studies of facility applications indicated accident reduction rates can range from 5 percent (for rear/side impact accidents in Denver) to 50 percent (total accidents in Detroit).[67] It is important to note that ramp metering also has an indirect effect of diverting short trips off highway facilities and onto neighborhood streets, thereby reducing peak-period congestion on highways.

To a lesser extent, *traffic signals* and *signal priority* systems produce facility-specific travel time savings. Traffic signal benefits range from 8 to 25 percent, whereas signal priority time savings range from 5 to 8 percent.[68] Traffic signals in Los Angeles, California, now adjust for current traffic conditions, even when incidents divert traffic from freeways. The result is that 41 percent fewer vehicles stop at red lights.[69]

A Georgia Tech study recently compared human factor issues for *VMS* deployment, testing (1) whether an automated traffic control system (ATCS) that supports VMS management improves operator and traffic management center performance and (2) whether a support system that automatically posts messages is more effective than a system that recommends the messages but requires operator approval before posting.[70] Test results from three separate support system configurations verified that the automated support system improved the operator's performance in identifying and responding to incidents. Another major conclusion was that, given a sufficiently reliable support system, the ATCS should be configured to post the incident-related messages directly to signs without waiting for operator approval. The results demonstrated that operator review of suggested messages created significant delays in posting time-critical messages.[71] FDOT will need to consider the cost factor for implementing a fully automated VMS management system on a case-by-case basis.

Unlike the applications above, the magnitude of reduced travel delay from *ATIS*, including VMS, will vary by scope. Because this technology can be deployed on a single facility or throughout a large region, the extent of benefits will vary by the scale of deployment. Estimates of delay savings from one region-wide integrated ATIS system in Long Island, INFORM, reach as high as 1,900 vehicle-hours for a peak-period incident and 300,000 vehicle-hours in incident-related delay annually.[72] Peak period speeds also increased from 34 mph to 46 mph.[73] INFORM is a complex freeway management system using changeable message signs, ramp meters, in-pavement traffic detectors, and signal coordination on parallel streets. This application could be deployed in Florida's urban areas, where motorists can be directed to alternate routes. Another ATIS, Florida's TravTek, reduced travel time for "unfamiliar drivers" by 20 percent.[74] This application is more relevant for areas related to tourist travel, such as airports.

The obvious winners are incident management and ramp metering, reducing delay between 10 and 42 percent and between 15 and 48 percent, respectively.[75] Florida's metropolitan areas would derive benefits from time savings from the majority of ITS applications that reduce travel delay; however, the greatest gains will depend on a specific ratio between the cost of ITS infrastructure and the magnitude of expected time savings from deployment in a given area. Florida would also benefit from travel delay savings from ATIS (TravTek, INFORM, or the APIS systems) to assist non-commuter traffic in locating attractions and available, safe parking.

5.2 Elimination Of Trips/Time Of Trips/Shift To Transit

Any ITS improvements to a highway system would improve the viability of single occupant vehicle (SOV) driving and thereby reduce transit use. However, recent advancements in ITS applications for transit have made transit easier to use. Smart Cards and ATIS for transit system information both improve customer satisfaction. Recently, a private-sector company in Finland, the Matkahoulto Group, persuaded the owners of about 90 percent of Finland's privately-owned intercity bus fleets, numbering about 4,500 vehicles, to install smart card readers. Smart cards, sold at bus terminals and sales outlets, sales accounted for more than 25 million trips, representing nearly 10 percent of the more than 360 million Finnish bus journeys per year.[76] New Jersey Transit as well as Rochester, New York, and Minneapolis/St. Paul transit agencies reported being able to handle up to 80 percent more calls as a result of ATIS.[77]

In special applications of demand response, transit fleet management (AVL/CAD) may increase shifts to transit. For example, the Winston-Salem Transit Authority reported a doubling of ridership (1,000 to 2,000) within the first six months of implementation.[78] In addition fleet management can increase bus on-time performance, reducing total operating costs due to the use of fewer buses.

