

**Technical Memorandum No. 3.10**

**Florida's 2003 Intelligent Transportation System  
Strategic Plan Update**

**System Monitoring and Performance  
Measures**

**March 2, 2005  
Version 2**



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*Technical Memorandum No. 3.10 – Florida’s 2003 ITS Strategic Plan Update  
System Monitoring and Performance Measures*

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## **List of Acronyms**

ATIS.....	Advanced Traveler Information System
AVL .....	Automatic Vehicle Location
<i>CFP</i> .....	<i>Cost Feasible Plan</i>
FDOT .....	Florida Department of Transportation
FHWA.....	Federal Highway Administration
FIHS.....	Florida Intrastate Highway System
FTC .....	Florida Transportation Commission
ITS.....	Intelligent Transportation Systems
LOS.....	Level of Service
NCHRP .....	National Cooperative Highway Research Program
PDO.....	Property Damage Only
PMT .....	Person-Miles Traveled
SPO .....	Systems Planning Office
TEOO.....	Traffic Engineering and Operations Office
TSP.....	Transit Signal Priority
V/C.....	Volume to Capacity ratio
VMT.....	Vehicle-Miles Traveled

## **1. Introduction and Purpose**

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

An initial objective of the ITS Program, in partnership with the FDOT Districts, was to develop the *Ten-Year ITS Cost Feasible Plan*, hereinafter referred to as the *CFP*,<sup>2</sup> which identifies, funds, and programs the deployment of a statewide ITS. Now that these initial efforts are complete, the next phase of the ITS Program focuses on the deployment, maintenance, operation, management, and monitoring of Florida’s ITS. This *Technical Memorandum* reviews national efforts in developing performance measures, analyzes the performance measures identified in the *CFP*, and recommends actions for the design and implementation of a system monitoring program to measure and assess the performance of ITS deployments. Aside from reviewing Florida’s experiences, this paper summarizes initiatives documented by the Federal Highway Administration (FHWA) and other nationally relevant entities concerning operational performance measures.

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<sup>1</sup> PB Farradyne, *Florida’s Intelligent Transportation System Strategic Plan – Final Report* (August 1999). Available online at [http://www.dot.state.fl.us/trafficoperations/its/its\\_default](http://www.dot.state.fl.us/trafficoperations/its/its_default).

<sup>2</sup> Florida Department of Transportation, *Ten-Year ITS Cost Feasible Plan* (May 2004). Available online at [http://www.dot.state.fl.us/trafficoperations/its/its\\_default.htm](http://www.dot.state.fl.us/trafficoperations/its/its_default.htm).

## 2. Background

The National Cooperative Highway Research Program’s (NCHRP) Project 8-32(02) regarding multimodal transportation for the development of a performance-based planning process,<sup>3</sup> defines performance measurement as:

*... the use of statistical evidence to determine progress toward specific defined organizational objectives. This includes both evidence of actual fact, such as measurement of pavement surface smoothness, and measurement of customer perception such as would be accomplished through a customer satisfaction survey. In a service industry such as transportation, the performance measurement process starts by defining precisely the services that the organization promises to provide, including the quality or level of service (e.g. timeliness, reliability, etc.) that is to be delivered. ... There are often good opportunities for collecting feedback from system users in “real time,” since the transportation service is often “consumed” at the same time it is “produced.” Performance measures provide information to managers about how well that bundle of services is being provided. Performance measures should reflect the satisfaction of the transportation service user, in addition to those concerns of the system owner or operator.<sup>4</sup>*

Transportation experts in Florida are seeking new ways to measure transportation system performance for the purpose of identifying and documenting the best alternatives for enhancing services to the citizens of Florida. Ideally, such performance measures should comprehensively describe the level of ease with which people and goods move throughout the system.

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<sup>3</sup> More information regarding NCHRP Project 8-32(2), *Multimodal Transportation: Development of a Performance-Based Planning Process*, is available online at [http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+8-32\(2\)](http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+8-32(2)) .

<sup>4</sup> Federal Highway Administration, *Performance Measurement Fundamentals* (July 2004). Available online at [http://www.ops.fhwa.dot.gov/perf\\_measurement/fundamentals.htm](http://www.ops.fhwa.dot.gov/perf_measurement/fundamentals.htm).

### **3. A Brief Review of National Efforts to Develop Performance Measures**

There are nationally relevant resources currently available that deal with the development and analysis of performance measures. These efforts typically focus on the variables that transportation professionals can best depend on to yield the most accurate performance assessments in terms of traveler mobility and system reliability.

