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PERFORMANCE MONITORING
A FRAMEWORK FOR FURTHER RESEARCH

by

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16. ABSTRACT

Performance monitoring is defined as the periodic measurement of progress toward explicit short and long run objectives, and the reporting of the results to decision makers to improve program performance. The Washington State Department of Transportation (WSDOT) should use performance monitoring to monitor conditions and trends in transportation on specific facilities and within specific geographic regions and the state as a whole.

This report presents a logical framework for WSDOT to use in investigating the development of performance measures. It briefly describes the current status of WSDOT's development of performance monitoring systems. It investigates WSDOT needs, the uses WSDOT has for performance monitoring data, the types of data that can or should be collected and reported for these purposes, and the interactions required between WSDOT and other transportation providers and governmental agencies. Finally, the report outlines ongoing WSDOT research and data collection efforts and recommends directions for further research and analysis.

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

EXECUTIVE SUMMARY

PERFORMANCE MONITORING
A FRAMEWORK FOR FURTHER RESEARCH

This report presents a logical framework for developing performance monitoring systems within the Washington State Department of Transportation (WSDOT). Performance monitoring, as defined by Theodore Poister in the book "Performance Monitoring," is "the periodic measurement of progress toward explicit short and long run objectives, and the reporting of the results to decision makers in an attempt to improve program performance." The Department should use performance monitoring to track conditions and trends in transportation on specific facilities and within specific geographic regions and the state as a whole. A well designed performance monitoring system will provide information on the strategies WSDOT has implemented that are successfully achieving the desired results and those that are not, leading to better implementation decisions and more cost-effective expenditures of scarce resources.

WSDOT's responsibilities are divided. Its first responsibility is to operate transportation facilities. This task includes the construction, maintenance, and operation of many of the state's larger roadways, and the operation of the state's ferry system. WSDOT's second responsibility is to be the state government's voice in the regulation, control, and promotion of transportation opportunities and facilities within the state. WSDOT needs performance monitoring information to successfully perform both of these functions. However, the *types* of data that are needed for performance monitoring and the Department's *ability to collect those data* differ dramatically for these two functions, and thus the Department's performance monitoring system must really be a combination of several smaller monitoring efforts, each designed to provide a specific type of information. Nevertheless, these smaller systems must be coordinated to reduce their cost.

Related to the Department's role as an operator of facilities are two levels of operational performance monitoring. The first level concerns the performance of specific facilities or projects. The second level involves larger geographic areas or groups of facilities. **Facility, or program specific, monitoring** determines how well specific WSDOT facilities and programs are achieving stated goals of moving people and goods. (For example, are the new HOV lanes causing more people to carpool, or are the automobile occupancy rates staying the same?) Facilities can be defined as either specific roads, specific corridors, or special types of roadways (e.g., HOV lanes). **Geographic area monitoring** involves the aggregation of highway performance statistics for roadways within some geographic boundary. It differs from corridor monitoring (which is considered "facility" monitoring) in that the performance of roadways within a geographic area may not be directly correlated, as are facilities within a corridor. These boundaries are usually political (city, county, state), although they may also include air quality basins. Statewide highway monitoring is the highest level of aggregation within this category and is already a subject of considerable effort by WSDOT. However, increasingly smaller jurisdictions are being asked to supply this same type of summary information.

Current Status

Many measures of effectiveness (MOE) can be used to monitor transportation system performance. Departmental staff understand the MOEs that they can use to describe system performance and already collect some of those data. However, these data are not collected in a sufficiently consistent or cost-effective manner for the expanded reporting requirements of performance monitoring. Furthermore, the Department has yet to select the specific variables to report, or the specific procedures to use to ensure consistent reporting between facilities or geographic areas.

Recommendations

The author recommends that, for both operational and statewide performance monitoring, the Department answer the questions listed below to create the necessary monitoring systems.

- What are the basic goals/objectives of the performance monitoring process as it relates to each aspect of the transportation system (i.e., regardless of whether it is needed for facility monitoring, area monitoring, or statewide monitoring)?

- What data (variables) can the state use to most effectively monitor these objectives?

- Will a specific statistical precision be associated with any of these estimates? If so, what is that level of precision?

- Which of the potential variables can be most easily collected while still providing an accurate measure of the desired system performance?

- What are the costs associated with the collection of the necessary monitoring information?

- Does the cost of data collection change the MOEs that have been selected or the selected precision?

- To what extent will the Department require submittal of these MOEs for facilities that are controlled by cities and counties in the state? (This information applies mainly to road networks and may be needed to meet both the federal congestion management requirements and the state's growth management requirements.)

- Will these submittals be at the same level of statistical precision as the the MOEs for state facilities?

- Who will fund the collection of the necessary data?

- Will the Department specify the methodology to be used to collect those data?

- Will the Department develop the sampling and/or extrapolation procedures for estimating area-wide performance monitoring statistics for jurisdictions around the state? If so, who will do this, and within what time frame?

The above list implies that not all of the data required for performance monitoring would be available to WSDOT, even if the resources were available to collect those data. Data for performance monitoring will come from both WSDOT facilities and from facilities over which WSDOT has no control or access. Resources will be needed to collect the data from WSDOT facilities. Some WSDOT resources will be needed to appropriately format currently available data from non-WSDOT facilities, but WSDOT may also need to arrange for the collection of data that are currently not collected from non-WSDOT facilities. This last effort may require WSDOT resources and the cooperation of other agencies, companies, and facility operators.

