# NCFRP

## REPORT 10

NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

Sponsored by the Research and Innovative Technology Administration

# Performance Measures for Freight Transportation

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NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

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# Performance Measures for Freight Transportation

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TRANSPORTATION RESEARCH BOARD

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## NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

America's freight transportation system makes critical contributions to the nation's economy, security, and quality of life. The freight transportation system in the United States is a complex, decentralized, and dynamic network of private and public entities, involving all modes of transportation—trucking, rail, waterways, air, and pipelines. In recent years, the demand for freight transportation service has been increasing fueled by growth in international trade; however, bottlenecks or congestion points in the system are exposing the inadequacies of current infrastructure and operations to meet the growing demand for freight. Strategic operational and investment decisions by governments at all levels will be necessary to maintain freight system performance, and will in turn require sound technical guidance based on research.

The National Cooperative Freight Research Program (NCFRP) is a cooperative research program sponsored by the Research and Innovative Technology Administration (RITA) under Grant No. DTOS59-06-G-00039 and administered by the Transportation Research Board (TRB). The program was authorized in 2005 with the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). On September 6, 2006, a contract to begin work was executed between RITA and The National Academies. The NCFRP will carry out applied research on problems facing the freight industry that are not being adequately addressed by existing research programs.

Program guidance is provided by an Oversight Committee comprised of a representative cross section of freight stakeholders appointed by the National Research Council of The National Academies. The NCFRP Oversight Committee meets annually to formulate the research program by identifying the highest priority projects and defining funding levels and expected products. Research problem statements recommending research needs for consideration by the Oversight Committee are solicited annually, but may be submitted to TRB at any time. Each selected project is assigned to a panel, appointed by TRB, which provides technical guidance and counsel throughout the life of the project. Heavy emphasis is placed on including members representing the intended users of the research products.

The NCFRP will produce a series of research reports and other products such as guidebooks for practitioners. Primary emphasis will be placed on disseminating NCFRP results to the intended end-users of the research: freight shippers and carriers, service providers, suppliers, and public officials.


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The project that is the subject of this report was a part of the National Cooperative Freight Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

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# FOREWORD

By William C. Rogers
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*NCFRP Report 10: Performance Measures for Freight Transportation* presents a comprehensive, objective, and consistent set of measures to gauge the performance of the freight transportation system. These measures are presented in the form of a Freight System Report Card, which reports information in three formats, each increasingly detailed, to serve the needs of a wide variety of users from decision makers at all levels to anyone interested in assessing the performance of the nation's freight transportation system.

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As the demand for freight transportation outstrips the capacity of the nation's highway, rail, waterway, air, and port systems, the effects are felt as congestion, longer and less reliable transit times, upward pressure on freight prices, and higher inventory levels. These impacts increase the cost of doing business and the cost of living and result in a less productive and competitive economy. A comprehensive, objective, and consistent set of performance measures for the U.S. freight transportation system is important for assessing the condition of that system, identifying its problems, prioritizing actions to resolve those problems, and measuring the effectiveness of the remedial actions.

Under NCFRP Project 03, Gordon Proctor & Associates reviewed current work on performance measures, identified freight transportation performance issues important to stakeholders, and, on the basis of this research, developed a framework for measuring the performance of the freight transportation system, subsystems, and components. The framework includes a Freight System Report Card, which is structured as a modified Balanced Scorecard and includes 29 performance measures in 6 categories. The performance measures and Freight System Report Card reflect local, regional, national, and global perspectives and are intended to serve as a resource for a range of stakeholders, both public and private, who need to make investment, operations, and policy decisions.

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SUMMARY

# Performance Measures for Freight Transportation

The objective of the research on which this report was based was to develop measures to gauge the performance of the U.S. freight transportation system. The measures as sought in the project statement are intended to support investment, operations, and policy decisions by a range of stakeholders, both public and private. The measures also are intended to reflect local, regional, national, and global perspectives. The project's areas of emphasis include efficiency, effectiveness, capacity, safety, security, infrastructure condition, congestion, energy, and the environment.

The breadth and scope of the project's objective reflect the breadth and scope of the national freight system. The U.S. freight system serves the world's largest economy. The freight system spans the 24 million square miles of the North American continent while linking it to international markets. The freight system comprises not only 4 million miles of public roads, 140,000 miles of railways, 360 commercial airports, and a 12,000-mile marine transportation system. It also consists of trucking firms, railroad companies, and maritime and aviation companies and the public agencies that both serve and regulate them. Each of the nation's diverse 6.2 million employers relies on some aspect of the freight system, some for their entire livelihood. This research documents that the interests of stakeholders in freight performance measurement are as diverse as are the stakeholders themselves.

The project's emphasis upon measuring efficiency, safety, security, infrastructure condition, energy, and the environment reflects society's cross-cutting and countervailing concerns about freight. Producers and shippers are most concerned about travel times, travel reliability, and travel costs. Other sectors of society primarily are concerned about freight externalities. Externality concerns are evident in national programs to measure and control freight emissions, hazardous material releases, and accidents involving trucks or trains. Another set of concerns addresses the control of certain types of freight shipments. Trade agreements regulate imports. Concerns over agricultural pests and food safety lead to control of agricultural imports. Illicit and unapproved drugs are controlled at the borders. Imports of firearms, explosives, and nuclear material are closely regulated. Society's concerns about the freight system span not only the system's efficiency at moving goods but also society's ability to reduce externalities and to regulate undesirable movements.

To address the project's ambitious agenda, and recognizing the lack of resources to create a new national freight data reporting structure, the project recommends creation of a Freight System Report Card that relies upon existing sources. To reduce the cost of performance measurement, the project bases it primarily upon existing federal data and proposes to link the data through a Web-based application to more detailed explanatory reports. In this way, the proposed Freight System Report Card can be succinct but also detailed.

The report card is proposed to be structured as a modified "Balanced Scorecard,"[1] which reports freight performance measures in six categories. These categories allow for the full

complexities and difficult tradeoffs of freight performance to be evident. Those six areas are: freight demand, freight efficiency, freight system condition, freight environmental impacts, freight safety, and the adequacy of investment in the freight system. The format of the Freight System Report Card and the categories of measures within it are predicated upon several critical findings from this research.

- First, successful performance measurement systems tend to provide summary, "at a glance" compilations of performance, while also linking to detailed reports that allow users to "drill down" into performance.[2,3,4]
- Second, successful performance measurement systems reflect a broad array of performance concerns, not just certain narrow areas. The Balanced Scorecard has become popular in performance measurement circles because it portrays broad, competing values so that the balancing of competing interests is evident.
- Third, successful performance measurement systems require an architecture. That is, they need data protocols, common definitions, taxonomies, agreed reporting cycles, quality control/quality improvement processes, and common consensus among users as to the accuracy and efficacy of the measurement system and the data it uses.[5]
- Fourth, most performance measurement systems are evolutionary. Most developers of performance measurement systems "begin with what they have." The systems tend to mature and evolve over time, sometime over decades.
- Fifth, although a comprehensive freight performance measurement system does not exist, important aspects of freight performance are available in federal data sources. These data sources are predominantly available regarding highway and waterway infrastructure condition, freight volumes, and freight externalities such as air emissions and crashes.
- Sixth, private-sector trade associations often produce robust freight performance metrics that can augment the public agency metrics.
- Seventh, there is no one agency or entity that has the mandate or resources to develop and sustain a comprehensive freight performance measurement system. Many individual agencies and private-sector trade organizations measure components of freight system performance, but no one agency cuts across the numerous silos to compile a comprehensive reporting system. Therefore, the recommended framework seeks to capture from existing federal and private sources the existing performance measurement information that does exist.

An important caveat to the report card is that not all of its metrics qualify as performance measures. The Government Accountability Office (GAO) defines performance measurement as

> the ongoing monitoring and reporting of *program accomplishments, particularly progress towards preestablished goals. Performance measures may address the type or level of program activities* conducted (process), the direct products and services delivered by a program (outputs), and/or the results of those products and services (outcomes).[6] [emphasis added]

There are no programs or goals for important aspects of freight performance such as growth in freight volumes, changes in mode split, or travel time reliability. Several of the included metrics are necessary to track important trends, such as freight volume growth. Mixed within the report card are some true performance measures and some more general indicators of freight trends.

Freight performance measurement is challenged by both an overwhelming abundance of data and by a lack of complete data for many important freight system performance functions. Sorting and selecting from the voluminous federal data sources is one daunting

challenge for freight performance measurement. Closing data gaps is another. Data about infrastructure condition are more available than are data for freight system performance. For instance, data for the condition of bridges and pavements have long been available. Data about highway truck travel speeds are just becoming widely available. Systematic data regarding multimodal freight performance are practically nonexistent.

Although freight system performance data are incomplete, information regarding freight system externalities is available. It is possible to measure significant components of the freight system's contribution to crashes, air emissions, and greenhouse gas emissions. In fact, the data regarding externalities appear to be among the most comprehensive, well defined, and granular of the freight data. The presence of targets and performance-measurement architecture in federal safety and air quality programs partially explains the comprehensiveness of performance data for them. As a corollary, the lack of national freight system performance programs, performance goals, or targets partially explains the lack of freight system performance data.

The various metrics within the Freight System Report Card were selected after a review of 360 potential freight performance measures. The voluminous set of potential measures was screened on the basis of surveys of public- and private-sector freight stakeholders, by the quality of data to support the measures, and by their relevance to the project objectives. In general, the public-sector stakeholders were interested in less frequently updated measures to assist with policy, planning, and investment decisions. Private-sector stakeholders were interested in more continuously available measures to make daily operational decisions. Public-sector stakeholders were interested in policy and infrastructure issues, whereas private-sector stakeholders were more interested in cost, reliability, and travel time measures. Two-thirds of private-sector respondents indicated that they never sought government-provided freight performance measures.

Several major impediments confront a national freight performance measurement system. First, no apparent agency or entity currently exists with the resources to independently develop, staff, and sustain a new, comprehensive freight performance measurement system that addresses all the issues raised in the NCFRP 03 problem statement. Second, the data needs are enormous to address all nine performance areas described in the research statement at the local, regional, national, and global levels for policy, investment, and operations. No national infrastructure exists to define, collect, scrub, and deploy such comprehensive data. Third, the lack of national goals or strategies obfuscates priorities for measurement. Fourth, there is less than complete consensus as to how measures should be used. Some favor their use for making policy and investment decisions, while others are concerned that standard national measures will obscure important local considerations and skew policy and investment decisions.

To overcome these constraints, the research report recommends creation of a first-generation Freight System Report Card that relies primarily upon existing freight performance reports. The reliance upon existing reports partially overcomes the lack of an agency and budget to generate a new measurement process. It also reduces the time, cost, and complexity of implementing a reporting system. The existing reports that are selected for the report card generally already have a supporting architecture. These reports result from mature processes that include taxonomies, data protocols, quality assurance processes, and an ongoing support structure. The population of the report card would require additional effort because the data producers would need to contribute their data to the report card. However, the level of effort would be orders of magnitude less than that of creating new measures. Models of such cooperation exist already with the seven Class I railroads contributing to common performance reports and the states in Australia and the nation of New

Zealand contributing to an Austroads performance website and to emerging efforts by the state transportation agencies to jointly identify performance metrics.

The framework seeks to simplify the enormous complexity of measuring the U.S. freight network by focusing primarily upon the disproportionate importance of key freight network components, such as the Interstate and National Highway systems, the Class I railroads, and the top 20 U.S. ports.

Finally, the framework is proposed to address a key requirement of performance report cards. They need to provide front-page "at a glance" summaries that provide busy executives with a succinct and instantaneous assessment of performance. However, the framework also needs to allow the user to drill into details to answer more nuanced questions, or to explore trends in further detail. The framework is heavily weighted toward inclusion of composite measures that provide both brevity and insight. The composite measures summarize trends but also can be disaggregated for drilling down into the factors that contribute to the performance.

In addition, the report card is proposed to function in a three-tiered fashion intended to serve the various levels of detail required by users. A governor or legislator can be served with highly consolidated, trend line information. A metropolitan planning organization (MPO) board member, a department of transportation (DOT) senior executive, or an inquisitive reporter may seek more detailed information. A DOT staff person, an academic researcher, or a logistics provider requires even more detail. The framework is envisioned to address the increasingly detailed information needs of all three levels of users. It provides varying degrees of insight by having a highly summarized Freight Transportation Report Card, a summary report for each measure in the report card, and a link to a much more comprehensive report that can explain the context of each measure. In this way, the report card is intended to be both succinct and insightful, as illustrated in Figure S.1.

The key in Figure S.2 includes four different colors of indicators used in the report card. The need for multiple indicators is reflective of freight's complexity. Some decreases are positive, such as decreases in emissions. Some increases are negative, such as increases in crashes. Other changes could be considered either positive or negative depending upon the stakeholder's viewpoint. Increases or decreases in freight volumes are shown in black, indicating their change could be viewed as either positive or negative depending upon the stakeholder's perspective. Changes in red clearly are negative, such as increases in freight-related fatalities. The report card attempts to illustrate trends but also whether those trends are positive or

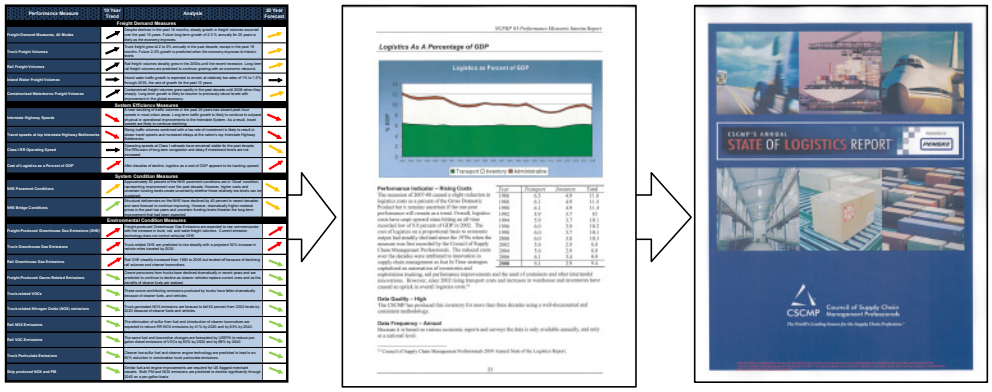



***Figure S.1. Tiers of reporting from general and summarized to highly detailed and granular.***

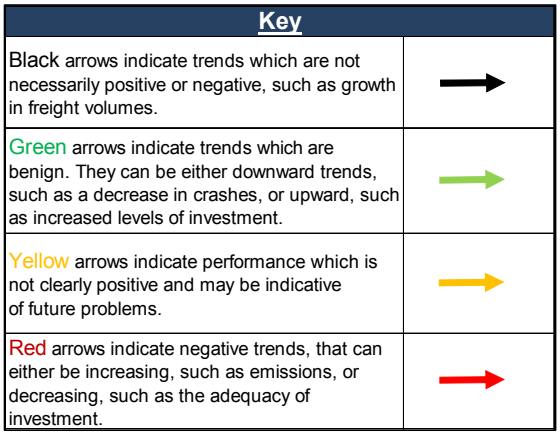



***Figure S.2. Report Card key.***

negative. Admittedly, stakeholders with strong positions may disagree with the characterization. For instance, advocates for one mode may see increases in freight volumes for another mode as negative. The formatting is oriented to a centrist, public-sector viewpoint.

Trend lines also are emphasized in the report card to provide additional context regarding how performance has changed over time, or how it is likely to unfold into the future.

As noted in Figure S.1, accompanying the report card are summaries that elaborate on each performance metric. Following the report card (see Figure S.3) is a representative summary for the cost of logistics as a percentage of gross domestic product (see Figure S.4). That summary defines and further elaborates upon the measure. The summary also includes references to even more detailed information that may be of interest to a more demanding user. In this example, the link is to the full report by the Council of Supply Chain Management Professionals (CSCMP) that examines the inputs into the 2009 analysis of logistics costs as a percentage of the nation's gross domestic product. The three-tiered structure addresses the project statement's requirement that the framework appeal to decision makers and users at various levels.

## Freight Performance Indices and Measures

The report card attempts to balance the tension between users desiring a wide array of measures and the potentially crippling cost and complexity of sustaining a massive measurement process. The score card relies on only six categories and 29 measures. However, most are composite measures that can be broken down into their component elements for greater understanding of performance. The data often can be broken down into categories, or into geographic regions and, in some cases, to corridors, links, and nodes. The composite nature is an attempt to provide both "at a glance" summation while also accommodating detailed deconstruction of underlying trends, factors, and performance.

## Links to Source Documents

In the proposed Freight System Report Card, this summary would be linked to the source document, in this case the CSCMP 2010 *State of Logistics Report.* The links to source documents provide the greater detail and context that some readers would desire.

The complete set of explanatory summaries is included in Appendix F.

| Performance Measure | 10-Year Trend | Analysis | 20-Year Forecast |
|---|---|---|---|
| **Freight Demand Measures** | | | |
| Freight Demand Measures, All Modes |  | Despite declines in the past 18 months, steady growth in freight volumes occurred over the past 10 years. Future long-term growth of 2-3 % annually for 20 years is likely as the economy improves. |  |
| Truck Freight Volumes |  | Truck freight grew at 2 to 3% annually in the past decade, except in the past 18 months. Future 2-3% growth is predicted when the economy improves to historic levels |  |
| Rail Freight Volumes |  | Rail freight volumes steadily grew in the 2000s until the recent recession. Long-term rail freight volumes are predicted to continue growing with an economic rebound. |  |
| Inland Water Freight Volumes |  | Inland water traffic growth is expected to remain at relatively low rates of 1% to 1.5% through 2035, the rate of growth for the past 10 years. |  |
| Containerized Waterborne Freight Volumes |  | Containerized freight volumes grew rapidly in the past decade until 2008, when they sharply declined. Long-term growth is likely to resume to previously robust levels with improvement in the global economy. |  |
| **System Efficiency Measures** | | | |
| Interstate Highway Speeds |  | A near doubling of traffic volumes in the past 25 years has slowed peak-hour speeds in most urban areas. Long-term traffic growth is likely to continue to outpace physical or operational improvements to the Interstate System. As a result, travel speeds are likely to continue declining. |  |
| Travel speeds at top Interstate Highway Bottlenecks |  | Rising traffic volumes combined with a low rate of investment are likely to result in slower travel speeds and increased delays at the nation's top Interstate Highway Bottlenecks. |  |
| Interstate Highway Reliability |  | Definitive Interstate Highway System reliability data do not exist for the past decade. However, increases in traffic volumes and freight volumes are well documented and extensive localized data indicate that travel on urban Interstate highways has become less reliabile. ATRI reliability measurement on 25 Interstate corridors indicates variability in reliability on congested urban segments, with future traffic volumes expected to increase. It is reasonable to assume that reliability will worsen if current trends continue. |  |
| Class I RR Operating Speed |  | Operating speeds at Class I railroads have remained stable for the past decade. The RRs warn of long-term congestion and delay if investment levels are not increased. |  |
| Cost of Logistics as a Percent of GDP |  | After decades of decline, logistics as a cost of GDP has become more uncertain. It rose in the mid-2000s but fell signficantly with the recession of 2008. The decline was due to unsustainable conditions such as freight prices falling below costs. |  |
| **System Condition Measures** | | | |
| NHS Pavement Conditions |  | Approximately 50% of the NHS pavement conditions are 'Good', representing improvement over the past decade. However, higher costs and uncertain funding levels create uncertainty whether those relatively low levels can be sustained. |  |
| NHS Bridge Conditions |  | Structural deficiencies on the NHS have declined by 40% in recent decades and were forecast to continue improving. However, dramatically higher material prices in the past two years and uncertain funding levels threaten the long-term improvements that had been achieved. |  |

***Figure S.3. The Freight System Report Card.***

## Balancing Competing Objectives

Reflecting the diverse and often competing interests in freight measurement, the report card is set up similar to a Balanced Scorecard. The Balanced Scorecard is a performance measurement system that includes measures that reflect the tensions that exist for decision making. Instead of focusing on a few narrow measures, the scorecard juxtaposes measures of competing values, such as freight efficiency and freight externalities. Normally, Balanced Scorecards have four components that balance metrics for finances, internal processes, customer satisfaction, and the institution's ability to learn and innovate. Reflecting the complex nature of the U.S. freight system, the proposed report card has six categories. They are freight demand, freight efficiency, freight system condition, freight environmental impacts, freight safety, and the adequacy of investment in the freight system, as seen in Figure S.5. These categories respond to the original research statement and reflect commonly expressed interests of stakeholders.

A similar logic led to a preference given to composite measures. Composite measures consist of an aggregation of data, such as combined speed on the Interstate Highway System. The overview, composite measure can be disaggregated, or "drilled into," in order to examine the performance of the constituent highway links. The use of composite measures was

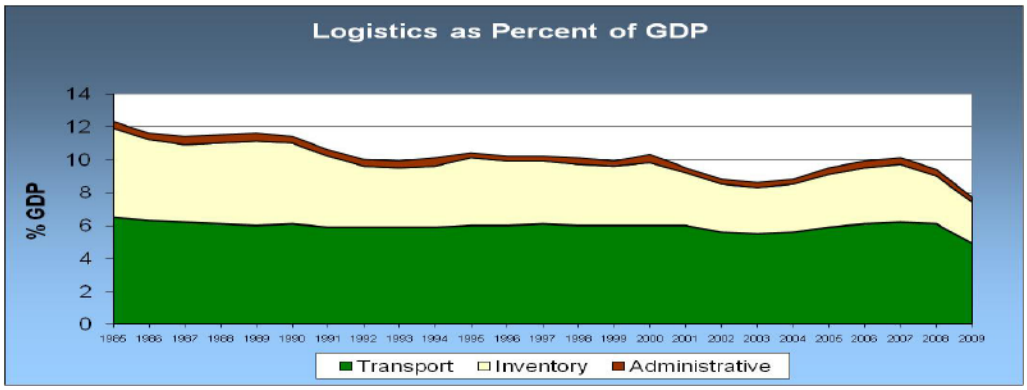
| Performance Measure | 10 Year Trend | Analysis | 20 Year Forecast |
|---|---|---|---|
| **Environmental Condition Measures** | | | |
| Freight-Produced Greenhouse Gas Emissions (GHE) |  | Freight-produced greenhouse gas emissions are expected to rise commensurate with the increase in truck, rail, and water freight volumes. Current emission technology does not control vehicular GHE. |  |
| Truck Greenhouse Gas Emissions |  | Truck-related GHG are predicted to rise steadily with a projected 30% increase in vehicle miles traveled by 2030. |  |
| Rail Greenhouse Gas Emissions |  | Rail GHG steadily increased from 1990 to 2005 but leveled off because of declining rail volumes and cleaner locomotives. |  |
| Freight-Produced Ozone-Related Emissions |  | Ozone precursors from trucks have declined dramatically in recent years and are predicted to continue to decline as cleaner vehicles replace current ones and as the benefits of cleaner fuel are realized. |  |
| Truck-related VOCs |  | These ozone-contributing emissions produced by trucks have fallen dramatically because of cleaner fuels, and vehicles. |  |
| Truck-related Nitrogen Oxide (NOX) emissions |  | Truck-generated $NO_X$ emissions are forecasted to fall 82% from 2002 levels by 2020 because of cleaner fuels and vehicles. |  |
| Rail NOX Emissions |  | The elimination of sulfur from fuel and introduction of cleaner locomotives are expected to reduce RR $NO_X$ emissions by 41% by 2020 and by 83% by 2040. |  |
| Rail VOC Emissions |  | The same fuel and locomotive changes are forecasted by USEPA to reduce per-gallon diesel emissions of VOCs by 60% by 2020 and by 88% by 2040. |  |
| Truck Particulate Emissions |  | Cleaner low-sulfur fuel and cleaner engine technology are predicted to lead to an 82% reduction in combination truck particulate emissions. |  |
| Ship produced NOX and PM |  | Similar fuel and engine improvements are required for U.S.-flagged merchant vessels. Both PM and $NO_X$ emissions are predicted to decline significantly through 2040 on a per-gallon basis. |  |
| **Freight Safety Measures** | | | |
| Truck Injury and Fatal Crashes |  | Between 1988 and 2007, the large truck injury crash rate decreased from 67.9 to 31.8 per million miles traveled. The 2007 rate is the lowest on record. The large truck fatal crash rate has also declined. In 2007, this rate was 1.85, down from a peak of 5.21 in 1979. The 2007 rate is the lowest rate on record. |  |
| Highway/Rail At-Grade Crashes |  | Between 1998 and 2008 the number of incidents at RR crossings involving both vehicles and pedestrians declined 32%. Nearly 2,400 annual incidents still occur, with 289 deaths in 2008. |  |
| **System Investment Measures** | | | |
| Estimated Investment in NHS to Sustain Conditions |  | The 2004 FHWA Condition and Performance Report indicated that then-current investment levels were adequate to sustain most NHS conditions. However, since then construction costs increased significantly and funding for the federal highway program remains undecided. |  |
| Rail Freight Industry Earning Cost of Capital |  | The Cost of Capital for the Class I railroads has steadily declined, which is a positive economic trend for them. Lower Cost of Capital reflects lower costs to acquire capital to improve the rail network. |  |
| Estimated Rail Capital Investment to Sustain Market Share |  | A rail industry analysis concluded that the Class I RRs need to increase capital investment in expansion to sustain market share. Their ability to raise sufficient investment capital is not definite and may not be sufficient to sustain market share. |  |
| Inland Waterway Investment to Sustain Lock and Dam Average Age at Less than 50 Years |  | The average age of locks on the inland waterways system is estimated to be in excess of 51 years. Current expenditure levels do not appear to be sufficient to improve that average age. |  |

***Figure S.3. Continued.***

emphasized to respond to the project objective of having measures that allow for analysis at national, state, and regional levels. Generally, measures based upon inventories allow for granular analysis, whereas those based on estimates do not.

The report card also is proposed to include trend lines of future performance, or leading indicators, in addition to retrospective measures. Most performance measurement systems begin with lagging indicators, but users have consistently grown dissatisfied with backward-looking trends alone. Leading indicators are important for policy and investment decisions. For instance, the indicators within the Report Card forecast that national emission targets for ozone-causing nitrogen oxide ($NO_x$) and volatile organic compounds (VOCs) are on track to be met. However, greenhouse gases (GHG) emissions are forecast to increase significantly if current trends continue. Such information could well indicate that traditional emission strategies to control harmful ozone precursors are working, while society has yet to develop an effective GHG strategy for freight. Likewise, the leading indicators that forecast that overall freight volumes are to increase for highways, railways, ports, and intermodal

# Logistics as a Percentage of GDP




### Performance Indicator – Paradoxical

The cost of logistics as a percentage of Gross Domestic Product fell to the lowest level ever recorded in 2009. [1] This precipitous decline generally represents negative trends such as the rapid decline in manufacturing output, the unemployment of thousands of truck drivers and a significant downturn in truck, rail, air and water freight movement. As can be seen in the table and chart, logistics costs as a percent of GDP had been generally declining since 1985. The gradual, long-term decline was generally viewed as a positive factor. It represented increased innovation and efficiencies in the logistics industry. Logistics costs were not rising as fast as GDP, which signaled increased productivity and lower relative costs for moving goods.

However, the severe recession of 2008 and 2009 caused logistics volume to fall significantly. The logistics costs decline was viewed as creating unsustainably low prices for goods movements, which were often below the costs of logistics firms. Layoffs, bankruptcies, and operating losses were prevalent in the logistics industry as a result.

| Year | Transport | Inventory | Total |
|---|---|---|---|
| **1986** | 6.3 | 4.9 | **11.6** |
| **1988** | 6.1 | 4.9 | **11.5** |
| **1990** | 6.1 | 4.9 | **11.4** |
| **1992** | 5.9 | 3.7 | **10** |
| **1994** | 5.9 | 3.7 | **10.1** |
| **1996** | 6.0 | 3.9 | **10.2** |
| **1998** | 6.0 | 3.7 | **10.1** |
| **2000** | 6.0 | 3.8 | **10.3** |
| **2002** | 5.6 | 2.9 | **8.8** |
| **2004** | 5.6 | 2.9 | **8.8** |
| **2006** | 6.1 | 3.4 | **9.9** |
| **2008** | 6.1 | 2.9 | **9.4** |
| **2009** | **4.9** | **2.5** | **7.7** |

### Forecasted Trend Line - Uncertain

The decline in oil prices and extraordinary softness in the economy caused the cost of logistics in relation to GDP to decline in 2008 and 2009, but long-term trends could send the costs upward. After rising 50 percent in the previous five years total logistics costs fell in 2008 and fell further in 2009. Inventory carrying costs plunged primarily in 2008 because interest rates were over 50 percent lower than 2007. In 2009, transportation costs fell significantly to push logistics as a percent of GDP to 7.7 percent. In the years leading up to the recession of 2001, logistics costs as a percentage of GDP had been rising until they surpassed the 10 percent mark. Greater efficiencies and innovations caused the rate to fall in the mid 2000s. The recession of 2008 caused overall freight movement to plummet, which drove overall logistics costs further downward. When the economy rebounds, there will be fewer trucks in service as the trucking industry has shed excess drivers and vehicles. Also, the recession softened demand for fuel. As the economy rebounds these factors plus inventory costs could put upward pressure on logistics costs.

[1] Council of Supply Chain Management Professionals 2010 *Annual State of the Logistics Report*.