#### **3.1 The Federal Highway Administration’s Mobility Monitoring Program<sup>5</sup>**

Sponsored by the FHWA, the Mobility Monitoring Program has two primary objectives:

- 1) To analyze and report mobility and reliability trends in urban areas using archived operational data; and
- 2) To provide incentives and technical assistance for the implementation of data archiving systems to support performance monitoring applications.

The primary mobility measures included in the program reports include the:

- Travel Time Index Mobility Measure, which is a ratio of travel conditions in the peak period to a target or acceptable travel condition. Typically, free-flow conditions are used. The travel time index indicates how much longer a trip will take during a peak period.
- Percent of Congested Travel Mobility Measure, which is a system measure that quantifies the extent of congestion. A free-flow speed is used as a congestion “benchmark” and any travel on a road section for a time period that is less than the free-flow speed is considered congested.
- Delay per Person Measure, which is expressed in person-hours per year and is used to reduce the total travel delay value to a figure more closely related to user experience. This measure also normalizes the impact of mobility projects that handle much higher demand than other alternatives.

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<sup>5</sup> The FHWA’s Office of Operations sponsors the Mobility Monitoring Program. The Program is a cooperative study by the Texas Transportation Institute (TTI) and Cambridge Systematics, Inc. More information regarding the Mobility Monitoring Program is available online at <http://mobility.tamu.edu/mmp>.

According to an FHWA brief entitled *Transforming Gigabytes of Archived Operations Data Into Mobility and Reliability Performance Measures*,<sup>6</sup> all of the mobility performance measures described above “... reflect an *average level* of congestion and mobility. However, a number of empirical studies and surveys have demonstrated that travelers value not only the time it usually takes to complete a trip but also the reliability in travel times. For example, many commuters will plan their departure times based on an assumed travel time that is greater than the average to account for this unreliability.”<sup>7</sup>

Consequently, the authors of this report found that it is more appropriate to track several different types of reliability performance measurements, as well as the mobility measures described above. The reliability measures they identified as the most promising for providing relevant information for other analyses included the:

- Buffer Index Reliability Measure, which expresses the amount of extra “buffer” time needed to be on time 95 percent of the time (e.g., late one day per month). Travelers can multiply their average trip time by the buffer index, then add that buffer time to their trip time to ensure that they will be on time for 95 percent of all trips.
- Percent Variation Reliability Measure, also known as the coefficient of variation, is the amount of variability in relation to average travel conditions. It is calculated as the standard deviation divided by the mean. Travelers can multiply their average travel time by the percent variation, then add that product to their average trip time to get the time needed to be on time for approximately 85 percent of all trips (i.e., one standard deviation above the mean). Higher values indicate less reliability.
- Misery Index Reliability Measure attempts to quantify the intensity of delay for only the worst trips. This index is calculated by subtracting the average travel rate from the upper 20 percent of travel rates to estimate how much more time the worst trips will take beyond the average trip rate.

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<sup>6</sup> Pearce, Vince, Shawn Turner, Tim Lomax, and Richard Margiotta, *FHWA’s Mobility Monitoring Program: Transforming Gigabytes of Archived Operations Data into Mobility and Reliability Performance Measures*. Presented at the Institute of Transportation Engineers’ 2002 Annual Meeting, Philadelphia, Pennsylvania, August 4-7, 2002.

<sup>7</sup> Turner, Shawn, Tim Lomax, and Richard Margiotta, *Final Report – Monitoring Urban Roadways in 2002: Using Archived Operations Data for Reliability and Mobility Measurement* (March 2004). FHWA Report No. FHWA-HOP-04-011.

### **3.2 The National Cooperative Highway Research Program Synthesis 311 – Performance Measures of Operational Effectiveness for Highway Segments and Systems**

As part of the research for the NCHRP Synthesis 311 project, an analysis was conducted to assess performance measure best practices from around the United States.<sup>8</sup> This synthesis consistently reported and recommended the use of the performance measures detailed below based on their ability to serve as foundations for other commonly reported measures, such as a congestion index. Recommended measures are listed below.

