Performance Based Systems for MCSAP Programs

Gene Griffin
Brenda Lantz
Julie Rodriguez
Ayman Smadi

UGPTI Staff Paper No. 136
July 1997

Upper Great Plains
Transportation Institute

Performance Based Systems for MCSAP Programs

Guidelines for State MCSAP Managers

Upper Great Plains Transportation Institute
North Dakota State University
430 IACC Building
P.O. Box 5074
Fargo, ND 58105-5074
(701) 231-7767
fax: (701) 231-1945
http://www.ugpti.org

Table of Contents

Preface iv

- The Upper Great Plains Transportation Institute iv
  - Project Team Members iv
  - UGPTI Program iv
- Goals – Purpose v

Introduction 1

- Government Performance and Results Act of 1993 1
- Comments by Rodney Slater 1
- Theme 2
- Reasons for Adopting a Performance-Based System 2
- Paradigm Shift 2
- Program Development Process 4
- Principles for Success 5
- Preservation of Existing CMV Safety Achievements and Standards 8
- Summary 8

Understanding Safety 9

- Introduction 9
- Human Factors 10
- Roadway Factors 12
- Environmental Factors 12
- Vehicle Factors 13

A Word about Crash Types 13
Summary 14
Problem Identification 15
Available National Databases 15
Fatal Accident Reporting System (FARS) 15
General Estimates System (GES) 16
Trucks Involved in Fatal Accidents (TIFA) 16
OMC's SafetyNet/NGA Crash Database 17
Highway Statistics from the Federal Highway Administration 17
Important Information for Users of *Highway Statistics* 18
Final Thought 20
State Databases 20
Fundamental Principles of Data Analysis 21
Summary 25
Performance Measurement 26
Introduction 26
How is the Process Carried Out 27
Terminology 27
Performance-Based System Process Model 29
Applications of Performance Evaluation 31
Program Evaluation vs. Performance Monitoring 31
Establishing Benchmarks or Targets 31
Resources 32
Factor Inputs 32
Factor Prices and Resource Value 32
Single-Factor vs. Multi-Factor Productivity 33

Criteria for Selecting Resources 33
Measuring Output 34
Quality of Service Adjustments 34
Criteria for Defining Outputs 34
Cause and Effect Relationship Concerns 35
Efficiency 36
Effectiveness 36
Glossary i

List of Figures

Figure 1. Example of a shift in the model used to administer the MCSAP by the Office of Motor Carriers 3
Figure 2. Process for the Development of a Public Program 4
Figure 3. Model of a Performance-Based System 6
Figure 4. Crash Causation Factors 10
Figure 5. Frequency Chart for State Fatality Rates (Sample) 22
Figure 6. Normal Distribution of Data Around a Mean 23
Figure 7. Model of a Performance-Based System 29

Preface

OMC has contracted with the Upper Great Plains Transportation Institute (UGPTI) at North Dakota State University, to conduct training in the application of performance-based systems.

The Upper Great Plains Transportation Institute

Project Team Members

This project was conducted by an inter-disciplinary team. Team members, in alphabetical order, consist of:

- Gene Griffin, Economics
- Brenda Lantz, Statistics
- Julie Rodriguez, Applied Economics
- Ayman Smadi, Civil Engineering

All the team members work in the *Motor Carrier Economics, Management, and Safety* focus area and are full-time employees of the UGPTI. Each team member has several years of experience in motor carrier research and outreach.

UGPTI Program

The UGPTI was initially created by an act of the North Dakota Legislature in 1967. The UGPTI is a freestanding inter-disciplinary and multi-modal transportation research, education, and outreach institute within North Dakota State University. The UGPTI answers directly to the Vice President of Academic Affairs within the university. The UGPTI collaborates with various academic departments on campus and other universities and non-university organizations as well. The UGPTI's theme is *Rural, Non-Metropolitan, Freight Transportation, and Logistics*. The UGPTI pursues seven distinct focus areas within this theme that include:

- Motor Carrier Economics, Management, and Safety
- Agricultural Transportation

- Statewide and Regional Transportation Planning
- Railroad Economics and Management
- Low Volume Roads and Rural Transit
- Logistics and Rural Economic Development
- Rural Aviation

Motor Carrier Economics, Management, and Safety is one of the most active focus areas in terms of number of projects, research staff, and funding.

The UGPTI currently employs a staff of 20 full-time research, teaching, and support employees. It also employs several graduate students and part-time employees. The UGPTI is also one of the competitively selected University Transportation Centers sponsored by the USDOT.

Goals – Purpose

The main purpose of this project is to provide state Motor Carrier Safety Assistance Program (MCSAP) personnel with a sufficient understanding of a performance-based system to begin implementing it in their state programs. To achieve this an explanation of the performance-based system (PBS) is developed along with examples that apply to the MCSAP and commercial motor vehicle (CMV) safety. The intent of this effort is not to create experts but provide state MCSAP personnel with a sufficient understanding to feel comfortable in getting started implementing a PBS.

Chapter

1

Introduction

The movement to a performance based system is an effort to provide a more structured decision making process for problem identification, resource allocation, and accountability. It is one more tool to add to the existing knowledge base of state MCSAP personnel to improve CMV safety. This effort does not imply that states have not been using a performance based approach prior to this effort. If implemented properly, It can result in a positive contribution to CMV safety. It is, however, not a panacea or silver bullet. And, as with all things, the success or failure of the system ultimately depends on the people implementing it at all levels.

Government Performance and Results Act of 1993

One of the driving forces for implementing a performance-based system is the passage by Congress of PL 103-62, the *Government Performance and Results Act of 1993 (GPRA)*. One of the main purposes of the act is to *improve Federal program effectiveness and public accountability by promoting a new focus on results, service quality, and customer satisfaction*. This law requires all Federal agencies to develop a performance based strategic plan for program activities. Thus, there is the force of Federal law that is encouraging this effort. In addition, there are several altruistic and economic reasons for implementing a performance-based system.

Comments by Rodney Slater

Recently, Mr. Rodney Slater indicated in his Senate confirmation hearing for Secretary of Transportation that the USDOT should focus on three primary goals:

1) Safety and Security

2) Strategic Investment

3) Common Sense Management

It is interesting to note that all three of those principles relate, in one way or another, to the application of a performance-based process to the MCSAP.

Theme

The theme for this effort is: *Doing the right thing, for the right reason, with the right people.* A performance based system focuses on doing the right thing for the right reason. However, without the right people, any effort is doomed to fail, or at least not meet expectations regardless of how good the process is.

Reasons for Adopting a Performance-Based System

The reason for developing performance-based systems is the most basic of economic principles: resources are scarce. It is because of the principle of scarcity that there is a continual effort to use resources more efficiently and focus resources on the right activities, *doing things right and doing the right things.*

There are several reasons for adopting a performance-based system beyond the fundamental economic principle that resources are scarce. The general credibility of government, as always, is an issue with the body politic of the United States. To the extent that a performance-based system adds to government credibility, it serves as a positive force in the issue of government's role in the lives of U.S. citizens. More specifically, a performance-based system provides accountability. It provides a mechanism to evaluate how well things are being done, and a way to hold accountable those people doing them. Additionally, because they are scarce, there is competition for resources. It is likely that those programs that are *doing the right things and doing things right* will be more successful in arguing for funding before the U.S. Congress and state legislative bodies for their programs. However, the most important reason for developing a performance-based system is the improvements that can result in CMV safety and the corresponding reduction in deaths, injuries, and property loss. In addition, there is the huge impact that improved CMV safety has on the economy. Finally, there is the altruistic notion that anyone involved in public programs has the obligation to be good stewards of public resources—a responsibility that is inherent in public employment. Regardless of the reason, this effort signifies a paradigm shift in the administration of MCSAP.

Paradigm Shift

The Office of Motor Carriers (OMC) in the Federal Highway Administration has been given a critical role in commercial motor vehicle (CMV) safety on the nation's public road system by Congress. OMC continually evaluates how CMV safety can be improved as part of meeting this responsibility. The Motor Carrier Safety Assistance Program (MCSAP) is one element of the OMC's overall program. It is a federal/state partnership designed to improve CMV safety. MCSAP provides funding to the states to conduct roadside inspections of CMV drivers and vehicles, compliance reviews of motor carrier firms, and other CMV safety efforts. Traditionally, the states have described what will be done in their *State Enforcement Plan* (how many roadside inspections, etc.) and the resources to conduct them were provided. Then there was an accounting to see if the services had indeed been performed as planned.