PERFORMANCE MONITORING

A FRAMEWORK FOR FURTHER RESEARCH

This paper briefly describes the current status of the Washington State Department of Transportation's (WSDOT) development of performance monitoring systems. It investigates WSDOT needs, the uses WSDOT has for performance monitoring data, the types of data that can or should be collected and reported for these purposes, and the interactions needed between WSDOT and other transportation providers and governmental agencies. Finally, the report outlines ongoing WSDOT research and data collection efforts and a framework for expanding this work through additional research and analysis.

PERFORMANCE MONITORING

Performance monitoring, as defined by Theodore Poister in the book "Performance Monitoring," is "the periodic measurement of progress toward explicit short and long run objectives, and the reporting of the results to decision makers in an attempt to improve program performance." These objectives can apply either to specific operating criteria or to broader goals.

Historically, WSDOT was responsible for building and operating roads. When congestion appeared, it built new roads to relieve that congestion. In such a climate, it was relatively easy to determine whether the Department was meeting its intended goals: monitors simply asked whether new roads were getting built as scheduled or needed. As WSDOT has changed from being solely a highway agency to being a Department of Transportation, and as the basic goals of the Department have changed from building new roads for moving more people and goods to moving people and goods as effectively and efficiently as possible, measuring the Department's success in achieving those goals has become more difficult.

In heavily congested urban areas, the opportunities to build new roads are limited. Instead, new, relatively untried, expensive techniques are being employed to maximize the use of existing rights-of-way. The Department must be able to determine which of these new techniques are successfully achieving the desired results, and which are not producing the anticipated results.

DIVISION OF WSDOT RESPONSIBILITIES

WSDOT's responsibilities are divided. Its first responsibility is to operate transportation facilities. This task includes the construction, maintenance, and operation of many of the state's larger roadways, and the operation of the state's ferry system. WSDOT's second responsibility is to be the state's voice in the regulation, control, and promotion of transportation opportunities and facilities. WSDOT needs performance monitoring information to successfully perform both of these functions. However, the *types* of data that are needed for performance monitoring and the Department's *ability to collect those data* differ dramatically for these two functions.

The type of data WSDOT operations personnel (as well as various oversight groups) need to determine whether WSDOT facilities are operating acceptably tend to be very specific. These data often relate directly to individual projects or facilities, not because broader summary data are not useful, but because the operation of these specific facilities can only be monitored at this smaller scale. These performance monitoring requirements are similar to those of an airline, which must determine whether specific routes are profitable and as a result should be continued, expanded, or eliminated. To WSDOT this information would be useful in determining whether expensive improvements were increasing the mobility of people and goods.

For the Department's role as overseer of all modes of transportation in the state a different set of performance monitoring information is needed. For this level, the Department is not concerned about the operation of specific facilities (that is the role of

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the service provider); instead, the Department is concerned about accurately describing the overall condition of the state's transportation system. This overview highlights the general needs of that system and determines the actions that are needed at the state level to ensure that people and goods move efficiently throughout the state.

Each of these categories is described in more detail below.

SOURCES OF DATA

In addition to dividing the needs of the Department into the two functional categories discussed above, it is also useful to look at performance monitoring from the perspective of data collection. For both of its functional categories of data requirements, WSDOT will have to rely on three distinct sources of data:

- data from WSDOT facilities that must be collected routinely or by some specifically designed sample program,

- data from non-WSDOT facilities that are already available from another agency but must be obtained and summarized by WSDOT, and

- data that must be collected by another agency and obtained by WSDOT, but that are not currently collected.

All three types of data collection are required for both WSDOT operational monitoring and WSDOT statewide oversight monitoring. However, the first two of these categories would fulfill the majority of WSDOT's system operations needs, while the statewide oversight needs would be met primarily by the latter two categories.

As might be expected, the source of the data will greatly impact WSDOT's ability to obtain, manipulate, and analyze information and thus perform the various monitoring functions. A significant task of future projects will involve determining ways to obtain the types of information needed for these functions. This subject is dealt with only briefly within this paper. The discussion below only describes locations where data are currently being obtained, and where data might be obtained later.

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MONITORING WSDOT OPERATION OF FACILITIES

This section describes the information that WSDOT could (or should) collect routinely to monitor the functioning of the facilities it operates. The section discusses the Department's highway operations and the state ferry system separately. Within each of these two subsections, four topics are discussed:

- the uses for performance monitoring data,
- the types of measures of effectiveness (MOEs) that could be collected and reported,
- ongoing data collection efforts, and
- planned data collection efforts or research projects.

WSDOT should be able to collect the majority of data it needs on the facilities that it operates with little difficulty, except for lack of resources. That is, because the Department operates the facilities, it does not need to obtain permission to collect data, it has control of the facilities if they need to be instrumented, and it has access to and control of the control electronics. This does not mean that data collection for these systems will be easy. In many cases, data collection will be expensive, both in terms of the staffing required and the need for data collection hardware and software.

The issue for operational monitoring is less concerned with the data that are available than with which of those data are most descriptive and cost effective to collect. So besides determining the data that can be collected, development of a monitoring system requires determining

- the benefits that will accrue from those data,
- the most efficient methods for collecting those data,
- the cost of collecting the data, and
- the resources available for collecting the data.

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WSDOT management must then use this information to make the necessary decisions. The subsections below describe the beginning of this process by outlining the current state of the WSDOT monitoring effort, ongoing projects that might affect WSDOT monitoring decisions, and future courses of action WSDOT could take.

Highway Operations

A large portion of the vehicle miles of travel (VMT) within Washington occurs on highways operated by the Department, although a majority of the center-line miles of highway are owned and operated by non-WSDOT agencies and jurisdictions. Thus, the Department needs to monitor both the operational performance of its own facilities and the general performance of the statewide system. In addition to reporting statewide monitoring information, the Department must also provide monitoring estimates for smaller geographic areas such as counties. Both facility and area monitoring needs are discussed below.

