Measurement Tools for Assessing Motor Vehicle Division Port-of-Entry Performance

FINAL REPORT 527

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16. Abstract

The Arizona Port of Entry (POE) Program provides a valuable service to the residents of Arizona, but lacks a clear means of evaluating the efficiency and effectiveness of its enforcement program. This in turn makes it more difficult to communicate the achievements of the Port of Entry Program, and to identify potential improvements in service quality. This research addresses the development of measures of performance for evaluation of the Arizona Port of Entry Program. By developing specific measures tied to the goals and objectives of the program, Arizona POE managers will have a better set of tools for decision making, and increased accountability to Arizona taxpayers.

Measures of performance should communicate the need for improvement in an organization, but should highlight accomplishments as well. Many of the performance measures discussed in the literature emphasized quantity of a particular unit of measurement (e.g., trucks weighed), but did not relate that quantity to the operational conditions under which it was achieved. In contrast, the measures recommended in this report provide a means of relating measurements to the intended outcome of each activity. Comparing revenues to truck travel, or overweight traffic to the percentage of traffic weighed, indicates the degree to which enforcement induces compliance with state regulations. Similarly, illustrating the benefits that accrue to highway users as a result of port of entry services provides a means of evaluating the overall value of POE services.

Performance measures need to be redefined as the priorities of an organization change, and special care must be taken when comparisons are made between multiple agencies or time periods. The best assessment of the needs of the port of entry program will come from port managers, who are most familiar with the goals and operating conditions that affect the ports of entry. The measurements developed for this study were intended to provide additional tools from which port of entry performance could be managed, but the ultimate responsibility for selecting and implementing an appropriate measurement system remains with port of entry administrators.

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SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
	ILLUMINATION			
fc	foot candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
	FORCE AND PRESSURE OR STRESS			
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	Square millimeters	0.0016	square inches	in^2
m^2	Square meters	10.764	square feet	ft^2
m^2	Square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	Cubic meters	35.315	cubic feet	ft^3
m^3	Cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
	TEMPERATURE (exact)			
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
	FORCE AND PRESSURE OR STRESS			
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

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Glossary of Acronyms

ADA	Arizona Department of Agriculture
ADOT	Arizona Department of Transportation
ADVMT	Average daily vehicle miles traveled
ATR	Automated traffic recorder
CA	California
CO	Colorado
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial vehicle operator
CVS	Commercial vehicle safety
CVSA	Commercial Vehicle Safety Alliance
DOT	Department of Transportation
DPS	Department of Public Safety
ESAL	Equivalent single axle load
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FTE	Full-time-equivalent
FY	Fiscal year
GA	Georgia
GVW	Gross vehicle weight
HM	Hazardous material
HURF	Highway User Revenue Fund
ID	Idaho
IFTA	International Fuel Tax Agreement
IL	Illinois
IRP	International Registration Program
k	1,000
LTPP	Long Term Pavement Performance
MAPS	Multi-jurisdictional Automated Pre-clearance System
MCD	Motor Carrier Division
MCMIS	Motor Carrier Management Information System
MCTD	Motor Carrier Transportation Division
MD	Maryland
MDOT	Michigan Department of Transportation
MN	Minnesota
MnDOT	Minnesota Department of Transportation
MO	Missouri
MOE	Measure of Effectiveness
MS	Mississippi
MT	Montana
MVD	Motor Vehicle Division
MVES	Motor Vehicle Enforcement Services

NCHRP	National Cooperative Highway Research Program
No.	Number
NY	New York
OMC	Office of Motor Carriers
OOS	Out of service
OR	Oregon
OW	Over weight
PASS	Port-of-entry Advanced Sorting System
PITWS	Permanent Intermittent Truck Weigh Sites
POE	Port-of-entry
PrePass	Electronic credential verification vehicle clearance system
SC	South Carolina
SD	South Dakota
TWEET	Truck Weight Enforcement Effectiveness Tool
USDOT	United States Department of Transportation
VMT	Vehicle miles traveled
WA	Washington
WDT	Weight-distance tax
WI	Wisconsin
WIM	Weigh-in-motion

SUMMARY OF KEY FINDINGS

The Arizona Port of Entry (POE) Program provides a valuable service to the residents of Arizona, but lacks clear means of evaluating that service in terms of the efficiency and effectiveness with which program activities are carried out. This in turn makes it more difficult to communicate the achievements of the Program, and to identify potential improvements in service quality. This research is intended to develop measures of performance for evaluation of the Arizona Port of Entry program. By developing specific measures tied to the goals and objectives of the program, Arizona POE managers will have a better set of tools for decision making, and increased accountability to Arizona taxpayers.

The mission of the Port of Entry program is to ensure that all commercial vehicles operating on Arizona highways have proper credentials and are in safe operating condition, while providing efficient, fair, and friendly treatment to port of entry customers and residents of the state of Arizona. Measures of performance must therefore reflect a variety of program activities: enforcement of weight and safety regulations, the timely collection of revenues, and non-enforcement services such as permit issuance. For the purposes of this research, port activities were grouped in the broad categories of weight enforcement, safety inspections, and financial responsibilities. Preliminary measures of performance were then developed for each group of responsibilities. The preceding enforcement activities, as well as customer service functions, were also grouped together under "service contacts," as an overall measure of all POE activities.

Preliminary measures of performance for each group of activities were divided into two categories according to the intent of the measurement. The first category, efficiency, considered the actual performance of POE duties. Measures in this category quantified the *output* of performance activity – the functional tasks performed by the POE staff as compared with a target or baseline measure of performance. The purpose of this type of measurement is to identify practices, staffing levels, locations, or other scenarios in which the activities of the POE are performed more quickly and/or accurately or with lower costs than the target(s). Measures of program efficiency help managers make decisions about the direction of resources, the identification of more efficient practices, and the results of different approaches to the agency's objectives.

Measures of efficiency recommended for evaluating port of entry performance were intended to be simple, but reflect the broad scope of program activities. The first three measures comprised a cohesive unit from which more detailed program assessments might be made.

- Service contacts per hour of operations.
- Unit cost of service contacts.
- Percentage of vehicles waved through.
- Number of trucks processed as a ratio of truck vehicle miles traveled (VMT).

The analysis can be done in greater detail by expanding service contacts into multiple components. These could then be compared on a standardized basis for the program or for each facility in order to determine the trade-off in efficiency that occurred as different activities were emphasized. A correlation matrix of several performance measures revealed unexpected results that emphasized trends in performance identified in the broad analysis.

The second category of performance measure was concerned with the *outcome* of port activities. These measures were intended to reflect the degree to which POE operations influence driver and vehicle characteristics that are the focus of enforcement activities. In other words, how well did performance of the POE mission effect external changes among drivers and vehicles? The most meaningful goals in terms of accountability go beyond a mere summary of program activities and define the outcomes of those activities, that is, whether performance is improved. Potential measures of program performance included the following, listed in order of simplicity and breadth of coverage:

- Port of entry and Highway User Revenue Fund (HURF) motor carrier revenues per truck-mile of travel.
- Revenue collections per dollar of spending at ports of entry.
- System-wide overweight vehicle travel versus enforcement level.
- Corridor or facility-specific changes in overweight travel versus enforcement.
- Estimated pavement preservation attributable to load adjustment.
- Estimated social cost benefits attributable to safety inspections.

Many researchers prefer outcome measures because they directly relate the agency's strategic goals to the results of the activities undertaken to achieve them. But because the baseline from which effectiveness is measured (e.g., the entire population of vehicles) can not be known, the effectiveness of POE activities is much more difficult to measure. Nonetheless, several states have made efforts to estimate the effectiveness of their POE operations, shifting emphasis from simply output (e.g., "number of trucks weighed") to outcome (e.g., "reduction in overweight truck travel'').

Over time, performance measurement should result in investment decisions that bring about the outcomes desired by both customers and those charged with system operation and development.

As with any operation, there will come a point at which investment of additional funds in enforcement will yield diminishing returns. It is in the interest of taxpayers to receive the best return on investment in port of entry enforcement. This return may be measured in terms of productivity for various outputs (e.g., service contacts or vehicles weighed per dollar spent) and in terms of the effectiveness of the program in inducing safe operations and regulatory compliance.

Measures of performance should communicate the need for improvement in an organization, but should highlight accomplishments as well. Many of the performance measures discussed in the literature emphasized quantity of a particular unit of

measurement (e.g., trucks weighed), but did not relate that quantity to the operational conditions under which it was achieved. In contrast, the measures recommended here provide a means of relating measurements to the intended outcome of each operational activity. Comparing revenues to truck travel, or overweight traffic to the percentage of traffic weighed, indicates the degree to which enforcement induces compliance with state regulations. Similarly, illustrating the benefits that accrue to highway users as a result of port of entry services provides a means of evaluating the overall value of POE services.

Performance measures need to be redefined as the priorities of an organization change, and special care must be taken when comparisons are made between multiple agencies or time periods. The best assessment of the needs of the port of entry program will come from port managers, who are most familiar with the goals and operating conditions that affect the ports of entry. The measurements developed for this study were intended to provide additional tools from which port of entry performance could be managed, but the ultimate responsibility for selecting and implementing an appropriate measurement system remains with port of entry administrators.

I. INTRODUCTION

Commercial vehicle traffic on the Arizona state highway system increased from 11.4 million average daily vehicle miles of travel (ADVMT) in calendar 1998 to 12.2 million in calendar 2000. The increased number of heavy trucks traveling on state highways places an additional burden on the structural integrity of the highway system, and requires ongoing maintenance and rehabilitation of roads the trucks damage. The state has imposed a variety of weight restrictions, weight fees and road use taxes on commercial vehicles in an effort to compensate for these added costs to the highway network. However, ensuring that motor carriers comply with fees and restrictions requires ongoing enforcement activity.

In addition, the weight, operating characteristics, and often long periods of continuous travel raise concerns about the safety of commercial vehicles and their drivers. While commercial vehicles have generally been among the safest on the nation's highways, as measured by relative crash rates, the size of commercial vehicles makes it much more likely that a crash will result in serious injury, death, or property damage. Large trucks account for approximately 7% of all motor vehicle travel and only 3% of motor vehicles involved in police-reported crashes. However, accidents involving large trucks account for 12% of U.S. traffic fatalities. [State of Florida Legislature 1999] The potentially high severity (i.e., risk of injury or fatality) of crashes involving commercial vehicles, has prompted regulations covering such safety-related concerns as the length of time of continuous operation and vehicle equipment standards.

Safety regulations, as well as weight and dimension regulations, play a very important role in commercial vehicle safety in all jurisdictions. The enforcement of weights is also in itself safety enforcement because vehicles are required to operate at a certain maximum weight to achieve acceptable levels of stability and control. [Middleton and Ruback 2001] But as with taxes, some carriers have an economic incentive to operate vehicles under substandard or illegal conditions. These incentives require that state enforcement personnel be constantly vigilant for non-compliance.

The objectives of most commercial motor carrier laws and regulations are "to keep people safe from harm and to keep the damage to the roadways to a minimum." [State of Colorado 1995, 1] Impediments to the achievement of these objectives occur when significant numbers of unsafe and overweight trucks are able to operate unchallenged. Without effective enforcement, including the certainty of penalties and sanctions sufficient to deter violation, weight limit laws and safety regulations become meaningless. [Middleton and Ruback 2001] Enforcement activities have been shown to reduce the amount of overweight traffic [Kishore and Klashinsky 2004] and thus the premature failure of highways. Strong enforcement has also been shown to reduce the number of highway crashes by removing unsafe drivers and vehicles from the highways. [State of Florida Legislature 1999]

In Arizona, commercial ports of entry staffed by the Motor Vehicle Division Enforcement Services provide the front line of enforcement for commercial vehicle

regulations. Staff at Arizona Ports of Entry attempt to screen all commercial traffic entering the state of Arizona. The ports of entry check commercial vehicles for compliance with a variety of regulations: registration, motor tax, size and weight restrictions, commercial drivers license requirements, insurance requirements, and motor carrier equipment safety requirements. Port enforcement officers issue permits to motor carriers and collect the required fees, and issue citations or place vehicles and drivers out of service when regulations are violated. The mission of the Port of Entry program is to ensure that all commercial vehicles operating on Arizona highways maintain proper credentials and are in safe operating condition, while providing efficient, fair, and friendly treatment to port of entry customers and citizens of the state of Arizona.

A large volume of data is typically collected at Arizona port of entry locations. In addition to measuring the amount of traffic passing through the port, the number of vehicles weighed, the number of credentials verified and safety inspections performed, many ports also provide permit services to commercial vehicles and coordinate more specialized inspections with other agencies. These activities require the recording of additional data, such as permit type, duration, and revenues. But the mere collection of data does not necessarily provide the information needed to improve performance. What is needed is a way to interpret data to evaluate organizational goals and opportunities for development.

Performance measurement is a practice intended to provide insight into the effectiveness and efficiency of operational programs, processes, and people. To use performance measures effectively, an organization must do more than simply collect data. Effective performance-based management requires that the organization decide on what indicators it will use to measure its progress in meeting strategic goals and objectives, gather and analyze performance data, and then use these data to drive improvements in the organization and successfully translate strategy into action. [Office of the Vice President of the United States of America 1997]

The Arizona Port of Entry Program provides a valuable service to the citizens of Arizona, but lacks clear means of evaluating that service in terms of the efficiency and effectiveness with which enforcement activities are carried out. This in turn makes it more difficult to communicate the achievements of the Port of Entry Program, and to identify potential improvements in service quality. This research is intended to address the interpretation of data by developing measures of performance for evaluation of the Arizona Port of Entry program. By developing specific measures tied to the goals and objectives of the program, Arizona POE managers will have a better set of tools for decision making, and increased accountability to Arizona taxpayers.

The remainder of this section addresses the concepts, procedures, and rationale for measuring performance in general. Section II examines the methods and measures used by other states to evaluate performance of various enforcement activities at ports of entry. Measures used by individual states, as well as comprehensive measures developed for comparisons between states are discussed. Section III describes the current conditions at Arizona ports of entry, highlighting some of the operational challenges to effective

enforcement. Based on the review of state practices and Arizona conditions, Section IV presents suggested performance measures for the Arizona ports of entry.

WHY MEASURE PERFORMANCE?

State transportation agencies face a growing need to align their ongoing operations with public demands for government to become more efficient and service oriented. Funding for transportation programs has shifted from a more reliable mix of annual grants and fuel tax revenues to a more variable mix of grants and appropriated funds, user fees and debt financing. At the same time, the mission of state transportation agencies has grown to encompass not only the construction and maintenance of extensive infrastructures, but the operation and improvement of increasingly congested transportation networks. [Transportation Research Board 1997] Thus, like many other organizations, the challenge to state transportation agencies is to accomplish more with less.

In many cases, they have responded to this challenge with a performance-based approach to managing the multiple objectives and priorities inherent in a complex organization. Public focus on accountability in the public sector has heightened awareness of performance in government agencies. State transportation agencies have endeavored to become more flexible and efficient, with added emphasis on the outcomes of programs and the satisfaction of constituents and customers.

To be held accountable, an agency needs a clear understanding of its purpose and goals, as well as ways to determine how well current methods lead to achievement of these goals. [Kassoff 1999] Measuring performance provides managers with a framework with which to assess current practices within the context of past successes and failures. This emphasis on performance requires continuous monitoring of existing programs, not only to determine the operational efficiencies and deficiencies, but also to identify new possibilities for more effective delivery of services, and to evaluate the changing role of outdated procedures and functions. These insights in turn provide guidance for future strategies to improve the organization.

Osborne and Gaebler provide a succinct rationale for measuring performance in *Reinventing Government* [Osborne and Gaebler 1992]:

- If you don't measure results, you can't tell success from failure
- If you can't see success, you can't reward it
- If you can't see failure, you can't correct it

Performance measurement, in theory, should be used as a tool to identify the accomplishment of goals or lack thereof. It should tell the manager where things were done correctly and where performance is not to expected levels. [Moreno *et al.* 2000] Like any tool or instrument, performance measurement can be a powerful force in bringing about positive change. However, measurement of performance can be a complex and often controversial endeavor.

HOW IS PERFORMANCE MEASURED?

The use of performance measures for decision making is referred to as performance management. Performance-based management entails selecting the most appropriate measurements (or performance indicators) for the organization, collecting data that reflect these indicators, and then analyzing the data to identify potential improvements that can be made toward meeting organizational goals and objectives. The 1997 National Performance Review [Office of the Vice President of the United States of America 1997, 6] defines performance measurement as:

> "A process of assessing progress toward achieving predetermined goals, including information on the efficiency with which resources are transformed into goods and services (outputs), the quality of those outputs (how well they are delivered to clients and the extent to which clients are satisfied) and outcomes (the results of a program activity compared to its intended purpose), and the effectiveness of government operations in terms of their specific contributions to program objectives."

In other words, performance measurement is a process that provides organizations with insight into the effectiveness and efficiency of their operations. Performance measures are quantitative or qualitative characterizations of performance. For example, they might be indicators of work performed and/or results achieved. [Kassoff 1999] Successful performance-based management is therefore dependent on the selection of performance indicators that provide concrete representation of progress (or lack thereof) in meeting a specified target level for organizational objectives.

The performance measurement process takes place in four stages: setting of goals, development of performance measures, collection of data, and analysis and reporting of results. [Dalton *et al.* 2001] While these stages might be thought of as a start-to-finish process, each step has the potential to affect other stages both "upstream" as well as "downstream." Therefore the process should be considered one of continuous feedback and, if necessary, adjustment.

The identification of goals varies by specific situations and is constrained by the resources available to the organization. Developing performance measures and collecting data can impact an agency's goals in that these processes require suitably precise definition of the intended outcome such that attainment can be measured. Performance measures need to be redefined as the priorities of an organization change, and special care must be taken when comparisons are made between multiple agencies or time periods.

The National Performance Review [Office of the Vice President of the United States of America 1997] established a set of guiding principles for performance-based management. These include setting a narrow focus on, and specific identification of, the processes to be measured. Measurements should be chosen that directly reflect these processes, and should serve as a means of achieving agency goals, not as an end in themselves.

DECIDING WHAT TO MEASURE

Performance measures, to be communicated clearly and to be applied effectively, should be as straightforward as possible. The array of possible measurements makes it easy to fall into the trap of measuring too much. A few basic, well-aligned measures are better than a large number of complex measures. But at the same time, oversimplification of measures can lead to applying them ineffectively and counterproductively. [Kassoff 1999] A useful way to begin the process is to ask what it is the performance measure is intended to address, who is interested in the results, and how the results will be used. [Office of the Vice President of the United States of America 1997]

Before deciding on specific measures, an organization should identify and understand the processes to be measured. Each key process should be analyzed to ensure a thorough understanding of the process and that a measure central to the success of the process is chosen. Good measures [Office of the Vice President of the United States of America 1997]:

- Are accepted by and meaningful to constituents.
- Are representative of agency goals and objectives.
- Are simple, understandable, logical, and repeatable.
- Are clearly and unambiguously defined, with respect to purpose, data requirements and calculation methods.
- Allow for economical data collection.
- Are timely, sensitive, and show a trend.

Reliable data, intelligently used and presented, are essential for the successful use of the type of measures described above. [Dalton *et al.* 2001] The availability and character of such data must be considered at each stage of a measure's development and use. Relevant and useful data can be gathered if the correct measures were set up in the first place. [Office of the Vice President of the United States of America 1997] Data collection should be based on a set of agreed-upon definitions to minimize dissonance when comparisons are made. Organizations should continually assess whether their current measures are sufficient or excessive, are proving to be useful in managing the business, and are driving the organization to the right result. As the goals of the agency change, so to should the priority of various measures, with emphasis added or lessened as needed. When measures become obsolete, they should be changed or discarded.

Measuring Efficiency Versus Measuring Effectiveness

In terms of POE operations, it is useful to consider measurements that provide feedback for two basic categories: efficiency and effectiveness. These categories will be used in this study to classify potential measures of performance that might be useful to POE managers.

The first, efficiency, considers the actual performance of POE functions. These measures may be made in gross terms (e.g., the total number of vehicles weighed) or relative terms

(e.g., the percentage of vehicles weighed). In either case, what is being measured is the *output* of performance activity – the functional tasks performed by the POE staff as compared with a target or baseline measure of performance. The purpose of this type of measurement is to identify practices, staffing levels, locations, or other scenarios in which the activities of the POE are performed more quickly and/or accurately or with lower costs than the target(s). The key question being asked is: How well does the POE internally perform its mission?

Most states collect data related to the efficiency (outputs) of port enforcement activity. The Federal Highway Administration (FHWA) requires that states submit data related to weight enforcement as part of the annual certification of enforcement. [Church and Mergel 2000] However, it has been recognized that the data submitted to the FHWA comprise direct measures of enforcement activity, and do not reflect the effectiveness of those activities with respect to outcome. However, measures of program efficiency help managers make decisions about the direction of resources, the identification of more useful or cost-effective practices, [Pickrell and Neumann 2001] and the results of different approaches to the agency's objectives.

The second measure of performance is concerned with the *outcome* of port activities. These measures are intended to reflect the degree to which POE operations have an influence on driver and vehicle characteristics that are the focus of enforcement activities. In other words, how well does performance of the POE mission effect external changes among drivers and vehicles? For example, whereas measures of POE efficiency might consider the percentage of commercial traffic weighed, the second type of measurement would consider how effective weight enforcement operations were in deterring overweight vehicle travel. Similarly, the effectiveness of POE safety inspections might be measured in terms of reduction in the unsafe vehicle population (e.g., out-of-service violations) or reductions in associated variables (e.g., rate of truck crashes with recorded safety violations).

The most meaningful measures go beyond a mere summary of program activities and define the outcomes of those activities, that is, whether performance is improved. Outcome measures are preferred by many researchers because they directly relate the agency's strategic goals to the results of the activities undertaken to achieve them. But although outcome measures are generally superior, transportation agencies need to consider data availability, cost, and validity when developing their system measures. [Dalton *et al.* 2001] Because the entire population of vehicles can not be known, the effectiveness of POE activities is a much more difficult measurement to make. Nonetheless, several states have made efforts to estimate the effectiveness of their POE operations, shifting emphasis from simply output (e.g., "number of trucks weighed") to outcome (e.g., "reduction in overweight truck travel''). Over time, performance measurement should result in investment decisions that bring about the outcomes desired by both customers and those charged with system operation and development. [Pickrell and Neumann 2001]

For all performance measurement activities, the "garbage in, garbage out" concept applies to the data used. Highly uncertain data will lead to the drawing of uncertain conclusions and will have reduced value for managing the agency. For this reason, great care needs to be taken in data collection. In reality, however, some important things either cannot be measured accurately or cannot be measured accurately at an acceptable cost. [Dalton *et al.* 2001] Transportation agencies need to consider the uncertainty introduced by inaccurate or incongruous data when taking action based on their system of performance measures.

ESTABLISHING BENCHMARKS AND PERFORMANCE TARGETS

Once an organization has decided on its performance measures, the next step in the process is to determine a baseline for each of the measures selected. In its simplest form, a baseline can be conceived of as the first data collected on a particular measurement. [Office of the Vice President of the United States of America 1997] However, virtually all measures will exhibit some variance between time periods. It is more useful to develop a performance measurement tool that measures performance changes across time. [Moreno *et al.* 2000]

Determining appropriate targets for each measure after these baseline data are collected can be accomplished in several ways. A common practice is to set goals that will force the organization to try to exceed its past performance. In some cases, targets, minimums, or maximums are defined for each measure. In others, a range of upper and lower statistical limits are built around a performance target. [Office of the Vice President of the United States of America 1997] It should be recognized that variation occurs in most measures, and that there are both normal and special causes for such variations. Significant changes in performance should be analyzed prior to making any changes.

Defining an acceptable or desirable level of performance can be tricky. Performance targets (sometimes called "objectives" or "standards") must reflect an agency's priorities, goals, and resources. It is best to begin with a cycle of objective measurement to define the agency's current position and to conduct sufficient analysis to determine how much improvement might reasonably be expected given current or likely resource availability before setting numerical targets or objectives. [Pickrell and Neumann 2001]

Perhaps the most important task is to establish benchmarks against which performance can be measured. [Transportation Research Board 1997] These benchmarks must be realistic, that is, achievable, and they must be meaningful, that is, related to decision points. In some cases, benchmarking to the performance level of a group of peer agencies may help an agency to initially define a reasonable or desirable level of performance. But it is not useful to compare an agency with a group of agencies that are not necessarily peers or if the reasons for the differences in peer scores are reported but not well understood or explained. [Pickrell and Neumann 2001]

By benchmarking measures, an organization can validate the fact that the goals are still attainable. For example, if peer standards have been at 80 percent customer satisfaction, a

goal of 100 percent may not be realistically attainable. Setting a 100 percent goal anyway can reduce employee morale by giving them an essentially impossible target. [Office of the Vice President of the United States of America 1997] However, this need not imply that targets can't be increased. If some incremental level of improvement is not possible, the performance measure itself will likely need to be reevaluated. It may be that the time required for effects to occur limit the agency's ability to measure performance, and a change in units of measurement (e.g., short-term outputs and long-term outcomes) are required. [Pickrell and Neumann 2001] Given the need for continuing reassessment and revision as experience is gained, the task of establishing benchmarks and performance targets will be an ongoing process.

II. PORT OF ENTRY PERFORMANCE: STATE FINDINGS

This section of the report is subdivided according to the means of assessment used to evaluate ports of entry. A variety of research literature is summarized in the first two parts of this section. The first part reviews published performance measures and state performance audits of specific port functions. These reviews are used to determine whether some overlap exists both in the evaluation of ports by different states, and in analyses using different goals or methods. Researchers have attempted to address port of entry performance in a number of ways. In some states, organizational goals related to POE performance have been specifically quantified by some of the agencies responsible for port enforcement, while in others performance has been evaluated via audits conducted by other branches of government. In the latter case, the performance of only one POE function, (e.g., weight enforcement), has usually been evaluated.

The second part examines research efforts to synthesize POE measurements across multiple states in order to make comparative measurements of uniform goals with respect to efficiency and/or effectiveness. A significant part of the difficulty with measuring performance in multifaceted operations is that the diversion of resources from one function to another may also impact tertiary functions. The measurement of performance at state ports of entry is complicated by the diverse enforcement functions performed at POEs. The evaluation of one aspect of POE performance may present an incomplete or distorted picture of the total operation. For example, many audits of weight enforcement activities have suggested that efforts at ports of entry be shifted to mobile enforcement crews to better capture the overweight truck population. However, these recommendations have largely ignored the other components of POE missions, such as safety and commodity inspections, credential verification, and the collection of taxes and fees. Several POE administrators have raised this objection in responses to a number of state audits of specific enforcement functions that did not consider the full range of POE activities when recommending courses of action.

The final part documents the results of a survey of state agencies made during the course of this research to determine what measurements were being taken at the operational level to evaluate ports of entry. When applicable, the survey results are compared to external measures and goals from various states identified in the preceding literature reviews to determine whether POE managers are making similar measurements as external studies. The survey instrument distributed to state agencies is included in Appendix C of this report.

STATE-SPECIFIC PERFORMANCE EVALUATIONS

A number of performance evaluations of motor carrier enforcement functions have been published by different states. These range among internal reviews developed by the agency, performance audits by government auditors, and operational evaluations made by external consultants. While states have made a variety of findings and recommendations, most studies have been limited to a subcategory of enforcement activity such as weight enforcement. Few studies address the multiple responsibilities of port of entry operations. Nonetheless, these provide relevant background material for the evaluation of the different components of POE operations. This section examines several studies, organized by state.

Arizona

A 1986 performance audit of the Arizona Weight Enforcement program found that ports of entry were insufficient for deterring overweight vehicles from traveling on Arizona highways. Citing several studies, the auditors claimed that between 10 percent and 33 percent of trucks on Arizona highways were exceeding weight limits. [State of Arizona Auditor General 1986] Furthermore, it was stated that the Motor Vehicle Division did not place a high priority on intrastate weight enforcement activities. [State of Arizona Auditor General 1986]

Port operations were found to be lacking in coverage, with a presence on only 13 of the 33 paved roads leading into Arizona from surrounding states and Mexico.[1] Weight enforcement was further weakened because port scales were frequently inoperative. Thirteen percent of trucks passing through ports in fiscal 1984-85 were not weighed due to inoperative scales, which were attributed to high port traffic volumes that exceeded the capacity of the scales. Finally, several bypass routes were identified for different ports of entry, with between 6 percent and 12 percent of vehicles avoiding the ports via these alternate routes.

Although these deficiencies might have been offset by adequate mobile enforcement, the auditors found that officers assigned to interior mobile crews spent less than 50 percent of their time on weight enforcement. The auditors also noted regulations that required officers to allow shifting of a load when a vehicle is only over axle weight, not over gross limits. If the load is shifted to be within legal axle load limits, the driver can not be cited. As a result, more than 90 percent of Arizona's weight enforcement violations between fiscal years 1982 and 1984 could not be cited.

While the Arizona performance audit focused exclusively on weight enforcement, this is a significant function of ports of entry. The auditors raised important possibilities for POE performance measurement, including the percentage of traffic that was not weighed (output), the proportion of the total vehicle population exceeding weight limits (outcome), and the amount of time spent on enforcement activity (output). But in the

[1] Because the performance audit focused on weight enforcement, roads were only considered covered if the port of entry had operational scales.

latter case, the amount of time spent performing other functions was not specifically accounted for. It is entirely plausible that other agency functions (e.g., credential verifications, safety inspections) required the time not devoted to weight enforcement. This drawback will also be observed in many of the following studies; that is, sufficient data are often not available or not considered for resource allocation among multiple functions.

Arizona Border Region

An analysis of international ports of entry on the Arizona-Mexico border [Transcore 1997] was performed by Transcore in 1997. The study focused on operations at the commercial and passenger ports in Nogales. Interestingly, the performance analysis was limited to the time spent in processing by commercial and passenger vehicles. No attempt was made to measure port performance in terms of the mandated responsibilities of port personnel or the outcome of port enforcement activities. Based only on processing times, the Nogales port was deemed to operate at a relatively high level of efficiency given prevailing staff resources, infrastructure capacity, and arrival patterns.

The sole recommendation made for improving operations was to increase port capacity. For these reasons, the results of the Nogales efficiency study were interpreted as inadequate for the goals of this research. However, it is acknowledged that the amount of time spent carrying out mandated functions is an acceptable measure of efficiency. Indeed, one of the principle shortcomings identified at fixed ports of entry has been the tendency of port traffic to back up as vehicles enter the screening area more quickly than port officers can clear them. Although some time-based measures are more readily calculated (e.g., number of vehicles processed per hour), the number of vehicles "waved through" (i.e., allowed to pass without screening) due to insufficient capacity will also be a function of immediate traffic volume. A potential measure of efficiency considered for this research is the percentage of vehicles processed per hour, which incorporates both processing time and traffic flow.