The purpose of this effort is to move to more of a performance-based system from an accounting based system, a paradigm shift (Figure 1). The column in the left is typical of the major element of a *State Enforcement Plan (SEP)* and how the system was administered before the current effort. The column on the right in Figure 1. depicts the process for a performance based system. The accounting based approach previously prescribed by OMC does not explicitly encourage the states to justify what they are doing, why they are doing it, or be accountable for program efficiency or effectiveness. It only required that the states conduct the activities that they had committed to in their *SEP*. The performance-based system encourages states to identify their problems and develop a process for addressing them and being accountable for that process. As stated earlier, this does not mean that some or all of the states were not conducting the MCSAP based, at least somewhat, on a performance-based system before this effort. This effort hopes to formalize the process of a performance-based system and implement it to the maximum extent possible. The transition to more of a performance-based MCSAP is an attempt to improve CMV safety by providing a process that encourages *doing the right things and doing things right.*

Paradigm Shift

- Accounting System
- SEP
  - Inspections
    - xxx Level I
    - xxx Level II
    - xxx HM
  - Compliance reviews
    - xxx Carriers
  - Education/Outreach
    - xxx Educational visits
    - xxx JOP contacts

- Performance Based Process
- CVSP
  - Identify the problem(s)
  - Select activities to address problem
  - Implement and track effort and collect data
  - Evaluate efficiency and if possible, effectiveness
  - Redesign system, if necessary

Figure 1. Example of a shift in the model used to administer the MCSAP by the Office of Motor Carriers

Program Development Process

A basic understanding of the process of the development of a public program is useful in implementing a performance based system. A public program is based on some perceived issue of a public policy nature; e.g., fatalities involving commercial motor vehicles on the nation's public road system (Figure 2.) The concerns of the public are made known to Congress and/or the executive branch through several mechanisms of varying complexity. If the issue is deemed important to the country, Congress can create a program to address the issue such as the MCSAP. The next step in the process is the establishment of program goals that address the concerns of the public. This can be done by congress or the administering agency. Once the goals have been established, program objectives are defined. Selection of program objectives should be based on a sound process for problem identification. There may be several objectives related to a program goal, however, they must be achievable and should be measurable. It is important to note that there must be a logical connection between the objectives and the goals. This connection is based on an understanding of CMV safety principles. It is not a result of implementing a

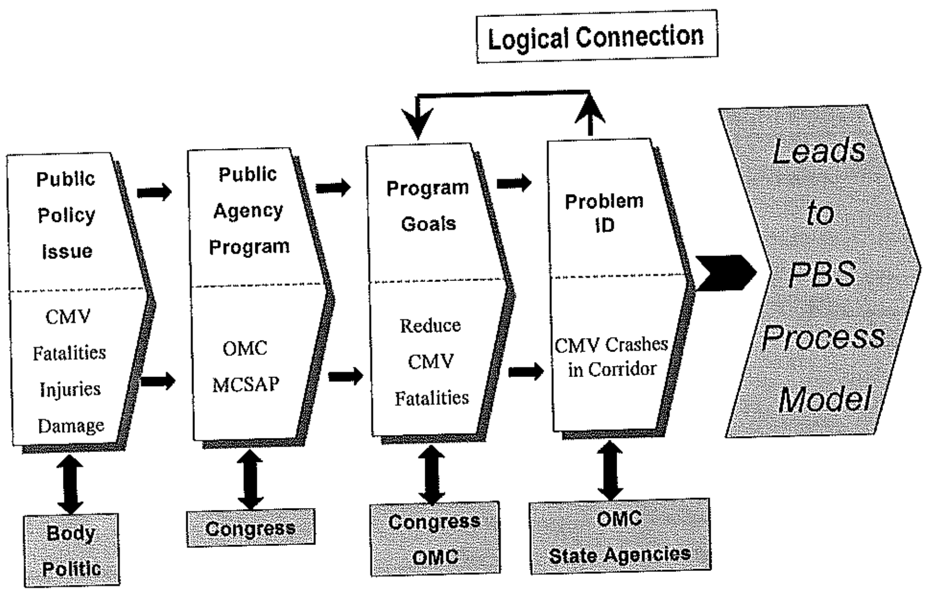

Figure 2. Process for the Development of a Public Program

performance-based system. A performance-based system is not intended to establish program goals and objectives. Over time it can contribute to the understanding of the linkages between the two, however, the main contribution to establishing the linkage between program goals and objectives has to come from the knowledge of the personnel involved in the program. Finally, program activities are defined that will result in the achievement of program objectives. Again, a logical connection must exist between the two. It should be emphasized again that the linkage between the activities and the objectives will be based on the knowledge of the personnel involved in the program. In the longer term, after several; periods of record, a performance-based system can provide insights into which activities are most effective. However, initially, this data is not usually available.

The process of the development of a public program is important to the success of a performance-based system for two fundamental reasons. First, the program goals are usually a given in most situations. Such is the case with the MCSAP. Second, it is important to understand the important and critical role that the program personnel play in establishing the important linkages between program objectives and program goals, and between activities and objectives. With this understanding it will be easier to comprehend the principles of success for a performance based system.

Principles for Success

There are a number of lynchpins that are essential to the success of a performance-based system that must be in place if such a system is to result in a safer CMV environment. Five fundamental principles have been identified which are necessary conditions for the success of a performance-based system. There are other considerations as well. However, these five principles are deemed essential to achieving the objectives of a performance-based system:

- Clear identification of program goals
- Objective problem identification
- Strong logical connection between program outputs and results
- Thorough understanding of the principles of CMV safety
- Good comprehension of performance-based methodology

The first principle, the identification of program goals is important to any performance-based system. However, the development of a program, and the corresponding program goals, is a complex socioeconomic and political process with input from various interest groups, and with information and analysis support from agencies, universities, and other groups. For purposes of this training, we will assume the program and program goals as a given. Furthermore, we will also assume that they are appropriate and in the best interests of the United States. Although it is important to clearly identify program goals, it may be difficult, or impossible, to scientifically measure the relationship between program activities and program goals (see Figure 3).

Second, problem identification, *doing the right things*, is paramount to the success of a performance-based system. Problem identification refers to the process of determining what the real problems are that stand in the way of achieving program goals. This may seem an easy task, however, to be done properly it requires an objective approach which lends itself to statistical and scientific analysis. There are several challenges in identifying problems correctly. The single largest difficulty is to make sure that personal feelings and anecdotal

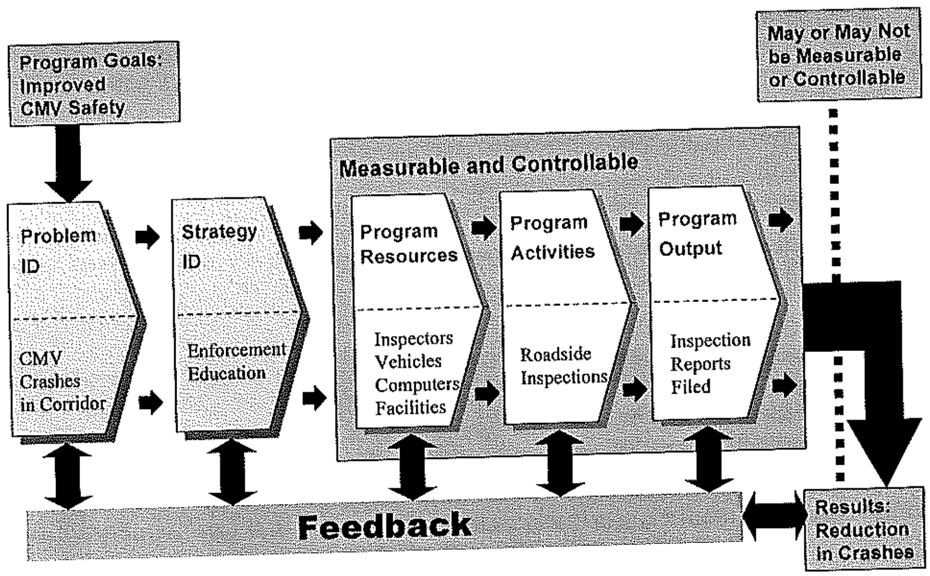

Figure 3. Model of a Performance-Based System

evidence do not bias the selection of the problems that the CMV safety program will address. In some cases, they may be very accurate. However, they may also be born of prejudice or simply represent a lack of complete information or misinformation. This is not to say that an individual's personal feelings and experiences should not be considered and are not correct. In some cases, they may be very accurate. Personal feelings based on experience and anecdotal evidence are important in developing a hypothesis of the existence of a problem. Nevertheless, the identification of that problem must be supported by objective analysis. It is imperative to develop as much supporting statistical evidence as possible to justify the selection of problems that are to be addressed within a CMV safety program. However, the significance of proper problem selection goes much further in its importance to a performance-based system. If appropriate problem selection is not conducted initially, the scarce resources available for any program will be focused on the wrong things. In other words, the program may end up *doing things right but doing the* ***wrong*** *things.*

Third, it is critical that strong logical connections (relationships) be developed between the program results being sought and the outputs that stem from the activities being implemented to address the identified problems (Figure 3). The reason for this is that it may not be scientifically or statistically possible, with significant confidence, to measure the relationship between program outputs and program results. An example could be a high crash corridor. A set of activities could be developed for this corridor to, (1) educate passenger vehicle drivers of issues associated with sharing the road with commercial vehicles, and (2) identify fatigued CMV drivers and put them out of service. After the careful development and implementation of these focused activities, it is possible to observe an increase in crashes. This would not necessarily mean that the wrong things are being done or that they are not being done right. There may be, and most likely are, external factors that influence the targeted results (crashes in the high crash corridor). These factors are beyond the control of the program and cannot always be adequately measured or analytically modeled to determine the impact that they have on the results. Changes in traffic levels, traffic patterns, traffic types, weather, economic circumstances and trends, driver age, driver experience, equipment, infrastructure quality and safety, and government policy (such as speed limits) are all examples of external factors that can affect program results beyond the influence of the safety efforts. If it is difficult, or impossible, to collect comprehensive data on the external factors, it becomes scientifically implausible to analyze how the program activities influence the results relative to the external factors. Furthermore, as was stated earlier, it may also be impossible to scientifically measure the relationship between the activities that are implemented to address the problem(s) that have been identified and the achievement of program goals. Therefore, it is extremely important that there is confidence, based on a good understanding of CMV safety, in the logical connections (relationships) that exists between the activities being implemented and the results being sought.

A fourth important, and essential, element of success is to have a well-developed understanding of CMV safety principles including crash factors. The development of the logical connections (relationships) is dependent on a thorough understanding of the business, wisdom gained from years of experience, application of a logical thought process, and a certain amount of confidence in a person's abilities. It is this understanding that provides the confidence in the relationship between program activities and desired program results in lieu of scientifically proven relationships. This is an essential element of success for another reason. The appropriate selection of program activities is critical to the achievement of program goals. The selection of program activities will be significantly influenced by one's understanding of safety issues.