***Figure S.4. Representative summary.***

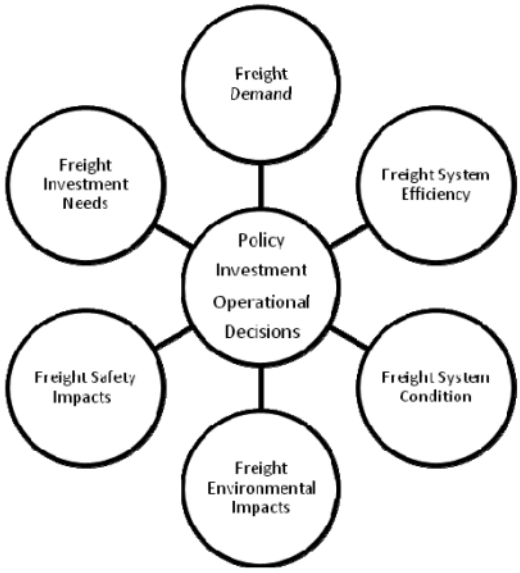



***Figure S.5. The Balanced Scorecard approach.***

shipments indicate that current levels of congestion are likely to become more severe. Also, the forecasts showing that current levels of investment are unlikely to sustain highway and rail performance lend insight into the magnitude and adequacy of system investment needs.

## Evolutionary Approach

The report card is proposed to be evolutionary. Much of the performance measurement literature and the experience of the practitioners who were interviewed indicated that performance measurement systems tend to mature and improve over time. Few of the agencies that today have comprehensive measurement systems began with those systems intact from the beginning. "Begin with what you have" is a near-universal recommendation from the performance management practitioners interviewed. Also, it is acknowledged that no proposed measurement system will meet the needs of all stakeholders. As a result, it is likely that stakeholders will advocate for additional measures, which can be added over time. Also, flaws in the current data will be found as the report card is published and examined. As a result, continuous efforts to improve the data that feed the report card should be anticipated.

The report card also attempts to select metrics that have companion interpretative reports. This is because it is unlikely than numeric values alone can provide insight for sophisticated investment and policy decisions. Factors that influence a rate of change for a measure are essential for understanding the measure, such as those factors enumerated in the CSCMP cost-of-logistics measure. Similarly, each metropolitan area's air-quality "conformity" analysis provides the context for its emission results. Unfortunately, not every metric has an explanatory report to provide context and analysis, but those that do were given higher consideration for inclusion as a metric. They provide context and interpretation for the changes in the metrics.

## Initial Focus on Key Freight Network Components

The framework seeks to simplify the enormous complexity of measuring the U.S. freight network by focusing primarily on the disproportionate importance of key freight network components, such as the Interstate and National Highway systems, the Class I railroads,

**Table S.1. Freight volumes consolidated on the key network components.**

| Facility | Size | Percent of Freight |
|---|---|---|
| Interstate Highway System | 1% of highway system | 49% of Truck VMT |
| National Highway System | 4% of highway system | 75% of Truck VMT* |
| Class I RRs | 7 out of 563 carriers | 93% of Rail Revenue |
| Top 20 container ports | Out of 124 nationally | 96% of Container Traffic |

and the top 20 U.S. ports. The powerful market forces that lead logistics professionals to seek the lowest-cost, most direct routes from freight origins to destinations have led to considerable consolidation of volumes on the network, as shown in Table S.1. This significant consolidation simplifies measurement considerably. Out of 4 million miles of public roads, 4 percent, the National Highway System, carries more than 70 percent of the truck freight. Container port traffic is highly concentrated, as are freight volumes on U.S. railroads. Monitoring of performance of the national system is greatly simplified by focusing upon these key networks. The framework is established, however, to allow all regions to measure their own freight network performance. The ability to disaggregate the data would allow a less populated region to break out the performance data down to its region and, in several cases, down to individual links, or bridges. In this way, the national report card could be mirrored at the state or metropolitan level.

## Deployment and Maintenance of Report Card

Despite the efforts to reduce the cost and other barriers to creation of the Freight System Report Card, the undertaking would still require a substantial effort by a yet-unidentified coalition of collaborators. However, such coalitions exist. As mentioned, Austroads has been producing a transportation agency performance reporting system for more than a decade by relying on contributions of data from the Australian state transportation agencies and by the central transportation agency in New Zealand. An association of Nordic States shares performance information, and the American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Performance Management has taken several preliminary steps to populate a Web-based compilation of state performance metrics.

The coalition for the Freight System Report Card would need to extend to various federal agencies, including the U.S. Department of Transportation (USDOT) with the Freight Analysis Framework (FAF) and its modal agencies, the U.S. Department of Commerce, the U.S. Environmental Protection Agency (EPA), and the U.S. Army Corps of Engineers (USACE), as illustrated in Figure S. 6. However, these agencies' contribution would be to provide the Web-based report card reports that they already produce.

One complexity would be the contractual arrangements and cost for the private-sector-produced measures and related reports, such as the CSCMP report, and the data produced by the American Transportation Research Institute (ATRI) and the Association of American Railroads (AAR). States and metropolitan regions' participation would be voluntary. Therefore the degree of coverage across states and metropolitan regions would depend upon the degree to which state and local participation is engendered.

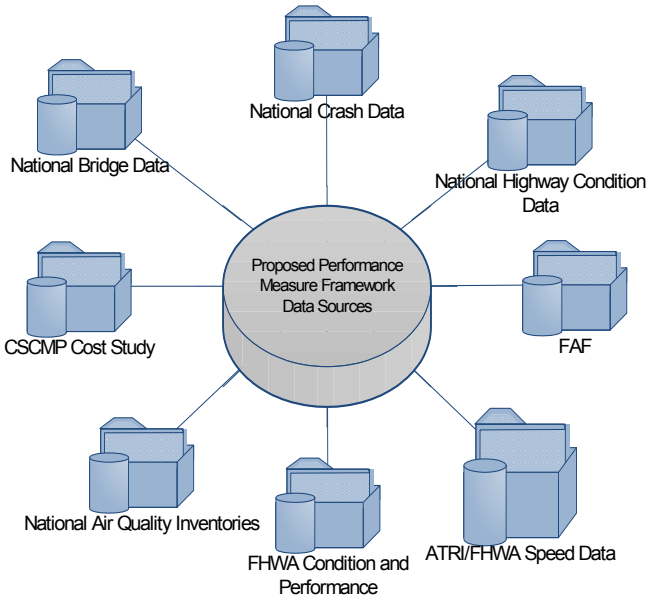



***Figure S.6. Report card data sources.***

A summary of the six categories of measures includes:

**Freight Demand Measures:** These measures provide insight into the past and future performance of the freight system and shed light on every other measurement category. They are particularly important for planning, investment, and policy decisions at all levels of government. In the case of freight performance measures, the measures of System Efficiency and System Conditions document increased congestion and declining key system conditions in recent years. In the System Investment Measures, it is documented that recent levels of investment are inadequate to sustain current conditions. Therefore, when the measures documenting inadequate system performance today are viewed in light of forecast future freight demands and continued underinvestment, an overall picture of further degradation in the condition and performance of the national freight network emerges. Although general in nature, the rate of growth in freight demand provides insight into the future trends of several other measures, such as levels of congestion. However, not all conditions are linearly linked to volume. For instance, some emissions are declining, even though freight volumes are expected to increase. As seen in the report card, the rates of growth are shown for truck, rail, and water volumes. These metrics are included pending more sophisticated forecasts being available in all measurement categories.

The Estimated Rate of Growth in Containerized Imports/Exports was chosen as an additional measure because of the disproportionate impact containerized goods play in the global economy. Additionally, growth in the movement of containerized goods will impact all three major freight transportation modes. Other waterborne freight is important, but inland domestic bulk shipping volumes have been relatively stable over the past 20 years. Meanwhile, containerized shipments have grown substantially. The relative per-ton value of containerized shipments is substantially above comparable values for bulk commodities. The containerized shipments represent the high-value, high-growth imports and exports critical in the modern global economy.

**System Efficiency Measures:** These measures are selected for insight into the overridingly critical Interstate Highway System (IHS) and Class I railroad network. Each network is disproportionately important to the overall freight system:

- The IHS comprises only 1 percent of public highway miles but accounts for 49 percent of all truck vehicle miles of travel.
- The seven Class I railroads generate 93 percent of all rail freight revenue of the more than 500 railroad companies.

Focusing upon these two systems greatly simplifies data collection and maximizes the return on investment in terms of system performance measurement. The IHS is proposed to be measured in terms of various average link speeds, as well as in terms of its most critical bottlenecks and its reliability. Performance measurement should eventually be expanded to the larger National Highway System (NHS). The NHS, including the IHS, is only 4 percent of the public highway network but carries 75 percent of all truck vehicle miles of travel.

The Class I railroad network is proposed to be measured in terms of the composite operating speeds of trains reported by the Class I railroads. Another critical railroad measure is rail's relative market share of overall freight ton-miles. This measure was selected as a barometer of change over time in the mode split of surface transportation.

The final measure in the efficiency category is the Cost of Logistics as a Percentage of the GDP. This measure is produced with statistical rigor by CSCMP and serves as an insightful barometer as to the relative cost of freight movement. Because it is a composite measure of all modes, and because it is produced as a percentage sensitive to overall economic growth, the project team believes it provides valuable trend line insight into the efficiency of the national freight network.

**System Condition Measures:** Obviously, the condition of the system is a critically important factor in the future performance of the freight system. The conditions of the NHS bridge and pavement inventories are proposed measures. In addition, the critical "last mile" of the NHS intermodal connectors is proposed for reporting, but only at the local level at this time. These two components—the NHS and its last-mile connectors—serve to reflect the condition of the national network and its performance in terms of its last linkage to key freight generators. At present, because the NHS intermodal connectors are not subject to any standardized reporting, they are not included in the national report card. They are recommended, however, in the local report card.

**Environmental Condition Measures:** Although other measures such as hazardous chemical spills or non–point source pollution caused by highway runoff could be considered, it is the air emissions that have been most extensively regulated. Therefore they are included in the freight performance measurement system. Various GHG emissions are combined into one measure each for the trucking, rail, and water modes. Ground-level ozone is regulated by addressing its primary precursors, which are VOCs and $NO_x$. Although GHG emissions are the focus of significant public discussion currently, VOCs and $NO_x$ have been the subject of more than 30 years of regulatory effort at the national, state, and local levels and are therefore included.

Diesel engines historically produced a disproportionate amount of particulate emissions, which have become an increasingly regulated emission category. The ability of microscopic particles to travel deep into the lungs has become recognized as a serious air quality and public health concern. The regulation of particulates affects trucking, rail, and water transport because of those modes' reliance upon diesel engines and their historical rates of particulate emissions.

**Freight Safety Measures:** Highway fatalities involving trucks tend to be a disproportionately low percentage of all highway crashes, considering the amount of miles traveled by these vehicles each year. Despite their relatively good safety record, concern over truck safety remains significant because of the size, weight, and reduced handling characteristics of trucks as compared to automobiles. To provide a more stable measure over time of the trucking industry's safety performance, the primary measure included in the framework is the number of injury and fatal crashes involving trucks per 100 million miles of travel.

For railroads, only about one-third of fatalities involve highway–rail crashes. The majority of fatalities are to trespassing pedestrians on railroad rights-of-way, or to railway workers. Nonetheless, public efforts to reduce highway–rail at-grade crashes have been extensive, and a measure to address them is included in the proposed framework.

**System Investment Measures:** The final set of measures relates to the level of investment necessary to sustain the freight system, both in terms of its condition and its performance. Regarding the highway mode, the level of investment sufficient to sustain conditions on the NHS is the proposed measure. Tracking of this measure provides insight into whether the NHS is likely to improve, sustain, or degrade in performance. For railroads, there are two measures. First is the measure of whether the railroads' earnings exceed the cost of capital, which is calculated by the Surface Transportation Board (STB). It is an indicator of the railroads' financial health and of their ability to generate earnings and attract investment sufficient for their long-term viability.

The second rail measure is the level of investment in rail system improvement to allow railroads to sustain existing market share. The level of investment necessary to sustain market share was determined by a definitive study performed by AAR. Their level of investment is reported in filings to the STB. Although there are no national goals for mode split or modal market share, there does appear to be significant public consensus to capitalize upon rail's greater energy efficiency and lower emissions on a per-ton basis compared to air or trucking modes. If the railroads are not able to invest sufficiently to sustain or grow market share, that fact could influence other goals, such as improving air quality, reducing GHG emissions, or improving energy efficiency.

For the inland waterway system, the U.S. Army Corps of Engineers reports the average age of the lock system at just over 50 years. The level of investment necessary to sustain this average age is proposed as a measure of the relative adequacy of investment into the complex and diverse inland waterway system.

To the extent possible, measures were selected because they offer discrete levels of granularity and meet the project objective of being comparable across geographic levels. For the most part, the performance measures based upon inventories—such as the National Bridge Inventory—or captured through national reporting processes, such as crash reports, allow granularity or comparability across geographic levels. Also, the uniformly collected ATRI truck-speed data allow for granularity. As illustrated in Figure S.7, the truck speeds can be generated for an entire interstate, for the interstate within one state, within a region, or down to an individual link. In this way, the congested links that degrade travel times can be identified and prioritized. Survey-based data such as the Freight Analysis Framework or rail operating speed do not provide local or temporal granularity. They are based upon private-sector reporting, which is intentionally consolidated to protect the privacy of the data providers.

The framework is intended to be included with the periodic interpretation of results, such as an annual freight system performance report. Isolated metrics by themselves provide a degree of insight. However, most require considerable interpretation. "Dashboards" and reports at most departments of transportation (DOTs) are accompanied by analytic reports, which provide context and interpretation. Such would be expected with a national freight

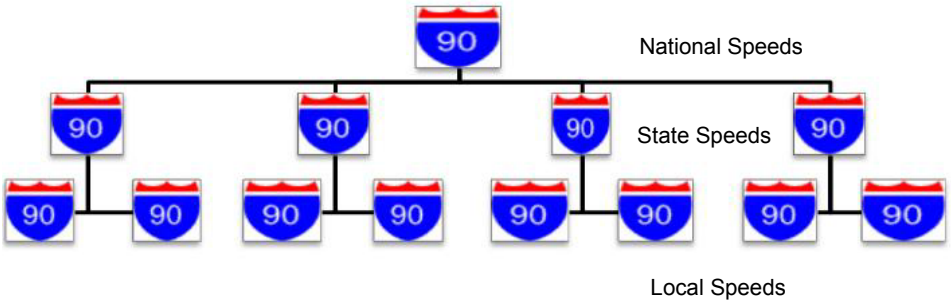



*Figure S.7. Possible granularity of Interstate Highway truck-speed data.*

performance measurement system. Most of the measures selected have at least one foundational report that can be referenced to give the reader greater insight into the performance of that aspect of the freight system.

All the measures chosen were selected at least in part because they had documented methodology for how their data were collected, normalized, and presented by a credible organization. Again, because there is no current budget or organization devoted to supporting a set of multimodal, comprehensive freight performance metrics, the framework relies upon existing data sources produced on an ongoing basis by some long-standing organization. Inherent in the assumption of the framework is that reliance on existing sources would lower the cost to sustain the framework.

As illustrated conceptually in Figure S.8, the framework is proposed with the potential for it to be populated at the national level, the state level, and then down to the MPO level. If populated in such a fashion, it would provide cascading levels of insight into the performance of the system. In such a fashion it partially satisfies the project problem statement for the framework to provide insight into global, national, regional, and local considerations. If a state or MPO chose to fully populate the framework with its comparable data, it would provide the state or MPO region with the ability to compare its freight network performance against other comparable regions or states. With such comparability, various analyses can be conducted to determine how performance changes over time by state, or by region. By putting all states and regions upon a comparable and consistent framework, greater insight could be gained over time into not only how the overall freight network is changing but also where best practices have been successful at improving conditions over time.

For instance, in terms of NHS operating speed or the top 10 freight bottlenecks on the IHS, those can be measured and their performance tracked over time to see the aggregate national performance of travel speeds on the IHS or the rate of change of performance for a selected cohort of representative bottlenecks. The data can be further separated at a state level. The state-level analysis can be used by federal decision makers to focus efforts or resources upon the states with the greatest degree of congestion or delay. Or each state can replicate the analysis for evaluation of its top bottlenecks and congested links. In addition, within a state, the individual links and bottlenecks can be evaluated and ranked for priority within each MPO's area.

In other words, the framework is designed to allow comparable analysis at all levels across the country—by aggregate national performance, by state performance, by multistate regions, or down to the MPO level.

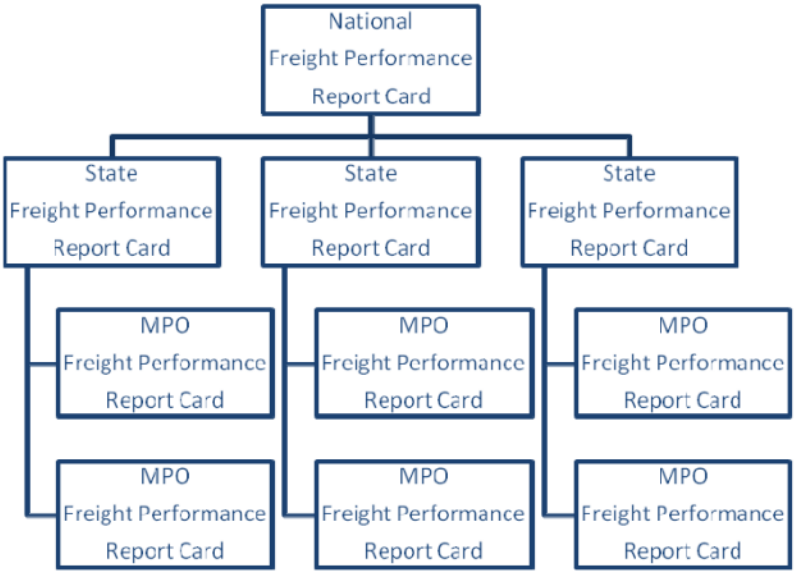



***Figure S.8. Framework from national to local measurement.***

In summary, the proposed measures are intended to provide a synopsis of the complex national freight network. They are designed to serve as a dashboard or report card summarizing at a very high level the major areas of freight system performance and condition. At the same time, the framework is brief, to minimize the crippling cost and complexity that a national freight performance measurement system could entail. The framework balances the cost and availability of data with the need to provide insight at the global, national, regional, and local levels in the areas of investment, policy, and operations.

Table S.2 shows how the broad national goals connect to each individual measure as it supports decision making in operations, investment, and policy. It also illustrates in the far right column the scope of granularity of the measure and whether it can provide insight into the national, state, or local level, or at all three levels.

## Recommendations and Further Research

NCFRP 03 had a broad scope, which was to identify freight performance measures pertinent to the public and private sectors, relevant to investment, policy, and operations decisions, made by a range of stakeholders at the national, regional, and local level and addressing the areas of efficiency, effectiveness, capacity, safety, security, infrastructure condition, congestion, energy, and environment. Important tasks in the research included identifying stakeholder interests in those broad subject areas.

The surveys and interviews conducted for this project revealed that stakeholder interests in freight performance are broad and diverse, covering almost every aspect of freight system performance. A review of national programs also revealed a host of what this report calls "inferred" stakeholder interests in the areas of environmental impacts, security, and trade. These inferred stakeholder interests are manifest in the numerous laws that affect freight performance, such as truck size and weight limits, emission standards for freight vehicles, and import-export controls that control many goods. Joining this existing list of

**Table S.2. A crosswalk of each measure to the elements it addresses.**

| Framework for National Freight Performance Measures | | | | | | |
|---|---|---|---|---|---|---|
| **National Goals** | **Proposed Measurement Categories** | **Measures within Categories** | **Decision Areas Supported** | | | |
| | | | **Operations** | **Investment** | **Policy** | **Scope** |
| **System Performance** | **Freight Demand** | Forecasted rate of growth for all modes of freight | | ■ | ■ | National |
| | | Truck freight forecast | | ■ | ■ | All |
| | | Rail freight forecasts | | ■ | ■ | National |
| | | Water freight forecasts | | ■ | ■ | National |
| | | Rate of growth in containerized imports/exports | | ■ | ■ | National |
| | | Transportation Services Index | | ■ | ■ | National |
| | **Freight Efficiency** | NHS travel speed urban | ■ | ■ | ■ | National |
| | | NHS travel speed rural | ■ | ■ | ■ | Variable |
| | | Trend line of top 10 highway freight bottlenecks | ■ | ■ | ■ | All |
| | | Composite Class I RR speeds | ■ | ■ | ■ | All |
| | | Rail freight market share | | ■ | ■ | All |
| | | Cost of logistic as percent GDP | | ■ | ■ | All |
| **System Condition** | **Pavement Measures** | NHS pavement conditions | | ■ | ■ | **All** |
| | | | | ■ | ■ | **All** |
| | **Bridge Measures** | NHS bridge conditions | | ■ | ■ | **All** |
| | | | | ■ | ■ | **All** |
| | **Intermodal Connectors** | Condition of NHS intermodal connectors | | ■ | ■ | **All** |
| **System Safety** | **Safety** | Truck injury and fatal crashes | ■ | ■ | ■ | **All** |
| | | Highway/rail at-grade crashes | ■ | ■ | ■ | **All** |
| **System Environmental Impacts** | **Air Quality** | Freight-related greenhouse emissions | | ■ | ■ | **Nat.** |
| | | | | | | **Reg.** |
| | | Other emissions: VOC, $NO_X$,CO, $SO_X$, PM | | ■ | ■ | **Nat.** |
| | | | | | | **Reg.** |
| **System Investment** | **Highway** | Estimated investment in NHS versus amount necessary to sustain conditions | | ■ | ■ | **All** |
| | **Rail** | Rail freight industry earning cost of capital | | ■ | ■ | **All** |
| | **Water** | Estimated rail capital investment to sustain market share | | ■ | ■ | **All** |
| | | Inland water investment to sustain age of system | | ■ | ■ | **All** |

stakeholder interests in freight are emerging issues such as the efficiency of freight movements. Researchers are exploring how efficiently freight moves between modes, and they are examining how best to improve freight efficiency.

The research also has documented the daunting obstacles to creating a national freight performance measurement system. For performance measurement systems to be credible, they have to compile metrics consistently over time, across the entire population being measured. AASHTO has sponsored research in recent years that addressed significant differences in how states measure basic performance, such as pavement smoothness and traffic crashes. That research addressed very basic highway-measurement processes and how those processes need substantial normalization in measurement for cross-state measurement to be accurate. Expanding performance measurement to the nine broad subject areas of this research is necessary but creates data-normalization challenges that are significantly more complex than measuring pavement or bridge conditions. The resulting conclusion of this project is that research into improved means of measuring freight performance must continue.

The research report notes, and the report card illustrates, that performance measures can be developed for many aspects of freight system performance, such as emissions, crashes, infrastructure condition, and basic measures of truck and train speed. Missing are measures of freight reliability. Research by ATRI and the FHWA have compiled reliability or "buffer indices" for 25 Interstate Highway corridors.

Such measures are still in the research stage, but they demonstrate that reliability measures within a single mode are possible, particularly when captured with technological means. The ATRI reliability data rely on capturing hundreds of thousands of anonymous truck movements by capturing distinct GPS signatures as trucks move across the highway network. By measuring the movement of hundreds of thousands of individual trucks across the highway network, both travel speeds and the variability in those speeds can be measured. From the variability, reliability can be estimated.

AAR publishes some similar train-speed data based upon self-reported results from the seven Class I railroads. Again, however, those data are mode specific.

Freight movement is often multimodal. The research illustrated that no existing source of cross-modal or multimodal freight reliability data resides in the public domain. Such data would be valuable for public decision makers who are interested in optimizing performance of freight efficiency across all modes. The private-sector logistics industry has voluminous data regarding the efficiency of its shipments across multiple modes. Consumers who use FedEx or UPS can glimpse such data when they track their packages on line. Third Party Logistics (3PL) firms, Class I railroads, and many trucking firms provide similar tracking services to freight consumers. However, this type of multimodal freight efficiency performance is not compiled and made available for public-sector research or decision making.

Future research into how to capture multimodal freight efficiency is recommended. The use of technology to track thousands of shipments from point of import to final destination—or from point of manufacture and ultimately to the consumer—could provide important insight into where freight bottlenecks exist. Mode-specific bottlenecks such as highway interchanges or long mountain highway grades can be identified today. Far less clear is whether other chokepoints exist, such as at multimodal transfer points. Some bottlenecks such as Chicago's rail-transfer inefficiencies are well known. Unclear is whether such modal conflicts exist to a lesser scale across the freight network and, collectively, whether they create substantial inefficiencies that raise the cost and lessen the reliability of freight transport.

As noted later in the research, freight data exist for many externalities such as freight-related crashes or emissions because national goals, national legislation, and national data systems exist for those externalities. The emerging interest in federal freight legislation eventually could result in greater focus upon measuring multimodal freight efficiency. Concurrent research into how to measure freight system reliability would complement those national policy efforts.

## Endnotes

1 "Balanced Scorecard" refers to the system originated by Robert Kaplan and David Norton. See http://www.balancedscorecard.org/BSCResources/AbouttheBalancedScorecard/tabid/55/Default.aspx.

2 Drucker, Peter. The Information Executives Truly Need (*Harvard Business Review*, Jan./Feb. 1995). In *Harvard Business Review on Measuring Corporate Performance,* Harvard Business School Press, Boston, Mass., 1998, pp. 1–24.

3 Frigo, M. L. Strategy-Focused Performance Measures, *Strategic Finance*, Sept. 2002.

4 Kaplan, Robert S., and David P. Norton. The Balanced Scorecard—Measures That Drive Performance (*Harvard Business Review*, Feb. 1992). In *Harvard Business Review on Measuring Corporate Performance,* Harvard Business School Press, Boston, Mass., 1998.

5 Eccles, Robert G., The Performance Measurement Manifesto (*Harvard Business Review*, 1991). In *Harvard Business Review on Measuring Corporate Performance,* Harvard Business School Press, Boston, Mass., 1998, pp. 25–45.

6 Government Accountability Office, *Performance Measurement and Evaluation, Definitions and Relationships*, 2005, p. 1.

CHAPTER 1

# Research Objective

## Research Statement

The objective of this project is to develop measures to gauge the performance of the freight transportation system, including its subsystems and components. The project's areas of emphasis include efficiency, effectiveness, capacity, safety, security, infrastructure condition, congestion, energy, and the environment. The measures are to be comprehensive, objective, and consistent and to reflect local, regional, national, and global perspectives. The measures are intended to support investment, operations, and policy decisions by a range of stakeholders, both public and private.

The key stakeholders who may be interested in a freight performance measurement framework were to be identified and their interests described. The framework was to include specific examples of performance measures.

Inherent within the project charge are several key implications. First, the framework and performance measures need to allow for assessment of broad, national transportation systems, with the ability to "drill down" into subsystems and components. An example would be performance measures of the National Highway System (NHS) that could allow aggregation to a national level, with granularity at a regional level and down to a specific link or interchange. Otherwise, the subsystems and components could not be measured.

Second, the framework needs to address all aspects cited in the project objectives and tasks ranging from freight system efficiency, to environmental externalities, to freight system costs. As a result, a variety of modes need to be considered and the issues surrounding each mode must be measured.

Third, the framework needs to include leading indicators, as well as lagging ones. This emphasis upon leading indicators is not explicit in the project objective but implicit. If the framework and measures are to be relevant to stakeholders, they need predictive capability, particularly for consideration of investment and policy alternatives. If freight volumes were expected to decrease, the need for system investment would fall. If freight volumes are to rise, then additional investment in system capacity is required. Without insight into future trends, investment and policy decisions are significantly hampered.

Fourth, the inclusion of operations measures infers the need for continuous travel-time performance information. Operations decisions in the private sector tend to be in real time or near real time in terms of selecting routes, choosing modes of transport, or selecting which warehouse, port, or depot to use. In the public sector, highway operations decisions also occur in near real time. Therefore, having operations measures increases the frequency, granularity, and detail of performance information that would be required to satisfy the project's objectives.

## Background on Research Need

Two trends converged to create demand for freight system performance measures. First, freight's importance has increasingly been recognized within local, state, and federal transportation programs. Secondly, the emphasis on measuring outcomes in transportation programs has grown. The convergence of these trends creates an interest in a set of measures that can provide insight into the functioning of the multifaceted freight transportation network.

Freight shipments and the transportation network have a symbiotic relationship. Freight patterns are affected by the configuration, condition, and performance of the transportation system, while the presence of freight affects both the condition and the performance of the transportation system itself. Efficient freight movement is an essential ingredient in a modern economy, yet, left unchecked, freight movement can create externalities that increase societal costs in terms of traffic crashes, emissions, growing energy consumption, and other impacts. Society in both explicit and implicit ways seeks to promote freight's contributions while diminishing its impacts.

Further complicating freight measurement is its inextricable linkage to every sector of the economy. Not only does a complex and diverse freight-movement industry (Table 1.1) have interests in freight system measurement, but all the customers of the freight industry also have their own mirror-image concerns. The private sector focuses heavily upon cost, speed, and reliability, but the value placed on all three varies dramatically by industry. An on-line retailer needs instantaneous delivery, whereas the user of high-volume, low-unit-value bulk commodities may find shipment times of several weeks acceptable. Therefore the needs of the private sector are as diverse as are the 6 million individual U.S. employers. See Table 1.2.