Uses for Performance Monitoring Data

Collecting and using operational data on roadway performance is necessary for WSDOT to predictably improve the operation of its facilities. This same statement is true for all jurisdictions that operate road systems. Operating agencies must know how a roadway is functioning to design, maintain, and operationally control that facility. Their information needs include the following:

- how many vehicles are using a road,
- what types and weights of vehicles make up that usage,
- when roads are becoming congested,
- how long and to what degree that congestion exists,
- whether the pavements are in good condition,
- whether the bridges are structurally sound, and
- whether too many accidents are occurring at some locations.

Only by understanding the answers to these and other basic questions can adequate decisions be made with respect to construction, maintenance, and operation of those roads.

A second reason for collecting and reporting roadway performance information is the increasing desire for public scrutiny of the operation of these facilities. Not only do WSDOT managers need this information, but so do legislative and public oversight groups that are charged with directing the work of the Department. This oversight occurs in the form of legislative review, federal review, and general public opinion. Each of these reviewers wants to know whether specific projects or programs are successful.

As noted in the introduction to this section, there are two levels of operational performance monitoring for highways. The first level relates to the performance of specific facilities or projects. The second level relates to the monitoring of larger geographic areas or groups of facilities. Each of these levels are discussed below.

Facility, or program specific, monitoring determines whether specific WSDOT facilities and programs are achieving stated goals of moving people and goods. Performance indicators that fall under these categories are especially important for monitoring the growth management provisions recently established by the legislature. A facility can be one road, a corridor, or some aspect of a road (e.g., HOV lanes). Program monitoring is similar to facility monitoring, except that instead of determining the performance characteristics of specific facilities, the Department determines whether specific types of projects (e.g., the HOV lanes, motorist information systems improvements, IVHS systems) are positively affecting facility operation.

Other jurisdictions within the state are also responsible for monitoring the performance of specific facilities. These other agencies have the same pressures to produce estimates of travel and congestion as WSDOT, but they often lack the resources and expertise available to the Department. The data requirements for non-WSDOT facilities are equivalent to those of the WSDOT's, and where state routes pass through

other jurisdictions, the WSDOT and these jurisdictions may be able to share in the collection of these data to benefit both agencies. In its role as the state's transportation overseer, WSDOT must also obtain these data from other jurisdictions to determine whether those jurisdictions are fulfilling their obligations under the growth management laws and regulations.

Key uses for this type of monitoring includes answers to questions such as, "Did this improvement increase vehicular throughput? Person throughput? Did it reduce delay? Increase vehicle speeds? Decrease pollutant emissions?" This type of data could also be used to monitor the need for implementing the next project scheduled in a corridor improvement plan. The specific uses of facility monitoring data depend on how WSDOT defines the project development/priority array process.

These types of statistics and MOEs are commonly used to evaluate the impacts of specific improvements WSDOT has built, but they are currently only collected for selected projects. Many of these data are not collected routinely, and in the vast majority of cases, the data that are collected for special projects are not collected for extended periods of time, precluding their use for trend analyses and other long-term monitoring functions.

Geographic area monitoring involves the aggregation of highway performance statistics for roadways within some geographic boundary. It differs from corridor monitoring in that the boundaries are set with criteria that are not related to transportation operations. These boundaries are usually political (city, county, state), although the need to provide traffic performance information for air quality basins, which frequently cross jurisdictions, may create other boundaries.

Statewide highway monitoring is the highest level of aggregation within this category and is already a subject of considerable effort by WSDOT. However, increasingly smaller jurisdictions are being asked to supply this same type of summary information.

WSDOT has responsibility for reporting statistics at the state level for both the state's entire road network and the roads in that network that WSDOT operates. These data describe total state highway travel and are often used for national analyses, trend computations, funding allocation, and comparisons between states.

These same data, when collected and reported at the jurisdictional level, are used as input to air quality and energy consumption models, calibration information for regional transportation models, input to state funding allocations, and base data for trend analysis within each jurisdiction.

Performance Monitoring MOEs

Many MOEs exist for both facility monitoring and area-wide monitoring. A number of national efforts are under way to determine the "best" set of MOEs for performance monitoring. Generally, these statistics involve some combination of the measurements of

- volume (the number of people/vehicles using the system or facility),

- speed or travel time (how well the system is operating),

- distance (the length of travel),

- safety, and

- physical condition (whether bridges/pavements need repair).

Many variables can be measured that provide different views of these five data categories. In addition, these values (and the variables that represent them) can be combined in innumerable ways to further describe and explain the functioning of the transportation system.

In most cases, a sample of these data is collected to represent the larger population. This sample may be one measurement on one road selected from many roads, continuous sampling at a specific site assumed to represent some length of road, or some combination of these techniques. In a few cases, data are taken from the entire

universe of the population (e.g., the pavement management system looks at all sections of road).

The required **facility and program monitoring** measures of effectiveness reflect the type of program or facility being monitored. If the facility is defined as a road or group of roads, basic highway statistics such as

- volumes (per day, per day-of-the-week, per year),
- vehicle miles of travel,
- average speed (in peak and off-peak periods),
- delay (per person, per vehicle, per capita, per VMT, etc),
- mode split,
- number of trips,
- accidents (fatalities, injury accidents, other accidents),
- pavement conditions, and
- bridge conditions

can describe the operation of the facility. If the data collection is performed over a length of time, these statistics can help monitor changes in that performance over time. The measured changes can direct the need for improvements to that facility.

