Exploring Methodologies for Comparing State Highway Performance

Supplement to NCHRP Report 357

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Prepared for
National Cooperative Highway Research Program
Transportation Research Board
National Research Council
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ACKNOWLEDGMENTS

This work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration. It was conducted in the National Cooperative Highway Research Program, which is administered by the Transportation Research Board of the National Research Council.

To undertake this assignment with the inherent time constraint required the understanding and patience of our students, colleagues, and others with whom we associate. Virtually everyone we contacted and requested information, guidance, or assistance were very supportive and understanding and to them we are indebted. We particularly thank the assistance of Mr. David Clawson from the AASHTO staff and the members of AASHTO’s Standing Committee on Planning for their timely response to our inquiries for state studies that are relevant to this work.

The authors wish to recognize Robert J. Reilly and Crawford F. Jencks of the NCHRP and Lester P. Lamm and Marshall F. Reed of the Highway Users Federation for their valuable assistance. Also, the final preparation of the report and all that it entails could not have been completed in such a timely and efficient manner without the dedicated commitments to this effort by Shekhar Govind, Assistant Professor, Civil and Environmental Engineering, Lafayette College, and currently Visiting Scholar at the University of Texas at Austin, Vicki Simpson, and Martha Sorrell of the Department of Civil Engineering, The University of Texas at Austin.
EXECUTIVE SUMMARY

The challenge associated with measuring performance is complex, often subjective and controversial, and requires careful and prudent forethought. Such is the case in determining the feasibility of making valid comparisons of the performance of state highway systems and evaluation of methodologies used or proposed for use in making such comparisons. This report states the finding and conclusions of a study undertaken to: 1) assess the current practice in comparative program/system evaluation; 2) explore the feasibility of making comparison of the performance of state highway systems; 3) define the characteristics of methodologies used and proposed for use in making such comparison; and, 4) propose appropriate actions.

A review of the literature on the topic of program performance and comparative analyses suggested several noteworthy observations. Concerning highway program performance studies; the states and the FHWA collect large volumes of statistics annually. FHWA must rely upon the accuracy of the data submitted, and they do take steps to maintain as high a degree of quality control as possible. However, based upon the review of the studies available for this project, there are a number of precautions that must be observed when using these data. They include:

- inconsistencies in the methods of reporting;
- differences in the assumptions that are used in gathering and reporting;
- the absence of qualifying factors, such as urban congestion, costs of labor and materials, sources of funding, use of funding, environmental concerns, demographic conditions, geography, topography, etc.; and
- inconsistencies in the analysis methodologies

There is clear agreement that the inconsistencies in the available data make it very difficult to compare states based upon those data. However, there is also agreement that it is desirable that appropriate measures of performance be established that would allow for a comparative "peer" analysis of state highway programs.

Several studies used to assess various aspects of the performance of state transportation programs were selected for review. Although each dealt with various aspects of program performance, each was also quite different in its motivation and in the approach used to achieve the stated objectives.

The studies illustrated the following relative to their potential for making state comparisons:

1. The data used for such purposes must be consistent in quality and appropriateness for the objectives to be served;
2. The analysis methodology must be appropriate and consistent if state-by-state comparisons are to be made;
3. External, often uncontrollable factors make it difficult and often inappropriate for the comparison of states; and
4. The inappropriate comparisons of state data can lead to inaccurate conclusions and be counterproductive in their misuse.
Throughout this report we have alluded to the desirability of establishing program performance measures.

An annotated bibliography of pertinent literature is provided in an appendix and is summarized in the report for highway, transportation, and non-transportation cases. Of note were examples of performance measures, system comparisons, and the issues associated with the use or non-use of particular factors. A conceptual framework for program assessment is presented with more focus and description given to three major elements of an assessment methodology: performance measures, input variable, and external factors.

The report concludes with a series of observations which provide direction to conducting any comparisons of state highway performance. It is concluded that the performance evaluation of a state's highway program is, and will continue to be, an important component of highway management. However, our review has made it clear that a comparative evaluation of state highway program performance is: 1) an extremely complex activity that must take into account the many external factors that could influence the value of the input or output variables or the relationship between the two; 2) dependent upon the underlying assumption of the cause-effect relationship that is common to all of the program being evaluated; and 3) dependent upon several characteristics of the data themselves that make consistent and reliable comparative estimates very difficult to do.

In summary, we did not find any report in the literature that provided a sufficiently complete framework and accounting of the above considerations that, in our opinion, produced pertinent or constructive comparative evaluation.
CHAPTER 1
INTRODUCTION

"Whether the goal is defending the nation or immunizing children against disease, government officials and the public need to know how well government is accomplishing its intended objectives. Assessing government accomplishments requires measuring program performance. Though the size and complexity of the government make it difficult, developing effective performance measurement systems is clearly possible."

—Government Accounting Office

Measuring program performance regardless of the mission or topic is complex, often controversial, and requires careful and prudent forethought. Assessing performance is a common occurrence in all aspects of human endeavor. The ordering of performance of athletic teams, for example, may be considered more direct and simpler than the ordering of an undergraduate academic program among universities; yet one can readily identify the annual controversy which springs from the annual or periodic arrangement of such orderings. The methodological approach, the selection of the performance measures, the relative importance of the measures, the quality of the data, and the integration of the results are often issues subject to challenge. With due recognition of the issues and risks involved, the goal remains noteworthy. The importance of the goal is not in the relative ordering of competing or comparable units but in seeking enhanced offering, productivity or similar priorities. Therefore, the selection of the approach must be such that the result yield insights into opportunities and strategies for improvement.

This report describes an effort undertaken as a result of Policy Resolution PR-25-92 approved by the American Association of State Highway and Transportation Officials Board of Directors on October 4, 1992. The action requested the "Transportation Research Board to address the issue associated with state highway performance comparisons." This effort, having been prompted by a recently released report, was proposed to determine the feasibility of making valid comparisons of the performance of state highway systems and an evaluation of methodology used and proposed for use in making such comparisons. The charge for the proposed study recognized the current effort underway by the Highway Users Federations entitled "Measuring State Transportation Program Performance" (NCHRP Project 20-24(6)A).

1.1. Objectives of the Study

Recognizing the activities currently underway or recently completed and the essence of the AASHTO Policy Resolution, the objectives of the study reflected in this report were four (4) fold:

1) To assess current practice in comparative program/system evaluation;

2) To explore the feasibility of making valid comparisons of the performance of state highway systems;

3) To define the characteristics of methodologies used and proposed for use in making such comparison; and
4) To propose actions which are deemed appropriate and which stem from this analysis.

1.2 Study Scope

The scope of work included the identification of relevant experiences in fields other than transportation where rank orderings were developed. The synthesis of the literature found and reviewed is reported in Chapter 2, with more complete information on the key documents found in Appendix B. More citations obtained during a broader sweep of the computerized TRIS files are given in Appendix A. This facilitated the search process by providing direction to resources beyond readily retrieved sources. Contacts and approaches were made to non-transportation organizations and fields of endeavor to explore pertinent activities and literature such as in health programs, social sciences, education and World Bank programs.

Particular attention was given to examples of the use of specific indications of performance and their use in monitoring performance or in other approaches to accountability. This related to highway and non-highway cases. Of particular importance were instances where highway system performance ratings and rankings had been used or might be used, and if so, by whom.

Similarly, attention was directed to identifying those factors such as bias or variation among individual states to include highway needs, system utilization, monetary costs, growth rates, climatic variation, topography, urban/rural balance, legislative policies, mileage and functional classification of highways under state control. Chapter 3 presents a review of the approach found to compare performance of various activities.

Lastly, the scope included the search for alternative applications for an overall ranking of each state highway system or indication of performance in specific activity such as the six management system mandated in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Chapter 4 suggests a means of characterizing a good highway performance assessment.

The remaining chapter in this report summarizes the findings of the study.
CHAPTER 2
SYNTHESIS OF LITERATURE AND REPORTS

2.1 Introduction

This chapter summarizes the results of a comprehensive assessment of recent studies, within the past five years, which have attempted to assess the performance of several major programs affecting the citizens of the United States. The programs are in the areas of transportation, education, health and other social service. For a variety of reasons described below, aspects of state highway and transportation programs have been the subject of numerous studies of this nature. Given the limited time available for this report, every effort was made to include all existing sources of information that were readily available. They were as follows:

For Highways:
- Transportation Research Information Service (TRIS) provided by the National Academy of Sciences;
- Contacts through the American Association of State Highway and Transportation Officials (AASHTO), its Standing Committee on Planning (SCOP);
- Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) reports to Congress;
- The Highway Users Federation (HUF); and
- Other sources.

For Education:
The U.S. News and World Report annual survey of higher education

For Health/Social Services:
A list of papers in this area can be found in Appendix A.

Appendix B summarizes each of the reports that were used for this study.

2.2 Summary of Sources of Information

2.2.1 Transportation

The survey of the sources of information described above resulted in the following:

1. Reports Through TRIS
   This search did not uncover any reports on the topic covered in this analysis.
2. Reports From AASHTO/SCOP

This provided an extensive number of reports, as shown below. (Each is summarized in Appendix B):

States That Submitted Relevant Reports

1. Alaska
2. Arkansas
3. California
4. Idaho
5. Kansas
6. Maryland
7. Minnesota
8. Nebraska
9. New Jersey
10. Oklahoma
11. Oregon
12. Texas
13. Utah
14. Vermont

States Reporting There Were No Relevant Reports

1. Florida
2. Hawaii
3. Louisiana
4. Mississippi
5. Missouri
6. Pennsylvania
7. Tennessee
8. West Virginia
9. Washington

We assume that those states which did not respond do not have studies relevant to this report.

Highway Users Federation

The HUF has completed more than a dozen projects over the past several years for the purpose of analyzing the management and operations of State Highway and Transportation Agencies. Many of the individual state reports are similar in their methodology and analyses. Consequently, although all that we could obtain were reviewed, only one - for New Hampshire, is summarized in this report.

In addition to the individual state reports, we also reviewed the HUF's recently completed national study under contract to the National Cooperative Highway Research Program (NCHRP) titled: "Measuring State Transportation Program Performance," Final Report, November 1992.

Other Sources

A study was recently published by the University of North Carolina titled: "Resources vs. Results: Comparative Performances of State Highway Systems; 1984-1990," July 1992. It is included in our analysis.

2.2.2 Program Evaluation

The relative performance effectiveness of state highway programs falls into the general category of program evaluation. A great deal of literature has been written on the different approaches that can be used to undertake an assessment of an individual
program (e.g., mental health, public welfare, enforcement, job training). Less has been written on how to conduct a comparative assessment of programs that are not under a single policy or jurisdictional responsibility (e.g., comparative performance assessments of highway programs). A literature review was conducted of both scholarly works on program evaluation and of examples of program assessments. The Urban Institute was contacted to determine whether any studies of urban programs were available. In general, the literature does provide some theoretical insights into the most appropriate experimental design for conducting such an assessment, but again there were few instances in which the performance of 50 individual state programs were compared to each other. Another type of performance assessment, similar in intent to program evaluation, which is designed to compare the effectiveness of different alternatives, is the cost effectiveness approach used in the Federal Transit Administration's Alternatives Analysis process. This process was also included in this literature search.

2.2.3 Organizational Studies

Another body of literature considered relevant to this study was the area of evaluating organizational performance. Once again, this literature does not usually focus on comparative assessments of organizations across the country, but instead examines how one can establish a valid cause-effect relationship between organizational resources consumed and the eventual performance of the organization. Again, a literature search was conducted of this approach to program evaluation. Several studies carried out in California in the late 1970's on transit system performance as it related to important organizational resource characteristics were found to have relevance to this effort. Other literature found to be important in this area included works on organization environment and productivity.

2.3 Synthesis of Highway Reports

2.3.1 Purpose of State DOT Evaluations

All State Departments of Highways and Transportation (hereafter referred to as State DOT’s) periodically conduct internal reviews of their operations. As alluded to above, and as summarized below, some states also request outside organizations to do an independent assessment of their operations. The results are used to critically evaluate and eventually improve the overall efficiency of the organization.

One method often used in these evaluations is to compare certain key program elements of one state to those of other states in order to compare program approaches and results. The data are usually obtained from FHWA statistics. Such information can also be used to help assess a state's program and its operations.

In the following discussion we summarize the methodologies used; the criteria used to analyze various program elements; the application of the results to individual state programs; and the potential application of such analyses in comparing one state to another.

2.3.2 Methodologies Used

The reports received from State DOT’s and the other sources available fall into the following four categories of "methodologies": 
A. Analyses undertaken by the HUF; our review has included Alaska, Idaho, New Hampshire, Oklahoma, Oregon and South Carolina. In addition, we have included the recently completed national analysis by the HUF for the NCHRP.

B. Analyses undertaken by a state to evaluate state-by-state statistics obtained from the Federal Highway Administration (FHWA). Our review included several states.

C. Special purpose individual state analyses undertaken by the state, but conducted by an outside organization; our review includes California, Kansas, Nebraska, New Jersey, Texas, and Utah.

D. State comparative analyses have included two studies.

The NCHRP study undertaken by the HUF and a study by a UNC/Charlotte research team.

The following summarizes each of the above categories of methodologies.

2.3.2.1 The HUF State Studies

1. Approach Used

The HUF has been involved in the analysis of state DOT programs for many years. During the past decade they have been invited by a dozen or more states to undertake these studies. The purpose of each is to evaluate the effectiveness of the state's highway program in meeting its citizens' needs for safety, service and cost effective transportation now and in the future. Each study typically covers many management, financial, highway needs, geographic, demographic, environmental, program performance and productivity issues.

The studies always involve detailed interviews with key members of the State DOT, State Legislature and various highway user groups. Studies and reports provided by the state are gathered and analyzed. The studies also typically obtain data from "peer" states to compare various highway performance measures. Each study always points to the social, environmental, demographic, financial and other unique characteristics of each state when making peer reviews.

The studies always result in a detailed set of recommendations to be used by the state to improve efficiency and productivity. Each study also identifies the constraints and barriers that must be considered in order to achieve the desired improvements.

2. Comments

The HUF reports are used extensively by the states who request them to guide them in modifying and improving their programs. Each report is very detailed in developing specific recommendations.

The state peer reviews are of particular relevance to this report. The HUF takes great care to point out that, although the comparative state-by-state statistics are of interest, they cannot be used to judge the effectiveness
or efficiency of a particular state. Comparisons between states may not be relevant because there are many significant demographic, geographic, financial, social and other factors that make each state unique. This is true even though the HUF carefully selects "peer" states that exhibit similar characteristics.