Georgia

The overall purpose of the Georgia audit was to identify opportunities for improvement in the Georgia Department of Transportation's Permits and Enforcement Program [Hinton 2000]. The Permits and Enforcement Program is responsible for enforcing state and federal laws governing the weight and dimension of motor vehicles using Georgia's roads and highways. The purpose of the Program is to protect the public from vehicles whose weight or size exceeds safe operating limits and to protect the state's roads and bridges from premature deterioration and damage caused by overweight/oversize vehicles. Due to their size and carrying capacity, multiple-axle trucks are the primary focus of the Program's regulatory activities.

Citing the number of enforcement crews (43) patrolling the 98,276 miles of non-interstate highways in Georgia, the auditors concluded that as it currently functions, the Program provides only limited assurance that the public and the state's roads and bridges are being

adequately protected from damage caused by overweight and oversize vehicles. The low probability of being caught by weight enforcement officers, as well as the small dollar amount of weight-related fines, were considered indicative of the inadequacy of the state's weight enforcement program.

Performance measures considered in the performance audit were:
1. Number and percentage of citations issued.
2. Fine and permit revenues.
3. Percentage of weighed vehicles in compliance with weight limits.
4. Number of vehicles weighed per staff hour (mobile crews).
5. Total number of vehicles weighed.

Auditors suggested improving the "overall efficiency and effectiveness of the Permits and Enforcement Program" by shifting resources from fixed scales at permanent weigh stations to mobile enforcement crews using portable scales. This recommendation was based on a number of findings with regard to the number and dollar amount of the overweight citations issued by the Program:

- Portable scales had a higher violation rate: In fiscal 1999, 1.4 percent of truck traffic was weighed on portable scales, but these vehicles received 20.5 percent of total overweight citations
- Portable scales had a higher severity rate: the average dollar amount of the citations resulting from portable and semi-portable scales was $123.50, or about three times the average dollar amount of the citations generated by the fixed weigh stations ($44.90)
- Fixed weigh stations were more susceptible to shift-related inefficiencies: the number of citations written at the weigh stations decreases substantially on Friday nights and weekends (as well as at shift change).

For fiscal year 2000, the Georgia Program's weight enforcement goal was to have 99.6 percent of trucks in compliance with the state's weight limits. While this was a reasonable measure of program effectiveness, the state auditors found that the method used to compute this percentage overstated effectiveness and did not provide an accurate measure of compliance. Compliance was estimated using the number of overweight trucks cited by permanent, semi-portable and portable scales. However, statistical data were not adjusted to account for the relatively small percentage of the truck population on secondary roads weighed on portable scales. Revised estimates prepared by the auditors suggested that compliance was reduced from 99.3 percent to 97.2 percent after adjusting for the low capture rate.

In recommending more careful monitoring of the use of portable scales, the Georgia auditors cited variance in efficiency and effectiveness of mobile weight enforcement. For the purposes of the audit, efficiency was measured as the "number of trucks weighed per man-day" and ranged from 5.3 to 31.1 among districts. The effectiveness of enforcement activity was measured as the percentage of trucks issued citations, and ranged from 6.3

percent to 50.2 percent. Both measures were considered jointly in identifying high-performing districts (i.e., districts with above average rates of weighing and citation).

It should be noted that the Georgia audit found an inverse relationship between measures of efficiency and effectiveness: "…the data indicate that the number of trucks weighed tends to decrease with an increase in the number of citations issued, [although] this relationship is not found in every district." [Hinton 2000, 22] Oddly, this observation was sidestepped when making the case for shift-related inefficiencies. The lack of citations issued on weekends and close to shift changes may have been the result of ineffectiveness (per the audit definition), or simply a change in the traffic stream, but not poor "efficiency" as measured in the audit.

The Georgia auditors also found that the citations for exceeding statutory weight limits were ineffective in discouraging overweight vehicle traffic and routinely went unpaid by many carriers with little or no consequence. Furthermore, the cost to issue and process citations was found, in many cases, to exceed the amount of the citation. Motor carrier program personnel estimated that the cost to issue and process overweight citations was approximately $21 per citation. In fiscal year 1999, a total of 1,519 citations were issued for $8 fines, or about $13 less than the cost of issuing the citation. This represented an aggregate loss to the Georgia DOT of approximately $19,747. Similarly, Georgia Motor Carrier Program staff estimated that current permit fees only approximate the cost of issuing the permits. The fees did not generate any additional revenue to cover the cost of the damage caused by overweight vehicles operating with the permits.

The Georgia Permits and Enforcement Program audit methodology was comprehensive in terms of measures selected, and provides means of adjusting results for changing traffic flows and staffing levels. However, the focus on citations issued as a measure of effectiveness is unreliable: the stated purpose of the program is to protect the state's roads and bridges from premature deterioration and damage caused by overweight/oversize vehicles. Because citations can only be issued when a vehicle is operating illegally, it can be assumed that the program has not deterred cited vehicles from traveling illegally. In other words, all other things being equal, citations should *decrease* if the program is more effective.

Nonetheless, while the number of citations issued is an inadequate measure of effectiveness in terms of program goals (reducing the number of overweight vehicles overall), it does provide a basis for comparison of different types of enforcement (e.g., mobile versus fixed scales). If the vehicle population has a given percentage of weight violators, then the percentage captured (i.e., cited) relative to the percentage screened represents a good means of identifying the most effective enforcement procedures. The difficulty is that this presumes a different goal, the capture of the greatest proportion of violators, as distinct from the reduction in illegal travel. Furthermore, it is possible that the means used to capture the largest *proportion* of illegal vehicles might not capture the largest *number* of illegal vehicles. In sum, the Georgia audit suffered from a lack of clarity in establishing the goals of the audit versus the goals of the program, and mixed measures that may have been appropriate to one at the expense of the other.

Minnesota

An audit of the Minnesota Department of Transportation Truck Safety Inspection Program [State of Minnesota 2004] compared program performance to the enforcement activities of the Minnesota State Patrol. Both agencies met their 1991 roadside inspection and safety review commitments made by the enforcement program, qualifying Minnesota for maximum federal financing. While Minnesota's rate of detecting violations was found to be slightly below the national average, the auditors noted that federal officials were "pleased with the way both agencies carry out Minnesota's truck safety program."

The auditors suggested that the data support a conclusion that the Patrol is more effective than Minnesota Department of Transportation (MnDOT) in detecting safety violations. In a concurrent review of the cost of conducting roadside inspections, it appeared that the Patrol achieved certain efficiencies relative to MnDOT owing to the more extensive statewide deployment of commercial vehicle inspectors engaged in weigh scale operations. While this finding indicated that a reduction in travel and lodging costs would be achieved by shifting enforcement activity from MnDOT to Patrol, the data were considered inconclusive, and no recommendation was made.

Much of the Minnesota comparison was based on Out of Service (OOS) levels for commercial vehicles and drivers as a result of enforcement activity. According to the program audit, the OOS rate "reflects the skill and thoroughness with which the inspections are conducted, as well as other factors, such as the part of the state where the inspection occurs and the types of trucks inspected." [State of Minnesota 2004, 3] Auditors noted that the Patrol and MnDOT chose locations and screening procedures that enhanced the probability of detecting serious safety violations, and concluded that the out-of-service rate was viable as a general measure of effectiveness.

The national OOS rates were used as a baseline for Minnesota agency performance. Nationally, between 1984 and 1990, about 36 percent of vehicles and seven percent of drivers inspected were taken out of service. In the early years of the program, both the Patrol and MnDOT had vehicle out-of-service rates significantly below the national average but this gap was considerably reduced by 1989. The Patrol was found to have a higher vehicle OOS rate than MnDOT between 1984 and 1990. But agency performance converged in 1991, with MnDOT achieving a vehicle OOS rate of 27 percent compared to 27.7 percent for the Patrol. Both agencies, however, lagged behind the national average of 33 percent.

Both agencies reported driver OOS rates (the number of drivers placed out of service per inspection) below the national norm until 1990, when the Patrol exceeded the national rate, 8.3 percent to 7.0 percent. In 1991, the Patrol's driver OOS rate more than doubled, to 18.9 percent. MnDOT's rate improved from 3 percent in 1990 to 3.6 percent in 1991, still below the national average of 7.0 percent and well below the Patrol's rate.

Table 1: Minnesota Out-of-Service Rates by Enforcement Type

Measurement	1990	1991	Change
Driver OOS (%)			
MnDOT	3.0	3.6	20.0%
Mn State Patrol	8.3	18.9	227.7%
National	7.0	7.0	0.0%
Vehicle OOS (%)			
MnDOT	NR	27.0	N/A
Mn State Patrol	NR	27.7	N/A
National	NR	33.0	N/A

Source: Minnesota Office of the Legislative Auditor, 1992. [State of Minnesota 2004]

The drawbacks to emphasizing one set of performance measures were illustrated in the agency responses to the Minnesota audit. The State Patrol attributed its improved performance to increased emphasis on driver-only inspections, and emphasis on intercepting interstate trucking on interstate highways. MnDOT pointed out that many of its inspections were done "in the interior of the state where a greater share of the traffic was local and thus either exempt from rules on how long a driver was allowed to drive without resting or less likely to be in violation of them than interstate traffic." [State of Minnesota 2004, 3] In the first case, the limited performance measures may not have captured the breadth of agency responsibilities, and in the second, the measurement may not have been appropriate for the type of enforcement being done. In other words, the Patrol emphasized activity that increased performance based on this set of measurements, but it was not clear whether performance of other duties changed as a result. The MnDOT response illustrated the difficulty of achieving a target when the measurement was not aligned with the program's emphasis.

Montana

The Montana Motor Carrier Services Program publishes performance measures related to the Program's goals and objectives for each fiscal year. [Montana Department of Transportation 2004] The stated goal of the program is to protect state and federal investment in Montana's highway system and assure the safety of the traveling public. This goal is to be accomplished through "customer service oriented regulation of the commercial motor carrier industry and enforcement of state and federal commercial motor carrier laws and regulations." [Montana Department of Transportation 2004, 1]

Program indicators for the 2002 fiscal year are shown in Table 2 below. The Montana program uses a gross measure of (1) service and enforcement contacts (i.e., aggregate of all enforcement-related transactions between officers and drivers), and (2) the number of trucks weighed. Program goals for fiscal 2003 include improvement of size and weight compliance and reduction in the number of Montana-based commercial vehicles that have not received an annual Level 1 safety inspection (see Appendix B for definitions). However, no specific measures were identified for these goals.

Table 2: Montana Motor Carrier Services Program Indicators

Fiscal Year	Number of Service and Enforcement Contacts[1.]	Number of Trucks Weighed
1996	60,601	710,299
1997	54,658	657,867
1998	69,424	661,071
1999	70,500	665,000
2000	126,557	599,697
2001	72,500	719,197

Notes: 1) A contact includes issuing oversize/overweight permits, performing commercial vehicle and driver safety inspections, issuing citations, taking commercial vehicle fuel samples.

Source: Montana Motor Carrier Services, 2002. [Montana Department of Transportation 2004]

While the number of trucks weighed is a fairly typical measure of program outputs among states, the "Service and Enforcement Contacts" measure is an interesting method of accounting for the wider variety of program responsibilities. This measurement recognizes that a finite quantity of activity can be accomplished with a given set of resources, and that time will necessarily be spent fulfilling these duties. But functions are not prioritized, ostensibly due to the mandate of the agency. In other words, it makes little sense to focus on a single type of contact if staff are required to conduct a variety of different contacts as needed.

The Montana measures have several shortcomings. First, the published results only measure program outputs. Second, these outputs are not defined in relation to the volume of traffic. For example, the program showed a 1.5 percent increase in contacts and a 0.5 percent increase in number of vehicles weighed from fiscal year 1998 to fiscal year 1999. However, this would not necessarily be considered an improvement in output if traffic increased by three percent over the same period. Finally, the rationale for setting performance targets is not spelled out. No mention is made of target levels of achievement for the two measures, nor of the expected effect of an increase in one measure on the other. Was year 2000 a trade-off of fewer trucks weighed for more service and enforcement contacts? If so, why the drop in both for 1997? Although changes in traffic, staffing levels, capital spending or enforcement priorities might explain year-to-year differences, the use of gross measures precludes any firm conclusion about program efficiency.

Colorado

The Colorado Department of Revenue completed an audit of the Colorado Port of Entry Division in 1995 [State of Colorado 1995]. At the time of the audit, the POE Division had operated the same 11 fixed ports since 1980 and had not conducted a comprehensive study of its fixed port operations, locations, and traffic volume for a number of years.

The 1995 audit identified several areas in which port of entry performance could be improved, and suggested that all ports be evaluated for closure based on productivity. In this sense, the measures used by Colorado auditors were more focused on the cost of port operations, the revenues generated (or lost) due to enforcement procedures, and the cost of enforcement to the trucking industry. The Division has a statutory responsibility to enforce all laws concerning commercial motor carriers and the owners and operators of motor vehicles. Lax enforcement of certain regulations was determined to be a significant impediment to the efficiency and effectiveness of POE operations.

The auditors recommended that the POE Division lower the costs of fixed port operations and ensure compliance with statutes by reducing the number of fixed ports to the smallest number needed to fulfill its regulatory activities. They also said the Division should evaluate the productivity, traffic patterns, and enforcement activities of each and recommend any statute change needed to allow fewer full-time fixed ports. Auditors suggested that the POE Division might be operating some fixed ports that are no longer productive or needed. If some of these ports were eliminated, workload could be absorbed by existing fixed and mobile operations at lower cost. As an example, auditors estimated that elimination of two fixed ports (Fort Garland and Platteville) could result in cost savings of $328,000 the first year and total one-time and recurring savings of about $1 million over five years.

According to auditors, a significant procedural shortcoming of the Colorado POE operations was the lack of enforcement of a statutory requirement that mandates a unique identification number on the side of each commercial motor vehicle over 16,000 pounds. The lack of enforcement was considered costly both to the state and the trucking industry, as trucks processed through ports despite lack of proper identification took about five times longer to clear. Using a fiscal year 1994 estimate of 261,000 incidents when trucks did not have the required identification, representing 15,812 unmarked individual trucks clearing ports on an average of 16.5 times annually, the auditors calculated the time cost to the industry as $392,000 and a loss to the state of at least $790,600 in statutory fines that went uncollected. Further, it was estimated that about 10,900 hours, or $209,300, of port officer time were needed to clear vehicles without proper identifications. This time, which is equivalent to about 5.25 full-time-equivalent (FTE) employees, could have been better spent on other activities, such as safety inspections or mobile port operations.

Another shortcoming was identified as the inadequate enforcement of sanctions against all trucks that illegally avoided a fixed port (i.e., “port runners”). According to its reports, the POE Division cited 55 percent of the trucks that were caught trying to illegally bypass a fixed port in fiscal year (FY) 1994. The Division could not explain why it issued citations to only a little more than half the port runners who were caught. However, a port runner violation, like the unique identification citation, requires a costly court appearance by the port officer and the driver. According to management, some of the port officers use an inappropriate statute that does not require a court appearance to cite port runners.

Finally, the predictability of enforcement activity was identified as an impediment to effective enforcement. Fixed ports of entry were not operated 24 hours a day in both directions, and generally followed the same operating schedule even during off-peak enforcement. The mobile scale teams and safety inspectors did not change locations or operate during higher-risk, off-peak hours with the frequency required by the POE Division's regulations and policies. Citing FHWA, Colorado and Virginia researchers, the audit found that predictable enforcement methods were inadequate for deterrence of illegal behavior by truck operators.

The Colorado approach illustrates a useful means of evaluating agency operations in terms of costs and revenue generation. Although specific measurements were not specified, the audit implied use of operating costs as a means of normalizing comparisons among ports of entry. Such a measure could be combined with gross measures of service contacts, weighings or traffic processed to identify the most efficient port operations. Furthermore, the Colorado audit also suggests that the outcome of particular activities might be best evaluated in terms of savings to the state or the trucking industry.

Ohio

On a smaller scale, the Truck Weight Limit Enforcement Program of Butler County, Ohio, has published measures of performance from 1991 to 1998 [Butler County, Ohio 2004]. The county program consists of two full-time deputies who patrol the county and check suspect vehicles for load limit violations by utilizing portable truck scales. Vehicles are screened for enforcement action based on visual criteria such as visible type of load, material being dropped on the roadway, tires deformed by axle weight, and handling characteristics of suspect vehicles.

As in the case of Montana, the Butler County program relies on just two measures. Like the Georgia program, the measures focus on the frequency of weight citations and the severity of the violation. In this case, severity is measured in pounds overweight rather than the amount of the citation. Butler County program measures are shown in Table 3.

During 1991, the truck enforcement program's first year, 487 overweight vehicles were cited for an average overweight of 12,800 pounds. Seventy eight of the citations (16 percent) were for more than 10 tons overweight. Overweight citations for January 1, 1998 through June 2, 1998 totaled 176 for an average of 10,434 pounds per truck.

Table 3: Butler County Truck Weight Enforcement Measures

Measurement	1991	1998[a.]	1991 – 1998
Overweight citations (number)	487	422	4,440
Average overweight (pounds)	12,800	10,434	9,972

Notes: a.) Annualized basis from January 1 to June 2, 1998.

Source: Butler County Truck Weight Limit Enforcement Program, Ohio

An assessment of efficiency can not be made due to the lack of measures of traffic, cost or time spent on enforcement. However, the Butler County results present a mixed

picture of program effectiveness. Assuming a constant level of traffic and time spent on enforcement, the number of violations appears to have increased. However, the average severity of each violation appears to have decreased. The net effect of these changes might be estimated by comparing the total overweight load in pounds for each year. For 1991, 487 citations at 12,800 pounds on average represented a total illegal weight of 6.2 million pounds. In 1998, after adjusting for only 5 months of data, the total illegal weight was 10.6 million pounds. But while it appears that the program has not reduced the number of overloaded trucks, or the total amount of weight, it is important to remember that (1) changes in traffic volume could offset the increase on a per vehicle basis, and (2) the nonlinear impact of vehicle weight on pavement may result in less pavement damage in 1998 due to the reduced load per vehicle. Thus, without a clear statement of program goals, it is difficult to draw any conclusions from the Butler County measures.

Florida

From 1999 to 2001, the State of Florida published two performance audits and a set of operating standards for the Florida Motor Carrier Compliance Program [State of Florida 2001; State of Florida Legislature 2001; State of Florida Legislature 1999]. The primary purposes of the program are to protect highway system pavement and structures from excessive damage due to overweight and oversize vehicles and to reduce the number and severity of crashes involving commercial vehicles. Specified Motor Carrier Compliance Program objectives are to reduce occurrences of overweight commercial motor vehicles and eliminate hazards caused by defective or unsafe commercial motor vehicles.

Inspectors weigh trucks and check registration and fuel tax compliance at fixed scale locations along major highways. The program's law enforcement officers patrol the state's highways and use portable scales to weigh trucks that do not pass through fixed scale stations. Officers also enforce commercial motor vehicle safety regulations by performing safety inspections and enforcing traffic laws. Commercial vehicle safety inspections include examination of vehicle parts such as brakes, lights, and safety equipment and, if carried onboard, the packaging and labeling of hazardous materials. Officers also determine whether commercial drivers are appropriately licensed, have maintained required logbooks of their hours of service, and are operating their vehicles in a safe manner (e.g., not speeding or operating under the influence of drugs or alcohol). Citing driver fatigue as one of the top commercial motor vehicle safety concerns, with commercial vehicle crashes more likely to be caused by driver error than by mechanical failure [State of Florida Legislature 2001], the Florida audits placed a relatively high importance on the safety-related enforcement procedures.

Agency performance in Florida is measured in terms of both program outputs and program outcomes. For 1999, measures of output were defined as the number of vehicles weighed (fixed and mobile scales) and number of safety inspections performed. Outcome measures were defined as the percentages of trucks that were found overweight on fixed scales and on mobile scales. Program staff did not report outcome measures for safety enforcement, due to problems of definition [State of Florida Legislature 1999].

Performance measures for the Florida Highway Operations and Motor Carrier Compliance programs are shown in Table 4.

Table 4: Selected Performance Measures, Florida Department of Transportation

Jurisdiction and Performance Measure	Type of Measure	FY 2001-2002 Standard
FDOT Highway Operations Program		
Maintenance condition[3] of state highways	Outcome	80
Percent of fixed scale weighings overweight	Outcome	0.3%
Percent of portable scale weighings overweight	Outcome	44%
Number of commercial vehicles weighed	Output	11,000,000
Number of CVS inspections performed	Output	50,000
Number of portable scale weighings performed	Output	35,000
Highway Safety and Motor Vehicles: Motor Carrier Compliance		
Ratio of IRP[1.] and IFTA[2.] taxes collected to cost of collection	Outcome	1.75 : 1
Number of IFTA Use Tax and IRP Plans audited	Output	309
Number of Motor Carriers audited per auditor[4.]	Output	22 : 14

Notes: 1) International Registration Program. 2) International Fuel Tax Agreement. 3) Measurement based on internal standard of condition. 4) Second number represents the total number of auditors.

Source: State of Florida. Department of Transportation and Department of Highway Safety and Motor Vehicles (2001). *Approved Agency Performance Measures and Standards for Fiscal Year 2001-2002*.

In the 1999 review, auditors highlighted several deficiencies in the state's performance measures for motor carrier enforcement. Differences between mobile and fixed scale (i.e., port of entry) outcomes were considered ambiguous, not clearly reflecting the level of overweight traffic on state highways. Auditors recommended using weigh-in-motion (WIM) station measurements to evaluate the outcome of weight enforcement, and suggested several measures related to safety. These were the number of safety inspections performed (output), the percentage of safety inspections resulting in driver and/or vehicle being placed out-of-service (outcome), and the number of crashes caused by commercial vehicles (outcome).

However, this last measure was questioned by the Motor Carrier Compliance Office. In a rebuttal, management stated that, since the program has "limited resources and a limited enforcement role," it would be misleading to establish a measure of the number of crashes caused by commercial motor vehicles or drivers. They noted that many things outside the control of the program influence the number of crashes.

The Florida measures provide a balance between gross and proportional measures of performance, with the former generally representative of operational efficiency, and the latter targeting the outcome of enforcement. However, as with various other states, measures of output are not controlled for staffing levels or port traffic. Therefore, any

increases in output are interpreted as improvement, despite the possibility that a smaller percentage of vehicles were screened or the results were achieved at a greater unit cost.

As a measure of outcome, the percentage of vehicles overweight appears to be a misleading measure. If this percentage keeps increasing, it suggests that weight enforcement activities are not deterring illegal vehicles; in fact, the opposite could be said. However, it was not clear from the audit whether an increase or a decrease in this percentage was considered an improvement.

The ratio of taxes collected to the cost of collection might better describe the efficiency (i.e., output) of collection rather than its effectiveness. But as a measure of efficiency, this measure provides a useful snapshot of the return on tax enforcement. Furthermore, a similar measure might be expanded to represent a benefit-cost ratio of enforcement activity. However, this type of analysis would likely be complicated and controversial, as savings benefits to one group of constituents might be construed as costs for another group.[2]

Oregon

A January, 2002 state audit of Oregon Motor Carrier Transportation Division [Oregon Office of the Secretary of State 2002] focused on the division's weight enforcement responsibilities. The purpose of the audit was to determine if the division was deploying its resources in the most cost-effective manner to protect roads and bridges from damage by overweight trucks. Truck weight enforcement activities at 87 permanent scales, as well as several mobile enforcement units, were evaluated based on a variety of criteria. Auditors reviewed the following measures of performance:

- *Number of trucks weighed* at different locations.
- *Percentage of weighings* to total through traffic.
- *Weight violation rates* factored by the percentage of weighings and hours of operation.
- *Proportion of trucks required to off-load* as a measure of overload severity.

The auditors also undertook a comparison of inbound and outbound weight enforcement with site-specific WIM measurements to illustrate the impact of non-enforcement on loads.

The review pointed out a common problem among port of entry operations: that despite the large amounts of data collected at scale sites, the division had not developed specific

[2] For example, the Colorado audit (page 19) identified a time/ cost savings to the trucking industry of $392,000 if enforcement standards were improved. However the same procedural change was estimated to generate an additional $790,000 or more in tax revenue to the state. These state revenues would be paid by the trucking industry. Therefore, from the trucking industry perspective, the change in procedures would result in a net loss of $398,000. Making things more complicated, it could be argued that the position of the industry as a whole would be improved because the costs would be borne by illegal operators who previously enjoyed an unfair competitive advantage. This example simply illustrates the potential for problems that can arise when enforcement revenues are considered measures of performance.

goals related to those data. The auditors recommended several outcome-specific measurements for future performance evaluations: monitoring the percentage of overweight trucks on the highway (presumably using WIM, although this was not specifically mentioned), the severity of overweight violations, average axle weights, and excess axle weights. However, these procedures did not appear to be used in the current audit.

The Oregon auditors concluded that the resources devoted to POE operations could be more effectively deployed at other sites around the state. Allocation of additional staff resources was specifically recommended for mobile enforcement on secondary state highways. More variable hours at POEs were also recommended, in order to reduce the predictability of enforcement efforts. Finally, the use of technology (e.g., portable WIM) was recommended to identify secondary routes that should be targeted for increased enforcement.

While generally receptive to the recommendations, the Oregon Motor Carrier Transportation Division (MCTD) pointed out shortcomings within the audit. The most significant limitation of the audit results was the consideration of only one function for which the division was responsible. While the re-deployment of staff from fixed POE to mobile units might augment weight enforcement efforts, such a move would diminish the capacity for credential and safety inspections, as well as fee collections related to state motor carrier taxes. This is a common shortcoming among the performance audits for a number of states.

The division response also pointed out the problem inherent in using violation rates to measure performance. Whereas the auditors suggested that higher violation rates at light enforcement locations were an indication that additional resources should be deployed to these sites, the motor carrier division countered that the lower violation rates at heavy enforcement locations were a direct result (i.e., success) of the additional enforcement. This observation is in direct contrast to the measures identified by other states (e.g., Ohio, Florida), but is a valid criticism of the use of overweight ratios as a positive measure.

The auditors recommended a shift in resources from ports of entry to mobile operations based on the success of the latter in capturing overweight vehicles. However, the audit did not consider the impact of the volume of transactions as a deterrent, not only for weight enforcement, but also in terms of tax, safety, and other regulatory avoidance. In addition, the cost differential between fixed location weighings ($0.48 to $2.24 per weighing) and mobile enforcement ($22.40 per weighing) was identified by MCTD staff as a limiting factor for allocation of spending.[3]

[3] Although specific measurements were not published in the audit, a potential alternative to the cost per truck weighed might be the cost per overweight truck identified. This would isolate the relative agency cost of identifying overweight vehicles based on traffic volume (ports) versus selective enforcement (mobile). However, such a measure would still be problematic in that a higher frequency of overweights would be construed as a positive change in the overall measurement.

Michigan

A year 2000 legislative report on commercial vehicle enforcement activities of the Michigan Department of Transportation (MDOT) [State of Michigan 2000] was followed by a state audit of the Michigan State Police Motor Carrier Division [Michigan Auditor General 2001] in 2001. MDOT and State Police Motor Carrier Division (MCD) conducted a comprehensive analysis of relevant issues related to truck law enforcement to develop cost effective strategies to improve enforcement of truck size and weight laws and enhance enforcement of truck laws in general. These two reports provide a framework [State of Michigan 2000] and performance analysis [Michigan Auditor General 2001] for the development of enforcement-related goals and activities across multiple agencies.

The Weight Enforcement and Safety Inspection Implementation Plan prepared by MDOT and MCD, approved by the MDOT Highway Steering Committee in May 1992, estimated that overweight vehicles cause over $54 million worth of damage to Michigan's federal-aid highways annually. Pilot studies from 1997 to 1999, indicated that enforcement could be improved by placing greater emphasis on mobile enforcement and less emphasis on scale house enforcement at interior weigh stations. The added emphasis on road patrol was suggested to lessen the predictability of enforcement and expand enforcement coverage area, thereby improving enforcement efficiency and effectiveness.

The State Police MCD and MDOT identified six interior weigh stations to consider for conversion to road based patrol operations use only, with no traditional scale house operations. MCD began investigating methods for improving efficiency in road patrol truck weighing procedures such as carrying additional portable scales and weighing one side of the truck at a time. MDOT funded a research effort for design and construction of Permanent Intermittent Truck Weigh Sites (PITWS) for use with portable scales. Finally, both agencies advocated increased usage of WIM sensors to screen truck weights and plan enforcement action.

To evaluate the utility of these recommendations and "assess the effectiveness and efficiency of MCD in meeting its mission to provide the public with a safe motoring environment and protect the highway infrastructure by promoting compliance with commercial vehicle laws through education and enforcement," [Michigan Auditor General 2001, 10] Michigan conducted a performance audit of the State Police Motor Carrier Division.

The audit examined program activity data and methodology for assigning weigh station, road patrol, and Specialized Transportation Enforcement Team staff. Auditors reviewed weighing and inspection activities at the weigh stations for three fiscal years. The measures of performance used to compare port of entry and road patrol operations are shown in Table 5.

Table 5: Michigan State Police Motor Carrier Division Enforcement Measures

Enforcement Type and Measures	Fiscal Year		
	1996-97	1997-98	1998-99
Weigh Stations			
Total Vehicles Weighed	3,268,424	2,867,892	2,337,649
Overweight Violations	1,438	1,309	1,545
Total Violations	8,056	7,752	8,176
Road Patrol			
Total Vehicles Stopped	37,249	30,809	32,349
Total Vehicles Weighed	3,969	3,904	3,638
Overweight Violations	1,857	1,778	1,873
Total Violations	22,842	19,490	22,278

Source: Michigan State Police Motor Carrier Division, 2001. [Michigan Auditor General 2001]

The Michigan auditors compared the measures shown in Table 5 to the output from 21 WIM sensors on Michigan highways.[4] Weigh-in-motion data from June 2000 identified 181,000 trucks with 6 or more axles, of which 69,000 (38 percent) were overweight. The percentage of overweight trucks was considerably lower for those with 5 axles and below. In comparison, auditors noted that MCD issued a total of 361 citations for trucks being overweight during the same month. Of these, 140 were issued from the permanent weigh stations and 221 by road patrol cars.

The 361 citations issued by MCD represented 0.2 percent of the total truck traffic as measured by the WIM units. However, the implication that enforcement activity was lacking because WIM identified a greater percentage of overweight vehicles is misleading. First, the auditors did not identify the number of vehicles passing through weigh stations or mobile enforcement sites. The violation rates for the fiscal years shown in Table 5 were 0.2 – 0.3 percent at fixed ports and 5.0 – 5.8 percent for mobile patrols, suggesting that all 181,000 vehicles did not pass through enforcement areas in the June 2000 sample. Second, the threshold for issuing citations was not specified. It is common practice among weight enforcement officers, particularly at high volume locations, to allow vehicles "slightly overweight" to pass without being cited.[5] Third, the margin of error cited for WIM measurements was not used to develop multiple estimates of the percentage of weight violators.