Freight's importance to the economy has become increasingly recognized by transportation officials. For the past decade they have developed increasingly sophisticated approaches to understanding how the transportation system affects freight movement, and how freight movement affects transportation system performance. The movement of goods is an essential component of traditionally important sectors of the economy

**Table 1.1. Selected statistics.**

| Selected Transportation Statistics | |
|---|---|
| Transportation as percentage of GDP | 10% |
| Total transportation employment (millions) | 13.1 |
| For hire transport and warehousing employment (millions) | 4.5 |
| Transportation-related manufacturing employment (millions) | 2.1 |
| Million miles of highways in US | 3.9 |
| Miles of Interstate Highway | 46,769 |
| National Highway System miles | 115,032 |
| Public use airports | 5,286 |
| Miles of Class I railroads | 98,944 |
| Regional freight lines miles | 15,648 |
| Local freight line miles | 26,347 |
| Navigable waterway miles | 26,000 |
| Public ports | 150 |
| Oil pipelines in miles | 64,336 |
| Product lines in miles | 75,565 |
| Gas transmission lines | 309,503 |

**Table 1.2. Summary of U.S. employers.**

| Types of U.S. Firms | |
|---|---|
| All Industries | 6,022,127 |
| Agriculture, Forestry, Fishing, and Hunting | 22,888 |
| Mining | 20,583 |
| Utilities | 6,554 |
| Construction | 791,558 |
| Manufacturing | 286,039 |
| Wholesale Trade | 334,594 |
| Retail Trade | 725,557 |
| Transportation and Warehousing | 171,947 |
| Information | 74,952 |
| Finance and Insurance | 263,028 |
| Real Estate, Rental, and Leasing | 305,981 |
| Professional, Scientific, and Technical | 772,025 |
| Management Companies | 26,760 |
| Waste Management | 323,282 |
| Educational Services | 73,793 |
| Health Care and Social Assistance | 605,845 |
| Arts, Entertainment, and Recreation | 115,049 |
| Accommodation and Food Service | 467,120 |
| Other Services, Except Public Administration | 672,056 |
| Unclassified Source | 27,027 |

such as manufacturing, agriculture, retailing, mining, and construction. Growth in freight movement has for the past two decades increased at a faster rate than overall growth in the economy. This has occurred despite the growth in economic sectors that do not rely primarily on goods movement, such as finance, information technology, and entertainment. The growth in freight has occurred because transport has been a relatively inexpensive input to the production chain, causing producers to "consume more transport." Supply chains have lengthened as producers sought inexpensive foreign sources of production. The high reliability of international and transcontinental shipments has reduced distance as an impediment to production. Producers and consumers could for the past 20 years be physically separated by vast differences but be linked continuously by a reliable and relatively inexpensive multimodal logistics chain.

The complexity of measuring freight performance reflects the vast dimensions and vast complexities of the North American freight transportation network. The U.S. economy is the world's largest, generating a gross domestic product (GDP) of $11.7 trillion in 2004.[1] The U.S. economy is closely tied to the Canadian and Mexican economies, which represent, respectively, the second and third largest U.S. trading partners.[2] In addition, the U.S. economy has increasingly relied on international trade. Trade has grown from 13 percent of the U.S. economy in 1990 to 26 percent in 2000.[3] Trade with China grew from $85 billion in 1998 to $343 billion in 2006, representative of recent trade patterns.[4] Therefore, the freight transport network in the United States has evolved to serve not only the immense amounts of domestic freight that move within the country but also an estimated 2 billion tons of freight that move into or out of the nation annually.[5]

The success of the national and international freight network led to a near doubling in freight volumes over the past two decades—and to commensurate degradation in freight system performance. The degradation has not been uniform. It has been displayed disproportionately as congestion on key links and nodes of the network of highways, railroads, ports, airports, and marine highways. Congestion and travel-time degradation on these individual networks is only partially understood. Even less understood by the public sector are impediments and delays caused by inefficient linkages between the modes. These inefficient handoffs between port and rail shipments, between trucks and trains at intermodal yards, or between ships and railroads at ports are not regulated, measured, or quantified by the public sector. As result, the magnitude of the inefficiencies at the linkages between modes is only partially and anecdotally understood.

Even the actual volumes of freight on the network are understood incompletely. The *Freight in America* report noted that an estimated 53 million tons of goods valued at about $36 billion moved nearly 12 billion ton-miles on the nation's transportation network every day in 2002.[6] The figures underestimate the total amounts actually shipped because they do not capture the estimated 300,000 private trucking companies alone, not to mention the rail, water, pipeline, and intermodal transporters. The federal statistics cannot capture all movements, such as those conducted by in-house fleets, such as those that serve Wal-Mart and other companies. Also, many commodities such as timber, farm products, or fisheries products cannot be completely calculated. Construction, solid waste, and crude petroleum are among several categories that are of economic importance but cannot be adequately estimated. Therefore, these and other estimates used nationally represent the best available but are acknowledged to be incomplete.[7]

Freight system impacts are experienced not only as congestion but also as degradation in the physical infrastructure of highways, railroads, ports, airports, locks, and dams. The lack of adequacy in infrastructure investment has been documented in most modes. The doubling of freight volumes, as shown for trucks in Figure 1.1, and the aging of the infrastructure have led to concerns over the future condition of the national freight network.

The 2007 *National Rail Freight Infrastructure and Capacity Study* forecasts that if the 2035 rail freight volumes were to occur on today's rail network, 30 percent of the major rail network would be operating above capacity and creating severe congestion. Because of the interrelated nature of the nation's rail network, this congestion would affect every region of the country. Frustrated shippers would potentially shift freight to already congested highways, the study suggests.

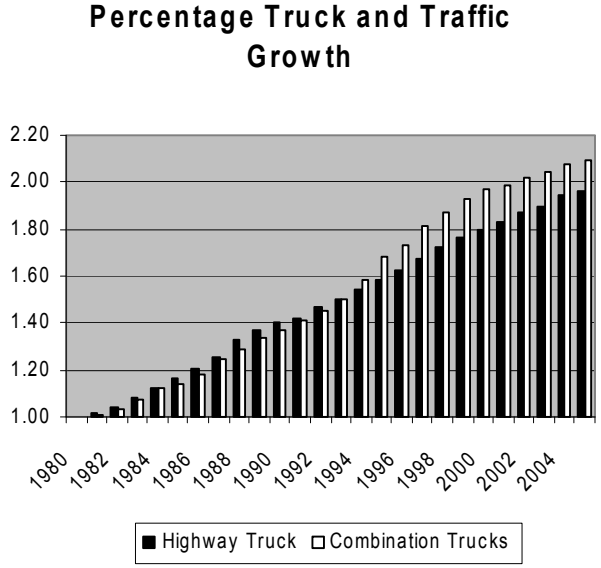



***Figure 1.1. Freight volume growth.***

For highways, the most conservative forecast of the National Surface Transportation Revenue and Policy Study Commission (the National Commission) indicates that the nation needs to be investing at least $199 billion annually in transportation through 2020. Today, the nation is spending from all sources $86 billion. The National Commission report's forecasts that at current levels of investment, delay *per traveler* on urban principal arterials would increase by 20 percent by 2020, by 50 percent in 2035, and double by 2055. Since more people will be traveling in a growing population, *total hours of delay* on principal arterials would double by 2035 and quadruple by 2055, the commission forecasts.[8]

The National Commission reported that the current 18.3 cents-per-gallon federal motor fuels tax would need to increase by an additional 40 cents to meet highway investment needs. It estimated that the nation is spending only 40 percent of what is needed to sustain and improve the highway network.

FHWA's 2006 *Condition and Performance Report* notes than an increase in capital outlay of 87.4 percent above current levels would be required to reach the projected $131.7 billion level, which provides the optimum highway investment level, according to its complex modeling.[9] For transit, the 2006 *Condition and Performance Report* says the average annual cost to improve both the physical condition of transit assets and transit operational performance to targeted levels by 2024 is estimated to be $21.8 billion in constant 2004 dollars, 73.0 percent higher than transit capital spending of $12.6 billion in 2004.[10]

Although there are no similar forecasting processes for the marine system, the U.S. Army Corps of Engineers (USACE) reports that the average age of the channels, locks, and dams that comprise the Marine Transportation System is in excess of 50 years. No infrastructure condition assessment system exists for the national network of ports. However, the top 20 U.S. ports have experienced substantial increases in container volumes driven by the increasingly globalized economy over the past 20 years. Localized congestion, along with impacts such as emissions caused by idling ships, trucks, and trains, has created significant localized air quality concerns.

In addition to measuring the performance and condition of the freight network, the externalities of freight system performance also have attracted significant societal attention. From the nation's earliest days, it was regulating imports to collect tariffs, to discourage certain imports, and to protect the health and safety of the public. Throughout the nineteenth century the nation and its states promoted expansion of a freight network of canals, ports, railroads, highways, and navigable river channels. Soon after the expansion of each mode came various regulations to promote competition, protect public safety, or to control monopolistic practices.

Today, regulation of freight externalities is common in terms of freight's contributions to highway crashes, air emissions, and hazardous waste releases, and also in terms of control of contraband at borders, even to the control of invasive species released in ballast water of international merchant vessels. The freight network's vast size, its enormous complexity, its fixed facilities, and its mobile rolling stock are so integrated into society that impacts are felt in many areas of health, safety, and the environment.

The measurement of freight performance, therefore, requires a comprehensive and multifaceted approach. Its measurement must include areas of travel speed and reliability, economic costs, environmental impacts, health and safety effects, and its influence upon security.

## Movement Toward Measurement

Despite the daunting complexities of freight system performance measurement, it appears likely that efforts to measure and manage the freight system will be attempted. The National Commission[11] strongly endorsed a performance-based federal transportation program. The Government Accountability Office (GAO)[12] did as well. Various Congressional proposals related to reauthorization of federal transportation programs include new provisions requiring the setting of targets and measurement of progress. The American Association of State Highway and Transportation Officials (AASHTO) has formed a series of committees and task forces to recommend a set of national transportation performance metrics.[13] Several states, including Washington, Iowa, and Minnesota, have added a handful of freight-related performance measures to their suite of performance metrics.

In addition to increased efforts to measure the freight system, it appears likely there will be increased federal efforts to improve the freight system. AASHTO proposes a seven-point freight position for the upcoming transportation program reauthorization. The position includes defining a national freight system, investing more heavily in it, and improving planning for it.[14] The GAO called for a clear definition of the federal interest in the freight system. That definition should then be used, the GAO concluded, to improve federal investment, policy, and planning efforts for the freight network.[15]

## Research Approach

The research approach sought to identify the major performance measurement interests of freight system stakeholders and to suggest a measurement framework that satisfied their diverse needs. At the same time, the research approach sought to balance a desire for measures against the reality that performance measurement can be expensive, intrusive, and complex to sustain.

The research began with a review of the history of the development of performance measures in the public and private sectors, particularly examining the lessons learned that could assist the development of a freight performance measurement system. The review included a summary of the freight performance measures that have been deployed, or at least proposed for public-sector agencies. This review included a detailed examination of the existing public-sector freight data and federal reports that could be used to populate a national freight performance measurement system.

Lessons from the private-sector literature on performance measurement were emphasized in the research effort for two reasons. First, the private sector has a much longer history of performance measurement than does the public sector, and the evolution of private-sector measures holds lessons for the development of a national freight measurement system. Second, the research statement specifically sought performance measures that would be of interest to the private sector. Understanding how the private sector used performance measures was deemed to be enlightening.

Considerable effort was expended to determine stakeholder interests. A survey of 4,000 members of the Council of Supply Chain Management Professionals (CSCMP) was distributed. It sought their opinions regarding which measures would be of greatest value to the private-sector logistics professional. Similarly, questionnaires were distributed to major trade groups with an interest in freight performance. Interviews with eight trucking firms were conducted to gather greater insight into their use of and interest in performance measures.

To determine public-sector interest in freight performance, a survey of all 50 state departments of transportation was conducted. Also, representatives of major public-sector agencies such as AASHTO, the Federal Railroad Administration (FRA), and the U.S. Environmental Protection Agency (EPA) were interviewed. The current freight performance measures in use at state DOTs also were examined.

A compilation was assembled of 360 potential freight performance measures that had been identified in the literature or through stakeholder interviews. A screening process was developed that prioritized and sorted the potential measures by how closely they met stated stakeholder preference; whether they were available from existing data; and how closely they met the project objectives.

From the screening and other steps, 29 potential measures were identified that were most promising in terms of meeting stakeholder preference, of having available data, and of meeting the project objective. The measures were included in a proposed Freight System Report Card that could be populated with measures at the national, state, and local level to allow uniform reporting, monitoring, and comparison of freight system performance at different functional and geographic levels.

The steps necessary to deploy the Freight System Report Card were described. Particular emphasis was placed upon reviewing issues surrounding data collection for performance measurement. The research quickly identified the primary challenges to a freight performance measurement system to be related to data and information. These challenges included developing common definitions for measures, capturing data in a timely manner, integrating disparate data from various data sources, and providing the institutional support to sustain a reporting system. Because freight performance and freight data cut across traditional agency silos, the challenge of capturing data and sustaining a reporting system were identified as particular challenges.

To further examine the complexity of measuring freight performance, case studies of the Freight Analysis Framework and the Transportation Services Index were conducted. The level of effort necessary for those two components of national freight measurement is predictive of the complexity of developing a much broader performance reporting system.

The research not only presents a Freight System Report Card but also suggests a three-tiered approach to performance reporting. The first tier is the highly summarized and condensed report card itself. The second tier consists of brief one- to two-page summaries that elaborate upon the performance of each measure. Finally, the reporting framework provides links from each measure to more voluminous standing reports. The three-tiered approach is suggested to provide brevity as well as detail, depending upon the level of information desired by the user.

## Anticipated Use of Research Findings

The research findings provide a road map for developing a national freight performance reporting process. As discussed in the "Background on Research Need" section, numerous public and private stakeholders seek to better understand the freight system to improve decision making regarding policy, investment, and operations decisions. The value of this research is to describe how a freight system reporting process could be started with existing data sources and to explore how it could evolve with increasing sophistication over time.

## Endnotes


1 Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2005–2014*—CBO's Economic Projections for 2004 through 2015, http://www.cbo.gov (accessed June 6, 2007).

2 FHWA Freight Analysis Framework Table 2-7. Top 25 Trading Partners of the United States in Merchandise: 1998–2006 (Current $ Billions), http://www.google.com/search?hl=en&q=Table+2-7.++Top+25+Trading+Partners+of+the+United+States+in+Merchandise%3A+1998-2006+%28Current+%24+Billions%29&btnG=Google+Search&aq=f&oq= (accessed Aug. 1, 2008).

3 Cambridge Systematics, Draft *Freight Transportation Bottom Line Report, Freight Demand and Logistics*, AASHTO February 2007, pps. 2–4.

4 U.S. Department of Commerce, International Trade Administration, *TradeStats Express*, available at http://www.ita.doc.gov/ (accessed June 12, 2007).

5 FHWA, "Freight Facts and Figures 2007" Table 2-1. Weight of Shipments by Mode: 2002, 2006, 2035 (Millions of Tons), http://www.google.com/search?hl=en&q=Table+2-1.++Weight+of+Shipments+by+Mode%3A+2002%2C+2006%2C+2035+%28Millions+of+Tons%29&aq=f&oq= (accessed Aug. 1, 2008).

6 Research and Innovative Technology Administration, Bureau of Transportation Statistics, U.S. Department of Transportation. *Freight in America: A New National Picture*, Jan. 2006, 1.

7 *Freight in America*, 1.

8 The National Surface Transportation Policy and Revenue Study Commission, vol. 2, chapter 4.

9 FHWA, Chapter 8: Executive Summary, *Status of the Nation's Highways, Bridges, and Transit: 2006 Conditions and Performance*, available at http://www.fhwa.dot.gov/policy/2006cpr/es08h.htm (accessed Feb. 11, 2008).

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11 The National Commission Surface Transportation Policy and Revenue Study, 37.

12 GAO, *Restructured Federal Approach Needed for More Focused, Performance-Based, and Sustainable Programs, Report to Congressional Requesters*, GAO-08-400, March 2008, 49.

13 AASHTO Standing Committee on Performance Management, Proposed Policy Resolution PPR-10AM-02 Title: Adoption of Candidate State Performance Measures, http://www.transportation.org/?siteid=97&pageid=2956 (accessed May 12, 2010).

14 AASHTO, *Freight Authorization Policy*, http://www.transportation.org/sites/policy_docs/docs/vi.pdf (accessed May 13, 2010).

15 GAO, *National Policy and Strategies Can Help Improve Freight Mobility, Report to the Ranking Member, Committee on Environment and Public Works, U.S. Senate*, GAO-08-287, January, 2008.

CHAPTER 2

# Performance Measurement Lessons from the Private Sector

The following chapter examines the private sector's use of performance measures, and how that use has evolved over the preceding five decades. The evolution of the private sector's use of measures was examined to anticipate how a national reporting system may need to be structured to meet evolving measurement needs. For instance, a key lesson from the private sector is that lagging measures alone soon prove to be inadequate for decision making. Therefore, the proposed framework includes a strong component of leading indicators. That and other private-sector findings are described.

## The Evolution of Private-Sector Measurement

The development of performance measures for the national freight network is belated in comparison to the extensive development of performance measures at state departments of transportations. The transportation agencies, in turn, were belated in comparison to the private sector. Business literature extensively discussed performance measures in the 1950s. By 1993, the Government Performance and Results Act (the Results Act), required federal departments and programs to adopt goals and performance measures to track progress toward those goals. By the late 1990s, transportation agencies were regularly developing performance metrics.

This late development of measures for the freight sector has one significant advantage. It allows the nascent effort to benefit from the evolution, mistakes, missteps, and lessons of several generations of performance measure development in other sectors. The research effort examined private-sector performance management for two reasons. First, the research statement called for performance measures that would be of interest to the private sector. Second, the lessons learned during the long evolution of private-sector performance measurement provides insights into how to approach the development of measures for this project.

The review of the private sector's literature reveals a continuous path of development and evolution as measures mature and evolve to address shortcomings perceived in earlier generations of measures. The literature reveals that the individual measures used in the private sector may have little direct relevance for national freight performance measures. However, the process by which private-sector decision makers identify, collect, and assess measures holds significant relevance for the public-sector decision makers who want to create a set of national freight performance measures.

## From Lagging to Leading Indicators

Peter Drucker[1] wrote that 70 years ago General Motors pioneered modern cost accounting systems and used its performance output for important resource-allocation and decision-support performance measures. The "Management by Objective" that Drucker popularized arose from his 1954 book, *The Practice of Management*. In later years after decades of observation, Drucker wrote that it is possible to define predictable evolutionary paths in organizations that have embraced performance measures. Initially, organizations embraced financial measures, such as Internal Rate of Return, Cash Flow, Liquidity, Return on Assets, and other similar measures. He labeled these "foundational" measures. He noted that they are inherently "backward looking" and lacking in granularity. They may tell if the firm is performing poorly or well but not why. The lack of specific performance insight led to the next evolutionary stage of measurement, which was "Productivity" measurement. These measures were intended to "drill down" into productivity within an organization and date from approximately the WWII era. The third set of measures evolved in the 1990s and are what Drucker described as "Competency" or "Innovation" measures. These are most common in the private sector and relate to whether a company possesses "best in class" or unique skills that dif-

ferentiate it from the competition. In the public sector, these sets of measures may be similar to benchmarking measures with other comparable organizations. The fourth and final evolution of private-sector performance measures relates to "Resource Allocation." Those measures evaluate different sets of potential investments to determine which provide the optimum return.

To restate, Drucker described four types of private-sector performance measures, which evolved in approximate order of:

- Foundational or basic financial measures;
- Productivity or internal performance measures;
- Competency or innovation measures comparing to external performance;
- Resource allocation or investment-tradeoff allocation measures.

Drucker and others have noted that this evolution is the result of trial and error over decades of well-intentioned efforts by decision makers to understand which measures provide critical insight into their companies. In reviewing decades of private-sector performance measure development, Drucker, Porter (2002), and Frigo (2002) stressed the need for performance measures to be properly aligned with the strategic direction or desired strategic outcomes of the organization. All three noted that organizations have developed performance measures only to be frustrated that they did not provide true insight, they created unintended disincentives, or they failed to measure customer satisfaction.

Drucker's findings that executives quickly grow dissatisfied with backward-looking, or lagging, indicators influenced the development of the Freight System Report Card. The report's inclusion of predictive indicators is a direct result of the Drucker finding.

## From Measuring Process to Measuring Strategic Outcomes

That strategy and performance measurement are inseparable[2, 3] is another lesson from the private-sector experience with performance measurement. Because performance measures drive organizational behavior, a clear linkage between the organization's goals and the activities the organization encourages is critical. Several private-sector authors emphasized the need to first conduct a strategic planning exercise to clarify organizational goals before identifying measures to gauge organizational effectiveness. Effectiveness should be considered in terms of achievement of institutional goals.

> The first questions some managers ask when embarking on a performance measure initiative are "What should we measure?" or "How should we measure performance in a given area?" In fact, these are the last questions management should focus on. Strategic performance measurement systems, like the balanced score card, are first and foremost about strategy.
>
> Strategic performance measurement begins with a sound philosophy pertaining to and a sound judgment surrounding how strategic decisions will be made and how performance measurement will be used to make decisions and execute strategy. Management must be vigilant in aligning performance measures with the strategy of the organization. . . .[4]

Wade and Recardo[5] described the common reaction of seasoned corporate managers who quickly grew disenchanted with performance measurement systems in the 1990s:

> Traditional corporate-level performance measures—financial and gross productivity results—have failed most corporations. Managers have become disillusioned with these "trailing" performance measures, because they have not helped them run the business. Savvy companies have learned that performance measures, used diligently, significantly affect organizational alignment. CEOs want performance measures that offer predictive power and provide a better understanding of the real costs associated with each process.

Authors describe at least four crucial strategy-development steps that need to precede the identification of measures so that the measures do more than only look backward. First, identify proper goals that serve the customer. Second, identify the different aspects of the organization or system and have goals and strategy for each. Third, understand how the organization serves its industry. Fourth, understand that many discrete activities must work in harmony to create an organization's success.[6] By having predictive measures that provide insight as to whether the organization's current activities are leading it to future success has improved the usefulness of many organization's performance measurement systems.

These writers conclude that more than five decades of Performance Measurement in the private sector led practitioners to reach three overriding conclusions. First, truly sound and effective measures must relate directly to customer satisfaction. Measuring success of processes and subprocesses that do not directly relate to satisfied customers does not guarantee success. Only satisfied customers guarantee an organization's success. Second, measures need to be balanced. That is they need to allow a holistic understanding of financials, processes, comparisons to peers, and customer satisfaction. Third, measures must capture an organization's ability to learn, innovate, and improve the quality of its products. "Quality measures represent the most positive step taken to date in broadening the basis of business performance measurement," was one typical conclusion.[7]

## From Skewing Performance to Balancing Competing Objectives

A common shortcoming described in private-sector performance measurement literature related to skewing of behavior or "suboptimization." This refers to organizational performance focusing inordinately upon achieving narrow, measured activities to the detriment of other important organizational goals. For instance, an unbalanced focus upon product cost could lead to fatal lack of product quality, which dooms the business. Or a unit can be measured for timeliness of a process, but not the cost or quality of the process. Organizations also frequently measured performance of individual divisions, or "silos," which can cause a disincentive for the divisions to devote resources to collaborating with other divisions. If the performance measurement incentives did not reward cross-divisional collaboration, then such collaboration was less likely to be achieved.

Thus, in 1992, evolved the Balance Scorecard.[8] The score includes at least four categories of measures, which reflect the tension between important considerations, such as cost versus quality or timeliness versus completeness or profitability versus customer satisfaction. The scorecard was developed to address the type of trade-off analysis and balancing of competing values that organizations frequently confront.

The Balanced Scorecard also was proposed because managers complained of being swamped with too many measures. A proliferation of measures left executives data rich and information poor. The Balanced Scorecard was created to answer four basic questions:

- How do customers see the organization?
- What must the organization excel at?
- How can the organization continue to improve and create value?
- How does the organization fare financially?

The Balanced Scorecard attempts to assemble in a single report the disparate and often competing values that must be addressed. Inherent in the Balanced Scorecard is the recognition that judgments must be made by executives. Although metrics provide insight, ultimately judgments are made to balance issues such as cost versus quality, profitability versus social obligations, and between customer satisfaction and available resources. See Figure 2.1.

This new generation of performance measurement as reflected in the Balanced Scorecard does not abandon the earlier four types of measures that Drucker had written about. Foundational measures are still used to measure basic financial and performance outputs. Operational measures still allow managers to drill down into areas that don't meet customer needs.

Competency or benchmarking measures are used in the "Innovating and Learning Perspective." Finally, the Resource Allocation measures still are inherent within all four sectors as measures to help make intelligent investment decisions. What the Balance Scorecard evolution has done is to:

- Sharpen measures into a "critical few";
- Acknowledge the need for artful trade-offs to achieve optimum overall performance;

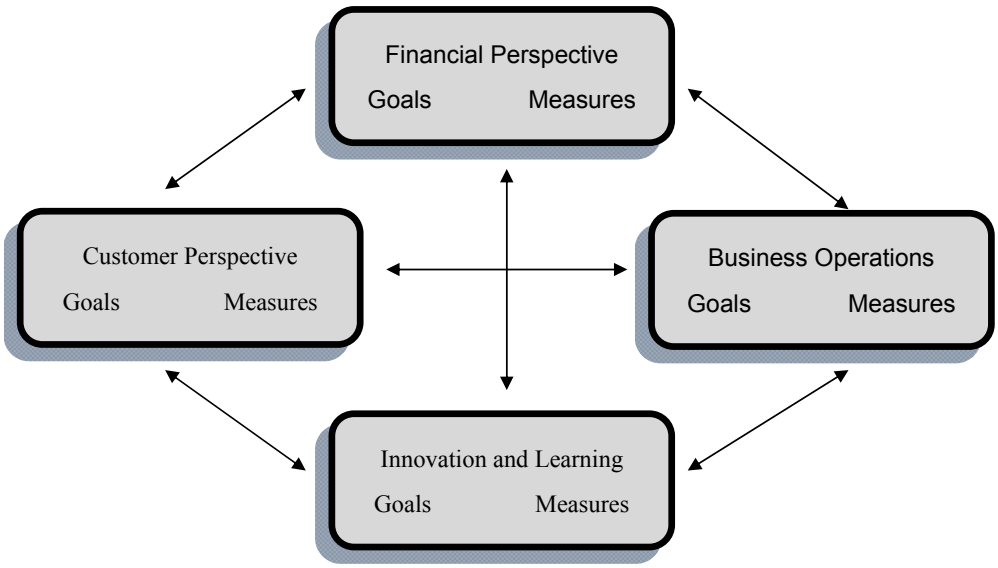


*Figure 2.1. A Balanced Scorecard.*

- Have measures reflect customers' perspectives;
- Have measures derived directly from the organization's strategic goals;
- Incorporate the dynamic "continuous improvement" ethos of the "Quality Movement" as a basic measure of a successful organization.

## Learning to Support Measurement Systems

An important lesson that was repeatedly emphasized by the private-sector literature is that a Balanced Scorecard and other performance measurement processes are systems.[9] Like all systems, they need constant maintenance, support, and refreshing to keep them current. At least five critical steps are necessary to establish a performance measurement system:

1. Developing an information architecture;
2. Putting technology in place to support the architecture;
3. Aligning incentives with the new system;
4. Drawing on outside resources, such as benchmarking or customer-survey resources;
5. Designing an ongoing maintenance and support process to perpetuate steps 1–4.

An information architecture has been described as, "an umbrella term for the categories of information needed to manage a company's businesses, the methods the company uses to generate this information, and the rules regulating its flow."[10] Key steps in developing the architecture are the definition of measures that translate the organization's goals into specific actions and identification of a reporting process to capture those carefully defined measures. It is necessary to develop a set of definitions, a taxonomy, and even technical manuals to clarify how to identify, collect, and classify the results of activities into the proper set of measures.

Putting technology in place requires integrating existing data and creating processes to capture needed but lacking data. In the private sector, financial measures tend to be the most accessible because of the long history of public accounting rules. In comparison, measures such as customer satisfaction, quality, and innovation are harder to obtain because of their lack of maturity in most organizations. These data also tend to be captured less frequently, such as annually or quarterly through sample-based surveys. Also necessary is a set of rules and protocols about who collects the data, who generates them, who receives and analyzes them, who can change the architecture rules, and who takes action when the data reveal a problem.[11] Once the architecture is in place, then the data-system compatibility processes must be addressed. Most organizations are large, with multiple systems developed in different years, with different technology. Reconciling and integrating legacy systems into a common performance-measurement reporting process can require significant effort.

Aligning incentives or consequences is important because, if the measurement results lack consequences or do not spur improvement efforts, the measures lack relevance and tend to atrophy. In the private sector, consequences can be in the form of profit, loss, or market share. In the public sector, the consequences can come in the form of executives initiating improvement efforts if the measures indicate that performance targets have not been reached. It is generally agreed in the literature that performance measurement systems that do not relate directly to key organizational consequences or outcomes tend to atrophy.

In a Balanced Scorecard framework another step comes from collecting data from outside points of comparison for benchmarking, peer comparison, or customer-satisfaction surveys. This can come in a variety of forms such as opinion surveys and comparative analyses with peer groups.

The final step is creation of an ongoing process to sustain and perpetuate the performance measurement system. Because the measurement process is a system, it requires ongoing resources to perpetually collect data, categorize it, review its quality, and disseminate the data.

Brue[12] stresses that measures must be customer-focused and succinct—yet at the same time allow granularity when necessary to drill down into problems. He describes efforts by companies to select the correct measures after reviewing up to 1,000 internal processes, each of which had up to 120 internal technical specifications. Such a volume of measures is impractical, and they need to be consolidated into composite measures that allow the high-level tracking of two major issues—customer satisfaction and financial viability. The lower-level process information is critical, but only to those process owners.

Brue describes what could be termed the "accordion" syndrome, which was frequently alluded to in the 1990s literature and which is being addressed by many organizations in the 2000s. First, managers hungrily consumed measures and kept broadly expanding them across a wide array of activities until the number of measures swamped organizational decision makers. Then, in reaction, the managers narrowed the array of measures that they tracked regularly. However, a deep and detailed array of "process" measures need to be available when processes break down and those processes needed to be reviewed. These process measures may not be regularly reviewed by senior leadership but are drawn on when needed.