2.3.2.2 Studies Based Upon FHWA Statistics

1. Approach Used

Each year the FHWA collects numerous statistics from each State DOT concerning state highway activities and programs. These data are published annually in a document titled: "Highway Statistics." Each edition contains detailed data covering among other information, motor fuel, motor vehicles, driver licensing, highway finance, and roadway extent, characteristics and performance. An individual state may be interested in where it stands relative to other states, but based upon a limited review of such reports the reasons for those differences are not analyzed.

2. Comments

The states that summarize these data cannot analyze the reasons why their "ranking" occurs without undertaking considerable additional analysis. It is assumed that the data required to undertake such an analysis are not available.

2.3.2.3 Special Purpose Individual State Reports

The group of studies identified in this category include California, Kansas, Nebraska, New Jersey, Texas, and Utah. (These reports are summarized in Appendix B.) They are particularly relevant to this study because of the depth to which they analyzed the reasons for their differences with "other peer states." They are each summarized below.

1. Approach Used: California Study

In a report titled "Cost of Developing Highway Projects", the California Department of Transportation (Caltrans) analyzed the data and procedures used to report project development costs by California and other states. This study was in response to severe criticism leveled at Caltrans based upon a published report stating that California's average annual cost of engineering exceeds 44% of total capital outlay. The national average (for all states combined) is 15%.

In September, 1991, the "Professional Services Management (PSM) Journal" published a report titled "The Effect of Contracting Out On Engineering Costs." This report was prepared for the American Consulting Engineers Council and was developed from data submitted annually by the states to the FHWA. Caltrans prepared its own analysis of the cost of developing highway projects. The Caltrans report compared the methods used by five other large states (Florida, Illinois, New York, Pennsylvania and Texas). The Caltrans report concluded that the California costs averaged 16.5% over the last three years when using consistent data and methodology. It concluded that the 1991 PSM Journal article's study methods and data used to compare states were flawed and led to inaccurate conclusions. An exchange of correspondence between Caltrans, FHWA and the PSM Journal, along with the Caltrans report, raises important
relevant issues concerning why inconsistencies in data reporting and inconsistent methodologies can lead to flawed conclusions.

The Caltrans analysis was based upon a very detailed study carried out by the University of California at Berkeley. That study collected detailed cost data for highway projects designed by in-house Caltrans personnel and for projects designed by outside contractors. The average costs of the projects showed that there were no significant differences between the cost to design a project in-house compared to the cost of contracting for those services. The study revealed that there are inconsistencies in data reporting by the states to FHWA and in methodologies used to evaluate comparable performance measures.

2. Approach Used: Kansas Study

The Kansas DOT contracted with the firm Peat, Marwick, Main & Co. to assess the present operations and to make recommendations to strengthen the management policies and practices, the organizational structure and staffing of KNDOT.

This report is similar to those prepared by the HUF. The analysis included a review of practices in three "peer" states (Iowa, Nebraska, Oklahoma), and interviews with state personnel. The conclusions indicated that the KNDOT was comparable to the programs in those states, relative to "performance" criteria that are published by the FHWA. The focus of the report was on management and organization.

3. Approach Used: Nebraska

A "Report to the State Board of Equalization," prepared by the Nebraska Department of Roads in 1986, answers the question posed by the Governor, "Why is the Nebraska gas tax so high?" It compares fiscal, demographic, mileage and condition statistics to six surrounding states. This study shows that the "raw statistics" (such as the amount of the state gas tax) do not tell the whole story. For example, Nebraska has the highest gas tax, but the lowest price at the pump for gasoline purchases. Nebraska's pavement condition is better than that of the surrounding states. The gas tax is also used to support other state functions (i.e., other than highways). This study illustrates that raw statistics may often compare "apples with oranges."

4. Approach Used: New Jersey

In a report titled "Nationwide Variations in the Cost of Highway Construction: Implication for Future Surface Transportation Policy," the New Jersey Transportation Coordinating Council, Committee on Transportation Financing, showed that there are significant cost variations in highway and bridge costs across the nation. It was developed as a resource to make a case for Congress to include these factors in allocating ISTEA funds. Using FHWA data (submitted yearly by each state), the study showed that the costs of highway and bridge construction vary by well over 100% among states. This is a very significant fact when comparing state needs and the ability to meet those needs. The report also emphasizes significant (but explained) inconsistencies in the FHWA statistics that are reported by each state.
5. Approach Used: Texas (1)

The Texas DOT has undertaken a series of studies to establish more precise measurements of highway system performances using the Analytic Hierarchy Process (AHP). The report comments on the Highway Performance Monitoring System (HPMS), which is the analytical computer model used by the FHWA as the basis for assessing highway needs and costs nationwide. Used since the late 1970's, each state collects sample data for a composite index of nine variables that quantify highway condition performance. The HPMS model is highly sensitive to the component weights of the performance functions, so some states have begun modifying "national average" default values in the model in order to represent their own specific highway condition priorities. The report stated that: "Failure to correctly quantify these priorities would cause the model to optimize the wrong factors, producing an inappropriate highway strategy for that state."

The purpose of the research described in this report was to examine what the weights should be in the HPMS model and how "Analytic Hierarchy Process" can improve the confidence in these determinations. The research concluded that all significant measurements of highway performance are not equally important, and that relevant weighting factors are needed. The report demonstrated how subjective weightings can be made with increased confidence using a feature of the Analytic Hierarchy Process. This is a very relevant analysis of the HPMS process that appears to clearly demonstrate that all measures of performance are not equally important. The key conclusion is that more meaningful weighting factors are needed.

6. Approach Used: Texas (2)

Another Texas DOT research report is titled "Assessing DOT Operational Efficiency with Data Envelope Analysis." Its purpose is to discuss the potential value of Data Envelope Analysis (DEA) in assessing the efficiency of the operational units of the Texas DOT.

DEA is a rigorous mathematical method developed over the last decade by Charnes and Cooper to analyze and compare operating efficiencies. Texas DOT examined the potential application of DEA to make comparisons between SHD District Offices for all functions (maintenance, construction, etc.). If successful, it could be used to evaluate the performance of all activities for each District.

This Texas study concluded that comparison of "efficiencies" to average values do not give useful information about how to attain peak efficiencies. This is especially true when there are multiple outputs and multiple complicating factors to take into account. The study shows how the DEA approach can provide supportable overall performance measures when multiple complicating circumstances must be correlated, while avoiding subjective weightings with some type of optimization technique.

7. Approach Used: Utah

In a report titled: "Revenue Available to Transportation Programs," the Utah DOT analyzes taxing sources that are used primarily for highway purposes in Utah. Utah DOT conducted this study in 1991 to show
transportation funding sources available in other states. It resulted in a table of "cents per gallon equivalent tax revenue" for each state. This resulted in a range of 78.6 cents for New York to 22.6 cents for South Carolina.

There is such a broad diversity in tax sources that this provides good reasons for the need to consider the many diverse conditions among different states. It is interesting to note that small rural states such as Kansas, New Hampshire and Nebraska have "equivalent" values that are in the same relative range as for very large urban states such as Minnesota, Wisconsin, Maryland, New Jersey, etc.

2.3.2.4 State Comparative Analyses

There were only two reports found that evaluated the performance of State DOT's on a national basis; they are summarized below.


The following is taken from the abstract of this final report.

"This report identifies key program performance measures and indicators needed by chief administrative officers of state highway and transportation departments for effective and efficient administration of state highway and transportation programs. The report also contains information on states' usage of these measures and indicators; the need to tailor the measures to each program; and the need to set goals and objectives against which transportation program performance can be evaluated. Finally, in recognition of the rapid turnover of state chief administrative officers in recent years, the report contains a compendium of basic information for the early needs of newcomers to state transportation program management. The suggested program performance measures are offered as the basis for Executive Information Systems (EIS). Much of the information is based on responses to a 1991 survey of the states and Canadian provinces. However, much is also attributable to the research team's recent experiences (14 states over the 1984 to 1992 period) in advising state highway and transportation officials on program management issues. Overall, the report responds to the current issue of citizens' demands for improved accountability for public resources."

Following is a summary of the conclusions reached by the study.

(1) Program performance measures will become increasingly important tools for legislators and citizens in judging the performance of public programs and in holding officials accountable for the efficiency and effectiveness of their programs.

(2) The nation's highway and transportation officials will lead the way for other state officials in the use of performance measures, as they have in adapting to computer technology and many other productivity enhancements.

(3) Much of the information needed to establish systems of transportation program performance measures -- more
commonly referred to as Executive Information Systems (EIS) -- are readily available. However, in order to make full use of program performance measuring systems, state highway and transportation departments need to devote more resources to monitoring the physical condition and the services provided by state supported transportation systems.

(4) Program goals are needed as benchmarks for measuring program performance.

(5) All state highway or transportation programs differ in mission, scope and goals. Therefore transportation program performance measuring systems have to be tailored to each state's needs.

(6) Chief administrative officers can use state-to-state comparisons of program performance in decisions on budgets and staffing. However, when comparing the performance of one state highway program with another, it is important to select states of similar geography, topography, population, etc., and then to use the information judiciously.

(7) Beyond the use of performance measures to judge overall program performance, there are other opportunities to use performance measures to improve the management of the many processes needed to accomplish state transportation program missions.


This study examines the overall performance of the U.S. highway system and of each state over the period 1984-1990. The intent was to compare changes in system performance over time, in relationship to resources expended and in relationship to other states' and national averages for the same performance measures. A letter grade was then assigned to each state by relating the state's performance over time to the national average, and by determining if the state's performance was improving, staying constant, or declining relative to this benchmark. The specific data items selected for tracking were: 1) total miles of highway under state control, 2) total receipts for state controlled highway systems, 3) capital disbursements for highways, 4) maintenance disbursements, 5) administrative disbursements, and 6) total disbursements. The state performance measures included: 1) percent of rural and urban interstates with a PSR less than 2.5, 2) rural other principal arterials and urban other freeways and expressways with pavement condition less than a PSR rating of 2.0, 3) percent urban interstates with V/C ratio greater than 0.7, 4) percent deficient bridges, and 5) fatal accidents per 100 million vehicle-miles. The data for the study came from reports submitted by the states to the Federal Highway Administration, in particular data submitted as part of the Highway Performance Monitoring System, the National Bridge Inventory System, and the Fatal Accident Reporting System. In order to take into account different sizes of state highway systems, the data were normalized to national averages, all revenue and disbursement statistics were divided by centerline mileage on the state-owned system, and each year's data were treated separately.
The paper concludes that the U.S. highway system is improving in performance and has been doing so since the early 1980's. With regard to the ranking of the 50 states, there was no discernible relationship established between the ranking for each state and geographic location, although it was noted that heavily urban states and those having a large percentage of through travel tended to be at the bottom half of the ranking. Those states with the highest unit costs appeared to be moving away from national averages rather than toward them. The authors conclude that the type of methodology outlined in this paper can be used by state DOT officials to better manage their state highway program.

The authors point out some of the limitations of the study. These include: 1) no use of lagged variables, 2) no treatment of travel from neighboring states, 3) labor cost differences across the country, 4) possible errors in the data base, 5) selection of the variables for analysis, and 6) no analysis of transportation need (e.g., changes in population or automobile registrations). However, the authors also state that these limitations of the study are neither fatal nor preemptive.

2.3.3 Application of Study Results To Individual States

With the exception of the two "State Comparative Analyses" reports summarized above, the studies undertaken by individual states have been used by those states to assist in the identification of methods, procedures and programs to improve their existing state highway programs.

In some cases, such as those summarized in Section 2.3.2.3, a number of special purpose studies have been undertaken to prove or reject assumptions that have been made about various aspects of state highway programs. In that section some very relevant points were made concerning the inconsistencies in the data reported to FHWA by individual states. Also, such as in the case of the California study, the methods used to analyze the same data resulted in conclusions that were significantly different.

The individual state analyses were also significant in that they were not aimed at a comparative analysis. Their intention was to evaluate specific activities or programs within that state. Although some "peer state reviews" were undertaken, it was made clear that state-by-state comparisons were not possible. This is because the unique characteristics of individual states make it difficult, if not impossible, to do so. Where some comparisons can be made, it is also clearly stated that such comparisons can be made only for those states having similar congestion, social, environmental, financial and demographic characteristics.

2.3.4 Potential for State Comparisons

Only two transportation reports were obtained that attempt to evaluate a large number of state highway programs, as described in Section 2.3.2.4. The HUF/NCHRP Report concludes that "...program performance measures will become increasingly important tools...." But, the report also concludes that all state highway or transportation goals differ in mission, scope and goals; thus, transportation performance measures must be tailored to meet each state's needs. It goes on to say that "... when comparing the performance of one state highway program with another, it is important to select states of similar geography, topography, population, density, climate, and state highway system characteristics, and then to use the information judiciously."

The second report prepared by the researchers at UNC/Charlotte uses FHWA statistics to rank the 50 State DOT programs from 1 (the best) to 50 (the worst).
This study is one of the first such studies that has attempted to apply a systematic, quantitative approach to comparing state highway program performance. As noted earlier, the means of doing so was by comparing the trends over time of an individual state's data on expenditures and resulting performance with national averages. Importantly, this work is one of the first in transportation that attempts to relate resource inputs with associated performance outputs. However, there are several limitations related to the analysis that should warrant significant caution in drawing conclusions about comparative performance of state highway programs — and the authors themselves identify and understand these limitations. The same national data can be interpreted differently by many different groups. For example, one critique of this paper pointed out that the 11 lowest ranking states as defined by the authors had the highest expenditure per mile of states in the country (a conclusion drawn by the authors). At the same time, these 11 states were included in a) 10 of 12 states with the highest average number of lanes per mile of state road system, b) 10 of 11 highest overall traffic per lane states, c) 11 of the 13 highest population density states, d) 11 of the 15 highest urban populated states, e) 10 of the 11 states with the highest percent of urban travel, f) 10 of the 12 most congested urban freeway states, and g) 11 of the 18 highest urban traffic per lane states. The point being made was that the need or demand for the road system clearly influenced both resource expenditure and system performance, and thus the methodology used in the study could not provide reasonable results for national comparative purposes.

Criticisms of this study have focused on several issues. Normalizing data for comparative purposes is an important approach, but some felt that using lane-miles, VMT or truck VMT as a normalizing factor would better take into account those characteristics of road systems that heavily influence performance and expenditures. Because of the often long time periods involved between changes in policy and the results, the use of time lagged variables would be appropriate. Importantly, some argued that construction costs vary dramatically from one region of the country to another, and thus national comparisons using dollars as a resource variable is misleading as clearly illustrated in the New Jersey report. Another major concern, as summarized in the California study, was the inconsistency in the quality or consistency of data provided by the states to the federal government, data which ultimately were used in this study.