The State Police MCD responded that it had attempted to utilize mainline WIM sites to detect overweight vehicles, but those attempts had minimal success because the WIM sites were frequently non-operational and, when operational, WIM equipment were not accurate or reliable. Manufacturer claims of accuracy rates of 80 percent and 90 – 95

[4] Auditors noted that the accuracy of WIM systems varied by type and installation, ranging from 80 percent to 90 – 95 percent for the units installed by the Michigan Department of Transportation.

[5] In Arizona, the fine for gross weight violations under 1,000 pounds is $1, an amount below the cost of issuing the citation. Michigan does not fine for gross weight violations, so there may be some leeway for axle weight violations as well.

percent accuracy were dependent upon proper installation, maintenance, and calibration. It should be noted that the criteria for "success" were not defined by the State Police.

The auditors identified several additional shortcomings with the MCD enforcement program. First, the MCD had not established specific goals and objectives with quantified outcomes for motor carrier size and weight enforcement and hazardous materials inspections and follow-up. This again raises the suspicion that the resistance to WIM-based enforcement was not based on concrete measures of success. Second, MCD had not developed an information system to gather output and outcome data. For example, MCD did not accumulate data from its PITWSs to evaluate effectiveness and efficiency. Although the use of PITWSs reduced the time it takes to weigh a vehicle, MCD did not determine whether there was a corresponding increase in weight enforcement effectiveness and efficiency. Last, MCD had not conducted a comparison of actual outcome data with desired outcomes. For example, MCD scheduled weekend enforcement coverage at a lower level than weekday coverage, but had not determined whether there was a relationship between limited enforcement coverage on weekends and the number of overweight vehicles or other traffic enforcement on the highways during weekends.

The Michigan State Police audit was unique in that customers of the Motor Carrier Division were invited to participate in the performance evaluation. Mail surveys were distributed to commercial carriers soliciting feedback about the division's activities. The survey results suggested that at least some carriers perceived enforcement activities as a deterrent to illegal travel.

Of the 55 respondents to the commercial carrier survey, eight (14.5 percent) indicated that at some point during travel on Michigan highways they had been found to be overweight on certain axles and required to adjust the load before being allowed to proceed. Six (10.9 percent) indicated that they had been found to be overweight on certain axles but were not required to adjust their load before being allowed to proceed.

Interestingly, while 14 respondents answered affirmatively to the two previous questions regarding load shifting, when asked how often a citation had been issued when their load required adjustment, 29 respondents (52.7 percent) responded to the question. This raises the possibility that, either the questions were not worded properly in order to exclude non-violators, or some overweight operators were reluctant to provide truthful responses to previous questions.

When asked a hypothetical question regarding the probability of detection, 14 respondents (25.5 percent) thought it "unlikely" or "very unlikely" that they would be detected if traveling overweight in Michigan. Fifteen respondents (27.3 percent) answered that detection was "likely" or "very likely" and 21 respondents were neutral. Five respondents didn't answer.

In a follow-up question to the probability of detection, respondents were asked to choose the type(s) of enforcement activity most likely to detect overweight violators. The most

frequently chosen activity was highway patrol cars (32), followed by permanent weigh stations (20) and temporary weigh stations (10). These results suggest that the perceived enforcement "threat" posed to illegal operators by mobile weight enforcement crews (i.e., temporary scales) is of less consequence than the benefit frequently cited in performance audits.

The use of weigh-in-motion data for evaluation of outcomes and planning enforcement activity has been the cause of some controversy between researchers and enforcement agencies. While the theoretical benefits of WIM measurements are undisputed, the Michigan State Police response illustrates the common complaint that such systems are far less reliable in practice. This problem is exacerbated by the lack of attention to WIM measurement variance when preparing estimates. For example, in the case of a perfectly calibrated WIM sensor with 88 percent accuracy for axle weight measurements, an axle 10 percent overweight stands a 20 percent chance of registering as legal [Bergan *et al.* 1998]. However, WIM can be interpreted conservatively as a broad measure of existing conditions. No other existing measurement provides as comprehensive a picture of traffic characteristics and weights. Further discussion of WIM measurements as indicators of effectiveness is included in the next section.

COMPARATIVE MEASURES OF PORT OF ENTRY PERFORMANCE

Several large-scale studies have been conducted at the national level in order to compare the efforts and achievements of multiple states. As in the case of state performance audits, these studies have tended to focus on the weight enforcement function carried out at state ports of entry. Two of the most comprehensive are discussed at length in the following section. The first examines the level of enforcement activity among nine states and makes comparisons based on the output (i.e., efficiency) of enforcement programs. In contrast, the second details the development of measures of effectiveness for assessing the outcomes (i.e., effectiveness) of weight enforcement activity. The use and validity of various measures of performance are compared among four states from disparate geographical areas.

Comparisons of Weight Enforcement Activity

An analysis of the effectiveness of violator penalties for ensuring compliance with truck weight limits was conducted for the US Department of Transportation Special Programs Administration in September, 2000 [Church and Mergel 2000]. The approach used for this study was to conduct discussions with enforcement officials in nine states, diversified by geography, fine severity, roadside enforcement practice and adjudication system, on whether their penalty imposition was considered to be effective. The results of these discussions included measures of weight enforcement activity for the states surveyed, as shown in Table 6.

The states studied for purposes of this report were: California (CA), Georgia (GA), Minnesota (MN), Mississippi (MS), Missouri (MO), Montana (MT), New York (NY),

South Dakota (SD), and Washington (WA). Researchers chose this group to represent states with various operational, statutory and procedural differences. These included three states using the PrePass electronic pre-clearance program (CA, MS and MT) plus two from NorPass (WA, originally from its MAPS component, and GA, originally from the Advantage I-75 corridor program); the original "shipper liability" state (MN); a state that no longer uses fixed weigh stations at all (NY); plus at least one relatively high-fine (SD) and one relatively low-fine state (either MT or GA) and some geographical dispersion.

The basic question of whether state penalties were satisfactorily inducing operator compliance could not be answered definitively based on available data. However, the state authorities generally indicated that there are persistent compliance problems on secondary roads and in local bulk trucking. This suggested the potential value of enforcement efforts targeted at these sectors, which were not subject to economical surveillance by permanent, fixed-site weigh stations. The researchers noted that a promising approach appeared to be expansion of the practice of analyzing data from "non-enforcement" weigh-in-motion equipment so as to efficiently deploy available mobile truck weight enforcement personnel. This practice was noted as already being underway in three of the nine study states.

Table 6 shows a comparison of parameters of the weight enforcement activity carried out in these nine states as reported to FHWA for 1997. In order to compensate for size differences between states, enforcement activity measures were normalized by estimated total heavy truck mileage on major rural roads[6] within each state, and also by the mileage of these roads. While acknowledging the large breadth of this estimate as single normalizing factor, with some states having a larger proportion of their road network within urbanized areas than do others, the rural roads were justified as the locations for which states typically had the most opportunity to detain certain trucks without creating an unsafe condition for, or grossly delaying, other traffic.

According to the researchers, there was no available measurement of weight limit compliance sufficiently comprehensive to permit determination of actual penalty effectiveness within different states. In other words, the available measures were insufficient for evaluating the outcome of penalty enforcement. However, the 1997 data in Table 6 show some distinct differences between the Study states in the pattern of their enforcement practices and in the extent of enforcement in relation to size.

Surveillance of truck weights, as indicated by their reported total of static and WIM screening weighings, varied by a maximum factor of about four among all but one of the study states when that total was expressed as a relationship to their major rural road truck traffic. The exception was New York, one of three study states that employed no WIM screening at all in 1997, where surveillance was vastly lower than in the rest of the group. Mississippi was highest, followed closely by Georgia. Georgia also had the highest citation rate in relation to major rural road truck traffic.

[6] Interstate and other arterial roads outside of urban areas.

New York reported a much higher total number of citations in relation to total weighings (4.6 percent) than did other states. All other study states showed 1997 citation-to-total-weighing rates under 1 percent, with Georgia the highest (0.9 percent) despite its very high volume of WIM screening weighings. However, over 30 percent of the reported 1997 citations, but fewer than 2 percent of the weighings, were generated by the authorities of the two counties located on Long Island and of New York City, rather than by the State Police, which performs weight enforcement in the rest of New York. New York City, which has its own weight limit regime, alone accounted for over a quarter of the reported citations, which actually outnumbered weighings due to repeat issuance for multiple types of weight violations by the same vehicle, a practice not generally followed by the New York State Police. The ratio of citations to weighings for the New York State Police was 3.2 percent. Given the exclusive use in New York of semi-portable or completely portable scales, this ratio was expected to be higher than that in other states. The deployment of mobile scales may be easily altered so as to concentrate on sites or areas where there are thought most likely to be actual violations, and the lower throughput capacity of mobile scales encourages the exclusion of empty trucks, and concentration on the most likely potential violators among loaded trucks.

Table 6: Comparison of Measures of State Truck Weight Enforcement Activity, 1997

Measures of Weight Enforcement Activity	California	Georgia	Minnesota	Mississippi	Missouri	Montana	New York	South Dakota	Washington	National Average [1]
Fines/ 10k GVW violation	$1,500	$318	$715	$1,000	$1,000	$250	$700	$2,625	$890	$726
Total Enforcement Activity										
Static Weighings	12,260,295	1,768,909	701,898	5,684,389	2,756,503	858,158	167,468	592,123	2,362,044	2,079,566
WIM Screenings	4,187,162	11,787,811	950,000	2,569,819	0	20,116	0	0	1,300,000	1,278,133
Citations	44,777	122,901	3,438	13,900	8,799	1,846	7,757	3,349	11,433	12,469
Load Shifts / Off-loadings	46,368	7,876	640	21,660	13,239	14,703	149	2,109	13,797	10,329
Structure of Enforcement Activity										
Citations per Static or WIM Weighing	.003	.009	.002	.002	.003	.002	.046	.006	.003	.004
Ratio of Load Shifts or Off-loads to Citations	1.04	0.06	0.19	1.56	1.50	7.96	0.02	0.63	1.21	0.83
Percent of Static Weighings on Fixed Scales	99.94	77.88	90.07	99.46	99.88	99.39	0	93.84	98.24	98.33
Ratio of WIM Screenings to Static Weighings	0.32	6.66	1.35	0.45	0	0.02	0	0	0.55	0.61
Enforcement Activity Compared to Estimated Truck Mileage on Major Rural Roads[2.]										
VMT Per No. of Static or WIM Weighings	339	304	816	284	1,136	908	13,458	1,161	342	1,105
VMT Per No. of Citations	122,618	33,542	392,256	168,513	355,875	432,161	290,543	205,235	109,436	153,601
VMT Per No. of Load Shifts or Off-loadings	118,411	523,408	2,107,148	108,141	236,524	54,259	15,125,779	325,904	90,685	185,425
Enforcement Activity Compared to Mileage of Major Rural Roads[2.]										
Static or WIM Weighings Per Road Mile	1,354.6	1,477.7	155.2	1,309.2	379.8	130.2	24.2	91.0	802.7	648.9
Citations Per Road Mile	3.8	13.4	0.3	2.2	1.2	0.3	1.1	0.5	2.5	2.4
Load Shifts or Off-loadings Per Road Mile	3.2	0.5	0.02	2.4	1.4	1.7	0.02	0.3	2.7	1.4

Sources: (1) Enforcement activity, Federal Highway Administration records (2) Vehicle and road miles - Federal Highway Administration statistics. Definitions: "Major" rural roads defined as the functional classes Rural Interstate, Rural Other Principal Arterial, and Rural Minor Arterial. Total length of such roads taken from Table HM-20 of Federal Highway Administration's *Highway Statistics*.

New York and Georgia (and to a lesser extent, Minnesota) required load adjustments much less frequently than the other study states in relation to the number of citations issued. Montana, by contrast, required them much more frequently. Variation among states' level of truck weight surveillance was greater when total weighings were expressed as a relationship to major rural road mileage than when expressed as a relationship to truck traffic. Again, New York was by far the lowest, followed by South Dakota, which also reported no WIM screening at all.

Only one state (Montana) expressed the firm opinion that penalizing weight limit violators was having a significant positive impact on general trucker compliance behavior. In New York, the establishment of a graduated penalty schedule was believed to have been followed by at least one industry shifting from what appeared to be virtually universal non-compliance up to an informally-estimated 90% compliance rate. But this favorable change in local bulk trucking compliance was also attributed in part to the concurrent establishment of a general annual permit system allowing axle, axle spacing and gross vehicle weights significantly above federal Interstate Highway standard limits. In Minnesota, it was thought that general compliance behavior had improved over the long period since introduction of their "relevant evidence" enforcement system, during which enforcement surveillance had also been increased and there had been somewhat more rigorous prosecution of violations in court.

Four other states offered contrasting views of the effectiveness of penalties. In Washington, the FHWA was told that a recent fine increase had not been accompanied by discernible improvement in general compliance. In South Dakota, a campaign to raise already-high fines and legislate greater enforcement powers implied past ineffectiveness of violator penalties to generate an acceptable level of compliance. This was attributed to general inattention on the part of truckers to weight requirements, as well as some acceptance of fines as an "expected cost of doing business." Missouri's enforcement effort was thought to have little effect on compliance in certain sectors of short-haul, secondary-road trucking, principally because of a low apprehension rate (i.e., probable penalty) relative to the potential additional earnings available from an overload. A similar observation was offered by Georgia, where the civil penalty being employed for overweight offenses was believed to be less effective in the local bulk than in the long-distance general trucking sector, with the possibility that in the former some intentional overloading was occurring.

Representatives of the two other States (California and Mississippi) did not have what they considered to be an adequate basis for evaluating the impact of the enforcement and penalty system on compliance behavior. However, California representatives allowed the possibility that their state's extensive network of permanent weight and safety inspection stations, many of which are kept open continuously, were deterring some potential violators.

The problems associated with using the percentage of weight violations as a measure of compliance, as noted in the previous section, were specifically identified by this study. Researchers pointed out that the rates at which overloads are detected at fixed-site weigh

stations, especially those located only on major through routes or open only at certain times of the day, were inadequate as a measure of overall weight limit compliance. These measures at fixed ports typically overstate compliance, whereas detection rates from mobile weight enforcement units could understate compliance because of the units' targeting trucks with high violation potential. Citation-to-weighing rates that were volunteered by five study states for their deployed portable scales varied from 3 percent to over 58 percent, such vast differences presumably being due both to differences in actual violation rates in the deployment areas chosen and in the extent to which only likely violators were being selected for weighing. A representative from Missouri hypothesized that the compliance rate among trucks on secondary roads carrying two problem commodities (grain and gravel) might be in the 10-20 percent range.

Representatives from two states volunteered informal, unofficial estimates of overall weight limit compliance within the whole state. Montana estimated 85 percent compliance, based on general observation, and California estimated 94-95 percent compliance based on data output from weigh-in-motion installations primarily used for highway planning. The enforcement authorities surveyed typically viewed secondary roads and local bulk trucking as the sectors where their state's violator detection and penalization system had an insufficient effect. Local trucking was less likely than interstate/interregional trucking to be exposed to surveillance by high-volume weigh stations set up at fixed sites to intercept a state's major truck traffic flows (often for purposes of simultaneously carrying out safety and tax/registration document checks). Also, to the extent that the rate of citation for serious overweights is greater for local truckers when subjected to enforcement, they presumably benefit more from any significant reduction of overweight fines during adjudication by local criminal courts, which was cited as an enforcement problem by some authorities.

Despite the lack of reliable data for measuring the outcome of enforcement and associated penalties, the comparisons yielded some potentially useful measures for evaluating productivity. The use of vehicle miles of travel, in particular, eliminates the variance that occurs when port traffic flows are considered as a normalizing factor for traffic. Although VMT estimates are in themselves subject to considerable variance, the temporary closure of a port (and thus non-measurement of traffic) would not enhance traffic-based measures by reducing the denominator of the equation.[7] Ratios of WIM screenings to static weighings, and load shifts to citations, could be used to respectively illustrate the effects of technology improvements on traffic processing and the relative severity of penalties assessed at different locations. However, these measures would not be indicators of overall productivity, and would be best used in conjunction with other measures to explain or test variations in practices.

[7] If the measure in question is the ratio of trucks weighed to port traffic, performance (efficiency) could be artificially enhanced by closing ports periodically and thus reducing traffic. Such a practice could especially skew results at peak operating times when a port is more subject to backlogs and forced wave-throughs. Estimated vehicle miles of travel, though variable, are not within the influence of POE staff.

Weight Enforcement Measures of Effectiveness: Weigh-in-motion Data

In a 1998 report for the National Cooperative Highway Research Program (NCHRP) [Hanscom 1998a], a different approach to performance measurement was taken by researchers. Rather than focus on the outputs achieved by state enforcement programs, the NCHRP study focused exclusively on measuring the outcome of agency activities. The rationale for this approach was based on the following goals of truck weight enforcement activities:

- Deter operation of overweight trucks and/or trucks with inappropriate axle spacing.
- Control pavement and bridge damage from overweight trucks.
- Protect the public from safety risks associated with overweight trucks.
- Protect law-abiding truck operators from illegal competition.

The authors noted that benefits of weight enforcement activity "must be recognized in terms of some, or all, of these objectives." [Hanscom 1998a, 4] In other words, a study to evaluate the outcome of truck weight enforcement must be based on measures that reflect goals of the weight enforcement program, such as changes in compliance, (e.g., instances and severity of overweight violations), and whether any enforcement benefit is achieved in terms of reduced pavement wear. A Measure of Effectiveness (MOE) of weight enforcement activity was defined as a "determinable quantity of what is achieved as a result of weight enforcement activity," used to quantify the contribution that a particular activity makes toward achievement of one or more of the weight enforcement goals described above.

Using weigh-in-motion data, several MOEs were developed and tested in four states, in order to determine the statistical validity of each and to make comparisons among states in terms of the outcome of enforcement activity. The four states used in the study were California, Georgia, Idaho and Minnesota. The measures of effectiveness and their definitions are shown in Table 7.

Sampling guidelines were developed to estimate the number of observation sites and truck sample sizes required for valid measurement of enforcement effects. These guidelines were provided for specified roadway classification and truck percentage conditions. Separate observation levels for sampling truck-weight violations were devised in order to meet the varied types of truck weight enforcement operations: (1) statewide or regional, (2) highway corridor or local level, and (3) spot or location-specific.

Table 7: NCHRP Measures of Effectiveness (M.O.E.s) for Weight Enforcement

Measure	Type	Definition
Gross Weight Violation	Proportion	The fraction (or percentage) of the total observed truck sample that exceeds the legal gross weight limit.
Gross Weight Violation	Severity	The extent to which average measured gross weights for the observed sub-sample of gross weight violators exceeds the legal gross weight limit.
Single-axle Weight Violation	Proportion	The fraction (or percentage) of the total observed truck sample with one or more axles that exceeds the legal single-axle weight limit.
Single-axle Weight Violation	Severity	The extent to which average measured single-axle weights for the observed sub-sample of single-axle weight violators exceeds the applicable legal limit.
Tandem-axle Weight Violation	Proportion	The fraction (or percentage) of the total observed truck sample with one or more tandems that exceeds the legal tandem-axle weight limit.
Tandem-axle Weight Violation	Severity	The extent to which average measured tandem-axle weights for the observed sub-sample of tandem-axle weight violators exceeds the applicable legal limit.
Bridge Formula Violation	Proportion	The fraction (or percentage) of the total observed truck sample that exceeds the legal Bridge Formula weight.
Bridge Formula Violation	Severity	The extent to which average measured bridge formula weights for the observed sub-sample of bridge formula violators exceeds the legal weight.
Excess ESALs	Proportion	The fraction (or percentage) of the total observed truck sample exhibiting excess ESALs (equivalent single axle loads); i.e., ESALs attributable to the illegal portion the individual single or tandem axle group.
Excess ESALs	Severity	The average value of excess ESALs observed for the truck sub-sample exhibiting excess ESALs.
Source: Hanscom, F. R.. Transportation Research Corporation. *NCHRP Web Doc 13 Developing Measures of Effectiveness for Truck Weight Enforcement Activities: Final Report*. NCHRP, Transportation Research Board (Mar 1998).		

The types of measurements, MOEs used, and results varied among the states in the study.

California

The California Department of Transportation provided output from a WIM scale located on I-5. An analysis of 3,678 truck combinations exhibited lower gross weights with a smaller proportion of overweight axles during the time when the weigh station was open. Data on a sub-sample of 2,370 tractor-semitrailer combinations was further analyzed to determine MOE sensitivity to enforcement activity. Results confirmed the validity of the following MOEs: Tandem-Axle-Weight Violation Severity, Bridge Formula Violation Proportion, and Excess ESAL Severity.

Georgia
Mobile truck weight enforcement operations, using a portable roadside weigh scale, were conducted at a rural interstate location. An analysis of WIM data gathered on 483 combination trucks revealed a number of valid MOE effects associated with observed axle and tandem weights. Under conditions of observable, and unexpected, mobile enforcement operations, the observed truck sample exhibited lower steering axle weights, lower rear-axle weights, and lower rear tandem weights. During the surprise enforcement operation, a number of overweight trucks were observed to either park alongside the roadway or divert to alternate routes. Results validated the following MOEs: Single Axle Weight Violation Proportion, Tandem Axle Weight and Excess ESAL Severity.

Idaho
WIM data gathered on 29,000 commercial vehicles, were provided by the Idaho DOT. A comparison of baseline versus enforcement conditions during three different weekdays produced several significant findings. While no day-of-week effects were readily evident to indicate on which days enforcement effort would more likely be effective, all of the tested operational measures were shown to be sensitive to enforcement activity. Measures of Effectiveness most consistently demonstrating sensitivity to enforcement activity were: Gross Weight Violation Proportion, Single Axle Weight Proportion, Tandem Axle Weight Proportion, and Excess ESAL Proportion.

Minnesota
Data sets representing two weeks of continuous traffic monitoring were provided by the Minnesota DOT. Bending plate WIM data were collected approximately five miles from a permanent truck weight enforcement scale during times when the scale was both open and closed. The Minnesota results were generally weaker than other study sites, but one WIM data set did exhibit a smaller proportion of gross weight and tandem axle violations, along with a tendency for less severe ESALs.

All of the tested Measures of Effectiveness were shown to be sensitive to actual weight enforcement activities, but validated measures varied from state to state. A number of factors were seen to affect MOE sensitivity to enforcement procedures, including actual truck weight/configuration characteristics, shipping commodity demands, observed truck sample size, and WIM equipment variables.

The authors asserted that proper quantification of effectiveness required measures which showed benefits in terms of: 1) compliance with operational weight and axle-spacing regulations, 2) pavement and bridge preservation, or 3) minimization of crashes, deaths, injuries and property damage. However, as shown in Table 7, only the first and second classes of benefits were considered for inclusion in the study. The omission of safety-related MOEs was due to the type of data being evaluated (WIM) and the relative difficulty in ascribing causal factors to crashes.

Also notable in the NCHRP study was that the authors specifically identified the need to measure enforcement compliance in the context of actual truck exposure (e.g., total truck volume), in order to ensure that the sample(s) observed adequately characterized the overall

truck population. In contrast with many of the state-specific performance measures, the NCHRP measures of effectiveness did not consider gross measurements, instead relying on the proportion of violators and the average severity of violations. This practice facilitates comparisons between states despite variances in truck traffic and commodities.

However, the NCHRP results served as tests to validate the proposed measures, and thus did not consider the cost of additional enforcement activity. Given that most states are constrained by budgetary limitations, the added cost of enforcement is a relevant consideration for evaluation of enforcement procedures. Furthermore, some states have expressed concerns that WIM data are not reliable enough for enforcement planning [State of Arizona Auditor General 1986; Oregon Office of the Secretary of State 2002; Arizona Department of Transportation 2001; Michigan Auditor General 2001]. While WIM measurements appear useful as a measure of program effectiveness, the variety of measures selected by different states in the study, as well as reservations about the utility of these data, indicate that WIM measurements should be considered in conjunction with other performance measures to gauge enforcement activity.

STATE PORT OF ENTRY PERFORMANCE SURVEY RESULTS

A survey of operational practices and performance measurement at state ports of entry was conducted as part of this research. The survey instrument is in Appendix C. Surveys were distributed by mail in November, 2002; eighteen states responded. Of the eighteen respondents, two states (Illinois and Nebraska) did not operate ports of entry per se, but provided information about fixed weigh stations used for commercial vehicle enforcement. Two more states (Texas and Maine) operated only international ports of entry. Neither of the latter two measured performance at international POEs, so no comparison could be made between these sites and interstate ports of entry.

Most states collected port or commercial enforcement data when applicable. Twelve respondents (75 percent) collected data for all aspects of the enforcement program. Four respondents only collected data for specific functions and not for the entire program. Most respondents collected a variety of data and used these data for multiple aspects of decision-making.

Table 8: Purposes of POE/Enforcement Data Collection

Uses for Data Collected	Total Responses
Allocation of Funds	6
Allocation of Staff	9
Facility design	7
Developing procedures	6
Enforcement planning	13
Tax and fee evaluation	3
Size/weight law review	11
Predicting traffic	9
Other research	9
Federal requirements	10
State requirements	1
Not used	2

The most commonly cited reasons for collecting data at ports of entry or commercial enforcement locations were for enforcement planning, evaluation of size and weight laws, and to meet federal reporting requirements. Fewer than half of respondents used enforcement data for allocation of funds, development of procedures and design of commercial vehicle facilities. Two respondents did not use data for decision-making and three used data collection to review taxes and fees for commercial vehicles. Most likely, the latter figure is the result of the separation of legislative tax authority and enforcement operations for most jurisdictions responding.

Although nearly 90 percent of respondents collected data for enforcement operations, only 50 percent used these data to measure performance. Of these, the majority only measured performance for specific functions, and did not evaluate the entire program. Virtually all respondents that did measure performance specified some type of weight enforcement as a unit of measurement.

Nine states provided measurement information, but only four identified specific targets or goals for items measured. The most frequently measured enforcement statistics were the number (or percentage) of weight violations (n = 6) and the number of trucks weighed (n = 5). Four states measured the number of safety inspections, and four recorded the amount of revenues collected by enforcement programs. Only three states explicitly measured port traffic, so it was not clear how other count values (e.g., vehicles weighed or inspected) were normalized, if at all. A summary of different measurements is shown in Table 9.

Table 9: Summary of Performance Measures Used by Survey Respondents

Measurement[a]	CO	ID	IL	MD	MS	OR	SC	WA	WI
Weight Violations	P		C[1]	C[2]	C[2]	C	C[2,3]		
Trucks Weighed	C	C	C			C[4]			C
Safety Inspections	C			C				C	C
Revenues	C	C	C[6]		C				
Traffic	C[5]				C		C		
Permits Issued	C[5]				C				
Vehicles Cleared	C								
Safety Violations	P[7]								
Other Violations							C[8]		
Productivity		Var[9]						Var[10]	

Notes: a) "C" refers to a count measurement (e.g., number or sum), "P" refers to a percentage measurement. 1) Illinois has two measures, citations and warnings. 2) Overweight (OW) and oversize measures. 3) Loads reduced and/or shifted. 4) Oregon has three distinct measures for this metric: total, static and WIM+preclear. 5) Hazardous materials only. 6) Overweight fines only. 7) Out of service (OOS) violations. 8) Credential and criminal violations. 9) Idaho conducts a benefit/cost analysis of enforcement activity every three years. 10) Washington considers overall activity, and number of hours spent weighing for each weight violation.

The nine respondents that had developed performance measures for commercial vehicle enforcement varied considerably in the type of measurements taken, even within a particular measurement category. When specified, performance targets varied from a percentage range of improvement over historical values to specific figures identified for each category. Some targets were set based on a forecast methodology, while others repeatedly used the same target percentage applied to the most recent historical period. Details for each survey respondent are given below.

Colorado

Numerous measurements are evaluated on a monthly and annual basis. These include the number of vehicles weighed, percent overweight, number of drivers and vehicles inspected, and the percentage placed out of service (OOS) for safety violations. Colorado also measures the total revenue collections at highway ports of entry, and breaks out the number of vehicles carrying hazardous materials, as well as the number of hazmat permits issued. Current year targets for all measurements are set based on historical values + 2 to 5 percent. An annual variance threshold is also specified, with an expected range of +/- 10 percent.

Idaho

The Idaho Transportation Department conducts a monthly review of truck weighings for federal reporting, and also produces a monthly revenue report for the port of entry program. In contrast to most respondents, Idaho conducts a benefit/cost analysis of the port program every three years. The study uses multiple measurements (e.g., revenue generated, operating and personnel costs, highway mileage influenced by each port and the life cycle of highways) to calculate a benefit/cost ratio for each POE station. The study attempts to calculate a benefit value for each port based on the reduction in highway wear attributable to enforcement activity.

Illinois
Data are reviewed monthly and annually. The fixed scale operations measure trucks weighed, overweight citations and warnings issued, and the dollar value of overweight fines assessed. No targets are set for these measurements.

Maryland
The State Police collect monthly statistics for fixed enforcement stations only. The weigh stations measure the number of overweight vehicles, the number of oversize vehicles, and the number of safety inspections performed. The survey respondent indicated that target values for each measurement were used, but that these values varied and no specifics were given.

Mississippi
The state measures performance at highway ports of entry on an annual basis. Ports measure truck traffic, the number of oversize/overweight vehicles, the number of trip permits issued, number of weight violations, and total revenue collected at ports of entry. Current and target values were specified for all measurements, with targets set based on annual averages for preceding periods. Targets ranged from 0.5 percent to 5.7 percent over the preceding year, depending on the measurement category.

Oregon
All measurements are reviewed on a monthly basis. Port managers count the number of trucks weighed on static scales and the number weighed in motion via the state's electronic clearance system. Ports also measure the number of weight citations issued. Although Oregon's port of entry program does not specify formal targets for these measurements, the aggregate scale crossing records are used by Oregon weight-mile tax auditors to set a target for weight-mile tax collections for a given month.

South Carolina
Data are collected for monthly review, but no target measures were specified in the survey. State Transport Police measure total commercial traffic, number of oversize and overweight vehicles, number of loads shifted and/or off-loaded (i.e., reduced). The number of permit, safety and criminal violations are also measured.

Washington
The State Patrol makes daily measurements of enforcement activities for each officer, as well as the number and type of Commercial Vehicle Safety Alliance (CVSA) inspections performed. The Patrol also reviews the number of hours spent daily in weight enforcement activity per violation issued. No target values were specified.