- Quantity of Travel Measures (from the users’ perspective)
  - Person-miles traveled (PMT)
  - Truck-miles traveled
  - Vehicle-miles traveled (VMT)
  - Persons moved
  - Trucks moved
  - Vehicles moved
  
- Quality of Travel Measures (from the users’ perspective)
  - Average speed weighted by the PMT
  - Average door-to-door travel time
  - Travel-time predictability
  - Travel-time reliability (i.e., the percent of trips that arrive in an acceptable time)
  - An average of the total, recurring, and incident-based delays
  - Level of service (LOS)
  
- System Utilization Measures (from an agency perspective)
  - Percent of the system that is heavily congested, such as LOS E or F
  - Vehicle density (i.e., the number of passenger cars per hour per lane)
  - Percentage of travel heavily congested
  - Volume-to-Capacity (V/C) ratio
  - Queuing (i.e., frequency and length)
  - Percent of miles operating in the desired speed range
  - Vehicle occupancy (i.e., the number of persons occupying each vehicle)
  - Duration of congestion (i.e., lane-mile-hours at LOS E or F)

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<sup>8</sup> More information regarding NCHRP Project 20-05 and NCHRP Synthesis Report No. 311 is available online at <http://trb.org/news/>.

- Safety Measures
  - Incident rates
    - Severity, including fatality, injury, property damage only (PDO) measures
    - Type, including rates for stopped vehicles, rail crossings, weather, or crashes
- Incident Measures
  - Incident-induced delay
  - Evacuation clearance time
- Output Measures (based on agency performance)
  - Incident response time by type
    - Stopped vehicles
    - Rail crossings
    - Weather
    - Crashes
  - Toll revenue
  - Bridge condition
  - Pavement condition
  - Percent of ITS equipment that is operational

## **4. Florida’s Intelligent Transportation System Performance Measures**

In the past, the FDOT’s ITS Program did not focus significant resources on performance measurement; however, as the program matures and a rapid deployment pace continues, much of the Program’s emphasis is shifting towards monitoring the performance of these systems. The FDOT’s objective should not only be to assess the impact of individual ITS deployments on improving traffic management, but to gauge whether ITS is contributing toward the broader goal of enhancing transportation services throughout the state.

### **4.1 Analysis of the Performance Measures Identified in the Ten-Year ITS Cost Feasible Plan**

Table 3.1 of *Technical Memorandum No. 3.3 – ITS Program Performance Measures*<sup>9</sup> summarizes the list of ITS performance measures related to the goals and objectives of the *CFP*, as documented in *Technical Memorandum No. 2 – ITS Needs Model*<sup>10</sup> of the same project. These performance measures were identified based on existing measures already conceived and developed by the FDOT as part of *Florida’s Intelligent Transportation System Strategic Plan*.

The measures listed therein were developed based on a number of best-practice guidelines, including the following.

- Measures should be compatible with national methods.
- Measures should be based on a consensus of opinion.
- Measures should reflect the users’ experience on the system.
- Measures should address the movement of both people and goods.
- Measures should address multimodal considerations.
- Fewer mobility performance measures are desirable.
- Measures should be quantifiable.
- Selection of measures should not be driven by existing data availability alone.
- Measures should not be too costly to estimate or collect.
- Measures should be understandable to the general public.
- Measures should be usable throughout FDOT activities.
- Measures can be forecasted into the future.

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<sup>9</sup> Shaw, Terrel (PBS&J), June 2002. *Technical Memorandum No. 3.3 – ITS Program Performance Measures: ITS Corridor Master Plans for Florida’s Principal FIHS Limited-Access Corridors, Version 2*. FDOT Contract No. C-7772. Available online at <http://www.dot.state.fl.us/trafficoperations/its/itsdeployment/deployment.htm>.

<sup>10</sup> Shaw, Terrel (PBS&J), June 2002. *Technical Memorandum No. 2 – ITS Needs Model: ITS Corridor Master Plans for Florida’s Principal FIHS Limited-Access Corridors, Version 3*. FDOT Contract No. C-7772. Available online at <http://www.dot.state.fl.us/trafficoperations/its/itsdeployment/deployment.htm>.

Development of all measures was based on the following two basic considerations:

- 1) How does ITS support the FDOT’s goals and objectives to improve how transportation services are provided to the citizens of Florida?
- 2) What is FDOT’s progress in successfully deploying ITS services and are the limited resources being spent as efficiently as possible?

Overall, the measures recommended as part of the *CFP* cover a wide range of mobility- and safety-related, and agency-oriented performance measures. However, for them to be successfully utilized, the FDOT needs to pursue not only their implementation, but also the supporting data collection and tracking requirements recommended as part of the *CFP* documentation. The *CFP* also includes a summary of desired data quality standards to facilitate the creation of highly accurate performance measurements.