These basic highway statistics can also be used as input to sophisticated models that can estimate other MOEs that describe the performance of the transportation system. These secondary variables, including

- air pollution emissions,
- water runoff conditions,
- noise levels, and
- fuel usage,

can sometimes be collected directly if the appropriate monitoring devices have been purchased, installed and operated. However, it is often less costly to use the traffic data collected for other purposes to estimate the secondary variables.

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Monitoring of specific transportation programs usually requires the same types of data listed above, but it often concentrates on specific variables or groups of variables. For example, monitoring an HOV lane program entails the number of vehicles and their speed and occupancy, but the primary variable of interest is the number of persons legally using the HOV lane.

Facility and program monitoring can be interrelated. Monitoring performed for a specific facility or set of facilities can also describe specific programs. Similarly, data collected to monitor the effectiveness of specific programs may also be useful for describing the functioning of the facilities that were monitored as part of that effort.

As with facility monitoring, **geographic area monitoring** can involve a large number of variables. The basic data collection variables are identical to those used for facility and program monitoring. Some variables, such as the number of accidents, must simply be aggregated to the appropriate degree to provide area-wide statistics, but other variables must be transformed for reporting at this level of aggregation.

The major reason for this transformation is that variables that have meaning for specifically defined facilities may not have much meaning when aggregated as summary statistics. For example, traffic volume on a short section of road is a very descriptive indicator of the use of that road. However, the variable vehicle miles of travel (VMT) for that short section is not as useful because it clouds the description of the number of people using that road. However, if a single summary value for three widely different road sections were needed, a single volume estimate might not have much meaning, whereas VMT would provide a useful measure of overall travel for all sections combined.

Among the variables that are conducive to area-wide reporting are

- vehicle miles of travel,
- total number of trips,
- total numbers of accidents, and
- percentage of travel exceeding 55 mph on urban freeways.

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Other variables such as mode split percentages and average vehicle occupancy are also used as area-wide estimates, but they tend to be more closely related to specific facilities than to geographic areas.

Ongoing Data Collection Efforts

When the number of data WSDOT collects is examined independently of the size of the facilities it operates and/or oversees, a large amount of traffic performance information appears to be collected. However, when the data are viewed in the context of the size of the systems and the extent to which those systems are being used, WSDOT appears to collect very little performance monitoring information, particularly at the facility and program level.

Facility and program monitoring data have traditionally been collected as "before" and "after" data on controversial projects, but they have rarely been collected on a routine basis (with some exceptions). Routine performance information has been collected only on the metropolitan Seattle freeway system because these data are used by the real-time control system that operates the ramp meters on the freeway.

Historically within the Department, the costs of routine performance data collection were viewed as greater than the benefits from collecting those data. This attitude may change as a result of recent legislation that mandates the collection and use of information on the need for transportation improvements before building construction permits are authorized for new developments in some counties. As a result of these growth management laws, WSDOT may have to routinely collect performance information (volume, speed, delay) on facilities subject to the growth management regulations. Funds have not been allocated for this function, and specific data collection procedures have yet to be established for this process.

The Department has considerable experience collecting performance monitoring data to analyze the operation of specific facilities, research projects, or other special topics. Data collected for these projects have consisted of the basic highway statistics of

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volume, speed, delay, and mode split, and have also included less traditional variables such as average vehicle occupancy. WSDOT has collected all of the MOEs that can be used for performance monitoring at one time or another, but these data collection efforts have covered only very limited time periods and facilities.

Other agencies have also been involved in collecting facility/program performance monitoring data used for Departmental facility monitoring. Many of the current programs that are a target of the Department's performance monitoring efforts include incentive programs designed to encourage ridesharing. Monitoring of these programs requires the collection of not only traffic volume data, but also data that indicate how those volumes are distributed by mode of transportation.

Transit authorities routinely collect transit ridership estimates on specific routes and within corridors. This information is necessary to determine mode split and also for WSDOT to monitor the impacts of HOV facilities on personal mobility. Similarly, the monitoring of park and ride use in lots that are partially funded by WSDOT will require cooperation with the transit authorities that operate those lots.

The Department's current ability to supply the data needed for **geographic area monitoring** is much better than that for facility monitoring, particularly for estimating statewide performance statistics. The vast majority of WSDOT's statewide highway monitoring needs can be met by an existing series of monitoring programs, plus a few proposed, but as yet undefined, programs. The existing programs include the HPMS sample program, the biennial truck weight submittal, the WSDOT pavement management program, the WSDOT bridge inspection program, and the statewide accident reporting system. These data collection efforts are large scale programs that either collect universal data (the pavement management system visually surveys pavement conditions on each mile of state highway every two years), or data from specially designed samples (the HPMS VMT estimates are based on a panel sample of highway segments that are distributed by functional class of roadway, one third of which are counted every year).

For the most part, these programs are already an integral part of the Department's data collection program. The data collected are essential for a number of significant analyses, and the funding for these programs has already been approved. Most of these programs already meet known WSDOT performance monitoring needs.

However, a few of these programs may need expansion or revision to meet new requirements or expected changes in federal and state data collection guidelines. The federal government will likely expand the monitoring requirements for urban congestion information and truck movements. The purposes of these additions will be to better define the performance of the urban road systems within the state, and to determine the level and impact of travel associated with various types of vehicles. For the most part, funds to pay for these increased data needs should be included in the new Intermodal Surface Transportation Act. (It is unclear how the increased planning funds within the new Transportation Act will balance against the requirements for providing congestion management, pavement management, bridge management, safety management, transit management, and incident management systems.) In addition, these increases are expected to require more of the same types of data collection, rather than entire new programs. Therefore, only modest increases in resource expenditures will be needed to meet the expanded data requirements.