Wisconsin
Data are evaluated monthly, and an annual summary is prepared. No target is set for the number of trucks weighed and measured, due to variance in traffic levels. Formal targets are established for the Motor Carrier Safety Inspection Program. A target of 1,200 inspections was established for fiscal 2002, and the survey respondent indicated that the

program had exceeded the target by 319 vehicles. A methodology for setting the target value was not specified.

Survey respondents were asked whether existing measures of performance reflected the responsibilities of enforcement operations and whether existing measurements indicated the desired outcome of enforcement activity. Answers to these questions were generally correlated with whether or not the respondent measured performance, and if so, the scope of measurement. All respondents gave the same response to the second question as they did to the first. This may indicate that little distinction was made between types of measurement, or that desired outcome largely reflected productivity of the enforcement program.

Tables 10 and 11 show the response to each of these questions. A positive bias was generally observed for respondents that gave an affirmative answer to the question of performance measurement in general. Respondents that measured only partial aspects of the enforcement program were generally more ambivalent in their responses, with two of five respondents either uncertain of or rejecting existing measurements of performance.

Interestingly, five of the nine respondents that did not measure performance nonetheless responded to these questions. Most indicated that measurements did not reflect responsibilities or outcomes, but did not provide clarification as to the measurements being evaluated. Respondents from West Virginia and Wyoming did not measure performance, but indicated that existing measurements reflected responsibilities and desired outcomes. A possible explanation is that the respondents were referring to data collected, as distinct from performance measures. These states did collect data for their enforcement programs, but did not use these data to create specific measures of performance.

Table 10: Existing Measures and Responsibilities

Do measures reflect port responsibilities?	Measure Performance?			
	No	Partial[1]	Yes	Total
No answer [2.]	4			4
No	3	1		4
Uncertain		1		1
Yes	2	3	4	9
Total	9	5	4	18

Note: 1) Partial indicates that performance measurements were only specified for some functions, and did not reflect responsibilities of the entire program. 2) No answer was expected from agencies that did not measure performance, as the question was not considered applicable if performance was not measured.

With the exception of Wisconsin, all states that measured performance indicated that existing measurements accurately reflected both the responsibilities of the enforcement program and the desired outcome of enforcement. However, four states (Illinois, Mississippi, Washington and South Carolina) rated the utility of their performance measurements as average, indicating the possibility that existing measurements could be improved.

Table 11: Existing Measures and Expected Outcomes

Do measures reflect desired outcomes?	Measure Performance?			
	No	Partial[1]	Yes	Total
No answer [2]	4			4
No	3	1		4
Uncertain		1		1
Yes	2	3	4	9
Total	9	5	4	18

Note: 1) Partial indicates that performance measurements were only specified for some functions, and did not reflect responsibilities of the entire program. 2) No answer was expected from agencies that did not measure performance, as the question was not considered applicable if performance was not measured.

Answers to whether or not respondents perceived existing measures as useful are shown in the following table. As with the previous example, five of the nine states that did not explicitly measure performance responded to this question. Of the nine respondents that did measure performance, four (44 percent) considered their measurements "Useful" or "Very Useful." These responses indicate that room for improvement in the collection, measurement and application of performance data may be perceived by some respondents. However, only three states offered suggestions for improving performance measures.

Table 12: Perceived Utility of Existing Performance Measures

How useful are existing measures?	Measure Performance?			
	No	Partial[1]	Yes	Total
No answer [2]	4			4
Not useful	3			3
Little use	1	1		2
Some use/neutral		2	2	4
Useful		1	1	2
Very useful	1	1	1	3
Total	9	5	4	18

Note: 1) Partial indicates that performance measurements were only specified for some functions, and did not reflect responsibilities of the entire program. 2) No answer was expected from agencies that did not measure performance, as the question was not considered applicable if performance was not measured.

Three states provided recommendations for performance measures that might be used to evaluate the efficiency (question 8) and effectiveness (question 9) of ports of entry. With regard to the former, a total of five suggestions were made:

1. Indiana suggested taking WIM measurements at POEs and on bypass routes in order to evaluate capture and evasion at fixed ports.
2. Mississippi suggested three related measurements of efficiency, the first being the number of trucks processed per hour of operation.

3. Mississippi made another suggestion closely related to the first: measure the hours of operation at each POE. Combining the two measures could ostensibly verify whether ports were being operated at peak traffic periods and whether staffing resources were up to the task of processing at these periods.
4. With respect to staffing, the Mississippi respondent also suggested measuring the number of citations versus the number of staff hours required to produce those citations.
5. The Wisconsin respondent suggested that POEs measure public service functions provided in addition to enforcement activities. It is often the case that POE staff provide permitting and registration assistance to walk-in and telephone customers. These functions should be considered when evaluating port of entry productivity.

As has been noted in the discussion of previous research, suggestions for measuring the effectiveness (i.e., outcomes) of port of entry operations were fewer and less specific. Mississippi did not specify any improvements, and Wisconsin suggested recording all activity electronically for "resource analysis," leaving the scope and intent of the analysis open. Indiana suggested recording levels of compliance, but was not clear on the scope of measurement (e.g., compliance at port scales, among vehicles screened by ports and mobile crews, statewide via WIM, etc.).

While the sample of survey responses was not large enough to make any statistically significant observations, a number of interpretations might be reasonably made from the data available. First, performance measurement was not universally adopted by state ports of entry and commercial enforcement programs. Only half of the survey respondents measured performance for these operations. Second, states had disparate perceptions of performance, as evidenced by the variety of measures that were considered to accurately reflect the responsibilities and effectiveness of enforcement activity. Third, the primary focus of performance measures adopted by most of the respondents appeared to be the productivity or efficiency of enforcement operations, rather than the outcome of these activities with respect to motor carrier behavior.

A few states did provide measures of effectiveness for port of entry programs. The Oregon program uses WIM measurements to forecast expected weight-mile tax collections, which are then used to evaluate compliance by state auditors. Idaho conducts benefit/cost assessments for each port of entry, based on the travel patterns on highways influenced by each port, the expected reduction in road damage attributable to enforcement, and the cost of providing that enforcement. A Maryland study (see Appendix D) established a methodology for evaluating the outcome of safety inspections. Several states reported the number of drivers and vehicles placed out of service (OOS), but none had adopted the Maryland methodology as a measurement of effectiveness.

SUMMARY OF PORT OF ENTRY PERFORMANCE MEASURES AMONG STATES

One of the most important aspects of selecting appropriate performance measures is assuring that operations are evaluated based on controllable measures. Little can be determined as far as program performance if the variables being measured are outside the influence of the program.

For example, a substantial number of port of entry evaluations consider the total number of trucks passing through ports of entry, as well as the number of trucks weighed. Neither of these is under the direct control of port of entry personnel. Traffic will vary with changes in season, commodity and trade flows, and overall economic activity. Therefore, it makes little sense to set targets for port traffic flow. On first consideration, the number of trucks weighed seems an adequate measure of port efficiency with respect to weight enforcement. However, it is plausible that changes in traffic flows will make the targets unrealistic or unattainable. One possibility, albeit extreme, is that new corridor construction or some equally disruptive change could reduce total traffic through a port to a level below the targeted number of weighings.

The alternative to external (i.e., outside the sphere of influence of the program) measures can often be developed by simply considering multiple external factors in such a way that the combination comes under the influence of the enforcement program. For example, by combining total port traffic and number of vehicles weighed, the percentage of port traffic weighed can be calculated. Because this percentage represents the enforcement level achieved at a given port under external conditions, it is a far more meaningful measure of the overall efficiency of weight enforcement efforts. While program managers can not directly influence the level of traffic, they can choose operational procedures, staffing levels, equipment and the like to affect what happens to traffic coming through the port of entry.

Given the inherent difficulty in evaluating the outcome of enforcement programs, most states place the greatest emphasis on measures of staff productivity and driver violations. In the former category, measures of weight enforcement activity tend to appear most frequently. The number or percentage of vehicles weighed and those waved through or otherwise bypassing scales are recorded by virtually every program reviewed. Similarly, the number of weight and size-related violations and the associated fines collected from violators are often reported as measures of performance. However, such measures do not necessarily reflect the desired outcome of driver compliance, particularly in cases when smaller changes are observed for such variables as port traffic or the number of vehicles weighed. An increase in violations is just as likely to be evidence of reduced compliance, unless some change in enforcement activity has been effected to warrant the increase in violations. What is generally needed for reliable measures of effectiveness are means of normalizing observations from one period to the next.

III. ARIZONA PORT OF ENTRY EXISTING CONDITIONS

This section discusses the general operation of Arizona ports of entry, including a review of port enforcement program goals, historical and current conditions at the ports in general, and a discussion of operational and procedural challenges identified in state audits and discussions with port staff.

ARIZONA POE GOALS AND INITIATIVES

The stated mission of the Port of Entry program is to ensure that all commercial vehicles on Arizona highways maintain proper credentials and are in safe operating condition, while providing efficient, fair, and friendly treatment to customers and citizens of the State of Arizona. In an effort to achieve this mission, Arizona ports of entry attempt to screen all commercial traffic entering the state for compliance with registration, motor tax, size and weight restrictions, commercial drivers license requirements, insurance requirements, and motor carrier equipment safety requirements.

The stated mission of the Port of Entry Program has been subdivided into more specific objectives [Arizona Department of Transportation 2001] for which performance can be evaluated. Key terminology and potentially quantifiable objectives have been italicized:

1. Meet the needs of the motor carrier industry, local, state or federal agencies in commercial vehicle operator (CVO) related tasks.
2. Provide *efficient service* and accessible facilities.
3. Ensure *compliance with laws, rules, and regulations* that apply to commercial vehicles.
4. Ensure the proper *collection and timely remittance of fees and taxes* to the State Highway User Revenue Fund (HURF).
5. Meet federal mandates on *size and weight enforcement* (protecting future federal funding), *minimize damage* to roads by overweight vehicles or loads and protect the past investments in the state highway system.
6. Maintain vigilance in *monitoring traffic* that could pose a *safety and environmental risk*, e.g., identify trucks carrying hazardous materials, screen for federal safety violations of vehicles or drivers, and perform Arizona Department of Agriculture (ADA) agricultural inspections of vehicles or loads that could pose a risk to agriculture in Arizona.

Enforcement-related tasks can be further illustrated according to the job description for motor vehicle field officers (Arizona Class Code 39503). Port officers examine documents and inspect domestic and foreign-based vehicle traffic entering and exiting the state for compliance with state and federal regulations on vehicle registration, operator licensing, tax credentials, financial responsibility, size and weight and safety equipment. Officers inspect commercial vehicles for safety compliance in accordance with the North American Standards of the Commercial Vehicle Safety Alliance (CVSA), and ensure

compliance with state and federal size and weight regulations through the use of scales or by manifest examination.

Port personnel duties are not limited to enforcement activity. Officers also issue applicable permits, provide routing information for over-dimensional loads and collect appropriate fees and taxes. These duties bear repeated mention due to the tendency of performance audits to focus on the enforcement of specific regulations without consideration of the multiple responsibilities of port personnel [State of Arizona Auditor General 1986; State of Arizona 2000; Norton 1997]. This does not imply that one-dimensional audits have little value, but rather that a broad interpretation of performance must incorporate multiple measures from a variety of sources in order to reflect the responsibilities of the port of entry program. Further discussion of the various services provided and service delivery challenges faced by Arizona's Port of Entry program is provided in the following sections.

ARIZONA POE CURRENT CONDITIONS

The Arizona Department of Motor Vehicles operates 22 fixed ports of entry (POE) at or near state borders on major commercial thoroughfares. The POEs vary considerably in terms of design, staffing, traffic levels, technology and hours of operation. However, all facilities provide a range of services related to motor carrier regulations.

The Motor Vehicle Enforcement Services (MVES) subprogram utilizes certified peace officers in the enforcement of transportation-related laws and regulations. Through the fixed port of entry system and mobile enforcement, commercial vehicles are checked for compliance with size, weight, and safety laws, including the transportation of hazardous materials. In addition, MVES inspects vehicles for authorized credentials, monitors and recovers stolen vehicles and vehicle components, and completes administrative and criminal investigations [State of Arizona 2002].

Operational Challenges

Various factors may play a role in the productivity of state ports of entry. These factors may also have an impact on the effectiveness of port enforcement. In a review of Arizona port of entry performance audits, port of entry program funding requests, and interviews with port staff, a number of impediments to optimal performance at the ports were identified. While most of the items raised were related to port operations per se (e.g., staffing, facility design), a few concerns were also raised with respect to outside influences on the effectiveness of port enforcement.

Officers at the Kingman and Ehrenberg POE facilities identified several operational problems that had a deleterious effect on port efficiency and the effectiveness of port enforcement authority. These constraints included facility design and capacity, staffing and technology issues, and disincentives to compliance by commercial carriers. These issues are discussed in greater detail below.

Design and capacity

Many of the operational inefficiencies that occur at state POEs are related to facility design. The most common problem is ramp capacity, which limits the number of vehicles that a port can flag for inspection at a given time. The diversion of trucks tends to create long queues, and truck back-up onto highways at peak periods can create serious safety problems [State of Arizona 2000; Oregon Department of Transportation 1998; Arizona Department of Transportation 2001]. If the number of vehicles entering the port exceed the ramp capacity, dangerous encroachment of slow or stopped vehicles onto the mainline highway will occur. Therefore, once the capacity of the ramp has been reached, the port must allow approaching vehicles on the mainline to bypass inspection.

Insufficient capacity at Arizona ports of entry has been cited as an impediment to enforcement in several reports, and a shortage of queue space has been noted for many of the higher volume ports such as Ehrenberg, San Simon and Topock. This problem has been identified in virtually every discussion of POE operations included in this research. It should be noted that the Ehrenberg facility had ramp space for approximately fifteen tractor-semitrailer (class 9) vehicles in a single lane. While this single-lane queue capacity was not sufficient for the traffic levels at Ehrenberg, the port had three entry lanes, two of which went unused due to phase out of facilities formerly used for collecting the weight-distance tax (WDT) (now obsolete). The WDT booths in these additional lanes created confusion among drivers who expected officers in the booths and would stop prior to reaching the staffed scale house. It is possible that a redesign of the Ehrenberg facility could make better use of the additional space in the vehicle staging area, thereby increasing the capacity of the port and reducing the bypass rate. However, environmental restrictions, development costs and other regulatory issues have been cited as impediments to redesign at many ports of entry [Oregon Department of Transportation 1998; Arizona Department of Transportation 2001].

Other design-related issues also impact the enforcement capabilities of POE operations. Staff at both Kingman and Ehrenberg cited a lack of visibility of key enforcement areas as a primary concern. Areas designated for safety inspections at the Kingman POE were not visible from the weigh station. Similarly, agricultural inspections and offloading of overweight vehicles could not be seen from the Ehrenberg weigh station. Such issues force an increase in staff to perform mandated duties, or require available officers to split time between various areas, thereby reducing coverage at one or more stations.

These problems are particularly acute at locations such as Kingman, where there may be only a single officer on duty at certain times. During an observational visit to the Kingman POE on such an occasion, scales had to be placed on bypass when customers were being issued permits because the scales and permit windows are placed too far apart to be covered by one individual at the same time. When issuing citations or performing vehicle inspections during single-staff shifts, officers had to shut down scales for 12 to 20 minutes to perform these functions.

While the proximity of permitting and scale areas was closer in Ehrenberg, a different design problem was identified at that POE. The Ehrenberg operation required two officers to perform weight and credential inspections. The weigh station was set back from the scales a sufficient distance that an officer must stand curbside to request driver credentials. However, the weigh scale display was only available to officers inside the weigh station, who then communicated any violations to the curbside officer. This design not only forced an inefficient allocation of staff, but also created a potential hazard, with the credential inspection officer standing at ground level, immediately beside large trucks, at one of the state's busiest ports of entry.

Staffing and technology

Current POE operations tend to be labor intensive, requiring significant staffing levels to monitor and inspect through-traffic. In some cases, the need for additional staff resources is dictated by design constraints that limit the number of duties a port officer can perform. However, lack of funding and allocation of resources can also impact the availability and effectiveness of POE staff. To some degree, shortages and costs can be mitigated through technological and other improvements to port facilities. However, in some cases, the implementation of new technologies can lead to a partial or ineffective solution to existing problems, and may create new difficulties.

A 1997 audit of the Motor Vehicle Department's revenue functions [Norton 1997] made several suggestions for the use of weigh-in-motion data to improve enforcement efforts. It was suggested that existing WIM and automatic traffic recorder (ATR) data collected by the Intermodal Transportation Division could be used to help identify routes used to avoid ports and to assess travel inside the state's borders. This information would be potentially valuable for targeting the placement of mobile enforcement crews and to determine which ports of entry should be considered for extended hours of operation.

Despite the promise of weigh-in-motion systems, legitimate criticisms of WIM as an enforcement tool have been raised. Weigh-in-motion readings taken on Arizona highways for the Long Term Pavement Performance (LTPP) analyses have demonstrated considerable variance from vehicle to vehicle. Weigh-in-motion measurements have typically shown variance from actual vehicle weight of 10 percent or more, [Kombe 2002] and a consistent bias that would allow for factoring has not been observed.

Weigh-in-motion systems can also create potential operating problems. Oregon has been evaluating mainline WIM-equipped PrePass systems to moderate congestion. Several drawbacks to mainline WIM were observed by Oregon researchers [Oregon Department of Transportation 1998]. These included the misreading of signs and signals, both by trucks and passenger cars, the deleterious effects of heavy traffic and weather on system reliability, and the ongoing maintenance requirements of WIM systems. Nonetheless, the use of mainline PASS systems was found to have a significant impact on weigh station operations. WIM-equipped facilities were found to save up to 11 minutes of delays for legal operators, an estimated $5 - $11 in time savings per bypass.

The PrePass electronic credential verification system in use at Arizona ports of entry provides an effective means of regulatory enforcement while allowing mainline bypass for vehicles with the proper credentials. However, a serious flaw in the system was observed during port visits in Spring 2002. Officers at ports visited stated that none of the Arizona ports of entry had a mainline WIM system paired with PrePass. Therefore, any vehicles with proper credentials that had been overloaded were not being identified by the system and were receiving green bypass lights.

Port officers set a random inspection level to call PrePass vehicles to the scales, but the random enforcement threshold was generally set at five percent. This meant that overloaded PrePass trucks usually had only a five percent chance of detection at ports of entry. It should be noted that mainline WIM scales were to be paired with PrePass screening at Ehrenberg in summer 2002. However, without implementation of weight and credential screening statewide, the potential for illegal overloading by PrePass vehicles remains high.

Bypass and evasion

Research has demonstrated that overweight and unsafe trucks often attempt to avoid detection by illegally bypassing ports [State of Colorado 1995]. A common problem at fixed ports of entry is the availability of alternate routes to commercial vehicles that wish to illegally avoid ports. These bypass routes typically have little or no regular enforcement of commercial vehicle regulations, and allow overweight and unsafe vehicles to avoid detection by port officers.

The Motor Vehicle Department operates ports of entry on only 22 of the 33 paved roads that enter Arizona. Motor carriers can easily bypass the ports by traveling on routes that do not have established ports. Staff at several ports visited pointed out there were nearby routes that truckers could quickly and easily use to avoid a port [Norton 1997]. A 1996 study confirmed the staff observations, concluding that up to 20 percent of the trucks crossing on routes without ports may be violating regulations [JHK & Associates 1996].

Even if drivers do not use a bypass route, they can drive through ports unchecked when the ports close, since only 12 of the 22 ports are open 24 hours. Port officials have noted that some drivers pull off the highway to wait until a port closes before crossing the border [Norton 1997]. Furthermore, motor carriers traveling primarily within the state are even more likely to go unchecked, since ports operate only at state borders.

Another related concern is “port running.” This practice refers to trucks on the enforcement route (i.e., mainline) avoiding the port facility, usually by one of two means. The first is to simply ignore the mainline signal instructions that inform the vehicle to enter the port. The truck simply continues past the POE without entering. The second method, referred to as “plugging” the port, involves a “convoy” of a large group of

trucks, with the heaviest vehicles bringing up the rear. As the port reaches queue capacity, the vehicles at the rear of the convoy are given the bypass signal so that vehicles do not back up onto the mainline highway.

While difficult to quantify, several studies have tried to estimate the evasion rate in Arizona. A 1996 study estimated the potential revenue lost from motor carrier tax evasion in calendar year 1994 at between $24 million and $45 million, or 29 to 55 percent of revenues generated from the tax in that year [JHK & Associates 1996]. This estimate is consistent with the *Arizona Highway Cost Allocation Study* for 1988-92, which suggested an evasion rate of as much as 35 percent of total motor carrier tax revenue [Norton 1997].

Procedural Challenges

Several institutional impediments to effective enforcement have been identified by port personnel. First, citations issued by port of entry officers fall under the jurisdiction of local judicial authorities. The net result of this arrangement is that fines are often reduced or dismissed by local judiciaries that are more sympathetic to individual driver interests. While POE staff can issue fines that are commensurate with the overload damage that a vehicle may cause, there is little incentive for local authorities to impose the maximum fine. Some port officers indicated that it was generally not worth the effort to issue weight citations to vehicles less than 1,000 pounds overweight. One reason offered was that these citations were the first to be waived or substantially reduced by local judicial authorities.

The level of penalties assessed for safety, weight and size violations is also outside the influence of the port of entry program. While this is not an operational challenge per se, the port of entry program must make expenditures for staff, equipment and facilities in order to collect these fines. Operating expenses have traditionally been justified in terms of the value of benefits the state receives for spending on port enforcement [Arizona Department of Transportation 2001]. However, operating expenses are subject to inflationary pressure that is generally more immediate than changes in taxes or fines. This disparity could lead to ill-conceived cost containment measures designed to limit funding based on the fixed price of fines.

A seemingly logical solution might be to increase fines and permit fees to offset not only the cost of enforcement, but also the cost of road damage and safety hazards imposed by illegally-operated vehicles. However, increases in penalties at the state level could in fact exacerbate the enforcement problems, with a greater percentage of vehicles avoiding or illegally bypassing ports, and local officials countering fine increases with increased dismissal rates or reductions. Furthermore, various states have expressed the opinion that increased fines have little impact on violation rates [Church and Mergel 2000]. The only solution to an increasing cost/revenue ratio available to the POE manager is to try to limit the cost of operation, as the revenue side of the equation is largely outside the program sphere of influence.

Officers at Arizona ports of entry also lack the authority to pursue vehicles that willfully violate inspection signals. Pursuit authority was the exclusive charge of the Department of Public Safety (DPS), and DPS officers were often unavailable when vehicles evaded or illegally bypassed ports of entry. While this was identified as a concern among port officers, it is not clear whether granting pursuit authority would result in more effective port enforcement. Port runners made up a small percentage of POE traffic, and pursuit of violators by POE personnel would reduce already limited staff resources even further.

On the other hand, the increased probability that a violator would be pursued might have a deterrent effect on potential violators. This could conceivably reduce the incentive to overload, and lead to reduced wear on the highway system. In other words, the potential loss of performance in terms of productivity might be offset by a performance gain in terms of enforcement outcome. Employee morale, and by extension job performance, might also be positively impacted if officers perceived a greater immediacy of influence on the behavior of illegal operators. The relative value of this tradeoff could be an important consideration for port of entry managers and state authorities to take into account.

As with any law enforcement operation, the port of entry program aims to reduce illegal activity. However, unlike more traditional roving enforcement, port enforcement efforts are constrained by fixed facilities, finite capacity, and limited jurisdiction. These barriers to effectiveness present considerable challenges to accomplishment of the program mission, and provide commercial truckers with incentives to skirt the law. As shown in the next section, many of the traditional measures of port activity indicate that productivity has suffered as traffic growth has outstripped the capacity and coverage of the port of entry program.

SUMMARY OF PORT OF ENTRY ACTIVITY, 1998 TO 2002

A summary of activity at Arizona ports of entry from fiscal 1998 to 2002 is shown in Table 13. The table shows that port traffic increased steadily from fiscal 1998 to 2000, and then dropped considerably. However, the drop in reported traffic appeared to be a function of port closures, as inbound traffic per hour remained constant from fiscal 2000 to 2002 at an average of 60 inbound vehicles per hour. Hours of operation fell from an estimated 111,000 in fiscal 2000 to approximately 95,000 in fiscal 2002, a drop of 14.4 percent.

By conventional measures of productivity, the Arizona ports of entry showed little improvement in operations over the five-year period. The percentage of vehicles "waved through" at the ports increased significantly from fiscal 1999 to fiscal 2001. However, it should be noted that much of the increase occurred in conjunction with a rise in inbound traffic per hour. But, the continued increase in wave-through traffic from 2000 to 2001 was not accompanied by a commensurate shift in traffic flow. Wave-through traffic dropped in fiscal 2002, but this productivity improvement coincided with a substantial drop in the number of safety inspections performed. Nonetheless, as a stand-alone measure of efficiency, the decrease in vehicles waved through ports in fiscal 2002 is promising, considering that traffic flow per hour did not decrease from the prior year.

As indicated in Table 13, the percentage of port traffic violating weight restrictions decreased from fiscal 2000 to 2002. Load reductions also decreased as a percentage of vehicles screened, while cargo loads shifted increased slightly. The number of weight citations issued generally declined over the same period, at a rate commensurate with the decline in port traffic, but increased slightly as a percentage of violations. This change might be interpreted in several ways.

It is possible that the increase in enforcement activity[8] led to a decrease in the percentage of overweight traffic over the five-year period. However, it is just as likely that the decrease in operating hours gave overweight vehicles a larger window of opportunity to bypass ports during closures. In this case, the number of overweight vehicles could have remained constant or even increased, with the majority of violators avoiding ports during regular hours of operation. This possibility makes the number or percentage of weight citations an unreliable, though frequently cited, measure of effectiveness.

Table 13: Arizona POE Operational Statistics, Fiscal 1998 – 2002

Totals, All Ports of Entry	FY Ended				
	1998	1999	2000	2001	2002
Traffic	6,987,424	7,149,318	7,228,176	6,700,834	6,738,433
Traffic/Hour (Inbound)	48.96	53.35	59.20	60.66	60.65
Wave Throughs	271,184	273,114	395,765	476,072	417,413
Percent of Traffic	3.88%	3.82%	5.48%	7.10%	6.19%
CVS Inspections	2,556	3,091	5,090	2,548	1,800
Percent of Traffic	0.04%	0.04%	0.07%	0.04%	0.03%
Vehicles Weighed	4,630,330	3,661,889	3,849,552	3,749,706	3,801,024
Percent of Traffic	66.27%	51.22%	53.26%	55.96%	56.41%
Weight Violations	23,558	23,915	24,412	21,099	20,625
Percent of Traffic	0.34%	0.33%	0.34%	0.31%	0.31%
Loads Reduced	3,656	4,662	2,079	1,802	1,315
Percent of Traffic	0.05%	0.07%	0.03%	0.03%	0.02%
Loads Shifted	17,698	16,647	19,906	17,299	17,061
Percent of Traffic	0.25%	0.23%	0.28%	0.26%	0.25%
Number of Wgt Citations	2,204	2,606	2,427	1,998	2,249
Percent of Traffic	0.03%	0.04%	0.03%	0.03%	0.03%
Pct of Violations	9.36%	10.90%	9.94%	9.47%	10.90%
Average Citation Fine	n/a	n/a	n/a	n/a	$687.24
Hours of Operation (est.)[1.]	117,243	112,977	110,943	111,019	94,947
Expenditures	$4,043,947	$4,463,669	$4,665,378	$4,802,929	n/a
Total Revenue	$15,062,783	$13,817,076	$12,671,153	$11,757,317	$10,732,737

Notes: 1.) Hours of operation estimated for each port based on maximum of inbound or outbound normal hours less documented closures for each fiscal year.

[8] Weight citations per number of violations increased, which may indicate greater vigilance or higher standards of enforcement at POEs.

Port revenues and expenditures exhibited an inverse relationship over the five-year period. Revenues collected at ports of entry steadily declined from a high of $15.1 million in fiscal 1998 to $10.7 million in fiscal 2002. Conversely, non-capital expenditures increased from $4.0 million in fiscal 1998 to $4.8 million in fiscal 2001, the last year for which data were available. While the decrease in hours of operation may explain lower revenue collections, the increase in personnel and other variable costs would not be expected under these circumstances.

As discussed in the preceding section, it is plausible that wage and price inflation were to blame for the disparity between operating costs and revenues. The sources of revenue collected at ports of entry are generally comprised of permit fees and fines, both of which are set by legislative mandate. While staff wages and prices paid for travel expenses and equipment will be quickly affected by inflation, the prices for fines and permits will only change as determined by the legislature, and could thus lag behind changes in operating cost.

SELECTED OPERATIONAL MEASURES

Measures of performance should communicate the need for improvement in an organization, but should highlight accomplishments as well. Many of the performance measures discussed in preceding sections emphasize quantity of a particular unit of measurement (e.g., trucks weighed), but do not relate that quantity to the operational conditions under which it was achieved. This practice can have a detrimental effect on organizational morale should conditions outside the control of the program create a decline in performance. A simple case of such decline might be a change in commercial activity, and thus truck traffic, for an organization that considers the number of vehicles weighed or processed as a measure of performance.

Weight Enforcement

The enforcement of weight and size regulations is perhaps the most frequently measured indicator of motor carrier enforcement activity. Virtually all of the states surveyed for this study, as well as those discussed in a review of the literature, made some effort to quantify weight enforcement activity at the program level. The importance of weight enforcement is twofold.

First, overweight truck traffic is associated with a number of detrimental impacts on highway travel. Overweight trucks place a disproportionate burden on highway infrastructure in terms of pavement and bridge wear. These vehicles also impose a competitive disadvantage on commercial operators of legal vehicles. Finally, overweight trucks have been associated with an increased highway safety risk to other motorists.

Second, the current system of taxation on motor carriers is based primarily on vehicle operating weight. Revenues collected from commercial vehicles are intended to offset a portion of the burden that trucks place on the highway system. Ports of entry and other

weight enforcement operations often play a key role in ensuring that commercial vehicles both comply with existing regulations and pay the appropriate fees. Measuring the success of enforcement programs is thus an important component of overall program performance. However, the Arizona ports of entry provide a wide range of services that should not be excluded from the performance analysis.

Safety Inspections

State safety enforcement programs, such as the Motor Carrier Compliance Program, place vehicles and/or drivers "out-of-service" (OOS) for serious safety violations found during state roadside safety inspections. Inspections involve an examination of vehicles, drivers, and hazardous material cargo; and focus on critical safety regulations. An out-of-service violation is one that is deemed to pose an imminent safety hazard (such as inoperative brakes). An out-of-service notice prohibits the driver from continuing the trip until the violation is corrected [Lantz 2000]. If inspected, the average commercial motor vehicle on today's highways stands about a one in three chance of failing an inspection and being placed out-of-service, most frequently for brake problems [Middleton and Ruback 2001]. It has been found that brake problems account for 43 percent of the total OOS violations [Weppner and Alexander 1996].