## **4.2 Preliminary Intelligent Transportation System Performance Measures**

In July 2003, the Florida Transportation Commission (FTC) requested that ITS performance measures be developed for the statewide ITS Program by July 2004. The preliminary measures, and the associated issues and activities related to their development are presented below.

An ITS Performance Measures Workshop was held in Orlando on October 14-15, 2003. Attendees included representatives from all seven FDOT District offices, Florida’s Turnpike Enterprise, the FDOT Systems Planning Office (SPO), and the FDOT Traffic Engineering and Operations Office (TEOO). During the Workshop, concurrence was achieved concerning several performance measure-related issues.

- The development of ITS performance measures is an ongoing process that will be solidified as more ITS infrastructure is deployed over a larger area and across other modes of travel throughout Florida. (Greater proliferation of integrated ITS is expected to provide greater benefits and the ability to document the benefits.) Major focus now is the interstate system, and selected corridors and intersections.
- Intelligent transportation system performance measures should be able to measure success in meeting the FDOT TEOO’s ITS Section goals and objectives.
- Even though ITS performance goals have not yet been formally established in Florida, it is generally believed that ITS will be viewed as an operational tool to better manage congestion.

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- It will be difficult, but not impossible, to isolate the benefits derived solely from ITS deployment.
- Incident response time is more indicative of ITS performance than incident clearance time.
- Deployment tracking measures may be more appropriate now, but as ITS deployments become more extensive throughout the state, evolving measures should be targeted more towards reporting actual performance.
- Performance measures can be used to justify the need for dedicated funding sources.
- Any measure that can be reported in economic terms, such as dollars saved or budget amounts reduced, will be much more effective. Benefit-to-cost ratios are not performance measures; they should be used for deployment analysis only.
- Intelligent transportation system performance measures selected for reporting should minimize or eliminate the need for additional data to be collected, and should be stated in terms that are easily understandable to policymakers and the general public.
- The current FDOT Customer Satisfaction Survey<sup>11</sup> should be modified to include questions related to the value placed on the information provided by ITS.
- As ITS performance measures are identified, they will fall into one of three categories or levels: primary measures, which will be chosen for inclusion in the FTC’s *Statewide ITS Performance Measures Final Report*<sup>12</sup>; secondary measures, which are those that will provide more comprehensive detail of impacts for project managers; and tertiary measures, which will be used by the FDOT internally.
- Besides actual measures of performance, it will also be important to report ITS benefits through the use of simplified case study examples, such as the feedback from **SunPass**<sup>®13</sup> and Road Ranger customers.

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<sup>11</sup> More information regarding the FDOT’s Customer Satisfaction Survey is available online at [http://www.dot.state.fl.us/planning/customers/customer\\_survey.htm](http://www.dot.state.fl.us/planning/customers/customer_survey.htm).

<sup>12</sup> Florida Transportation Commission, *Statewide ITS Performance Measures Final Report* (November 2004). Available online at [http://www.dot.state.fl.us/trafficoperations/its/its\\_default.htm](http://www.dot.state.fl.us/trafficoperations/its/its_default.htm).

<sup>13</sup> **SunPass** is a registered trademark of the Florida Department of Transportation.

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- Specific and detailed project performance measurements, and the selection of specific project performance measures, should be determined by each District for internal monitoring purposes, but the FDOT should develop understandable standardized measures to report general statewide ITS performance.

Recommendations stemming from the ITS Performance Measures Workshop included the following:

- Modest, simple performance measures will be most appropriate at this time.
- Year 2005 should be established as the “baseline year” for measuring and comparing ITS performance throughout Florida.
- A statewide workshop should occur each year to review and assess performance, and to modify statewide performance measures as needed.

Recommended measures developed as part of the ITS Performance Measures Workshop included:

- Total annual number of 511 calls by hour of the day (by location to be defined);
- Total annual number of Road Ranger assists (by location to be defined);
- Average annual incident response time on limited-access miles managed using ITS, by District and statewide;
- Percent limited-access miles managed using ITS, by District and statewide;
- Travel time for peak period(s) on limited-access miles managed using ITS, by District and statewide;
- Average annual passenger-hours of delay on limited-access miles managed using ITS, by District and statewide;
- Percent automatic vehicle location (AVL)-equipped transit fleet, statewide; and
- Percent of eligible signalized intersections on state facilities that have operational transit signal priority (TSP) systems, statewide.

Data collection and testing of preliminary performance measures is being conducted, and final ITS performance measure recommendations were prepared in July 2004 for consideration by the FTC.

