Establishing Performance Measures for Alabama's Transportation System

Final Report for:
Alabama Department of Transportation
Research Project 930-698

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February 19, 2009

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December 11, 2008

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1. Executive Summary

The goal of this research is the establishment of a set of measures that will allow the agency to answer the following questions:

- How can we improve the performance of Alabama's transportation system to enhance service to individuals and businesses in the state?
- What is the return on investment to Alabama from improvements to the transportation system?
- Are investments in the transportation system being made as effectively and efficiently as possible?

Along with answering these questions, performance metrics will provide ALDOT with the capability to track transportation system performance over time in relationship to short-term and long-term goals and objectives. At the November 2000 conference, *Performance Measures to Improve Transportation Systems and Agency Operations*, Pickrell and Neumann listed six fundamental reasons for adopting performance measures (4):

- Accountability
- Efficiency
- Effectiveness
- Communications
- Clarity
- Improvement

There simply cannot be improvement without measurement. Performance measurement is typically successful when meaningful measures are selected, the proper data needed for the measurement is obtained, and the measurement is incorporated into an overall planning process that guides decision making based off the measurement.

The result of this research project is a suggested set of performance measures that ALDOT can begin to use to quantify the performance of Alabama's transportation system:

- Safety
- Need vs. Wants
- Economic Development
- System Preservation
- Percent of System Congested
- Travel Cost
- Vehicle Occupancy
- Traffic count
    - Vehicles
- Passengers
    - Freight
- VMT

- Travel Time
- Speed
- Density
- Recurring Delay
- Duration of
- Congestion
- Travel Time
- Reliability
- Number of incidents
    - Weather-relatedtraffic incidents
    - Rail grade crossings
- Duration of delay caused by incidents
- Response time to incidents
- Commercial vehicle safety violations
- Security for highway and transit
- Weather-related route closures
- Evacuation times
- Toll
    - revenue
    - delay from toll collection
    - delay from incidents
- Operating budgets
- Maintenance funds
- Construction costs
- Schedule Compliance
- Budget Compliance
- Compliance w/ FHWA Regulations & SAFETEA-LU
- Annual Reports to FHWA, legislature
- Effectiveness of Project Based on Reduction of Crashes, Fatalities
- Public Opinion/Approval

The recommendations for next steps include:

1. **ALDOT Performance Improvement Steering Committee**
2. **Pilot Implementation of Performance Measurement System**
3. **Statewide Intelligent Transportation System**

2. Introduction

The purpose of this project was to research current transportation system metrics and develop a set a performance measures appropriate for establishing the level of performance for Alabama's multimodal transportation system and the effectiveness and efficiency by which it is able to supply reasonable user access to jobs, goods, and services (both public and commercial). The multimodal transportation system was defined as the roadway network used by passenger cars, mass transit systems, and freight vehicles, the railway network used for passenger and freight movement, the navigable inland waterways, and general aviation.

Although performance measures have been applied to state transportation systems since the 1950's, they became more widely used after the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991 and finally became required by the Government Performance and Results Act (GPRA) of 1993. However, as stated by Pratt and Lomax in their article "Performance Measures for Multimodal Transportation Systems" (Transportation Research Record 1518, 1996):

> "Change is coming … performance measures are being put to broader uses. The goals and objectives with which they are being paired have been augmented or changed. A measure designed to gauge the achievement of vehicular flow is not necessarily going to be a good measure for assessing the satisfaction of reasonable access to jobs, goods, and services with the least social cost."

Since access to an efficient transportation system has proven to be necessary to promote economic growth and development within a region, it is essential that the performance measures used by Alabama are chosen with that goal in mind. It is also important to choose metrics appropriate to the needs of the intended audience: the state government, the state legislature, ALDOT management and staff, elected officials, and the public at large.

2.1 Why are Performance Measures Important?

Over the last two decades, due to the legislation of the early 1990s, the development and execution of performance measures and performance-based management have been at the core of national and state transportation policy. Performance measures and management strategies have long been utilized by the private sector (1) and are being incorporated within the public sector to provide a means to assess the success or failure of projects/initiatives (2). Performance measures are important because they allow the stakeholders in the transportation system to get more value from the dollars spent, taking special significance when considering the diverse nature of potential transportation stakeholders that have interest in the system performing well (commuters, state and local governments, trucking companies and associated customers, emergency response personnel, law enforcement, and environmental groups to name a few) (3).

The importance of performance measures have been studied by many researchers across a variety of disciplines. Most notably, the works of Pickrell and Neumann (3) (4) (5) (6) have been a frequently referenced guideline in describing the values and capabilities of performance measures. At the November 2000 conference, *Performance Measures to Improve Transportation Systems and Agency Operations*, Pickrell and Neumann listed six fundamental reasons for adopting performance measures (4):

- **Accountability:** Performance measures can indicate how well an organization is meeting its planning goals (5). Since funding is typically limited for transportation improvements and transportation projects can have significant environmental implications, data that can link performance to priorities is important.

- **Efficiency:** Performance measures can guide the allocation of resources to areas that need the most immediate attention as well as divert resources from failed programs (5). Performance measures also provide for benefit/costs and other trade-off type analyses that can determine which projects have the highest return per dollar invested or which projects can provide a more timely response to transportation needs (7).

- **Effectiveness:** Performance measurement can provide a means to rate system performance against established benchmarks that define expected performance standards (such as 90% of all bridges should meet a certain structural condition) (8). Effective programs allow for the allocations of funding resources and managerial decisions to be based on performance measurement (7).

- **Communications:** Performance measures allow for easier communication and potential support of transportation policy to the diverse audiences that exist both inside and outside the agency (5). In addition, receiving feedback from the users of the transportation system can allow for refinement of performance measures in order to capture the most relevant information.

- **Clarity:** Performance measures can simplify existing programs by establishing clear links between goals and projects to see which methods best improve performance. Also, transparency of project selection when relying on performance measures can help to build trust among stakeholders.

- **Improvement:** Performance measures provide a decision-making tool that can help identify system deficiencies and opportunities for improvement (9). Additionally, the establishment of benchmarks amongst performance measures can help identify specific programs that may be successful in one state or region and easily adaptable to another.

Performance measurement is typically successful when meaningful measures are selected, the proper data needed for the measurement is obtained, and the measurement is incorporated into an overall planning process that guides decision making based off the measurement. In many cases, agencies have collected performance data, such as vehicle

collisions at an intersection or incident clearance times, but only recently has a push existed to link the collected data with programming to achieve established benchmarks.

As public transportation agencies have moved forward with performance measures, the primary focus has been on passenger car-related performance, but recently other areas, such as freight movement, have become more important (10). Performance measures allow for agencies to manage to plans that have been selected due to their ability to achieve high-level performance in areas that the users/owners of the transportation system have deemed important (3).

3. Literature Review

In order to effectively determine which performance measures were appropriate for Alabama's transportation infrastructure, it was necessary to examine the existing research and literature on performance measures. Several other state DOTs have well-established performance measurement systems from which best practices can be learned. NCHRP has also sponsored several research projects to determine how performance measurement can and should be applied to the roadway system.

3.1 NCHRP Documents Address Transportation Performance Measures

In developing performance measures for ALDOT, the research team consulted *NCHRP Report 446: A Guidebook for Performance-Based Transportation Planning* and *NCHRP Synthesis 311: Performance Measures of Operational Effectiveness for Highway Segments and Systems*. These comprehensive documents provide a wealth of information regarding the development of performance-based measurement programs and provide needed insight into the state of the practice and recommendations for the future. Though some overlap exists between these documents, *NCHRP Report 446* provides broad guidelines for instituting performance measures into existing planning programs while *NCHRP Synthesis 311* provides more tangible detail regarding the selection and usefulness of specific measures for highway applications. Both documents provided needed guidance in developing this report.

3.1.1 NCHRP Report 446

Published in 2000, *NCHRP Report 446* addresses the incorporation of performance measures into a broader performance-based planning process. The purpose of the report is to offer flexible, widely applicable guidance for establishing performance-based planning that can be applied to diverse audiences (State DOT's, MPOs, county and local governments, transit agencies, special transportation commissions, policy boards or management agencies). *NCHRP Report 446* can be classified into two major components – the first of which describes an overarching framework and development process, and the second discusses data collection procedures (including freight) and analytical tools that may be useful for interpreting data. An eight-step development procedure is described in detail for setting up a process to incorporate performance measures into system planning.

The steps include the following:

Step 1: Getting Started

This step includes setting up a project team, developing a mission statement, developing a budget, and making a schedule for completion.

Step 2: Select Application

This step determines the scope of the project - such as a statewide or regional plan, corridor study, strategic business plan, or transit system route planning and operations.

Step 3: Develop a Working Group

This step requires the selection of a group that will develop the plan – careful consideration should be given to ensuring consistent participation amongst group members in addition to group breadth.

Step 4: Develop Goals and Objectives

This step consists of setting goals (defined as general statements of desired function of transportation system), developing objectives (defined as concrete steps toward achieving a goal, stated in measurable terms), potentially setting performance standards or benchmarks for the objectives, and grouping goals and objectives into categories (such as mobility, safety, and economic development).

Step 5: Develop Performance Measures

This step calls for the classification of the dimensions of the performance measure (e.g., what mode, level of responsibility or time frame should be measured?), the development of selection criteria for the performance measures (e.g., is the characteristic controllable by the agency doing the measuring?), and consideration of developing composite performance indices, such as an index value to asses mobility.

The plan should distinguish between output-based measures (e.g., money spent on alcohol education programs) and outcome-based measures (e.g., percent of accidents that are alcohol related).

Step 6: Identify Data Needs

This step involves considering existing data sources and evaluating the potential for other sources.

Step 7: Identify Analytical Tools

This step involves selecting tools that have the capability of calculating a particular measure, such as Geographic Information Systems (GIS), traffic flow simulation models, and capacity and delay modeling packages.

Step 8: Report Results

This step calls for the generation of "report cards" issued to various levels of agency management, the general public, and system users.

NCHRP Report 446 also lists and describes the procedures needed to acquire performance data. Various types of survey methods (e.g., workplace, transit on-board, truck, and parking) are detailed as well as traffic data collection procedures, customer satisfaction polling, and national databases compiled by the Federal Highway Administration, such as the Highway Performance Monitoring System (HPMS).

The document also describes the existing and future applications for Intelligent Transportation Systems (ITS) data. Since ITS can collect continuous, highly-detailed data, these systems offer much promise in easing and improving the collection process as well as offering objective, expedient feedback to gauge program performance. Additionally, issues with freight data are addressed, including existing collection methods and data shortcomings and deficiencies.

Table 1 (replicated from NCHRP Report 446) details the public sector needs for performance-based planning. Among the freight data needs that are currently deficient among many State DOTs and MPOs are the number of trucks and type of commodity delayed by traffic congestion, time of day information regarding truck traffic within intermodal facilities, accident data regarding type of trucks and associated industry costs, and the value of freight flowing into and out of metropolitan areas.