## From Measuring Performance to Improving Performance

The private sector's collection and review of performance measures beginning in the 1950s led to the eventual development of "quality" systems in the 1980s. The "Total Quality Management" concepts developed by W. Edwards Deming resulted in large part by a rigorous review of performance data. As the source of failure to achieve targets was analyzed systematically, then "continuous improvement" developed. The continuous improvement processes took the form of Total Quality Management, International Standards Organization (ISO) processes, Six Sigma, the Baldrige process, or the Japanese Kaizen process.

As noted earlier, measurement systems that are not tied to some consequence or action tend to atrophy. Those systems that are tied to consequences have contributed to continuous improvement efforts.

Metrics necessary for continuous improvement fall into two categories—those to measure customer satisfaction in its various forms and those to measure the processes that create the products the customers use. When customers are dissatisfied, investigation occurs into the organizational performance that led to the dissatisfaction.

Therefore, many modern performance measurement systems include both quantitative and qualitative measures.[13] The quantified measures will be based on process, outcome, or financial measurements, while the qualitative ones will be based upon the perceived satisfaction of customers, employees, and other stakeholders. Employee satisfaction and customer satisfaction are the most common qualitative key performance measures.[14]

## Relevance of the Private-Sector Lessons

The private-sector performance measurement lessons include:

- Organizations that are highly experienced in evolving generations of performance metrics have learned that they soon grow dissatisfied with static, lagging indicators that measure only past performance. Such measures may be all organizations initially have, but they quickly prove inadequate to provide insight into future performance;
- Current performance measurement is heavily invested in measuring customer satisfaction and system performance from the customer perspective;
- Leading indicators that provide insight into likely future performance are strongly desired;
- Performance measures must be part of an ongoing system that has its own architecture, data system rules, and grammar and a control process that keeps it accurate, current, and relevant;
- Successful measurement systems overcome a contradiction. They must be high-level and simple while allowing granularity to drill down into processes if the high-level measures indicate a breakdown in performance;
- Private companies struggle to get good performance data from within their own organizations, which only further highlights the challenge of getting consistent data from public and private sources for a set of national freight performance measures;
- Modern private-sector performance measures are used to drive organizational strategy;
- Performance measurement systems that become integral to an organization tend to drive "continuous improvement" efforts, while systems that are not integral tend to atrophy.

## Endnotes

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12 Brue, Greg. *Six Sigma for Managers*, McGraw-Hill, 2002, pp. 36–61.
13 Wade and Recardo, *Corporate Performance Management*, p. 12.
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CHAPTER 3

# Performance Measurement Experience in the Public Sector

The research for this project included an extensive review of public-sector use of performance measures. Appendices A–D describe: (1) freight-specific performance measures in use by state transportation departments, (2) the measures published by federal agencies, (3) the availability of performance metrics by individual modes, and (4) a summary of the performance measures relating to environmental and safety issues.

Several summary points can be made based upon the review described in the appendices. First, although public-sector performance measurement has matured and expanded significantly, the number of freight-specific performance measures remains limited. The few states that included freight performance measures in their performance reporting suites typically had fewer than four freight measures. The measures tended to be captured from existing data sources. Second, no consensus as to which freight measures were most important to states was evident. No two states had selected the same measures. It was not possible from an examination of the state freight measures to identify a common cohort of measures that were generally agreed on. Third, considerable ambivalence exists among states about performance measurement. Although many embrace it, some expressed concern that it will be difficult to capture accurate, consistent, and meaningful measures across such a diverse set of states, modes, and issues. Several state officials expressed concern that, if the measures were not accurate, consistent, and meaningful, the measures would not lead to improved decision making. Fourth, performance measures related to freight system condition are more available than measures of freight system performance. Fifth, performance data related to externalities, such as emissions and crashes, are among the most complete performance data available.

## Migration of Performance Measures from the Private to Public Sectors

A major turning point in the migration of performance measures from the private to the public sectors occurred with the 1992 publication of Osborne and Gaebler's *Reinventing Government: How the Entrepreneurial Spirit Is Transforming the Public Sector.*[1] Osborne and Gaebler posited several primary points that have become widely accepted now in the public sector:

- What gets measured gets done.
- If you can'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 reward success, you're probably rewarding failure.
- If you can't see success, you can't learn from it.
- If you can't recognize failure, you can't correct it.
- If you can demonstrate results, you can win public support.

Osborne and Gaebler identified the parameters of public-sector performance measures. They accordingly offered the following recommendations:

- Use both quantitative as well as qualitative measures. Some important results are impossible to quantify.
- Watch out for creaming, or the tendency to select the easily accomplished while avoiding the difficult.
- Anticipate powerful resistance to accountability.
- Involve stakeholders in developing measures.
- Subject measures to periodic review and evaluation.
- Don't use too many or too few measures.

- Watch out for perverse incentives.
- Keep measurement functions independent.
- Focus on maximizing the use of performance data.

The Government Performance Results Act of 1993 codified many of the private-sector lessons into a framework for federal performance management. Inherent in the Act are the key findings of earlier performance measurement research:

- A strategic plan and strategic mission statement are the foundation for performance measurement.
- General goals and objectives are to be established and are to be described in terms of outcomes, not inputs or outputs.
- Strategies for achieving the objectives are to be identified.
- Performance measures should be defined that measure the effectiveness of the strategies in achieving the outcomes.
- Key factors beyond the agency's control that can influence the achievement of the goals need to be identified.
- Processes will be established to evaluate the effectiveness of the measures and to update them as needed.

## The Maturation of Public-Sector Performance Measurement

By the early 2000s, the use of performance measures in public-sector transportation agencies was widespread and exhibited evolution similar to that reported earlier in the private sector. A 2004 report, *Performance Measurement in Transportation: State of the Practice,*[2] notes that use of performance measures among transportation agencies has expanded significantly and that agencies have become increasing informed and insightful in using them. In reviewing more than a decade of performance measurement by departments of transportation (DOTs) and local transportation agencies, the report notes the following trends:

- Although more states are using measures, the leading states are involved in second- and third-generation measures, which are increasingly sophisticated.
- States are relying more on measures that emphasize strategic outcomes and customer-focused measures.
- States that are early in the use of measures tend to proliferate them, whereas more mature states tend to focus upon a "vital few."
- The use of measures to support broader planning, management, and decision-making processes is becoming common.
- There is increased reporting directly to the public and policy makers.
- Elements of the Balanced Scorecard approach are evident in several states that rely on customer satisfaction as a balancing measure to augment engineering and financial performance data. Likewise, measures of environmental quality are increasingly prominent.

States are increasingly careful about how they specify performance measures, because they realize that they can be critically important in driving decisions and actions. Measuring an aspect of performance encourages the agency to focus upon that aspect, sometimes to the neglect of other important functions. Skewing organizational behavior can be an unintended consequence of performance measurement, particularly if measures are narrow or are not tempered by qualitative considerations.

*State of the Practice,* cited above, notes significant variation among the states' use of measures. A few agencies, though, have mature systems, all of which could be characterized as possessing:

- a range of sophisticated measurement systems in place;
- the alignment of measures with performance-oriented goals, objectives, standards, and targets;
- useful performance-reporting processes tailored for various audiences and management needs; and
- systematic procedures for reviewing performance data and using the information to strengthen performance and decision making.

The report also cited a set of continuing challenges that include:

- Agreeing on common terminology;
- Developing measures for cross-modal comparisons of performance;
- Developing freight measures;
- Getting broader public and constituency feedback and balancing that with engineering and planning criteria;
- Implementing useful benchmarking criteria for comparative analysis; and
- Institutionalizing performance measurement and strategic planning to prevent their being derailed by changes in administration.

By the end of the decade, the use of performance measures was common in the majority of states. AASHTO's Standing Committee on Performance Management supports a website linking performance reports or annual reports to 41 state transportation agencies. Although not definitive, the links indicated that more than 50 percent of the states produced some kind of performance reports.

Another trend is that the states with the most mature and expansive performance reporting produced interpretive reports to accompany the published metrics. The Washington State DOT's *Grey Book* includes more than 100 pages of metrics quarterly. In addition, the DOT accountability website includes links to other department reports of their performance.

The Missouri DOT's *Tracker* includes more than 100 measures, and its monthly report includes more than 220 pages of data and interpretation. The Minnesota DOT's *Annual Transportation Performance Report* tracks 16 basic areas of performance and includes 38 pages of explanatory material.

Commonly used metrics address infrastructure condition, highway safety, project delivery, budgeting, personnel goals, and progress toward specific programs. Less common are mobility measures and freight measures. *NCHRP Synthesis 311* reviewed the use of performance measures for the monitoring and operational management of highway segments and systems.[3] An assessment of the relative strengths and weaknesses of over 70 performance measures in use then was performed. The survey of DOTs and metropolitan planning organizations (MPOs) yielded the list of performance measures shown on Table 3.1. The Responses column shows how many responding agencies use the measure. Note that freight performance measure use is low, as is the use of measures that capture real-time highway operations.

Measures of the number of persons or vehicles served were most commonly reported as the most important measures, including volume, vehicle-miles traveled (VMT), persons served expressed in person-miles traveled, and freight-volume served expressed in truck-miles traveled. With respect to freight, the synthesis suggests that measures could be developed to reflect the freight system and could use data such as vehicle length, height, and weight, the number of axles, safety inspection statistics, truck crashes, commercial vehicle enforcement/inspection times and costs, railroad crossing protection, and weigh-in-motion information.

## Public-Sector Logic for Selecting Measures

*NCHRP Report 551*[4] recommends a step-by-step process specifically for developing asset management measures, but the process can be applied to most categories of measures:

*Identify Performance Measures*

- Inventory existing performance measures and identify how they are being used,
- Identify gaps to be addressed based on coverage of critical outcome areas for agency goals and objectives and support for the asset-management best practices,
- Define criteria for selecting new measures,
- Identify additional candidate measures, and
- Select a set of measures from the list of candidates for further design and implementation.

*Integrate Performance Measures into the Organization*

- Engage internal and external stakeholders to achieve buy-in,
- Identify the different decision contexts in which performance measures are to be used (project, corridor, and network levels and for short- or long-range decisions) and refine measures so that they are at the appropriate level of sensitivity,
- Identify opportunities for using measures that are consistent across different organizational units responsible for various asset classes, modes, or work types,
- Identify needs for additional data collection, data management, and analytic tools to support the selected measures,
- Design communication devices with formats appropriate to the target audiences, and
- Document measure definitions and procedures.

*Establish Performance Targets*

- Define the context for target setting and establish time horizon(s),
- Determine which measures should have targets,
- Develop long-term goals based on consideration of technical and economic factors,
- Consider current and future funding availability,
- Analyze resource allocation scenarios and tradeoffs,
- Consider policy and public-input implications for target setting, and
- Establish targets and track progress.

## States Use Only a Handful of Freight Measures

Although the research literature identified hundreds of potential freight performance measures, in practice the minority of states that have freight performance measures use only a handful. Mature performance measurement states such as Washington, Missouri, and Minnesota use between 5 and 10 measures. It was noticeable that no two states had the same measures, and in most cases there were wide differences in the metrics. Although states reported freight performance metrics, most of the metrics were not used to calibrate performance of specific state programs. Exceptions were for Missouri's customer satisfaction with its motor carrier office. Generic measures such as travel time in freight-significant

**Table 3.1. Examined performance measures.**

| Performance Measure | Typical Definition | Responses |
|---|---|---|
| Level of Service (LOS) | Qualitative assessment of highway point, segment, or system using A (best) to F (worst) based on measures of effectiveness | 11 |
| Traffic Volume | Annual average daily traffic, peak-hour traffic, or peak-period traffic | 11 |
| Vehicle-Miles Traveled | Volume times length | 10 |
| Travel Time | Distance divided by speed | 8 |
| Speed | Distance divided by travel time | 7 |
| Incidents | Traffic interruption caused by crash or other unscheduled event | 6 |
| Duration of Congestion | Period of congestion | 5 |
| Percent of System Congested | Percent of miles congested (usually defined based on LOS E or F) | 5 |
| Vehicle Occupancy | Persons per vehicle | 5 |
| Percent of Travel Congested | Percent of vehicle-miles or person-miles traveled | 4 |
| Delay Caused by Incidents | Increase in travel time caused by an incident | 3 |
| Density | Vehicles per lane, per period | 3 |
| Rail Crossing Incidents | Traffic crashes that occur at highway-rail grade crossings | 3 |
| Recurring Delay | Travel time increases from congestion; this measure does not consider incidents | 3 |
| Travel Costs | Value of driver's time during a trip and any expenses incurred during the trip (vehicle ownership and operating expenses or tolls or traffic) | 3 |
| Weather-related Incidents | Traffic interruption caused by inclement weather | 3 |
| Response Times to Incidents | Period required for an incident to be identified, to be verified, and for an appropriate action to alleviate the interruption to traffic to arrive at the scene | 2 |
| Commercial Vehicle Safety Violations | Number of violations issued by law enforcement based on vehicle weight, size, or safety | 1 |
| Evacuation Clearance Time | Reaction and travel time for evacuees to leave an area at risk | 1 |
| Response Time to Weather-related Incidents | Period required for an incident to be identified, to be verified, and for an appropriate action to alleviate the interruption to traffic to arrive at the scene | 1 |
| Security for Highway and Transit | Number of violations issued by law enforcement for acts of violence against travelers | 1 |
| Toll Revenue | Dollars generated from tolls | 1 |
| Travel Time Reliability | Several definitions are used | 1 |

Source: PBS&J. *NCHRP Synthesis 311: Operational Effectiveness for Highway Segments and Systems.* Transportation Research Board of the National Academies, Washington, D.C., 2003, Table 6, p. 22.

corridors were likely a contributing factor to state efforts to improve overall travel times. However, it appeared to be rare that state DOT freight performance measurement was used to make frequent decisions. Most of the measures appear to be indicators of broad trends of overall transportation system performance.

The Iowa DOT freight-related performance measures include highway crash rates per million vehicle miles for large trucks, total crashes at rail–highway crossings, and railroad derailments per million ton-miles.[5] Freight efficiency measures include the percentage of Iowa rail carriers earning a reasonable return on investment and average rail revenue per ton-mile. The quality-of-life performance measures identify approximate travel times to major external markets in the Midwest Region, percentage of railroad track-miles able to handle 286,000-pound cars, percentage of railroad track-miles able to operate at 30 miles per hour or more, and rail fuel use per ton-mile.

Washington State DOT's *Grey Book* includes a handful of freight performance measures. It reports upon truck volumes on state highways, the number of truck border crossings, rail freight tonnage, and container shipments through state ports.

The Missouri DOT *Tracker* includes 111 measures, of which five relate to freight: freight tonnage by mode; percentage of trucks using advanced technology at weigh stations; interstate motor carrier mileage; percentage of satisfied motor carriers; and customer satisfaction with timeliness of Motor Carrier Services response. The customer satisfaction ratings focus on users' satisfaction with service received by the Motor Carrier Services office.

## Relevance of the Public-Sector Experience

A significantly more detailed discussion of the public-sector use of freight performance measures is included in Appendices C and D. The summary of that review indicates that widespread use of freight performance measures is not common. A consensus as to which freight measures should be adopted was not apparent from a review of the measures states were using. An AASHTO task force on examining freight performance measures recommended three measures: travel speeds on the freight-significant routes; reliability on freight-significant routes; and border crossing delay. Although those three are important, they fall far short of the expansive objective of this research, that is, to have a comprehensive set of measures that examines multiple aspects of freight performance for all modes.

Chapter 4 summarizes the types of freight performance data available to support a performance measurement framework.

## Endnotes

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3 PBS&J. *NCHRP Synthesis 311: Performance Measures of Operational Effectiveness for Highway Segments and Systems.* Transportation Research Board of the National Academies, Washington, D.C., 2003.

4 Cambridge Systematics, Inc., PB Consult, and Texas Transportation Institute. *NCHRP Report 551: Performance Measures and Targets for Transportation Asset Management.* Transportation Research Board of the National Academies, Washington, D.C., 2006.

5 Iowa DOT, *Performance Measures for Iowa Transportation Systems*, 2006. Prepared by Iowa State University, Center for Transportation Research and Education.

CHAPTER 4

# Freight Performance Measures

Whereas Chapter 3 found relatively little use of freight performance measures by state DOTs, this chapter documents that a significant amount of freight system performance information is available from other sources. Much of this information exists as data within federal databases, as reports to federal regulatory agencies, and as published reports by private-sector companies such as railroads.

A primary finding is that freight performance measurement is challenged both by an abundance of data and by a lack of complete data for many important freight system performance functions. Sorting and selecting from the voluminous available data sources is one daunting challenge. Closing data gaps is another.

The following section summarizes the performance information that is available. More detail is provided in Appendices C and D.

## Trucking Data

For the trucking mode, data from which performance measures could be derived are extensive. The Freight Analysis Framework synthesizes several databases to produce truck volume data nationally and by state.[1] The Fatality Analysis Reporting System includes statistics and a data base query tool for highway crashes, including those involving trucks.[2] Further drilling into performance of truck safety is possible through the Federal Motor Carrier Safety Administration (FMCSA) query tools that allow analysis of the safety records and inspection histories of individual motor carriers.[3] FHWA is partnering with ATRI to use global positioning system (GPS) data from hundreds of thousands of trucks to measure the speed and reliability of truck movements on the Interstate Highway System (IHS).[4] USDOT's Pipeline and Hazardous Materials Safety Administration maintains databases of hazardous materials releases[5] for highway, air, water, and rail modes. The American Trucking Associations' (ATA) *Motor Carrier Annual Report* lists the key elements of a cost-per-mile calculation for trucking. The ATA's *U.S. Freight Transportation Forecast* tracks trends and forecasts in manufacturing, construction, agricultural commodities, mining, and non-oil merchandise imports that affect truck freight volumes. ATA's *Trucking Trends* report provides information regarding trucking company commodity flows, the number of company failures, tonnage and revenue growth, revenue per mile, and trucking producer price indices.[6]

From the available data, performance measures can be produced annually for categories such as the number and severity of truck crashes, volumes of freight shipped, general trends of trucking costs, and periodic measures of travel time and travel reliability on the IHS. Real-time operation performance information is much less available across the network. Also, because trucking occurs disproportionately upon the higher functional classes of roadways, the condition data regarding pavement and bridge conditions can be used to measure the relative condition of the functional classes that carry the majority of freight.

## Rail Data

Although largely deregulated, the U.S. railroads still produce significant volumes of performance information to the FRA, to the Surface Transportation Board (STB), and to individual state regulatory commissions. More than 1,500 categories of statistics are reported for each of the Class I railroads in the *Statistics of Class I Freight Railroads* report required by the STB.[7] These data include uniform reporting of income, expenses, investments in track, equipment investments, and depreciation by various categories. The Federal Railroad Administration Office of Safety Analysis provides search and query tools to conduct analyses of railroad crashes.[8] The query tools link to federal crash databases that allow for analysis of crashes by railroads, state, crash types, and

localities. Links to individual crash reports are provided. The Association of American Railroads (AAR) produces its own extensive website of performance data, background papers, and policy analyses.[9] These performance data address railroad cost indices that track the inputs to railroad pricing, the speed of trains and dwell time in yards, volumes of freight shipped, and various other statistics of railroad employment, safety, efficiency, and performance. The Class I railroads are all publicly traded companies. As a result, their annual filings with the Securities and Exchange Commission include voluminous financial performance information.

From this significant volume of data, it is possible to report important aspects of rail freight system condition and performance, including average railroad operating speeds, general rail freight prices, and the magnitude of reinvestment by the railroads into system capital, and to measure the safety trends of U.S. railroads.

## Ports and Waterways Data

Data regarding port volumes and the quantity and type of cargo imports and exports are available to generate some performance trends for U.S. ports. However, the Maritime Administration (MARAD) reported to Congress that it was unable to measure the performance of ports because of a lack of common metrics, a lack of a performance reporting process, and a lack of definitions as to how ports should be measured in terms of performance, preparedness of national emergencies, or for efficiency.[10]

Condition statistics are produced by the U.S. Army Corps of Engineers (USACE) for the maritime transportation system of inland waterways, locks, and dams and for the tonnage they accommodate each year.

## Highway Condition Data

Highway condition data are mature and abundant, but highway performance data regarding travel speeds and reliability are less available. The FHWA's National Bridge Inventory records current and past conditions of bridges for all states, Washington, D.C., and Puerto Rico. The FHWA's Highway Performance and Monitoring System (HPMS) tracks pavement conditions and estimated congestion levels on the highway network. It also makes planning-level estimates of levels of service.

## Freight Externality Data

One of the more robust areas for freight system measurement is in the area of externalities. The data regarding externalities appear to be among the most comprehensive, well-defined, and granular of the freight data.

Data systems exist for highway emissions, hazardous material releases, and accidents involving trucks, railroads, and air freight carriers. The Clean Air Act Amendments of 1990 created the current air quality "conformity" process. Under that process, transportation emission budgets, which are like targets, are established through a cooperative process involving the U.S. Environmental Protection Agency (EPA), state environmental agencies, state transportation agencies, and metropolitan planning organizations (MPOs). Public involvement is included. The emission budgets serve as a ceiling, above which transportation emissions cannot rise. The regional long-range transportation plans and short-range transportation programs are modeled, and the emissions estimate produced is compared to the emission budgets. Emissions for the current year, the short-term program, and the long-range plan all must meet the emission budgets. Included in the models are the trips generated by trucks using the highway system. The analysis of vehicle emission factors has led to a number of truck-related emission-control strategies to reduce oxides of nitrogen ($NO_x$), particulates (PM .10 and .25), and volatile organic compounds (VOCs). The conformity process was not designed as a performance measurement system, but it includes the elements of one. It has goals, targets, an accepted architecture and technical protocols, and a reporting and quality-assurance process. The outputs of the conformity process indicate whether highway freight movements are contributing adequately to air quality goals.

Similarly, the data from the hazardous materials releases and for crashes allow for high-level trend analysis as well as for granular drilling down into performance at the local, regional, or state level. Although the data for both crashes and hazardous releases have some well-documented reporting flaws, they are available for continuous reporting of performance.

The types of performance measures that could be produced from the externality data sources include freight emissions by truck and rail, broken down by major category of pollutant; crashes by both highway and rail modes; and hazardous material release incidents.

## Emerging but Incomplete National Measures

Considerable federal efforts have been undertaken to measure many aspects of freight system performance, although an official set of federal freight performance measures does not exist. The Freight Analysis Framework and the Transportation Services Index provide considerable information about short-term freight volumes and long-term estimates of freight volumes, origins, and destinations. U.S. Department of Commerce data regarding economic output by sector also can contribute significantly to approximating freight

volume trends. The USACE tracks waterborne freight volume on the U.S. Maritime Transportation System (MTS), as well as monitoring the age and condition of locks and dams. Rail volumes are reported by the FRA, as are aviation freight volumes by the FAA. Overall information about freight volumes, the modes they travel on, their value, and their origins and destinations are available.

## Disjointed Data

Separate from the challenge of data volume is the challenge of inconsistency and integration of freight data to construct a performance measurement framework. Most of the freight data sets were developed independently by different organizations for different purposes. One study concluded that the data sets were a "disjointed patchwork" that frustrate users.[11]

> The disjointed array of data sources is cumbersome and difficult to use, lacking in geographic detail, and notably deficient in covering increasingly important motor carrier flows. Several users also expressed concern about the unnecessary burden on data providers, who may be asked to provide similar data to different organizations—sometimes in different formats. This heavy respondent burden is likely to hinder efforts to gather quality data.

AASHTO's Standing Committee on Performance Management has sponsored research projects that illustrate that differences exist in how two basic sets of transportation performance data are gathered. The research projects[12, 13] examined how state transportation agencies collected and reported data for pavement conditions and project completion. Although pavement roughness data are collected by profilometer vehicles, the study noted that variations in how the equipment was calibrated, whether states measured one or two wheel paths, and how consistently the vehicles stayed in the wheel path all affect results. The issue of differences in how states collect pavement roughness data prompted the FHWA to include a separate table in its Highway Statistics report that notes the variations in the data collection methods.[14]

In its *Report to Congress on the Performance of Ports and the Intermodal System*,[15] MARAD noted that a lack of common performance measures and the lack of a reporting process has stymied its attempts to measure the efficiency of major U.S. ports. It informed Congress that it was unable to assess congestion levels at ports or to assess the performance of the nation's intermodal system overall.

> MARAD was unable to provide the requested comparison of the most congested ports in terms of operational efficiency due to a lack of consistent national port efficiency data. Given the diverse characteristics of U.S. ports, comparing port efficiency would require the creation of new methodologies and the collection of data that were not available for this report.

The GAO reported to Congress repeatedly on efforts by FMCSA to improve the quality of truck-crash reports:

> Overall, commercial motor vehicle crash data does not yet meet general data quality standards of completeness, timeliness, accuracy, and consistency. For example, according to FMCSA, as of fiscal year 2004 nearly one-third of commercial motor vehicle crashes that states are required to report to the federal government were not reported, and those that were reported were not always accurate, timely, or consistent.[16]

## Lack of Performance Data

Another finding of the research is that data about infrastructure condition are more available than are data for freight system performance. For instance, data for the condition of bridges and pavements have long been available through the National Bridge Inventory and through HPMS. However, information on overall performance as measured by truck speeds is only recently being developed through research by the FHWA and ATRI. Although USACE measures the infrastructure condition of the maritime transport system and the volumes on it, the Corps does not report on the travel time or reliability of water shipments. Likewise, despite the voluminous information available on railroads, information on the speed and reliability of shipments is not being produced. Data on the relative speed of individual modes are available in some forms. The FHWA/ATRI data, HPMS speed estimates, and the AAR train-speed data provide general insight into the travel times on major highways and railroads. However, the overall speed and travel reliability of supply chains that rely upon handoffs between modes is not available in the public domain. Package firms such as UPS and FedEx, major truck carriers, and the Class I railroads generally use GPS to track packages and freight. However, the data are available to their customers only for individual shipments. It is not aggregated for publication.

## Lack of Well-Defined Goals

As has been mentioned, most performance measurement systems evaluate the success of policies, programs, or entities to achieve their goals. As there is no national freight policy, few explicit freight programs, and no single national freight agency, freight performance measurement lacks a clarifying set of priorities upon which measures would focus.

In the *Framework for a National Freight Policy*,[17] USDOT has taken the first steps toward outlining the components of a national freight policy. USDOT emphasizes that a true freight policy would come as the result of extensive consultation with the many public and private stakeholders and would probably involve considerable political dis-

course. Such consultation and discourse have only partially occurred. Therefore, USDOT emphasizes that it has produced a framework for a national freight policy, and not a national policy itself.

USDOT has adopted a vision statement for the framework, from which the subsequent objectives derive: "The United States freight transportation system will ensure the efficient, reliable, safe and secure movement of goods and support the nation's economic growth while improving environmental quality."

The "overarching themes" for this national freight policy framework include four elements. First, the framework relies upon not only USDOT but also upon a large number of public and private stakeholders. Second, the national transportation system requires extensive investment, both public and private. Third, public and private collaboration is essential not only for investment but also for the operation of the freight system. Fourth, the framework and its objectives must evolve as conditions and strategies change.

The national framework is organized around a traditional structure of objectives, strategies, and tactics. The objectives are:

- Objective 1. Improve the operations of the existing freight transportation system.
- Objective 2. Add physical capacity to the freight transportation system in places where investment makes economic sense.
- Objective 3. Better align all costs and benefits among parties affected by the freight system to improve productivity.
- Objective 4. Reduce or remove statutory, regulatory, and institutional barriers to improve freight transportation performance.
- Objective 5. Proactively identify and address emerging transportation needs.
- Objective 6. Maximize the safety and security of the freight transportation system.
- Objective 7. Mitigate and better manage the environmental, health, energy, and community impacts of freight transportation.

Specific program targets and a well-defined methodology for measuring progress toward those targets exist for the air-quality program. Such targets exist less explicitly for the hazardous materials and safety programs, but targets in those programs are implicit: both programs seek continuous reductions in crashes and in hazardous material releases.

The presence of targets and performance-measurement architecture in those programs partially explains the comprehensiveness of performance data for them. As a corollary, the lack of national freight system programs, performance goals, or targets partially explains the lack of freight system performance data.

In "Strategy-Focused Performance Measures," Frigo says "strategy first, then performance measures."[18] This conclusion is shared by many performance measurement authors. They first recommend clarity regarding strategy and desired outcomes, then the development of metrics to gauge the strategy's effectiveness. The GAO has made similar recommendations regarding the national interest in freight:

> Compounding these challenges facing state and local transportation planners is that the federal government is not well positioned to enhance freight mobility due to the absence of a clear federal strategy and role for freight transportation, an outmoded federal approach to transportation planning and funding, and the unsustainability of planned federal transportation funding. When combined, these challenges and factors hinder the ability of public sector agencies to effectively address freight mobility and highlight the need to reassess the appropriate federal role and strategy in developing, selecting, and funding transportation investments, including those for freight transportation.[19]

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CHAPTER 5

# Freight Stakeholder Preferences

In the earlier tasks, the literature was reviewed to analyze the evolution of performance measurement in the private and public sectors, with a particular emphasis upon freight performance measurement. Sources of data also were examined to determine what measures were possible.

The next phase consisted of several related efforts to determine the interests of key stakeholders in freight performance measures. To capture private-sector interests, a survey was conducted of members of the CSCMP and interviews were conducted with private-sector freight companies. To assess public sector interests, a survey was conducted of all 50 state transportation agencies, and interviews were conducted with public sector organizations, such as AASHTO and the FHWA.

Each aspect of the freight system creates a potential stakeholder who may have an interest in measuring and managing the freight system. These stakeholders cut across nearly all public and private sectors because of the symbiotic relationship between the agencies and corporations that build freight networks and the shippers who use them.