It can be argued that any measure of the efficiency of DOTs should also include the time taken to complete transportation projects (and not just the cost of the project). For example, a certain project in one state may have cost 10 million dollars and started to provide service to the populace within 1 year of inception. A similar project in another state may cost 11 million dollars, but may start to provide service in only 6 months. Can it be decisively argued that the first project is more efficient simply because the second project cost 10% more? How about the 50% savings in time which the second project accomplished? Such factors are completely missing from the UNC/Charlotte report, and their impacts have not been acknowledged.

In an October 1992 update of the paper, the authors responded to the criticisms of the earlier paper by arguing that, even with some limitations, the approach was still valid, and, in the absence of better data or approaches, provided useful information. In particular, the authors agreed that incorporating "need" into the methodology would be valuable, but that there is no agreement on how to do so. In other situations, such as spillover traffic from other states or through traffic, the authors argued that there was no agreed upon measure or data to back up any measure that was defined. Overall, the authors felt that the study was a point of departure for the development of a good management tool that could be used to assess highway program effectiveness.
The use of this methodology for comparative analysis shows some promise. As it stands, however, there are several limitations that need to be addressed. As pointed out above, these limitations relate specifically to the inability of the methodology to take into account need, differential construction and labor costs, and other factors that could cause a state's resource input and performance output measures to be significantly skewed when comparing the national averages or to other states. The latter is particularly important because there are so many significant differences among the states in many of the performance "statistics."

2.4 Synthesis of Education Report

For the past several years, *U.S. News and World Report* has been providing a rank ordering of colleges and universities in the U.S. This is the only education report studied for this project.

2.4.1 Approach Used:

Here's how *U.S. News* ranked graduate schools of engineering for 1992:

**Student Selectivity:** This is based on two statistics for doctoral and master's degree candidates who enrolled in the fall of 1991, the percentage of applicants a school admitted and the "yield," or the percentage of those accepted who decided to attend.

**Faculty Resources:** This statistic is based on a number of variables — the current percentage of full-time faculty members holding Ph.D.'s, the current ratio of both full-time doctoral and master's degree candidates to full-time faculty, the current percentage of full-time faculty members, and the number of Ph.D. degrees granted in 1991.

**Research Activity:** Research activity has been measured by two indicators — the total dollar amount of publicly and privately funded research administered by the engineering school, and the total dollar amount divided by the number of faculty members doing research.

**Reputation:** The reputation of a program was determined by two surveys. The first survey, sent to all deans of engineering and/or academic affairs asked all respondents to rate each school by quartiles representing levels of academic quality. The second survey asked 785 practicing engineers to select the top 15 graduate engineering schools based upon their academic quality.

Overall rank was based upon the above criteria. Data for each of the above indicators were converted into percentiles. A value of 100 was assigned to the school with the highest score within each indicator, and the scores of other schools were determined as a percentage of the total achieved by the top school. Weight values were assigned to each factor (25% each to the two surveys, 20% each to faculty resources and research activity, and 10% to student selectivity), and a final rank computed.
2.4.2. Comments

The procedure adopted above, while compact and easy to analyze, is not without some flaws. The number of students applying to a particular school can depend on a number of hidden variables, one of the more notable ones being geographical location. Using this number to determine student selectivity could be particularly misleading. The idea of using dollar amounts to quantify research activity may be a pragmatic and utilitarian approach, but it says little about the quality of said activities. Finally, the lack of standard definitions for the data is perhaps the biggest flaw. Institutions submitted data to the magazine based on their own definitions or interpretations of the categories requested. A simple example can further illustrate this point.

One institution, for example, might count only those faculty with 100 percent appointments as full-time, while another might include all faculty with 51% (or more) appointment as full-time. Similar variation might exist in reporting full-time and part-time students. Further confounding the issue is the inclusion of professional librarians in the number of full-time faculty members (some institutions such as Texas A&M University give a faculty rank to all professional librarians).

Another common error occurs due to the usage of total student enrollment rather than full-time-equivalent numbers. The magazine calculated a 26-to-1 student-faculty ratio for The University of Texas at Austin, by dividing the number of full-time students (42,040) by the number of full-time faculty (1,637). The method used more frequently by institutions of higher education in calculating this ratio is based on Full Time equivalencies (FTE) of both faculty and students. Using FTE figures, the student-faculty ratio for UT Austin drops down to 21.9-to-1.

2.5 Comparative Program Evaluation Literature

The most traditional approach to comparative program evaluation is simply to identify key measures of performance and to then list the corresponding data for targeted systems in an evaluation framework, most usually a matrix. Such an approach resembles the evaluation matrix that is often found in transportation studies that shows the relative values of key characteristics of the alternatives under consideration. Classic examples of such approaches can be found in Ashford's Comparing Public Policies, Hyde and Shafritz's Program Evaluation in the Public Sector, and Parks' article "Complementary Measures of Police Performance" in Public Policy Evaluation. Few efforts have been made to attach a composite value to the relative worth of one program versus another.

The only book published which examines performance monitoring for state highway programs was written by Poister and entitled, Performance Monitoring (1983). In discussing a performance monitoring program established for the Pennsylvania Department of Transportation, Poister identifies a major issue that must be taken into account when interpreting the results of the system. He notes that numerous external factors can influence the ultimate performance of the system. Evaluating the ultimate performance of the highway system within this context needs "indicators and analytical approaches which can assess the effects of specific program factors, while controlling for the major influencing variables."

Transit planning and evaluation provides one of the few instances where efforts have been made to reduce the dimensionality of the "performance" of the alternatives under consideration so that the relative value can be assessed. This is found in the cost effectiveness index that is a required calculation for all applicants seeking federal monies for transit capital investment (see Urban Mass Transportation Administration, Process and Methods for Transit Service Planning (1986)). In essence, this index represents a dollar amount society will pay per new rider attracted to a new service. A threshold value is
established at the federal level above which federal funds (minus political intervention) will not be expended. This cost effectiveness index is an attempt to assign relative worth to alternatives under consideration. As noted earlier, the key way of doing this is to reduce the number of performance characteristics to a level at which relative worth can be determined. This is a key issue when trying to develop an overall approach for comparing the performance of alternative programs or facilities.

2.6 Studies on Organization Performance

Organization theorists have been conducting research on organizational effectiveness and performance for many years. The relevance of this research for this study is that it has examined several issues that are directly related to defining performance and linking it to resources expended. Organizational researchers have written numerous articles on the challenges of defining valid measures of performance, and on establishing the cause-effect relationship that is necessary to determine the effectiveness of resource allocation. Not surprisingly, much of the early research in the area focused on industrial organizations which related output (in quantifiable terms) to inputs such as labor and finance. Some of the more recent studies have examined the effect of the organization's environment on the structure and overall performance of the organization (see Lawrence and Lorsch, Organization and Environment, for some of the earlier work in this area). One of the major conclusions that has surfaced from much of this research is that it is very difficult to relate performance to input variables without accounting in some way for environmental factors. This is particularly true when attempting to conduct comparative assessments. As noted by Hannon and Freeman in their article, "Obstacles to Comparative Studies," there are four major methodological problems that are encountered when attempting to conduct a comparative study or organizational performance: 1) time horizon, 2) identification of system boundaries, 3) appropriate levels of analysis, and 4) identification of exogenous variables that could influence the ultimate performance measures but which are not accounted for in the input variables. These problems are certainly present in comparative assessments of program performance that also attempt to relate inputs to output variables.

One of the few studies in the transportation field that has attempted to examine the relationship between organizational performance and input variables was a study done for the Urban Mass Transportation Administration in 1978 (see Fielding et al, "The Effect of Organization Size and Structure on Transit Performance and Employee Satisfaction," 1978). This study collected data on 16 fixed route bus systems in California relating to organizational characteristics and system performance. Performance was measured in terms of service efficiency (e.g., revenue vehicle hours per vehicle) and effectiveness (e.g., total passengers per vehicle). The researchers concluded that, although one could generally associate certain relationships between input and output variables, there was no conclusive evidence to suggest that a direct cause-effect relationship existed. The concluding paragraph provided words of caution when trying to compare performance characteristics of different organizations, especially when first relating them to resources expended to produce this level of performance.

Perhaps the most important contribution of this literature to the study of highway program effectiveness is that comparative studies must be done very carefully, with a well-thought-out experimental design. Most all of the literature in this field suggests that evaluators must develop a strategy as part of the approach that controls for, or at least takes into account, external environmental factors that could influence the measurement of performance or resource input variables.
2.7 Summary and Conclusions

A review of the literature on the topic of program performance and comparative analyses suggested several noteworthy observations. Concerning highway program performance studies; the states and the FHWA collect large volumes of statistics annually. FHWA must rely upon the accuracy of the data submitted, and they do take steps to maintain as high a degree of quality control as possible. However, based upon the review of the studies available for this project, there are a number of precautions that must be observed when using these data. They include:

- inconsistencies in the methods of reporting;
- differences in the assumptions that are used in gathering and reporting;
- the absence of qualifying factors, such as urban congestion, costs of labor and materials, sources of funding, use of funding, environmental concerns, demographic conditions, geography, topography, etc.; and
- inconsistencies in the analysis methodologies

There is clear agreement that the inconsistencies in the available data make it very difficult to compare states based upon those data. However, there is also agreement that it is desirable that appropriate measures of performance be established that would allow for a comparative "peer" analysis of state highway programs. In the next chapter we develop more details concerning approaches to comparative performance measures.
CHAPTER 3
APPROACHES TO COMPARATIVE PERFORMANCE

3.1 Introduction

In Chapter 2 we summarized several studies of state DOT's that have been used to assess the performance of transportation programs that impact the lives of citizens in the United States. The purpose of this chapter is to focus upon what we have identified as several approaches used to evaluate the performance of state highway programs. We shall describe in more detail the following comparative analyses:

1. The HUF studies of State DOT's that have occurred over the past several years.
2. The NCHRP sponsored project completed by the HUF on "Performance Measures Used By State Highways and Transportation Agencies."
3. The California study on the costs of highway project design.
4. The New Jersey study on the variations in the cost of highway construction.
5. The Texas research that evaluated new methods for measuring highway program performance using the Analytic Hierarchy Process (AHP) and Data Envelope Analysis (DEA).
6. The FHWA Highway Performance Monitoring System (HPMS).
7. The UNC/Charlotte study titled "Resources Verses Results: Comparative Performance of State Highway Systems."

For each of the above approaches we will present the following analysis:

- Motivation for undertaking the study,
- Sources of data,
- Discussion of the methodology/approach that was used,
- Criteria/factors used to assess program performance, and
- Potential for making state-by-state comparisons or rank-orderings.

3.2 The HUF Studies of State DOTs

3.2.1 Motivation For Undertaking the Studies

As reported earlier, during the past ten years the HUF has undertaken more than a dozen comprehensive studies of state DOT programs and operations. Each study has been undertaken because of a specific request from a state agency to do so. Those requests are based upon a desire on the part of the state to critically and objectively evaluate overall program performance.
One of the most recent of those studies was undertaken for New Hampshire. The final report is titled: "An Evaluation of the Management of the New Hampshire State Program." It was presented to the New Hampshire Highway Program Review Advisory Committee, which included representatives from the State Legislature and the New Hampshire DOT.

Since the New Hampshire report is typical of those prepared by the HUF, it is used in this study as representative of those completed by the HUF.

3.2.2 Sources of Data

The HUF has been involved with this type of analysis for many years. As in the case of New Hampshire, a study team spends considerable time in residence at the State DOT. The team collects and analyzes reports, studies and data that have been developed by the DOT. The HUF study team also interviews many individuals in the state (within and outside the DOT). A comparative analysis is also made using data from HUF files and from the FHWA. Every attempt is made to make possible a comparative analysis of "like" states.

3.2.3 Discussion of Methodology

The review of the data and interview material is undertaken by experienced HUF engineers. Their observations and analyses are made as constructively and objectively as possible, based upon a detailed and exhaustive evaluation of facts and ongoing programs.

3.2.4 Criteria/Factors Used to Assess Program Performance

The New Hampshire study is typical of the HUF studies. In this case, the following were evaluated.

1. Highway Finance, including
   - Travel on state highways
   - Total expenditures
   - Correlation of travel and funding
   - Personnel costs
   - Construction costs
   - Maintenance costs
   - Sources of funds and needs
   - Local road finance
   - Fund projections

2. Highway Condition and Performance, including
   - Pavement condition
   - Bridge condition
   - Local condition
   - Safety

3. Highway Program Needs, including
   - Organization and management
   - Plans and programs
   - Legislative involvement
   - Federal programs
   - Public participation
   - Maintenance and operations
4. Management and Productivity, including
   - Current organization
   - Proposed reorganization
   - Strategic planning
   - Analysis of other state programs funded with highway user taxes and fees
   - Administration
   - Personnel and training
   - Private sector involvement
   - Equipment and facilities
   - Management systems

3.2.5 Potential for Comparison of New Hampshire to Other States

An appendix compares critical data obtained for New Hampshire to the same data obtained for five other states (Vermont, Maine, Massachusetts, Idaho and Nebraska). No attempt is made to evaluate one against the other. Even though some of the characteristics of the six states might be considered similar, there are so many significant differences that it does not appear possible to compare them or to rank order the states for any given objective function.

3.3 The NCHRP Sponsored Project Completed by HUF

3.3.1 Motivation for Undertaking this Study

The NCHRP sponsored this project titled "Measuring State Transportation Program Performance." The final report is dated November 1992. The study was generated by AASHTO and undertaken through the NCHRP program process. Its purpose was to isolate and describe the key program performance measures and indicators needed by all administrative officers of state highway or transportation departments in administering state transportation programs.

3.3.2 Sources of Data

A survey questionnaire was sent to 50 state DOT's, the District of Columbia, Puerto Rico and ten Canadian Provinces to gain a national consensus of:

1. A set of program performance measures for evaluating the effectiveness and efficiency of state transportation programs; and

2. A set of internal management factors that should be used in managing state programs.

3.3.3 Discussion of Methodology

Forty-two states, the District of Columbia and eight Canadian Provinces returned completed questionnaires. The data summaries are included in the final report.