Table 1. Public-Sector Freight Data Needs for Performance-based Planning

Function	Data Needs	Support for Performance-Based Planning
Congestion Management	Truck-hours of travel	Understand impact of congestion on goods movement
	Average truck speed	
	Added truck-hours due to congestion	
	Truck transport cost	
	Added cost due to congestion	Understand contribution of trucks to urban congestion and air quality problems
	Transport time reliability	
	Types of trucks and commodities caught in congestion	
	Energy consumption for trucks	

	Emissions rates for trucks	
Intermodal Access	Volumes of truck entering or exiting an intermodal facility	Identify land-side access improvement needs
	Variability in demand for, and supply of access to, intermodal facilities	
	Congestion-related delays on access road to the facility	
	Queuing counts related to the capacity of the facility	
	Accident rates on access roads	
	Travel time contours around the facility	
	Number of people living or working within *x* miles of facility	
Truck route designation and maintenance	Truck traffic volumes	Identify high-volume truck routes and corridors
	Origin-destination patterns	Assess pavement damage and replacement needs
	Truck size and weight data	
Safety mitigation	Accident rates	Identify safety hazards and develop mitigation strategies
	Rail-grade crossings	
	Low-clearance bridges	
	Steep grades	
Economic development	Truck volumes	Assess economic benefits and costs of freight transportation investment projects
	Commodity movements	
	Origin-destination patterns	
	Shipping costs	

Though *NCHRP Report 446* is written at a level high enough to provide guidelines for all modes of travel, most of the case studies and examples are oriented towards highway performance measurement. Appendix A, however, provides a list of many known performance measures and is not limited to a highway context. Appendix A was used as a preliminary resource for the research team when considering the potential performance measures relevant to ALDOT.

3.1.2 NCHRP Synthesis 311

NCHRP Synthesis 311 was published in 2003 and seeks to summarize the current knowledge and practice of the use of performance measures for the monitoring and operational management of highways. The document has a narrower scope than *NCHRP Report 446* with most of the content focusing on the key factors for selecting performance measures and which measures have been successfully implemented in practice. *NCHRP Synthesis 311*

presents a literature review of the seminal works on highway performance measures, summarizes the results of a nationwide survey, and lists highlights of federal, state, and local agency practices.

The literature review from *NCHRP Synthesis 311* contains many valuable insights about the selection of performance measures. In separate studies, Pratt and Lomax (1996) and Turner et al (1996) recommended similar key principles and guidelines for instituting performance measures, including matching performance measures with objectives, using common denominators to facilitate comparisons between multimodal systems, remembering the intended audience, and emphasizing the importance of quantification over subjective judgment. Additionally, Lomax et al (1997) in *NCHRP 398: Quantifying Urban Congestion* developed specific performance measures to gauge congestion that include:

- Travel rate in minutes per mile
- Delay rate in minutes per mile
- Total delay in person-hours
- Corridor mobility index (speed of person movement divided by a normalizing value)
- Accessibility, percent of destinations within *x* minutes
- Congested travel in person-miles, sum of congested lengths multiplied by number of persons

Additionally, the literature review indicated that more recent research on highway performance has emphasized a reliance on reliability measurement – namely, the accepted variability between expected travel time and the actual travel time that users of the system experience on a daily basis. Survey data and other research indicate that travel time reliability consistently ranks as one of the most important expectations from system users.

NCHRP Synthesis 311 outlines several research efforts to quantify travel time reliability, including the *Florida Reliability Manual* (2000) and the Texas Transportation Institute's *Urban Mobility Report*. The *Florida Reliability Manual* proposes to classify travel reliability by considering the median travel time across a corridor during a specific period of interest plus an additional amount of time estimated as a percent of the median travel time (such as 15%) that a traveler would find acceptable. Preference surveys are recommended to determine the acceptable additional time depending on the route and community.

Additionally, the *Urban Mobility Report* uses a reliability "buffer index" that is defined as the difference in the average travel rate and the 95th percentile travel rate divided by the average travel rate times 100%. This index is meant to illustrate the extra time that a traveler must budget when traveling during peak periods of the day. In any case, reliability measures are a very important component to any highway performance measurement system.

As mentioned, *NCHRP Synthesis 311* conducted a survey of state transportation agencies and MPOs to determine the state of the practice. The survey covered many aspects of performance measurement, including the agencies' history regarding performance measures, their intended audience, the data collection procedures, how the information is reported, and what measures are used for highway operations.

Among the most notable findings --- the most important type of performance measures collected were those that described *quantity* and *quality* of service. Quantity measures of volume, vehicle-miles traveled, and truck-miles traveled were important to agencies with stated goals of maximizing the movement of people/goods that can use the system. In addition, these basic measures allow for the derivation of important environmental measures, such as fuel consumption and noise and air quality impacts. Measures that describe the quality of travel were also identified by agencies as having a high importance. These measures include highway volume to capacity ratios, delay, speed, travel time, and highway segment level of service. Additionally, several agencies reported measures that relate more to agency output than system-related outcomes. These output measures include performance-based budgeting, percent of railroads with active crossing protection, and the number of signals retimed per year. These measures are less important to the users of the system, but can be very important to agencies in prioritizing goals and allocating funding.

In addition to the survey, *NCHRP Synthesis 311* includes information about specific performance measurement programs instituted by the Federal Highway Administration and several states and cities. For example, the California DOT has a well-established system that seeks to establish performance measures that are outcome-based, multimodal, easy to understand, reliant on existing data, and are able to both monitor and forecast. Table 2 depicts the performance measures used by the California DOT.

Table 2. California DOT's Performance Measures/Indicators

Desired Outcome	Definition	Candidate Measure/Indicator
Mobility/accessibility	Reaching a desired destination with relative ease within a reasonable time, at a reasonable cost with reasonable choices	Travel time
		Delay
		Access to desired location
		Access to system
Reliability	Providing reasonable and dependable LOS by mode	Variability of travel time
Cost-effectiveness	Maximizing the current and future benefits from public and private transportation investments	Benefit/cost ratio

Sustainability	Preserving the transportation system while meeting the needs of the present without compromising the ability of future generations to meet their own needs	Outcome benefit per unit cost
Environmental quality	Helping to maintain and enhance the quality of the natural, physical, and human environment	Household transportation costs
Safety and security	Minimizing the risk of death, injury, or property loss	Accident and crime rates
Equity	Distributing benefits and burdens fairly	Benefits per income group
Customer satisfaction	Providing transportation choices that are safe, convenient, affordable, comfortable, and meet customers' needs	Customer survey
Economic well-being	Contributing to California's economic growth	Final demand (value of transportation to the economy)

Other states of interest that were profiled in the report include Florida and Minnesota. Florida has developed very detailed standards for measuring mobility built around assessing the quantity of travel, quality of travel, accessibility, and system utilization. Minnesota's performance measurement was unique to the research in that it specified freight and intermodal performance among its many measures. The freight performance measures identified include shipper point-to-point travel time, travel time to major regional, national, and global markets (by air, rail, water and truck), shipment cost per mile, and crash rate per mile traveled by freight mode.

Finally, *NCHRP Synthesis 311* provides a summary table (Table 3) that adapts evaluation criteria from various studies to assess the strengths and weaknesses of highway performance measures. The study then used these evaluation criteria to assess the relative value of the nearly 70 performance measures considered in this research. The assessment indicated that the following measures received favorable scores according to the criteria:

- Quantity of travel (user perspective): person-miles traveled, truck-miles traveled, vehicle-miles traveled, persons moved, trucks moved, vehicles moved.
- Quality of travel (user perspective): average speed weighted by person-miles traveled, average door-to-door travel time, travel time predictability, travel time reliability, average delay, and level of service.
- Utilization of the system (agency perspective): percent of system heavily congested, density, percentage of travel heavily congested, volume to capacity ratio, queuing,

percent of miles operating in desired speed range, vehicle occupancy, duration of congestion.

- Safety: incident rate by severity or type.
- Incidents: incident induced delay and evacuation clearance time.
- Outputs (agency performance): incident response time by type, toll revenue, bridge condition, pavement condition, percent of ITS equipment operational.

Table 3. NCHRP Synthesis 311 Evaluation Criteria

NCHRP Synthesis 311	
General Criteria	**Specific Criteria**
Clarity and simplicity	The measure is simple to present, analyze, and interpret
	The measure is unambiguous
	The measure's units are well defined and quantifiable
	The measure has professional credibility
Descriptive and predictive ability	Technical and nontechnical audiences understand the measure
	The measure describes existing conditions
	The measure can be used to identify problems
	The measure can be used to predict change and forecast condition
Analysis capability	The measure reflects changes in traffic flow conditions only
	The measure can be calculated easily
	The measure can be calculated with existing field data
	There are techniques available to estimate the measure
	The results are easy to analyze
Accuracy and precision	The measure achieves consistent results
	The accuracy level of the estimation techniques is acceptable
	The measure is sensitive to significant changes in assumptions
	The precision of the measure is consistent with planning applications
	The precision of the measure is consistent with an operation analysis
Flexibility	The measure applies to multiple modes
	The measure is meaningful at varying scales and settings

3.2 Performance Measurement in Non-Highway Modes

The transportation system includes not only highway transportation, but also rail, water, air, and intermodal transport. While the literature on performance measurement in these alternate modes is not as abundant as in the highway modality, there are several examples available of performance measurement applications. The research team reviewed these examples to document the state of performance measurement in the multiple transportation modes present in Alabama.

3.2.1 Rail Performance Measures

Rail performance measures were gathered from two major railroad organizations; the Association of American Railroads (AAR) and the Federal Railroad Administration (FRA). The Association of American Railroads tracks freight performance such as the types of railcars used by a particular class I railroad or the number of terminal dwell hours. The AAR publishes these types of performance measures for each of the major class I railroads weekly on their performance measurement website (www.railroadpm.org). The FRA tracks safety performance measures such as equipment-caused train accidents and grade crossing incidents. A complete list of the performance measures currently tracked by each organization can be found in Appendix A.

The research team also looked at the NCHRP Report 446 which includes a broad range of performance measures for the railroad industry and is compiled from various research reports documenting state and local practices. NCHRP 446 lists dozens of potential rail measures across several categories, including system preservation (e.g., measures of track condition) and operational efficiency (e.g., rail revenue versus operating expenses). The complete list of rail performance measures can be found in Appendix A.