The fifth and final principle of success is a solid comprehension of what a performance-based system is and what it can and cannot do. For instance, can a performance-based system be relied upon to select the appropriate program activities? Probably not, at least in the short term. In the long term performance-based systems can provide evidence that will assist in the selection of activities, but at no time does a performance-based system substitute for sound judgement based on understanding of transportation safety. It is imperative to understand the strengths and weaknesses of a performance-based system in order to have any success in implementing it.

Preservation of Existing CMV Safety Achievements and Standards

MCSAP has been a successful government program in improving CMV safety. It has resulted in the achievement of several safety goals and the establishment of CMV safety standards. The accomplishments that have been achieved and standards that have been established should be evaluated and considered when implementing a performance-based system. There is the risk, because of the lack of resources, that these achievements may have to be sacrificed to move to a performance-based system if they are not consistent with the problems identified in this new effort. If this is the case, care should be taken in evaluating that this is indeed appropriate. Appropriate, in this case, is that the newly established program objectives and activities will contribute more to CMV safety than the previous objectives and activities. If this tradeoff can be ascertained, one should still be careful not to eliminate previous gains, if possible.

Summary

Re-emphasizing the opening paragraph of this chapter, this movement to a performance based system is an effort to provide a more structured decision making process for problem identification, resource allocation, and accountability. It is one more tool to add to the existing knowledge base to improve CMV safety. It can, if implemented properly, result in a positive contribution to CMV safety. It is, however, not a panacea or silver bullet. It also must be remembered that, the success or failure of the system ultimately depends on the people implementing it at all levels.

Chapter **2**

Understanding Safety

What Causes Accidents, Really

A good understanding of the factors and the issues involved in commercial vehicle crashes is imperative for effective performance-based systems. Proper information and understanding of crash causation will guide the problem identification process, identify proper data analysis schemes, and support developing successful countermeasures to target critical safety issues. Further, understanding the contributing factors, especially external factors, will help explain some of the results of the program and the impact of program activities (if any) on the results, and the potential tradeoffs resulting from shifting priorities.

It should be noted that the information on crash factors from available data sources is suggestive. The information in these data sources depends largely on the judgement and skills of the officer filling the report at a crash scene and the level of detail of the report. In some cases, that information may not be adequate or accurate enough to provide the level of detail needed to target specific problems. Proper crash causation analysis requires detailed crash investigation and reconstruction.

Introduction

Several factors usually contribute to a crash with varying degrees. However, a single incident (referred to as the first harmful event) is usually what triggers a series of events that could lead to a crash. Crash causation refers to identifying the factors responsible for the occurrence of a crash. These factors may be classified into the following groups:

1) Human factors (driver)
2) Roadway factors
3) Environmental factors
4) Vehicle factors

To understand the concept of contributing factors consider the following example:

A commercial vehicle driver has been on the road for several hours. He/she enters a congested urban area. A passenger car trying to catch the next exit makes an improper (sudden) lane change in front of the commercial vehicle. The commercial driver has two courses of action: slow down (brake) to a safe distance behind the passenger car which pulled in front or make a lane change to avoid hitting that car depending on the traffic and road conditions. Assume that because the traffic is so dense in the other lanes, the commercial driver will have to slow down safely in the same travel lane. A number of scenarios could take place depending on the driver, the vehicle, and current road and traffic conditions. When the commercial driver decides to apply the brakes to slow down behind the passenger car, this action will require: 1) adequate attention from the driver to recognize the obstacle and react in time to apply the brakes, 2) adequate braking power in the vehicle, and 3) adequate road surface conditions to provide necessary traction (friction force). A number of things could cause the driver's action (to slow down) to fail and result in a rear end crash, including: driver slow to react, faulty brakes, and a slippery road surface.

In this example, the first harmful event was caused by the passenger car, which changed lanes abruptly in front of the commercial vehicle without leaving an adequate gap. Other driver, vehicle, and road condition factors came in to play to cause the crash.

Human Factors

One of the major factors contributing to crashes is related to the driver. About 85 percent of the contributing factors to all highway crashes can be associated with the driver.[1] Some studies suggest that the driver is the sole factor in 57 percent of the crashes, the road environment in 3 percent, the vehicle in 2 percent, the interaction between road environment and driver contributes in 27 percent, and the interaction between the driver and the vehicle in 6 percent of crashes. Further, in fatal crashes involving commercial vehicles and another vehicle, the driver of the other vehicle (car) was cited as a crash factor about 70 percent of the time.[2]

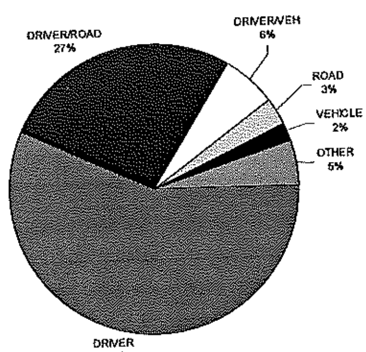

Figure 4. Crash Causation Factors

Human factors include several elements related to the driver attentiveness to the driving tasks. This includes interaction with his/her own vehicle, other vehicles (drivers), and the road environment. A properly qualified driver in good physical condition, paying attention to the driving tasks, and not impaired by fatigue or chemical substance is less likely to contribute to a crash. Further, that driver is more likely to react effectively and promptly to harmful events that could result in a crash. Human factors include the following elements:

- Driving skills
- Information processing and decision making
- Physical impairment
- Chemical impairment
- Fatigue impairment
- Driver's reaction time

Driving skills are largely dependent on training and driving experience. Crash statistics for example, indicate young drivers are more likely to be involved in crashes than other drivers with more experience. Consequently, commercial vehicle drivers go through a more rigorous training and certification process, which requires CDL holders to be at least 21 years of age. Many trucking companies require their new hires to drive with an experienced driver for a year or a number of miles before they can drive alone. However, the certification and training of drivers of other vehicles (passenger cars) do not follow similar standards.

The ability to process information and make appropriate decisions is a critical component of the driving tasks, which directly affect reaction time. Reaction time refers to the times (in seconds) it takes the driver to recognize an obstacle or a harmful event, decide on a safe action to avoid the situation, and start implementing that action. In the previous example, it is the time when the truck driver sees the car pulling into his/her lane and the time he or she starts applying the brakes or changing the lane. In order to avoid hazardous situations, the driver must be aware of the changing conditions of his/her own vehicle, other vehicles, and the road environment.

Several factors could negatively impact driving performance by impairing one or more of the driver's skills required for safe driving. Alcohol is the top cause for driver impairments. About 41 percent of highway fatalities occur in alcohol related crashes.[3] Alcohol use among commercial vehicle drivers involved in crashes was cited significantly less than other drivers. However, driver fatigue is considered a major cause of crashes involving commercial vehicles. Fatigue is a complicated issue because of the lack of proper scientific understanding of the causes and measures to combat fatigue. Fatigue is not solely caused by the number of hours behind the wheel, but could rather be a combination of inadequate sleep, irregular sleep patterns, monotonous driving, etc. Several studies are being conducted nationwide to examine some of the issues related to fatigue causes. In addition, there are several dimensions to the fatigue issues including government policies and industry practices.

Roadway Factors

Roadway factors refer to road features including geometric design, surface attributes, and traffic control devices. Improper horizontal and vertical alignment may contribute to crashes because of difficulty in maneuverability, sight distance limitations, and safe stopping sight distances. Several studies suggest that many highway features such as ramps were designed based on the performance of passenger vehicles, not taking commercial vehicle size and performance into full consideration. For example, about one third of fatal crashes involving commercial vehicles were intersection related.[4] Other geometric attributes such as number of lanes, lane widths, and the width and grade of the shoulder and the median have been cited as possible contributors to crashes.

The condition of the road surface can also affect the braking distance depending on the friction forces generated under the tires. For example, pavement surfaces with extensive areas of bleeding (asphalt patches on the surface) would reduce friction required to safely stop motor vehicles during braking. In addition, deep ruts in the pavement surface could cause vehicle handling problems. On the other hand, rumble strips are used to alert drivers through a sudden change in tire sound and sensation. When placed on road shoulders, they have proven to reduce run-off-the road highway crashes. This practice is gaining popularity and wide use in several states.

Finally, traffic control devices such as traffic signals, traffic signs, and road markers can be contributing factors to crashes. Issues related to these devices include proper function and visibility.

It should be noted that road factors become even more critical when combined with environmental factors, such as adverse weather (ice, snow, fog, and high wind).

Environmental Factors

Several environmental factors could interact with the roadway and driver to contribute crashes. These factors complicate the driving tasks, could create hazardous situations, and delay proper action to avoid harmful events. These factors are related to visibility, road surface condition, and maneuverability.

Roadway surfaces covered with ice and snow reduce the amount of friction force between the road and the tires, reducing traction and increasing the distance required for stopping. Fog reduces the visibility and causes strenuous driving conditions that could contribute to crashes. Heavy rain has similar effects by reducing visibility. High winds can cause handling problems for commercial vehicles forcing lane swings that could result in jackknifing at horizontal curves. Light conditions have often been investigated to identify their impact on crashes. Several studies suggest time of the day trends in crash occurrence. Generally, time periods around sunrise and sunset have shown higher crash rates than other periods. Adequate lighting at urban intersections and highway ramps reduces the impact of dense fog and improves nighttime driving conditions.

Vehicle Factors

Several vehicle systems could contribute to crashes when they are not functioning properly. The most critical elements are related to braking system, tires, and cargo securement equipment. Improper brake systems would increase the safe stopping distance and may cause handling problems. Similarly, tires with inadequate tread depth could reduce traction and braking ability. Other vehicle elements include light systems, turn signals, mud flaps, windshield, and windshield wipers.