This was one of the most extensive surveys of this nature ever performed. It provided the substance needed to meet project objectives.
3.3.4 Criteria/Factors Used to Assess Program Performance

The survey described above used fifty-four questions to obtain data on the performance of the entire transportation system. They included information for:

- The highway system
- Highway program costs
- Highway needs and condition
- Highway improvements
- Highway safety and risk management
- Mass transit service use and cost
- Air transportation
- External factors

In addition to the above, a comprehensive set of data were collected concerning performance measures. They included:

- Financial (5 data items)
- Improvement programs (7 data items)
- Human resources (9 data items)
- Other factors (2 data items)

The comprehensive data were then subjected to an exhaustive analysis, under the direction of NCHRP Panel and Staff, composed of eleven experienced professionals. The conclusions and recommendations were based upon their analysis of the survey results.

3.3.5 Potential for Making State Comparisons

The NCHRP project panel and the HUF Staff responsible for the study concluded that it is not possible at this time to realistically compare the performance of State DOT's, because there is a clear absence of consistent and accurate information for doing so. However, the study does recommend that there is a need to develop such data and provides the mechanics for doing so.

3.4 The California Study of Design Costs

3.4.1 Motivation for Undertaking This Study

As summarized in Chapter 2, this study was undertaken because a report published in the "Professional Services Management Journal" (PSMJ) in 1991 concluded that the cost to design highway projects by in-house Caltrans personnel was approximately three times the national average. This caused significant controversy in California. Consequently, Caltrans undertook their own analysis.

3.4.2 Sources of Data

PSMJ based its report on data compiled by the FHWA. The source of those data is the individual state DOT's. The Caltrans analysis used the same data. Their study concluded that inconsistent data furnished by the states to FHWA results in a very inconsistent tabulation of results.
3.4.3 Discussion of Methodology Used By Caltrans

The FHWA acknowledges that differences exist in the manner in which states report the requested statistical data. Although the data are valid for many statistical evaluations, they were not collected, nor intended to be used, to compare engineering costs between states (some items may or may not be included by all states in their cost calculations). Consequently, it was concluded that the FHWA statistics used as the basis for the PSMJ study cannot be used to accurately compare California's engineering costs.

In an attempt to determine the magnitude of differences in reporting costs, Caltrans surveyed 14 other state departments of transportation regarding specific types of expenditures included or excluded in their annual statistical report to the FHWA.

The survey showed that California reports more items as engineering costs than any other state contacted. As an example, some states classify a portion of their engineering costs as administrative expenses, while others classify construction engineering as a highway construction item. California does neither.

Some of the other major areas of difference among reporting systems used by California and other states include:

- Employee benefits
- Construction engineering cost classification
- Engineering for specially funded projects
- Internal classification centers
- Engineering for future programming

3.4.4 Criteria/Factors Used to Assess Program Performance

The factors used to assess the engineering costs of Caltrans' projects appeared to be more comprehensive than those of the analysis reported in the PSMJ, even though the assumption was made that the data were consistent. Consequently, the Caltrans study concluded:

- California's project development cost for highway projects has averaged 16.5 percent of total capital outlay over the last three years.
- Published reports stating that California's average annual cost of engineering exceeds 44 percent of total capital outlay are wrong.
- The study methods and data used to report an unacceptably high cost of engineering were flawed and led to inaccurate conclusions.

3.4.5 Potential for Making State-by-State Comparisons

This study showed clearly that an in-depth analysis is required in order to correctly utilize data from statistics reported by states to FHWA. There are too many inconsistencies in the reporting mechanisms to allow for "micro-level" (i.e., state-by-state) analysis, even though the data may be useful for national "macro-level" analysis.
3.5 The New Jersey Study

3.5.1 Motivation for Undertaking This Study

As reported earlier, the New Jersey Transportation Coordinating Council undertook a study of highway construction costs to determine if there are significant differences among the states. That being the case, New Jersey then argued that federal aid highway financing distribution formulas were not equitable.

3.5.2 Sources of Data

The extent and distribution of cost variations around the country were investigated using data from FHWA (which are obtained from each state) and private sector sources.

3.5.3 Discussion of Methodology

Based upon the analysis of available data, overall it was found that the difference in spending power of federal highway aid can be well over 100 percent between the highest and lowest cost states. The specific findings of the analysis included the following:

- Based on FHWA data used to allocate bridge program funds among states, the cost-per-square-foot of replacing a bridge varies by as much as 337 percent between the highest and lowest cost states.

- Analysis of FHWA data on the price of six contract items commonly used in highway construction found a lower but still wide (137 percent) difference in the spending power of federal aid between the highest and lowest cost states.

- New Jersey ranked among the highest cost states based on both the FHWA’s bridge and highway data. Its bridge replacement cost of $100 per square foot is almost twice the national average of $58.

- Aggregated by census region, the highway construction data suggest that four regions on the two U.S. coasts -- Middle Atlantic, New England, Pacific and South Atlantic regions -- experience the greatest disadvantages in the spending power of federal aid. Together, these regions, representing twenty-two states and the District of Columbia, account for 53 percent of the U.S. population.

- States ranking among the top twenty in high costs based on both the FHWA bridge and highway data were the following:

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<td>Hawaii</td>
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<td>Rhode Island</td>
<td>Washington</td>
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<td>Vermont</td>
<td>New Mexico</td>
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- Analysis of data on prevailing wages in selected metropolitan areas and on prices of nine highway construction materials in selected cities tended to confirm the existence of wide differences in the cost of highway construction.

- The prevailing base wages for power equipment operators and laborers on highway projects were found to differ by 182 percent and 191 percent, respectively, between the highest cost and the lowest cost metropolitan areas.

- The prices for highway construction materials were seen to be influenced not only by overall regional cost structures but by specific local market conditions affecting each material, such as the number of local suppliers of a material.

- Additional burdens on high cost states were found resulting from the expenses faced in acquiring Right-of-Way and relocating homes and businesses to make way for improvement projects.

3.5.4 Criteria/Factors Used to Assess Program Performance

The report analyzed detailed construction cost data. It was possible to evaluate the differences between states, because the data are considered sufficiently accurate for the purposes of the study.

3.5.5 Potential for Making State-By-State Comparisons

This study clearly illustrates that it is not possible to reasonably compare construction and maintenance programs between states using cost data as reported by FHWA, unless an appropriate accounting is made of the significant differences that exist in construction costs. This is not necessarily so because the reported data are incorrect, but more so because there is a significant variation in the items categorized under construction and maintenance costs.

3.6 The Texas DOT Research Studies

3.6.1 Motivation for Undertaking This Study

The Texas DOT has been actively involved in performance measurement issues recently, because the Texas state government is currently revamping the state-wide budgeting process. The Division of Planning and Policy Staff at the Texas DOT has identified the problem of synthesizing multiple measures in the most critical area of performance measurements. Consequently, they have focused on the problems through a series of organizational pilot studies using promising techniques from the field of management science/operations research.

3.6.2 Sources of Data

The data used for the work reported by Texas DOT is based primarily upon their own internal studies. Also used are the FHWA methods, procedures and data, such as the HPMS monitoring programs.
3.6.3 Discussion of Methodology

The following five reports have been developed by the Texas DOT as part of their research. For each they have indicated its relevance to this study.

1. High-Precision Determination of State HPMS Component Weighting Factors Using the Analytic Hierarchy Process; Relevance: Since all significant measures of performance are not equally important, weighting factors are needed. Subjective weightings can be made with increased precision using a feature of the analytic hierarchy process.

2. Improving R & D Project Selection With the Analytic Hierarchy Process; Relevance: The overall performance rating for a state system should encompass the significant individual performance scores together with their weightings. The full analytic hierarchy process could provide the framework to meld the scores and weightings to produce a complete overall measure for a full system. This presentation demonstrates how this method produces merit scores for alternative research projects.

3. SDHPT Performance Measurement Project — Assessing Effectiveness and Efficiency; Relevance: Extensive lists of performance effectiveness measures are relatively easy to compile, but the numerous resulting efficiency measures are difficult to interpret as a group. This briefing paper presents a basic framework for such evaluations and the associated problems.

4. Assessing DOT Operational Efficiency with Data Envelopment Analysis; Relevance: Comparisons of efficiencies to the average do not give useful information about how to attain peak efficiencies — especially when there are multiple inputs and outputs, and a host of other complicating factors, to take into account. This presentation discusses how the DEA approach can produce supportable overall performance measures under these circumstances, while avoiding subjective weightings with an optimization technique.

5. A Pilot DEA Analysis of Maintenance Section Relative Efficiencies; Relevance: The comparisons among state systems desired by AASHTO can be viewed as analogous to comparisons among maintenance sections within a state. This report presents the results of using DEA to analyze Texas maintenance sections, producing both overall measures and attainable improvements at the input and output level of detail.

3.6.4 Criteria/Factors Used to Assess Program Performance

In Chapter 2 we summarized two Texas research reports which provide a unique insight into the application of various measures of performance, using the Analytic Hierarchy Process (AHP) and the Data Envelope Analysis (DEA).

The Highway Performance Monitoring System (HPMS) is an analytical computer model developed by the Federal Highway Administration, originally to assess highway needs and costs nationwide. It is now being adopted by states as a highway planning tool.

One of the ways of determining highway improvement needs with HPMS is to direct the system to maximize its "Composite Index," a performance measurement
function which is a weighted summation of nine quantified highway condition factors. The model can be run with no budget limit to determine total needs, or it can be run with a constrained budget to determine the priority set of highway improvements. However, the model is sensitive to the component weights in its performance function, and some states have modified the national average default values in the model to better represent their own specific road condition priorities. Failure to correctly represent these priorities would cause the model to optimize with the wrong factors, producing an inappropriate highway strategy for that state.

The Texas study finds that while the order of the rankings produced by the two approaches (i.e., HPMS and AHP) are similar, there are substantial differences between the two sets of numerical weighting values. Because the AHP method does not produce the numerical biases seen in a single-step method, it appears that AHP yields these preferences with greater precision.

3.6.5 Potential for Making State-by-State Comparisons

The application of AHP to evaluate the performance of transportation programs was applied successfully by the Texas DOT. It identified a number of significant problems in using the HPMS approach. This is not a criticism of the HPMS program, but it illustrates that great care must be used in applying the data available for that purpose.

3.7 The Highway Performance Monitoring System (HPMS) Program

3.7.1 Motivation

One of the most important data collection activities in the U.S. relating to the assessment of transportation system performance is the Federal Highway Administration's Highway Performance Monitoring System (HPMS). The FHWA developed the concept of an HPMS database and corresponding analytical process so that it could assess on a continuous basis the condition and performance of the nation's highway system. In particular, this approach has been useful in developing the periodic report to Congress on the performance of the highway system that is required by law.

3.7.2 Sources of Data

State departments of transportation collect traffic performance and facility condition data on a select sample of highway segments in their state. For each sample section, there are approximately 70 data items collected ranging from traffic counts to geometric design characteristics. The extent of data collection depends on the functional classification of a road. Freeways, for example, have a greater sample size than local roads. Data such a traffic counts is collected on a cyclical basis. The FHWA requires states to submit data for state highways and for highways under the jurisdiction of other government entities. Nationally, over 100,000 samples sections are part of the HPMS data set.

3.7.3 Discussion of Methodology

The HPMS database is used by the FHWA to prepare reports to Congress on the status of the nation's highway system. The methodology used for determining future performance is the HPMS Analytical Process (several states and metropolitan areas used this Process as well.) The base case is calculated by using the condition, safety, and performance.
Future conditions on the road system are estimated through formulas which reflect condition deterioration and demand increase. A composite index for future years is then calculated which provides a relative "effectiveness" measure of system performance.

The analysis determines the level of funding needed to keep the highway systems at a condition and performance level above pre-defined minimum tolerable condition. The process examines each sample section in the database to determine if the section characteristics are greater than these minimum tolerable conditions. The model then "makes" improvements to the sample sections where deficiencies exist based on an improvement priority. The priorities are capacity-related deficiencies such as low operating speed, high V/C ratio or insufficient lane width; pavement deficiencies, and alignment deficiencies (rural areas only).

The Process considers three major types of improvements — reconstruction, widening, and resurfacing. Once an improvement is made to a sample section, the section's data record is changed to reflect the upgrading received. The costs assigned to the improvement are nationwide average values for construction and right-of-way. The nationwide costs are then adjusted based on relative State cost index. The average values are calculated from the costs reported by the states, reduced to a per-lane basis. Different funding strategies can be used to estimate what effect they will have on the future effectiveness of the road system (i.e., how they affect the future composite index). These funding strategies relate to a set or priorities that can be established within the model for the types of reconstruction, rehabilitation and maintenance activities that could be emphasized. For example, one funding scenario might be to maintain pavement conditions at their current level. Another might be to provide as much capacity to handle demand as is feasible. For each scenario, the Analytical Process will indicate the level of funding that is necessary to meet the objective, and the resulting system performance.

3.7.4 Criteria/Factors Used to Assess Program Performance

System condition and performance is reduced, through a weighted function, to a dimensionless index (the composite index). Each component of this index has several factors that relate to its relative value. These factors are as follows:

Condition
- Pavement type
- Pavement condition
- Drainage adequacy

Safety
- Lane width
- Shoulder width
- Median width
- Alignment adequacy

Services
- Operating speed
- V/C ratios
- Access control

The relative comparison of this index over time provides a comparison of whether the system is improving or deteriorating.
3.7.5 Potential for Making State-by-State Comparisons

The HPMS Analytical Process has some merit in comparing state highway programs. By reducing the important factors to a dimensionless composite index, one state's performance could be compared to another. However, there are important factors that influence the validity of this approach. Most importantly, the validity of the output depends very much on the quality of the input data. For comparative purposes, the data procedures and approaches would need to have a high level of standardization. In addition, the weights assigned to the development of each composite index would either have to be the same, or accurately reflect the priorities of each state. The comparability of the weighting scheme from one state to another is the greatest challenge in using HPMS for comparative purposes.

3.8 Federal Transit Administration Section 15 Monitoring

3.8.1 Motivation

Section 15 of the Urban Mass Transportation Act (amended) required that transit operators submit to FTA data on costs and service. Similar to FHWA's HPMS database, this data is used by the Federal Transit Administration to submit to Congress every two years a report on the status of the nation's public transportation performance and condition.

3.8.2 Sources of Data

Every transit operator is required to submit a wide variety of data on their respective cost and service characteristics. This data is submitted annually. Examples of the type of data submitted include total operating revenues, dedicated state operating assistance, total capital revenues, dedicated local capital assistance, etc.