The monitoring least covered by WSDOT's current programs is area-wide monitoring below the statewide level. That is, the existing systems do not accurately provide estimates of VMT (or other summary variables) by county or city. (This subject might be more appropriately covered under the section "Monitoring Statewide Activity" later in this report, but it is discussed here because of its close relationship to the Department's operational responsibilities.) Most of the universal WSDOT data collection efforts, such as the pavement performance database, cover only the state highway system. Roads maintained by local jurisdictions are not incorporated in this effort. The statewide samples (e.g., HPMS) collected by WSDOT are not designed to produce statistically

valid estimates at smaller geographic levels. (The random sampling technique used to select the sample sizes and locations for these surveys has resulted in little or no data collection in some counties, but fairly extensive data collection in other counties. Even for those counties that have been represented by a relatively large number of WSDOT data collection points, the existing data can not accurately estimate jurisdiction-wide statistics because those data points are not statistically representative of that jurisdiction.) Thus, many jurisdiction controlled facilities are not covered by either of these types of WSDOT data collection efforts and must be surveyed by the jurisdiction's staff or consultants.

In some cases, individual agencies have maintained similar systems for their own records and performance information. In many cases, little or no data exist because the jurisdiction has not had the resources to collect those data. In still other cases, some data exist, but the data are not comparable to those collected in other jurisdictions because the data collection techniques have been different, the sampling process has been different, or even the equipment has been different.

Ongoing Research and Planning

WSDOT does have a number of initiatives under way that are starting to provide data that can be used for the needs of both **facility and program monitoring and geographic area monitoring**. These projects include the following.

- <u>HOV Lane Evaluation and Monitoring</u> — This is an ongoing research project that is developing a system for monitoring the performance of the Puget Sound's HOV system. This data collection effort yields information on the number and occupancy of vehicles using the HOV lanes during peak and off-peak hours. These data can then be used to determine the impacts of programs such as the switch from 2+ to 3+ carpool definitions on I-5, as well as the impact of the completion of various new sections of the HOV system.

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- <u>Auto Occupancy Monitoring</u> — This ongoing data collection effort is monitoring (with statistical precision) the auto occupancy rate at selected locations in the Seattle metropolitan area. Data from these locations show peak and off-peak occupancy rates for each facility. The locations selected provide occupancy data for the majority of major facilities in the Seattle metropolitan region, but the data collected are not sufficient to accurately estimate occupancy rates within any given political or geographic area.

- <u>Incident Response Database</u> — This is a proposed data collection, storage, manipulation and reporting system that will be investigated this year by University of Washington researchers. The proposed project will investigate the feasibility of creating a relational database from accident reports, the State Patrol's computer aided dispatch system, and computerized logs kept by WSDOT personnel responding to incidents. If successful, the prototype will provide a system for monitoring the performance of the incident response system in District 1.

- <u>Congestion Monitoring</u> — Three projects are currently being pursued in this subject area. An NCHRP panel is attempting to develop one or more congestion indices that can be used on a national level. FHWA is attempting to revise the procedures it has used to estimate congestion in urban areas with the AADT information included in the HPMS volume sample. The revision is intended to make these estimates more accurate and the results more consistent among urban areas across the nation. Finally, WSDOT has proposed a project to examine the Department's options for collecting traffic performance information that would accurately measure congestion in urban areas.

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- Use of Automatic Vehicle Identification Techniques for Measuring Traffic Performance and Performing Incident Detection — This project is investigating the use of an IVHS technique to provide a more accurate, lower cost system for routinely measuring traffic performance. The performance information provided by these systems is primarily in the area of vehicle speed for a defined section of highway. The project is using technology developed under the HELP program.

Even if these projects do not result in specific data collection programs the Department can pursue, they will provide insight into the costs of data collection, the capability of the Department to collect data, and the types of data that must be used to monitor the Department's facilities.

All of these ongoing projects are incorporating the results of studies being performed by researchers from other states working on similar problems. For example, the Texas Transportation Institute recently completed a report that describes possible methods for evaluating HOV lanes. This report served as an input to the Department's HOV lane evaluation project. National IVHS projects such as HELP, Advantage I-75, and California's PATH project will provide useful information on the use of newer technologies for monitoring traffic.

Several other WSDOT efforts affect the collection of performance monitoring data because they may define specific monitoring system requirements. These efforts include, but are not limited to, the following;

- the corridor planning process, which may define the decision points that indicate a need for the next level of corridor build out (the monitoring process would need to be able to detect this condition);
- the TAG committee's efforts to revise and improve the Departmental project prioritization procedure;

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- any changes the TAG committee proposes as part of the results of the Roadway Jurisdiction study; and

- the Trip Reduction Ordinance passed by the state legislature.

One area of concern for statewide monitoring is that the legislature will request statewide summary statistics for measures of effectiveness that are not provided by the existing data collection programs. For example, the legislature may want to know the average automobile occupancy for all vehicle miles traveled in the state. Many of the performance monitoring statistics described in this document could be requested on a statewide basis, although many of these would have little meaning. It is doubtful that accurate estimates of performance measures not already estimated on a statewide basis could be soon provided. Extensive new data collection programs would have to be designed and implemented to make those estimates.

Of course, the legislature may not request this type of data. Although it is not required by the existing growth management statutes, the full implications of these laws are not clear.