A Word about Crash Types

In addition to accurately identifying the factors contributing to motor vehicle crashes, it is important to understand their relationship with crash type. Crashes may be classified in several ways related to the number of vehicles involved and the manner of the collision. A possible scheme could include:

- Single vehicle crashes
  - Run-off-the road
  - Collision with a fixed object
- Multiple vehicle crashes
  - Head-on collisions
  - Rear-end collisions
  - Right-angle collisions
  - Other

Information on crash type provides important insights about possible causation factors and the appropriate actions or strategies that could effectively reduce the number of crashes in that category. Single vehicle crashes for example are largely caused by driver factors. If the data do not show high alcohol impairment, then driver fatigue could be a major factor. By understanding the causes, effective countermeasures may be formulated including, for this example, detecting fatigued drivers through enforcement or installing rumble strips, etc.

Further, understanding potential causes of different crash types helps explain possible tradeoffs that result from shifting program activities. For example, traffic engineers often respond to a high number of right angle crashes at uncontrolled intersections by installing traffic signals. The new signals are proved to reduce the number of those types of crashes. However, an indirect impact of installing traffic signals is an increase in rear-end crashes, caused by unfamiliar drivers failing to slow down or stop as they approach the intersection. This increase in a different type of crashes will subside as more drivers are aware of the presence of the traffic signal. In this example, it is clear how a full understanding of the direct and indirect impacts of a safety countermeasure is crucial to justify safety decisions to the public and to policy makers.

Summary

Understanding crash factors is an integral part of the problem identification process. This understanding will also assist in developing logical conceptual connections between program outputs and results. Crash causation factors provided in available crash data bases are suggestive factors and may not be reflective of actual causes.

Human factors are the most critical causes of crashes, accounting for about 85 percent. Further, in crashes involving commercial vehicles, the car driver accounted for about 70 percent of the crashes. Road environment factors and vehicle factors account for small percentages of highway crashes. In addition, the crash type provides additional information on the potential causes of crashes and must be included in the problem.

Chapter 3

Problem Identification

Putting Numbers Behind the Hunches

The success of performance-based systems depends on sound and thorough problem identification and measurement. The problem identification process addresses the "what, who, where, and when" questions with respect to commercial vehicle safety. What are the problems? Who is contributing to the problems? Where are the problems happening? When are the problems occurring?

Available National Databases

The following information on available national truck safety data was obtained from Internet web sites for the individual systems as well as information contained in the OMC *MCSAFE* publication. Where applicable, the Internet web address is given for the individual site. Much of this data is accessible from the different sites or through the Bureau of Transportation Statistics (http://www.bts.gov/).

Fatal Accident Reporting System (FARS)

The Fatal Accident Reporting System (FARS) contains accident data provided by the 50 states, Puerto Rico, and the District of Columbia. According to NHTSA documents, throughout the states, Puerto Rico, and the District of Columbia, trained state employees gather and transmit these data to NHTSA's central computer database in a standard format. State employees obtain data solely from each state's existing documents—including police accident reports, vehicle registration files, and vital statistics records—and then enter them into a central computer database. NHTSA analysts periodically review a sample of the cases.

The National Center for Statistics and Analysis (NCSA) conceived, designed, and developed the FARS data system (http://www.nhtsa.dot.gov:80/people/ncsa/). It is meant to assist the traffic safety community in identifying traffic safety problems, developing and implementing vehicle and driver countermeasures, and evaluating motor vehicle safety standards and highway safety initiatives.

NCSA responds to over 3,000 requests for information and sends out more than 50 computer tapes of FARS data each year. FARS data are used extensively within NHTSA, and requests are received from sources such as state and local governments, research organizations, private citizens, the auto and insurance industries, Congress, and the media.

FARS data can be used to answer many questions on the safety of vehicles, drivers, traffic situations, and roadways. FARS data can also be accessed at the state level by the FARS analyst to respond to state safety issues. To protect individual privacy, no personal information, such as names, addresses, or specific crash locations, is coded.

The FARS Internet site (http://www.fars.idinc.com:80/fars/fars.html) is the first stage in making FARS data accessible to the public. Through this web interface, all of the 1995 FARS data is searchable and downloadable. This site also provides access to frequent user-specified queries, FARS documentation, the *1995 Traffic Safety Factbook*, and an on-line forum.

The Fatal Accident Reporting System has enabled NHTSA to document that the rate for one of its desired results—reduction in the fatality rate—has decreased from 2.3 to an estimated 1.7 per 100 million vehicle miles of travel from 1988 to 1995.

The FARS provides good data on all fatal crashes, but nothing on nonfatal crashes.

General Estimates System (GES)

The General Estimates System (GES) contains data from a nationally representative sample of police-reported accidents. To compile the database, NHTSA data collectors randomly sample about 48,000 reports each year from approximately 400 police jurisdictions in 60 sites across the country, according to NHTSA documents. NHTSA staff then interpret and code the data directly from the reports into a central electronic data file. The data are checked for consistency during both coding and subsequent processing.

NHTSA has recognized that its data have limitations. For example, the GES is based on police reports, but various sources suggest that about half of the motor vehicle crashes in the country are not reported to police, and the majority of these unreported crashes involve only minor property damage and no significant injury. A NHTSA study of the costs of motor vehicle injuries estimated the total count of nonfatal injuries at over 5 million compared to the GES estimate for that year of 3.2 million. NHTSA intends to study the unreported injury problem.

NHTSA has used data from the GES to document another one of its desired results—a reduction in injury rates—from 169 to an estimated 138 injuries per 100 million vehicle miles of travel from 1988 to 1995.

The GES is a reliable national *sample* of all crashes. However, since truck crashes are not sampled from each state, GES can provide national totals but no state specific data.

Trucks Involved in Fatal Accidents (TIFA)

The Center for National Truck Statistics, located at the University of Michigan Transportation Research Institute (UMTRI) (http://www.umtri.umich.edu/), was established in 1988 to formalize a developing national program to collect and analyze truck accident and travel data. The mission of the Center is to provide an independent source of truck statistics, and to pursue a comprehensive statistical approach to the study of truck safety. The activities of the Center cover data collection, evaluation, and dissemination, including:

- A national survey of Trucks Involved in Fatal Accidents (TIFA), providing detailed descriptions of the trucks. This project has operated continuously since 1980.

- An evaluation of the quality of truck accident and exposure data.

- The publication of annual descriptive statistics on truck and bus accidents for FHWA, using data from the Office of Motor Carriers SafetyNet accident module, NHTSA's Fatal Accident Reporting System (FARS) and General Estimates System (GES), and TIFA. This publication is *the Truck and Bus Accident Factbook*.

The TIFA provides the best truck data, but only includes fatal truck crash data. There are fewer than 5,000 fatal truck crashes each year, compared to an estimated 160,000 total truck and bus crashes that meet the NGA reporting criteria.

OMC's SafetyNet/NGA Crash Database

SafetyNet is a system allowing states to report truck and bus accidents meeting a common threshold to a national file, using common data elements. When fully implemented by the states, the file will be a census of all truck and bus accidents where at least one involved vehicle was towed due to damage. SafetyNet data can be supplemented by data from NHTSA's General Estimates System and UMTRI's Trucks Involved in Fatal Accidents survey. In addition, there are quality control and consistency checks on the SafetyNet data as well as analyses of truck and bus accident rates and distributions.

The SafetyNet/NGA Crash Database aspires to be a census of all truck and bus crashes that meet certain criteria, but since many states still report little data, the total crashes in the 1994 database is probably only slightly more than half the actual number.

Highway Statistics from the Federal Highway Administration

Highway Statistics (http://www.bts.gov/fhwa/HighwayStatistics95/) contains general information about our national roadway system, among other topics. This publication brings together annual series of selected statistical tabulations relating to highway transportation in three major areas:

- highway use—the ownership and operation of motor vehicles;

- highway finance—the receipts and expenditures for highways by public agencies; and

- highway plant—the extent, characteristics, and performance of the public highways, roads, and streets in the Nation.

The arrangement of contents follows this general order:

1) Motor-fuel use and taxation,

2) Vehicle ownership,

3) Driver licensing,

4) Financing of highways by all government agencies,

5) Highway mileage and performance,

6) Statistics for the U.S. Territories and the Commonwealth of Puerto Rico,

7) Selected international data, and

8) Metric tables.

Statistics in this publication have been analyzed and reported using procedures that provide comparability of values among states. Therefore, some values reported here may differ from values reported by other agencies for similar items.

Important Information for Users of *Highway Statistics*

Purpose of Information

The Federal Highway Administration (FHWA) collects from the states and publishes in *Highway Statistics* information necessary to support its responsibilities to the Congress and the public. This information is used in the development of highway legislation at both the federal and state levels. The information is also used in preparing legislatively required reports to Congress, in calculating and evaluating federal fund apportionment, in keeping state governments informed, and, in general, as an aid to highway planning, programming, budgeting, forecasting, and fiscal management. It is also used extensively in the evaluation of federal, state, and local highway programs. From an FHWA perspective, the information in *Highway Statistics* meets the federal need of providing a national perspective on highway program activities very well. Since this information was developed primarily to meet FHWA and state needs in administering the highway programs of the Nation, other users need to exercise thoughtful care in using this information for other purposes.

Quality Considerations

Information published in *Highway Statistics* comes from a number of sources. These sources include various administrative agencies within the 50 states, over 30,000 units of local government, the FHWA, other federal agencies, and the five U.S. territories.

Information included in *Highway Statistics* is the result of a cooperative effort between the FHWA and the states. Nearly all of the data provided to FHWA, including the Highway Performance Monitoring System (HPMS) data, come through state Departments of Transportation from existing data bases or business records of many individual state and local governmental agencies, including metropolitan planning agencies (MPOs). The existing databases and record keeping systems of these governmental units were designed and are maintained to meet their individual business needs.