Federal Highway Administration studies show that commercial motor vehicle crashes are more likely to be caused by driver error than faulty equipment. As a result, the Federal Highway Administration has directed state programs to reduce the emphasis on vehicle inspections in favor of safety inspections that emphasize driver requirements and commercial motor vehicle traffic enforcement.

Roadside safety inspections have been determined to have both direct and indirect deterrent effects that reduce the number of crashes [State of Florida Legislature 1999]. The Motor Carrier Safety Analysis model used by the USDOT Office of Motor Carriers assumes that the very existence of roadside inspection programs reduce the number of crashes through a general deterrence factor. The model estimated that in 1996 the total national benefits (direct and deterrent) from state roadside inspection programs were 640 crashes avoided at a cost of $86 million [State of Florida Legislature 1999].

Ensuring the safety of commercial motor carriers is a key component of port of entry operations, and a specific objective of the Arizona POE program. However, communicating this responsibility has generally been of less importance than weight enforcement in existing studies and planning documents. Nonetheless, methods exist for not only evaluating productivity, but also for estimating the benefits that accrue from vigorous safety enforcement.

Service Contacts

Weight enforcement and safety inspections are both important components of what might be considered one broad class of responsibilities. The Montana DOT has a comparable measure referred to as "service contacts," which encompass not only enforcement efforts,

but also the customer-oriented functions that ports provide. For the purpose of this study, a "service contact" refers to any direct transaction between POE staff and port customers. Rather than subdivide permitting, licensing, citations, weighing, safety inspections, credential verifications and other port functions into smaller categories, the use of a service contact metric allows for a single assessment platform.

Each type of contact requires an investment of time and energy on the part of POE staff. In the case where staff is expected to provide both enforcement and customer service contacts, there will be a necessary offset in the performance of one responsibility while another is being attended. This will be particularly evident for locations with fewer staff – a 20-minute safety inspection or citation may mean that several other vehicles bypass the port without being screened.

By accounting for all activities, a port will not be penalized if productivity losses in one area are offset by gains in another. However, the tradeoff between activities would still be evident when combined with other metrics. For example, if two facilities demonstrate a significant difference in cost per service contact, the relative cost impact of each type of contact can be investigated.

The service contact metric provides a broad assessment of the overall productivity level, from which more specific cases can be narrowed down. When considering such wide measures as productivity per dollar spent, the most logical place to begin to define production is with all service contacts. For ports with abnormal deviation from program-wide measurements (e.g., deviation from program mean or median), an examination of subcategories would be warranted.

Financial Measures

The final broad category of port metrics encompasses two themes. First, as the enforcement authority charged with ensuring remittance of motor carrier revenues to the state, the POE program has a valid interest in reporting revenue collections. One of the service contact functions performed by port staff is issuing permits. There is a direct benefit to the state, and by extension the taxpayers who ultimately fund the roads, in seeing that these revenues are collected.

Similarly, port of entry officers have the authority to cite motor carriers that violate weight and size regulations, thereby recovering at least some of the costs that these vehicles impose through deterioration of highway infrastructure. The reporting of revenues collected at ports of entry provides an indication of the level of regulatory compliance that the ports elicit on behalf of highway users. While this does not imply that no revenues would be collected without ports of entry, enforcement at the POEs does serve as an incentive for commercial vehicles to pay the appropriate fees.

The collection of revenues and performance of other enforcement functions will necessarily come at a cost. The cost of operations is the second theme of financial measurement. As with any operation, there will come a point at which investment of

additional funds in enforcement will be subject to diminishing returns. It is in the interest of taxpayers to receive the best return on investment in port of entry enforcement. This return may be measured in terms of productivity for various outputs (e.g., service contacts or vehicles weighed per dollar spent), or in terms of compliance as a proxy for effectiveness. The latter measure might be estimated as revenues generated by enforcement for every dollar spent.[9]

Summary of Operational Measures

Ideally, a port of entry performance measurement plan would account for several or all of the preceding categories. This need not imply that all port of entry activities have the same importance, or that the chosen measurements all be reported on the same scale. However, limiting performance measurement to a single category not only excludes program achievements in other essential functions, but also omits any reference to the influence of one operational category on another.

For example, safety inspections require significantly more time per inspection than static scale weighing. A facility measuring performance solely in terms of vehicles weighed would likely suffer a drop in performance in a month during which more safety inspections were performed. But in terms of output, the facility may have achieved the same level or even an improvement, once the disparity in hourly "cost" of each activity is considered.

At some point, it becomes necessary to weigh the expected benefit of various activities against the productivity cost that each activity imposes on operations. However, acting on such an assessment may be outside the authority of program managers. For example, if managers determined that issuing permits was not "worth" the loss of productivity that this process hypothetically created, they would not necessarily have the authority to discontinue issuing permits at state ports of entry. In a case where program responsibilities are mandated by the state, the most useful tool that a manager has for influencing decision makers is a broad evaluation of program activities that clearly communicates the tradeoffs associated with each.

To better illustrate the wide range of Arizona Port of Entry responsibilities, several measures have been developed to evaluate port productivity, and to emphasize the effects of port enforcement on a wider scale. These measures are discussed in the following chapter.

[9] Revenues per dollar can not be considered a measure of productivity, as officers have no influence over the rates charged for permits or the fees assessed for violations. However, the extent to which fees are paid or collected does reflect an outcome of enforcement, as it is reasonable to conclude that a substantial portion of revenues would not be paid if little or no enforcement were in effect.

IV. ARIZONA PORT OF ENTRY PERFORMANCE MEASUREMENT

The Motor Vehicle Enforcement Services Subprogram used several performance measures in recent reports. While the Motor Vehicle Division maintains a wider range of enforcement measures related to Port of Entry activities, the following measures of performance have been used to gauge performance of the Enforcement Services Subprogram and to set goals for improvement [State of Arizona 2002; Johns and D.M. Griffith and Associates 1998]:

- Pre-cleared inbound commercial vehicles as a percentage of POE traffic (1997)
- Traffic waved through (not screened) at ports of entry (1997, 2001)
- Number of commercial vehicles violating size and weight restrictions (2001)

Two studies in the past five years have addressed performance measurement for the Motor Vehicle Enforcement Services (MVES) Subprogram of the Arizona Motor Vehicle Division. In fiscal 1997, the MVES subprogram set the following goals. First, to increase the percentage of pre-cleared inbound trucks from 4.5 percent to 15.0 percent by fiscal year 2000. Second, to reduce the number of vehicles waved-through the ports without screening by 25 percent in the first year. The second year target for wave-through reductions was 50 percent, and increased to 100 percent for fiscal 2000 and thereafter. These measures are shown in Table 14.

Table 14: Ports and Enforcement Services Performance Measures, FY 1997

Performance Measure	FY 1997	FY 1998		FY 1999		FY 2000	
	Actual	Goal[1]	Actual	Goal[1]	Actual	Goal[1]	Actual
Increase percentage of pre-cleared[2.] inbound commercial vehicles at ports of entry	4%	5%	9.5%	10%	15.2%	15%	16.7%
Reduce level of waved through[3.] traffic at all ports of entry	419,164	314,373	271,184	209,582	273,114	0	395,765

Notes: 1) Goals reported as percentage for pre-cleared vehicles and reduction from 1997 values for wave-through traffic. 2) Pre-cleared vehicles are authorized to pass through ports by means of electronic credential verification. 3) Waved through vehicles are unable to be inspected due to safety requirements and capacity constraints at the ports of entry.

Source: Veucasovic, Mike, Motor Vehicle Division (MVD) Deputy Director, in Johns, J.P., and D.M. Griffith and Associates. *Arizona Department of Transportation Motor Vehicle Division Organizational Study*. Burlingame, CA (Apr 1998).

In fiscal 2001, the MVES subprogram goals were modified. The pre-clearance target was abandoned in favor of a new measurement. For fiscal 2002, a new target was set for the number of vehicles detected by mobile enforcement units as violating weight or size standards. This target was increased annually from 850 vehicles in fiscal 2002 to 2,200 violators in fiscal 2006. The wave-through metric was retained in the second plan, but the measurement was changed from the number of vehicles to the percentage of traffic

waved-through the ports of entry. The performance target for wave-throughs was set at 3.0 percent of traffic from fiscal 2002 to 2006. A summary of the more recent performance targets is shown in Table 15.

Table 15: Motor Vehicle Enforcement Services Performance Measures, FY 2000

	Fiscal Year						
Performance Measure	**2000[a]**	**2001[a]**	**2002[a,b]**	**2003[b]**	**2004[b]**	**2005[b]**	**2006[b]**
No. of weighed vehicles detected by mobile enforcement as violating size/weight standards	572	675	850	1,200	1,500	2,000	2,200
% of vehicles waved through at POEs during hours of operation	5.48	7.10	6.12[(a)] 3.00[(b)]	3.00	3.00	3.00	3.00

Notes: a) Actual fiscal year data; b) Forecast of target goals
Source: Motor Vehicle Enforcement Services Subprogram Strategic Plan, 2001 [State of Arizona 2002]

EXISTING MEASUREMENTS VERSUS GOALS AND INITIATIVES

The stated performance targets of the MVES subprogram for fiscal 1997 and 2001 were reasonably aligned with the goals of the program. However, in some cases, the performance measurements were not the best indicators of program success. In both years, the first performance target identified had a tenuous relationship with the port performance and the goals of the program.

Increasing the percentage of pre-cleared vehicles has no clear relationship to port performance. Pre-clearance provides a better service to motor carrier customers in terms of time savings, and reduces the workload of POE staff. This, in turn could ostensibly reduce wave-throughs. But pre-clearance of trucks without weight screening is an incentive for abuse of the program, and is not an indicator of program effectiveness.[10]

The volume of traffic waved through ports is a reasonable measure of performance, and is well aligned with the stated mission of the POE program. Port managers have much greater control over managing staff workflow and port traffic clearance in comparison to influencing the adoption of pre-clearance technology. However, the fiscal 1997 performance goals for reducing wave-through traffic were problematic for two reasons. First, reliance on reduction in gross volume does not take into account potential changes in the traffic stream relative to port operating capacity. Second, the magnitude of the target reductions was clearly overstated. Despite an increase in pre-cleared traffic, wave-throughs increased dramatically from fiscal 1997 to 2000. As stated, the performance measurement did not provide any indication of what may have caused this decline in performance.

[10] Staff at the Kingman and Ehrenberg ports of entry stated that none of the PrePass systems in Arizona had operating weigh-in-motion sensors as of March 2002.

Vehicles waved through was retained as a performance measure in the second planning document, but the focus of the measure was improved by replacing gross volume with a standardized measure – percentage of port traffic waved through. The change makes for a more reliable indicator of performance by controlling for changes in port traffic levels. In other words, if the gross number of wave-throughs increases in line with traffic growth, no decrease in performance will be observed.

Interestingly, this approach was not taken for the other performance measure included in the 2001 MVES Strategic Plan. While not specific to port of entry operations per se, the number of weight and size violations detected by mobile crews could just as easily be applied to ports of entry. However, as in the case of pre-cleared traffic, the meaning of this target is ambiguous at best. Setting a performance target for a number of violations fails to account for the commercial, regulatory and economic changes that might influence traffic patterns and driver behavior.

Second, the expectation for enforcement (at least in theory) is that it will demonstrate some effectiveness in reducing the number of violators. In contrast, the implication of an increasing number of violations might be to demonstrate the ineffectiveness of enforcement. While it can be argued that a few thousand vehicles out of the whole traffic stream do not provide sufficient basis from which to evaluate regulatory compliance, a violation quota provides little context from which to assess the impact, if any, of enforcement.

Although each period had one performance measure of questionable value, the continued use of wave-through traffic as a measure of productivity provides several benefits. First, despite the fact that the metric calculation did not remain consistent, the intention of the measurement itself did not change. Both managers and personnel thus had long-term knowledge of program expectations, as well as an historical basis from which to evaluate performance. Second, the measurement was easily understood, and was improved in its second iteration in order to better gauge performance relative to changes in operating conditions. Similarly, the performance targets were refined to better capture plausible rates of success. Setting difficult but attainable goals based on clearly defined and, when necessary, refined measurements, is an illustration of effective performance management. The following sections expand on this example to provide the Arizona Ports of Entry with additional measurements that may enhance the scope of POE performance measurement and encompass a greater range of port activities.

RECOMMENDED PERFORMANCE MEASURES

This section discusses several measures of performance recommended for the Arizona Port of Entry Program. Performance measures have been categorized according to the type of measurement, and subcategorized by scope. The type of measurement includes two broad categories, output efficiency and outcome effectiveness. The scope of sub-categories refers to the recommended level of analysis, i.e., the individual port facility or the port of entry program in its entirety. Each measure is briefly discussed in terms of expected benefits and drawbacks, and is followed by a summary of recent data when

available. Most measures are recommended for annual review, but in some cases a monthly or weekly assessment is warranted.

Several measures have been recommended based on observed deficiencies in data collection and/or reporting. In these cases, data were generally not available for the recommended analysis, and the discussion is limited to the expected benefit of collecting the data and making the measurement. These measures have been developed to reflect the broad scope of POE responsibilities, and whenever possible, to normalize performance variables that may be influenced by changes external to the POE program. However, these recommendations are not conclusive or comprehensive, and it remains the responsibility of port of entry program managers to implement an appropriate performance measurement plan.

Measures of Efficiency: POE Outputs

Measures of efficiency or productivity are concerned with program output. The outputs chosen can be standardized in a number of ways, several of which have been considered in the measures below. The use of normalizing techniques ensures that measures are comparable from period to period and between program facilities. This standardization may be done based on variables under the control of port managers (e.g., hours of operation) or external factors such as the prevailing level of truck traffic. The following measures have been developed using multiple standardization techniques, and vary between fiscal and calendar year reporting, based on the most readily available data.

It is recommended that the final performance plan rely on a specific time period for all measurements in order to more effectively communicate trends in performance. Whenever possible, the following examples include multiple periods of analysis to facilitate trend identification over a longer term. Monthly data are reported for 18 to 24-month periods, and annual data are reported over five years.

Four measures of productivity are discussed in this section. At the facility level, service contacts per scheduled hour of operations, percentage of traffic waved through, and operational costs per service contact are evaluated. These same measures are considered for the port of entry program as a whole, along with an additional summary measure of vehicles processed per estimated mile of truck travel on state highways.

Measures of Productivity: Facility Level
1. Average service contacts per hour of operation.
2. Percent of traffic waved through.
3. Operational cost per service contact.

Measures of Productivity: Program Level
4. Annual number of vehicles processed per truck VMT.

Monthly Service Contacts per Hour of Operation

As a general measure of efficiency, the number of service contacts per hour of operation provides a broad view of overall activity at each port of entry. For this analysis, a service contact includes any direct contact between port staff and customers, from credential verification and static scale weighing to permit issuance and safety inspections. The productivity levels for each port can be compared to the entire program, or among ports with similar staffing and traffic profiles. Monthly service contacts per hour of operation for calendar 2000 and 2001 are shown in Tables 16 and 17.

Measuring service contacts has the benefit of clarity and simplicity. Port of entry managers can see instantly where changes in monthly activity occur. Resources can be deployed based on changes in the number of contacts per hour, and the number of contacts can be managed by focusing resources based on the frequency of various activities at different sites. Performance goals can be set based on the expected efficiency improvements from reallocation of resources to facilities with the greatest needs.

While this measurement is potentially useful as a summary, it also has several drawbacks. First, it encourages the deployment of resources to higher volume ports during the busiest traffic periods. While these may be effective strategies for managing workflow, it is possible that additional enforcement would not have a commensurate increase in effectiveness at these locations or time periods.

Second, as shown in Tables 16 and 17, the measurement does not control for existing staffing levels. A potential solution to these problems would be to replace hours of operation with total staff hours. This would alleviate the bias toward the busiest ports and busiest times of the day, but would eliminate the benefit of reporting facility flow, which is a reliable indicator of the potential for capacity problems. Measuring by hour of operations gives a clearer indication of which ports are experiencing the greatest difficulty in managing traffic flow. By combining this measure with the next two, wave-through rate and operating costs, a more comprehensive picture of port operations emerges.

Monthly Percentage of Traffic Waved Through

The percentage of vehicles waved through Arizona Ports of Entry has been maintained as a recommended measure from previous MVES plans. However, it is useful to consider the impact of individual ports on the program measurement. This added level of detail is particularly effective as a complementary measure to service contacts by each facility. The percentage of traffic waved through each port of entry demonstrates the impact that service contact volume has on efficiency. Percentage of traffic waved through Arizona Ports of Entry on a monthly basis is summarized in Tables 18 and 19.

Replacing gross counts with percentages allows for the identification of operating inefficiencies regardless of port size. For example, the gross number of wave-throughs at

the Sasabe POE from 2000 to 2001 was negligible in terms of overall program outputs, but represented a sizable percentage of traffic at the Sasabe facility. Comparison of wave-through percentages to service contact volume can help managers focus on potential inefficiencies, whether in terms of staff productivity or facility design.

For example, consider the difference between the Ehrenberg and San Simon facilities. Both locations averaged roughly 90 service contacts per scheduled hour of operation from 2000 to 2001. Approximately 6 percent of traffic was waved through at San Simon, whereas coverage at Ehrenberg was much lower. The Ehrenberg facility waved through 23 percent of traffic in 2000 and 33 percent of traffic in 2001. Clearly, the Ehrenberg facility is affected by an operational inefficiency that is not as significant at the San Simon location. As will be discussed in the subsequent measure of cost per contact, Ehrenberg has comparable costs to San Simon, indicating similar staffing levels and output per staff member. The operational problems at Ehrenberg are thus likely to be a function of facility design.

Unit Cost per Customer Service Contact

The third measure of performance recommended at the facility level is the monthly operating cost per customer service contact. These costs for Arizona Ports of Entry are shown in Tables 20 and 21. Using operating costs to standardize service volume outputs meets the same objective as using staff hours, but also permits managers to control for variation in non-staff costs at each location.

The values in Tables 20 and 21 have been indexed to inflation in order to provide an unbiased summary of the cost of output at each port. When combined with the two prior measures, the program manager can see the total output per hour of operation at a facility, the impact of service volumes on port capacity and traffic coverage, and the marginal outlay necessary to achieve a given level of productivity. These measures of efficiency can be considered separately, but the most reliable performance summary evaluates all three variables.

Setting goals based on the preceding metrics might best be done using two measurements as a baseline and a third to set targets. For example, returning to the Ehrenberg facility, the port output per hour and operating costs are both in line with results achieved at San Simon. Because these two metrics are comparable to the measurements taken at a similar facility, it makes the most sense to use them as a baseline from which to evaluate changes aimed at improving the wave-through ratio. Similar service volume and costs also indicate that the problem at the Ehrenberg facility is likely a function of capacity – higher traffic volumes at Ehrenberg may be the cause of the wave-throughs, as the current level of service output approaches the maximum capacity of the port. In this case, a goal might be set for a capital improvement project to reduce the wave-through ratio by a target percentage, with no change in the baseline conditions of service volume and operating costs per customer contact. The same process would be useful for evaluating one or more changes in operating conditions at the program level.

Table 16: Monthly Service Contacts per Scheduled Hour of Operations, Jan 2000 to Dec 2000

Port of Entry[1,2]	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	2000
Douglas State	7.14	7.48	5.21	5.20	5.63	5.80	3.38	4.39	3.72	3.98	3.57	2.91	4.87
Douglas Federal	16.60	18.32	17.24	16.05	19.77	17.07	13.39	17.42	12.99	14.43	15.09	13.36	15.98
Duncan	3.18	3.35	3.60	3.53	3.04	3.41	2.68	2.71	2.07	2.01	1.51	1.80	2.74
Ehrenberg	89.74	123.50	97.48	96.68	91.31	97.82	89.02	91.88	95.84	103.21	79.78	57.19	92.79
Fredonia	3.03	3.50	4.36	7.42	6.10	6.81	4.89	7.64	5.16	6.09	6.01	2.65	5.30
Kingman	24.93	27.86	27.48	26.98	26.64	27.41	24.89	27.19	25.54	21.09	3.48	3.38	22.24
Lukeville	1.83	2.22	3.07	0.62	0.49	0.72	3.21	3.20	2.64	3.17	2.60	1.46	2.10
Naco	5.63	4.76	5.70	5.15	5.32	3.99	3.75	4.67	3.69	3.04	5.38	4.10	4.60
Nogales[2.]	149.39	160.01	144.26	141.44	119.86	69.24	15.97	13.40	8.91	38.32	84.17	104.57	87.46
Page	2.83	4.09	3.43	4.15	4.41	4.77	3.83	4.45	4.19	3.64	2.76	2.83	3.78
Parker	2.43	2.75	2.84	1.36	1.70	2.07	1.29	2.33	1.90	2.26	3.12	3.48	2.29
Sanders	181.02	197.75	175.34	196.92	197.97	211.63	204.41	224.35	214.46	208.09	193.05	170.88	197.99
San Luis	12.74	19.08	15.91	10.27	9.53	7.03	9.67	9.92	7.77	9.17	10.35	10.48	10.99
San Simon	98.31	112.08	104.72	95.08	92.71	83.74	79.53	147.16	67.69	69.36	74.12	63.14	90.64
Sasabe	0.90	0.93	0.42	0.05	0.01	0.69	0.82	1.19	0.92	1.00	0.86	0.94	0.73
Springerville	27.09	33.35	30.08	33.01	31.53	33.63	21.37	6.26	21.08	33.18	-	28.57	24.93
St. George	63.86	66.05	66.24	70.52	71.80	72.01	63.43	70.79	56.44	56.98	47.94	46.76	62.74
Teec Nos Pos	2.15	2.26	2.85	2.64	2.62	2.16	2.62	2.74	2.63	2.64	2.58	2.53	2.54
Topock	73.65	81.26	76.67	79.90	83.76	87.46	80.02	91.61	87.43	84.50	80.53	67.34	81.18
Yuma B-8	8.89	9.59	8.43	6.32	6.53	8.40	5.76	7.11	5.76	6.80	8.48	8.75	7.57
Yuma I-8	61.44	68.03	64.08	30.46	28.78	28.48	23.90	23.54	23.12	29.35	42.30	58.84	40.19
All Ports Of Entry	**47.76**	**54.20**	**49.17**	**47.75**	**46.79**	**46.20**	**40.66**	**48.08**	**40.84**	**42.37**	**39.99**	**37.63**	**45.12**

Notes: 1. Service contacts defined as number of vehicles processed, excluding pre-cleared vehicles, plus number of permits issued. 2. Nogales POE experienced extreme fluctuations in monthly activity, most likely due to the influence of agricultural seasons on commercial vehicle activity.

Table 17: Monthly Service Contacts per Scheduled Hour of Operations, Jan 2001 to Dec 2001

Port of Entry[1,2]	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	2001
Douglas State	3.53	2.78	3.03	3.41	3.36	3.24	3.25	2.72	3.48	4.70	3.19	2.51	4.57
Douglas Federal	11.31	10.70	10.33	10.99	10.63	11.00	10.57	9.76	9.80	11.00	9.95	8.32	15.54
Duncan	1.54	1.87	1.60	1.69	1.01	1.33	1.74	2.65	2.43	2.28	0.65	0.66	2.60
Ehrenberg	67.34	71.25	57.09	80.05	68.10	66.83	62.74	72.59	64.13	56.84	43.85	48.18	90.92
Fredonia	1.80	1.89	1.89	1.37	2.64	2.36	0.88	1.27	1.34	2.11	1.10	1.41	5.20
Kingman	3.58	14.41	5.15	4.65	3.19	4.33	3.89	5.10	2.57	2.89	1.63	2.33	20.46
Lukeville	1.52	1.72	1.20	2.07	2.29	0.69	3.08	4.27	3.45	3.24	3.21	1.54	2.08
Naco	4.40	6.39	4.43	4.29	5.49	3.34	2.95	2.53	2.09	5.10	3.69	2.27	4.50
Nogales	156.67	167.21	171.89	136.59	127.92	84.17	37.48	34.95	30.63	48.82	78.70	91.30	88.07
Page	2.66	2.31	3.08	3.21	3.90	3.88	3.18	3.67	2.94	3.83	3.47	2.30	3.77
Parker	3.53	3.54	2.86	2.50	2.26	3.16	2.08	2.94	2.98	3.06	3.16	3.08	2.39
Sanders	152.55	170.21	170.26	177.94	170.92	202.58	179.70	179.35	170.26	185.29	172.00	153.81	195.62
San Luis	13.73	14.89	15.36	10.20	7.49	5.29	4.58	0.70	3.41	0.60	6.55	8.00	11.07
San Simon	68.26	65.91	64.95	63.77	73.96	75.14	72.64	71.05	135.94	4.26	75.89	76.88	88.13
Sasabe	-	-	-	-	-	1.42	0.76	-	0.04	-	0.01	0.03	0.65
Springerville	30.84	27.29	31.27	30.93	31.53	34.92	32.84	31.80	35.24	33.95	30.28	28.07	25.24
St. George	54.49	53.15	60.15	66.06	72.90	79.58	71.22	73.62	70.87	72.98	49.79	44.35	61.95
Teec Nos Pos	2.48	2.23	2.18	2.25	2.31	2.51	2.42	2.76	2.52	2.54	3.17	2.29	2.56
Topock	59.54	67.28	73.50	79.50	67.00	66.32	65.94	89.51	82.18	72.50	64.58	47.78	80.00
Yuma B-8	10.35	11.63	10.52	7.04	6.55	7.64	6.92	7.26	6.84	7.95	9.32	8.15	7.69
Yuma I-8	62.75	63.46	70.35	35.55	31.71	29.14	22.99	19.81	22.38	27.16	45.05	55.51	40.30
All Ports Of Entry	**39.76**	**42.59**	**42.45**	**41.25**	**39.63**	**40.58**	**35.67**	**37.96**	**40.10**	**32.68**	**35.72**	**34.16**	**44.45**

Notes: 1. Service contacts defined as number of vehicles processed, excluding pre-cleared vehicles, plus number of permits issued. 2. Nogales POE experienced extreme fluctuations in monthly activity, most likely due to the influence of agricultural seasons on commercial vehicle activity.

Table 18: Percentage of Port Traffic Waved Through, Jan 2000 to Dec 2000

Port of Entry[1,2]	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	2000
Douglas State	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Douglas Federal	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Duncan	0.0%	0.0%	0.4%	0.0%	0.0%	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%
Ehrenberg	23.1%	18.6%	24.5%	22.2%	26.3%	24.9%	23.3%	26.0%	20.2%	18.1%	24.8%	33.1%	23.4%
Fredonia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Kingman	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lukeville	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Naco	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nogales	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Page	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Parker	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sanders	8.6%	4.0%	5.5%	4.2%	4.0%	2.7%	2.5%	2.1%	3.0%	5.4%	6.3%	5.2%	4.4%
San Luis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
San Simon	8.6%	3.5%	6.8%	6.8%	6.0%	7.2%	4.2%	2.8%	5.3%	6.3%	9.2%	4.2%	5.8%
Sasabe	11.1%	12.7%	0.0%	0.0%	n/a	9.9%	0.0%	33.4%	0.0%	0.0%	0.0%	0.0%	9.6%
Springerville	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	n/a	0.0%	0.0%
St. George	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Teec Nos Pos	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Topock	0.1%	0.0%	0.0%	0.0%	0.0%	0.6%	2.2%	2.6%	3.5%	5.2%	4.9%	2.3%	1.8%
Yuma B-8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	0.0%	0.0%	0.0%	0.3%
Yuma I-8	2.3%	1.9%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.8%	0.9%
All Ports Of Entry	**7.3%**	**5.0%**	**6.5%**	**5.8%**	**6.2%**	**6.0%**	**5.5%**	**5.1%**	**5.6%**	**6.2%**	**7.7%**	**7.0%**	**6.1%**

Notes: 1. Table refers to vehicles permitted to bypass port of entry during normal operating hours without screening by port staff or electronic credential verification. "Wave-throughs" usually occur when a port has reached its staging capacity and lacks queue space for additional vehicles. 2. Listing of "n/a" indicates that the port of entry did not record any through-traffic for the corresponding period.

Table 19: Percentage of Port Traffic Waved Through, Jan 2001 to Dec 2001

Port of Entry[1,2]	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	2001
Douglas State	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Douglas Federal	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Duncan	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.2%	0.1%
Ehrenberg	37.5%	29.3%	30.9%	36.1%	35.9%	32.1%	36.3%	30.7%	32.3%	32.5%	40.3%	26.2%	33.4%
Fredonia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	21.2%	5.6%	0.0%	0.0%	0.0%	2.2%
Kingman	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lukeville	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Naco	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nogales	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Page	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	0.3%	0.1%
Parker	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sanders	7.0%	7.5%	9.2%	6.4%	6.8%	4.9%	2.6%	6.5%	3.4%	6.0%	4.9%	4.8%	5.8%
San Luis	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	n/a	0.0%	0.0%	0.0%	0.0%	0.0%
San Simon	10.5%	14.7%	14.3%	5.3%	5.6%	3.8%	4.9%	3.1%	1.0%	3.4%	5.0%	5.7%	6.1%
Sasabe	n/a	n/a	n/a	n/a	n/a	8.5%	0.0%	n/a	0.0%	n/a	0.0%	0.0%	5.5%
Springerville	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
St. George	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Teec Nos Pos	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	6.4%	5.5%	1.0%
Topock	0.1%	0.2%	0.0%	0.0%	1.5%	0.5%	6.3%	19.6%	3.6%	6.7%	4.2%	0.7%	4.2%
Yuma B-8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Yuma I-8	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
All Ports Of Entry	**9.7%**	**8.7%**	**8.4%**	**7.8%**	**7.8%**	**6.3%**	**7.8%**	**9.8%**	**6.3%**	**8.0%**	**8.4%**	**5.6%**	**7.9%**

Notes: 1. Table refers to vehicles permitted to bypass port of entry during normal operating hours without screening by port staff or electronic credential verification. "Wave-throughs" usually occur when a port has reached its staging capacity and lacks queue space for additional vehicles. 2. Listing of "n/a" indicates that the port of entry did not record any through-traffic for the corresponding period.