3.8.3 Discussion of Methodology

The methodology used for developing national statistics and comparisons between transit properties is straightforward. The performance indicators are calculated as a weighted average of urbanized area totals which are aggregates of all reporting operators in the urbanized area. For national comparisons, areas of similar size are grouped. Of interest for this report is a statement made in one of the reports to Congress which relates to performance measures,

"Measures of external transit performance are not well established. Conceptually they would be analogous to the highway measures and might include such factors as coverage, service frequency, travel time, ride quality, crowding and comfort. Resulting benefits from changes in performance over time along these lines would include reduced travel time and cost for users and economic efficiency improvements for non-users. The body of knowledge which exists on these subjects is extremely limited.... thus this report provides only limited treatment of the external performance of transit...."

3.8.4 Criteria/Factors Used to Assess Program Performance

As noted above, transit operators are required to submit data on costs, revenues, and service levels. This base data is then aggregated for national comparative purposes.
(e.g., by size of operator or region of the country). Some researchers have used this data to provide comparative evaluations of individual transit operators with such criteria as operating cost per rider.

3.8.5 Potential for Making State-by-State Comparisons

This approach does not lend itself well for state-by-state comparisons because it has great difficulty incorporating into the analysis the external or environmental considerations that can affect a state's program performance. The Section 15 program, and those few reports which have attempted to undertake comparative evaluation of transit properties, has been criticized by the transit industry in particular for failure to take these factors into account.

3.9 The UNC/Charlotte Comparative Analysis of State Highway Programs

3.9.1 Motivation

This study was undertaken to develop a methodology that could be used by transportation managers to better understand and assess the performance of their highway program. In particular, the authors state that few comparative assessments have been done that compare costs incurred versus performance obtained. Therefore, one of the major contributions of this paper was an attempt to develop a methodology that allowed one to compare both resource variables and performance variables at the same time. This study illustrated the application of such an approach by conducting a national assessment, resulting in a relative ranking of all 50 states.

3.9.2 Sources of Data

Every state DOT submits data annually to the Federal Highway Administration on a wide variety of highway program characteristics, including performance measurements, resources consumed, and finance/expenditures. In addition, state DOT's provide data for several national data reporting systems that are used by the FHWA to assess national trends and policy implications of alternative finance scenarios. The most used reporting systems include the Highway Performance Monitoring System (HPMS), the National Bridge Inventory System, and the Fatal Accident Reporting System. This report used the data that had been submitted to the FHWA by the states.

3.9.3 Discussion of Methodology

The resource and performance measures for each state are measured for that portion of the state road system under the jurisdiction of the state transportation agency. Resources expended are measured by total receipts and expenditures per centerline mile of responsibility. The resulting data are normalized against national averages over time. Performance is measured as the percent of pavement deterioration and congestion on the highest classified state systems, and by percent deficient bridges and fatal accident rates for the state. A letter grade was then assigned to each state by relating the state's performance over time to the national average, and by determining if the state's performance was improving, staying constant, or declining relative to this benchmark. A template for determining this letter grade is found in the paper.

The authors discuss the criticisms of the methodology in the report and respond as follows:
1. **Selection of inappropriate variables.** Particularly the use of centerline mileage as normalizing factor: Centerline mileage is the only normalizer that is consistently available in the data base.

2. **No measure of need:** Change in population could be used to measure need, but there is no agreement on how to use this measure.

3. **Traffic effects from bordering states:** There are no available data on the percent of such traffic in each state.

4. **Use time series or lagged statistics:** Using lagged data would be helpful.

5. **Differences in construction costs around the country:** A more complete study would account for such variations; FHWA publishes selected regional cost data.

6. **Use of relative ranking:** Ranking is appropriate for highway systems, and the data bases used in this study are appropriate for comparisons.

7. **Use of data for unintended purposes:** The data were used appropriately.

8. **Differences in state data collection:** Differences in states' measurement of data items have declined over time as uniform procedures have been adopted.

9. **Mixed responsibility within state for highway system:** Data are not well documented for all road systems, especially non federal-aid-systems. The data in this study focus on highway expenditures and do not include non-highway expenditures.

10. **Lack of urban focus:** There is no reason to just include urban factors if such is desires to take into account unusual circumstances. One should also need to include factors to account for traffic, weather, climate, trucks, etc.

11. **Inappropriate use of data:** This analysis is of systems, not agencies. The data are used appropriately.

12. **Differential inflation:** Using different inflation rates for individual regions would be useful, but is beyond the scope of this study.

The authors conclude that the above limitations are neither fatal nor preemptive. They argue that work should continue on the development and analysis of transportation performance measures in spite of these problems.

### 3.9.4 Criteria/Factors Used to Assess Program Performances

Program performance was based on the temporal tracking of several state data items. They were: a) total miles of highway under state control, b) total receipts for state controlled highway systems, c) capital disbursements for highways, d) maintenance disbursements, e) administrative disbursements, and f) total disbursements. The state performance measures included a) percent of rural and urban interstates with a PSR less than 2.5, b) rural other principal arterials and urban other freeway and expressways with pavement condition less than a PSR rating of 2.0, c) percent urban interstates with V/C ration greater than 0.7, d) percent deficient bridges, and e) fatal accidents per 100 million vehicle-miles. As noted earlier, "performance" was then determined by comparing the trend in a state's data to national trends, and using a template to assign a letter grade.
3.9.5 Potential for Making State-by-State Comparisons

The authors portray this study as an important point of departure for developing a methodology that can be used to develop valid comparative assessments of state highway program performance. It is one of the first studies in highway performance that attempts to relate resource inputs to performance outputs. It does produce a ranking of states based on a benchmark of national trends. However, the effort at establishing causality between resource expenditures and performance, and then determining relative position of one state versus another requires a more careful consideration of those factors that could, in fact, explain resource or performance levels, rather than assuming they occur because of the simple relationship between the two.

3.10 Summary and Conclusions

The purpose of this chapter has been to summarize selected studies that have been used to assess various aspects of the performance of state transportation programs. Although each dealt with various aspects of program performance, each was also quite different in its motivation and in the approach used to achieve the stated objectives.

The studies illustrated the following relative to their potential for making state comparisons:

1. The data used for such purposes must be consistent in quality and appropriateness for the objectives to be served;

2. The analysis methodology must be appropriate and consistent if state-by-state comparisons are to be made;

3. External, often uncontrollable factors make it difficult and often inappropriate for the comparison of states; and

4. The inappropriate comparisons of state data can lead to inaccurate conclusions and be counterproductive in their misuse.

Throughout this report we have alluded to the desirability of establishing program performance measures. In the next chapter we suggest a possible approach to highway program assessment, with an appreciation for the major pitfalls to be avoided in doing so.
CHAPTER 4
CHARACTERISTICS OF GOOD HIGHWAY PROGRAM ASSESSMENT

4.1 Introduction

The previous chapters have examined the current state-of-practice of comparative program assessment. In most instances, the literature has recommended a great deal of caution in undertaking comparative studies. This caution has been particularly focused on the "control" of external factors that could influence program performance but which were not captured in the input variables. Therefore, it is important to develop overall guidelines for highway program assessment that considers the role of external factors and yet produces information useful to highway program managers. The characteristics of such assessment are discussed in this chapter.

4.2 Conceptual Framework for Program Assessment

The characteristics of a good assessment of programs can be derived directly from a basic understanding of the underlying phenomenon being examined and how key variables relate to one another. One way of accomplishing this is to develop a conceptual framework of the program development process which leads to an understanding of how highway system performance is actually achieved. This framework recognizes that the inputs into program delivery are primarily the domain of state transportation agencies, and thus are subject to all of the organizational priorities that influence how these inputs are used. Importantly, this framework also recognizes that there is a distinct difference between organizational outputs and the actual outcomes that occur over time. This is primarily oriented to the external factors (the giant question mark) that can influence these outcomes. From a methodological perspective, this means that fair and valid comparisons of one system's performance to another's requires some way of taking the external factors into account. Only by controlling for these external factors can one produce a consistent and valid comparison.

The conceptual framework suggests three major elements of an assessment methodology that need to be discussed — performance measures, input variables and external factors.

*Performance Measures:* The measures used in assessing the performance of a system must be defined appropriately and must be truly measuring the desired effect of program implementation. In the transit industry, for example, it took many years before appropriate performance measures were defined for transit service. These focused primarily on the concepts of service efficiency and effectiveness. For highways, engineers have traditionally used vehicle miles traveled and volume to capacity ratios for analyzing the operations of a road system. The first is not a system performance measure, and the second is difficult to apply at a network level. The concept of a composite index that is used in the HPMS Analytical Package is an attempt to better define a measure of performance that allows comparison over time and space. A current NCHRP research project on developing a congestion index is another effort to develop some measure of system performance that reduces the dimensionality of the measure such that relative comparisons can be made.
Another key issue in the definition of system performance is answering the question of "performance compared to what?" Simply listing the different characteristics of system operation (e.g., average speed, VMT, lane miles, etc.) merely permits the user to compare system characteristics with little relationship to input variables or external factors that might influence the performance of the system. The analogy to alternatives evaluation is noteworthy. The evaluation matrix which lists for each alternative the values associated with the evaluation criteria in the assessment process does not often include some measure of resource input to system output. However, during the last ten years, cost effectiveness approaches have been used to provide such a comparison. These ratios compare some level of system performance with the resources needed to achieve this performance level. In most cases, the measure of resources is dollars and the system performance relates to the major objective of the assessment. For example, cost effectiveness has been used to determine the dollar per decibel reduction in noise barrier construction; dollar per milligram of sodium chloride reduction for road drainage treatments; and, of course, in transit, dollar per new rider served with transit investment.

It is suggested that the key characteristics of performance measures are as follows. These characteristics are offered in some sense as a checklist for testing the suitability of using performance measures for comparative purposes.

1. They must be appropriate for the objective of the performance system. For example, if the intent of the performance system is to provide information to decisionmakers over time on where key problems exist in the system, the measures need to be defined in such a way to provide this information. This might mean a spatially disaggregated measure which could be used to pinpoint where problems exist.

2. They must be valid in a sense that they truly measure the underlying performance characteristics. For example, use of center line miles versus lane miles in an effort to compare effectiveness of maintenance and rehabilitation expenditures over time and between agencies could be misleading.

3. They must be consistently defined spatially and temporally. For example, measures of highway performance in one highway district need to be similarly defined for all other districts so that comparative assessments can be made. The same is true for comparisons over time.

4. They must reduce the dimensionality of the performance so that external factors cannot significantly affect the resulting value. For example, the FHWA Highway Performance Monitoring System reduces the many components of highway condition and performance into a composite index. This composite index consists of data whose basic measure is not directly affected by external factors.

5. They must be based on data that can be collected. For example, performance measures oriented to safety considerations need to be based on reliable accident data that can be collected. Experience in the safety area has shown that the collection of consistent accident data from many different jurisdictions is very difficult.

6. They must be defined such that consistent data collection in the monitoring phase is maintained. One of the problems in comparing state DOT program performance is the inconsistency in the quality and quantity of data collection from one state to another. This is particularly true for those data items that are subject to qualitative assessments of condition or performance (e.g., pavement surface conditions or ridership estimates). Even when good experimental designs and data collection strategies are used, there is still variability in the instrumentation reliability.
Input Variables: As noted previously, not all performance measurement needs to be related to resource inputs. One can conduct performance monitoring of a system simply by defining important measures (with the characteristics of measures defined above) and showing how one system compares with another. Of course, one would not be able to say "why" a system shows different performance, nor for that matter would one be able to indicate if a particular system were better than the other (unless a standard or threshold value were used). Relating performance to resource inputs primarily is aimed at determining the efficiency of resource utilization for that particular input-output production system. It is very difficult to rely on this simple relationship for comparing different systems without somehow controlling for external factors.

However, assuming that one is interested in the input-output relationship, the input variables also need to be selected with great care. The characteristics for these variables are similar to those discussed for performance measures. In most cases, the input variables are defined in dollar or personnel terms (thus, the cost effectiveness measure). However, even in this case, resources must be defined with caution. For example, transit and safety programs may be funded from highway revenue. Total highway program sums, for example, can incorporate many different expenditures, some not at all related to the ultimate performance measure of concern. In other cases, the resource variable/performance output relationship could be defined differently by various groups. A recent survey of state DOT's that was intended to determine the amount of funds directly related to encouraging economic development illustrates this point. In response to a question that asked what level of DOT funding was focused on encouraging economic development, the answers ranged from $800 million (that is the entire DOT construction budget) to $0. Thus, the resource variables to be used in the input/output relationship must be linked in a logical way.

External Factors: Probably the most important consideration in assuring a valid comparative assessment of similar programs is the influence of the external program environment on system performance. These factors could range from natural causes (e.g., weather-induced expenses for maintenance and rehabilitation) to physical location considerations such as being positioned along a major transportation corridor which results in heavy demands on the road system. One example of the critical significance of these factors was illustrated by New Jersey when it was shown that the costs of labor and materials can vary by a factor of two or more from state to state. A comparative assessment must incorporate or control these factors if the results can be considered valid. This can be done in different ways. Normalizing variables with respect to some dimension(s) is one way of reducing the bias. If regression analysis is being used to establish relationships, dummy variables can be used to account for unique occurrences in the data. However, the most useful approach for controlling these external factors is to cluster the program units such that the external factors are similar within each cluster. The influences on system performance when compared across clusters is therefore reduced. The most common means of doing this is through the use of peer groups.

Peer groups are used quite commonly in the transit industry. Transit agencies discovered some time ago that comparing their agency performance to all agencies, regardless of situation, produced useless information. Instead, they grouped transit systems with similar characteristics, such as metropolitan area size, size of transit system, and labor characteristics, and used this peer group as the comparative set. Even in this approach, not all extenuating circumstances can be controlled. However, it seems that establishing such clusters does provide enough control that at least some of the major external factors can be accounted for. For state highway comparisons, it makes much more sense to compare a highway program for a state like Nevada with programs in Wyoming, Utah, and New Mexico, than it does to compare it with programs in Massachusetts, Pennsylvania, or New Jersey. The identification of factors most important for this clustering is critical and is an important research issue.
4.3 National Quality Initiative

A major national initiative called the National Quality Initiative (NQI) was launched in 1992. The charter members include the Federal Highway Administration, the American Association of State Highways and Transportation Officials, the American Road and Transportation Builders Association, the Associated General Contractors of America, the American Concrete Pavement Association, the National Asphalt Pavement Association, the National Ready Mixed Concrete Association and the American Consulting Engineers Council. The purpose of the NQI is to establish a partnership of Federal, State and industry highway officials to ensure that our nation's highways provide the highest quality facilities and services for the safe and the most cost-effective mobility possible. This is also necessary to ensure that we maintain economic competitiveness in the global market place. FHWA and AASHTO have established as a high priority the need to take quality to the highest plateau possible.