Significant diversity of interest in freight performance measurement was documented. Among private-sector firms, the cost, timeliness, and reliability of their own supply chains were of intense interest, whereas they expressed considerably less interest in measures of system condition or externalities. Private-sector logistics officials and trucking executives expressed keen interest in their own fleets, customers, and vendors but less interest in government-provided metrics. Two-thirds of private-sector respondents indicated that they never sought government-provided freight performance measures. Performance measures are important enough to the members of the Association of American Railroads (AAR) that it produces extensive rail system performance indicators compiled from the Class I railroads. The trucking industry's research arm, ATRI, is working closely with FHWA to produce measures of truck speed and reliability. However, the American Association of Port Authorities (AAPA) expressed skepticism that measurement of the ports of its diverse members would be meaningful. AAPA's position was the ports have such significant variability that comparing performance to means or averages would be suspect. Responses to surveys and interview requests from individual ports were low.

State transportation officials were very interested in highway system performance at the local and regional level. They displayed markedly less interest in national highway measures, or in measures related to modes for which they lack oversight. National transportation officials were interested in national measures, while other national agencies such as the EPA were interested in the air-quality areas for which they have jurisdiction. In short, interest in freight performance measurement was as varied as are the roles of the respondents. The eight trucking company officials interviewed each recommended a different set of measures as being important to them, even though they are all in the same industry. No two state DOTs that have identified freight performance measures have adopted the same measures. The CSCMP survey produced great variation among recommended measures. Likewise, among the state DOTs surveyed, substantial variation in proposed measures was evident. Generally, public-sector officials were interested in policy, planning, and investment measures, whereas private-sector respondents were most interested in cost and operational measures. Beyond those generalities, it was difficult to identify precise measures that appealed to a broad cross section of stakeholders.

## Private-Sector Perspectives

The great diversity of private-sector stakeholders is evident from earlier tables and descriptions of the substantial diversity that exists within the U.S. economy. Nearly every category of firm would have some interest in freight system performance. Those interests, however, would be quite diverse, even within similar categories of industries. A very localized

small manufacturer's interests will be different than those of a multinational manufacturer who relies upon tightly strung global supply chains. Likewise, the real-time high-value-package focus of UPS is quite different from that of an upper Midwest grain shipper barging corn to New Orleans. Their scale of timeliness, cost, waste, and reliability are significantly different.

The CSCMP membership was surveyed because it represents a cross section of the private-sector logistics industry. Among its largest groups listed in approximate order by category are: 1,985 logistics and management planning firms; 1,938 manufacturers; 1,061 third-party logistics providers; 630 food and beverage providers; 420 consulting firms; 411 transportation management firms; 400 educators; 398 warehouse operators; 307 pharmaceutical and toiletry producers; 222 auto and transportation equipment producers; and 206 department store or general merchandise firms. These, of course, are only the largest categories; more than 2,324 members list themselves as "Other" firms. The remaining members listed themselves among nearly 40 smaller categories.

For the survey, not all members were solicited. The intent was to get the opinions of private-sector logistics practitioners as to which performance measures would be of greatest import to them. Nonpractitioners, such as academics, other trade associations and consultants, were deleted from the survey list. The remaining 4,000 included groups such as retailers, manufacturers, third-party logistics firms, warehouse operators, and other groups who are involved in day-to-day movement of freight.

The response rate was not high. Out of 4,000 firms e-mailed, only 73 responses were received. Clearly, such a low rate does not provide a statistically valid number of responses, but it does provide a useful convenience sample. The comment from two-thirds of the respondents that they had never sought publicly provided measures perhaps helps to explain the low response rate.

The responses, however, did provide consistency in several informative areas. Primarily, the results appeared to indicate that, although the majority of respondents had never expressed a desire for government-produced freight system performance measures, the private sector would—if such measures were produced—clearly prefer measures related to timeliness, reliability, and costs of shipping freight. This apparent trend will be further explained.

## Responses to Individual Measures

Two-thirds of the respondents rated as "very" or "moderately" high their interest in the CSCMP's measure of the cost of logistics as a percentage of gross national product (GNP), as seen in Figure 5.1. This report tracks a variety of logistics cost indicators and compiles them into an annual report that uses GDP as a denominator. Twenty-seven percent rated it as "somewhat" useful and only 5 percent said it was not useful at all. The relatively high interest in the cost metric by the private sector was not shared by the public-sector respondents, who rated it among the least important measures. Another difference noted was that the private-sector respondents' role in national and international supply chains caused them to be more consistently interested in national and international measures, as opposed to local or regional ones, which were preferred by the state agency respondents.

As seen in Figure 5.2, a significant majority of respondents listed as "very" important potential measures of changes in logistics costs. The CSCMP survey breaks down logistics costs into labor, inventory, overhead, fuel, and other major categories. When asked if such categories were important, the clear majority answered in the affirmative. They also rated highly


***Figure 5.1. Respondents' rating of measurement of cost of logistics.***

the usefulness of the cost-related performance measures at national, local, and regional levels.

In regard to truck travel speeds on major corridors, Figure 5.3, a plurality of respondents rated the potential of such a measure as "very" important to them and gave near equal weight to such measures at the local, regional, and national levels. Fewer than 14 percent indicated the measure would be of no value to them. Open-ended comments also revealed considerable interest in operating-speed data to be available daily, as opposed to monthly or annually.

Travel-time reliability was another highly rated measure. When responding to performance measures regarding congestion, slightly higher preference was shown for state and local measures. Local granularity was desired. One trade association reported that 20 percent of its members reported that they had lost or risked losing a customer during the past five years because of a freight bottleneck.

Slightly less interest was stated for measures that reported upon environmental issues, such as air pollution, energy use, or greenhouse gas emssions (GHE) related to freight, as shown in Figure 5.4. There was a slightly smaller majority who rated such measures "very" or "moderately" important to them. As will be seen later, these measures appeared to be of more interest to the public-sector respondents than to those from the private sector. The public-sector respondents face many environmental compliance requirements that create a strong interest in such data.

By a fairly wide margin, the respondents reported that they had never desired freight performance measures that would be produced by the public sector. Sixty-three percent of respondents (Figure 5.5) said they had never desired such measures, and approximately 36 percent indicated that they had. Also, the respondents reported little certainty as to how they would use such measures if provided. As can be seen in Figure 5.6, the

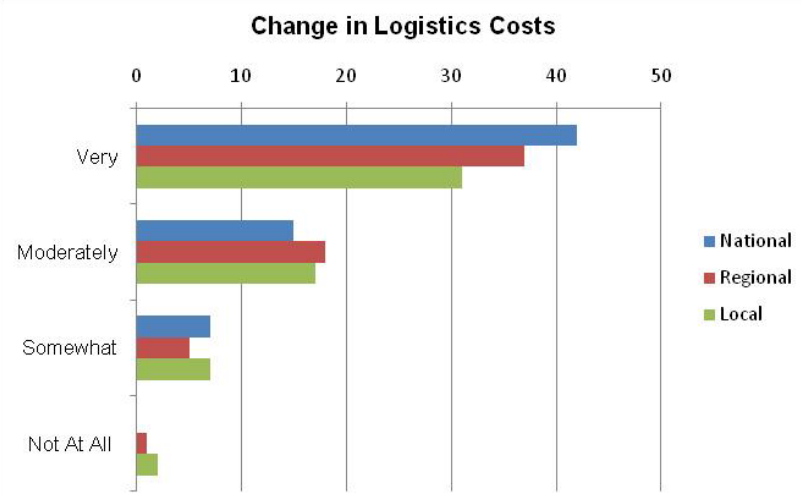


***Figure 5.2. Respondents' rating of measurement of changes in logistics costs.***

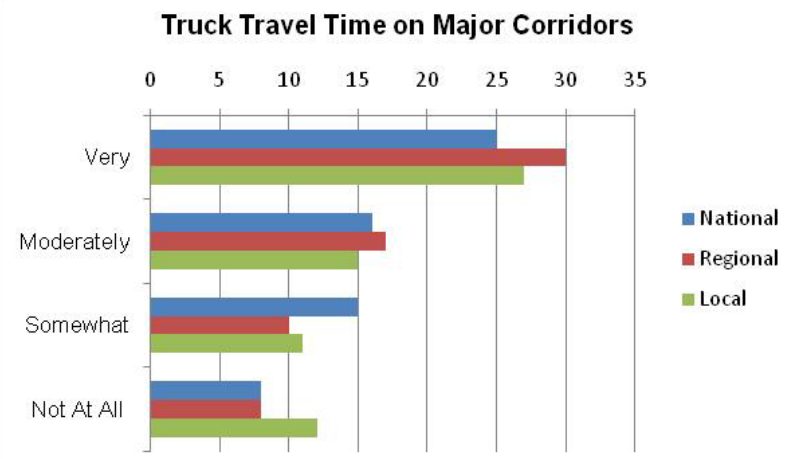


***Figure 5.3. Respondents' rating of measurement of travel time.***

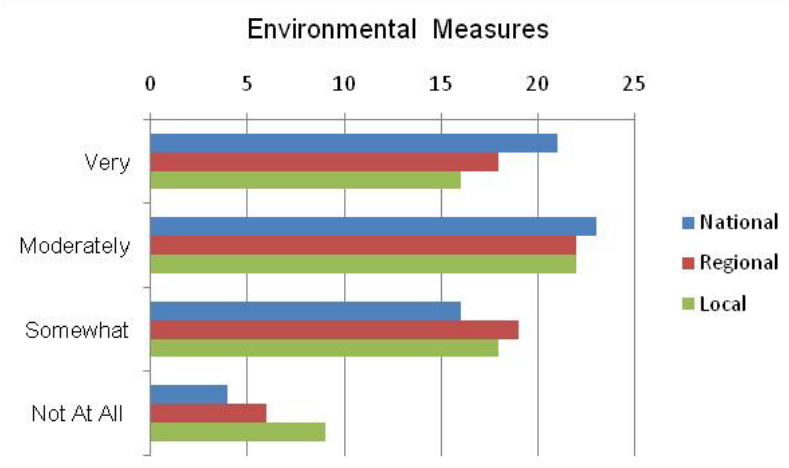


*Figure 5.4. Rating of environmental measures.*

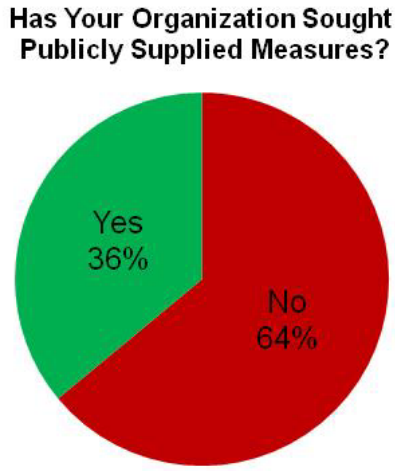


*Figure 5.5. Respondents seeking measures.*

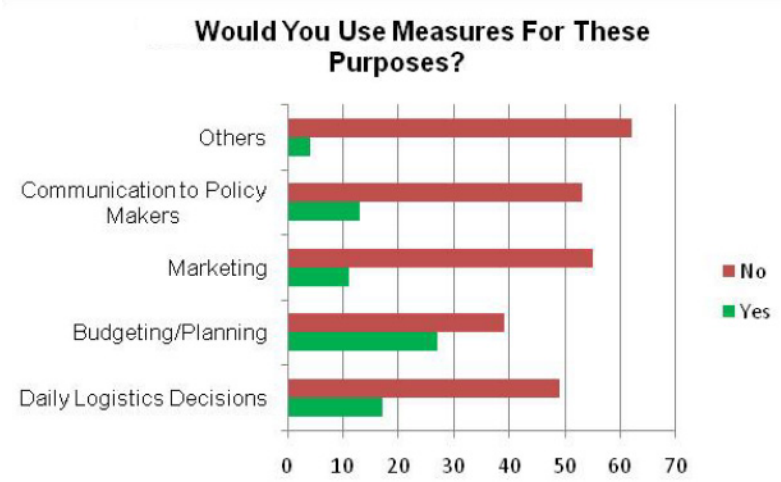


*Figure 5.6. Uses for measures.*

majority of respondents did not report a specific use for such measures, beyond approximately 30 respondents who said they would use such data for budgeting and planning purposes.

In an open-ended comment section related to the uses of freight performance measures, no dominant consensus of opinion was evident, either. No two comments were the same, although it was clear that issues of on-time delivery and transport costs were of overall importance, as would be predictable in the highly competitive logistics industry. "We pass many of these requirements off to our freight carriers but it's very important for us to be knowledgeable about these issues when we're negotiating our annual contracts and fees. These issues are critical for us to be able to leverage our shipments," said one respondent.

## Public-Sector Perspectives

Public-sector perspectives tend to fall into three categories: Network condition, network performance, and transportation impacts. As will be shown later, public-sector transportation respondents generally rated as most important those measures that capture performance on the network for which they are responsible. Public-sector policy groups were most interested in measures related to their policy purviews, be they environmental, safety, military, regulatory, or transportation related.

## State Perspectives

Surveys were distributed to all 50 state DOTs. Targeted were officials within the state freight offices, of which approximately 22 exist. In state transportation agencies that do not have freight offices, the surveys were sent to the DOT's planning officials. The state DOTs generally expressed a keen desire for freight performance measures, with some strong exceptions. State officials overall expressed greatest interest in measures that captured information regarding the performance of local and regional freight networks, such as highway, railway, and port systems, with lesser interest expressed in aviation and inland waterway systems (Figure 5.7). This probably is attributable to their lack of responsibility for those systems, and their lack of eligible funds to invest in them.

The states generally indicated that they would use the performance measures as one input for a wide array of purposes, including project selection, funds allocation, legislative communication, system monitoring, and long-range planning. For the most part, the states indicated a higher interest in performance measures at the regional and local levels, and on an annual or quarterly basis. Performance measures regarding the national freight network and daily freight system performance generally were not ranked as highly by the states. The exception was for travel-time

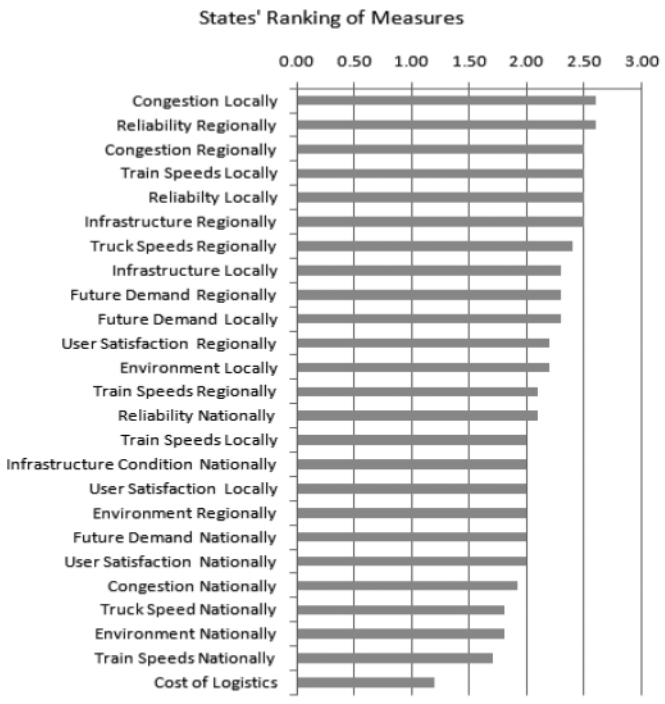


*Figure 5.7. Public-sector ranking of measures.*

data, which some indicated they would like on a daily basis. Because the states indicated they would use the performance measures for planning and project-selection purposes, the need for daily operational measures probably is less acute for them than it would be for logistics providers, who are concerned about daily freight routing decisions.

The states were asked to rate potential measures on a simple scale of 0–3, with 3 indicating they would find a potential measure to be "very" important to them. They also were asked to indicate any difference in preference if the measure were available at a local, regional, or national level. The highest overall scores were for measures addressing congestion and reliability at the local and regional level. Both were scored at a value of 2.5 or higher out of a possible highest score of three. As can be seen in the chart, the lowest overall scores were for the Costs of Logistics as a Percent of Gross Domestic Product, train speeds nationally, and performance regarding the emissions, pollution, and energy impacts of freight. The Costs of Logistics as a Percent of Gross Domestic Product had an overall value of only 1.2 from the state respondents, while the environmental and energy measures scored 1.8. However, the states indicated a higher interest in the energy and environmental measures if they were available at the local level. The Costs of Logistics Measure may also have been affected by its availability only at a national level. The score for that measure was notable because that category was among the highest rated by the private-sector respondents. It should be noted that respondents were commenting upon their need for and use of specific freight performance measures. They were not asked to comment upon the importance of national freight data sets, from which they could pull local freight data.

The difference in the importance of local versus national measures was clear-cut between the state respondents and the later private-sector respondents. The state respondents highly ranked all measures if the measures were local or regional. The private sector highly ranked most measures as long as they were national. The private sector appeared to be influenced by its involvement with long international and intercontinental supply chains. The state officials were influenced by their local and state responsibilities.

One strong sentiment expressed by at least two states was opposition to any national set of performance measures. Some state respondents expressed strong concern lest any set of measures be used to inaccurately measure states and to make arbitrary national fund allocation decisions. This concern has been strongest among officials of some of the Great Plains states, who stated that their low populations and large distances create unique transportation conditions. When national statistics for congestion, crashes, and other traditional indicators of "need" are examined, they said, the Great Plains states can appear to have little need and may therefore not receive adequate federal investment. These states have strongly urged that any performance measures be state specific and developed by the states in a fashion that best meets their individual needs. Their concerns have been incorporated by AASHTO in its official positions regarding performance measures. AASHTO advocates that no national targets be set, instead allowing states to set targets that meet their needs.

## Federal Agency Perspectives

Interviews were conducted with six federal agencies to assess the agencies' use and need for freight performance measures. The interviews sought to obtain perspectives upon the agencies' need for performance indicators beyond the indicators that the agencies already compile to satisfy federal statutes. The five interviewees were either current or former employees of one of the following entities:

- U.S. Department of Transportation, Federal Highway Administration (FHWA)
- U.S. Department of Transportation, Federal Motor Carrier Safety Administration (FMCSA)
- U.S. Department of Commerce (DOC), International Trade Administration
- U.S. Army Corps of Engineers (USACE)
- U.S. Environmental Protection Agency (EPA), Office of Transportation and Air Quality
- The U.S. Army

All the officials interviewed indicated that their federal agencies had sought freight performance measures. However, each agency sought different measures, and ones unique to its responsibilities. The FHWA sought highway travel time and reliability data while the FMCSA sought measures related to the number and efficacy of truck safety inspection programs. The EPA was predictably interested in emissions from freight operations, whereas the USACE was interested in the condition and performance of the maritime system. The U.S. Army reported that its interests could not be summarized because they vary considerably. The respondent noted that the freight needs in a battlefield environment would be much different than those for a stateside, noncombat administrative function. He reported that beyond very generalized categories, it would not be realistic to select only a handful of performance measures that would provide insight for all military situations.

The federal agencies were asked to rate various categories of measures. They clearly rated highly those measures that predicted future freight volumes, as seen in Figure 5.8.

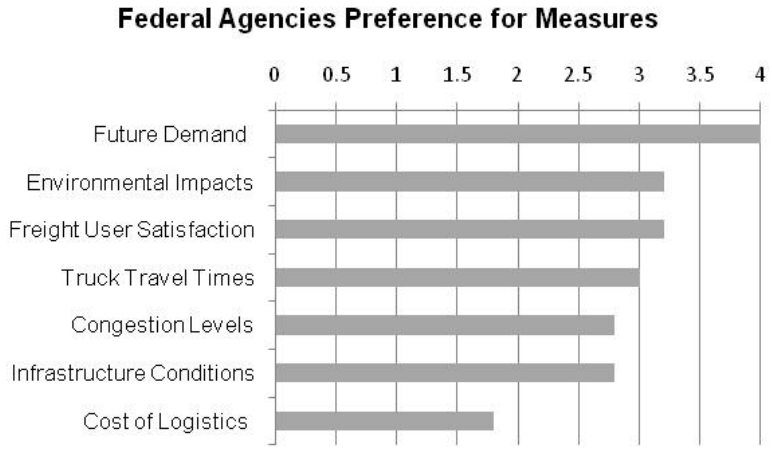


***Figure 5.8. Federal agencies' preference.***

Each agency is affected by freight, and therefore future freight volume holds important implications for each agency's programs, investments, or regulatory strategies. All the agencies rated future freight demand as very important to them.

## Trucking Industry Perspectives

Eight interviews with trucking company managers and executives were conducted to ascertain that industry's perspective on measures. Insights were sought on both the measures they use and their interest in potential publicly provided measures. Such a small sample size was not intended to be representative of the entire industry but rather to be illustrative of how a small cross section of the industry used performance measures.

As noted by the company representatives, they rely heavily on performance measures but only on those that provide specific and highly granular insight into the operations of their company, their suppliers, their fleets, and their employees.

All eight indicated that their companies rely on performance measures, with the primary use of them being, in the order of frequency:

- Efficiency, Profitability, and Cost Savings (13)
- Customer Service (5)
- Competitiveness (3)
- Compliance (1)
- Pricing (1)
- Routing (1)

The use of performance measures to make business practices more "efficient" was by far the strongest motivator. Thirteen of the top motivators fell into the Efficiency, Profitability, and Cost Savings category and included rationales such as:

1. To improve efficiency and bottom-line return on resources;
2. To increase operational efficiency;
3. To increase productivity;
4. To control costs;
5. To increase and measure profitability; and
6. To measure employee performance.

The most important measures used by the companies were:

- Labor productivity;
- On-time pickup and delivery;
- Revenue yield by shipment or by mile;
- Shipments per truck/ truck productivity;
- Fuel economy;
- Profit or loss per truck;
- Equipment utilization;
- Maintenance costs;
- Out-of-route and loaded miles;
- Loading and unloading times; and
- Border crossing time/delays.

## Railroad Industry Perspectives

Railroad stakeholders, their goals and objectives, and their subsequent interest in railroad freight performance measures have evolved over the more than 150 years that railroads developed, were regulated, and then were largely deregulated.

As a result, a rich array of railroad freight performance data is available, particularly at the national or corporate level. The basic data available that already are used for performance or statistical measurement include:

- Data on overall rail volumes, both for passenger and freight, by railroad and by type of commodity on a weekly, monthly, and annual basis;
- Extensive information on rail safety, including not only highway–rail crashes but also injuries and fatalities to trespassers, railroad employees, and others on railroad property;
- Information on hazardous material cargoes, in terms of volumes and releases—including various categories of releases caused by accidental spills or crash-caused releases;
- Environmental and energy data, including the volume of fuel used, which can then be extrapolated into GHE, $NO_x$, and other air pollutants; and
- Extensive financial data, including not only total revenues, profits, return on income, and return on equity but also whether railroads have earned their cost of capital.

What is not as readily available is information at a local level or at an individual producer level. For instance, Class I railroads have significantly increased their revenue and profitability by hauling larger volumes over longer distances to improve their efficiencies and economies of scale. Just between 2006 and 2007, average length of haul rose from 905.6 miles per train to 912.8 miles,[1] a trend that has been evident for several decades. This reflects their increased hauling of massive volumes of coal from Wyoming and their increased movement of high-valued intermodal containers containing Asian imports. These relatively long-haul movements may have reduced the volume of long-haul truck moves on highways, with commensurate savings in fuel, emissions, infrastructure deterioration, and crashes. However, the increased model of "hook and haul" of large-unit trains has resulted in some loss of service to local shippers. This has become a significant issue in some markets, such as among grain producers who are captive to one railroad. Local producers of commodities such as grain, timber, ethanol, chemicals, and minerals often desire rail service as an alternative to truck or to water. While extensive data exist regarding what railroads haul, less information is available about what service they have discontinued, particularly at the local, regional, or individual producer level. This type of local service information is of acute interest to many public officials, as well as to the private producers who desire rail service.

Likewise, local transportation planners have complained about a lack of information regarding very localized rail operations that may affect plans for passenger rail service, commuter rail service, highway–railroad crossings, and other local transportation projects. Highway designers have voiced repeatedly the need for information regarding the railroad's long-term track-expansion plans and how those plans may affect the repair or construction of highway–railroad overpasses.[2]

Thus, although extensive performance and statistical data exist regarding national and regional railroad performance, the information needs of individual shippers and local stakeholders are not so well met. It should be noted, however, that the same is true regarding the other modes of travel. The service patterns, prices, and frequencies of inland barge companies, air freight carriers, and truckers likewise constitute proprietary information that is seldom shared with the public and local policy makers.

## Maritime Industry Perspectives

The U.S. Marine Transportation System (MTS) is a vast, diverse system of waterways and ports stretching along all U.S. coasts, Hawaii, and Puerto Rico and deep into the continental interior along the Mississippi, Missouri, and Ohio river systems. The physical network consists of more than 1,000 harbor channels; 25,000 miles of inland, intercoastal, and coastal waterways; 300 ports; and 3,700 terminals.[3] This system is responsible for approximately $673 billions' worth of goods movement or 5.2 percent of the nation's total value of freight and 8.6 percent of all tons shipped.[4]

In addition to its physical diversity, the MTS involves multiple stakeholders—private ship owners, public and private terminal operators, labor unions, the owners of modal connections into port facilities, and local, state, and federal government agencies that regulate and promote waterborne traffic. In recent years, this government network has been substantially augmented by security forces concerned about drugs, terrorism, and immigration. These governmental functions are in addition to the historic national regulatory function of capturing import duties and tariffs.

It is also important to recognize that there are many different types of ports, further complicating measurement and comparison efforts. The equipment of ports that primarily handle containers is different from that of ports or terminals that handle bulk commodities such as petroleum, chemicals, grain, aggregates, minerals, or coal. Inland waterway ports tend to be commodity specific to serve local industries such as steel production, mining, grain production, or mineral extraction. The size and scale of ports differ considerably, as do the ports' connections to local highways, railroads, and pipelines. The geographic location of ports varies considerably, with some of them on the coasts but others miles inland on river channels. These variations compound the differences

in issues such as port throughput, port connectivity, port efficiency, and port costs per unit shipped.

While many individual stakeholders regularly apply performance metrics to their particular function within the MTS, to date there has been no successful effort to characterize or measure the performance of the system as a whole. For example, a report by MARAD concluded that the federal agency could not apprise Congress of the nation's ports' ability to handle a large military deployment because of a lack of common measures.[5] It noted that the significant diversity in ports, the types of cargo they handle, their inland connections, and the geographic configuration of their harbors and channels all created great diversity. The ports as an industry have a few common denominators but none that are uniformly monitored or reported, MARAD stated. MARAD concluded in its congressional report:

> In preparing this report, MARAD reviewed articles and studies from the academic and scientific communities that set forth methodologies for measuring port efficiency. The literature reviewed supported MARAD's finding that there is no widespread agreement on an approach to measuring the efficiency of a port as a link in the logistics chain. A 2004 article in *Maritime Policy & Management* states: "Measures of port efficiency or performance indicators use a diverse range of techniques for assessment and analysis, but although many analytical tools and instruments exist, a problem arises when one tries to apply them to a range of ports and terminals. Ports are very dissimilar and even within a single port the current or potential activities can be broad in scope and nature, so that the choice of an appropriate tool of analysis is difficult. Organizational dissimilarity constitutes a serious limitation to enquiry, not only concerning what to measure but also how to measure. Furthermore, the concept of efficiency is vague and proves difficult to apply in a typical port organization extending across production, trading and service industries."
>
> MARAD was unable to provide the requested comparison [to Congress] of the most congested ports in terms of operational efficiency due to a lack of consistent national port efficiency data. Given the diverse characteristics of U.S. ports, comparing port efficiency would require the creation of new methodologies and the collection of data that were not available for this report.

Internally, port operations have generated some standards measures, but these are mainly of interest to the internal, business operations of the port. They tend to regard how efficiently port crews operate, whether labor rules restrict efficiency in loading and unloading, and whether internal configuration of ports, parking lots, cranes, and storage areas are efficient.[6] These measures are unlikely to be appropriate for a national set of performance measures because they tend to be proprietary, would be difficult to collect, and may not influence public policy but rather internal port and terminal operations. Each port is a unique business, operating over unique infrastructure, and a measure appropriate for one may not be relevant to another. Ultimately, ports are providers of transportation services, and the fundamental common metric is "customer satisfaction." The American Association of Port Authorities addresses this issue on its website:

> AAPA continuously receives requests on how ports rank nationally and internationally. The question is ambiguous, however, since ports can be compared in many different ways—by volume or value of trade, number of cruise passengers, revenues, and storage capacity, as examples. Moreover, sheer size of a port, in terms of traffic flow, says nothing about productivity, efficiency, or responsiveness to customers. These are just some of the criteria that a shipper might consider in evaluating port performance.

## Additional Practitioners

In an effort to solicit additional responses from the private sector and from researchers who have worked with the private sector, approximately 10 additional practitioners who have been active in NCFRP programs were contacted. Seven of them responded to the survey and provided additional insight into the freight performance–measure issue. They were a mix of private-sector logistics professionals, researchers, and government officials.

As can be seen in Figure 5.9, this group gave consistently higher scores to all of the proposed performance measures than did the state officials. This may reflect a self-selection influence in that these individuals were specifically selected because of their interest in freight research. This group ranked all measures with an average score of 3.05, while the state officials' average score was 2.14 for the value of all the measures, out of a scale of 0–4.

Also perhaps reflecting the national perspective of this group, the national measures were consistently ranked higher than they were by the state officials. In fact, national versus local measures switched rankings between the two populations. For this group, national measures were ranked highest in six of the top eight highest-ranked measures. For the state officials, national measures did not appear even in the top 10. All the top measures ranked for state officials consisted of local or regional measures.