Table 20: Inflation-Adjusted Monthly Operating Cost per Service Contact, Jan 2000 to Dec 2000

Port of Entry[1,2]	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	2000
Douglas State	$5.31	$1.37	$1.50	$1.52	$2.06	$1.37	$3.84	$2.72	$3.32	$3.49	$5.33	$9.95	$3.48
Douglas Federal	$1.06	$1.21	$1.12	$1.11	$1.40	$1.10	$1.99	$1.79	$2.46	$1.77	$1.61	$3.03	$1.64
Duncan	$1.74	$1.77	$1.50	$1.58	$2.75	$1.73	$3.05	$2.97	$3.89	$4.03	$5.44	$6.42	$3.07
Ehrenberg	$0.54	$0.36	$0.43	$0.40	$0.53	$0.50	$0.58	$0.51	$0.51	$0.48	$0.64	$1.15	$0.55
Fredonia	$2.13	$2.29	$1.51	$0.90	$1.61	$1.00	$2.03	$1.32	$2.02	$1.68	$1.64	$4.87	$1.92
Kingman	$0.74	$0.72	$0.65	$0.69	$1.00	$0.70	$1.33	$0.90	$0.97	$1.05	$7.09	$10.09	$2.16
Lukeville	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Naco	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Nogales	$0.19	$0.21	$0.21	$0.18	$0.29	$0.35	$1.85	$2.26	$3.53	$0.86	$0.54	$0.32	$0.90
Page	$3.79	$2.80	$3.07	$2.56	$3.54	$2.50	$4.75	$4.13	$4.54	$4.56	$5.30	$5.60	$3.93
Parker	$4.15	$4.40	$3.77	$7.95	$7.73	$4.58	$11.61	$4.89	$6.18	$5.36	$3.82	$5.30	$5.81
Sanders	$0.27	$0.27	$0.29	$0.25	$0.31	$0.28	$0.33	$0.30	$0.33	$0.37	$0.37	$0.57	$0.33
San Luis	$0.29	$0.39	$0.43	$0.69	$1.09	$1.02	$0.98	$0.95	$1.26	$1.04	$0.99	$1.28	$0.87
San Simon	$0.45	$0.41	$0.42	$0.44	$0.64	$0.47	$0.64	$0.34	$0.77	$0.68	$0.68	$1.09	$0.59
Sasabe	$22.67	$26.00	$59.71	$361.85	$6,040.51	$34.48	$33.23	$22.14	$29.49	$29.41	$35.58	$44.98	$63.60
Springerville	$0.76	$0.68	$0.69	$0.65	$1.00	$0.64	$1.24	$4.50	$1.31	$0.85	n/c	$1.39	$1.25
St. George	$0.58	$0.69	$0.54	$0.51	$0.74	$0.55	$0.73	$0.63	$0.82	$0.83	$1.05	$1.41	$0.76
Teec Nos Pos	$9.82	$6.71	$4.98	$5.12	$7.69	$6.64	$6.61	$6.49	$6.98	$6.65	$6.75	$10.02	$7.04
Topock	$0.59	$0.57	$0.55	$0.53	$0.72	$0.48	$0.67	$0.59	$0.64	$0.64	$0.67	$1.12	$0.65
Yuma I-8	$0.62	$0.58	$0.60	$1.19	$1.82	$1.22	$2.06	$2.00	$2.18	$1.71	$1.24	$1.28	$1.37
All Ports Of Entry	**$6.26**	**$5.81**	**$5.63**	**$11.50**	**$17.01**	**$13.18**	**$19.94**	**$19.52**	**$20.49**	**$15.95**	**$11.40**	**$10.90**	**$13.13**

Notes: 1. Listing of "n/a" indicates that the port of entry did not record any operating costs for the corresponding period. 2. Listing of "n/c" indicates that the port of entry did not record any through-traffic for the corresponding period.

GDP Deflator 1996 = 100	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
	106.07	106.07	106.07	106.68	106.68	106.68	107.12	107.12	107.12	107.68	107.68	107.68

Table 21: Inflation-Adjusted Monthly Operating Cost per Service Contact, Jul 2000 to Jun 2001

Port of Entry[1,2]	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	FY 2001
Douglas State	$3.84	$2.72	$3.32	$3.49	$5.33	$9.95	$5.41	$7.81	$7.80	$5.45	$4.32	$6.78	$5.52
Douglas Federal	$1.99	$1.79	$2.46	$1.77	$1.61	$3.03	$2.87	$3.48	$2.17	$2.38	$3.94	$2.65	$2.51
Duncan	$3.05	$2.97	$3.89	$4.03	$5.44	$6.42	$5.14	$4.91	$6.04	$6.02	$8.09	$9.17	$5.43
Ehrenberg	$0.58	$0.51	$0.51	$0.48	$0.64	$1.15	$0.73	$0.71	$0.79	$0.59	$0.68	$1.09	$0.70
Fredonia	$2.03	$1.32	$2.02	$1.68	$1.64	$4.87	$5.33	$6.09	$5.26	$7.51	$3.22	$7.36	$4.03
Kingman	$1.33	$0.90	$0.97	$1.05	$7.09	$10.09	$7.15	$1.57	$4.34	$5.17	$7.53	$8.25	$4.62
Lukeville	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$0.84	$1.76	n/a	$1.30
Naco	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$0.02	n/a	$0.02
Nogales	$1.85	$2.26	$3.53	$0.86	$0.54	$0.32	$0.19	$0.15	$0.15	$0.21	$0.18	$0.39	$0.89
Page	$4.75	$4.13	$4.54	$4.56	$5.30	$5.60	$3.83	$6.24	$3.77	$3.59	$3.14	$4.43	$4.49
Parker	$11.61	$4.89	$6.18	$5.36	$3.82	$5.30	$4.44	$4.00	$3.53	$4.50	$5.16	$4.64	$5.29
Sanders	$0.33	$0.30	$0.33	$0.37	$0.37	$0.57	$0.43	$0.45	$0.40	$0.39	$0.45	$0.58	$0.41
San Luis	$0.98	$0.95	$1.26	$1.04	$0.99	$1.28	$0.72	$0.70	$0.65	$1.75	$1.56	$3.39	$1.27
San Simon	$0.64	$0.34	$0.77	$0.68	$0.68	$1.09	$0.79	$0.83	$0.83	$0.86	$0.78	$1.19	$0.79
Sasabe	$33.23	$22.14	$29.49	$29.41	$35.58	$44.98	n/c	n/c	n/c	n/a	n/c	$13.05	$17.32
Springerville	$1.24	$4.50	$1.31	$0.85	n/c	$1.39	$0.84	$1.15	$0.83	$0.95	$0.93	$1.21	$1.38
St. George	$0.73	$0.63	$0.82	$0.83	$1.05	$1.41	$1.13	$1.01	$0.84	$0.80	$0.70	$1.02	$0.91
Teec Nos Pos	$6.61	$6.49	$6.98	$6.65	$6.75	$10.02	$7.08	$8.67	$8.09	$8.12	$8.18	$10.72	$7.86
Topock	$0.67	$0.59	$0.64	$0.64	$0.67	$1.12	$0.92	$0.84	$0.67	$0.62	$0.68	$1.05	$0.76
Yuma I-8	$2.06	$2.00	$2.18	$1.71	$1.24	$1.28	$0.86	$0.88	$0.74	$1.50	$1.66	$2.54	$1.55
All Ports Of Entry	**$19.94**	**$19.52**	**$20.49**	**$15.95**	**$11.40**	**$10.90**	**$7.69**	**$7.83**	**$6.40**	**$13.07**	**$14.73**	**$23.99**	**$14.33**

Notes: 1. Listing of "n/a" indicates that the port of entry did not record any operating costs for the corresponding period. 2. Listing of "n/c" indicates that the port of entry did not record any through-traffic for the corresponding period.

GDP Deflator 1996 = 100	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01
	107.12	107.12	107.12	107.68	107.68	107.68	108.65	108.65	108.65	109.32	109.32	109.32

Vehicles Processed per Truck Miles of Travel

In contrast to the preceding measures that specifically control for port operating conditions, program output might also be standardized in terms of vehicle traffic. Table 22 depicts one such measurement. In this case, an estimate of statewide truck traffic (vehicle miles of travel) is used as a baseline from which to compare program outputs. The performance metric is vehicles processed, which includes vehicles that have crossed the port scales and/or had manifest and credentials verified by port officers. Processing is distinct from service contacts in that it does not include such port activities as issuing permits and writing citations. These activities have been omitted because the metric is intended to represent program coverage in the same sense as wave-throughs, but on a broader scale. The target measurement is a reasonable estimate of the proportion of truck traffic presumed to have been screened by POE enforcement.

Table 22: Vehicles Processed at Ports of Entry per Million Truck Miles of Travel

Calendar Year	Vehicles Processed	Total Truck VMT (millions)	Processed per Million VMT	Fiscal Year	Vehicles Processed	Total Truck VMT (millions)	Processed per Million VMT
1997	6,236,217	4,291	1,453	1997	5,684,060	4,322	1,315
1998	6,040,933	4,650	1,299	1998	6,052,611	4,470	1,354
1999	5,669,936	4,873	1,164	1999	5,789,550	4,762	1,216
2000	5,352,202	5,022	1,066	2000	5,627,224	4,948	1,137
2001	4,539,435	5,214	871	2001	4,883,649	5,118	954

Notes: 2001 estimate based on projection of 10.5 percent of total VMT, Arizona Simplified Highway Cost Allocation Model

A "coverage" metric considers the output of the enforcement program in terms of utility. It is meant to answer questions such as "Do the ports of entry screen a meaningful share of traffic?" and "Has POE output kept pace with traffic volume changes?" The benefit of this type of measurement is that it is independent of port hours of operation and provides a less biased ratio than port traffic, the latter being limited to traffic recorded during hours of operation.

However, as will be observed in the following section, external variables present additional challenges for data collection and interpretation. Vehicle miles of travel are often estimated based on extrapolation from small, infrequently collected samples, and are therefore subject to considerable yearly fluctuation. This problem is mitigated in part by using statewide estimates, but the potential for error still exists. A related measure that might be more useful if the data were readily available, would be the total traffic volume as measured at an ATR location downstream of the port of entry. This would more closely tie port performance to the vehicle population targeted by the ports for enforcement (i.e., interstate carriers). However, intrastate travel is a significant component of truck miles, and a program-wide assessment of enforcement output should focus on the entire traffic stream.

Measures of Effectiveness: Enforcement Outcomes

The measurement of enforcement outcomes is considerably more complicated than developing measures of efficiency. As long as incentives exist for motor carriers to circumvent existing regulations, it is not rational to expect enforcement to result in 100 percent compliance. As with any activity, commercial vehicle enforcement is subject to diminishing returns on investment. In other words, there will come a point when an increase in the level of enforcement will yield negligible returns in terms of compliance.

The effectiveness of an enforcement program is also subject to a wide range of confounding influences. For example, an increase in enforcement levels such as longer hours of operation at ports of entry might be expected to create an increase in the number of vehicles cited for weight violations. This might in turn lead to the expectation that overweight vehicle traffic will decrease. However, if the increase in port enforcement is concurrent with such events as a reduction in penalties for weight violations, an increase in shipping rates due to greater marketplace demand, or a reduction in interior enforcement as resources are shifted to ports of entry, the net result could be no change or even an increase in overweight traffic.

The preceding examples are not intended to dissuade attempts to measure the effectiveness of Arizona's port of entry program. However, when assessing the outcome of enforcement activity, it should be noted that enforcement is only one of a variety of factors that influence behavior. Unrealistic expectations of effectiveness can result from setting goals that do not consider incentives to avoid regulation.

It is not practical to rely on measures of effectiveness for day-to-day decision making for a number of reasons. First, the relationship between enforcement and other influences on behavior may confound any direct assessment of performance. While a longer term analysis may be able to account for multiple variables, using this information for short-term decision making would subject the planning process to volatile and unreliable data.

Second, as with any enforcement program, there will be a delay between program changes and any pending influence on target behavior. In other words, a change in motor carrier enforcement strategies may not have an immediate discernible impact on motor carrier business practices. It is far more likely that the costs borne by carriers as a result of heightened enforcement will be recognized only after some time has elapsed. The amount of time that a change in enforcement takes to elicit a change in behavior will also vary by enforcement strategy, driver profiles and business realties.

Third, as discussed in the previous section, many of the data sets used to normalize effectiveness are inherently unreliable. Variables such as weigh-in-motion scale data and vehicle miles of travel are subject to a range of potential errors, including limited sampling, sample bias, classification and calibration errors, and non-representative extrapolation. Aggregating multiple collection sites and longer periods of data collection can reduce the magnitude of potential error, but may not lessen the possibility for variance in data to skew performance results.

For the purposes of this study, several measures of effectiveness have been developed to more effectively communicate the value of the MVES Port Of Entry operations. These measures use a variety of methods to normalize data, but it bears repeating that the potential for errors in estimation may be significant. Nonetheless, any analysis of the effectiveness of enforcement activities must be made in terms of the target population for the enforcement effort. While the means of measuring motor carrier population characteristics may be imprecise, the analysis of performance in terms of program outcomes would not be worthwhile if these characteristics were not considered.

Eight measures of effectiveness are discussed in this section. Impacts on revenue collection, overweight traffic and avoidance are discussed at both the facility level and for the program as a whole. Additional measures at the program level attempt to quantify benefits associated with some enforcement activities.

Measures of Outcome: Facility Level
1. Revenues per dollar of operating cost.
2. Facility enforcement and estimated number of overweight vehicles.
3. Effect of facility enforcement on bypass route traffic.

Measures of Outcome: Program Level
4. Revenue collected per estimated truck VMT.
5. Program enforcement and estimated number of overweight vehicles.
6. Estimated benefit of safety inspections.
7. Estimated benefit of load shifting and reduction.
8. Pre-cleared vehicle violation rate.

Measures of effectiveness are grouped for discussion based on the unit of measurement. For example, the analysis of revenue-based measurements for the entire program is followed by revenue-based outcomes on a per-facility basis. Insufficient data were available for calculation of two of the above measures: bypass route traffic and violation rates for pre-cleared vehicles. However, these measures are discussed as potential means of isolating significant portions of the violator population. In both cases, it is conceivable that the port of entry program could collect the necessary data with little additional effort, and the insights afforded by these measures have the potential to improve program effectiveness.

Port Revenue Collections per Estimated Mile of Truck Travel

Perhaps the simplest measure of port of entry effectiveness is the relationship between revenue collections and miles traveled by trucks in Arizona. A principal goal of the Port of Entry program is to ensure the timely remittance of fees and taxes to the State Highway User Revenue Fund (HURF). In addition to the direct collection of commercial user revenues, the ports of entry have been credited with an indirect impact on fee compliance of approximately ten times the direct collections at the ports of entry [Arizona Department of Transportation 2001]. This measure is intended to reflect

the degree to which fee compliance is elicited by ports of entry, whether voluntarily in the form of permits, or involuntarily in the form of citations. The indirect impact of port enforcement on total revenues remitted by motor carriers should also be evaluated. While the ports of entry cannot claim full responsibility for these payments, it is quite likely that payment of specific fees is influenced by the level of enforcement. In other words, the violation rate for motor carrier taxes and fees is expected to demonstrate an inverse relationship to the probability that a violator will be caught.

The figures presented in Table 23 appear to support this assumption. Port of entry revenue collections declined steadily from fiscal 1997 to fiscal 2001, even as truck miles of travel on Arizona roads increased. The payment of motor carrier taxes and apportioned registration fees to the HURF also exhibited a declining trend, though with greater variability than port revenue collections.

Table 23: Revenues Collected per Truck-Mile of Travel, Fiscal 1997 to 2001

Port Revenue Collections and Truck VMT[1.]	**Fiscal Year**				
	1997	**1998**	**1999**	**2000[3.]**	**2001[3.]**
Program Revenue	$18,879,779	$17,047,585	$15,980,921	$14,796,879	$14,153,149
POE Revenue	$17,215,192	$15,062,783	$13,817,076	$12,671,153	$11,757,317
HURF Revenue[1.]	$125,501,357	$101,617,805	$94,700,132	$106,829,364	$91,435,298
Truck VMT(000)[2.]	4,321,574	4,470,266	4,761,522	4,947,516	5,117,924
Revenue/ VMT (thousands)[1.]					
MVES Program[4.]	$4.369	$3.814	$3.356	$2.991	$2.765
POE Study Group	$3.984	$3.370	$2.902	$2.561	$2.297
HURF Subgroup[1.]	$29.041	$22.732	$19.889	$21.593	$17.866

Notes: 1. Highway User Revenue Fund (HURF) subgroup collections consider only motor carrier tax and apportioned registration fees. 2. Combination truck VMT reported in thousands. 3. VMT for calendar years 2000-2001 based on forecast distribution of combination vehicle traffic on rural and urban systems using Arizona HPMS data and the Arizona Simplified Highway Cost Allocation Model, 2000. 4. Program information includes mobile enforcement units and the Phoenix central permits operation.

For fiscal 1997 to 2001, the number of vehicles weighed at ports of entry had a correlation of 83.1 percent with POE revenue collections, and a 67.9 percent correlation with total HURF collections of motor carrier taxes and apportioned registration fees. The ratio of vehicles weighed to truck VMT was even more highly correlated to revenues. The ratio of vehicles weighed to truck VMT was 91.3 percent correlated with POE revenues and 72.2 percent correlated with motor carrier and apportioned registration fee collections. When compared to the declining motor carrier revenue collections at ports of entry and by the HURF, the correlation of these variables indicates a drop in compliance and a decrease in the effectiveness of enforcement. The results displayed in Table 23 also indicate that the collection of fees has shifted from ports of entry to mobile enforcement units and the Phoenix central permitting facility. Port of entry revenue collections represented 91.2 percent of MVES revenues in fiscal 1997. By fiscal 2001, the share of revenues collected at ports of entry fell to 83.1 percent.

Port Revenues per Dollar of Operating Cost

A related measure considers the amount of revenues collected by ports of entry versus the cost to the state of running the ports. This measurement has the added benefit of being easily subdivided among individual facilities, so that analysts can easily ascertain the revenue returned by each dollar of spending at different locations. Given the decline in revenues collected at ports of entry, the return on investment in performance would be expected to fall unless operating costs were reduced. However, it is plausible that an increase in certain types of investment could produce a greater yield through enhanced productivity and greater screening capacity at ports of entry.

Port revenue collections per dollar of operating cost for fiscal 1997 to 2001 are shown in Table 24. As indicated in the table, the ports with the largest volume of traffic generally exhibit the highest revenue collections per variable dollar of spending.[11] However, with the exception of the Nogales and San Luis facilities, which have a large proportion of international traffic, revenue collections have generally fallen over the five year period.

Table 24: Port Revenues Collected per Dollar of Operating Cost

Port of Entry	FY1997	FY1998	FY1999	FY2000	FY2001
Douglas	n/a	$ 0.22	$ 0.27	$ 0.42	$ 0.43
Federal Customs	$ 0.31	$ 1.14	$ 1.20	$ 1.56	$ 0.80
Duncan	$ 0.62	$ 0.43	$ 0.41	$ 0.41	$ 0.29
Ehrenberg	$ 5.92	$ 4.74	$ 3.43	$ 3.35	$ 3.34
Fredonia	$ 0.85	$ 0.49	$ 0.87	$ 0.85	$ 1.03
Kingman	$ 2.65	$ 1.11	$ 0.91	$ 0.93	$ 0.93
Lukeville	$ 0.37	$ 0.77	n/a	n/a	n/a
Naco	$ 0.22	$ 0.58	n/a	n/a	n/a
Nogales	$ 14.84	$ 13.60	$ 15.05	$ 16.02	$ 19.41
Page	$ 0.78	$ 0.89	$ 0.84	$ 0.80	$ 0.85
Parker	$ 1.29	$ 0.67	$ 0.35	$ 0.29	$ 0.29
Sanders	$ 4.58	$ 3.40	$ 2.57	$ 2.26	$ 1.84
San Luis	$ 1.33	$ 1.80	$ 1.66	$ 4.54	$ 3.69
San Simon	$ 4.74	$ 3.80	$ 2.89	$ 3.12	$ 2.92
Sasabe	$ 0.09	$ 0.12	$ 0.15	$ 0.06	$ 0.05
Springerville	$ 0.66	$ 0.27	$ 0.19	$ 0.21	$ 0.13
St. George	$ 3.01	$ 2.82	n/a	$ 2.88	$ 2.26
Teec Nos Pos	$ 0.79	$ 0.61	$ 0.53	$ 0.53	$ 0.50
Topock	$ 3.92	n/a	$ 1.47	$ 1.11	$ 1.10
Yuma (Combined)	$ 3.62	$ 3.75	$ 3.25	$ 2.88	$ 2.35
All POEs Total[1.]	$ 4.24	$ 4.22	$ 3.58	$ 3.17	$ 2.95
Study POEs Subtotal[2.]	$ 3.86	$ 3.72	$ 3.10	$ 2.72	$ 2.45

Notes: 1. Includes Phoenix, mobile units and discontinued operations

2. Includes only continuing operations with positive values in each category

[11] This analysis focuses exclusively on variable costs such as employee compensation, travel and non-capital expenditures. It is assumed that fixed costs are largely outside the influence of the program.

The decline in revenues per dollar of spending has been dramatic in some cases (e.g., Parker and Springerville) and shown a slower erosion in others (e.g., Topock and St. George). In many cases, ports collect less revenue than the cost of operations. It might be argued that wages and other operating costs are subject to inflation, whereas tax rates are fixed for years. This argument is of particular significance in Arizona, since the motor carrier weight-mile tax was replaced by a flat fee structure in 1997. The flat fee has remained constant while inflation has driven operating costs higher. But while the disparity in price adjustment between port revenues and operating costs poses a challenge to port of entry managers, the comparison of these variables remains a valid measure of productivity.

The taxpayer is concerned with the value received for each dollar spent. If revenue collections kept pace with the growth in truck traffic, the inflation argument would carry more weight. But the inverse relationship between truck traffic and both port revenues and HURF collections indicates that improvements to the enforcement of motor carrier fees are likely needed. The port of entry program has made suggestions that may improve coverage and elicit greater compliance. These include facility overhauls to increase capacity, mainline weigh-in-motion, and internal inspection stations to induce compliance among intrastate carriers. However, these improvements will come at considerable cost to the taxpayer, and one or more metrics to illustrate the expected return from these investments, the relationship between compliance and enforcement, or the relative performance among regions with varied capital investment are recommended in order to ensure that spending is effectively deployed.

State System Enforcement and Number of Vehicles Overweight

The use of weigh-in-motion equipment to evaluate pavement loading and weight violation rates has received a great deal of attention in the literature. A study for the NCHRP [Hanscom 1998a] provided specific guidelines for the application of WIM scale readings as a measure of enforcement effectiveness. The WIM measures of performance can be used for an entire program, or when appropriate WIM stations exist, for the evaluation of a single facility.

The analysis of weigh-in-motion data can be applied at the program level to determine whether overweight vehicle traffic on the entire highway system is related to the intensity of weight enforcement activity. As indicated in Table 25, truck weighings on a gross and relative scale are compared with estimates of system-wide overweight traffic. Sufficient data were not available for a reliable comparison, and the results shown in Table 26 are inconclusive. It appears that a weak correlation exists between overweight vehicles and port enforcement, but additional measurements would be necessary to confirm this hypothesis. From a performance standpoint, changes in program activity should be compared to WIM measurements covering a longer-term period in order to model the overall impact of enforcement.

Table 25: Systemwide WIM Measurements, Calendar 1996 to 1998

Measurement	1996	1997	1998
Vehicles Weighed	4,572,469	4,598,442	4,319,716
Percent of Traffic	0.105%	0.107%	0.092%
Percent Axles Overweight[1.]			
Single	0.7%	0.9%	0.9%
Tandem	11.0%	12.7%	15.1%
Tridem	4.5%	7.0%	7.3%
Total Axles[2.]	5.3%	6.2%	7.4%

Notes: 1. Axle counts from statewide LTPP WIM stations for vehicle classes 4 to 13;
2. Total axles reflect distribution of axle types among all vehicles measured.
Source: LTPP DataPave Database, FHWA, 2001.

This methodology has a number of limitations which bear mentioning. First, weigh-in-motion measurements are applied to the total traffic stream by correlating WIM stations with automated traffic recorder (ATR) stations in order to distribute WIM measurements over the percentage of vehicle types in the total vehicle population. The potential for error exists not only for WIM calibration and measurement problems, but also for the appropriate distribution of those measurements by assigning WIM data to the correct traffic monitoring stations. The process is complicated, and as evidenced in the years reported for the DataPave analysis shown in Table 25, not very timely. Nonetheless, WIM has been applied in various measures of effectiveness, and research has suggested that, over the longer term, a stronger correlation between WIM readings and weight enforcement exists [Hanscom 1998a; State of Florida 2001; Oregon Department of Transportation 1998; Oregon Office of the Secretary of State 2002; Hanscom 1998b; State of Michigan 2000; Bergan *et al.* 1998]. This correlation is also supported by the single-corridor performance analysis in the following section.

Corridor-Specific Effect of Enforcement on Overweight Traffic

Weight enforcement effectiveness can be estimated for individual port of entry facilities when it can be reasonably assumed that the port of entry has a direct impact on traffic in a limited corridor or region. If this assumption is valid, and measuring sites are readily available, changes in enforcement coverage at the facility can be related to changes in overweight traffic on the affected corridor. The analysis entails two steps: grouping enforcement into two or more test cases and then determining the significance of these cases on vehicle loads. The following analysis provides details of a summary analysis for the Nogales port of entry, using weigh-in-motion data collected by the Long Term Pavement Performance Program on Interstate 19. The analysis follows the corridor-specific methods developed by Hanscom [Hanscom 1998a] and discussed in Appendix E.

Table 26 shows the variance in traffic and weight enforcement operations on a monthly basis at the Nogales port of entry. The measurement of through traffic is subject to a variety of considerations, particularly the agricultural seasons that influence the amount of international commercial travel. Staffing levels may have also had an impact on port closures, and thus the amount of traffic recorded versus the actual amount of through

traffic. However, of greater interest with respect to performance is the monthly variation in the percentage of vehicles weighed at the Nogales POE.

Monthly traffic measured at the POE ranged from roughly 2,000 vehicles to 20,000 vehicles. The percentage of vehicles weighed ranged from zero to nearly 30 percent. A clear distinction could be made between months of low enforcement (0 to 3 percent of vehicles weighed) and high enforcement (greater than 16 percent of vehicles weighed). April was the only month that could not be classified in this manner, and was coded as "medium enforcement" with 6.9 percent of vehicles weighed. Interestingly, vehicle weighings did not appear to follow traffic levels. In other words, no correlation was observed between the total amount of traffic and the percentage of vehicles weighed. This may indicate staffing imbalances, operational problems, resource constraints, or other unidentified circumstances that affected coverage at the port.

Table 26: Nogales POE Monthly Enforcement Level, 2000

Month	Total Traffic	Vehicles Weighed		Enforcement Level
		Count	Percent	
January	19,942	0	0.0%	Low
February	20,158	5,988	29.7%	High
March	20,742	3,395	16.4%	High
April	19,857	1,374	6.9%	Med
May	16,837	223	1.3%	Low
June	10,267	1,690	16.5%	High
July	2,191	593	27.1%	High
August	2,101	342	16.3%	High
September	1,993	423	21.2%	High
October	6,264	167	2.7%	Low
November	14,281	0	0.0%	Low
December	16,139	486	3.0%	Low

Source: Arizona MVES Port of Entry Subprogram, 2001

For the year 2000, the Nogales POE averaged 12,564 commercial vehicles per month. The average number of vehicles weighed was 1,223, or 11.8 percent. Low enforcement months (n = 5) had a total measured traffic volume of 73,463 vehicles (14,693 per month), of which 876 were weighed; an aggregate enforcement level of 0.12 percent. In contrast, high enforcement months (n = 6) had less traffic (57,452 vehicles total, 9,575 per month), but an average enforcement level of 21.6 percent.

In order to determine the impact of enforcement levels on the incidence of overweight vehicle traffic, records from LTPP WIM station 6060 on Interstate 19 were grouped by month according to the prevailing enforcement level for that month at the Nogales POE.[12] An analysis of low enforcement versus high enforcement scenarios was then done using

[12] Interstate 19 is the most commonly traveled route north from Nogales, and links traffic to the Tucson and Phoenix metropolitan areas, as well as major commercial thoroughfares such as Interstate 10. In contrast to many ports of entry, which are served by a variety of routes, Interstate 19 is the only major highway in close proximity to the Nogales POE. This exclusivity made the selection of an appropriate WIM station more reliable than for alternate test sites.

the TWEET 2.1 (Truck Weight Enforcement Effectiveness Tool) software (Transportation Research Corporation, 1998) provided by FHWA. Additional discussion of this methodology is in Appendix E of this report.

Table 27 summarizes the TWEET analysis. It should be noted that the WIM station recorded truck traffic volumes comparable to the Nogales POE during low enforcement months. But during periods of high enforcement, much higher traffic volumes were recorded at the WIM station than at the Nogales port. There are a number of implications that may be drawn from this difference. First, based on results from the same weighing station, it appears that port of entry weight enforcement had a statistically significant impact on weight violations on Interstate 19. Gross vehicle weight overloads decreased by 19.3 percent during periods of high enforcement, and tandem axle overloads fell by 16.5 percent. These results were statistically significant at the 95 percent level of confidence. However, given the large disparity in port traffic and WIM station traffic during high enforcement periods, it is likely that a substantial increase in port evasion took place during these months.

Table 27: Weight Violation Summary for Nogales Enforcement Scenarios, 2000

Totals	Low Enforcement		High Enforcement		Change
	Count	Percent[1.]	Count	Percent[1.]	
Number of Trucks	76,740		81,066		
Trucks Over Legal Limit					
GVW	14,009	18.26%	11,944	14.73%	-19.33%
Single Axle	12,024	15.67%	10,259	12.66%	-19.21%
Tandem	16,239	21.16%	14,317	17.66%	-16.54%
Tridem	35	0.05%	22	0.03%	-40.00%
Bridge Formula	9,229	12.03%	7,168	8.84%	-26.52%

Notes: 1) All percentages statistically significant at 95 percent ($a = 0.05$).
Source Data: Arizona LTPP Program WIM unit 6060, Arizona Department of Transportation, 2000.
Software: TWEET 2.1, Transportation Research Corporation, 1998.

Weigh-in-motion measurements have the added benefit of identifying violations by specific classes of vehicles. Knowing which types of vehicles are over-represented in regional weight violations can assist in the effective targeting of enforcement efforts. In the case of Interstate 19, the typical 5-axle semi-trailer combination accounted for 50 to 55 percent of traffic, but was responsible for roughly 85 to 90 percent of weight violations. Single unit trucks with four or more axles (e.g., garbage trucks and concrete mixers) also had a disproportionately high percentage of violations (0.2 percent) relative to their percentage of total traffic (0.1 percent).

The TWEET program software is also capable of assessing the severity of overweight violations. However, in the single-facility analysis, the results of such an assessment are not statistically significant. If data are available for system-wide coverage, or for multiple observation sites in a region of analysis, the magnitude of weight reduction or increase at different enforcement levels can be approximated. Corridor-specific analyses such as the preceding example, are recommended for a more direct assessment of the benefits that investment in ports of entry provide. In cases where a port cannot be shown

to have a meaningful impact on violations, a reevaluation of resource allocation or specific port functions may be warranted.