3.2.2 Waterway Performance Measures

Waterway performance measures were compiled from the US Department of Maritime Administration (MARAD) and the US Army Corps of Engineers (USACE) – Mobile District as well as the NCHRP Report 446. MARAD measures waterway and port performance such as the number of foreign and domestic container imports and exports. Many of their performance measures can be found in the US Water Transportation Statistical Snapshot which highlights major changes occurring in the water transportation industry. While the MARAD data focuses primarily on port trade, the USACE performance measures are more concerned with inland waterways, dams, and locks. The USACE collects measures of mobility (e.g., delay at locks/dams), system preservation (e.g., dams needing structural upgrades), safety (e.g., collisions/maritime injuries), and economic development (e.g., cargo volume). The NCHRP Report 446 includes several areas of waterway performance measurement not covered by the MARAD or USACE, including customs/administrative processing time, number of miles needing dredging, and percent of on-time performance. It is important to note that while the NCHRP document details a large number of measures, many states do not track waterway performance.

A complete list of the performance measures from each source can be found in Appendix A.

3.2.3 Air Performance Measures

Air performance measures were gathered from the Federal Aviation Administration (FAA), The Huntsville International Airport, NCHRP Report 446, and *"Aviation System Performance Measures"* by Geoffrey D. Gosling. The FAA tracks performance measures such as departures, arrivals, and seating capacity for each airport. Huntsville International Airport collects many of the same performance measures as the FAA as well as additional passenger, cargo, and military metrics. The NCHRP Report 446 lists a broad range of

performance measures for air transportation many of which are found in the Gosling paper. These two documents contain comprehensive lists and include measures of mobility, accessibility, reliability, economic development, sustainability, safety, and environmental conservation. The Gosling paper differentiates the performance measures specific to commercial airports and general aviation airports, which have differing operating characteristics.

A complete list of the performance measures from each source can be found in Appendix A.

3.2.4 Intermodal Performance Measures

Intermodal performance measures were gathered directly from the Huntsville Intermodal Center as well as the NCHRP Report 446. The Huntsville Intermodal Center collects basic information for performance measurement including the number of inbound and outbound train loads and truck gate activity. The NCHRP Report 446 includes a wide variety of intermodal related performance measures such as the transfer time between modes, number of accidents per intermodal transfer, and dwell time.

A complete list of the performance measures from each source can be found in Appendix A.

4. Short & Long Term Goals

Outlined in the research proposal for Task 1, the research team indicated a need to identify short-term (less than 5 years) and long-term (greater than 5 years) goals and objectives for the performance of the multimodal transportation system in Alabama. The multimodal transportation system includes the roadway, railway, and waterway networks used for moving people and goods to destinations throughout the state.

4.1 ALDOT Baseline

The first step in any performance improvement process is to document the current or baseline state of the system. This task was accomplished during the initial Project Advisory Committee meeting, which was attended by Don Vaughn (Chief Engineer), Bob Jilla (Head of the Multimodal Planning Bureau), and other PAC members representing the various Bureaus. During this meeting, the PAC members clarified the ALDOT environment for the research team, indicating that ALDOT goals and objectives are not necessarily based off of an arbitrary time requirements, but instead are governed by either strategic or project-level decision needs.

Strategic goals are employed to help ALDOT employees determine which projects need to be undertaken given the time and budget constraints in any given fiscal year. The three major strategic initiatives used at this decision-making level are:

- Safety Improvements
- Demonstrated need versus local/regional community “wants”

- Support for economic development

At the time of this meeting, Don Vaughn indicated that a fourth strategic initiative was gaining in importance, and would join those three in the very near future:

- System preservation

Short-term or project-level goals were identified through discussion with PAC members include:

- Schedule compliance
- Budget compliance
- Accident rates after project completion (used during project cost justification)
- Fatality rates (measured separately from accident rates)
- Compliance with FHWA and SAFETEA-LU regulations
- Annual reports to FHWA and Alabama governor/legislature
- Public opinion/approval

The two types of goals, strategic and project, are used in conjunction. Essentially, the strategic initiatives are used to determine which projects are funded through state funds. Projects are evaluated on their potential to achieve success in each of the four strategic areas, and the strongest contenders are more likely to be funded than not. Of course, there are political maneuverings that can adjust the attractiveness of a potential project, no matter what the potential strategic values are. The political interests can be influenced at both the state and local level by state representatives, regional planners, interest groups, MPO officials, and also at the congressional level though participation in funding committees. Once the projects have been selected, the primary performance drivers are schedule and budget compliance and achievement of safety goals used during project selection.

Figure 1. ALDOT Goals & Objectives Chart

At the time of this research project, ALDOT has not set specific goals for the each of the individual components of the multimodal transportation system. The same strategic goals are used by all modalities; however, the project-specific measures used by aeronautics differ from those used by the roadway divisions. These differences have evolved from the

physical nature of the underlying systems rather than from a management decision to treat the two modalities independently. An example of the differences would be that aeronautics tracks measures such as cost per square feet of runway paved, which the roadway divisions track the cost of time and materials to repave a section of roadway to an acceptable level of service.

5. Performance Measures Currently Used By ALDOT

Based on the performance measures documented in the literature review, the research team developed a list of 29 performance metrics commonly used in highway systems which also had parallel implementation in alternate transportation modes. The state of ALDOT's current use of performance metrics was then documented through the use of a survey instrument based on this subset of performance measures (see Appendix C for survey). The survey questions were organized into seven categories: Operations, Level of Service, System Measures, Safety, Environmental, Toll, and Financial.

The ALDOT Planning, Construction, Maintenance, Bridge, Design, and Aeronautics Bureaus were surveyed, and the responses were confirmed during a follow-up meeting with the Project Advisory Committee. The survey results and follow up meeting indicated that performance measures used by ALDOT are not systematically collected and archived for analysis, but instead are primarily collected and used on a project-based schedule.

Traffic count, construction costs, and number of safety incidents were reported as the primary measures by bureaus outside of Planning but none of those departments actually collected metrics. Planning, however, collected metrics in all seven categories and provided the data that was needed to the other bureaus as necessary. The performance measures reported in the survey responses are as follows:

- Traffic Count
- Construction Costs
- Number of Safety Incidents
- Vehicle Miles Traveled
- Travel Time
- Speed
- Density (passenger cars per hour per lane)
- Level of Service
- Travel Time Reliability
- Percent of System Congested
- Travel Costs
- Vehicle Occupancy
- Weather-related Traffic Incidents
- Rail Grade Crossing Incidents
- Duration of Delay Caused by Incidents
- Response Time to Incidents
- Commercial Vehicle Safety Violations
- Security for Highway and Transit
- Weather Related Road Closures
- Response Time to Weather-Related Closures
- Evacuation Times
- Toll Revenue
- Operating Budgets
- Maintenance Funds

The Maintenance Bureau is an exception to this general finding; during the time of this research project, Maintenance was using an automated computer system called the "Maintenance Management System" (MMS). This system collected and made available information on labor, equipment, and materials cost and usage. During a telephone interview with a representative from the Maintenance Bureau, it was indicated that an update to MMS was imminent, after which the system was hoped to include information pertaining to Quality Assessment/Assurance and Condition Assessments of Assets to trigger maintenance activities.

It is important to note that the Bureaus surveyed are currently dedicated almost exclusively to the roadway system. ALDOT currently has an Aeronautics Bureau, but their role in developing the state transportation system is limited to general aviation. They currently do not interact with commercial aviation facilities. Likewise, there is a Rail Division, but those personnel are limited by the lack of state involvement in the private rail industry and have little power over the decisions made and implemented by the various rail companies operating in the state. There is no bureau dedicated to the waterway system, nor one to intermodal connectivity.

6. Research Process

After the literature review and the survey responses were analyzed, the research team reviewed the preliminary results with the PAC. Based on the feedback from the PAC, the research team then performed a gap analysis to determine the difference between the measures that ALDOT currently tracks and the measures the research team believed were most appropriate to determine system performance.

6.1 Selection of Performance Measures

The first step in building the list of most appropriate measures was to examine the measures listed in NCHRP 311. There are 26 measures listed in the survey that NCHRP gathered from state DOTs across the United States. These measures, shown in Table 4, were all included in the survey of the ALDOT Bureaus. In addition, the survey included financial measures: operating budgets, maintenance funds, and constructions costs.

The Transportation Research Board's National Cooperative Highway Research Program (NCHRP) Synthesis 311 published in 2003, is a compilation of performance measures for evaluating the operational effectiveness of highway segments and systems. NCHRP 311 was based on research into the performance measures used by state departments of transportation, metropolitan planning organizations, and local governments. The report provides information on over 70 performance measures identified by the NCHRP research panel. It also provides information on the use and collection of performance measures and an assessment of strengths and weaknesses of specific measures. Because of the reasonably comprehensiveness of NCHRP Report 311, the UAH –OFLT team chose to use it as the basis for their study of performance measures useful for managing the Alabama Department of

Transportation (ALDOT). The NCHRP 311 survey listed 26 performance measures that were utilized in this study. These measures, shown in Table 4, were chosen because they were of the greatest relevance to ALDOT.

Table 4. NCHRP 311 Performance Measures

Performance Measure	Definition
Traffic count	annual average daily traffic, peak-hour traffic, or peak-period traffic
Vehicle-miles traveled	volume times length
Travel time	distance divided by speed
Speed	distance divided by travel time
Density	passenger cars per hour per lane
Recurring delay	travel time increases from congestion but does not consider incidents
Level of service/Highway Capacity Manual	qualitative assessment of highway point, segment, or system using "A" (best) to "F" (worst) based on measures of effectiveness
Duration of congestion	period of congestion
Travel time reliability	several definitions are used that include (1) variability of travel times, (2) percent of travelers who arrive at their destination within an acceptable time, and (3) range of travel times
Percent of travel congested	Percent of vehicle-miles or person-miles-traveled
Percent of system congested	percent of miles congested (usually defined based on Level of Service)
Travel costs	Value of drivers time during a trip and any expenses incurred during the trip (vehicle ownership and operating expenses, tolls, or tariffs)
Vehicle occupancy	Persons per vehicle
Number of incidents	Traffic interruption caused by a crash or other unscheduled event
Weather-related traffic incidents	Traffic interruptions caused by inclement weather
Rail grade crossing incidents	Traffic crashes that occur at highway-rail grade crossings
Duration of delay caused by incidents	Increase in travel time caused by incidents
Response times to incidents	Period required for an incident to be identified and verified and for an appropriate action to alleviate the interruption to traffic to arrive at the scene
Commercial vehicle safety violations	Number of violations issued by law enforcement based on vehicle weight, size, or safety
Security for highway and transit	Number of violations issued by law enforcement for acts of violence against travelers
Weather-related road closures	Traffic interruption caused by inclement weather
Response time to weather-related closures	Period required for an incident to be identified and verified and for an appropriate action to alleviate the interruption to traffic to arrive at the scene

Evacuation times	Reaction time and travel time for evacuees to leave an area at risk
Toll revenue	Dollars generated from tolls
Delay from toll collection	Increase in travel time caused by toll collection
Delay from incidents	Increase in travel time caused by incidents

There are other metrics in NCHRP 311 and in the literature review that were deemed inapplicable or not useful to ALDOT in measuring Alabama's transportation system performance at this time. These include items such as road closures due to snow and ice, efficacy of freight movements, HOV lane performance, equipment inventories (ramp meters, snowplows), incident detection, accessibility, annual hours of delay, delay at border crossings, wetland replacements, percent-miles bicycle and pedestrian accommodations, and duration of congestion. These metrics are all important and can help ALDOT personnel with decision-making and should be revisited at a later date once a more basic performance measurement system has been established.