Data quality and consistency of information published in *Highway Statistics* are, therefore, dependent upon the programs, actions and maintenance of sound data bases by numerous data collectors, manipulators and suppliers at the state, local and metropolitan area levels. In general, specific data items that are used by the collecting agency are likely to be of better quality than data items that are collected solely for the FHWA. Data quality and consistency are also dependent upon the nature of the individual data items and how difficult they are to define, collect, etc.

HPMS data are collected in accordance with the Highway Performance Monitoring System Field Manual for the Continuing Analytical and Statistical Database. This document contains standard codes for the various data items to be reported in a consistent format.

Highway statistical data other than the HPMS are collected in accordance with *A Guide to Reporting Highway Statistics* (*The Guide*). Reporting procedures contained in the Guide are not rigid standards; rather, they represent a reporting reference system that the FHWA recommends the states use in collecting and reporting state and local highway data to the FHWA.

Nearly all of the state reported data are analyzed by FHWA for consistency and for adherence to reporting guidelines. In a number of cases, data are adjusted to improve consistency and uniformity among the states. The analysis and adjustment process is accomplished in close working relationship with the states supplying the data.

Using Data for Comparisons

Even when data are consistently collected and reported, users need to recognize that highway statistical information is not necessarily comparable across all states. For many of the data items reported in *Highway Statistics*, a user should not expect to find consistency among all states, due to many state-to-state differences. When making state level comparisons, it is inappropriate to use these statistics without recognizing those differences that influence comparability.

Use of reported state maintenance expenditures provides a clear example. Maintenance expenditures per mile can vary between states depending upon a number of factors including differences such as climate and geography, how each state defines maintenance versus capital expenditures, traffic intensity and percent trucks, degree of urbanization, types of pavement being maintained, and the level of system responsibility retained by the state versus that given to other levels of government. It would be inappropriate, therefore, when using data from

Highway Statistics to compare per mile maintenance costs across all states to draw any conclusions without taking into account the differences that should be expected in these parameters based upon differing state conditions.

If choosing to compare state data, the user must be prepared to thoughtfully select a set of peer states that have similar characteristics in relationship to the specific comparison being made. Improperly selected peer states are likely to yield invalid data comparisons.

Differences that the user needs to consider in determining suitability of peer states for data comparison purposes include characteristics such as urban/rural similarities, population density, degree of urbanization, climate, geography, differing state laws and practices that influence data definitions, administrative control of the public road system, similarity of the basic state economies, traffic volume similarities, and the degree of state functional centralization.

While the Office of Highway Information Management is responsible for the preparation of this publication, a number of the statistical summaries are prepared by other units within the Federal Highway Administration (FHWA) as indicated by notes on the tables involved.

Responsibility for administering the highway network of the United States, providing funds for its continued improvement and maintenance, and regulating its use is a complex affair involving federal and state agencies, together with nearly 39,000 county, township, and municipal governments and, to a limited degree, the private sector. These agencies work in concert in many ways in the management of the Nation's highway plant.

Final Thought

As indicated in OMC's *MCSAFE,* none of the above databases contains information on crash causation, contributing factors, or fault. The data can be only suggestive about why truck and bus crashes occur. Even so, the data can point highway safety personnel toward problem areas that may need to be addressed, and toward possible countermeasures.

State Databases

In addition to national sources of data, several states keep some data on commercial vehicle safety. The extent and format of these data varies greatly. However, one of the effective formats is using Geographical Information Systems (GIS) to combine crash data with location attributes. These systems allow effective identification and analysis of problem areas and facilitate presentation of information to decision-makers and the public.

Some of the national databases may also contain more information at the state level. For example, SafetyNet data at the state level would contain information for additional state-defined variables which are not uploaded to the national database. The information at the state-level may also be more up-to-date.

Fundamental Principles of Data Analysis

A good way to begin data analysis is with a "hunch." Hunches about problem areas may come from individual state expertise, a complaint, a serious incident, etc. Once there is a hunch about where the problem areas may be in a state, it is then useful to obtain data to support or refute this hunch.

Once the data are obtained, the best way to begin to describe them is to create a *frequency chart*. This will give a graphical display of the data. For example, the following table lists the fatality rates per 100 million vehicle miles traveled for all 50 states, and the District of Columbia.

State	Fatalities per 100 million vehicle miles traveled	State	Fatalities per 100 million vehicle miles traveled
AL	2.2	MT	2.3
AK	2.1	NE	1.6
AZ	2.6	NV	2.2
AR	2.4	NH	1.1
CA	1.5	NJ	1.3
CO	1.8	NM	2.3
CT	1.1	NY	1.5
DE	1.6	NC	1.9
DC	1.7	ND	1.1
FL	2.2	OH	1.4
GA	1.7	OK	1.7
HI	1.6	OR	1.9
ID	2.1	PA	1.6
IL	1.7	RI	1.0
IN	1.5	SC	2.3
IA	2.0	SD	2.1
KS	1.8	TN	2.2
KY	2.1	TX	1.8
LA	2.3	UT	1.7
ME	1.5	VT	1.7
MD	1.5	VA	1.3
MA	0.9	WA	1.3
MI	1.8	WV	2.2
MN	1.4	WI	1.4
MS	2.9	WY	2.4
MO	1.9		

Source: Traffic Safety Facts 1995; NHTSA

To create a frequency chart of this data, simply divide the data into an arbitrary number of intervals. In the example, the lowest fatality rate was 0.9 and the highest was 2.9, the difference is 2.0. Dividing 2.0 by the arbitrary number seven gives a value of approximately 0.2857. Therefore, beginning with 0.9 and adding 0.2857 to each interval creates a table as follows:

Class	Class Boundaries	Tally	Class Frequency	Class Relative Frequency
1	0.00-0.900	1	1	1/52
2	0.900-1.186	1111	4	4/52
3	1.186-1.471	~~1111~~ 1	6	6/52
4	1.471-1.757	~~1111~~ ~~1111~~ ~~1111~~	15	15/52
5	1.757-2.043	~~1111~~ 111	8	8/52
6	2.043-2.329	~~1111~~ ~~1111~~ 111	13	13/52
7	2.329-2.614	111	3	3/52
8	More than 2.614	1	1	1/52

Figure 5 gives a good idea of what the distribution of the data (i.e., fatality rates) looks like. For example, very few states have fatality rates higher than 2.614 or lower than 1.186, while the majority of the states have fatality rates between 1.186 and 2.614. A frequency chart is a good way to begin to get a feel for the data. Many spreadsheet programs will create frequency charts.

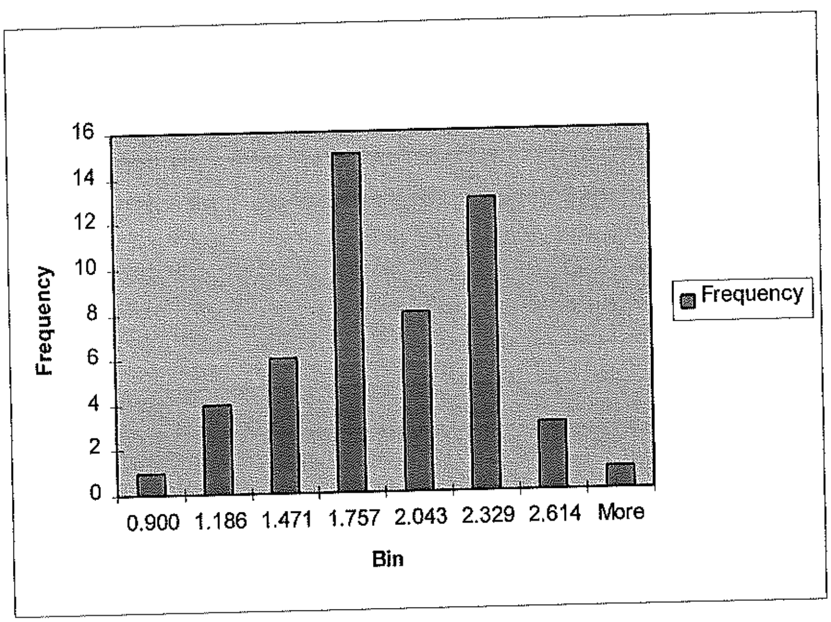

Figure 5. Frequency Chart for State Fatality Rates (Sample)

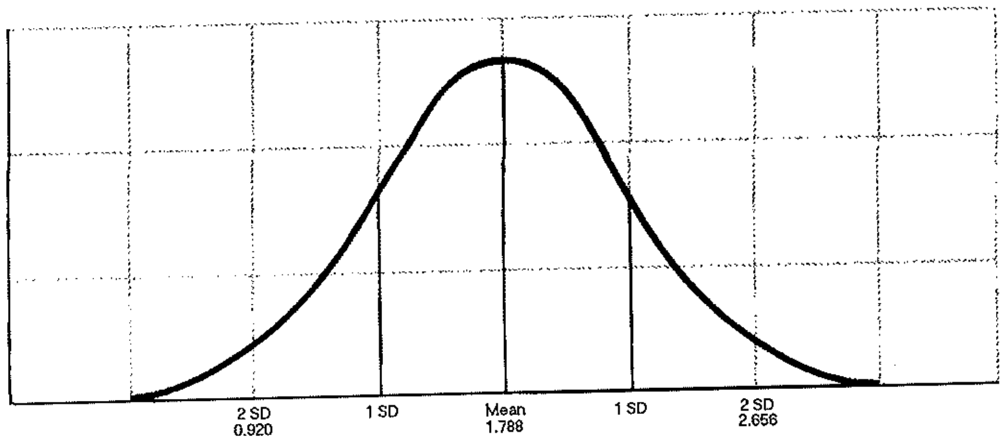

Figure 6. Normal Distribution of Data Around a Mean

The *mean* and *standard deviation* are numerical methods for describing a data set and are very useful for determining if a particular measurement falls within the "expected range" of the data. Specifically, the mean plus or minus twice the standard deviation gives a range which accounts for approximately 95 percent of all the measurements in an approximately normal population as illustrated in Figure 6. Measurements falling outside of this range are different from what would be expected simply by "chance." These terms are described in detail in the following paragraphs.