## 5. Recommendations for Supporting the Design and Implementation of an Intelligent Transportation System Performance Monitoring and Measurement Program

An effective performance monitoring and measurement program will play a crucial role in the FDOT’s achievement of its goals for the statewide ITS Program. Over time, performance measures will become the fundamental tools upon which FDOT policies will be set and limited resources will be allocated. The FDOT has previously identified a set of performance measures in the *CFP* that were based primarily on objectives identified in *Florida’s Intelligent Transportation System Strategic Plan* and FDOT’s *Mobility Performance Measures Program*. In addition, the FTC has asked the ITS Florida Advisory Committee to identify performance measures that assess the effectiveness with which various ITS technologies are having a positive impact on Florida’s transportation system. The measures the Advisory Committee recommended were published in the FTC’s *Statewide ITS Performance Measures Final Report*, with updates published as implementation progresses.

As a great deal of work is underway to develop ITS performance measures for Florida implementation, the recommendations below identify actions the FDOT can take to support performance measure design, implementation, and usage.

- *Achieve consensus on performance measures to be implemented.* A set of proposed performance measures was developed as part of the FDOT’s *CFP*. The FTC is also considering another set of ITS performance measures for use in Florida. No matter which measures are implemented, they should subscribe to the following criteria:
  - Focus on evaluating the level of success achieved pursuing the goals and objectives outlined in *Florida’s Intelligent Transportation System Strategic Plan*.
  - Metrics should be based on a consensus of opinion; failure to do so may result in lack of use.
  - A baseline must be established against which future results are compared.
  - Implementation of any plan for ITS performance monitoring and measurement must be systematically organized so as to be consistently repeatable.
  - Implemented measures should not be considered final; that is, their development should be looked upon as an ongoing process.
  - Implemented measures must utilize reliable, equivalent data sources.

- *Seek to enlarge roadway sensor data collection coverage.* To effectively utilize adopted performance measures for evaluating the statewide transportation network, it is first necessary to have access to sufficient data concerning roadway operations. Although the FDOT and other public agencies are beginning to make inroads pertaining to roadway data collection capability across Florida, a more coordinated effort is needed to ensure that sufficient data is available to support the development of a truly comprehensive picture of systemwide performance. In particular, enhancements in data collection capability will be required along both the Florida Intrastate Highway System (FIHS) and major arterial roads. To achieve this goal, the FDOT should work with its partners to: a) assess current data collection capabilities in Florida; b) determine where data collection capability is insufficient; and c) develop a plan for deploying supplemental infrastructure to fill the “gaps.” Finally, the data types collected by such supplemental infrastructure should be standardized to the maximum extent possible to establish the groundwork for objectively comparing roadway performance throughout Florida. In pursuing this effort, the FDOT should consider making use of innovative data collection technologies to the greatest extent feasible.
- *Ensure that data collected from roadway sensors is archived and readily available for analysis.* Much of the data collection infrastructure currently deployed in the field is not connected to archiving systems, or is not available in formats that can be readily utilized by a wide range of users. Consequently, the FDOT should work with other public stakeholders to expand the archiving of field sensor data, keeping in mind not only the need for storage, but also the need to make such data available in a standardized format. Such standardization will help promote the storage and analysis of data by a wider range of interested parties in both the public and private sectors. This concept should play a key role in the development of requirements for any new infrastructure deployed as part of Recommendation 2.

- *Improve the maintenance and calibration of data collection equipment and standardize the processes for managing “bad data.”* It is commonly accepted that much traditional roadway-based data collection infrastructure suffers from significant service outages during which no data is collected or only “bad” data is generated. Some of the missing or inaccurate data are easy to detect and correct, others less so. In developing performance monitoring and measurement metrics, some consideration should be given to standardizing both the processes through which raw or fused data for performance evaluation is validated (i.e., inspected), as well as what actions are taken to manage such data quality problems. This effort should include the development of data quality guidelines to support data analysis, such as the Intelligent Transportation Society of America, or ITS America™<sup>14</sup> guidelines defined in *Closing the Data Gap: Guidelines for Quality Advanced Traveler Information System (ATIS) Data*.<sup>15</sup> As with Recommendation 3, such standardization is necessary to help ensure consistent results.

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<sup>14</sup> ITS America is a trademark of the Intelligent Transportation Society of America.

<sup>15</sup> ITS America and the United States Department of Transportation, *Closing the Data Gap: Guidelines for Quality Advanced Traveler Information System (ATIS) Data, Version 1* (September 2000). Available online at [http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPT\\_MIS/13580.html](http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPT_MIS/13580.html)