One final measure that was included in the final list of suggested metrics is public opinion/approval. Although it is not directly tied to determining the system performance level, public opinion is of vital importance to ALDOT's ability to maintain and increase the funding levels and support necessary to effectively perform their stated mission.

6.2 Gap Analysis

In Task 4, the research team performed a gap analysis comparing the metrics necessary to measure desired system performance and the metrics currently being collected and used.

Based on the preliminary feedback from PAC members, the research team was able to make some general assessments about the state of performance measurement at ALDOT, as shown in Figure 2 below:

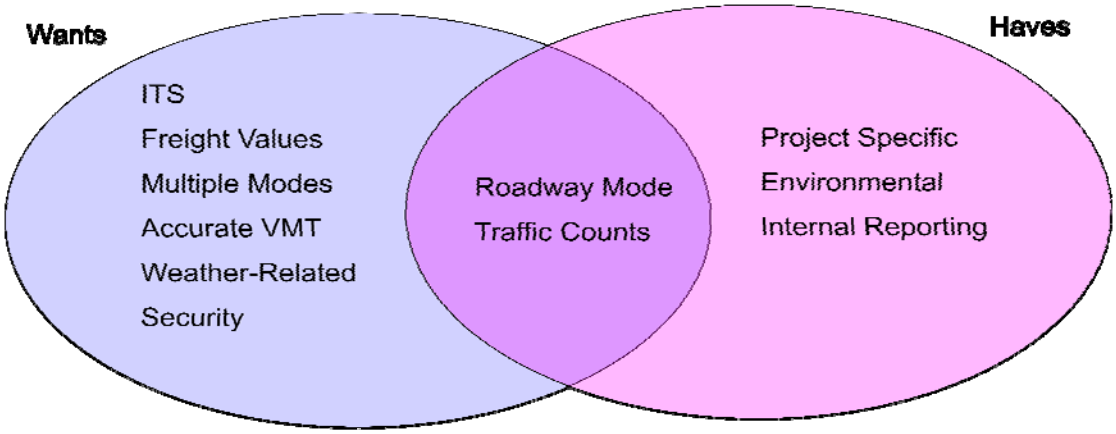

Figure 2. ALDOT Current State of Performance Measures

After the preliminary list of performance measures was reviewed by the Project Advisory Committee, the research team took the remaining metrics and compared them to the survey results and PAC review. The gap analysis that was performed looked at two questions: first, was the metric under consideration currently collected and/or analyzed by ALDOT and second, what method was used to collect and/or analyze the data.

The first subset of performance metrics is the set of strategic level objectives(Table 5). Information on System Safety and System Preservation are directly collected and used by ALDOT personnel. In the comparison of System Needs versus Wants, metrics such as Return on Investment are calculated during the project evaluation phase, but some subjective decisions are also involved in determining whether or not to undertake a project. Measuring Economic Development is even more subjective, since there are many methods used but no industry standard to determine the impact of a construction project on a local economy. Some estimates can (and are) made during both the project proposal evaluation and after the project has been completed, but these estimates are subject to manipulation from political influence and personal bias.

Table 5. Strategic Metric Subset

Transportation Metric	Method Utilized in Acquisition of Metric Data	Data Tracked & Utilized by ALDOT
Safety	Collected	Yes
Need vs. Wants (Critical System Needs)	Calculated, Estimated	Yes
Economic Development	Estimated	Inconclusive
System Preservation (Maintenance)	Collected, Estimated	Yes

The second subset of performance metrics is related to overall system performance(Table 6). Information on the cost of travel on the system is calculated from base data, but the amount of system congestion and vehicle occupancy measures can only be estimated. The data collection that is currently supported by systematic activities does not yield the necessary data to calculate the results of these measures, and there is no way to directly observe and/or collect that information.

Table 6. System Performance Metric Subset

Transportation Systems Metric	Method Utilized in Acquisition of Metric Data	Data Tracked & Utilized by ALDOT
Percent of System Congested	Estimated	No
Travel Cost (time, fuel, safety, environment)	Calculated	Yes
Vehicle Occupancy	Estimated	No

The third and final subset of metrics is the operational level performance metrics(Table 7). Of special note, several of the performance metrics in this subset are marked with an asterisk. Those metrics could all be collected or calculated if an Intelligent Transportation System (ITS) was in place in the transportation network.

Table 7. Operational Performance Metric Subset

Transportation Metric	Method Utilized in Acquisition of Metric Data	Data Tracked & Utilized by ALDOT
1. Traffic count	---	---
- Vehicles	Collected	Yes
-Passengers	Estimated	No
- Freight	Calculated	Yes
2. VMT	Calculated	Yes
3. Travel Time*	Estimated	No
4. Speed*	Estimated, Calculated	No
5. Density	Calculated	Yes
6. Recurring Delay*	Estimated	No
7. Duration of Congestion*	Estimated	No
8. Travel Time Reliability*	Estimated	No

9. Number of incidents	Collected	Yes
- Weather-related traffic incidents	Collected	Inconclusive
- Rail grade crossings	Collected	Yes
10. Duration of delay caused by incidents	Estimated	Inconclusive
11. Response time to incidents	Estimated	Inconclusive
12. Commercial vehicle safety violations	Collected	Yes
13. Security for highway and transit	Estimated	Inconclusive
14. Weather-related route closures	Collected	Yes
15. Evacuation times	Collected, Estimated	Yes
16. Toll	---	---
- revenue	Collected	Yes
- delay from toll collection	Estimated	No
- delay from incidents	Estimated	No
17. Operating budgets	Collected	Yes
18. Maintenance funds	Collected	Yes
19. Construction costs	Collected, Estimated	Yes
20. Schedule Compliance	Collected	Yes
21. Budget Compliance	Collected	Yes
22. Compliance w/ FHWA Regulations & SAFETEA-LU	Collected	Yes
23. Annual Reports to FHWA, legislature	Collected	Yes
24. Effectiveness of Project Based on Reduction of Crashes, Fatalities	Estimated	Inconclusive
25. Public Opinion/Approval	Estimated	Inconclusive

The above gap analysis is only applicable to the roadway system. There is no gap analysis for the alternate modes because ALDOT does not collect or track any data for non-highway modes except for railway crossing safety/incidents.

7. Final Results/Outcomes

The final step in this research project was to illustrate the use of metrics in the transportation system by employing the Alabama Transportation Infrastructure Model (ATIM) to simulate freight and transportation network activity.

7.1 Application of Performance Measurement in Transportation Modeling

In task 6, the research team used the Statewide Transportation model, developed by UAHuntsville, to illustrate the use of the metrics and show the impact of systemic changes on the transportation system. In order to demonstrate how performance measures can be used in conjunction with traffic simulation to better predict the effect of growth and increased demand for the transportation infrastructure system, the research team exercised the Alabama Transportation Infrastructure Model (ATIM) and observed the impact on the performance measures included in the model output.

The application of the two-pronged modeling approach to evaluate the performance of the transportation system included the base understanding of congestion in the roadway network and forecast of congestion for 2015 – using the Freight Analysis Framework Database Version 2 (FAF2). The base data is derived from 2002 (the base year in FAF2) and was modeled in TRANPLAN as well as in ATIM. With a volume to capacity ratio of 0.9 to indicate congestion, the centerline miles of congestion in Alabama for the base year were calculated by the models and are shown in Table 8:

Table 8. ATIM/TRANPLAN 2002 Centerline Miles of Congestion

2002 Centerline Miles of Congestion	TRANPLAN Model	ATIM Model
Interstate	25	28
US Highways	33	46

The numbers are slightly different due to the method used to assign the trips to the roadway network. The TRANPLAN model allows for path selection to avoid congestion while the ATIM model relies on fixed paths. From the TRANPLAN model, there were 130 lane-miles of congested interstate and 104 lane-miles of congested US Highway.

The anticipated centerline congestion in the system using the FAF2 freight projection data for 2015 and growing passenger cars at the accepted ALDOT rate is shown in Table 9.

Table 9. ATIM/TRANPLAN 2015 Centerline Miles of Congestion

2015 Centerline Miles of Congestion	Tranplan Model	ATIM Model
Interstate	343	305
US Highways	128	138

Figure 3 indicates the location for the congestion identified for 2015.

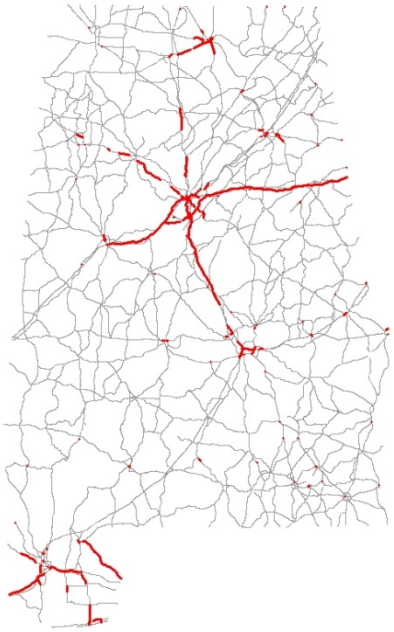

Figure 3. 2015 Centerline Miles of Congestion

It is important that the congestion levels and locations indicated in these tables and via the image are the result ONLY if there is not additional roadway construction efforts performed by ALDOT. Obviously, this is not likely to happen as ALDOT is constantly working to improve roadways through added capacity.

An additional capability of the models to understand roadway congestion is the anticipated travel speed for the selected facilities. Using the ATIM model and examining the output, in 2015 there will be several segments of Interstate 65 and Interstate 20 where the travel time will increase to more than 25 percent versus traveling at the posted speed limit. These increases happen if there are no improvements to the present roadway network, which is known to be untrue.

The ability to model the roadway network is an important performance measurement tool. Understanding the current state of congestion and anticipated state of congestion will allow for improved decisions regarding the investment of scarce ALDOT resources. Having updates to the model run frequently, adjusted to contain the actual capacity of the facilities will help ALDOT personnel determine if the mileage of congestion and travel times are being addressed in an appropriate fashion. Additionally, monitoring of the system will allow ALDOT representatives to justify requests for funds for roadway infrastructure improvements and answer traveler queries as to how they are utilizing public funds.