Washington State Ferries

WSF performance monitoring differs from WSDOT highway performance monitoring in that information on ferry performance comes almost exclusively from WSF. WSDOT provides almost all ferry service available in the state. Thus, essentially all of the state's performance monitoring needs can be met with operational data collected within WSF. Reporting of operational performance by jurisdiction can be performed simply by subdividing WSF operational data.

WSF monitoring is also different from highway system monitoring because WSF directly generates revenue. (Gas tax revenue generated indirectly as a result of the vehicle miles of travel in the state is not collected by WSDOT, but fares for use of the state ferry system are collected by the Department.) Thus WSF can (and should) use revenue variables as part of the performance monitoring process.

The information below came from an interview with two WSF staff members, Director of Planning Ray Deardorf and Service Planning Manager Dave Remagen, and a review of a previously completed WSDOT research report, "Ferry System Data Scheduling and Billing, Data Analysis," from May of 1987. A more thorough analysis of WSF performance monitoring needs should include a detailed investigation of the uses of performance monitoring information within the areas of vessel and terminal engineering, vessel maintenance, and revenue collection, as these areas are not significantly incorporated into this report.

Uses For Performance Monitoring Data

As an operating agency, WSF has the opportunity to modify service in relation to the performance of different service elements. That is, additional capacity can be provided where demand is largest, while capacity can also be reduced where it is not adequately utilized. In addition, sometimes WSF can not provide sufficient capacity to meet demand. For these cases, WSF has started examining demand management actions to reduce peak demand, and the Department will have to monitor the success or failure of those efforts.

Many of the data described below would be useful in the day-to-day operation of the system. They would also have significant value to the public input that is a large part of the vessel schedule design process.

Performance Monitoring MOEs

The WSF has three categories of performance information that describe service operations. These categories are traffic statistics, revenue statistics, and operating statistics. Another category of performance information is expenditure tracking, and the last category of MOE explored briefly in this paper quantifies the performance of the maintenance functions for both (or either) vessels and terminals.

Traffic statistics measure the WSF ridership. Ridership levels (both passengers and vehicles) can be tracked by a number of variables, including by fare, route taken, sailing (date and time), and others.

Revenue statistics are similar to the traffic statistics and come from the same source (with minor exceptions). They include the number of fares purchased by fare category and route, as well as more aggregated variables such as total revenue for the system during a fiscal year.

Operational data describe the service that is provided (as opposed to the traffic statistics, which measure the use of that service). Operational data include information such as

- the number of trips provided in a given period,

- the presence and size of overload conditions,

- the capacity provided on those trips,

- the number of hours of service provided,

- the number of hours of revenue service provided,

- on-time performance and the number of missed or extra trips,

- vessel miles traveled,

- breakdowns,

- vessel moves, and

- accidents.

Each of these types of data can be used to monitor "how well" some aspect of the WSF system is working and then track how policies and plans meant to improve those aspects of ferry operations are progressing.

Ferry system expenses fall somewhere between a performance monitoring variable (e.g., Is the WSF spending too much money on some specific type of service?) and program monitoring (e.g., The WSF planned to provide this much service at this price, how close are we?). Variables that track expenditures are taken from the

accounting system WSF uses, and compared against budgeted amounts for program monitoring.

The WSF may also want to monitor maintenance statistics for vessels and terminals to track these costs and the performance of the maintenance process. Maintenance statistics track the time between failures of important vessel parts to avoid service disruptions. Insufficient time was available during the development of this position paper to fully explore the types of information needed (or collected) for monitoring the maintenance performance.

Ongoing Data Collection Efforts, Research and Planning

Traffic statistics are routinely collected and reported by the existing revenue collection process. Data on the number of tickets sold for each sailing are printed at each terminal, sent to Olympia, keyed into computer files, and stored on a WSDOT mainframe. Software programs on the mainframe generate a number of standard reports that describe passenger and vehicle usage of the different WSF routes. Current improvements to the WSF electronic cash register system should increase the system's level of automation, decrease the cost of collecting these data, and improve the reliability and accuracy of the data.

Revenue statistics also come from the cash register system and are routinely reported to WSF management. WSF also routinely performs expense reporting. The existing accounting system is designed to provide managers with reports that compare expenditures with budget estimates by expense category.

Operational data are, for the most part, not collected and reported. Some of this information can be obtained from the new computer aided vessel scheduling system and the traffic statistics information, but to collect the necessary operational data in an accurate and cost-effective manner requires the development of a new data collection process.

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While the above systems do not provide adequate data for monitoring the performance of all important facets of the WSF, the current traffic and revenue systems do create a base for developing such a system.

WSF is currently examining its needs for operational data and traffic statistics. WSF completed the definition of its revenue control needs as part of previous revenue control efforts. WSF does not currently have a good understanding of the options available for obtaining operations information, nor has it defined those uses of operational data that should be automated for management use. Initial steps towards identifying and obtaining this information may come from a proposed research effort to automate the vessel logs. Final decisions on these matters should come from internal WSF discussions scheduled for late January.

MONITORING STATEWIDE TRANSPORTATION ACTIVITIES

The second major type of performance monitoring the Department should undertake relates to general statewide transportation activity. As the state's designated agency for coordinating transportation activity, WSDOT is responsible for providing the state's legislature and public with information and expert judgment on the tasks needed to regulate and promote transportation opportunities and facilities for the good of the state. The Department's duties in this area are best summed up in the Statewide Transportation Policy Plan that WSDOT recently completed.

Uses For Performance Monitoring Data

The primary purpose for performance monitoring information at this level is to compare statewide trends in transportation with the goals and objectives of the state. In a practical sense, statewide monitoring provides insight into the state's transportation system's strengths and deficiencies. This information can then be used to determine the transportation alternatives that warrant attention and the funding level that is required to meet those deficiencies.