Estimated Impact of Weight Reduction Enforcement

Weight enforcement at ports of entry can be summarized in two categories of effect on the target population, deterrent effects and capture effects. Deterrent effect refers to the change in motor carrier behavior as a result of enforcement activity. This type of change is manifested by the decision to not overload trucks, to pay appropriate fees, or to obey safety regulations. Sample deterrent metrics are discussed in the preceding measurements using WIM screening. However, the measurement of deterrence suffers from significant lag time between measurement and analysis, and requires a large volume of data in order to achieve reliable results.

While deterrence is likely to be the primary benefit of enforcement, the following analysis demonstrates a means of calculating secondary benefits that accrue to highway users as a result of enforcement activity. This second category, "capture effect," refers to the actual changes in vehicle operating characteristics that are made when a violation is detected and captured. Although this measurement encompasses a much smaller portion of total truck traffic, the magnitude of change elicited is more easily quantified.

The measurement of capture effects begins with variables that can be readily calculated from known sources of information. When overweight vehicles are detected at ports of entry, port officers can require that the vehicle cargo load be shifted or reduced in order to put the vehicle in compliance with weight and size regulations. Assuming that port staff record the magnitude of the adjustment, and the mileage that the vehicle manifest indicates will be driven in Arizona, the expected benefit to the highway system can be calculated for each enforcement contact.

Sample pavement life benefits for port of entry load adjustments, calculated in terms of the reduction in pavement wear, are shown in Table 28. Note that the availability of data required that a number of assumptions be made for the analysis shown in the table. Load shifts were estimated to average 1,500 pounds, transferred between two tandem axle pairs. Load reductions were assumed to average 3,000 pounds, with the excess weight carried on one tandem axle. Equivalent single axle loads (ESALs) were calculated using uniform values for pavement terminal serviceability and structural number. Finally, truck mileage was converted to an estimate of average motor carrier trip length using vehicle registrations, apportionment ratios and Arizona truck VMT.

The net result shown in Table 28 is a pavement benefit measurement that indicates the expected increase in highway structural life that can be directly attributed to the port of entry program. The assumptions used in the table could be readily replaced by actual measurements made by port authorities at the time that each enforcement contact took place. It should be further noted that, at such time as more reliable measures of deterrence can be calculated (e.g., program-wide effect of enforcement on weight violation rates), a measurement of overall highway benefit might also be estimated.

Table 28: Sample Pavement Life Benefit Calculations for Port of Entry Weight Adjustment Activity

Load Adjustment Benefit Calculation	Fiscal Year Loads Shifted					Fiscal Year Loads Reduced				
	1997	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
POE Load Adjustments	18,713	17,698	16,647	19,906	17,299	1,403	3,656	4,662	2,079	1,800
Sample Highway Benefit per Load Adjustment										
Assumed overload (lb.)	1,500	1,500	1,500	1,500	1,500	3,000	3,000	3,000	3,000	3,000
Pre-shift distribution										
Steering Axle	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Tandem axle (front)	32,500	32,500	32,500	32,500	32,500	34,000	34,000	34,000	34,000	34,000
Tandem axle (rear)	35,500	35,500	35,500	35,500	35,500	37,000	37,000	37,000	37,000	37,000
ESAL Estimate[1.]	2.4303	2.4303	2.4303	2.4303	2.4303	2.8309	2.8309	2.8309	2.8309	2.8309
Post-shift distribution										
Steering Axle	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Tandem axle (front)	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
Tandem axle (rear)	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
ESAL Estimate[1.]	2.4082	2.4082	2.4082	2.4082	2.4082	2.4082	2.4082	2.4082	2.4082	2.4082
ESAL Reduction[1.]	0.91%	0.91%	0.91%	0.91%	0.91%	14.93%	14.93%	14.93%	14.93%	14.93%
Estimated trip mileage[2.]	977	977	977	977	977	977	977	977	977	977
Pavement Benefit[3.]	**0.004%**	**0.003%**	**0.003%**	**0.003%**	**0.003%**	**0.005%**	**0.011%**	**0.014%**	**0.006%**	**0.005%**

Notes: (1.) ESAL calculations based on Pt (pavement serviceability) = 2.5 and SN (structural number) = 4.5. values will change based on actual terminal serviceability and structural number values for a stretch of roadway. (2.) Motor carrier monthly mileage estimate from Arizona FMS Motor Carrier Tax Proposal, 1996. Estimate of single-trip length using 4.3 trips per month, 0.5 trips under current load. (3.) Pavement benefit refers to estimate of aggregate increase in highway life based on trip share of annual VMT, multiplied by ESAL reduction.

Sources: Arizona Department of Transportation, Traffic Planning Data Team (2000) and Financial Management Services (1996).

Estimated Safety Benefit of Vehicle Inspections

As in the preceding example for load adjustments, a capture benefit can also be estimated for unsafe drivers and vehicles removed from the traffic population during commercial safety inspections. A study of the Commercial Vehicle Information Systems and Networks (CVISN) in Maryland [Bapna *et al*. 1998] quantified the effects of current and alternate enforcement scenarios with respect to improved highway safety resulting from identification of high-risk vehicles and/or drivers. Benefits were assumed to be a reduction in the number of crashes observed as a result of placing violators out of service (OOS). In other words, it was assumed that the crash rate for commercial vehicles would decrease as more "unsafe" drivers or vehicles were identified for inspection. The methodology for estimating these benefits is included in Appendix D of this report.

Table 29: Arizona MVES Monthly OOS Safety Benefit

OOS Inspections	Total Drivers & Vehicles Placed Out of Service (OOS)					
	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01
Arizona POEs	0	17	18	43	30	46
Arizona Mobile Enforcement	0	17	145	94	43	72
Benefit Calculations[1.]						
Safe Vehicle Mileage[2.]	-	856,447	4,105,906	3,450,976	1,838,841	2,972,374
Carrier Crash Factor[3.]	1.8594	1.8594	1.8594	1.8594	1.8594	1.8594
Carrier Crash Estimate	-	2	8	6	3	6
Direct Safety Benefit, drivers[4.]	-	0.09	0.44	0.37	0.19	0.32
Direct Safety Benefit, vehicles	-	0.07	0.35	0.30	0.16	0.25
Total Benefit (1996 $)[5.]	$0	$22,144	$106,159	$89,226	$47,544	$76,851
Total Benefit (Current $)[6.]	$0	$24,059	$115,342	$97,542	$51,975	$84,014
POE Benefit, (Current $)	$0	$12,030	$12,737	$30,615	$21,359	$32,751

Notes: 1. Safety benefit calculations adapted from Maryland CVSIN study (1998) using Arizona and national estimates of travel, crashes and costs. 2. Safe mileage refers to number of vehicle miles driven "safely" after vehicle/driver placed OOS for 3 month impact period. 3. Carrier accident factor and crash estimate based on 5 year average of combination truck crash rate in Arizona , multiplied by 1.316 to reflect 31.6% increased likelihood that unsafe carriers will be involved in a crash. 4. Safety benefits based on national average for crashes attributable to vehicle (4.6%) and driver (5.7%) defects. 5. Based on average weighted societal cost of $135,000 per crash in 1996 dollars. 6. US GDP deflator used to adjust quarterly benefits to current dollars for each month.
Sources: Bapna, S., J. Zaveri, and Z.A. Farkas. *Benefit-Cost Assessment of the Commercial Vehicle Information Systems and Networks (CVISN) in Maryland*. National Transportation Center. Morgan State University. Baltimore, MD (Nov 1998) and Moses. L. and I. Savage. "A Cost-Benefit Analysis of US Motor Carrier Safety Programmes." *Journal of Transport Economics and Policy*. Vol 31. p 52-67. 1997.

Table 29 depicts a sample analysis of the estimated benefits that safety inspections at Arizona ports of entry provide. As with the load adjustment metric, the estimate includes only direct benefits of placing drivers or vehicles out-of-service, and does not quantify the deterrent effect of enforcement on operator behavior. In current dollars, the ports of entry provided an estimated $109,452 in direct safety benefits to Arizona highway users over the last six months of 2001. Including the mobile enforcement units, the total benefit increased to $372,932. While this measurement provides a potentially useful tool for communicating the effectiveness of safety enforcement, additional research is needed to determine more precise effects of unsafe commercial vehicles on crash rates in

Arizona. A validation of the expected crash reduction from enforcement activity would lend greater weight to the sample results, and provide a more effective measure of safety-related performance.

Several potential measures of effectiveness could not be made based on the data available. However, the following measurements would be of some utility in gauging the impacts that port enforcement had on motor carrier behavior.

Effect of Facility Enforcement on Bypass Route Traffic

Data were not available for comparison of port enforcement activity with traffic on bypass routes. However, in cases where bypass routes are readily identified by port of entry staff, it is recommended that managers identify the correlation, if any, between traffic on bypass routes and the number or percentage of weighings or service contacts recorded at the corresponding ports of entry. Not only would this measure provide an indication of the normal levels of evasion that typically occur at the ports, it would also allow for analysis of the changes in violator behavior elicited by port enforcement efforts.

If the port of entry serves as a deterrent to illegal motor carrier travel, a significant increase in bypass route traffic is presumed to occur when enforcement levels at a port increase. The same measure could be made on mainline routes for ports that do not operate on a twenty-four hour basis. Again, a significant increase in truck traffic might be expected during hours when the port is closed.

Getting a reliable estimate of evasion rates is significant for a number of reasons. First, the evasion rate signifies the perceived level of enforcement at a port of entry. Although an evasion rate per se is a negative measure of effectiveness (i.e., for enforcement to be effective, the evasion must be captured), it gives the POE program a clearer understanding of the degree to which drivers change their behavior under various enforcement conditions. Second, for effective counter-evasion strategies to be developed, managers should have reliable knowledge of the scope and determinants of the problem. For example, coordinating mobile enforcement on bypass routes with POE enforcement would be most effective if program managers were able to make a reliable estimate of when and where the mobile units should be deployed. Finally, the evasion rate provides the port of entry program with a justifiable argument for changing levels of coverage and funding to better contain violators.

Pre-cleared Vehicle Violation Rate

Another related measure also considers evasion, though in this case by a vehicle population assumed to be operating legally. During visits to the Ehrenberg and Kingman ports of entry, port staff discussed the lack of weigh-in-motion screening equipment for mainline traffic as a shortcoming of the electronic credential verification vehicle clearance system (PrePass). If vehicles allowed to register and have credentials verified electronically are not subject to the same weight enforcement practices, it stands to reason that the pre-clearance system will encourage violation of weight regulations. An

evaluation of weight violation rates among PrePass and non-PrePass vehicles would determine the extent to which, if any, this incentive induces changes to motor carrier behavior.

Port of entry screening systems are typically set up to pull an arbitrary percentage of pre-cleared vehicles into the ports for screening. According to Kingman and Ehrenberg officers, this percentage was routinely set at 5 percent of pre-cleared traffic. The ports of entry have the capacity to review weight measurements for previously screened vehicles throughout the day. A simple analysis of daily violation rates for the two vehicle samples could be performed on a regular basis, and would be facilitated by periodic screens of 100 percent of traffic when conditions permitted.

If evasion is determined to occur at a greater rate among the pre-cleared vehicle population, a new approach to vehicle screening is warranted. This need not imply that the pre-clearance system is not worthwhile, but only that a better approach to managing the system is needed. One such method, though costly, would be the installation of mainline WIM at all ports of entry. Another might be a random change in the percentage of pre-cleared vehicles flagged for screening on a periodic basis. However, the latter approach would have the potential to increase wave-throughs at ports already reaching maximum capacity.

Although evasion is a "negative" measure of performance (i.e., a lower measurement indicates better performance), improving methods for the identification of potential violators is a principle of improving the effectiveness of enforcement practices. As with wave-through vehicles and bypass route traffic, measuring the degree to which operators that are assumed to be "legal" are actually violating regulations gives the port program more reliable information from which to better target potential violations. Enhancing the screening process can in turn boost both the efficiency of operations and the effectiveness of program activities.

SIMPLIFYING THE PERFORMANCE ANALYSIS

The measures of performance discussed in the preceding section provide a comprehensive description of the various activities at Arizona ports of entry. However, not all measurements can be easily made or evaluated. In particular, measures of effectiveness are subject to considerable variation in the data used to normalize results. These results are in turn open to differences in interpretation, which makes it difficult to gauge the impacts of various operational strategies on short-term performance.

Normalizing the results of performance measurement makes the data more reliable in terms of comparative value, but also requires the analyst to gather information from exterior sources. It is of little value to the performance measurement process to base metrics on data that can not be readily obtained. The simplest solution to this problem is to develop a group of performance measures that are standardized using the same unit of measurement. The chosen unit of measurement should be one that can be readily collected by the program managers and analysts. A sample evaluation using this approach is given in Table 30.

Various standardized measures of output per hour of operation are shown in Table 30. Using a uniform denominator allows for easy identification of changes in output from one unit of measurement to the next. For example, from fiscal year 1999 to 2000, inbound port traffic per hour increased by 11 percent. Port productivity increased for many metrics in conjunction with the traffic growth. The number of vehicles weighed and the number of safety inspections increased on an hourly basis. Port staff issued slightly more permits and slightly fewer citations per hour. However, productivity did not keep pace with traffic growth. The 47 percent increase in vehicles waved through on an hourly basis provides an indication that operating capacity and/or port staff were overwhelmed by the increase in traffic. Operational expenditures per hour increased by 6.4 percent and revenues fell by a comparable amount.

Table 30: Arizona Ports of Entry Output Statistics per Hour of Operation

Measurement[1.]	FY1998	FY1999	FY2000	FY2001	FY2002
Inbound Traffic	48.9580	53.3495	59.1953	60.6619	60.6502
Vehicles Weighed	39.4936	32.4128	34.6986	33.7754	40.0331
Vehicles Waved Thru	2.3130	2.4174	3.5673	4.2882	4.3963
CVS Inspections	0.0218	0.0274	0.0459	0.0230	0.0190
Weight Violations	0.2009	0.2117	0.2200	0.1900	0.2172
Citations	0.0188	0.0231	0.0219	0.0180	0.0237
Expenditures	$34.49	$39.51	$42.05	$43.26	n/a
Revenues	$128.48	$122.30	$114.21	$105.90	$113.04

Notes: 1.) Hours of operation estimated for each port based on maximum of inbound or outbound normal hours less documented closures for each fiscal year.

While the measures shown in Table 30 provide a useful snapshot of port of entry operations, what is missing is a frame of reference. It is difficult to determine whether the change for the worse in operational performance was directly related to the unit of measurement chosen to standardize the performance. A reduction in operating hours might reduce costs, or it might increase costs per hour. Similarly, operating only during the busiest times might increase the reported number of vehicles waved through per hour. Whereas the chosen metrics might be appropriate for 24-hour facilities, the comparison of these locations with limited service ports would be skewed. Thus, the tradeoff of simplicity is a lack of predictive ability and a less objective framework from which to set targets and measure achievements.

Another means of evaluating program activities is to calculate basic measures of correlation for port of entry statistics. Using the hourly performance measures given in Table 30, the correlation matrix shown in Table 31 indicates the extent to which various port activities were related. Some results show relationships that would be expected under normal operating conditions. The number of vehicles waved through had a strong positive relationship to inbound traffic, which is an obvious indication of the fixed capacity at port of entry screening facilities. Revenues exhibit a strong negative correlation with the number of vehicles waved through, which might also be expected if

an increased probability of being waved through led to changes in operator behavior based on a perceived reduction in the risk of enforcement.

Table 31: Port of Entry Measurement Correlation, Fiscal 1998 to 2002

Measurement	Inbound Traffic	Vehicles Weighed	Waved Through	CVS Insp.	Weight Viol	Citations	Revenue
Inbound Traffic	1.0000						
Vehicles Weighed	-0.1538	1.0000					
Wave Throughs	0.9445	0.1128	1.0000				
CVS Inspections	0.1735	-0.4544	-0.0723	1.0000			
Weight Violations	0.1450	0.1365	-0.0148	0.4932	1.0000		
Citations	0.2075	0.0319	0.0496	0.1764	0.8877	1.0000	
Revenues	-0.9505	0.2767	-0.9181	-0.0896	0.1563	0.0677	1.0000

In some cases the results are counterintuitive, which may also indicate areas in which performance might be improved. For example, inbound traffic showed a strong negative relationship with revenue collections, but it would be entirely reasonable to expect the opposite. If the percentage of vehicles purchasing permits remained constant and the flow of vehicles increased, a positive relationship between revenue and traffic would be expected. This measure provides similar evidence of declining compliance as the revenues per truck mile discussed in the previous section. However, port of entry traffic and system-wide traffic are on different orders of magnitude, and the analysis of port-specific traffic levels will be subject to greater potential for bias effects (e.g., changes in operating hours).

The correlation between POE operating costs and other measures was omitted from the results in Table 31 because insufficient data were available to make the calculations for the entire period. However, the cost of operating ports of entry remains an important metric to assess in relation to other measures of performance. The correlation between spending and the variables shown in the previous example are given in Table 32.

Table 32: Port of Entry Expenditure Correlation, Fiscal 1998 to 2001

Measurement	Correlation to Expenditures
Inbound Traffic	0.9760
Vehicles Weighed	-0.7810
Vehicles Waved Thru	0.8609
CVS Inspections	0.4289
Weight Violations	0.0106
Citations	0.0977
Revenues	-0.9377

Of considerable interest are the first two correlation coefficients. Spending demonstrated a strong positive relationship to inbound traffic, which would be expected. However, a strong negative relationship between spending and the number of vehicles weighed was

also observed. The implication is that, despite the increase in costs, the program weighed fewer vehicles even as port traffic increased.

Based on the preceding observations one possible hypothesis is that the performance decline was due to an increasing disparity between traffic and port capacity. Increasing operational costs suggest that port managers attempted to mitigate this problem by deploying additional staff to overwhelmed facilities, but these resources could do little to solve a structural problem (i.e., capacity). Efficiency at ports may have decreased as a result, and motor carriers, observing a reduction in the probability of detection, decreased compliance with fee payments.

The above hypothesis is just one of many possibilities for the change in port of entry performance over the past five years. More important from the standpoint of performance measurement is the interaction between the multiple variables that comprise port of entry operating conditions. It is not enough to observe that an increasing number of vehicles were waved through the ports of entry. Effective management requires further investigation of the "why" questions that accompany this observation. A complete picture of activity should be the basis from which to manage for increased performance.

However, the performance analysis need not be weighed down by voluminous data collection and reporting requirements. Relying on a single measurement is of little value for assessing a complex program, but a select few measurements could be effectively combined to present a meaningful summary of operations. For example, the first three measures of productivity discussed in the preceding section (page 63) might be combined with a correlation matrix of sub-activities that comprise the "service contacts" measure. Performance targets for one or more of the three measures of output[13] could then be set by reviewing the expected effect on each activity that a new approach to a sub-activity might entail.

Similarly, the alignment of enforcement activity with program goals could be reasonably expressed by adding one or two measures of effectiveness to the performance analysis. At the program level, the broadest measure of program outcome would be the ratio of motor carrier revenues collected to statewide truck vehicle miles of travel. For more specific results, the changes in WIM observations for different levels of enforcement could be included at the program or facility level. Finally, options exist for showing the benefits of various enforcement activities. If deterrence measures were calculated, a composite "value" measure might be compared to program costs to yield an expected return on program investment that included more than just revenue collections.

The measurement of performance at Arizona ports of entry should incorporate the breadth of POE responsibilities. Not all of the preceding measurements are necessary to communicate these duties, nor is the formation of program performance targets limited to

[13] Correlation is not a performance measurement, but an expression of the relationships between variables. It is not possible to manage for performance using correlation as a target, but awareness of the interplay between program activities is useful for defining clear expectations for the organization.

the measures discussed. These tools are intended to provide a greater field of vision for POE assessment, and port managers may develop alternative measures that serve the same purpose. The ultimate responsibility for choosing the appropriate measurement tools is in the hands of program management.

V. CONCLUSIONS

The Arizona Port of Entry Program provides needed services to the citizens of Arizona, but lacks clear means of evaluating services in terms of the efficiency and effectiveness with which enforcement activities are carried out. This makes it difficult to communicate the achievements of the Port of Entry Program, and to identify potential improvements in service quality. This research has addressed the interpretation of data by presenting various measures of performance for use in evaluating the Arizona Port of Entry program.

By developing specific measures tied to the goals and objectives of the program, Arizona POE managers will have a better set of tools for decision making, and increased accountability to Arizona taxpayers. But performance measurement consists of more than just collecting data. Continuous and regular review of measures as they relate to the corresponding program goals and strategic plan are key to success in performance measurement. It not only helps in deciding the right things to measure, but provides needed information to assess progress toward reaching goals of all levels within the organization [Office of the Vice President of the United States of America 1997]. Performance measurement has no purpose if data are not used to improve organizational performance.

Several performance measures were suggested for Arizona ports of entry as part of this research. Recommended productivity measures focused on the overall volume of service contacts, the cost of providing those contacts, and the number of vehicles bypassing (i.e., waved through) the ports as measures of efficiency. Combining the recommended measures provides a broad measure of total program outputs and the cost required to achieve these outputs. The percentage of vehicles waved through the ports was retained from previous studies as a measure of the potential improvement for enforcement coverage.

The effectiveness of port enforcement can be expressed in a variety of ways, but a review of practices among state ports of entry and weight enforcement programs indicated that this aspect of performance is often neglected. Measuring effectiveness is a complicated process, and in many cases is subject to considerable variation in requisite source data and the interpretation of results. Nonetheless, the measurement of enforcement outcomes is an important component of the performance measurement process. Managing for productive efficiency ensures that the organization does the best it can with what it has; managing for effectiveness ensures that this productivity achieves a meaningful end.

A variety of measures were considered to communicate the outcome of port enforcement efforts. These ranged from facility-level measures such as the ratio of revenue collections to operating costs and the impact of port enforcement on overweight vehicle traffic on relevant transportation corridor(s). Program-wide measures of effectiveness included the amount of revenues collected per truck-mile of travel, both by port facilities (direct effects) and total remittance of commercial fees to the Highway User Revenue Fund (indirect or induced compliance), and system-wide changes in weight violations.

Several sample metrics for communicating the benefits of port activities to highway users were also presented for consideration as measures of outcome. These included the direct impact on highway life provided by port of entry load adjustments, and the estimated social benefit of crash reductions as a result of POE safety inspections.

Establishing viable performance measures is critical for organizations; making those measures work is even more important [Office of the Vice President of the United States of America 1997]. Clearly, not all of the recommendations in this research are necessary for measuring performance at Arizona ports of entry. In many cases, a meaningful assessment can be made using a few simple measures that are most closely aligned with program goals. The preceding examples illustrate the breadth of services provided by the POE program, and should be useful to program managers in determining the most appropriate measures to reflect current operating conditions and performance targets set for the program.

A significant impediment to the measurement of performance at Arizona ports of entry is the lack of a standard format for archived data. Over the six-year period used for preliminary data collection in this report, POE metrics in a variety of spreadsheet formats were provided by MVD staff. Not only did report formats vary from year to year, and in some cases, month to month, but the data collected varied as well. The lack of a standardized reporting format makes it likely that data will have to be assembled by hand, as they were for this report. This creates several problems for regular performance measurement. Manual assembly of data is time consuming, which reduces the likelihood that regular performance reviews will take place. Manual transcription also increases the likelihood of errors in reporting, which reduces the reliability of the performance measurement(s).

As a corollary to the development of appropriate performance metrics, it is recommended that the Arizona Port of Entry program develop a data management system to track current and future measurements. The reliance on paper summaries and spreadsheets makes comparison of multiple periods difficult, and reduces the likelihood that significant changes in operating conditions will be identified quickly. A simple database could replace the existing spreadsheet reporting system with limited effort. Alternatively, a more complex system could incorporate the monthly operating expense data that are extracted from the financial management system. Regardless of the format chosen, having comparable data stored in a uniform format would greatly simplify the performance management process.

Port of entry managers possess the most reliable knowledge of program activity, and the recommendations made herein are not intended to supplant the judgment of the individuals that make the port of entry program work. The selection of meaningful metrics that facilitate performance management is the ultimate responsibility of program authorities. The measures developed for this research, and the discussion of performance measurement in other states, are intended to provide the Arizona Port of Entry program with a wider range of tools from which to develop the most appropriate measures of program performance.

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APPENDIX A: PORT OF ENTRY STATISTICS

Table 33: Arizona Port of Entry Locations

Facility	Phone	Street	City, State, ZIP
Douglas Federal POE	520-364-7311	1st Street and Pan American	Douglas, AZ 85608
Douglas State POE	520-364-5011	MP370.4 US60	Douglas, AZ 85608
Duncan POE	928-359-2562	MP384 US70	Duncan, AZ 85534
Ehrenberg POE	928-927-6652	MP3.8 I-10 E/B	Ehrenberg, AZ 85334
Fredonia POE	928-643-7096	699 N. Main	Fredonia, AZ 86022
Lukeville POE	520-387-6942	MP 80 Hwy 85	Lukeville, AZ 85341
Kingman POE	928-565-2222	MP67 Hwy 93	Kingman, AZ 86402
Naco POE	520-432-2674	3867 Towner Ave	Naco, AZ 85620
Nogales POE	928-287-3861	210 Mariposa Road	Nogales, AZ 85621
Page POE	928-645-3269	US Hwy 89 MP551	Page, AZ 86040
Parker POE	928-669-2534	310 California Avenue	Parker, AZ 85344
San Luis POE	928-627-2970	MP01 SR95	San Luis, AZ 85349
San Simon POE	520-845-2280	MP383.3 I-10	San Simon, AZ 85632
Sanders POE	928-688-2741	MP340 I-40	Sanders, AZ 86512
Sasabe POE	520-823-4341	MP 0 SR 286	Sasabe, AZ 85633
Springerville POE	928-333-4415	Hwy US60	Springerville, AZ 85938
St. George POE	435-673-3786	MP1 I-15	St. George, UT 84771
Teec Nos Pos POE	928-656-3214	MP 465.2 US 160	Teec Nos Pos, AZ 86514
Topock POE	928-768-3756	MP3 I-40	Topock, AZ 86436
Yuma POE	928-783-5141	MP1 I-8	Yuma, AZ 85366

Source: Arizona Department of Transportation, Motor Vehicle Division, 1999.

Figure 1: Arizona Port of Entry Faciliy Locations

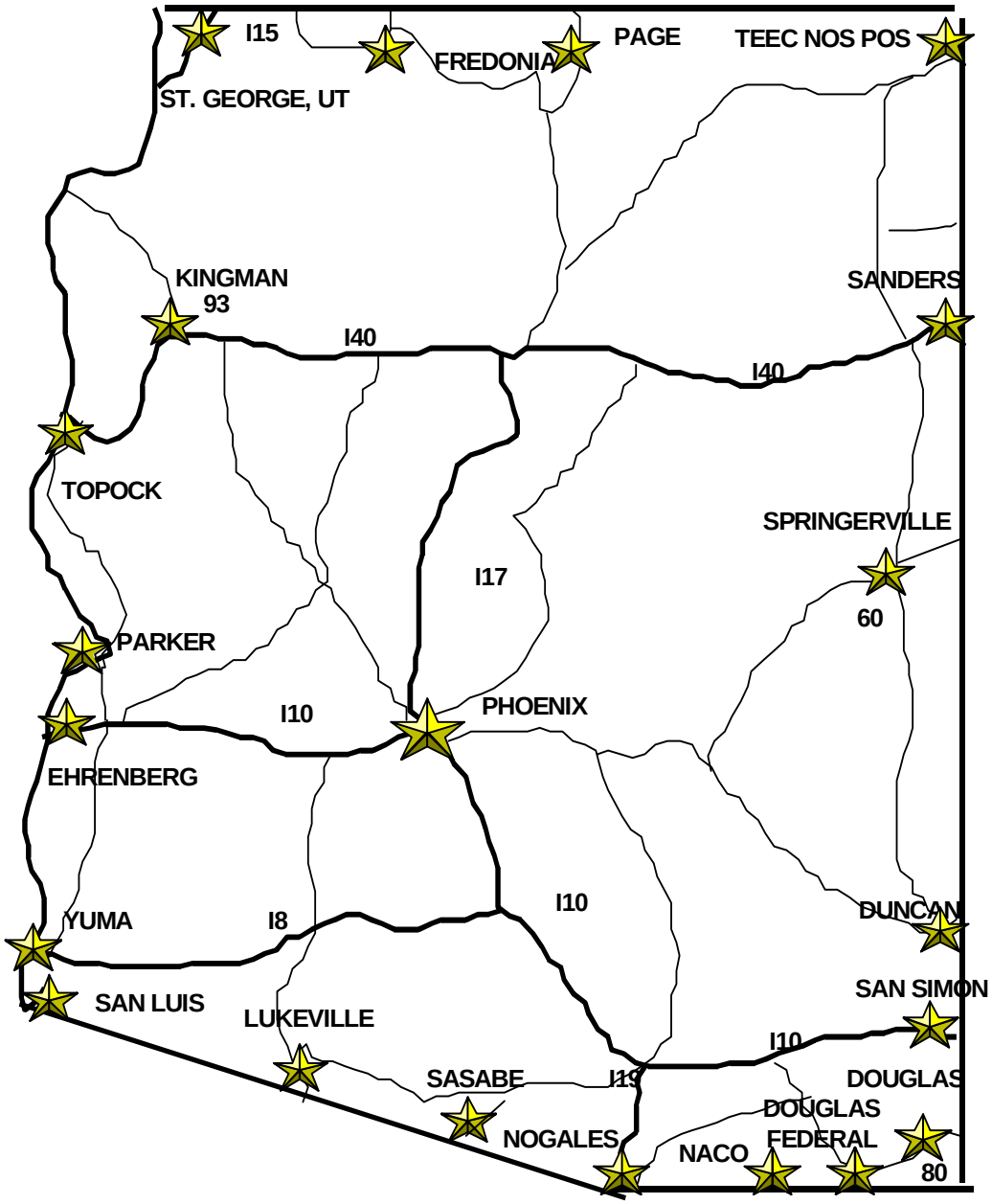

Image source: Arizona Department of Transportation, Motor Vehicle Division, Port Enforcement, 2001 [Arizona Department of Transportation 2001].