The *mean* (or average) of a set of measurements is the most common and useful measure of central tendency. It is simply calculated by summing all the measurements and dividing by the number of measurements. Using the same data as before, the sum of all 51 measurements is 91.2. Dividing this by 51 gives a mean for the data set of 1.788.

The *variance* is the most common way to measure variability in data. This is simply the sum of the squared differences of the measurements from the mean divided by the number of measurements. Most spreadsheet programs will calculate the mean and variance of any given data set, so it is not necessary to remember how to calculate it. For the above data, the variance is approximately 0.188.

Since the variance is measured in terms of the square of the original measurements, it is useful to take the square root of the variance, termed the *standard deviation*, to return the measure of variability back to the original units of measurement. The standard deviation for the fatality rate data is 0.434.

Calculating the mean plus or minus twice the standard deviation for the fatality rate data set gives a range of 0.920 to 2.656 as shown in Figure 6. Thus, Massachusetts had a fatality rate lower than what would be expected by chance, while Mississippi had a fatality rate higher than what would be expected by chance.

Thus, the mean and standard deviation can be used as described above to help identify problems by conducting similar analyses between different parts of a particular state (i.e., different counties, cities, roadways) or between a state and a particular region or the nation as a whole. Analyses can also be conducted between other categories such as age of the driver, time of the year, or the conditions of the road or weather at the time of the accidents. In addition, one could look at trends across recent years to search for any changes which may be occurring.

Once problems have been identified and specific countermeasures have been developed, statistics can then be used to determine if there has been any change in the data since the countermeasure was put in place. It must be stressed that statistics cannot identify causation, they can simply show, for example, whether there is enough evidence to judge two samples of data significantly different from each other. For example, if one wanted to examine the accident rates for counties in one-half of a state versus that for counties in the other half, statistics could help to do that. If a difference is found between the two populations, it is still difficult to determine what may have caused the difference. Many factors could have possibly contributed to the difference in addition to or instead of the particular countermeasure employed. One needs to take into account these external factors when making any conclusions from the data. These factors could include various weather or road conditions at the time, or even other implemented programs such as a change in speed limits.

Some specific examples of data analysis which were identified in various states during the peer review of best practices related to hours-of-service enforcement include:

1) Using SafetyNet data to examine trends in violations and crashes to determine program direction by focusing on problem areas.

2) Using SafetyNet data for program management activities to identify use and need for resources, to examine how program goals are met, and to help in personnel management (i.e., to ascertain inspector's certification).

3) Concentrating enforcement efforts on high crash locations, areas, or roadways.

4) Supervisors and inspectors keeping documentation on inspectors' activities.

5) Improving crash causation analysis by including fatigue factors on crash investigation forms.

6) Using technology such as computers and available software to provide timely and accurate data.

7) Analyzing crash data to try to identify causation and to develop appropriate enforcement and educational activities.

8) Identifying crash locations using mapping.

9) Having one agency responsible for SafetyNet data collection and analysis, and to assist in coordination efforts, information management, and timely updates to FHWA.

In addition, the Analysis Division of the Office of Motor Carriers currently compiles basic statistics for individual states, as well as comparisons to national data and neighboring states. In addition to this, the Analysis Division will provide any other report on state statistics upon request.

Summary

The problem identification process attempts to answer the "what, who, where, and when" questions associated with commercial vehicle safety. In order to do this, several national databases (FARS, GES, TIFA, SafetyNet, *Highway Statistics)* as well as individual state information are available. Although each has limitations, using these databases, along with hunches, and statistics such as the mean and standard deviation, can help states to identify problem areas. In addition, OMC's Analysis Division is available to help states with this problem identification process. From this information, countermeasures can be developed and implemented.

Chapter 4

Performance Measurement

Are We Doing Things Right, Are We Doing the Right Things

Introduction

Performance measurement can be defined as the assessment of an organization's output as a product of the management of its resources (dollars, people, vehicles, facilities) and the environment in which it operates.

Performance-based systems are regularly used to evaluate service delivery and the results achieved in public programs. In many cases, performance monitoring includes typical measurements such as program costs, services delivered, and numbers served. However, it can also include short-term and medium-term results (see definition of "results" below).

Performance indicators are used as a means of determining the efficiency of programs or processes in achieving their desired results. Measuring performance is important for the following reasons:

1) Using performance indicators helps to determine if a program or policy is effective. They allow evaluators to investigate objective and observable results in a systematic way.

2) The use of specific performance indicators allows the continuous evaluation of a program over long periods of time.

3) Performance indicators provide feedback. This feedback should be used to make important changes or to develop new strategies associated with a program or policy.

To be effective, a performance-based system must help program managers improve their programs, rather than using the information strictly for external accountability purposes. Past impediments to management use include infrequent feedback of performance data and over-aggregation of performance data. These problems must be addressed or performance monitoring will not be successful.

Performance indicators are part of the evaluation process, which involves several steps:

1) Identify and specify program or policy goals.

2) Develop multiple performance indicators that allow progress toward goal attainment to be monitored.

3) Collect the data.

4) Analyze the data by comparing actual results, as determined by the performance indicators, with the specified program or policy goals.

5) Based upon results of the data analysis, make appropriate changes in the program or policy. Then, continue the evaluation process by continuing to collect and analyze the data based on performance results.

How is the Process Carried Out

A specific example of how one enforcement agency developed indicators to assess field performance may provide the best illustration of the process.

> The Metropolitan Nashville Police Department desired some method to determine the effectiveness of their police skill training of junior officers. The primary concern was if the skills learned during classroom training actually transferred to performance in the field. To resolve the issue, the department developed performance indicators of police performance in the field that could be monitored and subjected to data analysis. Before the indicators were developed, those involved in the study outlined the goals and objectives regarding specific areas of police work that needed to be assessed. Two indicators, which assessed the majority of police work or performance, were developed. They were specific indicators of report writing and of routine patrol activity, including assessments of speed, movement, mileage, and use of emergency equipment. Data for each indicator were continually collected, and could be compared with present standards of performance or compared among the junior police officers participating in the study. Evaluating the performance of the junior officers in this manner led to many beneficial effects for the Nashville Police Department, including long-term changes in the policies regarding police performance standards.

Please note that in the above example, the focus is on the actions and activities of the officers (report writing and patrol activity) and not on the results of their work (public safety).

Terminology

Several concepts and terms are important to understanding the objectives of performance monitoring. These concepts include efficiency, effectiveness, productivity, etc. Effectiveness is the degree to which program goals are met, while efficiency is the ratio of an output to the resources required. More succinctly, efficiency is doing things right and effectiveness is doing the right things. The distinction between output and result is of particular importance.

Activity A task performed by an organization to produce a desired output. Examples include miles driven, trucks serviced, and meters read. Sometimes described as "Workload."

Effectiveness The degree or extent to which program goals and results are met, such as percent of population served or percent of clients successfully treated. For MCSAP this could include percent of carriers audited, percent of trucks inspected.

Efficiency The ratio of outputs to resources such as work performed per staff hour or downtime as a percent of total hours. Includes productivity, unit costs, and technical efficiency.

Function A government service such as police, fire, and education. "Function" and "Service" are used synonymously.

Goal A statement that describes what is to be accomplished by a program, service, or agency such as "insure a safe and secure environment."

Impact The long-term effect of a program on a community of its citizens. "Impact" and "Result" are used synonymously. See "Result."

Output The result of work performed or produced by an agency. Outputs are what government produces. Examples of outputs are the numbers of individuals served, gallons of water delivered, or tons of trash collected.

Performance Indicator A measure used to determine efficiency of programs in achieving their desired results.

Productivity Index Inverse of the change in resources used per unit of output.

Resource The inputs used by an agency to produce a function or service. Examples of resources are labor, facilities, equipment, and materials. Also referred to as "Input."

Result The effect of government programs or services such as improved citizen safety, increased longevity, and reduced infant mortality. For MCSAP this would include safer highways, reduced fatalities, and decreased crashes. Also referred to as "Outcome" or "Consequence."

Service A government function such as police, fire, or education. "Service" and "Function" are used synonymously.

Social Indicator A measure of societal well being, such as longevity or happiness. These measures are of interest because they are considerations which governments wish to promote.

Workload A measure of the amount of work performed, usually an intermediate output, such as the number of miles driven, or number of machines serviced. See "Activity."