Variable pricing (dynamic ETC), in contrast to transit ITS, has demonstrated shifts in travel time to avoid peak-period charges. The *91-Express Lanes* in Southern California caused traffic to shift; one-third shifted to toll lanes (to take advantage of predictable travel times) and 1996 "freeway" levels dropped to 1982 levels.[79] Florida's Lee County has implemented a discount pricing scheme to encourage shifts in travel time, however, this pilot project, as designed, may not produce the desired level of volume shifts due to the relatively low cost of tolls ($1.00 peak charge drops to $0.50 in the shoulder). However, this scheme does provide valuable lessons for managing bond restrictions in the event of changing a fixed toll to a variable toll scheme and could have considerable value for other toll facilities in Florida.

5.3 Vehicle Operating Cost Savings

ITS frequently reduces operating costs, including lowering life-cycle costs due to operating cost and productivity improvements. Estimates from case studies indicate ETC offers the highest return: Operating cost reductions range from 34 percent to 91 percent. Fleet management systems reduce operating costs by between 5 percent and 25 percent. Providing less of an impact relative to the other applications, Automated Vehicle Location/Computer-Aided Dispatch (AVL/CAD) percent cost reductions range from 4 percent to 9 percent.[80] The highest level of savings to vehicles operating in Florida likely will be produced by converting its existing manual toll operations to ETC.

5.4 External Cost Savings

ITS benefits to the environment from a given project can be estimated only by analysis and simulation in most situations. However, early evidence indicates ITS impacts to energy consumption and the environment are significant. ITS technologies, such as signal system optimization, ETC, and traveler information systems, can reduce emissions (and fuel consumption). Signal optimization and ETC help reduce emissions in local areas, e.g., intersections and toll plazas.

Traffic signal systems continued to be upgraded primarily for traffic flow and system maintenance reasons. Improved flow and reduced delays have a positive impact on emissions and energy consumption at current traffic levels. Several recent system re-timings and equipment upgrades have included emission evaluations. Documented results were obtained from systems in Abilene, Texas, Southern California, and Toronto, Ontario, Canada.[81]

Traveler information systems also have a positive effect on emissions. Surveys performed in the Seattle, Washington, area and the Boston, Massachusetts, area indicate that, when provided with better traveler information, there is a nearly even split between travelers who change route of travel and travelers who change time of travel, with an additional 5 to 15 percent changing travel mode based on traveler information.[82] Assuming that 30 percent of the 96,000 daily callers projected for 1999 change travel plans according to this breakdown, the impact of Boston’s SmarTraveler on emissions has been estimated using the MOBILE5a model. On a daily basis, this adjustment of travel behavior nets an estimated reduction of 498 kg of volatile organic compounds, 5,032 kg of CO, and 25 kg of NOx, representing reductions of 25 percent, 33 percent, and 1.5 percent, respectively, of these pollutants from travelers changing travel plans.[83]

Table 2. Projected Environmental Benefits of ITS (External Cost Savings)

Intelligent Transportation System	Projected Benefits
ATSAC (Los Angeles) Traffic Signaling	13% decrease in fuel consumption 14% decrease in emissions
City of Abilene Traffic Signaling	6% decrease in fuel consumption 10% decrease in HC 13% decrease in CO
SmarTraveler, (ATIS) Boston	Potential reduction of 25% organics, 33% CO, 1.5% NOx (based on 1999 projections)
Toronto's SCOOT	6% decrease in fuel consumption 5% in CO emissions 4% in HC emissions.[84]
Oklahoma PIKEPASS Electronic Toll System	27-70% reduction in pollution, $160,000 cost savings annually per toll lane

The most significant savings to Florida would likely come from ETC deployment or traffic management ITS deployment in urban areas where air quality is a significant issue.

5.5 Enhanced Business Efficiency/Productivity

A transportation network system can enhance business efficiency and productivity in one of two approaches, either by significantly reducing overall travel time or by providing a consistent travel time. ITS applications for construction management or commuter traffic management include the traveler information systems described previously and localized traffic management systems. Either of these types of applications has the potential to improve productivity by reduced travel time or consistent travel time.

Dallas Smart Signs, a reversible lane technology, facilitated US-75 freeway reconstruction to allow existing levels of traffic to use lanes from the opposite direction, producing a 33 percent increase in peak-period capacity.[85] Managed from a remote location at the traffic operations center, "smart" 24-by-30-foot overhead electronic signs placed an average of every 1,000 feet alert motorists to the gradual switch of lane direction by displaying an amber "X" in a lane about to change direction and a red "X" once the shift is complete. Each smart sign mechanism is internally programmed with timing sequences; all report to a control center, where computers monitor and synchronize activity and alarms signal any problems. Total capital expense was $1.2 million. This application could easily be tested at construction sites in Florida's densely populated urban areas.