Unfortunately, the research team realized after two years of continued development of the multi-modal ATIM that the software used to create and run the discrete event simulation, ProModel, was essentially at the limits of its capabilities. The UAHuntsville research team had expanded the functionality of the ProModel program to such an extreme level that several software patches were developed by ProModel technical support technicians to fix problems encountered due to the demands of running the ATIM.

At the same time, the UAH research team was working with researchers from the University of Hamburg on a project involving discrete event simulation and education. The Hamburg team was working in the Java-based programming environment for discrete event simulation. The capability of Java expands the capabilities of discrete event modeling into "agent-based" simulation where each entity in the model is capable of using a logic framework to maneuver the simulated network. This capability overcomes many of the limitations the UAH research team had encountered with ProModel. The decision was then made to pursue an enhanced ATIM Version 2.0 built in a Java environment to continue the development of the capacity and capabilities of the ATIM discrete event simulation.

The UAHuntsville research team has developed a highly flexible and extensible agent-based model of freight traffic on Alabama highways. Agent-based modeling works under the premise that entities in the model are somewhat "intelligent" and have a high level of autonomy. Each agent makes its own decisions as to how it will behave according to a set of internal characteristics and external stimuli. Internal characteristics may include knowledge-base, goals and pre-dispositions; external stimuli may include environmental conditions or "observation" of particular emergent events. Agent-based modeling has been used very successfully for research purposes in a host of different modeled scenarios, including excitable crowd vignettes, urban mass casualty events, and terrorist attacks on airports. In the ATIM V2.0, the agent is the driver of a vehicle; each vehicle has a unique driver agent. The logical distinction between the driver and the vehicle is currently under development and the code set supports such a distinction.

ATIM V2.0 is a powerful, flexible and extensible agent-based model of freight traffic on Alabama roadways. In a few short months, the research team has incorporated a large number of core functionalities ready for verification and validation study. The validated model will allow further development in exciting new areas and expand the capacity to

communicate transportation systems and issues, and potential solutions, to decision makers.

8. Recommendations

8.1 ALDOT Performance Improvement Steering Committee

The first recommendation of the research team is that ALDOT create a steering committee dedicated to supporting the implementation of systematic performance measurement for Alabama's transportation infrastructure. This steering committee should be composed of representatives from each of the ALDOT Bureaus to facilitate participation from all areas. The committee also needs to be composed of individuals in positions of responsibility within ALDOT to ensure that decisions made by the committee be implemented in the most efficient and effective manner.

The Steering Committee has several roles to play. One of the first items to undertake is to establish a vision and strategy for system-wide performance improvement and then communicate that vision and execute the strategy for improvement.

No improvement can happen without measurement, thus the establishment of appropriate performance measures is critical. The Steering Committee would recommend and validate the appropriate measurements for each operation based upon the strategic goals and objectives for each unit.

Standardization of the collection, use and communication of performance measures would then become the goal of the Steering Committee. Recognition of units achieving performance goals then becomes a part of the Steering Committee responsibilities.

8.2 Pilot Implementation of Performance Measurement System

The second major recommendation from this research is that ALDOT pick a Bureau or department to begin pilot implementation of a performance measurement system. During the survey process, several departments indicated that they wanted to pursue more precise performance measurement, but did not have the in-house experience or funding to do so. Once chosen, use historical data to "go back in time" and determine what the performance measure was signaling, then compare that signal to the actual events. In this way the relationship of the performance measure to the outcome can be understood and utilized.

It is important to note that although Performance Measurement will give ALDOT personnel more insight into system behavior and the key pressure points in the system, it does not guarantee that they will be able to influence those behaviors into favorable patterns. For example, ALDOT might have the ability to re-engineer a sharp curve into a less dangerous turn, but they cannot force drivers to not drive under the influence or passengers to always wear their seat belts. To this end, the research team has attempted to classify the amount of control or influence that ALDOT has over the outcomes of each of the suggested

performance metrics. In Table 10, each performance metric is classified as "direct control", meaning ALDOT can change the performance associated with the metric through application of effort, funds, or legislation. A second classification is "indirect", meaning that ALDOT can make changes to the system in an attempt to affect the outcome of the metric, but those changes may or may not have the desired effect, depending on driver behavior and the participation of environmental factors. An example of this is construction costs; ALDOT can consciously choose a least-cost bid in an attempt to control costs, but the current global environment has supported rising construction costs as demand for materials such as oil and steel have increased dramatically and beyond expected levels.

Table 10. ALDOT Influence & Comments for Implementation of a Performance Measurement System

Transportation Metric	Able to Control/Influence Metric	Comments
Safety	Indirect	ALDOT can create or re-engineer safer system components, but cannot change driver behavior.
Need vs. Wants **(Critical System Needs)**	No Control	
Economic Development	Indirect	ALDOT can support economic development efforts, but not generate new projects.
System Preservation **(Maintenance)**	Direct/Indirect I.	ALDOT has direct control over how they choose to spend their budget, but cannot control funding levels.
Percent of System Congested	Indirect	ALDOT can create or re-engineer system components to improve capacity, but cannot change driver behavior.
Travel Cost **(time, fuel, safety, environment)**	Indirect	
Vehicle Occupancy	No Control	
1. Traffic count	---	
- Vehicles	Indirect	ALDOT can encourage car-pooling or use of mass transit, but cannot change driver behavior.
-Passengers	No Control	ALDOT can encourage car-pooling or use of mass transit, but cannot change driver behavior.

- Freight	No Control	
2. VMT	No Control	
3. Travel Time*	Indirect	
4. Speed*	Indirect	
5. Density	Indirect	
6. Recurring Delay*	No Control	
7. Duration of Congestion*	No Control	
8. Travel Time Reliability*	Indirect	
9. Number of incidents	No Control	
- Weather-related traffic incidents	No Control	
- Rail grade crossings	No Control	
10. Duration of delay caused by incidents	No Control	ALDOT is dependent on the response time of highway patrol, paramedics, and fire department personnel to ensure short delay duration.
11. Response time to incidents	No Control	ALDOT and Highway Patrol need to create and enforce a procedure followed by state patrol officers to accurately and consistently measure the start and clearing times of incident responses.
12. Commercial vehicle safety violations	No Control	
13. Security for highway and transit	No Control	
14. Weather-related route closures	No Control	
15. Evacuation times	Indirect	

16. Toll	---	
- revenue	Indirect	
- delay from toll collection	Indirect	
- delay from incidents	Indirect	
17. Operating budgets	Indirect	
18. Maintenance funds	Indirect	
19. Construction costs	Indirect	
20. Schedule Compliance	Indirect	
21. Budget Compliance	Indirect	
22. Compliance w/ FHWA Regulations & SAFETEA-LU	Direct Control	
23. Annual Reports to FHWA, legislature	Direct Control	
24. Effectiveness of Project Based on Reduction of Crashes, Fatalities	Indirect	
25. Public Opinion/Approval	Indirect	

8.3 Statewide Intelligent Transportation System

The next recommendation based on this research is that ALDOT commit to implementing a statewide Intelligent Transportation System. At the time of this research report, the Phase II of the Travel Times ITS system in Birmingham has been completed. The research team believes that phased implementation in and around the other major cities (Montgomery, Huntsville, and Mobile) would provide a basis for a comprehensive statewide performance measurement system.

The U.S. Department of Transportation Research and Innovative Technology Administration recently published their report on Intelligent Transportation Systems: *ITS Benefits, Costs,*

Deployment, and Lessons Learned: 2008 Update. This report includes best practices on how to use ITS in order to manage better such transportation systems components as:

- Arterial Management
- Freeway Management
- Crash Prevention and Safety
- Road Weather Management
- Roadway Operations and Maintenance
- Transit Management
- Transportation Management Centers
- Traffic Incident Management
- Emergency Management
- Electronic Payment and Pricing
- Traveler Information
- Information Management
- Commercial Vehicle Operations
- Intermodal Freight
- Intelligent Vehicles

Specific measures chosen during the gap analysis for ALDOT that would be directly provided by an ITS are:

- Travel Time
- Speed
- Recurring Delay
- Travel Time Reliability

One of the benefits of implementing an ITS system is that the data is available almost immediately after the system is operational, and can be returned close to real time for users.

APPENDIX A

Rail Performance Measures

Association of American Railroads Performance Measures

Performance Measure	Definition
Cars On Line	The average of the daily online inventory of freight cars.
Car Type On Line	The average of the daily online inventory of freight cars by type, such as box car, covered hopper, gondola, intermodal, multi-level, open hopper, tank, and other.
Car Ownership	Whether the train cars are System Cars meaning they are owned by the railroad on which they are located, Foreign Cars which are owned by rail companies other than the rail line they are on, and Private Cars which are owned by a non-railroad.
Train Speed	Measures the line haul movement between terminals. The average speed is calculated by dividing train miles by total hours operated, excluding yard and local trains, passenger trains, maintenance of way trains, and terminal time. Train speeds are given for the following train types: Intermodal, Manifest, Multi-level, Coal Unit, Grain Unit, and All trains.
Terminal Dwell Hours	The average time a car resides at the specified terminal location expressed in hours. The measurement begins with a customer release, received interchange, or train arrival event and ends with a customer placement (actual or constructive), delivered or offered in interchange, or train departure event.