Performance-Based System Process Model

Conceptually, government draws on a series of *resources* to undertake a series of *activities* that result in one or more *outputs* intended to produce a series of desirable *results.*

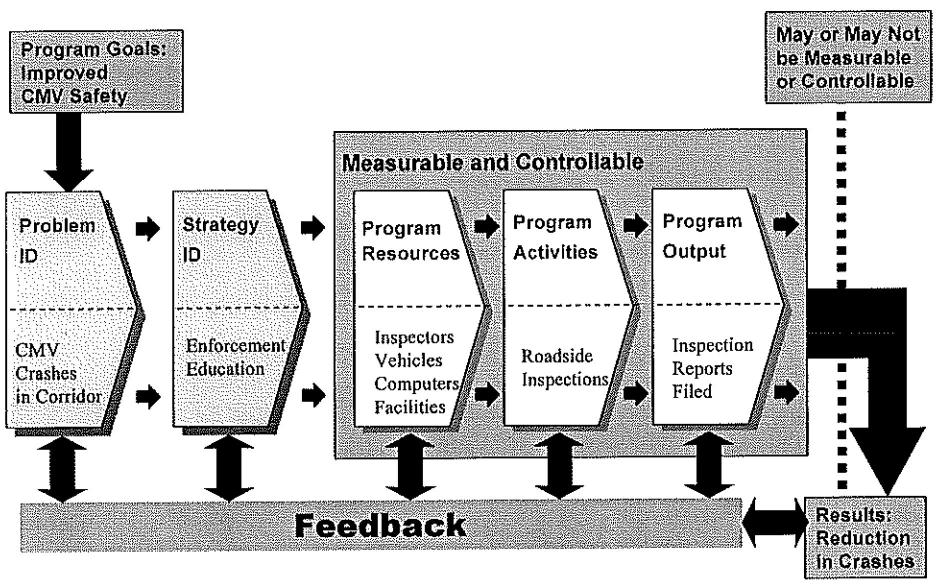

Figure 7. Model of a Performance-Based System

Resources consist of labor, capital, and purchased materials. Activities are intermediate services or processes. Outputs are the final goods or services produced by the government. Results, which are sometimes known as outcome or impact, are the intended effects of government action. The above diagram illustrates this process.

To further illustrate this process, the U.S. Department of Labor has prepared analogies to sanitation and police services.

For sanitation, the model is relatively straightforward. Laborers, drivers, trucks, brooms, gas, and uniforms all serve as resources to the sanitation service. These resources are deployed to produce a series of activities such as sweeping streets, emptying litter cans, and picking up discarded furniture. Outputs might be the collection of trash. The results should be cleaner streets and neighborhoods, fewer fire and health hazards, and (presumably) happier citizens.

With police services, resources would be police officers, police vehicles, and communication equipment. Activities include recruiting and training officers and taking calls from citizens. Outputs might include patrolling and the number of arrests. The results of these actions should be a safer community.

The following table lists other examples of the process applied to government services:

Service	Resource	Activity	Output	Results
Corrections	Clothing Food Prisons	Clothe inmates Serve meals Patrol cell blocks	House offenders	Reduce crime Protect society
Education	Buildings Desks Teachers Food Buses	Conduct classes Give tests Serve meals Operate buses	Educate students	Increase literacy rate Reduce unemployment
Fire	Trucks Firefighters Parts Trainers	Maintain fire trucks Train firefighters	Put out fires Rescue citizens Inspect property for fire hazards	Reduce fire losses Reduce fire deaths
Road Maintenance	Trucks Radios	Maintain trucks Dispatch trucks	Repair streets	Reduce traffic deaths Reduce travel time
MCSAP	Inspectors Computers Facilities Cars	Inspections Audits	CVSA decals OOS Safety ratings	Safer highways Reduced accidents Reduced injuries/deaths

In the MCSAP program, examples of resources are officers, computers, weigh stations, paper, etc. The activities could include inspections, audits, and education. The outputs might be out of service vehicles, safety certified vehicles (CVSA decal), safety ratings, etc. The results are safer highways and reduced accidents and fatalities.

Applications of Performance Evaluation

Any level of government can be evaluated using performance indicators including unit, agency, program, subprogram, or activity. Performance evaluations are used for various purposes including evaluating the efficiency and effectiveness with which an agency or program pursues its goals and objectives.

Program evaluation is a term used to describe a performance evaluation focusing on a specific program. *Feedback* is a term meaning evaluation of progress in implementation.

Program Evaluation vs. Performance Monitoring

Special-study performance measurement is usually labeled *program evaluation.* Individual program evaluations typically require substantial amounts of resources and one or more staff-years of time. Such studies aim at identifying both the extent to which a particular program has been successful, and the extent to which a particular program itself has caused the observed results. Because they are done infrequently and irregularly, they are not useful in guiding managers in the ongoing management and control of their operations.

Program evaluations are quite useful in helping governments identify whether a particular program should be continued, dropped, expanded, or contracted. If the evaluation is appropriately designed, it can also provide information on ways to improve the program.

The other form of productivity and performance measurement is called performance monitoring. Its focus is on measuring the results on a regular basis, at least once a year, and probably for many performance indicators quarterly, monthly, or even weekly.

Performance monitoring has two important advantages: 1) it can provide regular feedback to public officials, managers, and supervisors, for managing and controlling operations; and 2) because it is not as costly as program evaluation, performance measurement can cover a wide range of programs, services, and work groups of an agency. The main limitation of performance monitoring is that, unlike special program evaluation studies, it does not directly address the issue of what has caused the observed results.

Establishing Benchmarks or Targets

In order to evaluate performance, administrators must define targets or standards for comparison. There are four methods of doing this:

1) **Previous years.** One method of evaluation is to compare current-year performance indicators and productivity indexes with those of previous years. In this way, progress or improvement can be identified. The previous year's values serve as the target or standard. However, previous years may have

had different conditions that no longer apply to the current year. These changes will not be reflected in the comparison.

2) **Peer groups**. Comparisons can be made across peer groups (e.g., states). This method has the same pitfalls as grading on a curve, if the whole class is doing badly or well, relative position may be unimportant. However, if a program is active in one group and not in others, this may be the best way to determine the effectiveness of the program.

3) **Ideal conditions**. This approach develops standard resource costs or unit costs that would be expected for a given service level under efficient conditions. This approach, however, must be realistic. Ideally, under MCSAP accidents would be reduced to zero. However, this cannot be achieved, no matter how well MCSAP is working.

4) **Expected service level**. This approach uses the expected service level (or demand) as a target for output level.

Resources

Factor Inputs

Factor inputs are the resources used in producing outputs. Some of the primary resources used are:

1) Labor (person-hours)

2) Equipment (machine-hours, truck-hours, etc.)

3) Materials and supplies (tons, gallons, or other units)

4) Contractual services

5) Long-lived capital assets (such as buildings, power plants, land, etc.)

These resources are transformed into outputs via the production or service process.

Factor Prices and Resource Value

Each resource has a price associated with it: labor has a wage rate, equipment has a rental, ownership, or operating cost, and materials have a price per quantity. The quantity of each resource used, multiplied by its respective price gives the value of the resource used in the production process. When all resource values are computed and summed, the result is the total value of resources used in providing services.

Single-Factor vs. Multi-Factor Productivity

A single resource or factor is frequently used to measure productivity or changes in productivity (such as labor). The use of single factor indicators such as employee-hours may obscure important technological features of the production or service process. For example, capital investments in equipment and technology could substitute for labor and improve overall productivity measurements although the physical productivity of labor has not changed. Thus, multiple-factor resources are desirable in productivity analysis. However, in practice, employee-hours is often used in a single-factor index.

Criteria for Selecting Resources

For obvious reasons, cost is one of the most important considerations of performance monitoring. Many resources may be required to develop and implement an effective performance-based system, and changing priorities may even render some performance-based systems counterproductive. Costs can be minimized by using existing data as much as possible, collecting random samples rather than the whole population being examined, and utilizing existing personnel to collect and analyze data on program quality and results. Regardless, the benefits of implementing performance monitoring must be balanced with the costs associated with implementing the program.

The U.S. Department of Labor suggests five criteria for selecting input measures for performance or productivity analysis:

1) **Resources should match outputs**. Calculation of productivity requires that the resources applied match the measured organizational output. For organizations with multiple outputs, like most government units, this will require careful identification of resources used to produce the outputs.

2) **Resources should be measurable**. Absolute numbers are required.

3) **Resource data should be accurate and comparable**. Much of the labor data collected on state and local government operations is inaccurate and inconsistent from period to period. Comparability is more important than absolute accuracy. Data checks and analysis must be part of the construction of any index.

4) **Resources calculations should use existing data**. New data collection procedures will likely be time consuming and costly to develop and maintain, and burdensome for those providing the data.

5) **Resources should be easily understood**. General acceptance, support, and use of an index are more likely if the construction is straightforward and easily understood. This is one reason that labor indexes are widely used.

Measuring Output

One of the most difficult tasks in performance evaluation is the identification and measurement of outputs. Measuring outputs in a manufacturing enterprise where a production run results in a single identifiable product is a straightforward process. However, government programs rarely produce a single output. Additionally, public sector output is typically a service as opposed to a product or commodity. In these cases, the importance of formulating several output measures, or a composite measure, increases.

Quality of Service Adjustments

As mentioned under the benchmark section, comparing output measures or productivity indexes over time can be very misleading if there are major changes in the scope or quality of services. When quality of service or scope of work changes, output measures and productivity indexes must be adjusted. If time-series productivity indicators are used, then a quality of service index must also be developed and used to adjust productivity indexes (or used jointly with productivity indexes). Otherwise, a misleading picture of productivity changes may result.

The U.S. Department of Labor suggests the following approach for analyzing the impacts of quality changes on output and productivity indexes:

1) Identify service output

2) List quality considerations for the output measure

3) Assess each quality factor for its potential impact on unit labor requirements

4) Create a quality index time-series if the impact is potentially important

5) Track the quality index through time

6) Adjust the input index or link a new productivity index with the old index if the quality index changes

Criteria for Defining Outputs

There are eight criteria for defining outputs according to the U.S. Department of Labor:

1) **Outputs must reflect the final product or service of the organization**. To determine productivity, the output must be the product or service leaving the organization, not the intermediate products. Output must reflect the work rather than the results of the work.

2) **Outputs must be measurable**. Absolute (cardinal) numbers are required. Arguments that government services cannot be measured usually fail to

distinguish among the measurement of intermediate products, final outputs, and results of government service. Whether or not a service can be measured has to be considered function by function.