5.6 Enhanced Regional Competitiveness

To date, no direct evidence defines benefits to enhanced regional competitiveness. However, ITS system improvements can be interpreted to have specific impacts on regional competitiveness. FDOT-supported CVO applications that meet the needs of the motor carrier industry will have the indirect affect of increasing shipping activity through Florida, which is likely to promote the location of manufacturing and distribution centers in the regions accessible to improved shipping.

5.7 Avoided Infrastructure Costs

Literature reviewed for this study did not explicitly address the impacts of ITS to avoid infrastructure costs. However, implicit conclusions can be made regarding infrastructure costs. ITS applications are invariably cheaper to implement than new construction. Because several ITS applications improve throughput without new construction, it can be assumed that ITS will reduce infrastructure costs to expand facilities. Depending on the application, case study evidence indicates throughput can be improved by as much as 300 percent (for ETC) or as little as 2 percent for Freeway Management System deployment (in Long Island).[86] The highest benefits will likely be realized from converting Florida's manual toll facilities to ETC.

5.8 Goods Movement/CVO Cost Savings

Specific CVO operations benefit from travel time savings generated by electronic credentialing. A nationwide American Trucking Association (ATA) study indicated that "willingness to conduct regulatory transactions electronically via EDI was expressed by 32, 61, and 79 percent of small, medium, and large carriers."[87] The ATA also estimated benefits of electronic credentialing at 4:1 for carriers with 11-99 vehicles and at 20:1 for carriers with 100 or more vehicles.[88] In addition to reducing travel delay (benefitting carriers), electronic credentialing saves administration time; order of magnitude estimates range from 33 to 40 percent, depending on the number of transactions.[89]

In 1998 eight case studies were performed in different states to determine the amount of investment involved in ITS/CVO deployment as well as additional revenues and savings resulting from the increased efficiency. It is important to note that each state processes a different number of applications and that the number of applications does not necessarily equal the number of trucks registered in the state due to the fact that an entire fleet can sometimes be registered for one application. These differences in the baseline characteristics of each case study help to account for the differences in required investments as well as fiscal benefits found for each state. For example, the high number of weigh stations in California would have an impact on total state investment if these facilities were converted to use weigh-in-motion technology. Similarly, a low volume of applications processes may not provide the threshold of activity that maximizes the fiscal benefits of electronic credentialing.[90]

Based on the lower end of the range of expenditures and savings, the *savings-to-expenditure* ratio for electronic credentialing ranged from 1.0 (Delaware) to 7.55 (California). At the high end, the lowest value, Delaware, dropped to 0.54 and the highest, California, dropped to 6.64. For roadside management, including safety and clearance ITS systems, ratios for the lower end range of expenditures ranged from 0.05 (Minnesota and Connecticut) to a "statistical deviant," 50 (New Jersey). The higher end ratio estimates ranged from 0.02 (Connecticut) to 0.10 (Colorado). In both cases different investment scenarios would substantially change the resulting savings-to-expenditures ratios.[91]

The low and high estimates consistently indicate that statewide electronic credentialing produced a fiscal payoff. Based on the savings-to-expenditures ratios associated with electronic credentialing, deployment of ITS/CVO technologies to support in-house administrative functions can be justified solely by the net savings to the administering agency.[92] Seven of the eight states involved in the case study experienced significant net savings due to implementation of electronic credentialing.

By contrast, the initial investment in ITS/CVO roadside management infrastructure exceeds the fiscal benefits that could be realized from any administrative savings or increased revenues as a result of higher enforcement of registration and revenue reporting. Consequently, to make a case for deploying a roadside management system, decision-makers need to look at factors outside of the fiscal analysis, such as enhanced regional competitiveness, time savings for the private sector, and impacts from emissions reduction and fuel savings.[93]

The benefits from roadside management also depend on the extent of expenditure for physical infrastructure. Even though these study findings indicate that roadside management costs exceeded administrative savings or revenues, newer types of ITS (since the study) are cheaper and likely to generate a higher return on investment.