An important element in achieving the major objectives of "total quality management" (TQM) is the need to establish highway performance measures that can be used as benchmarks to determine the quality of state highway programs. The TQM process requires the development of an effective partnership with one's customers. Consistent with this process would be involving the customers of the state highway program in the selection of the performance measures. As this process suggests, it is entirely possible that many of the measures would vary from state to state, within regions, or many areas within a single state (e.g., urban vs. rural areas). The importance of this requirement in the TQM process is in reflecting the customer's values in the performance evaluation process and to recognize that there will, in all likelihood, be significantly different priorities among the 50 states. Some states (Minnesota, for example) have already begun the difficult task of establishing various standards and "measures" that will be used to make periodic evaluations of highway program performance.

The research undertaken by this project leads the authors to conclude that a concerted effort should be launched by the state DOT's, perhaps through appropriate AASHTO Committees, to develop an appropriate follow-up effort that will build upon the conceptual framework suggested in this chapter. A commitment has been made by FHWA and the states through the NQI to develop more explicit programs aimed at total quality management. We trust that this report will provide some assistance in launching such an effort.

4.4 Potential For Highway Program Monitoring In The Future

This report has stated that there is an important need for a good methodology to assess the performance of highway programs. Such a methodology should be a critical element of good management. If the methodology is developed carefully and in a meaningful fashion, it can produce important information on the trends in program performance over time, and in comparison with state peers. The Intermodal Surface Transportation and Efficiency Act (ISTEA) provides a great opportunity to establish such a program monitoring capability in every state. The ISTEA mandates that every state develop a statewide congestion management system and an intermodal management system. The Metropolitan Planning Organization's (MPO) will be developing a congestion management system for urban areas. Although not yet in place, and in some cases not yet defined, these management systems offer promise for producing the type of information that can feed into effective program performance monitoring. The results of two national meetings on congestion management and one on intermodal management systems indicates that this potential does exist.
During one of the congestion management workshops, participants identified six elements that, at a minimum, constitute a congestion management system. These elements were:

- Identification of Targeted Systems or Areas;
- Identification of Performance Measures;
- On-Going Data Collection and System Monitoring;
- System Performance Evaluation Process;
- Congestion Reduction Strategy Identification and Evaluation; and
- Implementation.

Two characteristics of this approach that relate to program assessment include the emphasis on performance measures, data collection, and system monitoring. There was considerable discussion on the desirability of performance measures and the development of a congestion index. Most of the participants felt that a limited number of performance measures, defined by state and local officials, should be the basis for determining progress in achieving performance objectives. These performance measures should measure the extent, severity, and duration of congestion and the reliability of system performance. A congestion index was considered to probably be useful for national comparisons, but participants felt that it was too broad to be of much use to state and local officials.

Two major types of data are required to make a congestion management system work: data on system performance and evaluation data on actions implemented. These data need to address people and goods as well as vehicles. The data on system performance would clearly be related to the types of performance measures adopted in the above step, and would likely have to be more sensitive than today's data to such things as on-time performance, speed, queues, and other performance characteristics. Of some importance in this regard are data on non-recurring congestion. In addition, the participants felt that implementing agencies will likely play a critical role in collecting the data for the system monitoring function.

The key point surfacing from this workshop was that a fundamental basis of a congestion management system was the measurement of system performance. Identifying performance measures will not be easy, and yet by doing so the planning process could very well take a step closer to becoming a program management strategy.

A recent conference on intermodal management systems provides additional linkages to program assessment. Once again the emphasis on performance measurement is a key issue. The focus of intermodal planning is on improving the performance of the intermodal transportation system. As was pointed out by many of the conference participants, some of the key bottlenecks in moving from one place to another, for both passenger and freight transportation, occur at connection points, e.g., terminals, ports, airports, transfer stations, and the facilities leading to them. The participation of private sector groups in the intermodal planning and decision making process provides added importance to the concept of defining and monitoring system performance. These groups in particular need to see the benefits that will occur by their participation and by the consequences of the decisions that are made. The implication of this emphasis on performance is that intermodal planning and, especially, intermodal management systems, should be based on a set of system performance measures. These measures should allow some sense of how the system is doing over time and where problems exist. Some example performance measures include:
- Level of service  
- Quality of travel  
- Travel cost  
- Convenience  
- Safety  
- Reliability  
- Flexibility for accommodating additional intermodal travel

The conference participants identified a list of possible performance measures and concluded that some would probably be more important than others. In some cases, measures could be combined into one factor, for example, an intermodal mobility index.

The following elements of an intermodal management system were considered as desired elements of a system. The basic elements of an intermodal management system include:

- inventory of modal/intermodal elements including institutions, markets, operations, and physical plant;
- identification of an "intermodal system" that becomes the focus of the intermodal management system;
- use of performance measures that will allow some sense of how the system is doing over time and where problems exist;
- identification of strategies and actions that will improve intermodal transportation efficiency and effectiveness, including non-investment options such as pricing, regulatory changes, etc.;
- analysis and evaluation of these strategies/actions from the perspective of intermodal concerns, e.g., economic value to system users, cost, improvement to system interconnectivity, etc.;
- establishing priorities among strategies/actions within the context of overall planning effort; and
- mechanisms for including users and providers in this process (e.g., advisory groups).

The ISTEA requires that states and MPO's develop six management systems. Given a working definition of management systems (designed to provide information for decision making), it is important that these six be integrated in such a way that maximizes the usefulness of the information provided. There are clear overlaps among the different management systems. These include:

- Cross referencing of data (e.g., bridge conditions)
- System definitions
- Policy tradeoffs that would affect more than one system
- Performance measure definition
- Database management coordination/relational database
- Users of systems
- Economic benefits/costs

Of particular interest in the discussion was the interrelationship between the intermodal and congestion management systems. Intermodal management systems are applied on a larger scale, that is the state, with the intent of improving the connectivity of the system. Clearly, many of the connection points and thus the locations of "hot spots" for the intermodal system will be in urban areas. Therefore, designers of both management systems need to be especially careful in interrelating the two systems. The development of ISTEA-required management systems is a unique opportunity to put in place a system performance program that provides a consistent and valid information base. These data would prove invaluable for program assessment.
CHAPTER 5
CONCLUSION AND RECOMMENDATION

The intent has been to provide a synopsis of reports and other literature found to be pertinent to the charge of the study, and this paper has reviewed various approaches to comparative performance. In all instances the use and quality of data were recognized as critical factors in the results obtained and in their use. Although this is not an unexpected observation, it is useful to note the widespread recognition of its importance. The observation reinforces the basic premise fundamental to every researcher, and that is to understand, with recognized confidence, the character of each data element to be used in any rigorous analysis. This should include an understanding of the data collection technique, what it is intended to represent, and the confidence limits associated with its recorded value.

Many similar key issues were identified as important to an impartial study of state highway performance:

- there are numerous uncontrollable and inconsistent factors affecting state-by-state comparisons which cannot be accurately or adequately captured by a single measure;
- there may be merit in making comparisons of specific program areas such as pavement conditions, bridges, levels of congestion, etc.;
- great care must be taken to insure that the statistics used to make any comparison are consistent and accurate (e.g., the California study);
- variables used in "resource allocation" may be significantly different from state to state (i.e., New Jersey includes labor and materials);
- any state-by-state comparison must consider unique factors such as variation in costs (e.g., New Jersey vs. California), priorities (e.g., pavements vs. bridges or capital expenditures vs. maintenance or prevention vs. routine maintenance);
- care in the use of data for varying levels of analysis (i.e., macro vs. micro levels; internal use vs. external comparison); and
- the issue of comparative evaluation is further complicated by defining satisfactory performance.

If state-by-state comparative analyses of highway program performance are to be undertaken, then the states must be requested to obtain and report more micro-level data that are consistent and reliable. This could be a very huge task, unless it becomes part of the development of, and reporting on, the six management systems required by ISTEA.

Before recommending that such large scale evaluations be established, we need to be certain we know what will be done with such analyses once they have been accomplished. If undertaken, they must be done in a way that will assist the state highway agencies in doing a better job of managing their programs. If not carefully designed, such comparative
analyses could be used in a punitive way, be viewed very negatively and be counter-
productive. This latter situation would result in states designing their programs to be
certain that the "right" statistics are produced. It would not at all measure or indicate "value
received" for resources expended if that were the case.

If we look at the HUF reports carried out for over a dozen states, they always include
some state legislative committee or transportation commission. By definition, there is
significant input by political leaders in the state, thereby contributing to the concept of
accountability. That kind of in-depth analysis of substance and politics seems to be the
right combination. It is not clear that a state-by-state comparison of such studies would be
useful or relevant if one were to "rank" the states numerically.

With the exception of the UNC/Charlotte report and possibly the HPMS analysis, we
have found no examples of state-by-state rankings or state-by-state comparisons of
highway program performance. We have concluded that at this time it is not possible nor is
it appropriate to develop composite ratings of state highway programs, because neither the
analysis methodologies nor the appropriate data are available to do so. It is particularly
inappropriate to make any attempts to rank states (1 through 50), because the data do not
exist that allow one to do so. Further, given the current availability of data, or lack of
appropriate data, it is not reasonable or feasible to consider developing such rankings in the
near future. Even if expensive and laborious data collection and analysis procedures were
established to accomplish such an objective, the value of doing so is questionable.

There are, however, potentially significant benefits to be derived when individual state
programs and methodologies are established to develop performance measures that serve
state management needs and those of their customers. If acceptable state performance
standards are established, then performance measures should be used periodically to
evaluate a state's highway program accomplishments. If "peer state" reviews can be made
using the same performance measures, then some useful comparisons are possible. Our
"conceptual framework for program assessment" provides a starting point for
accomplishing the objectives desired for relevant and appropriate comparative measures.
APPENDIX A

ANNOTATION OF RELEVANT LITERATURE

TITLE       Evaluating the Efficiency of Nonprofit Organizations: An Application of Data Envelopment Analysis to the Public Health Service
AUTHOR      Vicente Pine and Lourdes Torres
JOURNAL     Financial Accountability and Management
ABSTRACT    The usefulness of the data envelopment analysis (DEA) model as a management tool when applied to the measurement of the efficiency of health centers (namely, the new health centers being introduced by the Spanish National Health Service) is evaluated. The DEA model is chosen because it does not require prior specifications, which could be useful when there is a lack of data on costs. The evaluation of global efficiency provides valuable information on the effect of size with respect to the health center. The 4 globally efficient centers have a lower population level than the others, but their consumption of inputs is similar to those centers that have been shown to be inefficient. Their efficiency is a result of the maintenance of a higher level of activity; they have been able to capture and keep the population as clients of the public health service. Taking full advantage of the information that might be provided by the DEA method will be useful only in the context of decisions that are taken in a decentralized manner.

TITLE       Sensitivity Analysis for DEA Models: An Empirical Example Using Public versus NFP Hospitals
AUTHOR      Vivian Valdmanis
JOURNAL     Journal of Public Economics
ABSTRACT    The data envelopment analysis (DEA) is applied to a sample of public (government-owned) and not-for-profit hospitals operating in Michigan in 1982. The focus of this research is twofold. First, assessing the relative efficiency between these 2 ownership types using the DEA rather than costs or profit functions can add insights into the production practices of these 2 ownership forms of hospitals. Second, testing the sensitivity of the DEA will add credence to this approach and resulting measures. Ten different specifications of the DEA are employed to test the sensitivity of the model. Public hospitals in the sample were relatively more technically efficient than not-for-profit hospitals. These results were not altered when the model specification was altered, therefore the model is considered robust.

TITLE       Measuring the Efficiency of the Logistics Process
AUTHOR      Richard L. Clarks and Kent N. Gourdin
JOURNAL     Journal of Business Logistics
ABSTRACT    The efficiency of the logistics process has been of interest to business for a long time. It has become increasingly important in the decade of the 1980s with growing global competition and reduced government regulation. The use of a management science model called Data Envelopment Analysis (DEA) is explained. DEA is designed to aid logistics managers in their efforts to measure logistics efficiency and identify weaknesses. The findings in a case study conducted with 17 vehicle maintenance organizations over a 4-year period indicate that DEA can help measure the relative efficiency of the logistics process and that nontechnical managers can understand and apply DEA in their organizations. DEA also was found to have some valuable implications for international logistics managers.

TITLE       A Methodology for Collective Evaluation and Selection of Industrial R&D Projects
AUTHOR      Muhittin Oral, Ossame Kettani, and Pascal Lang
JOURNAL     Management Science
ABSTRACT    A methodology is proposed for evaluating and selecting research and development (R&D) projects in a collective decision setting, especially useful at sectorial and national levels. The methodology consists of 2 major phases: evaluation and selection. The evaluation process repeatedly used mathematical programming models to determine the relative values of a given R&D project from the viewpoint of the other R&D projects. The selection process of R&D projects is based on these relative values and is done through a model-based outranking method. The salient features of the methodology are its ability to: 1. permit the evaluation of an R&D project from the viewpoint of the other R&D projects without at first imposing a uniform evaluation scheme, and 2. maximize the level of consensus as to which projects should not be retained in the R&D program being funded, thus minimizing the level of possible resentment in organization or department whose projects are not included in the R&D program.

TITLE       Efficiency Considerations in the Social Welfare Agency
AUTHOR      Joseph Heffneran
JOURNAL     Administration in Social Work
ABSTRACT    Professional social workers and other staff members are often in conflict with administrators over the right place for the use of efficiency criteria. The efficiency criterion is based on net return to investment and assumes that all appropriate costs and benefits can
be tabulated. The efficiency criterion assumes that efficiency is an unambiguous good. Consistent use of normative modifiers attached to the term "efficiency" is one way that a mutually dependent and consistent set of perspectives with regard to the place and value of efficiency can be formed. Efficiency is judged and measured in a variety of contexts. Data Envelopment Analysis (DEA) is a procedure for the measurement of instrumental efficiency in nonprofit contexts. In DEA analysis, neither the output nor the input needs to be measured in dollar terms. The entities responsible for committing inputs in pursuit of outputs are called decision-making units (DMU). Each DMU can be ranked relative to all others without regard to budget constraints.

- **Title:**Profit Incentives and Technical Efficiency in the Production of Nursing Home Care
- **Author:**John A. Nyman and Dennis L. Bricker
- **Journal:**Review of Economics and Statistics
- **Abstract:**During recent years, nursing home expenditures have approached 1% of gross national product. Their growth is a major contributor to the escalating costs of health care. A sample of 184 Wisconsin nursing homes was analyzed to determine the characteristics of efficiently operated nursing homes. Data envelopment analysis is used to calculate efficiency scores for the various nursing homes in the sample. Then, regression analysis is used to investigate the determinants of efficiency, holding constant the characteristics of the output. The evidence suggests that for-profit nursing homes have significantly higher efficiency scores. An for-profit home used about 4.5% fewer labor resources per patient day than a nonprofit home. Homes with higher short-run occupancy rates also have higher efficiency scores.