Federal Railroad Administration Performance Measures

Safety	• Grade Crossing Incidents • Human-Factor Train Accidents • Track-Caused Train Incidents • Equipment-Caused Train Accidents • Signal/Misc Train Accidents • Non-Accident Hazmat Releases

NCHRP Report 446 Performance Measures

Accessibility	• Miles of track in operation (by FRA rating) • Existence of railroad electrification

Mobility	• Origin-destination travel times • Total travel time • Average travel time from facility to destination • Average speed • Delay per VMT • Delay due to incidents • Reserve Capacity • Queuing of vehicles and its relationship to overall delays • Interference of movement at grade crossings – delay time and speed • Percentage of on-time performance • Minute variation in trip time • Fluctuations in traffic volumes • Percentage of scheduled departures that do not leave within a specified time limit • Ton miles of rail freight into/through metropolitan areas • Traffic at border crossings • Delay per ton mile traveled • Capacity restrictions • Facility usage by mode(V/C)
Economic Development	• Percent of state gross product • Economic costs of pollution • Economic costs of accidents • Economic costs of fatalities • Economic costs of lost time • Economic costs of congestion • Tonnage originating and terminating
Quality of Life	• Tons of pollution generated
Environmental & Resource Conservation	• Number of accidents involving hazardous waste
Safety	• Number of fatalities and injuries occurring on the rail system • Exposure (AADT and daily trains) factor for rail crossings • Accidents at major intermodal crossings • Railroad/highway at-grade crossings • Grade crossing safety improvements • Number of accidents per VMT • Number of accidents per year • Number of accidents per trip • Number of accidents per capita • Number of accidents per ton mile traveled • National rank for accident, injury, fatality rates • Fatality (or injury) rate of accidents

Operational Efficiency	• Rail freight revenue versus operating expenses • Additional revenue earned by producers when shipping via rail • Line-haul speed • Average travel time between intermodal facility and rail • Number of carloads shipped/received on rail project lines • Public cost for transportation system • Private cost for transportation system • Total public expenditures on modal systems (freight vs. passenger) • Cost/benefit of existing facility vs. new construction • Infrastructure maintenance expense • Average cost per mile • Insurance costs • Value of fuel savings • Productivity and utility by mode
System Preservation	• Track condition • Miles of track not useable by certain traffic because of design or condition deficiencies • Miles of track in operation (by FRA rating) • Track miles abandoned • Track miles under threat of abandonment • Miles of rail line acquired and rehabilitated for rail service • Remaining service life • Capacity/remaining useful life index • Present serviceability rating • Maintenance condition as measured against departmental standards • System condition • Customer perception of condition of system • Maintenance hours • Current average maintenance costs

Waterway Performance Measures

U.S. Department of Maritime Administration Performance Measures

US Waterborne Trade	• Foreign container imports and exports • Domestic container coastal, inland, and lake
US/Foreign container trade by US Port of entry	
US and Global Waterborne Trade	• coal • iron ore • petroleum • grain • container • liquefied natural gas

Vessel Calls at US Ports	• tanker • product • crude • container • dry bulk • ro-ro • gas • combo • general
Container ship calls at US ports	
US flag vessel calls at US ports	
Vessel calls by US coast	
North American cruise passengers by departure port	
Employment in water transportation and port services	
Water transportation gross output	
Energy inputs by mode	

U.S. Army Corps of Engineers Performance Measures

Performance Measure	Definition
Delay at river locks and dams	A mobility measure. The average delay in time for vessels moving through river locks and dams.
Locking time by dam	A mobility measure. The average locking time at each dam in the waterway system.
Dams in need of structural upgrade	A system preservation measure. The number of dams in need of structural upgrade.
Operating ports and terminals	An economic development measure. The number of operating ports and terminals in the waterway system.
Collisions and maritime injuries	A safety measure. A 5 year average of the number of collisions and maritime injuries occurring in the waterway system.
Compliance with the Maritime Transportation Security Act	A safety measure. A measure of an agency's compliance with the Maritime Transportation Security Act
Cargo Volume by Port	An economic performance measure. The volume of cargo handled by each port, containerized, tonnage, bulk, etc.

NCHRP Report 446 Performance Measures

Accessibility	• Number of ports with railroad connections • Lift capacity (annual volume)

Mobility	• Number of dockage days at seaports • Origin-destination travel times • Total travel time • Average travel time from facility to destination • Average speed • Delay per VMT • Delay due to incidents • Reserve Capacity • Percentage of on-time performance • Minute variation in trip time • Fluctuations in traffic volumes • Percentage of scheduled departures that do not leave within a specified time limit • Delay per ton mile traveled • Capacity restrictions • Facility usage by mode(V/C)
Economic Development	• Number of cruise embarkations • Percent of state gross product • Economic costs of pollution • Economic costs of accidents • Economic costs of fatalities • Economic costs of lost time • Economic costs of congestion • Tonnage originating and terminating
Quality of Life	• Tons of pollution generated
Environmental & Resource Conservation	• Number of accidents involving hazardous waste
Safety	• Accidents (or injuries or fatalities) caused by waterborne transportation • Shipping accidents occurring on waterways • Number of accidents per VMT • Number of accidents per year • Number of accidents per trip • Number of accidents per capita • Number of accidents per ton mile traveled • National rank for accident, injury, fatality rates • Fatality (or injury) rate of accidents
Operational Efficiency	• Average cost for vehicle on ferry system • Customs and administrative processing time • Public cost for transportation system • Private cost for transportation system • Total public expenditures on modal systems (freight vs. passenger) • Cost/benefit of existing facility vs. new construction

	• Infrastructure maintenance expense • Average cost per mile • Insurance costs • Value of fuel savings • Productivity and utility by mode
System Preservation	• Miles to be dredged • Remaining service life • Capacity/remaining useful life index • Present serviceability rating • Maintenance condition as measured against departmental standards • System condition • Customer perception of condition of system • Maintenance hours • Current average maintenance costs

Air Performance Measures

Federal Aviation Administration – Aviation System Performance Measures
Huntsville International Airport Performance Measures

Performance Measure	Definition
Departures	Percentage of on time departures.
Arrivals	Percentage of on time arrivals.
Efficiency	The efficiency of the Airport, its departures, and its arrivals.
Capacity	The capacity of arrivals, departures, and the total number.
Traffic Counts	Traffic counts on all scheduled operations.
Times (Average Minutes)	Time in average minutes for departure activities such as Gate Delay, and Taxi Out Delay. Time in average minutes for arrival activities such as Airborne Delay, Taxi In Delay, Block Delay, and Arrival Delay.
Facility Reported Operations	Air Carrier, Air Taxi, General Aviation, Military, Total
AFSS Customer Satisfaction Rating	The resulting survey rating based on a series of questions gauging customer satisfaction with the quality, timeliness, accuracy, customer service, and relevance of overall and specific services received.
Number of Operational Errors	The sum of the operational errors year to date as defined in FAA Order 7210.56, Air Traffic Quality Assurance, attributed to SP performance.
Number of Operational Deviations	The sum of the operational deviations year to date as defined in FAA Order 7210.56, Air Traffic Quality Assurance, attributed to SP performance.

Aviation System Performance Measures by Geoffrey D. Gosling

Commercial Service	General Aviation
Mobility and Accessibility	
Travel Time • Percent of air trips in markets served by nonstop flights • Percent of air trips in markets without nonstop service but served by connections through an airline hub or one-stop service • Percent of air trips in markets with at least six nonstop, one-stop or connecting flights per day • Number of international destinations served with nonstop flights with daily departures • Number of international destinations served with nonstop flights with at least three weekly departures	
Delay • Average delay experienced in traveling to and from the airport, measured as the average difference between actual access/egress highway travel times and free-flow travel times, weighted by the distribution of trip ends • Average delay experienced during the flight, expressed as the difference between actual flight times and scheduled flight times during periods of light traffic	• Average delay experienced in traveling to and from the airport, measured as the average difference between actual access/egress highway travel times and free-flow travel times, weighted by the distribution of based aircraft owner locations • Average delay per flight, estimated from the ratio of annual aircraft operations to the Annual Service Volume of the airport
Access to Desired Destinations • Percent of air trips in markets served by three or more carriers with nonstop, one-stop or connecting service • Percent of international departures in markets with at least two carriers • Percent of air trips for which the nearest commercial airport provides direct or connecting air service through one intermediate hub • Percent of air trips for which the nearest commercial airport provides direct jet service to the destination or to an intermediate hub with direct service to the destination • Average additional distance to access the nearest airport with direct air service to the destination, or connecting air service through an intermediate hub when the destination is not served directly, compared to the distance to the nearest commercial airport	• Percent of regional/statewide based aircraft at airports with available hangar space • Percent of regional/statewide based aircraft at airports with available tie-down space • Percent of regional/statewide itinerant operations at airports with a control tower • Percent of regional/statewide itinerant operations at airports with an instrument approach capability • Percent of regional/statewide itinerant operations at airports with approach and runway lighting

Access to the Airport System • Percent of air trip ends within 45 minutes highway travel time of the nearest commercial service airport • Percent of air trip ends within 45 minutes highway travel time of the commercial service airport used • Average airport access/egress highway travel times under free-flow travel conditions, weighted by the distribution of trip ends • Percent of air trip ends within 5 miles of stops served by scheduled airport ground transportation services, including rail transit and express airport bus services • Percent of air trip ends in communities served by airport shared-ride van services • Percent of air passenger airport access/egress trips using shared-ride public transportation	• Percent of aircraft owners within 30 minutes of a general aviation airport, under free-flow travel conditions • Percent of population within 30 minutes of a general aviation airport with instrument landing capability, under free-flow travel conditions
Reliability	
• Percent of flights arriving more than 15 minutes late • Percent of flights arriving more than 30 minutes late • Average departure delay per flight • Standard deviation of highway airport access/egress travel times, weighted by the distribution of trip ends	
Cost Effectiveness	
• Average fare paid per mile for intrastate air trips • Average fare paid per mile for air trips **from** California to domestic destinations outside the state • Average fare paid per mile for air trips **to** California from domestic origins outside the state	• Average annual hangar space rental cost • Average annual tie-down space rental cost • Average cost per gallon paid for aviation gasoline • Average cost per gallon paid by general aviation for jet fuel
Economic Well-Being	
• Commercial airport productivity in terms of equivalent passengers per dollar of annual operating cost, including airline station costs and annualized cost of capital investments in airport and air traffic control infrastructure	• General aviation airport productivity in terms of aircraft operations per dollar of annual operating cost, including annualized cost of capital investments and provision of air traffic control services
Sustainability	
• Average percentage of household income spent on commercial air travel • Average percentage of gross state product spent on commercial air transportation	• Average cost of owning and operating a private aircraft used primarily for personal flying • Average cost of owning and operating a private aircraft used primarily for business

• Average fuel consumption per ton-mile of all commercial flights originating in California • Percent of airfield pavement at commercial service airports in California in fair condition, as reported in the FAA Airport Safety Data Program • Percent of airfield pavement at commercial service airports in California in poor condition, as reported in the FAA Airport Safety Data Program	purposes • Percent of airfield pavement at general aviation airports in California in fair condition, as reported in the FAA Airport Safety Data Program • Percent of airfield pavement at general aviation airports in California in poor condition, as reported in the FAA Airport Safety Data Program
Environmental Quality	
• Number of households exposed to aircraft noise levels exceeding 65 dB California Noise Equivalent Level (CNEL) near commercial service airports • Number of households exposed to aircraft noise levels exceeding 60 dB CNEL near commercial service airports • Tons per year of carbon monoxide (CO) generated by aircraft operations at commercial service airports in the state • Tons per year of volatile organic compounds (VOC) generated by aircraft operations at commercial service airports in the state • Tons per year of nitrogen oxides (NOx) generated by aircraft operations at commercial service airports in the state • Tons per year of sulfur dioxide (SO_2) generated by aircraft operations at commercial service airports in the state • Tons per year of greenhouse gases generated by commercial aircraft operations departing from airports in the state • Vehicle-miles of travel per year by automobiles making trips to and from commercial service airports • Vehicle-miles of travel per year by diesel or gasoline powered buses or passenger vans making trips to and from commercial service airports • Vehicle-miles of travel per year by lowemission buses or passenger vans making trips to and from commercial service airports • Vehicle-miles of travel per year by trucks making trips to and from commercial service airports	• Number of households exposed to aircraft noise levels exceeding 65 dB CNEL near general aviation airports • Number of households exposed to aircraft noise levels exceeding 60 dB CNEL near general aviation airports • Tons per year of criteria pollutants (CO, NOx, VOC and SO_2) generated by aircraft operations at general aviation airports in the state • Vehicle-miles of travel per year by automobiles making trips to and from general aviation airports
Safety and Security	
• Accident rate on commercial airline flights,	• Accident rate to general aviation operations,

expressed as the moving average five-year probability of being killed on a commercial flight taken at random from a California airport	expressed as the number of fatal accidents per flight hour
Equity	
• Ten-year moving average of federal Airport Improvement Fund grants at each commercial service airport, expressed as a ratio of the enplaned passenger traffic at the airport • Ten-year moving average of aircraft noise mitigation program expenditures by airport authorities in communities adjacent to the airport, expressed as a ratio of the number of households within the 60 dB CNEL contour • Ten-year moving average of airport ground access/egress traffic mitigation program expenditures by airport authorities, expressed as a ratio of the enplaned passenger traffic at the airport	• Ten-year moving average of state airport development grants to general aviation airports in each county, expressed as a ratio of the number of registered aircraft owners with addresses in the county • Ten-year moving average of state airport development grants to general aviation airports in each county, expressed as a ratio of the number of based aircraft at airports in the county
Customer Satisfaction	
• Air passenger satisfaction index • Air cargo shipper satisfaction index	• Aircraft owner satisfaction index