As can be seen, the top performance measures for this group were related to congestion, infrastructure condition, and environmental externalities of freight. However, it should be noted that eight categories were listed and three choices were available for each category—a national, regional, or local category for that measure. In nearly all cases, this group rated the national measure more valuable than the same measure provided at the regional or local level. Again, this emphasizes this population's national perspective.

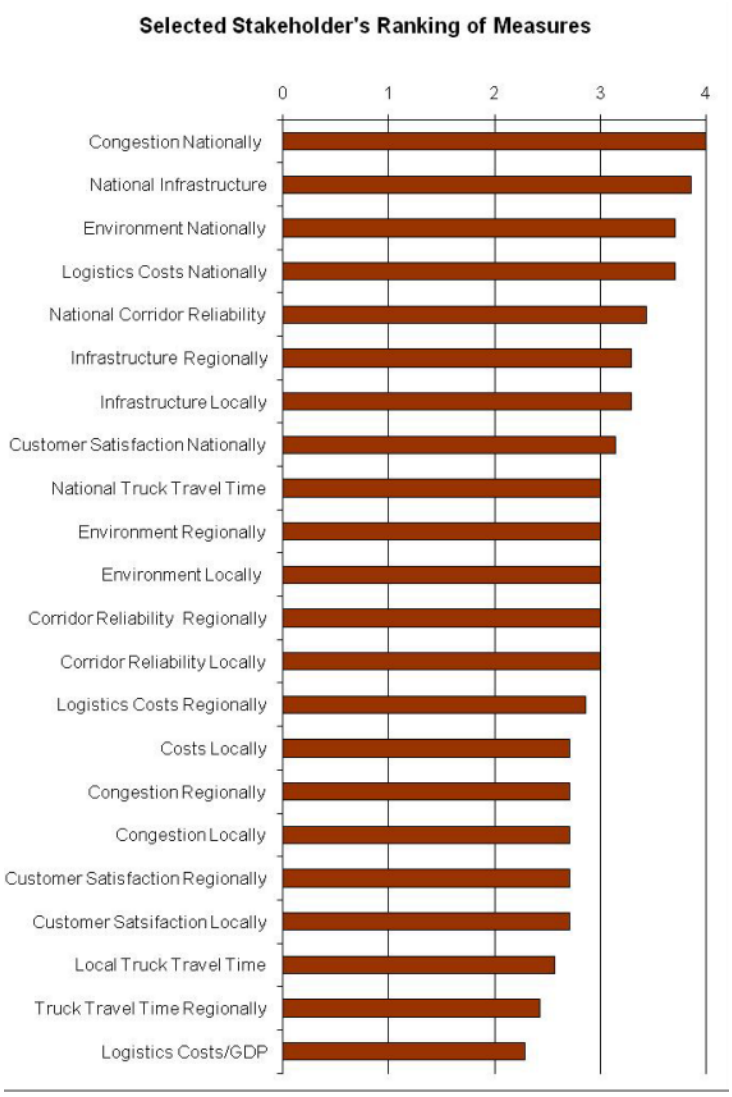


***Figure 5.9. Stakeholders' preferences.***

When asked the open-ended question of what regulatory issues were most important, no two respondents identified the same issue. The issues cited were funding for the highway trust fund; open access to rail lines; supply chain security; greenhouse gas (GHG) emissions; California Air Board legislation; truck size and weight; hours of service; and wetland regulations.

## Endnotes

1 AAR Statistics, http://www.aar.org/~/media/AAR/Industry%20Info/Statistics.ashx (accessed on February 27, 2009).
2 Strategic Highway Research Program 2 Project R16, *Railroad–DOT Institutional Mitigation Strategies*, unpublished study.
3 MARAD. *An Assessment of the U.S. Marine Transportation System*, 1999, p. 43.
4 RITA. *Freight in America*, 2006, p. 7.
5 MARAD.
6 Chung, Kek Choo. Port Performance Indicators. In *Infrastructure Notes*, prepared for the Transportation, Water and Urban Development Department of the World Bank, December 1993, http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1119275973157/td-ps6.pdf (accessed May 24, 2010).

CHAPTER 6

# Data Considerations to Support Performance Measurement

## Summary

Of the many challenges to developing a nationwide freight performance measurement system, the greatest is the complexity of gathering adequate data. It is self-evident that performance measurement relies on data and that the measurement system can only be as sound as the data it consists of.

As mentioned in earlier chapters, the availability of sound, consistent, sustainable data was an overriding consideration in the selection of measures for the first-generation Freight System Report Card. Although stakeholder interviews indicated a desire for additional measures, the measures selected for the report card were ones for which data are readily and consistently available.

Although measures were selected for which data exist, the ongoing population of the report card will represent an enormous data challenge. This section examines the challenges of freight system data collection that will need to be addressed. It also includes two relevant case studies—one of the Freight Analysis Framework (FAF) and one of the Transportation Services Index (TSI). Both are highly relevant in that they are analogous efforts to integrate freight data from a wide array of sources into a common reporting format. Their experience illustrates, on a smaller scale, the type of effort necessary to develop a freight report card.

## Freight Data Issues

State and federal practitioners have identified significant gaps in the freight data available for performance measurement. In *A Concept for a National Freight Data Program: Special Report 276*[1] the shortcomings in federal freight data sets were summarized.

> [T]he current disjointed patchwork of freight data sources is costly to generate and maintain but does not provide decision makers with the data they require. To remedy this deficiency, a national freight data framework is needed to guide the development of a national freight database and related data collection and synthesis activities with the potential to meet users' data requirements.

The report notes that many users' needs require freight data that are not available from any single source. Thus, it is frequently necessary to combine data from different sources. The combination of data from different sources, often known as "data fusion," is frequently problematic. Much of the existing data were developed by different entities, over different times with different generations of technology. The sources differ in their modal coverage, collection techniques, and data definitions. Significant concerns were identified in *Special Report 276* regarding the use of the existing data for a comprehensive national freight database:

> A further deficiency of existing sources of freight transportation data is that some of the information required by decision makers is simply not available. For example, informed efforts to alleviate highway congestion require data on routes traveled, time of day, and the types of trucks and commodities caught in congestion—data that are rarely collected, at least in the United States. Both the committee's discussions with users and the personal experience of individual members revealed a sense of frustration with existing freight data. The disjointed array of data sources is cumbersome and difficult to use, lacking in geographic detail, and notably deficient in covering increasingly important motor carrier flows. Several users also expressed concern about the unnecessary burden on data providers, who may be asked to provide similar data to different organizations—sometimes in different formats. This heavy respondent burden is likely to hinder efforts to gather quality data.

A pending NCFRP Project 12 has been scoped to further develop a national freight data architecture. Its objectives include developing the specifications for the content and structure of a freight data architecture, to identify the value and challenges of the potential architecture, and to specify institutional strategies to develop and maintain the architecture. This architecture is intended to serve the needs of

public and private decision makers at the national, state, and local levels.

A study conducted for the Washington State DOT[2] identified 32 different data sets that the state could include in its freight data system. Despite the number of sets that can supply some data, the report noted that "very little systematic data exists to inform decision makers about the economic impact, system bottlenecks, and supply chains flowing through freight systems that support Washington State producers and delivery of goods to consumers."

In Texas, the authors of a study on potential freight performance measures summarized the state of current freight data for performance measures thus:

> Freight performance measures (FPM) in the U.S. are currently at a very early stage in their development. Some states have made a push to look into FPMs or to begin some data collection to assess what would be required for an integrated ITS-PM system. However, most states have not yet utilized their performance measures across modes. The general consensus is that the implementation of a comprehensive set of FPMs requires far more data-collection capability than most states currently possess.[3]

The authors note that even the leading work that has been done has focused on broad goals and objectives, rather than specific performance metrics. Another study of data sources in Texas identified 31 separate databases that could be used for some aspect of freight system performance analysis.[4]

At least two major areas of data improvement will need to be addressed to implement a freight performance measurement report card. First are the issues related to the integration and governance of state and federal transportation data, or the processes by which data from different sources are synthesized and stored so that they can be analyzed by users and decision makers. The literature indicates that transportation data integration from a wide array of providers will present significant technical, policy, and logistical challenges.

Second is the issue of the quality and quantity of freight-related data. The experience of other transportation agencies suggests that freight-related data has continually improved in recent years but still lacks the detail, breadth, and completeness necessary for consistent, nationwide performance measurement.

## Data Integration and Governance

Data governance and data integration will be essential elements of a freight performance measurement system. Data governance has been defined as "the overall management of the availability, usability, integrity, and security of the data employed in an enterprise. A sound data governance program includes a governing body or council, a defined set of procedures, and a plan to execute those procedures."[5] One author has noted, "Data governance is a system of decision rights and accountabilities for information-related processes, executed according to agreed-upon models that describe who can take what actions with what information, and when, under what circumstances, using what methods."[6]

FHWA defines data integration as "The process of combining or linking two or more data sets from different sources to facilitate data sharing, promote effective data gathering and analysis, and support overall information management activities in an organization."[7]

Following are some of the governance and integration issues that will need to be addressed in deploying a dashboard for freight-related performance measures.

1. The development of common data definitions for organizations providing data to a national set of freight performance measures;
2. Development of data quality and accuracy standards;
3. Development of protocols to integrate multiple sources of data into the framework;
4. Development of strategies to close data gaps;
5. Development of strategies to assure data availability;
   a. From sources;
   b. From the report card or sets of measures themselves;
6. Time to access data from the framework;
7. Identification of real-time versus archived data needs; and
8. Sustainability of the data framework.

The *Data Integration Primer*[8] notes, "The data integration process can be extremely involved and challenging, especially for organizations that have a long history of stand-alone files or rarely share data across database systems. " Although the *Data Integration Primer* focuses only upon asset management, its underlying principles apply to broader types of data integration efforts. It notes that a careful analysis of organizational needs should precede data integration efforts. Use cases (analyses of the activities to be performed) and customer requirements are clearly needed to ensure whether the data integration effort meets the performance measurement effort's needs. Also, a wide range of stakeholders and practitioners should be involved to identify the different needs that different users have for the performance measure data to be eventually integrated.

## Freight Data Quality and Quantity

Many national transportation-related data systems that could feed a freight performance system are generated by data produced by the states. This is the case for such applications as the Highway Performance Management System, the Fatality Analysis Reporting System, and the National Bridge

Inventory. As states have increasingly focused upon performance measures and performance benchmarking with peer states, the deficiencies in their performance data have become more apparent. *Comparative Performance Measurement: Pavement Smoothness*[9] notes significant variation in how different state highway agencies gather a very basic piece of performance data, the International Roughness Index (IRI) data for pavements. This variation occurs even though the data are machine gathered, protocols exist to calibrate the machines, and standards exist to assess the data. The study estimated that up to a 15 percent variation exists between how states record the data. In addition, it found that wide variation exists as to how states could manipulate and extract the data for comparative analysis. These variations occurred even though all states must record IRI and that considerable effort has been expended to establish clear standards and protocols to ensure national consistency. The study noted that factors such as the tire pressure of the test vehicle, speed of the vehicle, or the driver's strict adherence to the wheel path all influenced whether the data were consistent, accurate, or replicable between states.

The General Accounting Office[10,11,12] noted the difficulty of accurately assessing the number of truck-related fatal crashes because of inconsistent data reporting by the states. It noted in 1999 that states failed to report 38 percent of all reportable crashes involving trucks and 30 percent of fatal crashes involving trucks. It attributed the data gaps to a lack of state laws compelling state and local officials to supply data to federal officials. In 2004 and 2007 follow-up studies, GAO reported that reporting had improved but still 21 percent of crash reports lack complete data. It reported that timeliness in reporting had improved from 32 percent reported on time in 2000 to 89 percent in 2007. GAO noted that the FMCSA spent $21 million in grants over three years to improve the data reporting practices of 34 states.

The studies of IRI data and truck-crash data illustrate the complexities of using even one traditional performance measure for comparative analysis. State DOT data practitioners describe complexities that are orders of magnitude greater when they described integrating data across a number of different legacy systems. The state's experiences were summarized in proceedings for the TRB Workshop on Challenges of Data for Performance Measures, in 2006.[13] Summaries of several states' observations of their own data challenges and needs were provided.

**California DOT** data are stored in myriad databases that are disjointed and uncoordinated, have varying usability, and are inconsistent or duplicated in other databases. Lane miles in one database may include miles maintained that are not state highways or could include proposed relinquishments. This confusion leads to different answers to the same question, resulting in duplicative manual recreation of data. More importantly, users lose confidence in the data. Most performance measures are developed within the division supporting its respective performance measures and are not developed as part of an overall data collection program.

**Alaska DOT** has a data steward role that includes collection, quality control, transformation, documentation, archiving, and access of transportation data. Some of the issues that the agency has to overcome are institutional, parochial, data stovepipes, technology changes, and evolving department business requirements.

**Minnesota DOT**'s representatives noted that there were limited numbers of tools for policy, programs, and executive-level decision making. This is at least partly due to issues related to data quality, availability, systems integration, and tools to retrieve data, analyze it, develop predictive models, conduct trade-off analysis, and report results in useful formats.

**Virginia DOT** reported that the effort of creating a dashboard of performance measures was made simpler by having a data warehouse. In the development of performance measures, the agency combined different kinds of data to produce a single measure. The data warehouse provided that one stop for the different data used to automate the generation of the performance measures. Where data do not exist, the business requirements are formalized for data needed before any changes are made to existing systems or before new systems are developed. For non-automated performance reports, data come from many sources, including spreadsheets, templates, and e-mail. A lack of standardization in the number and definition of data fields collected has made statewide incident management reporting difficult. The agency is in the process of overhauling the system that tracks the operations.

**Washington DOT** notes that there is consensus that the agency needs better or more complete data. Based on a directive by the legislature, Washington DOT completed a study of 11 core technology systems. According to the study none of the 11 core systems met even 20 percent of the agency's current and future business and technical requirements. WSDOT is currently addressing the unmet needs through tremendous manual effort and use of multiple ad hoc systems.

**Florida DOT** notes that data intricacies in collection and storage can get lost in generalization of a large database. There were challenges with keeping the data current and repeatable and having consistent data and sources. The blended measures may have data from various sources and new data need to be addressed.

## Case Studies

The complexities of data integration and of addressing data deficiencies were clearly evident in the development of two representative freight information systems, the FAF and the TSI. Although neither are performance measurement systems, both provide comprehensive data regarding freight volumes, origins, destinations, and other trend information. The level of effort that was necessary for these two systems provides an order-of-magnitude example of the complexities facing the development of a comprehensive freight performance measurement system.

### Freight Analysis Framework Case Study

The Freight Analysis Framework integrates data from a variety of sources to estimate commodity flows and related freight transportation activity among states, regions, and major international gateways. The first version of FAF provides estimates for 1998 and forecasts for 2010 and 2020. The second version provides estimates for 2002 and the most recent year plus forecasts through 2035.

The FAF Commodity Origin-Destination Database estimates tonnage and value of goods shipped by type of commodity and mode of transportation among and within 114 areas, as well as to and from seven international trading regions throughout the 114 areas plus 17 additional international gateways. The 2002 estimate is based primarily on the Commodity Flow Survey and other components of the Economic Census. Forecasts are included for 2010 to 2035 in five-year increments.

Officials of FAF report that at present the effort requires one full-time U.S. DOT staff person and two full-time consultants. Both Battelle Memorial Institute and the Oak Ridge National Lab support the ongoing FAF efforts.

The initial FAF setup cost was about $1 million and was spent on acquiring private data. Because there were privacy issues with the data, the detailed analysis and input/output data could not be shared with users. The next phase cost $600,000 and was a two-year effort focused on constructing models. This allowed the agency to share the commodity data with users. The system captures data from the Bureau of Transportation Statistics (BTS), the Federal Aviation Administration, the U.S. Army Corps of Engineers, and the Energy Information Association, as well as trans-border U.S. Customs Service data, census data, and foreign trade data. Private-sector data come from ATA and AAR. FAF captures only "for hire" shipping and does not capture shippers who use internal fleets, such as Wal-Mart and others who transport their own goods.

There are no precise data available about who uses the FAF data and how frequently. From experience, the program managers believe that MPOs, the state DOTs, and private-sector users have regularly consulted the data. They believe that private-sector firms such as GE, UPS, FedEx, and Wal-Mart have used it to help determine the location of warehouses and assembly sites and to choose shipping routes.

Although the FAF data provide unprecedented new insight into the national freight network, FAF is not now scalable down to the local level. FAF is focused on the national and regional aspects of freight movement. It does not capture movement less than 50 miles and was not designed to provide a local perspective. The managers of the FAF program said that augmenting the FAF data for local granularity would be very data intensive and probably expensive. The FAF program managers say they do not anticipate scaling the data down to the local level.

The FAF program incorporates data from the following data systems:

*Commodity Flow Survey*: This is a domestic shipper survey conducted by the U.S. Census Bureau. It has origin/destination data for manufacturing, mining, and agriculture sectors. It is conducted every five years. The last one was conducted in 2007. The survey seeks sample data from shippers randomly identified from federal tax files.

*Vehicle Inventory and Use Survey (VIUS):* This survey was conducted by the U.S. Census Bureau. Last done in 2002, it collected information about trucks to be used to compute and calibrate tonnage for various products. The data will be analyzed and incorporated into FAF.

*Highway Performance Management System:* These data are obtained from state DOTs that collect data from samples of roadways statistically selected annually. The data address information about the performance, use, and operating characteristics of U.S. highways.

*Vehicle Travel Information System (VTRIS):* This annual update provides data about the number of trucks weighed, weight by vehicle type, and the classification of vehicles moving on the U.S. highway system. This information is used for calibration of tonnage of freight moved.

*Transborder Surface Freight Data:* This information gives North American trade data by commodity and mode. The data include imports and exports to and from Canada and Mexico. This is updated monthly and annually.

*Waterborne Domestic and Foreign Commerce*: This is domestic information updated annually and foreign trade information updated monthly from USACE.

*Oil Pipeline*: Oil movement data by multistate region are obtained from the Energy Information Administration.

*Air Traffic Statistics*: Air traffic, tonnage, and revenue ton-mile data are obtained from carriers quarterly from the FAA.

The managers of the FAF program say their experience holds significant lessons for development of a freight performance measurement process. They acknowledge current uncertainties about roles and responsibilities and a lack of clarity about the role of federal, state, and local agencies in providing data. In several states the relationship between the state and the local agencies is contentious. The authority and responsibility are tied to the availability of funds and the agency controlling the funds. A lack of clarity on roles, coupled with shortage of funds and lack of publicly available data at various points of the network, makes it difficult to have an integrated approach to national freight performance measures, they indicated. Fund shortages have led to the cancellation of funding for the Vehicle Inventory and Use Program (VIUS). FAF1 used private data that could not be shared with users looking for input and output data. This lack of publicly available data led to FAF2.

The measures were derived from FAF1 modeling that could be accomplished by using data that could be made public.

The FAF data can play a significant role in monitoring and evaluating the nation's freight system. FAF provides information about the volume and value of freight flow in the United States, and it provides information about the network over which the freight moves, as shown in Figures 6.1 and 6.2. The snapshot of information it provides can be compared across years and across the network to provide information about the performance of freight movement, quantities moved, and revenue generated. It also provides information about speed,

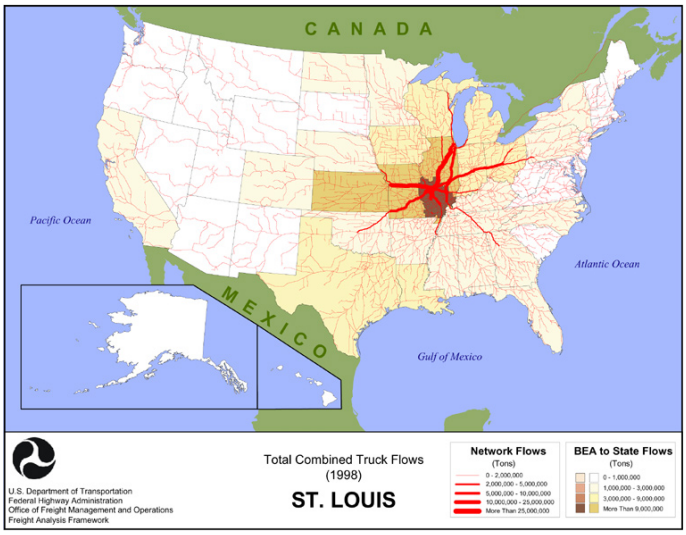


***Figure 6.1. Example of FAF data useful for assessing freight movement.***


***Figure 6.2. FAF illustration of California's import volumes.***

reliability, and congestion of movement of freight through the nation. It does not provide geographic or temporal granularity. In other words, it is annualized data available at the state and national level, not the local level.

## Transportation Services Index

The Transportation Services Index (TSI) was created by the USDOT Bureau of Transportation Statistics (BTS), and it measures the movement of freight and passengers nationally. The index, which is seasonally adjusted, combines available data on freight traffic, as well as passenger travel, that have been weighted to yield a monthly measure of transportation services output (Figure 6.3).

The TSI is a monthly measure of the volume of services performed by the for-hire transportation sector. The index covers the activities of for-hire freight carriers, for-hire passenger carriers, and a combination of the two. The TSI has been active since 2002 but is still under development and is therefore experimental. It is being examined for refinements in data sources, methodologies, and interpretations.

The TSI provides insight into how the output of transportation services has increased or decreased from month to month. The index can be examined together with other economic indicators to produce a better understanding of the current and future course of the economy. The movement of the index over time can be compared with other economic measures to understand the relationship of transportation to long-term economic changes.

The managers of the TSI note that it is the broadest measure of U.S. domestic transportation output. The project started with a grant from BTS in 2002 and was brought in-house that same year. The first official release of TSI occurred in March 2004. Initially the project had 22 staff and several consultants working on the project. Over the course of time the process was streamlined and staff resources were reduced to five federal employees and two contractors.

The products delivered by TSI are:

- Freight Index
- Passenger Index
- Combined (Total) Index

The process of refining the data and integrating it to provide the three different indexes involves many detailed steps. Those include:

*Data Gathering*

The BTS staff gather monthly data for each mode of transportation from a range of government and private sources (Table 6.1).

*Forecasting*

Some data series were not complete through December 2003, the ending date through which the original TSI was published. Therefore, staff needed to forecast the one or two missing months, using a statistical technique known as an autoregressed moving average. As production of the TSI continues, the need to forecast missing data will be reduced. However, it is not uncommon in indexes of this type for monthly data to be delayed because of reporting or other problems and for preliminary data to be substituted.

*Deseasonalizing*

Because the principal purpose of the index is to reflect monthly shifts in transportation services output and to analyze short-term trends, it is essential that it be adjusted for the normal seasonal changes that affect the transportation sector. Transportation is highly seasonal, and without adjustment the index would not give an accurate picture

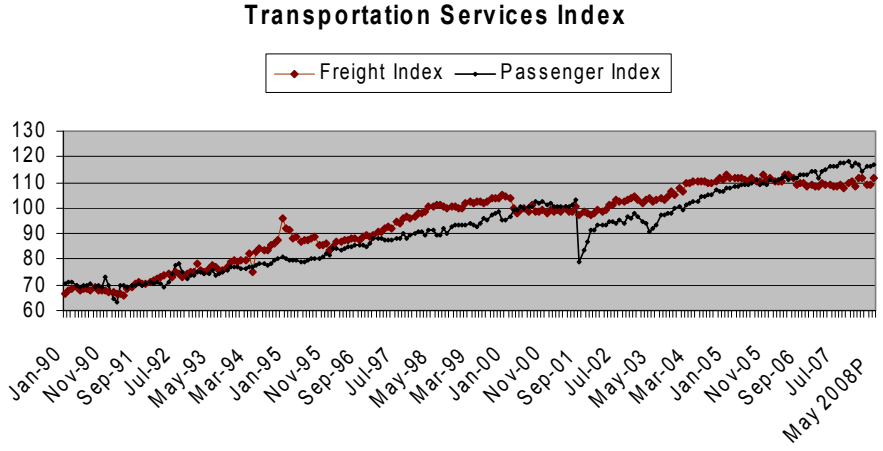


***Figure 6.3. TSI trends.***

**Table 6.1. TSI source data.**

| | | |
|---|---|---|
| **Freight TSI** | Trucking | American Trucking Association |
| | Air | BTS and Carrier Websites |
| | Rail | Association of American Railroads |
| | Water | US Army Corps of Engineers |
| | Pipeline | Energy Information Administration |
| **Passenger TSI** | Air | Bureau of Transportation Statistics and carrier websites |
| | Rail | Federal Railroad Administration |
| | Transit | American Public Transportation Association |

Source: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

of underlying changes in transportation output. BTS has therefore deseasonalized the data using standard statistical methodologies.

*Indexing*

While physical measures are gathered for each mode, ultimately for combination and analysis, the data from the different modes must be converted into an index. BTS uses 1996 as the base year and indexes by dividing the current monthly value by the average value for the 12 months of 1996.

*Weighting and Chaining*

The final step in creation of the index is combining the individual mode indexes into the three summary indexes: the freight index, the passenger index, and the overall, or combined, TSI. The weighting is based on the relative economic value added of each mode. Not all ton-miles are equivalent in their economic importance, nor are all passenger-miles. For example, the average price paid per ton-mile for freight moved by rail is less than the average price paid per ton-mile for freight shipped by truck because of differences in factors such as haul length, shipment volumes, and resultant economies of scale. By using an economic measure for weighting, the TSI staff recognizes these differences and makes the index more valuable as a transportation measure that can be used together with other economic measures, such as GDP.

Value added is used for consistency with other indicators that are used in relation to GDP, for example, industrial production. By using value added, rather than gross revenues, for each sector, they seek to avoid double counting inputs (i.e., diesel fuel) to the transportation sector.

Because value-added data is available from the Bureau of Economic Analysis on an annual basis only, weights are determined annually and applied throughout the year. Valued added reflects the volume of physical transportation as well as the value of that volume. Because they have already measured monthly changes in that volume, it is necessary to ensure that changes in volume are not double-counted in the process of adjusting the weights for the index. This is accomplished through a mathematical process called chaining, which follows standard methodologies established by the U.S. Census Bureau for similar indexes.

The "For-Hire Only" freight data are collected for all five modes: trucking, air, rail, water, and pipeline. Passenger data include air, rail, and transit.

As with the FAF data, the producers of the index do not have statistics on who uses the data or for what purposes. Anecdotally, they know the TSI is used by Wall Street as a general indicator of the economy. It is used to evaluate the performance of the transportation sector by stock analysts. It is used as a forecaster of the economy. Companies such as Global Insight use this information as a factor in their analysis to provide economic projection and forecasting information to clients such as GE and Wal-Mart. It is used by companies such as AllianceBernstein to provide research and information on investment related to services globally. This information is also published on the White House website.

TSI officials note that the index is not scalable down to the local level. The TSI was intended to be a national-level index. Scaling it down to the local level poses many difficulties, foremost being availability of data. Trucking information at the local level is not available, nor is railroad freight information. There was a request from Fannie Mae for quarterly regional information. Given the current processes and sources of data collection, analysis, seasonal adjustments, and indexing and the weighting and chaining process involved in generating the TSI, there is no plan to scale the national index to a local or regional level.

The systems and processes involved are detailed, often requiring manual manipulation of data and collecting of data from air carrier websites and revising the data for three months prior to making it available in a stable state. The TSI team has gone through significant streamlining of the process and data analysis, making it possible to generate the reports in a timely manner.

The TSI staff report that the level of effort involved is significantly high. There are also some current uncertainties about roles and responsibilities. Even in its current state, reports are published as tentative for the last three months. After monitoring changes for a quarter, the earliest month is moved from preliminary to a final state and the latest monthly report is added in a preliminary state. In this way the current three months of data are always shown in a "preliminary" state.

*Trucking*

Monthly truck ton-mile data is not available through a federal agency, so the data are obtained from the American Trucking Association using a calculated truck tonnage index. When the official data become available the preliminary values are replaced. There is a small cost associated with purchase of these data.

*Air*

Aviation data are collected from the airline websites and the Office of Airline Information (OAI). Often times the data are not readily available from the OAI dataset. The data change frequently, and the TSI team have to be prepared to include the changes and to replace data as the data become officially available from the airlines.

*Rail*

The data are obtained from FRA and do not include data from Amtrak and the Alaskan Railway Corp. Commuter rail is included in transit.

## TSI Challenges and Lessons Learned

Among the challenges that the TSI effort faces is the need for continuous effort to educate the management, the public, and other potential users on the value of the measures. The TSI team has a media person who is focused on educating and communicating the use and value of the TSI.

The TSI experience also suggests that long-term funding and the ability to recruit expertise will be necessary to establish a comprehensive freight performance measurement system. As noted, the TSI project started with a team of 22 people. After the initial start-up effort, the staff was reduced to five federal employees and two consultants.

The TSI experience also illustrates that process and quality reviews are integral where data from varied sources have to be collected, analyzed, scrubbed, filtered, and then combined to create the index. Data availability has to be studied and various alternative sources of data need to be tapped. The TSI team notes that 50 percent of the data is lost through the process of data scrubbing, cleaning, and filtering prior to being included in the published TSI. Where possible, receiving processed data from the source reduces some of the data scrubbing efforts. One such example of scrubbed data is the rail data received from FRA. Also, making sure that the required data will be available through the life of the measure is important. Moreover, sometimes data is not available timely to complete all necessary tasks required to meet the tight windows of generating the monthly reports. At least one set of trade association data was only available, forcing a three-month lag for the TSI.

# Data Considerations for the Freight Report Card

Based upon the findings of the literature, the case studies, and the interviews with stakeholders, the following data-quality considerations will need to be addressed in the development of a Freight System Report Card.