- **Title:**Using Data Envelopment Analysis to Measure the Efficiency of Not-for-Profit Organizations: A Critical Evaluation
- **Author:**T. Ahn, A. Charnes, W. W. Cooper, and Thomas R. Nunamaker
- **Journal:**Managerial and Decision Economics
- **Abstract:**Nunamaker (1985) addresses inadequacies in data envelopment analysis (DEA) as a method for: 1. measuring efficiencies of not-for-profit entities identified as decision-making units (DMU), and 2. locating sources and amounts of inefficiencies in each of the inputs utilized and in each of the outputs produced by each DMU. Nunamaker's interpretation of the concept of Pareto-Koopmans efficiency as presented by Charnes et al. (1978) for use in DEA is erroneous and seriously affects Nunamaker's presentation. Nunamaker's central proposition is that, when a DMU has been accorded efficient status by DEA, introducing a new variable will not alter this previously achieved efficient status. This proposition is erroneous, as illustrated through example. In reply, Nunamaker emphasized that he did not intend to examine all facets of DEA in his analysis.
ABSTRACT

Data Envelopment Analysis (DEA), a linear programming technique, can be used to: 1. compare the productivity of similar service organizations, 2. identify inefficient operations, and 3. provide ways to reduce inefficiencies. DEA, best used by firms using multiple resources to produce multiple services, has been successfully applied to banks, hospitals, and customer service organizations. DEA uses a comparison of inputs with outputs to develop a set of relative efficiency ratings. DEA also calculates the relative value of inputs and outputs to provide management with a basis on which to improve inefficient operations. DEA, when applied to a set of teaching hospitals, identified inefficient hospitals that other productivity-measuring techniques had failed to identify. When applied to 14 branches of a savings bank, 6 branches were found to be inefficient. In both cases, DEA provided input and output data that helped management take action to improve productivity. DEA can be applied using successive time periods to control efficiency over time and complement other management control techniques.

TITLE Measuring Managerial Efficiency in Rural Government

AUTHOR Steven C. Deller, Carl H. Nelson, and Norman Walzer

JOURNAL Public Productivity and Management Review

ABSTRACT

A method is presented for assessing the efficiency of producing local public services that seeks to incorporate microeconomic theory into the measurement process. The method is illustrated using the case of producing low-volume rural road services in the Midwest. A statistic comparing the ordinary least squares estimate and the maximum likelihood estimate of the cost function is significantly different from zero at the 95% level of confidence. The findings imply that managerial inefficiencies exist in the Midwestern rural road data. On average, nearly 45% of rural road expenditures may be unnecessarily incurred due to managerial inefficiencies. The results also indicate that cost savings from economies of scale and from a reduction in managerial inefficiencies may be realized through consolidation of production-related responsibilities.

TITLE The State of the States

AUTHOR Katherine Barrett and Richard Greene

JOURNAL Financial World

ABSTRACT

Financial World examined the state of business in the 50 US states and ranked them according to their performance in 9 areas: 1. accounting and financial reporting, 2. revenue estimations, 3. expenditure estimation, 4. rainy day funds, 5. other budgeting issues, 6. program evaluation and performance measurements, 7. pensions, 8. bond ratings, and 9. infrastructure controls. States earned low places in the rankings by spending money that they do not really have. Virginia was ranked number one, up from number 4 in 1991. The state has good long-range planning, quick adjustment of errors in revenue estimates, accurate estimates of Medicaid and corrections expenditures, and excellent and multifaceted program evaluation. Further, Virginia achieved a balanced budget in current year on cash basis with no major new taxes. Wyoming was ranked 50th because of its serious expenditure-revenue imbalance, drained general fund balance, and its lack of performance measurements.

TITLE Making Government "Profitable"

AUTHOR David J. Harr and James T. Godfrey

JOURNAL Management Accounting

ABSTRACT

A 1988 Executive Order mandated a program to improve the quality, timeliness, and efficiency of services provided by the federal government. A study was undertaken to examine financial and related performance measure used by private sector service-oriented organizations and how they could be applied to government operations. The study focused on logistics operations to assess the applicability of both traditional and more recently developed techniques from businesses in an actual government operation, the Department of Defense Depot in Mechanicsburg, Pennsylvania. Seven major principles for effective development and use of cost-based financial performance were employed at the depot: 1. Use output-oriented measures. 2. Identify total costs of service delivery. 3. Take an operational view of costs. 4. Use measures relating total costs. 5. Provide incentives for financial and operating performance. 7. Improve quality and timeliness of service delivery.

TITLE Public Productivity Measurement: Diseases and Cures

AUTHOR Geert Bouckaert and Walter Balk

JOURNAL Public Productivity and Management Review

ABSTRACT

In discussions about productivity measurement, there has been a shift from a belief in the power of quantified measures to an awareness of their dysfunctional effects, and there has been a shift in discussion from the meaning of management to the management of meaning. The 13 "diseases" in measuring productivity in a management context can be divided into 3 groups: 1. those associated with the assumptions of measurement, not with measurement itself, 2. those associated with perceived numbers and volumes, and 3. those concerning the content, position, and amount of measures. Managers in the public sector need to direct more attention toward the extrinsic requirements, that is, the impact on the organization of the use of measurement. They must search for optimal measures that minimize dysfunctional effects and maximize functional effects, allowing managers to focus on the extrinsic requirements of the organizational purpose.
the issues faced in the design and implementation of performance measurement in Wichita, Kansas, are examined. Six issues that are important hurdles for efforts to make performance measurement germane to decision making are: 1. triangulating measures for valid assessments of performance, 2. establishing targets for improved performance and human resource planning, 3. linking performance measurement to strategic planning, 4. integrating management information with resource allocation, 5. defining the appropriate level of flexibility in performance reporting, and 6. defining and reducing resistance to performance measurement. The experiences of Wichita in the design and implementation of performance measurement provide empirical evidence for performance measurement validity, practical application of performance targets, the integration of strategic planning, budgeting, and performance measurement, flexibility in reporting formats, and reduction of resistance to performance measurement.

The specific objective of this project is to produce a compendium of performance measures and indicators to assist state highway and transportation department and their CAOs in evaluating and continuously improving the operational performance of their agencies. This compendium will include performance measures and indicators most commonly used by individual states and provide a recommended composite list of measures and indicators with synthesized definitions that could be acceptable to a large number of states. It is recognized that there are many terms and secondary performance indicators that an agency may use. The contractor should focus on those that appear to be most common. The purpose here is not to develop new performance measures or indicators, but rather to identify, collect, and categorize measures by transportation mode. This is an attempt to empirically test the effectiveness of engineers as strategic managers, as measured by the economic performance of the organizations they direct. Although it is not possible to precisely test the degree to which occupational loyalty and a narrow task-oriented perspective restrict the effectiveness of engineers as strategic managers, it could be stated that these characteristics are inconsistent with the responsibilities ascribed to strategic managers. An analysis of organizations from three different industries showed that organizations directed by business-oriented strategic managers performed consistently better, and in one industry significantly better, than organizations directed by engineering-oriented strategic managers.
This report examined ways in which the Minnesota Department of Transportation (MnDOT) might use performance measures to increase the productivity of twenty-five rural and small city transit systems supported by the state. The author isolates five problem areas that impede the productivity of the state's transit operators, suggesting that these may be improved through the application of transit performance measures. He recommends that MnDOT develop and implement an integrated system of goal-setting, performance targets, project evaluation, and performance-based financial incentives as an alternative to the existing transit subsidy process which is non-performance based. An evaluation program utilizing standardized measures of transit performance is proposed. The author recommends that MnDOT use financial incentives to reward performance that surpasses established standards. As an alternative to retention of funds for substandard performance, MnDOT could replace funds with technical assistance.

The Urban Institute's RANN project, Effectiveness Measurement Methods, is designed to help satisfy the need for substantive information on the effects of government services on citizens and the community. The lack of this information has limited the ability of local officials to evaluate services, allocate resources, and formulate policy. The objectives of the study were to develop the tools and an implementation system that would afford local officials significantly improved information on their services; specifically, the measure were intended to help identify current problem areas, indicate progressive or retrogressive trends, indicate inequities in service delivery, provide a data base and methods for its use in productivity-incentive plans, and provide a data base for use in comparison research between cities. Cities throughout the nation are adopting the techniques derived in this project. The techniques are readily modifiable for almost any local government.

A consumer-oriented approach is made to assessing the quality of local transportation. The authors propose a system that local governments may use to estimate how well their transportation-related services are serving their citizens. Twelve specific measures of effectiveness, keyed to such broad goals as accessibility, convenience, travel time, safety, and maintenance of environmental quality, are proposed. Ways to collect and analyze the necessary data are indicated. Summary recommendations and cost estimates for carrying out the measurement system are provided.
APPENDIX B

ANNOTATION OF SELECTED REPORTS

Outline of Reports Selected For Inclusion in This Study

The purpose of this Appendix is to provide a brief outline of the reports obtained during the research for this project. The following outline is used for each, when possible:

1. State (where appropriate)
2. Report title, date, author(s), and contact persons (where appropriate)
3. Purpose
4. Methodology used
5. Factors/criteria used to evaluate state programs
6. Application of results to a state (or states)
7. Potential applications to compare state programs
8. Comments/observations/critique

STATE
NCHRP Report: Nationwide Analysis

TITLE
Measuring State Transportation Program Performance: Final Report

DATE
November 1992

PREPARED BY
NCHRP/HUF

CONTACT
Marshall F. Reed

PURPOSE
To isolate and describe the key program performance measures and indicators needed by all administrative officers of state highway or transportation departments in administering state transportation programs.

METHODOLOGY
A survey questionnaire was sent to all state DOT's to gain a national consensus of:

1. A set of program performance measures for evaluating the effectiveness and efficiency of state transportation programs.
2. A set of internal management factors that should be used in managing state programs.

Most states do not measure either of the above indicators in any systematic way. Many data items are collected, but they are not suitable for evaluating state performance. The closest measure of performance may be the evaluation of bridge condition. HUF also noted a "lack of goals or benchmarks" for measuring performance.

FACTORS/Criteria USED
Based upon the survey results, the following factors/criteria were used to evaluate state programs:

- Details of the highway system
- Highway program costs
- Highway needs and conditions
- Highway improvements
- Highway safety and risk management
- Mass transit service use and cost
- Air transportation
- External factors
- Financial data
- Improvement programs
- Human resources

APPLICATION OF RESULTS TO A STATE
The data were obtained from 42 states, the District of Columbia and eight Canadian provinces. The results were used to form the conclusions summarized below.
POTENTIAL APPLICATIONS TO COMPARE STATE PROGRAMS

The study concludes that it is not possible at this time to realistically compare the performance of state DOT's. This is because there is a clear absence of consistent information for doing so. However, the study concludes that there is a need to develop methods for doing so.

COMMENTS/OBSERVATIONS/CRTIQUE

This is probably the most comprehensive analysis of the performance of state highway programs conducted to date. It provides a significant amount of new information. But it also identifies major data deficiencies in the attempt to accomplish the study objectives. The report concludes that it is not possible at this time, given the absence of relevant data, to make state-by-state comparisons.

STATE  Alaska
TITLE  An Evaluation of the Management of the Alaska Highway Program
DATE  December 1987
PREPARED BY  Highways Users Federation
CONTACT  M. Clyde Stoltzfus

PURPOSE

To evaluate the effectiveness of Alaska's total highway program in meeting its citizens' needs for safety, service and cost-effective transportation now and in the future.

METHODOLOGY

This is a typical HUF evaluation, covering many management, finance, needs, performance and productivity issues.

RELEVANCE TO NCHRP STUDY

As in the case of each of the HUF reports, this contains a chapter on "Productivity" which compares Alaska to other states. Each report also identifies the state differences concerning demographic, financial, geographic, etc. characteristics.

See New Hampshire Summary
To compare Arkansas highway data to all other states.

METHODOLOGY

This study summarized the FHWA Highway Statistics in several categories. It shows how Arkansas compares with all other states. No analysis is made, and no comparisons are made.

FACTORS/Criteria USED

The Caltrans study showed that the FHWA statistics used as the basis for the PSMJ study cannot be used to accurately compare California's engineering costs with other states because numerous items are included in California's engineering costs that may or may not be used by other states in their cost calculations. Caltrans surveyed 14 other state DOT's to form this conclusion. The differences in cost calculations included whether or not items were included such as administrative expenses, construction engineering, employee benefits, special-funded programs, internal service centers, time period included in the computations, etc.

APPLICATION OF RESULTS TO A STATE

The Caltrans analysis identified a number of flaws in the comparative analysis prepared by the PSM Journal. This was shown to be covered by a number of significant inconsistencies reported to FHWA by the states.
POTENTIAL APPLICATIONS TO COMPARE STATE PROGRAMS

This analysis provides some valuable insights into the pitfalls associated with comparative analyses, based upon a simplistic acceptance of data reported for purposes other than another intended use.

COMMENTS

An exchange of correspondence between Caltrans, FHWA and the PSM Journal, together with the Caltrans report raises important relevant issues concerning why inconsistencies in data reporting can lead to flawed conclusions.

STATE
California (2)

TITLE
A Cost Comparison of Contracting Out For Engineering Services by Caltrans, versus In-house Engineering (310 Pages)

DATE
June 30, 1992

PREPARED BY
University of California at Berkeley

CONTACT
Allan H. Hendrix
Deputy Director, Transportation Planning, Caltrans

PURPOSE

To compare the cost of contracting out engineering services, with the costs of performing those services with in-house forces. This was the more detailed study requested by Caltrans in response to the criticism that the costs of in-house project development by Caltrans averaged 44% of capital costs; this was about three times the national average of 15% by all other states.

SUMMARY

The study collected detailed cost data for highway projects designed by in-house Caltrans personnel and for projects designed by outside contractors. The average costs of the projects showed that there was no significant differences between the cost to design a project in-house compared to the cost of contracting for those services.

RELEVANCE TO NCHRP STUDY

The study did reveal that there are inconsistencies in data reporting and in methodologies used to utilize comparable performance measures.
STATE: Idaho
TITLE: An Evaluation of the Idaho Highway Program
DATE: April 1985
PREPARED BY: Highways Users Federation
CONTACT: Keith E. Longenecker

PURPOSE
To evaluate the effectiveness of Idaho's total highway program in meeting its citizens' needs for safety, service and cost-effective transportation now and in the future.