Table 34a: Port of Entry Traffic, Fiscal 1997 to 1999

FY ENDING	1997			1998			1999		
FACILITY	IN	OUT	TOTAL	IN	OUT	TOTAL	IN	OUT	TOTAL
Douglas AZ	9,976	5,648	15,624	7,644	7,834	15,478	6,119	6,887	13,006
Douglas US	40,498	24	40,522	38,034	0	38,034	41,431	0	41,431
Duncan	12,787	12,763	25,550	16,645	15,019	31,664	14,022	13,479	27,501
Ehrenberg	906,097	3,107	909,204	1,122,258	0	1,122,258	1,033,013	4,409	1,037,422
Fredonia	30,499	0	30,499	31,980	1,650	33,630	23,269	0	23,269
Kingman	206,302	0	206,302	133,844	0	133,844	223,395	0	223,395
Lukeville	10,873	0	10,873	8,946	0	8,946	1,586	0	1,586
Naco	6,029	847	6,876	6,014	0	6,014	6,854	0	6,854
Nogales	174,180	0	174,180	155,701	0	155,701	198,539	644	199,183
Page	29,691	11,769	41,460	22,443	21,276	43,719	24,768	24,051	48,819
Parker	41,495	0	41,495	21,011	40	21,051	19,803	0	19,803
Sanders	939,816	236,528	1,176,344	1,020,198	840,904	1,861,102	1,129,647	833,801	1,963,448
San Luis	27,593	0	27,593	25,080	0	25,080	21,081	0	21,081
San Simon	728,068	593,176	1,321,244	912,294	278,652	1,190,946	941,311	167,192	1,108,503
Sasabe	641	199	840	1,464	930	2,394	1,091	0	1,091
Springerville	31,238	32,934	64,172	32,673	31,815	64,488	34,417	32,924	67,341
St. George	430,966	429,409	860,375	527,520	510,195	1,037,715	543,328	542,283	1,085,611
Teec Nos Pos	26,677	13,474	40,151	22,891	13,870	36,761	72,635	12,613	85,248
Topock	666,203	106	666,309	717,152	2,835	719,987	716,130	329	716,459
Yuma B-8	82,040	0	82,040	86,239	0	86,239	101,890	0	101,890
Yuma I-8	323,136	38,435	361,571	342,553	9,820	352,373	318,742	10,454	329,196
TOTAL	4,724,805	1,378,419	6,103,224	5,252,584	1,734,840	6,987,424	5,500,252	1,649,066	7,149,318

Table 34b: Port of Entry Traffic, Fiscal 2000 to 2002

FY ENDING	2000			2001			2002		
FACILITY	IN	OUT	TOTAL	IN	OUT	TOTAL	IN	OUT	TOTAL
Douglas AZ	11,520	10,874	22,394	6,005	6,627	12,632	6,285	5,702	11,987
Douglas US	39,324	97	39,421	31,631	0	31,631	21,558	2,282	23,840
Duncan	14,991	12,693	27,684	9,300	7,953	17,253	10,133	8,679	18,812
Ehrenberg	1,180,889	10,701	1,191,590	1,021,597	15,957	1,037,554	1,014,525	4,407	1,018,932
Fredonia	19,497	0	19,497	17,725	0	17,725	12,363	0	12,363
Kingman	240,019	1,866	241,885	182,962	0	182,962	169,713	0	169,713
Lukeville	2,516	398	2,914	3,932	0	3,932	5,491	334	5,825
Naco	8,152	0	8,152	8,175	50	8,225	5,567	303	5,870
Nogales	197,818	0	197,818	167,446	0	167,446	212,303	0	212,303
Page	27,701	26,922	54,623	28,310	25,056	53,366	32,094	28,394	60,488
Parker	21,626	0	21,626	22,266	0	22,266	37,875	0	37,875
Sanders	906,817	1,013,200	1,920,017	912,521	1,014,821	1,927,342	1,011,996	890,584	1,902,580
San Luis	19,074	54	19,128	23,882	0	23,882	20,811	0	20,811
San Simon	995,262	0	995,262	769,665	61,166	830,831	766,879	45,612	812,491
Sasabe	1,252	709	1,961	837	483	1,320	2,434	2	2,436
Springerville	42,732	40,990	83,722	36,865	33,833	70,698	46,601	43,897	90,498
St. George	524,217	528,032	1,052,249	483,710	494,148	977,858	571,918	590,170	1,162,088
Teec Nos Pos	15,775	11,589	27,364	15,761	12,970	28,731	18,964	17,093	36,057
Topock	863,060	4,029	867,089	831,116	0	831,116	697,385	0	697,385
Yuma B-8	78,085	0	78,085	80,240	0	80,240	71,001	0	71,001
Yuma I-8	348,793	6,902	355,695	355,698	18,126	373,824	352,899	12,179	365,078
TOTAL	5,559,120	1,669,056	7,228,176	5,009,644	1,691,190	6,700,834	5,088,795	1,649,638	6,738,433

Table 35a: Vehicles Processed by Port of Entry, Fiscal 1997 to 1999

FY ENDING	1997			1998			1999		
FACILITY	In	Out	Total	In	Out	Total	In	Out	Total
Douglas State	9,823	5,520	15,343	7,516	7,666	15,182	6,119	6,887	13,006
Douglas Federal	40,482	24	40,506	38,008	0	38,008	41,431	0	41,431
Duncan	12,783	12,756	25,539	16,613	14,995	31,608	14,022	13,479	27,501
Ehrenberg	722,683	3,107	725,790	930,356	0	930,356	759,533	2,460	761,993
Fredonia	28,041	0	28,041	31,980	1,650	33,630	23,269	0	23,269
Kingman	188,654	0	188,654	132,921	0	132,921	209,423	0	209,423
Lukeville	10,873	0	10,873	8,946	0	8,946	1,586	0	1,586
Naco	6,029	847	6,876	6,014	0	6,014	6,854	0	6,854
Nogales	174,180	0	174,180	155,701	0	155,701	156,976	644	157,620
Page	29,686	11,769	41,455	22,443	21,276	43,719	11,518	14,557	26,075
Parker	41,414	0	41,414	21,011	40	21,051	19,803	0	19,803
Sanders	759,665	236,528	996,193	945,651	840,904	1,786,555	980,562	830,664	1,811,226
San Luis	27,593	0	27,593	25,080	0	25,080	21,081	0	21,081
San Simon	718,396	593,176	1,311,572	798,166	278,652	1,076,818	814,310	165,475	979,785
Sasabe	641	168	809	1,464	779	2,243	1,091	0	1,091
Springerville	31,238	32,934	64,172	32,549	31,815	64,364	34,417	32,924	67,341
St. George	430,966	429,337	860,303	279,038	270,153	549,191	270,431	282,351	552,782
Teec Nos Pos	26,631	13,107	39,738	21,679	11,134	32,813	68,259	7,164	75,423
Topock	641,431	0	641,431	657,099	2,795	659,894	592,175	329	592,504
Yuma B-8	82,040	0	82,040	86,239	0	86,239	74,599	0	74,599
Yuma I-8	323,103	38,435	361,538	342,458	9,820	352,278	289,189	8,787	297,976
Ports Sub-Total	4,306,352	1,377,708	5,684,060	4,560,932	1,491,679	6,052,611	4,423,829	1,365,721	5,789,550

Table 35b: Vehicles Processed by Port of Entry, Fiscal 2000 to 2002

FY ENDING	2000			2001			2002		
FACILITY	In	Out	Total	In	Out	Total	In	Out	Total
Douglas State	11,520	10,874	22,394	6,005	6,627	12,632	6,046	5,592	6,046
Douglas Federal	39,324	97	39,421	31,631	0	31,631	21,374	1,330	21,374
Duncan	14,832	12,544	27,376	8,516	6,533	15,049	6,862	4,028	6,862
Ehrenberg	813,533	5,569	819,102	631,279	7,982	639,261	515,803	1,610	515,803
Fredonia	19,497	0	19,497	13,295	0	13,295	5,253	0	5,253
Kingman	221,048	1,866	222,914	96,872	0	96,872	22,636	0	22,636
Lukeville	2,516	398	2,914	3,932	0	3,932	5,491	334	5,491
Naco	8,152	0	8,152	8,175	50	8,225	5,313	303	5,313
Nogales	197,777	0	197,777	166,236	0	166,236	138,127	0	138,127
Page	12,723	15,095	27,818	13,140	13,791	26,931	13,103	14,067	13,103
Parker	21,626	0	21,626	22,266	0	22,266	35,252	0	35,252
Sanders	698,407	1,013,200	1,711,607	602,174	1,014,821	1,616,995	586,106	890,584	586,106
San Luis	19,074	54	19,128	23,882	0	23,882	20,811	0	20,811
San Simon	817,765	0	817,765	577,580	53,954	631,534	571,985	45,612	571,985
Sasabe	1,252	286	1,538	837	359	1,196	500	2	500
Springerville	39,465	40,990	80,455	36,865	33,833	70,698	46,601	43,897	46,601
St. George	244,130	274,631	518,761	220,828	253,484	474,312	217,435	260,723	217,435
Teec Nos Pos	11,692	6,732	18,424	11,468	6,536	18,004	15,867	8,346	15,867
Topock	694,196	3,962	698,158	645,321	0	645,321	481,321	0	481,321
Yuma B-8	57,179	0	57,179	59,791	0	59,791	60,828	0	60,828
Yuma I-8	288,785	6,433	295,218	288,109	17,477	305,586	269,629	11,408	269,629
Ports Sub-Total	4,234,493	1,392,731	5,627,224	3,468,202	1,415,447	4,883,649	3,046,343	1,287,836	3,046,343

Table 36a: Vehicles Waved Through by Port of Entry, Fiscal 1997 to 1999

FY ENDING	1997			1998			1999		
FACILITY	In	Out	Total	In	Out	Total	In	Out	Total
Douglas State	153	128	281	128	128	256	0	0	0
Douglas Federal	16	0	16	26	0	26	0	0	0
Duncan	4	7	11	32	24	56	0	0	0
Ehrenberg	183,414	0	183,414	152,481	0	152,481	168,110	1,949	170,059
Fredonia	2,458	0	2,458	0	0	0	0	0	0
Kingman	17,648	0	17,648	75	0	75	0	0	0
Lukeville	0	0	0	0	0	0	0	0	0
Naco	0	0	0	0	0	0	0	0	0
Nogales	0	0	0	0	0	0	0	0	0
Page	5	0	5	0	0	0	0	0	0
Parker	81	0	81	0	0	0	0	0	0
Sanders	180,151	0	180,151	16,511	0	16,511	47,439	3,136	50,575
San Luis	0	0	0	0	0	0	0	0	0
San Simon	9,672	0	9,672	81,588	0	81,588	42,917	1,717	44,634
Sasabe	0	31	31	0	151	151	0	0	0
Springerville	0	0	0	0	0	0	0	0	0
St. George	0	72	72	0	0	0	0	0	0
Teec Nos Pos	46	367	413	420	1,304	1,724	738	0	738
Topock	24,772	106	24,878	18,263	40	18,303	6,697	0	6,697
Yuma B-8	0	0	0	0	0	0	0	0	0
Yuma I-8	33	0	33	13	0	13	411	0	411
Ports Sub-Total	418,453	711	419,164	269,537	1,647	271,184	266,312	6,802	273,114

Table 36b: Vehicles Waved Through by Port of Entry, Fiscal 2000 to 2002

FY ENDING	2000			2001			2002		
FACILITY	In	Out	Total	In	Out	Total	In	Out	Total
Douglas State	0	0	0	0	0	0	0	0	0
Douglas Federal	0	0	0	0	0	0	59	192	59
Duncan	159	149	308	3	0	3	332	564	332
Ehrenberg	248,989	5,132	254,121	288,850	7,860	296,710	258,164	2,797	258,164
Fredonia	0	0	0	0	0	0	284	0	284
Kingman	0	0	0	0	0	0	0	0	0
Lukeville	0	0	0	0	0	0	0	0	0
Naco	0	0	0	0	0	0	0	0	0
Nogales	0	0	0	0	0	0	0	0	0
Page	190	415	605	0	0	0	153	76	153
Parker	0	0	0	0	0	0	0	0	0
Sanders	65,299	0	65,299	104,002	0	104,002	81,480	0	81,480
San Luis	0	0	0	0	0	0	0	0	0
San Simon	63,744	0	63,744	50,106	7,212	57,318	37,028	0	37,028
Sasabe	0	423	423	0	124	124	9	0	9
Springerville	0	0	0	0	0	0	0	0	0
St. George	0	0	0	0	0	0	0	0	0
Teec Nos Pos	0	0	0	0	0	0	711	906	711
Topock	7,215	67	7,282	17,095	0	17,095	34,150	0	34,150
Yuma B-8	0	0	0	231	0	231	7	0	7
Yuma I-8	3,983	0	3,983	589	0	589	269	232	269
Ports Sub-Total	389,579	6,186	395,765	460,876	15,196	476,072	412,646	4,767	412,646

Table 37: Commercial Vehicle Safety Inspections, Fiscal 1997 to 2002

	FY ENDING					
FACILITY	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Douglas State	31	80	38	22	26	10
Douglas Federal	76	117	152	95	27	69
Duncan	0	4	3	2	1	0
Ehrenberg	308	394	1,356	2,052	1,142	655
Fredonia	46	29	37	29	25	34
Kingman	0	0	9	18	38	44
Lukeville	14	11	14	49	50	34
Naco	17	64	64	61	55	12
Nogales	113	288	177	144	61	104
Page	23	58	56	143	68	46
Parker	0	24	57	0	8	0
Sanders	53	88	192	740	387	240
San Luis	0	6	0	64	64	19
San Simon	144	403	24	343	3	84
Sasabe	0	0	11	0	7	32
Springerville	0	10	3	23	3	2
St. George	435	604	423	594	301	191
Teec Nos Pos	42	123	9	57	47	31
Topock	261	253	464	654	132	125
Yuma B-8	0	0	2	0	41	10
Yuma I-8	0	0	0	0	62	58
Ports Sub-Total	1,563	2,556	3,091	5,090	2,548	1,800

Table 38: Number of Vehicles Weighed, Fiscal 1997 to 2002

	FY ENDING					
FACILITY	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Douglas State	5,835	7,068	10,503	19,474	12,020	10,620
Douglas Federal	209	1,637	7,108	14,225	15,156	13,940
Duncan	15,268	23,727	20,325	17,321	13,394	16,422
Ehrenberg	864,084	924,821	406,032	787,379	686,221	470,267
Fredonia	509	117	1	20	1	21
Kingman	190,009	97,757	214,441	221,739	160,527	169,897
Lukeville	19	31	54	302	178	246
Naco	2,806	2,127	3,845	4,993	4,448	4,041
Nogales	98,706	96,901	86,307	37,366	2,321	53,518
Page	23,884	19,924	24,642	27,489	28,130	35,393
Parker	41,476	20,997	19,649	20,876	22,184	38,946
Sanders	749,374	783,865	603,489	369,529	474,919	394,800
San Luis	9,974	9,106	9,007	6,667	3,146	5,135
San Simon	695,385	731,454	554,546	781,477	550,079	648,591
Sasabe	0	162	48	7	28	141
Springerville	0	0	0	0	0	0
St. George	929,992	843,594	1,021,017	932,484	889,709	1,172,086
Teec Nos Pos	2,806	860	1,675	2,361	2,719	2,723
Topock	577,228	652,675	608,518	241,861	490,425	378,867
Yuma B-8	79,366	85,979	67,315	60,621	66,249	71,019
Yuma I-8	322,629	327,528	3,367	303,361	327,852	314,351
Ports Sub-Total	4,609,559	4,630,330	3,661,889	3,849,552	3,749,706	3,801,024

Table 39: Average Inbound Traffic per Hour, Fiscal 1997 to 2002

	FY ENDING				
FACILITY	**1998**	**1999**	**2000**	**2001**	**2002**
Douglas State	2.3	2.1	3.5	0.8	2.7
Douglas Federal	13.5	14.8	14.5	3.9	8.7
Duncan	3.3	3.8	2.9	1.4	4.0
Ehrenberg	130.3	132.4	137.2	153.1	154.0
Fredonia	10.3	9.5	13.9	2.7	9.5
Kingman	29.0	41.2	43.6	36.6	36.1
Lukeville	5.8	1.1	1.7	0.5	3.4
Naco	3.1	3.4	48.5	1.1	2.8
Nogales	33.2	42.3	42.1	21.5	63.7
Page	6.6	6.8	8.2	6.9	10.0
Parker	6.0	7.9	14.3	6.6	16.0
Sanders	117.0	131.8	159.9	179.4	184.4
San Luis	8.2	7.2	6.5	3.1	8.1
San Simon	107.3	112.6	114.3	139.4	99.3
Sasabe	0.8	0.7	0.8	0.1	2.8
Springerville	26.5	13.3	16.5	4.7	18.7
St. George	60.7	62.5	113.4	110.6	81.8
Teec Nos Pos	3.2	11.8	3.0	3.2	3.9
Topock	82.7	83.5	100.4	128.4	114.2
Yuma B-8	10.6	13.3	10.6	13.7	11.5
Yuma I-8	39.1	36.6	40.1	54.7	42.8
Ports Sub-Total	49.0	53.3	59.2	37.4	60.7

Table 40: Selected Violation Measures, Fiscal 2002

Facility	Driver Violation	Driver OOS	Driver Citation	Vehicle Violation	Vehicle OOS	Vehicle Citation	Vehicles OvrWgt	Percent Ovrwgt	Average Fine (Wgt)
Douglas State	0	0	0	30	5	0	19	0.2%	$595.56
Douglas Federal	8	0	0	264	22	2	98	0.7%	$1,260.00
Duncan	0	0	0	0	0	0	525	3.2%	$265.78
Ehrenberg	760	128	226	281	31	19	4,632	1.0%	$611.54
Fredonia	28	3	0	15	0	0	0	0.0%	n/a
Kingman	9	4	0	39	4	0	1,363	0.8%	$422.64
Lukeville	44	2	1	81	1	0	0	0.0%	$840.00
Naco	5	1	0	34	4	0	5	0.1%	$1,110.00
Nogales	0	0	0	97	14	0	798	1.5%	$950.00
Page	26	4	0	21	2	0	79	0.2%	$875.00
Parker	0	0	0	0	0	0	1,034	2.7%	$388.89
Sanders	322	80	46	307	31	4	3,738	0.9%	$639.45
San Luis	5	4	0	58	2	0	49	1.0%	$762.00
San Simon	167	66	2	133	18	0	1,246	0.2%	$754.79
Sasabe	7	1	0	218	11	2	8	5.7%	$1,260.00
Springerville	0	0	0	0	0	0	0	n/a	n/a
St. George	31	8	0	218	14	1	2,856	0.2%	$997.48
Teec Nos Pos	4	0	0	12	0	0	18	0.7%	$1,253.85
Topock	74	4	3	272	7	0	976	0.3%	$940.00
Yuma B-8	4	1	0	50	0	0	512	0.7%	$921.33
Yuma I-8	15	1	0	169	13	0	2,566	0.8%	$548.33
Ports Sub-Total	1,509	307	278	2,299	179	28	20,522	0.5%	$687.24

APPENDIX B: VEHICLE INSPECTION STANDARDS

Inspection Type- The following inspection types are included in this report:

All- Includes inspection levels 1, 2, 3, 4, and 5.
Driver- Includes inspection levels 1, 2, and 3.
Vehicle- Includes inspection levels 1, 2, and 5.
Hazmat- Includes inspection levels 1, 2, and 3 (when Hazmat is present).

Data Source: North American Standard Truck Inspection Procedures, Federal Motor Carrier Safety Administration (FMCSA) Motor Carrier Management Information System (MCMIS) September 22, 2001

LEVEL I - North American Standard Inspection - An inspection that includes examination of driver's license, medical examiner's certificate and waiver, if applicable, for alcohol and drugs, of driver's record of duty status as required, hours of service, seat belt, vehicle inspection report, brake system, coupling devices, exhaust system, frame, fuel system, turn signals, brake lamps, tail lamps, head lamps, lamps on projecting loads, safe loading, steering mechanism, suspension, tires, van and open-top trailer bodies, wheels and rims, windshield wipers, emergency exits on buses and HM requirements, as applicable.

LEVEL II - Walk-Around Driver/Vehicle Inspection - An examination that includes each of the items specified under the North American Standard Inspection. As a minimum, Level II inspections must include examination of: driver's license, medical examinees certificate and waiver (if applicable), driver's record of duty status as required, hours of service, seat belt, vehicle inspection report, brake system, coupling devices, exhaust system, frame, fuel system, turn signals, brake lamps, tail lamps, head lamps, lamps on projecting loads, safe loading, steering mechanism, suspension, tires, van and open-top trailer bodies, wheels and rims, windshield wipers, emergency exits on buses, and HM requirements, as applicable. It is contemplated that the walk-around driver/vehicle inspection will include only those items which can be inspected without physically getting under the vehicle. Level II inspections must also include screening drivers for alcohol and/or drug usage.

LEVEL III - Driver-Only Inspection - A roadside examination of the driver's license, medical certification and waiver, if applicable, driver's record of duty status as required, hours of service, seat belt, vehicle inspection report, and hazardous material requirements, as applicable.

LEVEL IV - Special Inspections - Inspections under this heading typically include a one-time examination of a particular item. These examinations are normally made in support of a study or to verify or refute a suspected trend.

LEVEL V - Vehicle-Only Inspection - An inspection that includes each of the vehicle inspection items specified under the North American Standard Inspection (Level I), without a driver present, conducted at any location.

APPENDIX C: STATE POE SURVEY INSTRUMENT

The survey on the next two pages was distributed by mail to state motor carrier enforcement agencies in November, 2002. Of the fifty surveys distributed, eighteen were returned for an overall response rate of 36 percent.

Arizona Department of Transportation
Survey of Port of Entry Performance Measures

The *Arizona Department of Transportation* is working to improve its methods for evaluating performance at state ports of entry (POEs). This research is intended to develop meaningful measurements for assessing port of entry performance. As part of this process, we are interested in learning how other states measure POE processes and how these measurements are used to improve POE operations.

We would appreciate your response to the following questions. This information will be used to assist the Arizona Department of Transportation in developing appropriate measures to improve the efficiency and effectiveness of its current practices.

Person completing this survey: _____ State _____

Department _____ Telephone _____ E-mail _____

If you have any questions regarding completion of this survey,
please contact Jason Carey at *jasoncarey@hotmail.com*.

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1. What are the primary responsibilities of highway ***Ports of Entry (POEs)*** in your state? *(check all that apply)*

   - ☐ Registration / credential verification
   - ☐ Permit issuance
   - ☐ Route information / guidance
   - ☐ Weight enforcement
   - ☐ Other, specify: _____
   - ☐ Other, specify: _____
   - ☐ Commercial vehicle safety inspection
   - ☐ Cargo / commodity inspection
   - ☐ Revenue collection

2. Do Ports of Entry in your state *collect data* related to these responsibilities?

   - ☐ Yes, all activities
   - ☐ Yes, only for specific functions (e.g., weight enforcement)
   - ☐ No

3. For what purpose(s) are your *port of entry* data being used? *(check all that apply)*

   - ☐ Allocation of funds
   - ☐ Allocation of staff
   - ☐ Facility design
   - ☐ Evaluation and/or development of procedures
   - ☐ Enforcement planning
   - ☐ Assessment of commercial fees / revenues
   - ☐ Other, specify: _____
   - ☐ Assessment of vehicle size and weight laws
   - ☐ Measurement of changes in traffic (e.g., weight distribution, safety violations, etc.)
   - ☐ Research
   - ☐ To meet federal data collection requirements
   - ☐ Not being used for decision making

4. Under which *jurisdiction(s)* are POEs in your state? *(check all that apply)*
   - ☐ Department of *Public Safety/Law Enforcement*
   - ☐ Department of *Motor Vehicles/Transportation*
   - ☐ Department of *Revenues/Treasury*
   - ☐ Other, specify: _____

5. Does your state ***measure performance*** for highway Ports of Entry?
   - ☐ Yes, all activities
   - ☐ Only for specific functions (e.g., weight enforcement)
   - ☐ No

6. If so, ***how is performance measured*** for highway Ports of Entry?
   (please complete the table below, indicating measurements taken and current and target values)

Measurement ***(please include a brief description)***	**How often?** ***(e.g., monthly, annual, etc.)***	**Current value and year**	**Target value and year**

7. How useful is your current system for measuring *port of entry performance*? *(circle your response)*

Very Useful				Not Useful
5	4	3	2	1

8. Do the performance measurements accurately reflect POE responsibilities?
   - ☐ Yes
   - ☐ No
   - ☐ If no, what should be measured? _____

9. Do the performance measurements accurately reflect desired outcomes of POE activities?
   - ☐ Yes
   - ☐ No
   - ☐ If no, what should be measured? _____

APPENDIX D: SAFETY BENEFIT CALCULATIONS

A benefit-cost study of the Commercial Vehicle Information Systems and Networks (CVISN) in Maryland [Bapna *et al.* 1998] quantified the effects of current and alternative enforcement scenarios with respect to improved highway safety resulting from identification of high-risk vehicles and/or drivers. Benefits were assumed to be a reduction in the number of crashes observed as a result of placing violators out of service (OOS). In other words, it was assumed that the crash rate for commercial vehicles would decrease as more "unsafe" drivers or vehicles were identified for inspection.

The baseline condition was the existing means of identifying violators at ports of entry and roadside inspections without benefit of the automated CVISN system. Baseline safety benefits were based on performance measures from an Office of Motor Carriers (OMC) study [Sienicki 1998] and a cost-benefit analysis by Moses and Savage [Moses and Savage 1997].

(1) $X = V * E * T$
(2) $Y = D * E * T$

Where
X = number of vehicle miles driven "safely" after vehicle placed OOS and repaired
Y = number of vehicle miles driven "safely" after driver placed OOS
V = number of vehicles placed OOS from existing inspection
D = number of drivers placed OOS from existing inspection
T = average number of miles traveled monthly by a vehicle in Maryland (= 3625.83 vmt)
E = effect in number of months for placing vehicle or driver OOS (= 3 months)

From these, estimate carrier accidents (CA) without OOS enforcement and accidents avoided (AA)

(3) $CA_X = 2.174 * X$
(4) $CA_Y = 2.174 * Y$

Where
2.174 = number of carrier accidents per million vehicle miles (1.65) for *all* heavy trucks in Maryland multiplied by unsafe vehicle probability factor[14] of 1.316

(5) $AA_X = 0.06 * CA_X$
(6) $AA_Y = 0.052 * CA_Y$

For equations (5) and (6), Maryland Statewide Accident Profile (1996) revealed that 6.0% and 5.2% of crashes were attributable to avoidable vehicle defects and driver problems respectively. Similarly, Sienecki reported 4.6% and 5.7% nationally [Sienicki 1998].

[14] According to Moses and Savage (1997), "unsafe" carriers were 31.6 percent more likely to have crashes

The average weighted cost of crashes to society per motor carrier was $135,000 in 1996 dollars [Sienicki 1998]. This figure was used to estimate the direct safety benefit (B) of safety inspection and enforcement efforts:

$B = \$135{,}000 * (AA_X + AA_Y)$

Note that additional "unquantifiable" safety benefits also were considered to accrue from motor carriers maintaining mainline highway speeds due to prescreening or other bypass. Safety research has established that potential for crashes increases when certain vehicles vary from prevailing speed of vehicle flow on a highway. Safety was possibly enhanced if fewer trucks were changing speeds to enter and exit POEs.

The time delay costs to carriers of OOS violations were estimated using $23 per hour out of service, and 1.5 hours and 4 hours delayed respectively for vehicle and driver violations [Bapna *et al.* 1998].

$C_{MC} = \$23 * (1.5 * V + 4.0 * D)$

Authors also assumed that illegally overweight vehicles (i.e., OW without permit) were more likely to have safety violations. However, the OW analysis used a percentage of total "unsafe" vehicles to estimate OW "unsafe" vehicles (18% probability factor = 57% of total unsafe population), after which the formulas used in the prior safety analysis were repeated. The indicator thus double-counted a part (57%) of the unsafe vehicle population and was therefore omitted from this adaptation.

APPENDIX E: WEIGHT ENFORCEMENT M.O.E.

The following sampling guidelines were developed by Hanscom [Hanscom 1998b] for measuring the effectiveness of weight enforcement programs. Additional discussion of the Hanscom study is included in Section II of this report. The measurement of effectiveness for weight enforcement at the Nogales POE was developed using the TWEET software and the corridor-specific guidelines below. The remainder of this section is excerpted from the Hanscom study (1998).

Nationwide analysis determined that a *single* observation site, within selected functional-class/truck-percentage categories, was sufficient to statistically detect certain enforcement effects. However, application of sound sampling strategy to a statewide or regional enforcement study requires a significant degree of generality to ensure its validity; therefore, the NCHRP M.O.E. guidelines mandate a minimum of two sites for each functional highway classification condition when evaluating state or regional networks.

Regional site number requirements were based on observed M.O.E percentage reductions found to be associated with enforcement activity. However, for situations in which an observed enforcement activity may produce greater or lesser percentage M.O.E differences, an appropriate adjustment to the number of observation sites may be required to statistically measure the effect. With the TWEET software, the user will be appropriately informed of the level of affected M.O.E. change (and the associated number of required sites to validly observe this effect) via application of the software package.

Importantly, the final designation of observation sites must consider prevalent conditions, e.g., specific hauling and commodity demands that affect truck-loading operations and the sub-regional areas to which they apply. Specifically, the user is cautioned against combining sites characterized by known non-homogenous loading conditions when applying the sampling procedure.

Designated data collection periods need to be sensitive to seasonal conditions, e.g., agricultural commodity hauling patterns. A minimum two-day data collection duration is required at each site for each observed enforcement condition. Truck weight enforcement efforts often concentrate on a corridor surrounding a specific route, e.g., commonly used for commodity hauling. Applied enforcement strategies involve monitoring primary routes as well as potential diversion routes within the corridor.

The corridor or local-level M.O.E. sampling procedure first involves designation of the potentially-affected roadways surrounding the primary route of interest. Routes in this area obviously need to be targeted (and WIM data sampled) by the corridor-specific enforcement program. Second, the highway network within the diversion area must be examined to determine the functional classification and associated truck percentage on each affected route.

Unlike wider-area, regional weight-enforcement efforts, a single observation site may suitable for use in a corridor-specific enforcement activity evaluation. M.O.E. sampling to evaluate a specific enforcement activity can involve data collection at a single observation site. The site would be designated as a feasible permanent or portable WIM installation at a highway location affected by trucks subjected to the enforcement procedures under study. A minimum data collection duration of two days is required for each enforcement condition.

Care must be taken that WIM instrumentation be installed and operated in an unobtrusive manner so as not to interfere with an objective evaluation procedure. Ideally, such an evaluation would be conducted at a location where no potential overweight-truck diversion route is possible. However, at sites other than long desert highways, bridges between two islands, or a few select routes along the Florida Keys, enforcement agencies are advised to monitor any parallel highways for increased truck volume. Furthermore, as an internal validity check with regard to the enforcement evaluation effort, user agencies are advised to compare truck volumes, time-of-day flow rates, and violation percentages between enforcement and non-enforcement data collection periods. Direct application of the TWEET software accommodates this task.