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Accessibility	• Air transportation capacity • Amount of scheduled service between major cities • Number of cities over one million population served directly by nonstop commercial airline flights from airports in state • Airport improvement and cost scheduled at airport • Airports within 30 minute drive of agricultural centers capable of supporting twin-engine piston powered aircraft • Percent of aviation community reached through aviation service programs • Percent of general aviation needs funded • Percent of jobs within 45 minutes of airports • Minimum layover times at airports or passenger terminals • Access time to passenger facility • Transfer distance at passenger facility • Existence of information services and ticketing • Availability of intermodal ticketing and luggage transfer • V/C of parking spaces during daily peak hours for bus, rail, park and ride, or other passenger terminal lots

	• Parking spaces per passenger • Parking spaces available for loading/unloading vehicles • Number of pick-up and discharge areas for passengers
Mobility	• Delay time at primary commercial airports • Origin-destination travel times • Total travel time • Average travel time from facility to destination • Average speed • Delay per VMT • Delay due to incidents • Reserve Capacity • Percentage of on-time performance • Delay per ton mile traveled • Capacity restrictions • Facility usage by mode(V/C) • Minute variation in trip time • Fluctuations in traffic volumes • Percentage of scheduled departures that do not leave within a specified time limit
Economic Development	• Percent of state gross product • Economic costs of pollution • Economic costs of accidents • Economic costs of fatalities • Economic costs of lost time • Economic costs of congestion • Tonnage originating and terminating
Quality of Life	• Tons of pollution generated
Environmental & Resource Conservation	• Number of accidents involving hazardous waste
Safety	• Accidents (or injuries or fatalities) caused by air transportation • Percentage of airports that meet federal and state planning and design standards • Number of landing areas inspected • Number of airports where weather information is collected for dissemination to pilots • Total annual attendance at pilot safety seminars • Number of accidents per VMT • Number of accidents per year • Number of accidents per trip • Number of accidents per capita • Number of accidents per ton mile traveled • National rank for accident, injury, fatality rates

	• Fatality (or injury) rate of accidents
Operational Efficiency	• Delay time at primary commercial airports • Cost per ton mile as it compares to cost per air, water, or rail mile • Enplanements per aviation system employee • Public cost for transportation system • Private cost for transportation system • Total public expenditures on modal systems (freight vs. passenger) • Cost/benefit of existing facility vs. new construction • Infrastructure maintenance expense • Average cost per mile • Insurance costs • Value of fuel savings • Productivity and utility by mode
System Preservation	• Runway resurfacing frequency • Hours or days out of service • Remaining service life • Capacity/remaining useful life index • Present serviceability rating • Maintenance condition as measured against departmental standards • System condition • Customer perception of condition of system • Maintenance hours • Current average maintenance costs

Intermodal Performance Measures

Huntsville Intermodal Center Performance Measures

Trains	• Inbound loads • Outbound loads • Inbound empties • Outbound empties • Inbound transfers • Outbound transfers
Trucks	• Inbound gate activity • Outbound gate activity • Gate activity per hour
Cranes/Lifts	• Total rail lifts • Total secondary lifts

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Accessibility	• Average distance to intermodal terminals from different community shipping points • Number of intermodal facilities • Capacity of intermodal terminals • Average travel time between intermodal facility and rail • Amount of turning radius from major highway to intermodal facility • Number of TEUs that can be stored on the premises of the intermodal facility • Number of trucks that can be loaded with bulk material per hour of loading time • Types of modes handled • Freight dock availability • Track capacity • Double stack capacity • Number of intermodal facilities that agency assists in development
Mobility	• Average transfer time/ delays • Dwell time in intermodal facilities • Truck turnaround time at intermodal facilities • Avg. processing time for shipments at intermodal terminals • Delay of trucks at facility per VMT • Delay of trucks at facility per ton mile • Frequency of delays at intermodal facilities • Customs delays • Tons of commodity undergoing intermodal transfer • Avg. travel time between intermodal facility and rail • Origin-destination travel times • Total travel time • Average travel time from facility to destination • Average speed • Delay per VMT • Delay due to incidents • Reserve Capacity • Percentage of on-time performance • Minute variation in trip time • Fluctuations in traffic volumes • Percentage of scheduled departures that do not leave within a specified time limit • Delay per ton mile traveled • Capacity restrictions

	• Facility usage by mode(V/C)
Economic Development	• Percent of state residents aware of intermodal opportunities • Percent increase in intermodal facility use • Percent of state gross product • Economic costs of pollution • Economic costs of accidents • Economic costs of fatalities • Economic costs of lost time • Economic costs of congestion • Tonnage originating and terminating
Quality of Life	• Tons of pollution generated
Environmental & Resource Conservation	• Number of accidents involving hazardous waste
Safety	• Number of accidents per VMT • Number of accidents per year • Number of accidents per trip • Number of accidents per capita • Number of accidents per ton mile traveled • National rank for accident, injury, fatality rates • Fatality (or injury) rate of accidents • Number of accidents per intermodal transfer
Operational Efficiency	• Percent of transfers between modes to be under 'X' minutes and 'N' feet • Transfer times between modes • Number of users of intermodal facilities • Percent of intermodal connecting points and facilities accurately placed on a map • Average processing time for shipments at intermodal terminals • Public cost for transportation system • Private cost for transportation system • Total public expenditures on modal systems (freight vs. passenger) • Cost/benefit of existing facility vs. new construction • Infrastructure maintenance expense • Average cost per mile • Insurance costs • Value of fuel savings • Productivity and utility by mode • Tons transferred per hour • Average transfer time/delays • Average processing time for shipments at intermodal terminals

System Preservation	• Remaining service life • Capacity/remaining useful life index • Present serviceability rating • Maintenance condition as measured against departmental standards • System condition • Customer perception of condition of system • Maintenance hours • Current average maintenance costs

APPENDIX B

Key States that Provide Excellent Examples of Performance Measures to use for Benchmarking:
Missouri and Washington State

Other examples provided: California, Florida, Delaware, Maryland, Minnesota, Virginia

A complete list of the measures associated with these measure types can be found in the NCHRP Synthesis #311 report.

Missouri DOT

Uninterrupted Traffic Flow	-Average travel indices and speeds on selected freeway sections -Average rate of travel on selected signalized routes -Average time to clear traffic incident -Average time to clear traffic backup from incident -Number of customers assisted by the Motorist Assist program -Percent of Motorist Assist customers who are satisfied with the service -Percent of work zones meeting expectations for traffic flow -Time to meet winter storm event performance objectives on major and minor highways
Smooth and Unrestricted Roads and Bridges	-Projects that contribute to the Better Roads, Brighter Future program goal -Percent of major highways that are in good condition -Percent of minor highways that are in good condition -Percent of vehicle miles traveled on major highways in good condition -Percent of deficient bridges on major highways -Percent of deficient bridges on minor highways -Number of deficient bridges on the state system (major & minor highways)
Safe Transportation System	-Number of fatalities and disabling injuries -Number of impaired driver-related fatalities and disabling injuries -Rate of annual fatalities and disabling injuries -Percent of safety belt/passenger vehicle restraint use -Number of bicycle and pedestrian fatalities and disabling injuries -Number of motorcycle fatalities and disabling injuries -Number of commercial motor vehicle crashes resulting in fatalities -Number of commercial motor vehicle crashes resulting in injuries -Number of fatalities and injuries in work zones -Number of highway-rail crossing fatalities and collisions
Roadway Visibility	-Rate of nighttime crashes -Percent of signs that meet customers' expectations -Percent of stripes that meet customers' expectations

	-Percent of work zones meeting expectations for visibility
Personal, Fast, Courteous and Understandable Response to Customer Requests (Inbound)	-Percent of overall customer satisfaction -Percent of customers who contacted MoDOT that felt they were responded to quickly and courteously with an understandable response -Percent of documented customer requests responded to within 24 hours -Average completion time on requests requiring follow up
Partner With Others to Deliver Transportation Services	-Number of dollars of discretionary funds allocated to Missouri -Percent of earmarked dollars that represent MoDOT's high priority highway projects -Number of dollars generated through cost-sharing and other partnering agreements
Leverage Transportation to Advance Economic Development	-Number of miles of new 4-lane corridors completed -Percent utilization of SIB & STAR loan programs -Economic return from transportation investment
Innovative Transportation Solutions	-Number and percent of research recommendations implemented -Number of external awards received -Percent of best practices by implementation status -Number of dollars saved by increasing MoDOT's productivity
Fast Projects That Are of Great Value	-Percent of estimated project cost as compared to final project cost -Average number of years it takes to go from the programmed commitment in the Statewide Transportation Improvement Program to construction completion
Environmentally Responsible	-Percent of projects completed without environmental violation -Number of projects MoDOT protects sensitive species or restores habitat -Ratio of acres of wetlands created compared to the number of acres of wetlands impacted -Percent of Missouri's clean air days -Number of gallons of fuel consumed -Number of historic resources avoided or protected as compared to those mitigated -Number of tons of recycled/waste materials used in construction projects
Efficient Movement of Goods	-Freight tonnage by mode -Percent of trucks using advanced technology at Missouri weigh stations Interstate motor carrier mileage -Percent of satisfied motor carriers -Customer satisfaction with timeliness of Motor Carrier Services' response