The Department is also partly responsible for setting reporting requirements for other transportation agencies and jurisdictions in the state. The need to develop these requirements and determine the data collection procedures to produce those reports has been discussed in the Highway Operations section above, but it is reinforced here because the Department must take the lead position in this effort within the state.

Performance Monitoring MOEs

A large portion of the statewide performance monitoring requirements are described in the WSDOT report "Monitoring the Performance of the Washington State Transportation Policy Plan," by Gary Pivo and Larry Frank. Table 1 presents a summary of the performance monitoring data necessary to monitor the implementation of the policy plan. The Pivo report states that the data collection requirements to monitor WSDOT's implementation of this plan encompass a wide variety of subjects, many of them only indirectly related to the actual operation of transportation systems. Many of the data must be collected from non-transportation agencies, and other requested data items are not currently collected or tracked by any agency.

Many of the Department's remaining statewide data collection needs can be inferred from the report "Transportation Studies in Progress by Mode," dated November 1991. This report indicates that the Department has a role in collecting, reviewing, and reporting summary statistics on airport operations, freight commodity movements, agricultural commodity movements, port operations (passenger and freight), and transit and road operations.

Ongoing Data Collection Efforts

Statewide statistics for highways and other roads can be readily obtained from the programs described in preceding sections of this paper (see page 5). Data for these estimates are collected as part of the Department's roles as an operator of many of the state's roads and as the funding conduit for federal appropriations.

Table 1. Indicator(s) for Each Goal Statement

Goal Statement	Indicator(s)
1) provide safe, reliable, and convenient access to employment, educational, and recreational opportunities in order to reinforce a sense of community statewide	- safety = # of incidents per pm pk hr in system - reliability = variation in travel time at specified locations - convenience = travel time at specified locations
2) provide cost effective accessibility for goods	- total cost of moving goods/ total value of trade
3) provide cost effective accessibility for people	- vehicle occupancy rates at specified locations
4) link land-use planning directly with transportation planning	- # of jurisdictions complying w/concurrency provisions in Growth Management Act - # of Regional Transportation Planning Organizations (RTPOs) formed
5) link land-use development directly with transportation system development	- # of dwelling units per acre - % modal split over time - average trip length - average travel time between specified points in trans. system
6) support international trade	- total value of freight in state per year
7) revitalize blighted urban areas	- average household income in distressed areas - # of jobs per unit of area in distressed areas
8) revitalize economically isolated areas	- unemployment rates measured in distressed areas
9) conserve scarce resources	- average fuel consumption per mile (both passenger and freight) - total consumption of fuel in state for transportation purposes
10) reduce pollutants and other wastes from transportation system	- AIR: amount of pollutants attributable to trans. - WATER: % of highway miles with runoff treatment system - WATER: particulate mix of runoff as compared to standards developed by Puget Sound Water Quality Authority (PSWQA) and other agencies - NOISE: # of people exposed to extreme levels from transportation system
11) avoid the disruption and degradation of historically and environmentally significant locations	- # of acres of environmentally sensitive land lost due to transportation infrastructure deployment - # of historically significant locations adversely affected by transportation system development

Source: Gary Pivo and Larry Frank, "Monitoring the Performance of the Washington State Transportation Policy Plan," Repot No. WA-RD 235.1. Olympia, Washington, Washington State Department of Transportation, October 1991.

Table 1. Indicator(s) for Each Goal Statement (Continued)

Goal Statement	Indicator(s)
12) include effective urban design in transportation facilities	- presence or absence of pedestrian amenities at transit nodes - presence or absence of pedestrian linkages to transit nodes - % of highway system with landscape treatment and buffering
13) ensure the collection of appropriate revenues to support the transportation system	- amount of revenue available to support the transportation system/amount of revenue required to support the transportation system
14) encourage opportunities for public/private partnerships	- presence or absence of policy that discourages joint development - presence or absence of policy that encourages joint development - # of jointly developed transportation projects
15) promote greater sharing and coordination of technical expertise between state and local government	- # of transportation projects with shared personnel - # of technical-applied manuals produced in state
16) promote sensitivity to public participation	- % of citizens who feel they have opportunities for participation - # of programs that promote public participation
17) facilitate interjurisdictional and regional coordination	- # of Regional Transportation Planning Organizations (RTPOs) formed - # of projects successfully built by Transportation Improvement Bureau with regional cooperation - # of interlocal agreements
18) assure the preservation of the needed system	- % of existing highway system at an acceptable standard of repair - % of existing railroad system at an acceptable level of repair - dollar value of deferred maintenance of transit facilities
19) sponsor innovative research and development in cooperation with academia, private sector and others in order to identify new cost effective methods and address current and future transportation needs	- % of annual transportation budget devoted to research - $ devoted to innovative research and development

Source: Gary Pivo and Larry Frank, "Monitoring the Performance of the Washington
State Transportation Policy Plan," Repot No. WA-RD 235.1. Olympia,
Washington, Washington State Department of Transportation, October 1991.

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For systems that WSDOT does not operate, the Department must rely primarily on data collected by external sources. Table 1 (shown on the previous page) indicates which of the data items identified by Pivo and Frank are currently available through some existing source and which are not currently collected.

The need to obtain data from non-WSDOT sources complicates the data collection process and prevents the Department from collecting the data by simply allocating the necessary resources to those activities. Many of the items that should be collected for reviewing implementation of the Statewide Transportation Policy Plan fall under this category. The Department and the legislature have committed to performing these monitoring functions, but many of the data collection functions have yet to be identified or funded.