## Use Common Definitions for Common Understanding

In order for stakeholders to generate and to use the data needed to create a set of national freight performance measures, there needs to be clarity regarding what each measure and each piece of data means. Clarity of definitions—not only for each measure, but also for the data that feeds each measure—will promote a common understanding of the data and the measure among all shareholders. This can be accomplished by defining the metadata, that is, data that describe data.

There are many variations to the definition of metadata, but a common definition is one provided by Webopedia, which defines metadata as "Data that describes how and when and by whom a particular set of data was collected, and how the data are formatted." The TRB *Final Metadata*

*Working Group Report 2006* states one of the many values of metadata thus:

> Metadata provides information necessary for data to be understood and interpreted by a wide range of users . . . metadata are particularly important when the data users are physically or administratively separated from the data producers. Metadata also reduce the workload associated with answering the same questions from different users about the origin, transformation, and character of the data.[14]

Metadata management is not an easy task, but it is essential when working with data from multiple sources and is easier to implement if formalized at the start of a project rather than enforced after the data has been pulled together from a variety of different sources. Agencies have worked independent of each other for decades and each has its own data structures, naming conventions, and formats. In the past decade, with public agencies collaborating and conducting peer studies informally, they have moved toward similar understanding and definitions of data in many areas of transportation. However, there is much that is still needed. In some of the newer areas, such as Geographic Information Systems, there is much more standardization. In order for the performance measures for the freight transportation system to be successful, the metadata for the framework should be defined early in the process.

## Ensure Data Quality

Data quality is the essential component that makes data valuable to users. This includes accuracy, consistency, timeliness, and completeness. Data quality, as defined by the British Columbia Government Information Resource Management Glossary, is "the state of completeness, validity, consistency, timeliness and accuracy that makes data appropriate for a specific use." Data quality refers to how closely the data can portray the real phenomena. The quality of the data is what determines if a decision maker will rely on the data to make decisions.

While the importance of having high-quality data is intuitively clear, it takes considerable effort to ensure that the quality of data is maintained. Because the quality of data will have a significant impact on decision making, a process will need to be implemented to systematically ensure quality checks of the data being used to populate the freight performance management framework.

## Draw On Multiple Data Sources

Organizations developing and deploying new applications routinely use available newer technologies, databases, and programming languages, in addition to those already in use. The result is a hybrid of databases and technologies within an organization; each often having varying standards, formats, and quality. Within an organization, even when the data are managed by one central group, the data often come from multiple databases that do not necessarily communicate with each other. This issue is magnified when data management is decentralized. The explosion of data leads to many challenges with sorting, selecting, and retrieving relevant data, including scrubbing, preprocessing, and integrating data from multiple sources. With data being stored in different systems that use different technologies and databases, the challenges of communicating between databases also has to be addressed. Therefore, dealing effectively with multiple sources of data becomes a major issue when working across agencies and crossing over to accessing data from the private sector.

In measuring the performance of a multimodal freight system, formal mechanisms will need to be put in place to ensure that data derived from multiple sources or silos, covering a range of technologies, systems, and databases, are adequately preprocessed and integrated prior to populating the framework.

## Adopt Data Standards and Formats

Data standards and formats play a very important role when integrating data from different sources. Some of these may seem very simple and conceptually easy to resolve, but in dealing with millions of records from multiple sources, the issues get compounded. All of these issues are resolvable, but the time required to address each of them adds to the time required for the overall analysis and preprocessing time.

One simple example of data formats involves a freight cost of $5,000.50 recorded in several databases. It would be common for one to store this information in a text format (five thousand dollars and 50 cents), another to save it in currency format but capture it as "Dollars 5000" and in yet another database to record it in a currency format, but with more detail, as "$5000.50." Several detailed steps will have to be followed in this simple example to integrate cost information from these multiple sources. A data format for the final integrated data will first have to be established. Data from each source will then have to be processed for conversion to that final format before it can be integrated. The analysis and preprocessing needed for use of such data for establishing a performance management framework will be dependent on the number of sources, which could involve numerous public and private organizations. Appropriate attention will therefore be necessary to bring together data from private and public agencies covering the multiple modes, standards, and formats involved, to ensure that the data are preprocessed appropriately for conversion to the final format established for the performance measures framework.

## Address Data Integration

As mentioned earlier, data integration is the process of the standardization of data definitions and data structures by using a common conceptual schema across a collection of data sources. Integrated data will be consistent and logically compatible in different systems or databases and can be used across time and users.

Historically, data warehousing has been a technique successfully used by organizations to bring together data from multiple sources for reporting and decision making. The Ohio DOT, an agency that is advanced in the use of performance measures, has at least five different types of databases that use various programming languages, ranging from newer languages such as Java to older languages such as COBOL. It has successfully used data warehousing to bring together data from many different applications and many different databases to provide information to assist with decision making. The model used by the Virginia and Ohio DOTs, to create a data warehouse to provide information about performance of operations and assets, has been successful. The data warehouse approach also addresses the issue raised by Minnesota DOT about parochial systems and systems that duplicate data.

In using a data warehouse, data can be extracted from different sources and the necessary logic can be applied to compute various statistical figures about performance of the measures (for example, percentage of time in a day that the traffic flow is below a specified service level). Alternatively, data may be summarized, integrated, or broken down and saved as more granular components. The granular information can then be used for the performance measure dashboard, decision support, or other reporting systems and to provide answers to ad hoc queries by users. Historical data required for trend analysis or computation of lagging and leading indicators of performance of measures can also be obtained from the data in the data warehouse.

## Consider Access Time

The time taken to access information is important to the usability of any system, particularly one envisioned for highway operation data as sought for this project. The information technology industry invests millions of dollars each year in researching user behavior to improve the user's experience. If the goal is to make these performance measures available nationally for users to access for decision making, then one factor that needs to be considered for usability is the time taken from the moment a user commences an attempt to access the information to the moment when the user actually retrieves the information. As the volume of data in the system grows, the time taken to access the information will also increase. Long time periods to access information discourage users from using a system. The database design will have to take into consideration the access time and also design for both active and dormant data. The design should consider a tiered approach to data storage in which cheaper storage is used for less frequently used data, while frequently accessed data could be on high-performing disk storage. Backup and recovery processes should be formalized, tested, and implemented from the very beginning.

## Plan for Archived vs. Real-Time Data Needs

In addition to archived data, the measures for the performance of the freight transportation system could include real-time systems such as Intelligent Transportation Systems (ITS). In the Freight Information Real-Time System for Transportation (FIRST), ITS was used by the Port Authority of New York and New Jersey from mid-2001 until December 2003 to provide real-time freight information.[15] The Port of Vancouver has also successfully used ITS to improve freight movement. In both instances, data quality and availability of data were among the items listed that required attention for successful deployment of the systems.

> According to the USDOT, "ITS can facilitate the safe, efficient, secure, and seamless movement of freight. Applications being deployed provide for tracking of freight and carrier assets such as containers and chassis, and improve the efficiency of freight terminal processes, drayage operations, and international border crossings."

The architecture required to report summary data is different from that required for real-time decisions or trend analysis. Any real-time or near real-time information that is required will need to consider additional factors such as data latency, frequency of refresh, and the frequency at which data need to be presented for each measure. Near real-time measures will require that data be captured, cleansed, and loaded in near real-time.

## Plan for the Sustainability of the Framework

For continuity of decision making, it is important that any set of measures be sustained beyond the initial deployment and continue to provide timely and accurate information during the entire period of its use or life. The purpose of freight performance measures is to provide information to allow decision makers to make informed decisions and for users to see the performance of the freight transportation system not for the short term, but for several years. This can happen only if the framework is sustainable and available for the period of its intended use. Sustainability involves ensuring that timely, accurate data are available, that they can be easily accessed by

users without concerns of privacy, and the necessary infrastructure needed to support the data and framework is implemented and maintained for the life of the measures.

## Continued Research into Additional Data Sources

A consistent theme throughout this research has been how data limitations constrain expansion of freight performance measurement. The performance measures included in the Freight System Report Card are those that are possible given existing data sources. As noted in the Summary and in Chapter 7, Findings and Recommendations, further research into how to capture additional performance data—particularly related to multimodal freight efficiencies—is important. Balancing the acquisition of such data with the cost and privacy of the private sector are among the most important of possible future research areas.

## Endnotes


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CHAPTER 7

# Findings and Recommendations

## A Reporting Framework Is Possible

Interest in measuring freight system performance will only increase as Congress, USDOT, and the state transportation agencies refine their efforts to enhance freight efficiency, safety, and convenience. Concurrently, private-sector freight professionals will continue to enhance their already sophisticated metrics for managing supply chains in highly competitive markets.

This research demonstrates that considerable freight system performance information exists today that could be consolidated into a Freight System Report Card that would benefit both public and private stakeholders. Such a report card could become a frequently used hub for performance information of major aspects of the nation's freight system. As proposed, the Freight System Report Card would provide users with a synopsis of performance in key areas of freight system performance, as well as insight into freight system externalities. With the proposed structure of the report card, it could be replicated at the state and metropolitan levels. Such replication would allow comparable analysis of freight system performance for comparative analysis of states and metropolitan regions.

The value added from such a report card could be significant. Because it emphasizes trend line metrics, it provides insight into the long-term performance of the transportation system. Its use of leading indicators is intended to focus decision makers on the likely outcomes of current freight policies. As such, it could be an important barometer for policy makers and one that prompts their attention to looming problems.

The report card is designed to serve a broad array of stakeholders, from those who need only the highest-level summary information to those who desire links to in-depth analysis. The report card is intended to allow quick, at-a-glance assessment of trends but also allow expansion of analysis for understanding the underlying trends that are at work. The linkage to performance summaries and to larger, source documents would allow a user to pursue easy links to reach detailed reports for context and interpretation.

The report card is assumed to be evolutionary and catalytic. The initial proposed report card reflects "the art of the possible." It is the type of reporting system that is possible in the existing environment of disparate agencies reporting results to address their individual areas of responsibility. At this preliminary stage of freight performance reporting, the report card is proposed to be a first-generation framework that would be expected to expand and evolve over time. The creation of such a report card is likely to be catalytic and lead to greater interest in freight metrics, requests for additional metrics, and the catalyzing of an expanded and more comprehensive reporting process over a number of years, if not decades.

## Overcoming Impediments

The impediments to creating a Freight System Report Card are numerous, but the framework proposed here was devised specifically to overcome as many of the impediments as possible.

First, as there is no multimodal freight entity with a span of control over all modes, all governments, and the private sector, there is no one organization that could produce a comprehensive Freight System Report Card on its own. Therefore the collaboration of many organizations is assumed in this framework. The framework proposed here was based on the premise that entities would be likely to cooperate if they are asked to provide existing reports that they already have demonstrated a long-standing commitment to produce. This report card is a synthesis undertaking that proposes to assemble in one virtual location the accumulated efforts of many public- and private-sector organizations. Examples of such cooperation exist. AAR and Austroads in Australia have produced such websites for more than a decade. This report card proposal is based, in part, on the long-standing success of those reporting frameworks.

Second, because the public-sector respondents demonstrate considerably more interest in a performance measurement report for publicly operated freight, the proposed report card is largely focused upon public-sector users. The private-sector users indicated a desire for highly detailed, often proprietary, data regarding their vendors, customers, and internal operations. The volume, frequency, and granularity of the performance measures that private-sector freight system users wanted appears to be orders of magnitude beyond what the public sector reasonably could be expected to provide.

Third, although the proposed report card may not meet many day-to-day needs of freight system users, it does address many of their long-term and more policy-related needs. Private-sector freight stakeholder trade groups such as the U.S. Chamber of Commerce, the American Trucking Associations, the Council of Supply Chain Management Professionals, and the Association of American Railroads all express significant interest in government policies to promote freight efficiency, safety, and competitiveness. At the higher, trade-organization level, the metrics in the proposed report card are very relevant to the private sector and germane to the interests they expressed.

Fourth, the framework is proposed to be evolutionary. "Beginning with what we have" allows a freight reporting process to begin. Expecting it to evolve allows it to expand and adapt to the many stakeholder interests that are not possible to address in its initial iteration. Eventually, there may need to be many freight performance reports, one for each major area of concern. Those could include the six major areas included in this recommended report card: Freight Demand, Freight Efficiency, System Conditions, Environmental Impacts, Safety, and Investment. Each could encompass a much more detailed set of metrics while still being linked though a common Web-based portal.

Fifth, related to the concept of an evolving reporting process is the recognition that emerging technologies will eventually allow economical performance reporting that currently is only experimental and undeveloped. This report discusses the use of GPS-enabled tracking of truck travel speeds. Capitalizing on GPS and other technologies will become increasingly possible. It will allow reporting of travel times, origins, destinations, and other metrics that today are not available. Therefore, it would be logical to expect the reporting framework to become more robust as technology reduces the costs and increases the availability of performance data.

## Creating a Coalition

These recommendations acknowledge the most obvious and substantial obstacle—that is there is no entity and no budget to develop a Freight System Report Card. However, this research documents that a reporting framework is possible and that such frameworks are deployed elsewhere through collaborative efforts. Therefore such collaboration among many interested stakeholders could be possible in the United States as well.

A coalition of interested parties will need to coalesce around the concept of producing a Freight System Report Card. The coalition for the Freight System Report Card would need to extend to various federal agencies, including USDOT and its modal agencies, BTS, the U.S. Department of Commerce, the EPA, and USACE. These agencies' contribution would be to provide to the Web-based report card the reports that they already produce. Also, the private-sector associations, such as the CSCMP, ATRI, AAR, and others, would need to cooperate to provide their metrics.

One complexity would be the contractual arrangements and cost for the private-sector-produced measures and related reports, such as the CSCMP report, and the data produced by ATRI and AAR. These entities incur costs to produce these reports, and those costs are passed on to members. Contractual and financial considerations would need to be addressed.

States and metropolitan regions' participation would be voluntary. Therefore, the degree of coverage across states and metropolitan regions would depend upon the degree to which state and local participation is engendered. The report card, however, provides state and metropolitan transportation agencies a template to follow for freight system reporting.

### Keys to Success of Report Card

The success of the report card is closely tied to its use. If the stakeholders use the report card and provide feedback for improvement, it will remain viable and relevant. It is important when developing a Freight System Report Card to address the key issues identified in the study.

### Establish It as a Central Information Source

A Web-based Freight System Report Card could include links to the one-page summaries and links to the more extensive source reports. As a Web-based tool, it could provide additional links to an unlimited number of freight performance sources. As such a comprehensive portal, it could become the definitive central hub for freight system performance information, domestically and internationally, with the report card as its central feature.

The application can be deployed on either the USDOT or the TRB website. Information about the web application and the report card should be disseminated through TRB, FHWA, and other freight newsletters websites. Additional

links could be solicited. Links could also be provided for users to download the data in Excel and Access formats as well as to download the pdf version of the report card.

## Plan for Iterative Improvement

A link on the website could be provided to obtain feedback from users of the Web applications. Feedback from the first iteration of the deployed Web-based report card as well as a survey of users should be used to refine the report card. The feedback should address (1) the user friendliness and enhancements that will be helpful and (2) the list of additional measures that would be useful.

The list of suggested measures should be prioritized and an analysis should be done to identify the availability of the additional data and the cost to collect them. The first iteration of the report card should then be revised to incorporate selected additional measures and improve its convenience.

This process of continuous review and enhancement should be done annually to systematically enhance the framework. As new performance measures are adopted nationally, the freight report card can be systematically enhanced. These new measures will also mean additional data will be collected nationally, leading to more availability of the data at lower cost. Similarly, measures that become irrelevant with time can be eliminated.

### *Develop Common Definitions*

Prior to deploying the report card, it is important to have a workshop that helps develop a glossary of terms and common data definitions The glossary can then be used to ensure that there is a common understanding and interpretation of the measures. The common definition can also be used to guide organizations providing data to a national set of freight performance measures.

### *Data Quality and Accuracy Standards*

A process needs to be put in place to do a check of the quality and accuracy of the data before the data are populated in the database to feed the report card.

### *Integration of Data from Multiple Sources*

Where data to feed the framework come from multiple sources, an analysis needs to be done and a mechanism needs to be put in place to integrate consistently the multisource data prior to populating the report card. Fortunately there are many products, tools, and techniques available today to complete this task successfully.

### *Data Gaps*

As new measures are expected to be included in the framework over time, there will be data gaps. A systematic approach to addressing these data gaps should be developed, and data collection should be initiated in a planned manner to address the gaps. The prioritization of new measures will also help to develop a systematic strategy for collection of important data.

### *Data Availability*

Service-level agreements need to be developed to ensure that data availability does not become an issue. Where possible, data should be obtained from state, local, and federal agencies. The assumption is also being made that if mandatory performance measures are passed by Congress, that action will cause states and local government to develop strategies to collect additional data. Ensuring that a consistent national strategy is developed ahead of the data collection effort will be important in collecting data consistently and economically in the long term.

### *Real-Time Data Versus Archived Data*

The first iteration of the report card being proposed does not require any real-time data. As the report card is refined, if it becomes necessary to have real-time data to populate the report card, then particular attention needs to be paid to the application and database architecture to ensure that the users see the real-time data. Stale data in a real-time measure can lead to users relying less and less on the application and the report card. The timeliness of the data will be particularly important if measures are expanded for real-time operational decision making or performance measurement. The application will need to be significantly more robust to handle the much greater volume of data required for real-time, versus archived, performance reporting.

### *Sustainability of Report Card*

Institutional support will be essential. Staff will be needed to sustain the report, answer users' questions, and maintain the technology. If the data become stale, if users' questions are not addressed, if technical problems are not resolved, the effort will atrophy. The case studies of the TSI and the FAF illustrate the significant level of effort that is required to sustain a reporting process. A level of institutional support similar to those two products will be required to sustain a Freight System Report Card.

APPENDIX A

# Summaries of Freight Performance Information for National Report Card Performance Summaries

## CONTENTS

## Introduction

The following section presents summaries of freight performance information that would support each individual performance measure from the Freight System Report Card at the national level. The framework is proposed to serve as a Web-based tool. Each line of the report card would link to the summary information that is presented on the following pages. In addition, more extensive source documents would be linked from the summary report to provide the reader with additional detail and analysis. Reports such as the Council of Supply Chain Management Professionals (CSCMP) report, the FHWA Condition and Performance report, or EPA air-quality analyses would be the types of supporting documentation provided as supplemental links. The intent of the format is to provide summary, high-level information with the ability for the user to drill down into more detailed analysis if it is desired. In some cases, one succinct document provides the needed context. In other cases, a variety of links may be needed to provide the reader with sufficient summary information. Although the reliance on supplemental reports does not provide uniformity to the reader, the reliance is unavoidable at this stage of national freight performance measurement. Consistently produced detailed analysis for each performance trend does not exist; therefore, the initial proposed framework opportunistically uses what sources are available.

The summaries on the following pages are for national measures. Appendix B provides summaries for the regional case studies, which are of Washington State and the Seattle metropolitan area. The two sets of summaries illustrate how the national report card could be replicated at state and metropolitan levels.

## Freight Demand Measures

Following are the measures for the category of Freight Demand.

## Freight Volumes, All Modes

### Freight Performance Trend: Increasing Volumes

Influencing all other freight performance trends has been and likely will continue to be the steady growth in overall freight volumes over the long term. The slight decline in actual volumes in the past 18 months is in sharp contrast to a steady, continuous increase in freight volumes overall since at least the 1960s. Between 1984 and 2004, ton-miles for both trucks and rail rose approximately 85 percent in the United States.

The Freight Analysis Framework (FAF) forecast depicted in Figure A.1 is based on composite forecasts that are updated comprehensively every five years and updated provisionally annually. The FAF forecast predicts a steady 2.03 percent rate of growth in freight volumes overall through 2035. Being a long-term estimate, the actual rate of growth will vary year to year. The long-term forecast is based on best available estimates, which account for the rate of economic growth, changes in sectors of the economy, and the influence of imports and exports. The relative mode splits remain relatively similar through 2035 according to the FAF forecasts, with truck and rail volumes both growing at approximately 2 percent annually, with water at 1.5 percent with one major exception. Intermodal movements of imports grow at a significantly faster rate than other types of movements. This FAF table (Table A.1) estimates freight volumes by dollar value. Intermodal movements of imports rise from $716 billion in 2002 to $3,708 billion by 2035, a more than five-fold increase. This reflects U.S. export imbalances and increased globalization of the economy. This import growth will affect most significantly the major container ports, rail movements, and truck/rail movements.

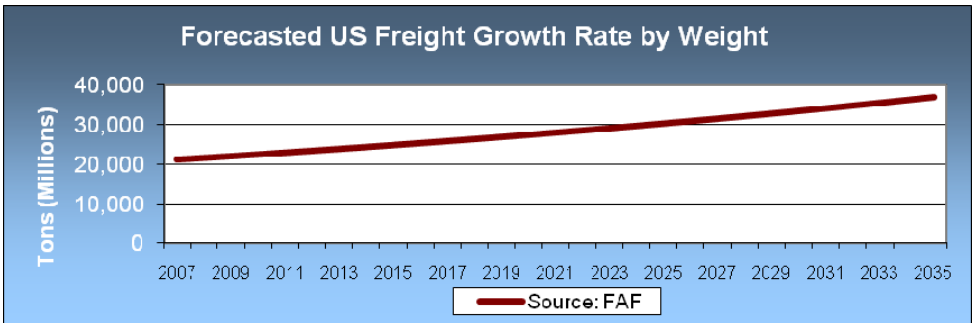



*Figure A.1. Freight volumes, all modes.*

**Table A.1. Freight volumes by value (billions of dollars).**

| Freight Volumes by Value (Billions of Dollars) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2002 | | | | 2035 | | | |
| | Total | Domestic | Exports | Imports | Total | Domestic | Exports | Imports |
| **Total** | 13,228 | 11,083 | 778 | 1,367 | 41,869 | 29,592 | 3,392 | 8,884 |
| **Truck** | 8,856 | 8,447 | 201 | 208 | 23,767 | 21,655 | 806 | 1,306 |
| **Rail** | 382 | 288 | 26 | 68 | 702 | 483 | 63 | 156 |
| **Water** | 103 | 76 | 13 | 13 | 151 | 103 | 31 | 18 |
| **Air, air & truck** | 771 | 162 | 269 | 340 | 5,925 | 721 | 1,548 | 3,655 |
| **Intermodal** | 1,967 | 983 | 268 | 716 | 8,966 | 4,315 | 943 | 3,708 |
| **Pipeline** | 1,149 | 1,127 | 1 | 22 | 2,357 | 2,315 | 1 | 41 |

## Truck Freight Volumes

### Freight Performance Trend: Increasing Truck Volumes

As illustrated in Figure A.2, truck volumes are predicted to sustain steady growth on the national level.[1] The growth is positive as an indicator of long-term economic health but creates additional pressures on the highway network. Though the current economic environment has reduced truck freight volumes in 2009, long-term growth for the Truckload (TL) and Less-Than-Truckload (LTL) sectors are expected. In general, LTL annual growth rates are forecast to remain higher than TL growth rates. Between 2009 and 2014, the annual rate of growth for the LTL sector is slightly above 2.5 percent per year, and beginning in 2015, the annual rate of growth is forecast to increase to over 3.5 percent.

The TL sector, the predominant industry sector, is expected to increase at a slightly slower pace. Tonnage hauled by this sector is forecast to increase nearly 2.5 percent per year until 2014, then experience a higher annual growth rate between 2015 and 2020. The Pacific region (which includes Alaska, California, Hawaii, Oregon, and Washington) experienced an increase in the percentage of total U.S. tonnage of primary shipments originating in this region from 13.6 percent in 2002 to 14.6 percent in 2007. It should be noted that the economic conditions and tonnage of shipments hauled by trucks originating in California significantly impacts these regional metrics.

The ATA forecast estimates that trucks will haul 13.3 billion tons in 2020. FHWA's FAF forecasts that by 2035 trucks will haul 22.8 billion tons of freight.[2]

The severity of the recent challenging economic environment and rapid decline in freight volumes for all modes was largely unanticipated by most industry experts. Though most sectors of the trucking industry have experienced dramatic declines in freight volumes, tonnage hauled by trucks is expected to grow in the long term, driven by population growth and increased economic activity.

## Rail Freight Volumes

### Freight Performance Trend: Increasing

Rail freight volumes are expected to increase overall through 2020, putting increasing pressure on an already congested national rail network (see Figure A.3). The source of the rail forecast is the next generation Freight Analysis Framework FAF2 database. FAF2 freight flow origin and destination (O-D) coverage spans 131 freight analysis zones that include 114 freight O-D zones and 17 major ports, border crossings, and freight ports. The FAF2 commodity flow data are benchmarked to 2002 and are forecasted to 2035. This analysis of the rail forecast utilizes the 2008 values and the 2035 estimates. The rail information is available for all transport and then divided into three potential submarkets: domestic, border crossings, and sea movements. Table A.2 presents the 2008 and 2035 values for the rail mode.[3] The forecast estimates that total rail traffic will increase by just under 2 percent annually. This increase is present even with an estimated decrease in rail traffic for origin–destination pairs involving sea traffic, with such traffic estimated to decrease by 1.4 percent. Domestic rail movements represent the highest growth, at an estimate of 2.1 percent.

The forecast rate of freight growth by mode may be defined as the estimated percentage increase in tonnage hauled in future years for the major modes of freight transportation. Baseline figures and forecast tonnage figures are limited to primary shipments (primary shipments are defined as those handled the first time). This measure estimates the rate of freight growth involving rail transport.

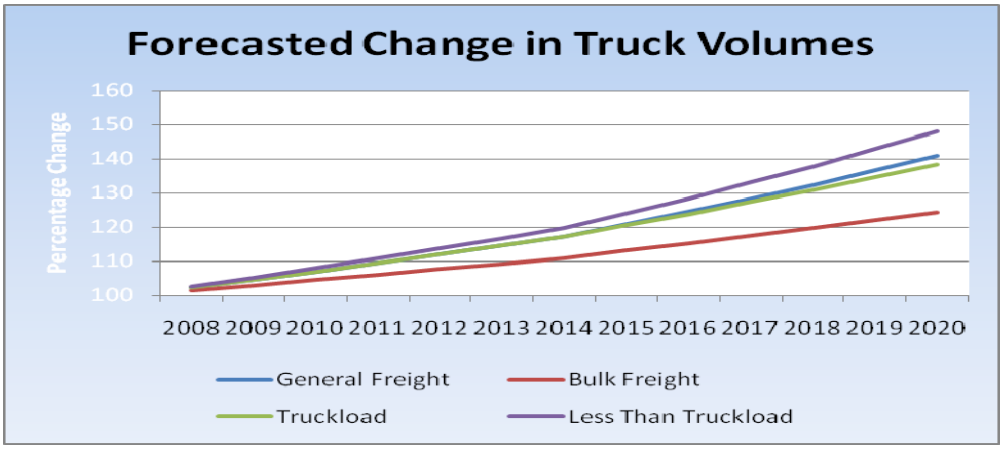



*Figure A.2. Truck freight volume forecasts.*

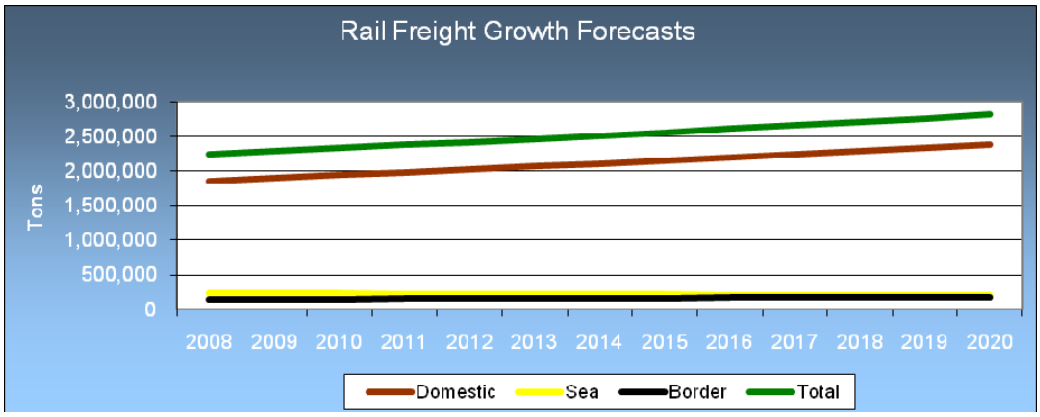



*Figure A.3. Rail growth forecast.*

**Table A.2. Rail volume by category.**

| Segment | 2008 Value (tons) | 2035 Forecast (tons) | Growth Rate |
|---|---|---|---|
| **Domestic** | 1,861,312 | 3,292,228 | **+2.1%** |
| **Sea** | 237,824 | 164,154 | **-1.4%** |
| **Border** | 145,748 | 232,987 | **+1.8%** |
| **Total** | **2,244,884** | **3,689,369** | **+1.9%** |

## Inland Water Freight

### Water Freight Performance Trend: Mixed

Domestic waterborne freight volumes declined slightly from 1991 to 2005 (see Figure A.4) while waterborne imports and exports increased significantly, according to the U.S. Army Corps of Engineers (USACE) *Total Waterborne Commerce of the United States.*[4] These trends are generally attributed to the relative decline of manufacturing in the United States, a sector that relied upon bulk shipments of raw materials. The increasingly globalized economy resulted in increasing import and export volumes.