3) **Outputs must be repetitive**. Construction of an output index requires a repetitive or recurring set of services or products. The level and quality of service can change, since they can be adjusted, but the basic service must be repetitive.

4) **Output data must be accurate and comparable**. Much output data currently collected, especially at the national level, is incomplete, inaccurate, and inconsistent from period to period. Construction of a viable output index requires accurate comparable data. Comparability is more important than absolute accuracy in preparing a time-series.

5) **Output calculations should use existing data and data collection procedures**. Two issues are involved here – whether the records exist in state and local government, and whether a procedure currently exists to collect national data. In either case, existing data and collection procedures should be used whenever possible, as new procedures will likely be costly and time consuming.

6) **Outputs should be easily understood**. An index that is simple and easily understood is most likely to be accepted, supported, and used. Esoteric indicators and complex quality adjustments should be avoided.

7) **Outputs should be physical measures**. The lack of a market price for most government services precludes the use of a deflation procedure when physical quantity data are difficult or impossible to obtain. Even for services that have a market price, such as government enterprises, physical output measures are preferable because prices are often subsidized and set by administrative decree.

8) **Output units should reflect the labor units spend in their production**. Since unit labor weights are used in constructing individual service indexes and functional groupings, the output measure should reflect base-year unit labor requirements.

Cause and Effect Relationship Concerns

It is important to realize that performance-monitoring systems are typically not used to identify cause and effect relationships between the production process and observed results. The reason for this is the impact of outside or "external" factors. However, knowing the result of a particular program, regardless of cause, is still important. Performance monitoring is only one tool that should be used to examine a particular situation and determine what further actions are called for.

Efficiency

The following illustrates the use of input and workload measures to compute sample efficiency measures.

Work Unit	Workload	Efficiency Measures
Sweeping **Resources (Costs): Person-hours, Supplies, Gas, Equipment, Repairs**		
Tons	# Tons Collected	Cost per Ton
Miles	# Miles Swept	Cost per Mile
Areas	# Areas Cleaned	Cost per Area
Tons	# Tons per Area	Cost per Ton per Area
Maintenance **Resources (Costs): Person-hours, Parts, Supplies, etc.**		
Tune-ups	# Tune-ups	Cost per Tune-up
Changes	# Oil Changes	Cost per Oil Change
Repairs	# Repairs	Cost per Repair
Inspection	# Inspections	Cost per Inspection
MCSAP Inspection **Resources (Costs): Person-hours, Supplies, Computers**		
Vehicles	# Vehicles Inspected	Cost per Vehicle
Inspectors	# Inspections	Cost per Inspector
MCSAP Audits **Resources (Costs): Person-hours, Supplies, Gas, etc.**		
Audits	# Audits	Cost per Audit
Revisits	# Revisits	Cost per Revisit
Complaints	# Complaints	Cost per Complaint

Effectiveness

It is very important for public administrators to distinguish clearly between efficiency and effectiveness. A program can be very efficient and yet be ineffective. In essence, outputs can be produced with minimal resources, but the efforts may not be directed towards goal achievement. Although measuring effectiveness can be more difficult than measuring efficiency, the effort is usually worthwhile.

The broadest level of decision about effectiveness involves the decision whether or not to provide a particular service at all, i.e., is there a true identified need or can a service that does not seem necessary be eliminated partially or in total. This type of decision will take place at a higher level of management. With services that are being provided, a department director needs to know if they are effective, if they do provide good quality service. Meeting the established public view of what constitutes and effective level of service is important.

This issue of effectiveness and effectiveness measures can be thought of as an evaluation of the service from the consumer's perspective to some extent. The quality of service is not always easy to quantify, but by using the "consumer" perspective, certain general types of effectiveness measures can be identified.

- Percentage or volume of community use of a service
- Percentage or community reached
- Percentage of citizen satisfaction
- Response time
- Visual inspection using some type of rating system and trained observers to see that quality work is being done
- Citizen complaints

For a smaller governmental unit, the key to selecting indicators of effectiveness is the cost of data collection. Several of the types of indicators just suggested are feasible because data can be collected through regular department record keeping. For example, citizen complaints, volume of use of facilities, or percent of community reached data are easily collectible in standard message forms, schedules of use, or by simply adding one or two pieces of data to collect on existing forms.

The general objective is to use every possible method available to check on the overall quality and effectiveness of major services. If some quantifiable indicator is not possible, the alternative is frequent firsthand observations of work quality.

Appendix

A

Glossary

Activity A task performed by an organization to produce a desired output. Examples include miles driven, trucks serviced, and meters read. Sometimes described as "Workload."

Benchmark A standard by which something can be measured or judged.[5]

Consequence See "Result."

Effectiveness The degree or extent to which program goals and results are met, such as percent of population served or percent of clients successfully treated. For MCSAP this could include percent of carriers audited, percent of trucks inspected.

Efficiency The ratio of outputs to resources such as work performed per staff hour or downtime as a percent of total hours. Includes productivity, unit costs, and technical efficiency.

Expected Range The range in a normally distributed curve that is within two standard deviations on either side of the mean.

FARS Fatal Accident Reporting System. A data system conceived, designed, and developed by the National Center for Statistics and Analysis. It is a census file with data on each fatal traffic crash occurring in the United States. Contains an extensive list of variables describing the accident, but limited detail about vehicles.

Feedback Evaluation of progress in implementation (used in strategic planning)

Frequency Chart A graph that describes the distribution of data.

Function A government service such as police, fire, and education. "Function" and "Service" are used synonymously.

GES General Estimates System. A reliable national *sample* of motor vehicle crashes of all severity compiled by NHTSA. Includes an extensive list of variables describing the accident and the vehicles involved.

Goal A statement that describes what is to be accomplished by a program, service, or agency such as "insure a safe and secure environment."

Impact The long-term effect of a program on a community of its citizens. "Impact" and "Result" are used synonymously. See "Result."

Input See "Resource."

MCSAFE A recurring publication of OMC's Analysis Division. It is intended to provide OMC staff and other stakeholders in the motor carrier safety environment with descriptive statistics and analyses about traffic crashes involving commercial motor vehicles and the programs and countermeasures OMC has implemented to promote motor carrier safety.

Mean Average. Sum all measurements and divide by the number of measurements.

Outcome See "Result."

Outcome Measure The assessment of the results of a program activity compared to its intended purpose. Also referred to as "Performance Measure."

Output The result of work performed or produced by an agency. Outputs are what government produces. Examples of outputs are the numbers of individuals served, gallons of water delivered, or tons of trash collected.

Output Measure The assessment of program activities; can be quantitative or qualitative.

Performance Goal A target level of performance expressed as a tangible, measurable objective, against which actual achievement can be compared.

Performance Indicator A measure used to determine efficiency of programs in achieving their desired results.

Performance Measure See "Outcome Measure."

Performance Monitoring A form of productivity and performance measurement focusing on measuring results on a regular basis.

Problem ID A quantitative and qualitative process to determine issues of public significance.

Productivity See "Efficiency."

Productivity Index Inverse of the change in resources used per unit of output.

Program Evaluation An assessment through objective measurement and systematic analysis of the manner and extent to which the program is achieving its intended objectives.

Resource The inputs used by an agency to produce a function or service. Examples of resources are labor, facilities, equipment, and materials. Also referred to as "Input."

Result The effect of government programs or services such as improved citizen safety, increased longevity, and reduced infant mortality. For MCSAP this would include safer highways, reduced fatalities, and decreased crashes. Also referred to as "Outcome" or "Consequence."

SafetyNet A system allowing states to report truck and bus accidents meeting a common threshold to a national file, using common data elements.

Service A government function such as police, fire, or education. "Service" and "Function" are used synonymously.

Social Indicator A measure of societal well being, such as longevity or happiness. These measures are of interest because they are considerations which governments wish to promote.

Standard Deviation Square root of the variance. See "Expected Range."

Strategy Plan of action intended to accomplish a specific goal.

TIFA Trucks Involved in Fatal Accidents. A census file with data on each *fatal* accident in which a *truck* was involved. Contains an extensive list of variables with a detailed description of the trucks involved.

Variance Measures variability in data. The sum of the squared differences of the measurements from the mean, divided by the number of measurements.

Workload A measure of the amount of work performed. Usually an intermediate output, such as the number of miles driven, or number of machines serviced. See "Activity."

Disclaimer and References

Most of the material in performance measures section was obtained from a book by Harry Hatry *Practical Program Evaluation for State and Local Government Officials*. Researchers at the UGPTI also wrote some sections. The information in the performance measures section combines the two sources and paraphrases them for the MCSAP program. There is a minor amount of original material inserted to make the examples relate to the MCSAP program directly.

Also used was: *Synthesis of Transit Practice 6: The Role of Performance-Based Measures in Allocating Funding for Transit Operations*, Ronald J. Hartman, Elaine M. Kurtz, and Alan B. Winn, Transportation Research Board, 1994, Washington, D.C.

Endnotes

[1] U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Statistics Annual Report 1996*, Washington, DC, 1996.

[2] Federal Highway Administration, Office of Motor Carriers, *Motor Carrier Safety Analysis, Facts, and Evaluation*, Vol. 2, No. 2, November 1996.

[3] U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Statistics Annual Report 1996*, Washington, DC, 1996.

[4] Federal Highway Administration, Office of Motor Carriers, *Motor Carrier Safety Analysis, Facts, and Evaluation*, Vol. I, No. 1, October 1995.

[5] *The American Heritage® Dictionary of the English Language, Third Edition* copyright © 1992 by Houghton Mifflin Company. Electronic version licensed from INSO Corporation; further reproduction and distribution restricted in accordance with the Copyright Law of the United States. All rights reserved.