METHODOLOGY
This is a typical HUF evaluation, covering many management, finance, needs, performance and productivity issues.

RELEVANCE TO NCCHP STUDY
As in the case of each of the HUF reports, this contains a chapter on "Productivity" which compares Idaho to other states. In addition, the report also identifies the state differences concerning demographic, financial, geographic etc. characteristics. No state-by-state comparisons are made.

See the New Hampshire DOT summary for more detail on HUF studies.

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STATE: Kansas
TITLE: Management, Organization and Staffing Findings and Recommendations
DATE: November 9, 1992
PREPARED BY: Peat, Marwick, Main & Co.
CONTACT: Deb Miller, KNDOT

PURPOSE
To assess and present recommendations to strengthen the management policies and practices, the organizational structure and staffing of KNDOT.

METHODOLOGY
This report is similar to those prepared by HUF. The analysis included a peer review of practices in three states (Iowa, Nebraska, Oklahoma), and interviews with state personnel. The conclusions indicated that KNDOT appears to be comparable to "peer" states, but no analysis is undertaken to analyze similarities or differences.

RELEVANCE TO NCCHP STUDY
Same as for HUF reports.
STATE: Maryland (1)

TITLE: Maryland's Highway System Compared to Other States

DATE: August 1992
Revised October 29, 1992

PREPARED BY: Md DOT

CONTACT: Neil J. Pedersen

PURPOSE
To compare Maryland to other state performance levels and expenditures.

METHODOLOGY
Uses FHWA data to show how Maryland ranks relative to other states. There are some significant statistics that relate "demand" (congestion, urban concentration, etc.) to performance.

RELEVANCE TO NCHRP STUDY
This report emphasizes that there are very unique state characteristics that must be considered in making state comparisons.

STATE: Maryland (2)

TITLE (a): Maryland Highway Program Review By HUFSA

(b): Md SHA Program Review

DATES: (a) October 26, 1992, and August 24, 1992
(b) September 4, 1992

CONTACT: Clyde E. Pyers and N.J. Pedersen

PURPOSE
To compare costs of highway program design, construction, maintenance and operation to eight other states.

METHODOLOGY
Statistics were obtained from HUF and FHWA. The data show very favorable comparisons of Md DOT to other states. This report also points out inconsistencies in data reporting which makes state by state comparisons very difficult.

RELEVANCE TO NCHRP STUDY
Data reporting inconsistencies make it very difficult to make comparisons between states.
To answer the question posed by the Governor, "Why is the Nebraska gas tax so high?"

METHODOLOGY

Compares fiscal, demographic, mileage and condition statistics to six surrounding states.

RELEVANCE TO NCHRP STUDY

This study shows that the "raw statistics" (such as the amount of the state gas tax) does not tell the whole story. Nebraska has the highest gas tax, but the lowest price at the pump for gasoline purchases. Nebraska's pavement condition is better than that of the surrounding states, but the gas tax is also used to support other state functions (i.e., other than highways). This illustrates that raw statistics may sometimes compare "apples with oranges."

The purpose of this study was to undertake a comprehensive review of the New Hampshire State highway program. It includes a detailed summary of the status of New Hampshire highways and their management. The results of a "comparable states" survey is also included as an appendix. It identifies the programs' strengths, some concerns and recommendations on actions to deal with those concerns.

METHODOLOGY

An Advisory Committee was established, consisting of representatives from the State Legislature (Senate and House of Representatives) and the State DOT. The HUF staff spent considerable time in residence at the DOT and collected large volumes of data that describe the highway system, highway finance, highway conditions and performance, highway program needs, and the management and productivity of the DOT.

The data were analyzed, numerous interviews were conducted, previous studies were evaluated, and data were obtained from the HUF files and other states.

FACTORS/CRITERIA USED TO EVALUATE PROGRAMS

The HUF staff collected and reported on dozens of factors used to analyze the highway and bridge programs in the state. (They are not listed here because they are so numerous.) The factors relate to all aspects of the highway program including management, operations, planning, design, maintenance, human resources, and physical facilities.

APPLICATION OF RESULTS TO A STATE

The results of this study provided detailed insights for the managers of the New Hampshire state highway program. A number of detailed recommendations were made on all aspects of the program.

This analysis and recommendations were based upon factual information relevant to the state which was analyzed by a team of experienced highway engineering professionals. The conclusions were also developed in consultation with political leaders in the state.
Although comparisons of some statistics were made with five "peer states" (Vermont, Maine, Massachusetts, Idaho, and Nebraska), no comparative analysis was feasible because they were not appropriate data available for doing so.

**POTENTIAL APPLICATIONS TO COMPARE STATE PROGRAMS**

One could conclude that this kind of detailed analysis for a particular state, if conducted for a number of "peer" states, would provide an excellent basis for a state-by-state comparative analysis.

**COMMENTS**

Even if such detailed data were available for a number of peer states, there is still an important concern. It may not be appropriate to simply make comparisons of certain statistics concerning a state highway program. An appropriate analysis methodology must be developed in order to do so in an objective and scientific way.

**METHODOLOGY**

Using FHWA data (which is submitted yearly by each state) the study showed that costs of highway and bridge construction vary by well over 100% among states. This is a very significant fact when comparing state needs and the ability to meet those needs. The report also emphasizes significant (but explained) inconsistencies in the FHWA statistics.

**FACTORS/Criteria USED**

This study analyzed FHWA data on the price of six contract items commonly used in highway construction. They included common excavation, portland cement concrete surfacing, bituminous concrete surfacing, reinforcing steel, structural steel and structural concrete. Data were obtained for the 50 states.

**APPLICATION OF RESULTS TO A STATE**

This study was undertaken to document the significant cost differences in states and regions.

**POTENTIAL APPLICATIONS TO COMPARE STATE PROGRAMS**

The costs for highway construction and maintenance can vary by well over 100% from state-to-state. This fact alone makes it clear that simple cost comparisons among states are inappropriate in evaluating state performance.
This study clearly illustrates that in order to make state-by-state comparisons of highway program, it is necessary to develop evaluation methodologies that incorporate significant costs variations. In addition, not only meet construction costs be considered, but in the case of NJ it was shown that the following must be considered in evaluating FHWA statistics:

- The New Jersey report utilized total funds received, but did not factor in actual disbursements for state administered programs.
- No consideration was given to funds collected for and used on toll facilities nor the revenues collected and used for transit.

**STATE**

Oklahoma (1)

**TITLE**

An Evaluation of the Management of the Oklahoma State Highway Program

**DATE**


**PREPARED BY**

Highway Users Federation

**CONTACT**

P.J. Driskill

**PURPOSE**

To evaluate the effectiveness of Oklahoma's total highway program in meeting its citizens needs for safety, service and cost-effective transportation now and in the future.

**METHODOLOGY**

This is a typical HUF evaluation, covering many management, finance, needs, performance and productivity issues.

**RELEVANCE TO NCHRP STUDY**

As in the case of each of the HUF reports, this contains a chapter on "Productivity" which compares Oklahoma to other states. Each report also identifies the state differences concerning demographic, financial, geographic, etc., characteristics.

See New Hampshire HUF report for more detail.
STATE: Oklahoma (2)

TITLE: Oklahoma Highway Program Review: Phase B
Recommended Plans for the Reorganization of the OK DOT and
Administration of County Roads Program

DATE: April 1991

PREPARED BY: Highway Users Federation

CONTACT: Marshall F. Reed, Jr.

PURPOSE:
To make recommendation for reorganizing the OK DOT and for improving the
administration of the state funds for county roads and bridges.

METHODOLOGY:
This was a separate report prepared for the purpose stated, but as a follow-on to the initial
management report dated December 3, 1990 by HUF.

RELEVANCE TO NCHRP STUDY
Statistical comparisons were made to Washington State and Mississippi. But there was no
comparative analysis undertaken.

STATE: Oregon

TITLE: Oregon Highway Program Review

DATE: 1988

PREPARED BY: Highway Users Federation

CONTACT: Mark Ford
Manager, Policy and Strategic Planning Section, Oregon DOT

PURPOSE:
To evaluate the overall effectiveness of the Oregon highway program.

METHODOLOGY:
This is a typical HUF report. See New Hampshire HUF report for more detail.
To determine if more precise measurements of highway system performance can be established using the Analytic Hierarchy Process (AHP).

**METHODOLOGY**

The Highway Performance Monitoring System (HPMS) is an analytical computer model used by the FHWA as the basis for assessing highway needs and costs nationwide. Used since the late 1970's, each state collects sample data that define a composite index of nine variables that quantify highway condition performance. The HPMS model is highly sensitive to the component weights of the performance functions, so some states have begun modifying "national average" default values in the model in order to represent their own specific highway condition priorities. The subject report stated that: "Failure to correctly quantify these priorities would cause the model to optimize the wrong factors, producing an inappropriate highway strategy for that state." The purpose of the research described in this report was to examine the extent of uncertainty about what the index weights should be in the HPMS model, and how "Analytic Hierarchy Process" (AHP) can improve the confidence in these determinations. The research concluded that all significant measurements of highway performance are not equally important, and that relevant weighting factors are needed. The report demonstrated how subjective weightings can be made with increased confidence using a feature of the Analytic Hierarchy Process.

**RELEVANCE TO NCHRP STUDY**

This is a very relevant analysis of the HPMS process that appears to clearly demonstrate that all measures of performance are not equally important. The key conclusion is that weighting factors are needed.

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**STATE**

Texas (1)

**TITLE**

High Precision Determination of State HPMS Component Weights

**DATE**

February 1992

**PREPARED BY**

Ronald F. Haggquist, Texas DOT

**CONTACT**

Thomas A. Griebel
Director, Planning and Policy Division, Texas DOT

**PURPOSE**

To determine if the application of the Analytic Hierarchy Process (AHP) can provide greater precision in prioritizing highway research projects.

**METHODOLOGY**

This document provides a large series of slides (transparencies) which summarize a procedure used by the Texas DOT, Division of Planning and Policy, to test the application of AHP in selecting priorities from among competing highway research projects. The results indicated that the AHP does provide a more analytical approach in providing a framework to meld the scores and weighting of various priorities to provide a better overall measure of potential research payoff.

**RELEVANCE TO NCHRP STUDY**

The presentation demonstrates that a complex set of variables can be analyzed with a greater degree of confidence when using AHP for measuring the potential "performance" of competing research projects. Thus, AHP could also be relevant for measuring highway performance characteristics as well.
SDHPT Performance Measurement Project: Assessing DOT Operational Efficiency with Data Envelope Analysis

DATE
June 1991

PREPARED BY
Ronald F. Hagguist, Texas DOT

CONTACT
Thomas A. Griebel
Director, Planning and Policy Division, Texas DOT

PURPOSE
To present a basic framework for evaluating extensive lists of performance effectiveness measures.

METHODOLOGY
There are potentially a large number of planning, performance measurement and efficiency analysis methods that provide feedback measurements between "resource allocation and results." Extensive lists of performance effectiveness measures are relatively easy to compile. But, the availability of numerous efficiency measures are difficult to interpret as a group. This brief paper suggests that an efficiency assessment system such as "Data Envelope Analysis" should be used to more accurately determine which ranking factors are most important in analyzing results of actions.

RELEVANCE TO NCHRP STUDY
This could provide a useful analytical framework for evaluating highway program performance.

Assessing DOT Operational Efficiency with Data Envelope Analysis

DATE
May 1991

PREPARED BY
Ronald F. Hagguist, Texas DOT

CONTACT
Thomas A. Griebel
Director, Planning and Policy Division, Texas DOT

PURPOSE
To discuss the potential value of Data Envelope Analysis (DEA) in assessing the efficiency of the operational units of the Texas DOT.

METHODOLOGY
DEA is a rigorous mathematical method developed over the last decade by Charnes and Cooper to analyze and compare operating efficiencies. Texas DOT examined the potential application of DEA to make comparisons between SHD District Offices for all functions (maintenance, construction, etc.). If successful, it could be used to evaluate the performance of all activities for each District.

RELEVANCE TO NCHRP STUDY
The Texas study concluded that comparison of "efficiencies" to average values do not give useful information about how to attain peak efficiencies. This is especially true when there are multiple inputs, multiple outputs and multiple complicating factors to take into account. The study shows how the DEA approach can provide supportable overall performance measures when multiple complicating circumstances must be correlated, while avoiding subjective weightings with some type of optimization technique.
To apply DEA analysis in comparing the effectiveness of Texas DOT maintenance programs.

METHODOLOGY
This report provides the data results, with no explanation.

RELEVANCE TO NCHRP STUDY
The comparisons among state systems could be viewed as analogous to comparisons among maintenance sections within a state (Texas is this case.)

STATE Texas (5)
TITLE A Pilot DEA Analysis of Maintenance Section Relative Efficiencies
DATE January 1992
PREPARED BY Ronald F. Hagquist, Texas DOT
CONTACT Thomas A. Griebel
Director, Planning and Policy Division, Texas DOT

STATE Texas (6)
TITLE Comparing State Transportation Systems and Agencies Through the Construction and Analysis of Regional and State Level Data Base
DATE November 1991
PREPARED BY W. Luker, Jr., and Dock Burke
Texas A&M, TTI
CONTACT Dock Burke

PURPOSE
To compare the functions and characteristics of transportation programs in the WASHTO states.

METHODOLOGY
This report describes the results of a study to construct and analyze a regional data base composed of information about the individual states and the state DOT's who are members of WASHTO. It clearly documents the similarities, but many differences among those states due to climate, geography, economics, etc.

RELEVANCE TO NCHRP STUDY
This study shows that there are such significant differences among the states, that it would appear to be unwise to compare states on simplistic grounds.
STATE: Utah
TITLE: Revenue Available to Transportation Programs
DATE: June 15, 1992
PREPARED BY: UTAH DOT
CONTACT: Van A. Sutherland

PURPOSE
To show taxing sources that are used primarily for highway purposes in Utah.

METHODOLOGY
UTAH DOT conducted this study in 1991 to show transportation funding sources available in other states. It resulted in a table of "cents per gallon equivalent tax revenue" for each state. This resulted in a range of 78.6¢ for New York to 22.6¢ for South Carolina.

RELEVANCE TO NCHRP STUDY
There is such a broad diversity in tax sources that this provides, no relevant information other than the need to consider "diversity". However, it is interesting to note that small rural states such as Kansas, New Hampshire and Nebraska have "equivalent" values that are in the same relative range as for very large urban states such as Minnesota, Wisconsin, Maryland, New Jersey, etc.