Ongoing Research and Planning

While the report "Transportation Studies in Progress by Mode" is slightly out of date, it provides a useful look at topics that are important to the Department. Among the projects mentioned in this report that deal (at least in part) with the need for monitoring some portion of the state's transportation system are the following.

- The Washington State Continuous Airport System Plan is an ongoing project that develops and monitors plans for general aviation airports in the state. This project monitors airport system performance for smaller airports. It provides operations forecasts, identifies airport needs and improvements, and establishes funding needs, as well as performing other functions not related to performance monitoring.

- The AG 2000 Transportation Subcommittee is responsible for monitoring the status of the state's transportation system as it relates to the movement of agricultural goods. Monitoring functions performed by this group include determining the road needs for facilitating agricultural movements,

monitoring rail line abandonments, estimating rail car needs and shortages, and monitoring safety in food transportation.

- The Transportation Analysis Group, or TAG (formerly the Road Jurisdiction Committee or RJC), is charged with several studies that will have significant impact on the Department's monitoring needs and functions. The most important of these projects is a study of the program and prioritization procedures the Department uses. This study is analyzing the ability of these procedures to adequately provide resources for the state's transportation problems. The study will review how the state's investment in transportation management alternatives and other nonconstruction approaches are considered in the priority process, as well as how inter-jurisdictional planning and coordination are accomplished.

- Truck Commodity Flow Data Collection Methodology is a project that will examine ways for the Department to collect sufficient information to understand the origins and destinations of commodity movements within the state.

- The Port and Transportation Systems Study — 1991 Update is an ongoing effort to forecast expected port shipments and compare those expected shipments with the capacity of non-seaborne transportation modes that haul that cargo to and from the port.

- The Washington State Three-Year Freight Rail Study included a task to review the inventory and condition of light density rail lines.

- A series of special studies deal with the potential for implementing new transportation technologies. These are the WSDOT High Speed Ground Transportation Study (HSGT) and the High Capacity Transit Study in Seattle and the Portland/Vancouver High Capacity Transit Study. All

three of these studies need information on the number of people traveling from one portion of the state to another.

While these studies do not encompass all of the Department's monitoring needs, they do give a good indication of the scope and breadth of the Department's interests.

FUTURE WORK

The above descriptions of needs and ongoing work within the Department share several common themes. The Department is aware of a need to provide more reliable estimates of the status of transportation systems in the state, regardless of whether those estimates are for individual facilities or composites of many facilities. Departmental staff understand the MOEs that can be used to describe system performance and already collect some of the data. However, these data are not collected in a sufficiently consistent or cost-effective manner for the expanded reporting requirements of performance monitoring. Finally, the Department has yet to select the variables to be reported, or the procedures to use to ensure consistent reporting of information among facilities or geographic areas. All of these issues need further analysis, and each analysis must culminate in decisions to pursue specific monitoring strategies.

The author recommends that, for both operational and statewide performance monitoring, the Department answer the questions listed below to create the necessary monitoring systems.

- What are the basic goals/objectives of the performance monitoring process as it relates to each aspect of the transportation system (i.e., regardless of whether it is needed for facility monitoring, area monitoring, or statewide monitoring)?

- What data (variables) can the state use to most effectively monitor these objectives?

- Will a specific statistical precision be associated with any of these estimates? If so, what is that level of precision?

- Which of the potential variables can be most easily collected while still providing an accurate measure of the desired system performance?

- What are the costs associated with the collection of the necessary monitoring information?

- Does the cost of data collection change the MOEs that have been selected or the selected precision?

- To what extent will the Department require submittal of these MOEs for facilities that are controlled by cities and counties in the state? (This information applies mainly to road networks.)

- Will these submittals be at the same level of statistical precision as the the MOEs for state facilities?

- Who will fund the collection of the necessary data?

- Will the Department specify the methodology to be used to collect those data?

- Will the Department develop the sampling and/or extrapolation procedures for estimating area-wide performance monitoring statistics for jurisdictions around the state? If so, who will do this, and within what time frame?

While developing the answers to these questions, the Department must also be aware of the work being done at the national level to develop standard congestion monitoring criteria. The USDOT is likely to adopt a national monitoring standard for highways and transit, and the Department will need to collect and report this information. As a result, decisions made at the national level may drive the selection of monitoring techniques and variables at the state and local levels.

Perhaps even more than the highway division of WSDOT, the WSF needs a careful analysis of the types of service criteria it wants to use as measures of its performance. Currently, little in the way of "concrete" service information is used in the service planning process. Instead, the planning process depends heavily on "informal" reporting of service problems via crew member reports, public complaints, a substantial public input process, and terminal agent reports.

The existing and planned WSF revenue collection and vessel scheduling procedures have the potential for producing a significant proportion of the needed performance monitoring information as part of their normal functioning. (See the 1987 report "Data Collection, Scheduling and Billing.") However, to obtain and use this information in a routine and cost effective fashion will require substantial additions to the systems. Before committing the resources necessary to collect these data, the WSF must pay particular attention to how the performance monitoring results will be implemented (i.e., what the objectives of performance monitoring really are within the WSF).

Lastly, WSDOT needs to consider the impact of performance monitoring on outside agencies and jurisdictions. Data from these sources are critical to WSDOT's monitoring needs, but the expansion of these data needs will not be easily accomplished, even by providing resources for those tasks. Thus, on top of the basic lists of MOEs, potential data needs, and data sources, WSDOT must consider whether the data collection task can reasonably be expected to occur, given the operating environment of the desired mode of transportation.