The difference in the amount of startup expenditures required for each regulatory function is due to relatively lower costs to deploy electronic credentialing (consisting mainly of computer hardware and software) and the higher costs to deploy roadside management ITS, (consisting of physical infrastructure for weigh-in-motion scales and improved roadside facilities). California is probably a close proxy for expected benefits from electronic credentialing and clearance.

5.9 Improved Efficiency At Intermodal Terminals

Similar to gains in regional competitiveness, efficiency gains from ITS deployment at intermodal terminals have not been well documented. Furthermore, these types of ITS applications are more appropriate for the private sector. Fleet management systems and goods tracking applications will be implemented to best meet specific company requirements. However, due to Florida's high trade activities, FDOT would gain from taking a proactive approach and recommend and encourage architecture standards between the four modes: rail, marine terminal, trucking, and air freight. In addition, FDOT should foster a greater understanding of how to distinguish between ITS needs for intermodal passenger travel (cruise ship embarkation and airport departures) and ITS needs for CVO at the same locations (marine terminals and airports), and, where possible, encourage standardization (i.e., Smart Cards, transponders, roadside management, and electronic credentialing). Pilot applications, by necessity, will need to be location specific, targeting an airport, marine terminal, or intermodal yard. The only exception will be to implement electronic credentialing statewide, whereupon a specific case of goods transfer would not be held up due to improper credentials.

5.10 Enhanced Competitiveness In Tourism

Two systems were studied that had applications for enhancing an area's ability to compete for tourism: TravTek and APIS. Both ITS applications provide tourists with travel information, producing time savings, and promoted perceptions of safety.

Table 3. Projected Benefits to Tourism from ATIS

Intelligent Transportation System	Projected Benefits
TravTek	• 19% reduction in tourist travel time relative to using paper maps. • Wrong turns decreased by 33%. • Travel planning time decreased by 80%.
APIS	• Perception of time savings. • Perception of safer parking conditions. • After a 6-month debugging, APIS worked 96% of the time.

In addition to benefits to motorists, APIS also produced benefits to parking operators. Occupancy rates at participating parking facilities were higher, though it was unclear whether this was due solely to APIS.[94] The City of St. Paul recognized that APIS impacts the surface transportation system, in addition to the overall economy, by serving as a mechanism to enhance the ability of St. Paul to attract special events.[95]

Tourist-oriented ATIS applications such as TravTek and APIS will only improve Florida's reputation as a tourist-serving destination. In addition, any ITS applications that improve perceptions of safety can only have positive impacts on a region where tourist safety is an issue, such as Miami.

5.11 Attracting High-Tech Industries

According to *Site Selection*'s Associate Editor, Tim Venable, high tech industries' site selection critieria, in order of priority, include the following: 1) proximity to a research university; 2) quality of life for its employees; 3) airport access within I hour; 4) near or in a city with a population of 500,000 or more; and 5) availability of educated/trained workers.[96] A survey conducted by the University of South Florida (USF), Office of Economic Development, concurred with Venable, indicating that the availability of trained workers (computer programmers, machinists, etc.) was a major concern for high tech industry location selection.[97] Another report ranked, on a 100-point scale, high tech location selection criteria as follows: avialability of labor (89.3); labor costs (72.2); tax climate (67.2); academic institute (58.8); cost of living (58.5); transportation (58.4); access to markets (58.1); regional regulatory practices (49.0); energy costs and availability (41.4); cultural amenities (36.8); climate (35.8); and access to raw material (27.6).[98] This same report indicated "the ability to interact with other high tech operations" is also a major selection criterion.[99] The site selection literature does not list ITS among the key factors, although ITS can be a part of the "quality of life" or "transportation."