Easily Accessible Modal Choices	-Number of airline passengers -Number of daily scheduled airline flights -Number of business-capable airports -Number of transit passengers -Average number of days per week rural transit service is available
Customer Involvement in Transportation Decision-Making	-Number of customers who attend transportation-related meetings -Percent of customers who are satisfied with feedback they receive from MoDOT after offering comments -MoDOT takes into consideration customers' needs and views in transportation decision-making -Percent of positive feedback responses received from planning partners regarding involvement in transportation decision-making
Convenient, Clean & Safe Roadside Accommodations	-Percent of customers satisfied with rest areas' convenience, cleanliness and safety -Percent of customers satisfied with commuter lots' convenience, cleanliness and safety -Number of users of commuter parking lots -Number of users of rest areas -Number of truck customers that utilize rest areas
Best Value for Every Dollar Spent	-Number of MoDOT employees (converted to full-time equivalency) -Percent of work capacity based on average hours worked -Rate of employee turnover -Level of job satisfaction -Number of lost workdays per year -Rate and total of OSHA recordable incidents -Number of claims and total claims expense for general liability -Cost of utilities for facilities -Fleet status -Percent of vendor invoices paid on time -Distribution of expenditures -Percent variance of state revenue projections -MoDOT national ranking in revenue per mile -Number of excess properties conveyed -Revenue generated from excess properties sold
Attractive Roadsides	-Percent of roadsides that meet customers' expectations -Number of miles in Adopt-A-Highway program
Advocate for Transportation Issues	-Percent of minorities and females employed -Transportation-related legislation passed by the General Assembly -Percent of federal earmarked highway projects on the state highway system identified as needs -Percent of customers who view MoDOT as Missouri's transportation Expert

Accurate, Timely, Understandable and Proactive Transportation Information (Outbound)	-Number of public appearances -Percent of customers who feel MoDOT provides timely, accurate and understandable information -Number of contacts initiated by MoDOT to media -Percent of MoDOT information that meets the media's expectations -Percent of positive newspaper editorials -Number of repeat visitors to MoDOT's web site

Missouri DOT Tracker:
http://www.modot.mo.gov/about/documents/Tracker_PDF_July08/TrackerJuly08.pdf

Washington State DOT

Strategic Objectives	Key Performance Measures
Highway Safety	-Fatality rates (vehicle) -Before and after collision analysis for safety projects -Fatality rates (bicyclists, pedestrians) -Cabinet Strategic Action Plan Measure: reduce highway fatalities by 4%
Incident Response	-Number of over-90 min incidents; average clearance time -Cabinet Strategic Action Plan Measure: reduce the average length of over 90 minute incidents by 5%
Delay and Congestion	-Travel time performance for 25 Puget Sound Routes; 95% -Reliable Travel Time -Duration of Congestion
Amtrak Cascades	-Percent of trips on time
Ferries	-Percent of trips on time
Highway Maintenance	-Rating for 33% maintenance activities tracked through the Maintenance Accountability Process (MAP) -Life cycle preservation performance: planned projects vs. actual systems/structures preserved, change in cost rating
Pavement Conditions	-Percent of pavement in good, fair, or poor condition. -Cabinet Strategic Action Plan Measure: maintain 90% of roads in good or satisfactory condition

Strategic Objectives	Key Performance Measures
Bridge Conditions	-Percent of bridges in good, fair, or poor condition. -Cabinet Strategic Action Plan Measure: maintain 97% of bridges in good or satisfactory condition
Capital Project Delivery Programs	-Planned vs actual results of scope, schedule and budget -Cabinet Strategic Action Plan Measure: complete 90% of highway projects on time and within budget.
Performance Reporting	-The Gray Notebook -GMAP Quarterly Review -Priorities of Government -Budget Activities
Workforce Training	-Compliance ratings for 25 statutory training classes
Workforce Safety	-Recordable injuries per 100 workers per calendar year
Freight	-Freight tonnage -Commercial trucks registered in the state if Washington -Trucks entering Washington from Canada -Border traffic -Seaport freight -Waterborne container traffic -Freight rail volumes -Air traffic volumes

Washington DOT - Gray Notebook: http://www.wsdot.wa.gov/NR/rdonlyres/BFF201B6-F6BD-406E-BEB7-71F0C4E7D92A/0/GrayNotebookMar08.pdf

California DOT

California DOT's Performance Measures/Indicators

Desired Outcome	Candidate Measure/Indicator
Mobility/accessibility	-Travel time -Delay -Access to desired location -Access to system
Reliability	-Variability of travel time
Cost-effectiveness	-Benefit/cost ratio

Sustainability	-Outcome benefit per unit cost
Environmental quality	-Household transportation costs
Safety and security	-Accident and crime rates
Equity	-Benefits per income group
Customer satisfaction	-Customer survey
Economic well-being	-Final demand (value of transportation to the economy)

Florida DOT

Florida DOT Mobility Performance Measures

Parameter	Mobility Performance Measure
Quantity of travel	-Person-miles traveled -Truck-miles traveled -Vehicle-miles traveled -Person-trips
Quality of travel	-Average speed -Delay -Average travel time -Average trip time -Reliability -Maneuverability
Accessibility	-Connectivity to intermodal facilities -Dwelling unit proximity -Employment proximity -Industrial/warehouse facility proximity -Percent-miles bicycle accommodations -Percent-miles pedestrian accommodations
Utilization	-Percent system heavily congested -Percent travel heavily congested -Vehicles per lane-mile -Duration of congestion

Delaware DOT

Components and Measures of the Delaware Statewide Long-range Transportation Plan

Plan Components	Measures
Goals	-Customer satisfaction -Travel time -Sustainability of investments
Strategies	-Support for existing communities -Increased system capacity

	-Increased safety -Improvement and protection of air quality, environment, and cultural resources
Policies	-Decrease in average trip length -Decrease in the rate of VMT growth -Increase in new revenue sources -Decrease in mode share for single-occupant vehicle travel
Actions	-Increase in the tonnage of goods moved -Increase in ridesharing -Decrease in crash rate -Increase in work zone safety

Maryland DOT

Performance measure types	-System extent -System use -Capital Invested -Factors influencing system design -Community enhancements

Minnesota DOT

System performance measures	-Pavement quality and estimated remaining service life -Deficient bridges and square feet of deficiencies -Crash rates -High accident locations -Miles and hours congested -Mobility -Reliability
Key customer needs identified by MnDOT	-Time predictable trips -Smooth, uninterrupted trips -Safe trips -Timely and accurate information -Responsibility with resources
Market segmentation needs for performance measures identified by MnDOT	-Commuters -Personal travelers -Farmers -Emergency vehicle operations -Carriers -Shippers -Intermodal

Data management needs identified by MnDOT	-Standard methods for collecting data -Data and methodologies to support system integration and linkages -Data currency (timeliness)

Also in the NCHRP report are proposed freight-oriented performance measures from Minnesota.

Virginia DOT

Virginia DOT's System Maintenance and Operations Performance Measures

Safety	-Crash rate -Equipment crash rate -Personal injuries as factor of hours worked and type of site
System Operation	-Traffic movement (number of people moved per hour by corridor)
Infrastructure quality	-Pavement sufficiency rating -Structures sufficiency rating

VDOT also has a customer satisfaction goal, but this is not included in the NCHRP report.

APPENDIX C

Please return this survey to Heather Shar at the University of Alabama in Huntsville.

Email: sharh@uah.edu
Fax: (256) 824-6970
Address: 301 Sparkman Dr.
VBRH A-4
Huntsville, AL 35899

Name: _____ Title: _____

Bureau: _____

Address: _____

City/State/Zip: _____

Phone: _____

Email: _____

What are the goals your bureau uses to measure success? _____

_____

	Do you use this information? Circle or mark *yes* or *no*	Do you collect this data? Circle or mark *yes* or *no.* If ***no***, write in from whom you receive the data	Do you distribute this information? Circle or mark *yes* or *no.* If ***yes***, write in to whom you distribute the data	How important is this measure to you? On a scale of 1 to 5, with 1 being most important and 5 being least important	How desirable is this measure to you? On a scale of 1 to 5, with 1 being most important and 5 being least important	Other Comments:

Operations

Traffic Count	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Vehicle-miles traveled	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Travel time	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Speed	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	

Level of Service

Density (passenger cars per hour per lane)	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Recurring delay	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Level of service/Highway Capacity Manual	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Duration of congestion	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Travel time reliability	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Percent of travel	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	

congested							

Do you use this information? Circle or mark *yes* or *no*	Do you collect this data? Circle or mark *yes* or *no.* If ***no***, write in from whom you receive the data	Do you distribute this information? Circle or mark *yes* or *no.* If ***yes***, write in to whom you distribute the data	How important is this measure to you? On a scale of 1 to 5, with 1 being most important and 5 being least important	How desirable is this measure to you? On a scale of 1 to 5, with 1 being most important and 5 being least important	Other Comments:

System Measures

Percent of system congested	Yes	No	Yes	No			Yes	No			1	2	3	4	5	1	2	3	4	5	
Travel costs	Yes	No	Yes	No			Yes	No			1	2	3	4	5	1	2	3	4	5	
Vehicle occupancy	Yes	No	Yes	No			Yes	No			1	2	3	4	5	1	2	3	4	5	

Safety

Number of incidents	Yes	No	Yes	No			Yes	No			1	2	3	4	5	1	2	3	4	5	
Weather-related traffic incidents	Yes	No	Yes	No			Yes	No			1	2	3	4	5	1	2	3	4	5	
Rail grade crossing incidents	Yes	No	Yes	No			Yes	No			1	2	3	4	5	1	2	3	4	5	
Duration of delay caused	Yes	No	Yes	No			Yes	No			1	2	3	4	5	1	2	3	4	5	

by incidents								
Response times to incidents	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Commercial vehicle safety violations	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Security for highway and transit	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	

Do you use this information? Circle or mark *yes* or *no*	Do you collect this data? Circle or mark *yes* or *no.* If ***no***, write in from whom you receive the data	Do you distribute this information? Circle or mark *yes* or *no.* If ***yes***, write in to whom you distribute the data	How important is this measure to you? On a scale of 1 to 5, with 1 being most important and 5 being least important	How desirable is this measure to you? On a scale of 1 to 5, with 1 being most important and 5 being least important	Other Comments:

Environmental

Weather-related road closures	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Response time to weather-related closures	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Evacuation times	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	

Toll

Toll revenue	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Delay from toll collection	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Delay from incidents	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	

Financial

Operating budgets	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Maintenance funds	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	
Construction costs	Yes	No	Yes	No	Yes	No	1 2 3 4 5	1 2 3 4 5	

Are there any other measures or data that you would like or could use that are not currently available?

_____

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3.2 Review of Performance Measures Used

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3.2.4 Air Performance Measures

"Aviation System Performance Measures."
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