As mentioned earlier, Florida is an economically diverse state, with many resources and conditions that attract high tech industries. Information processing, computer simulation, semi-conductors, telecommunications, aerospace/aviation and medical technology are some of the state's leading growth industries – and key targets for current state recruitment efforts.[100]

In fact, Florida has demonstrated that it can attract high tech industry without wide-scale ITS deployment. Recent experiences indicate that Orlando and the I-4 Corridor are already attracting high tech industry. According to the USF survey, 530 microelectronics companies are located in the I-4 region, compared to a 1997 Enterprise Florida survey that identified 730 microcomputer companies statewide. The I-4 Corridor High-Technology Initiative is a partnership between USF and the University of Central Florida in Orlando to attract high-tech companies to the region. According to *Site Selection's* recent profile of Florida, the USF survey (conducted between October 1997 and February 1998) is the second recent boost to the I-4 Corridor. Bell Laboratories opened a $650 million research and development center in metropolitan Orlando.[101] Additions such as Bell Laboratories, and the availability of local research institutions' resources to address high tech industry needs (the survey), clearly have had a profound impact already without ITS deployment.

However, ITS can improve the attractiveness of a given location to industry. Companies dependent on major shipping operations typically locate where transportation links are efficient. ITS systems improving traffic flow for the public-at-large can improve network efficiency. Large-scale COV ITS deployment, such as the I-75 corridor project or rail applications, will help improve Florida's ability to compete with other states for import/export and domestic trade.

A recent study's findings concluded that total economic benefits nationwide (including both transportation system efficiency gains and multiplier effects from employment, etc.) from ITS applications were likely to reach $300 to $350 billion and generate almost 600,000 jobs over the time period 1996-2015.[102] The same study concludes that public infrastructure-driven markets in U.S. metropolitan areas will exceed $80 billion over the same time period, whereas private markets – including those for consumer and commercial-driven ITS products and services – will exceed $340 billion. Because ITS companies presently operate in Florida, continued support of the ITS industry will help the Florida benefit from the location of the rapidly growing private-sector ITS industry.

6. CONCLUSION

For policy purposes, this paper has identified ITS interrelated transportation management strategies and a variety of specific applications that benefit transportation uses and, in so doing, confer individual benefits. Individual benefits include time savings, enhanced public safety, reduced congestion, improved access to travel information, reduced air pollution levels, and cost savings to motor carriers, transit operators, and toll authorities.

This issue paper reviewed a wide array of specific applications in order to estimate which types were likely to have the greatest impact to the economy. Per case study evidence, the clear winner was electronic toll collection. ETC had the strongest impact on all measures of effectiveness including: improved time savings, reduced accidents, reduced emissions, and reduced vehicle operating costs. More dependent on the specific area and scope where ITS would be deployed, other likely winners include: ramp metering; tourist and travel information systems; traffic signal system optimatization; incident management; and CVO ITS for weigh-in-motion and electronic preclearance activities.

With respect to overall potential benefits, from both public- and private-sector investment in ITS, initial analysis suggests these are in the range of billions of dollars over a period of 20-years. According to a prior key study, ITS impacts to the economy are estimated to reach $252 billion aggregated across the U.S. beginning in 1996 to 2015. Florida's share of these ITS impacts is likely to reach $12 billion over the same time period. These benefits primarily accrue from accident reduction and time savings (41 percent each).

Out pacing the U.S. rate of growth, Florida's fast-growing economy is heavily tied to tourism and global trade - both equally dependent on Florida's transportation network connectivity. Representing only a piece of the total economic effects of trade, exports alone were identified as generating $24 billion in 1996. Tourism was found to generate $41 billion the following year, 1997. ITS applications supporting these industries are likely to have the greatest impacts to the economy as a whole. The two most relevant categories of ITS strategies for Florida DOT, therefore, are CVO and tourism ITS. Commercial vehicle operations will benefit from electronic credentialing and clearance (weigh-in-motion), safety assurance, fleet management (private-sector based) and any freeway management systems benefitting freight shipment corridors. Florida tourism will gain from ATIS - including APIS, VMS, Kiosks, and TravTek's intelligent rental-cars Last, ancillary benefits from ITS deployment may include attracting high-tech industry.

The case study examples of ITS applications described in this Issue Paper provide policy makers with candidates for deployment on a demonstration basis. The objective would be to focus initially on ITS applications that produce the most significant benefit – cost savings. These would be implemented on a demonstration basis at selected locations and, upon successful implementation, migrated to other parts of the state. Future analysis and evaluation should focus on value capture, to the extent that the benefits of ITS applications can meet market tests. This will require substantial innovative pricing applications to begin to approach the financial feasibility of wide-scale ITS deployment.

The next course of action will be to build on other states' experiences in adopting systems that are truly effective in order to avoid the onslaught of vendors attempting to sell "vapor-ware," that is, costly products with very little true value. The University of Kentucky's Joe Crabtree (606-257-4508) is a good source of information regarding CVO. Caltrans and SANDAG experiences with ETC are valuable as well. Along the same lines, US DOT is preparing several courses and training seminars to address the likely trends in ITS CVO deployment. Seminar and course attendance will help FDOT to better understand the direction of private-sector ITS deployment and how FDOT can support these initiatives. U.S. DOT's Jeff Loftus is preparing the seminar and training schedules (202-366-4516).

A recent study published by the National Governor's Association provides some final insights regarding key policy considerations to help states determine the best approach for CVO deployment:

- In designing and deploying ITS/CVO technologies, FDOT should take the opportunity to change its regulatory climate and processes.
- Interstate cooperation on ITS/CVO deployment will maximize motor carrier participation rates and reduce Florida's overall investment costs.
- Incentives will encourage more rapid participation in state ITS/CVO programs by the motor carrier industry.

The Governor's Association study asserted that the extent to which a state maximizes the net benefits associated with ITS/CVO systems is directly proportional to motor carrier participation in these systems. As motor carrier participation increases, the number of transactions reaches the threshold at which ITS/CVO systems approach cost effectiveness.[103] The study indicated that the number of motor carriers adopting the ITS/CVO systems will lag behind the deployment. To address this problem, therefore, states should actively promote high levels of ITS/CVO participation by offering monetary and nonmonetary incentives to motor carriers.

GLOSSARY OF TERMS USED IN THE REPORT

ACAS: Advanced Collision Avoidance Systems - focuses crash avoidance, in contrast to traditional safety systems (seat belts, air bags, etc.).

AEI: Automated equipment identification.

APIS: Advanced parking information systems.

APTS: Advanced Public Transportation Systems - seek to improve operation and encourage use of shared ride modes by applying technologies in fleet management, traveler information, and electronic fare payment.

ATCS: Automated traffic control system.

ATIS: Advanced Traveler Information Systems - provide information to travelers on both highway and transit system performance before and during travel using infrastructure-provided equipment as well as personal and vehicle-based devices.

ATMS: Advanced Traffic Management Systems - seek to improve efficient management of traffic on freeways and surface streets using traffic monitoring, communications, traffic signal systems, and freeway management systems.

AVCSS: Advanced Vehicle Control and Safety Systems - will use technology to improve vehicle control and crash avoidance, with full implementation to take the form of automated operation on specified facilities.

AVL: Automated vehicle location - a computerized system that tracks the current location vehicles in a fleet. It is used to assist in applications such as dispatching.

CAD: computer-aided dispatch - uses advanced communications to coordinate and relay information efficiently to vehicle fleets, such as transit buses, patrol cars, emergency-response vehicles, and private carriers.

CCTV: Closed circuit television.

COFC: Container on flat car.

CVO: Commercial Vehicle Operations - assist the safe and efficient movement of trucks and buses using electronic screening and identification systems, advances in administrative function automation, automated inspections and reporting, hazardous materials response, and on-board monitoring.

CVISN: Commercial Vehicle Information Systems and Networks - the federally-initiated collection of information systems and communications networks that provide support to trucking operations.

DOD: U.S. Department of Defense

EDI: Electronic data interchange.

ETC: Electronic toll collection - scanners at toll plazas read transponders on vehicles entering the facility and allow traffic to flow without stopping to pay toll fees.

GPS: Global positioning satellites.

GSP: Gross state product.

GOS: Geo-synchronous orbital satellites.

HAR: Highway advisory radio.

LEO: Low earth orbit satellites.

MPO: Metropolitan Planning Organization.

TEU: Twenty-foot equivalent unit - a unit of cargo shipment.

TOFC: Trailer on flat car.

MCSAP: Motor Carrier Safety Assistance Program - offers state grants to fund uniform roadside driver and vehicle safety inspections, traffic enforcement, compliance reviews, and other complementary activities.

VMS/(CMS): Variable message signs (changeable message signs) - electronic sign on a highway that can change the message it displays, used to way and redirect traffic.

WIM: Weigh-in-Motion - technology that determines a vehicle's weight without requiring the vehicle to stop on a scale.

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