The water information is found for all transport, and then divided into three potential submarkets: domestic, border crossings, and sea movements. Table A.3 presents the 2008 and 2035 values for the water mode.[5] The forecast estimates that

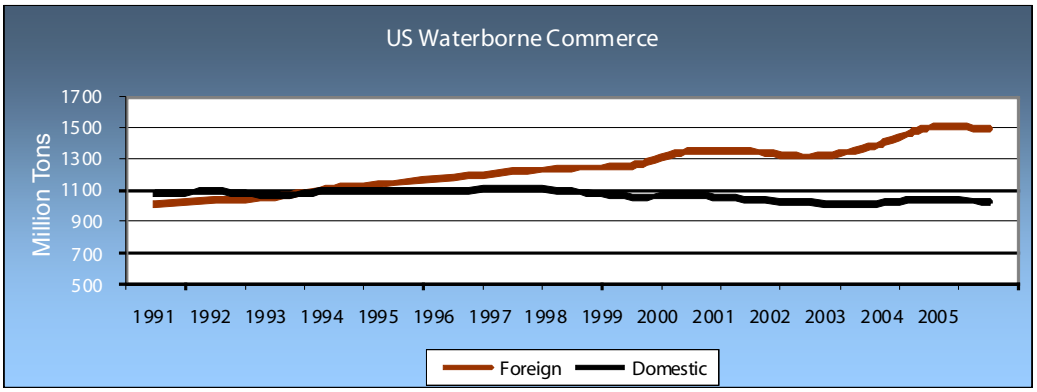



*Figure A.4. Waterborne volume.*

**Table A.3. Water freight volumes.**

| Segment | 2008 Value (tons) | 2035 Forecast (tons) | Growth Rate |
|---|---|---|---|
| **Domestic** | 519,944 | 873,863 | **+1.9%** |
| **Sea** | 110,281 | 161,173 | **+1.4%** |
| **Border** | 1,624 | 6,457 | **+5.2%** |
| **Total** | **631,849** | **1,041,394** | **+1.9%** |

total water traffic will increase by just under 2 percent. Water movements that involve cross-border, origin–destination pairs but are not classified under the Sea category have an estimate for substantially higher percentage growth (5.2 percent), but the estimate is based on a very small base forecast (0.26 percent of total traffic), and caution must therefore be given to the rate forecast for this subset.

## Containerized Imports/Exports

### Freight Performance Trend: Steady Growth

U.S. container traffic through ports has more than doubled since 1995, rising from 22 million TEU[6] in 1995 to 45 million in 2007 (see Figure A.5).[7] The economic slowdown of 2008 caused units to decline from 45 million in 2007 to 38 million

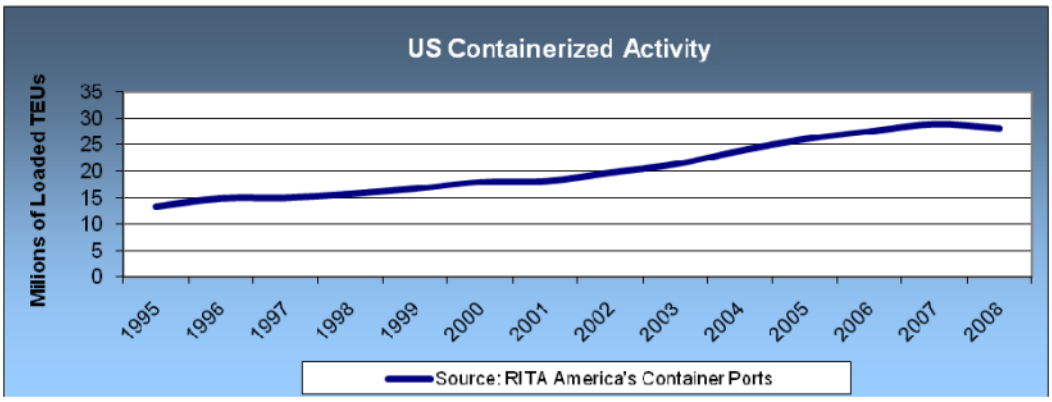



*Figure A.5. U.S. container volume growth.*

in 2008. This represents an annualized rate of growth of 4.5 percent for the United States since 1995. The port volumes are not uniform. The top 20 U.S. ports handle more than 96 percent of all container movements. Globally, container movements tripled from1995 to 2007, rising by 8 percent annually.

Three sources of data were identified. Actual data from 2007 are available from USACE's Navigation Data Center.[8] In 2007, U.S. ports handled 17,821,238 TEU of loaded inbound containers, and 10,349,603 TEU of loaded outbound containers.

Growth over the last decade was identified through a recent report, *America's Container Ports: Freight Hubs That Connect Our Nation to Global Markets*, released by the Bureau of Transportation Statistics (BTS) of the Research and Innovative Technology Administration (RITA). The report covers the impact of the recent U.S. and global economic downturn on U.S. port container traffic, trends in container throughput, concentration of containerized cargo at the top U.S. ports, regional shifts in cargo handled, vessel calls and capacity in ports, the rankings of U.S. ports among the world's top ports, and the number of maritime container entries into the United States relative to truck and rail containers.

Estimates of growth have been developed by private organizations, but they are generally presented as global estimates. In November 2007, Global Insight, Inc. predicted a global growth rate for 2010 of approximately 6.9 percent.[9] More recently, PIERS Trade Horizons forecast a 2.8 percent decline in import volumes in 2009, and a weak recovery to 1.5 percent growth in 2010. The same forecast expected exports to contract 6.6 percent in 2009 and fall a further 1.3 percent in 2010. Long-term global growth is expected as China, India, and other developing countries continue to expand their economies.

## Freight Efficiency Measures

Following are the measures for the category of Freight Efficiency.

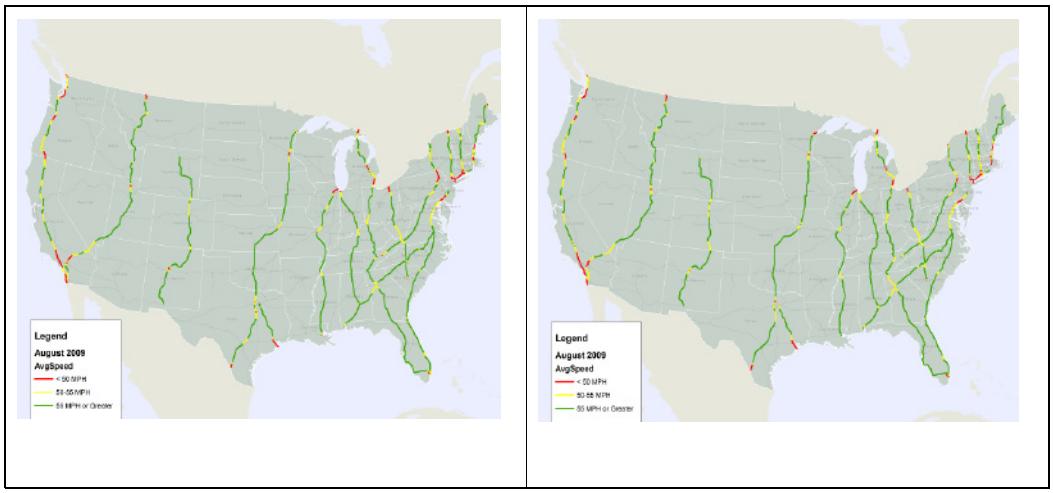
### Interstate Highway Speeds

FHWA sponsored the Freight Performance Measures program, which is managed by the American Transportation Research Institute (ATRI). It collects and analyzes truck position data to produce key freight performance measures. As part of this effort, ATRI calculates average speeds over time for a strategic set of U.S. interstate corridors with significant levels of truck activity.

The data described in this section are derived from several hundred thousand trucks that operate in the United States. For analytical purposes, interstate routes are divided into 3-mile segments. Truck speeds for each truck movement on one of the 25 interstates studied are calculated and attributed to each segment. The end result is a dataset that allows users to query and conduct customized analyses on more than 60,000 miles (by travel direction) of interstate highway.

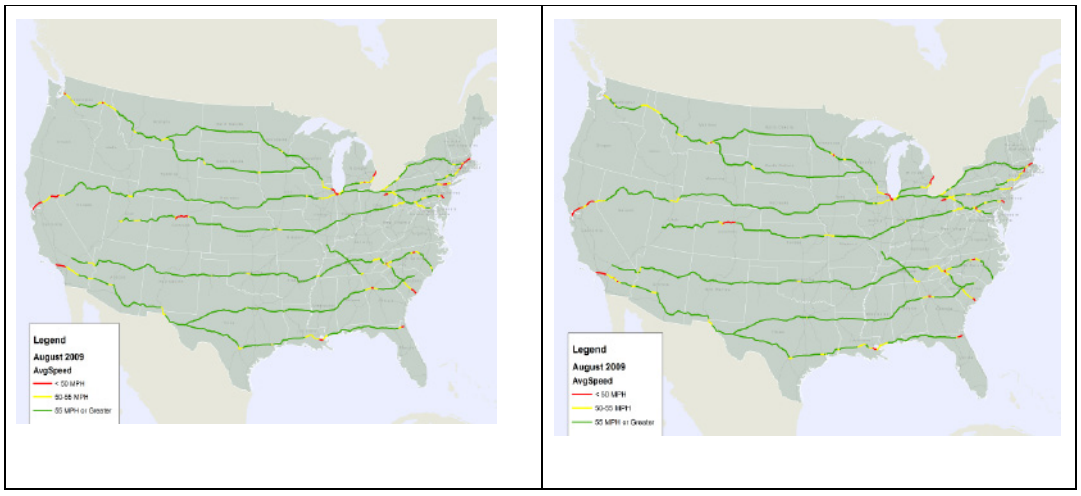
### Freight Performance Trend: Decreases in Overall Average Speed Are Expected

Interstate highways are a key component of the U.S. freight transportation system. Figures A.6 and A.7 show average truck speeds over a one-month time period on interstate highways in the United States as calculated by the FHWA/ATRI system. Although these aggregated data over one month do not




**Map 1- Northbound** **Map 2- Southbound**

*Figure A.6. Northbound and southbound IHS speeds.*




**Map 3- Westbound** **Map 4- Eastbound**

*Figure A.7. Westbound and eastbound IHS speeds.*

highlight peak periods or incidents and system disruptions, they do indicate that average speeds are higher in rural areas and lower in larger urban regions. As more years of data are analyzed, additional trend lines can be produced to illustrate changes over time.

### Future Trend Line: Congestion on Interstates Will Increase

Recent declines in both truck and automobile travel are in contrast with historical increases in vehicle miles traveled (VMT). In the long term, FHWA predicts that, with no significant increases in capacity, portions of the National Highway System (NHS) with recurring congestion will increase four-fold by 2035.[10]

Figure A.8 offers one method of measuring the performance of the transportation system for freight movements via truck. As shown above, the majority of roadway segments have an average aggregate truck travel speed between 55 mph and 60 mph. The distribution of this curve over time could be a future performance indicator to illustrate change in the number of interstate highway sections with below-average speeds.

As shown in Figure A.9, another system performance metric is to measure trends related to particular deficiencies. In this case, the focus is on the number of segments with average aggregate speeds that are less than 50 mph; a trend line may be developed as the total number of segments with speeds less than free flow is compared month to month.

Figure A.10 identifies the percentage of total segments on each interstate corridor with an average speed less than 50 mph. This measure can be used to compare the performance of various interstates, regardless of overall length.

## Interstate Highway Reliability Measure

In addition to average truck travel speeds or a comparison of the percentage of segments with average truck speeds less than free-flow, the ATRI/FHWA system can measure the travel-time reliability of corridors and specific segments. Reliability refers to the predictability of travel speeds or travel times. Reliability is highly valued because of the need to predict estimated shipment times. In Figure A.11, Interstate 45 is an example of a highway with a high buffer index, which indicates a large variability in average speed across the entire interstate route. Conversely, Interstates 24 and 65 have lower buffer index scores, suggesting that travel times on the corridors are more reliable and vary less.

The ATRI/FHWA Freight Performance Measure (FPM) system features a database that contains historical truck position data for most of the last decade. The system is updated monthly, and trucks can report position reads as frequently as every 1–5 minutes. Wireless truck position reports are received from approximately 600,000 trucks and cover major highways and surface streets throughout the United States and Canada, as well as Mexico. With the use of this system, it

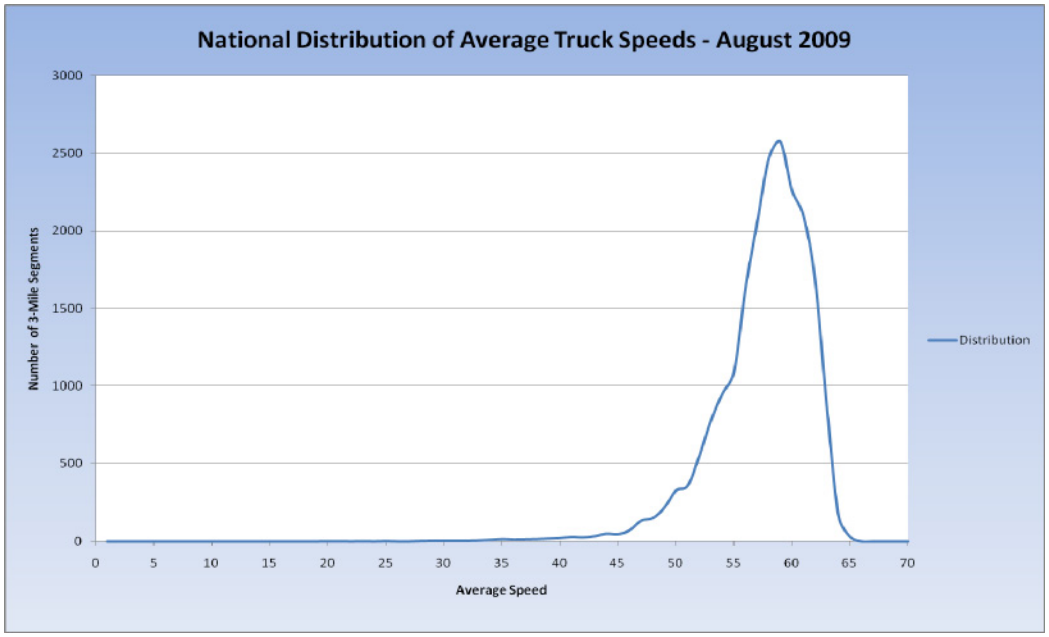



*Figure A.8. Distribution of truck speeds.*

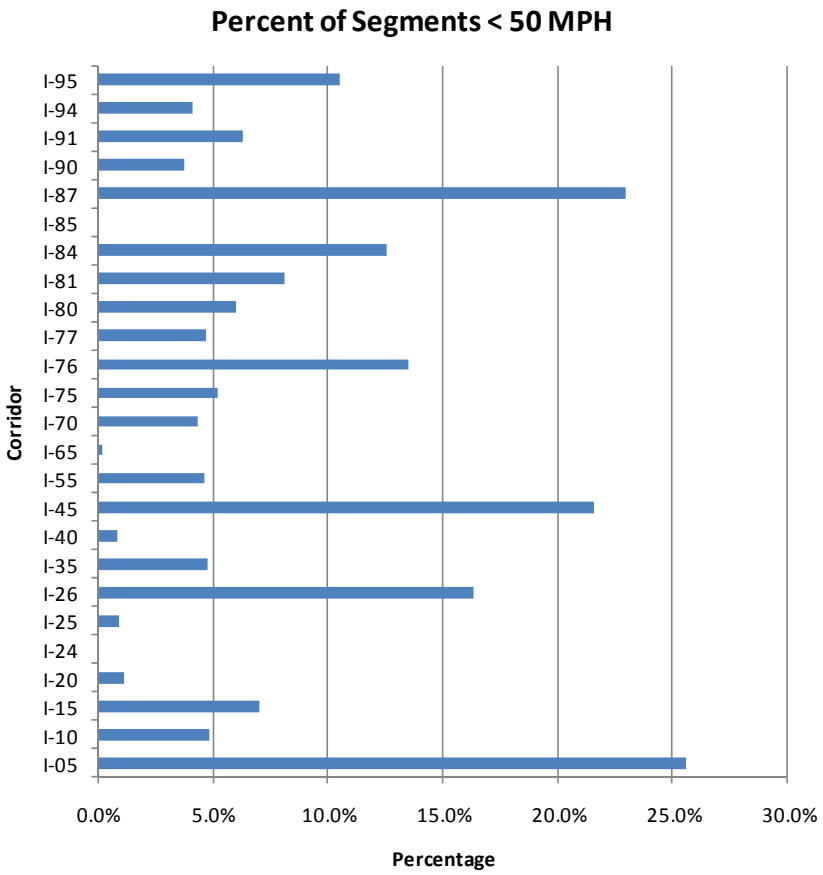



*Figure A.9. Segments below 50 mph.*

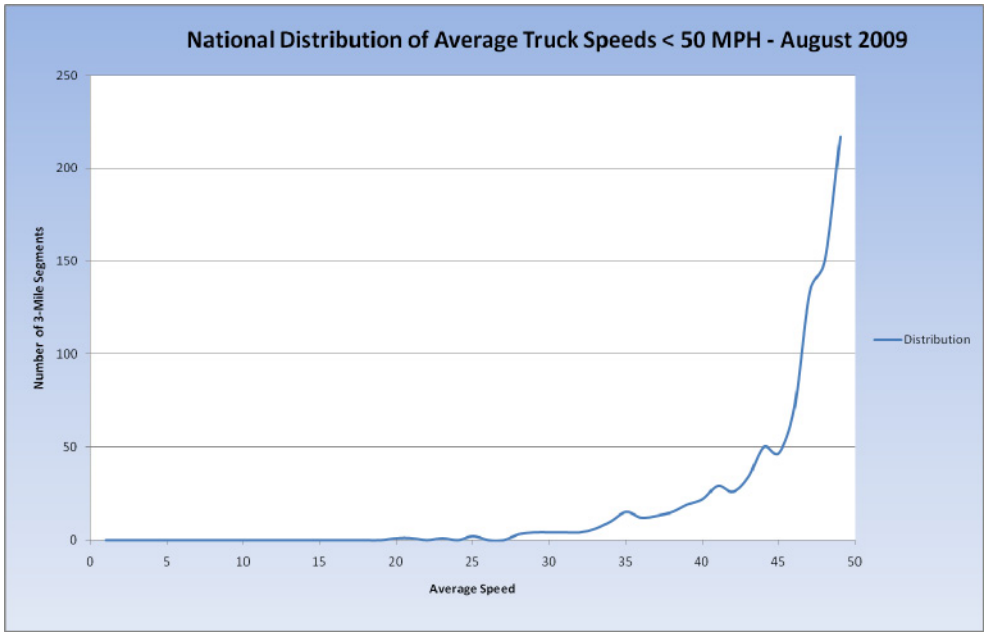



*Figure A.10. Distribution of speeds.*

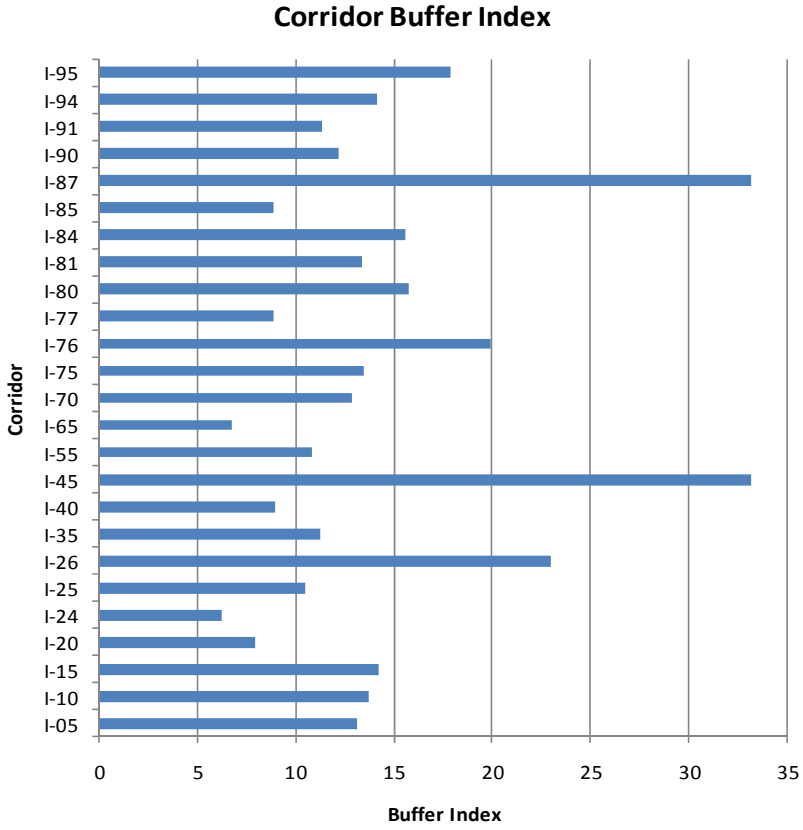



*Figure A.11. Buffer index by roadway.*

is possible to conduct a far more focused analysis of average travel rates or system reliability over time. Additional analyses could focus on specific days or hours of the day. Data can be analyzed at levels ranging from transcontinental corridors (e.g., Interstate 10) to specific urban intersections.

## Trend Line of Top Interstate Bottlenecks

Table A.4 illustrates how the FPM system can analyze trends in severe highway bottlenecks. The rankings are based on a measure called the total freight congestion value, which is an index that uses truck delay and relative volume information within bottlenecks as inputs. As evidenced by the highest total freight congestion value, the top bottleneck affecting freight movement via truck (among the nine listed) occurs in Bergen, New Jersey, on I-95 at SR-4.

The ATRI/FHWA FPM system has the ability to produce performance trends for bottlenecks at any freight-significant location, and an index of 100 bottlenecks will be compiled on a quarterly basis during 2010. In the long term, this system could be used to provide trend lines extrapolated over time. Figures A.12, A.13, and A.14 represent graphical depictions of the severity of the Table A.4 freight bottlenecks.

### Future Trend Line: Negative

The negative impacts of freight bottlenecks are expected to become more severe as the demand for freight transportation continues to grow and peak period congestion increases. Additionally, the annual vehicle miles traveled by passenger vehicles will bolster congestion levels even further.

The high quality of data used to identify and rank the top interstate bottlenecks is due to the source of the data—actual trucks that produce a location, time stamp, and speed measure. Before these data are processed by the ATRI/FHWA FPM system, the data undergo extensive data quality procedures.

The ATRI/FHWA FPM database contains historical data across much of this decade, and the database is updated monthly. Truck position reports for each truck are produced based on how frequently individual trucks are pinged, which can range between every few minutes to every few hours.

**Table A.4. Significant truck freight bottlenecks.**

| Bottleneck Number | Total Freight Congestion Value | 2007 Ranking | 2009 Ranking | Bottleneck Name/ Location | County/State |
|---|---|---|---|---|---|
| 1 | 446962 | 1 | 1 | I-95 @ SR-4 | Bergen, NJ |
| 2 | 446579 | 4 | 2 | I-95 @ SR-9A (Westside Hwy) | New York, NY |
| 3 | 367781 | 2 | 3 | I-90 @ I-94 Interchange ("Edens Interchange") | Cook, IL |
| 4 | 311761 | 3 | 4 | I-285 @ I-85 Interchange ("Spaghetti Junction") | Dekalb, GA |
| 5 | 219711 | 6 | 5 | SR-60 @ SR-57 Interchange | Los Angeles, CA |
| 6 | 198088 | 8 | 6 | I-45 (Gulf Freeway) @ US-59 Interchange | Harris, TX |
| 7 | 176064 | 5 | 7 | I-40 @ I-65 Interchange (east) | Davidson, TN |
| 8 | 140206 | 9 | 8 | I-45 @ I-610 Interchange | Harris, TX |
| 9 | 102906 | 7 | 9 | I-10 @ I-15 Interchange | San Bernardino, CA |

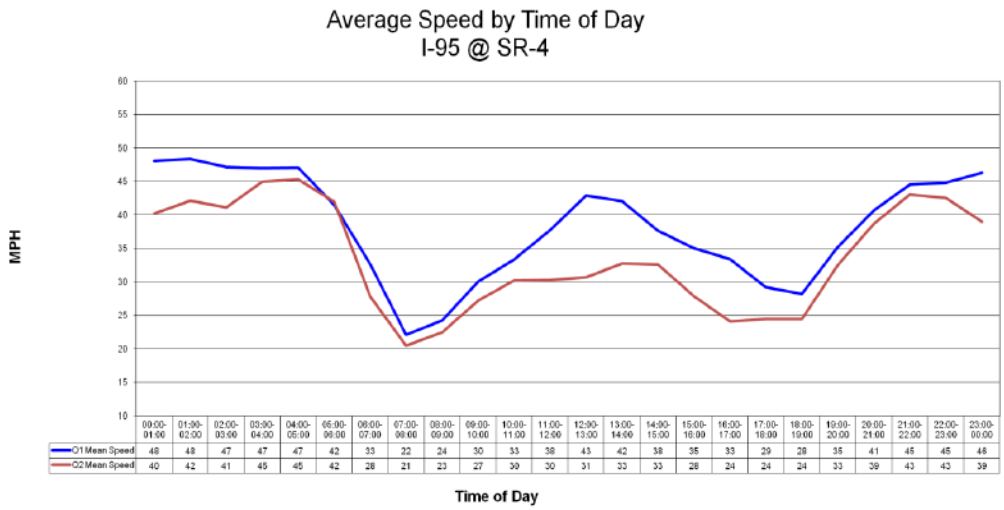



*Figure A.12. I-95 and SR 4 bottleneck data.*

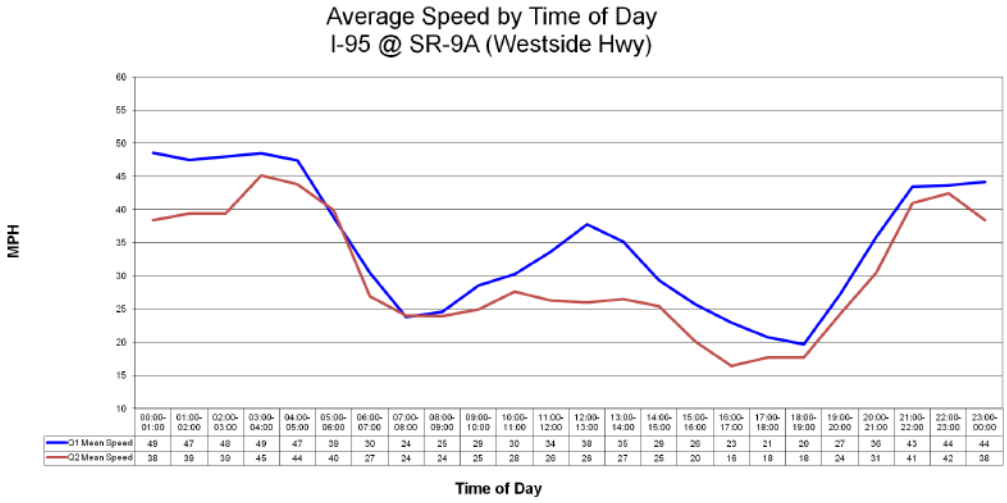



*Figure A.13. I-95 and SR 9A bottleneck data.*

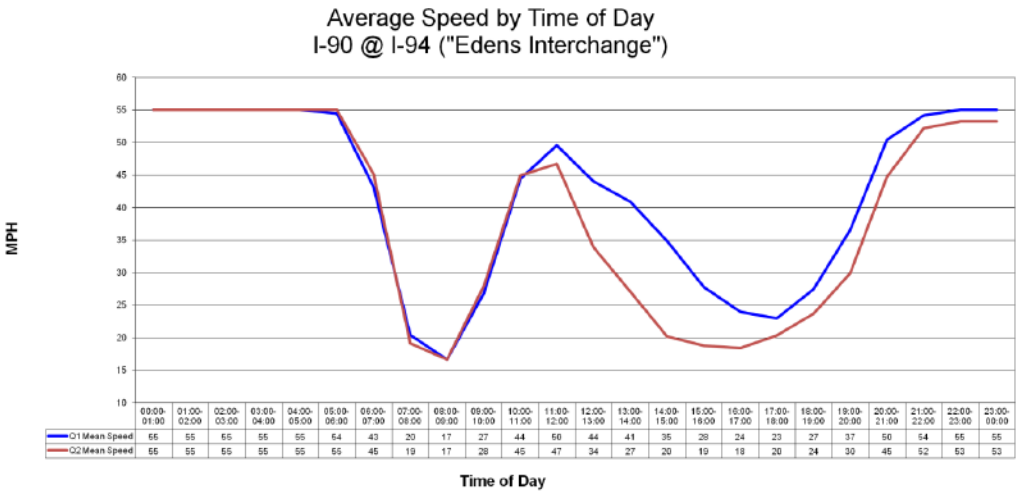



*Figure A.14. I-90 and I-94 bottleneck data.*

### Granularity: Very High

Wireless truck position reports are received from approximately 600,000 trucks and cover major highways and surface streets throughout the United States and Canada, as well as Mexico. Data can be analyzed at levels ranging from transcontinental corridors (e.g., Interstate 10) to specific urban intersections.

## Composite Class I RR Operating Speed

### Freight Performance Trend: Slight Decline

Train speed measures the line-haul movement between terminals. The average speed is calculated by dividing train-miles by total hours operated, excluding yard and local trains, passenger trains, maintenance-of-way trains, and terminal time.

Six major North American railroads voluntarily report train speed on a weekly basis.[11] In addition to a composite speed, the railroads report train speed for various components of their network, such as Intermodal, Multilevel, and Coal Unit. The last 53 weeks of data are available.

Table A.5 presents the 53-week unweighted average and standard deviation (across 53 weeks) for each reporting railroad, for all traffic, as of August 28, 2009.

Each railroad also reports the information for multiple categorizations of equipment such as intermodal, coal, or grain trains.

While the data are presented in a rolling 53-week format, the presentation of the website is sufficiently simple that an

Table A.5. Class I operating speeds.

| Railroad | Operating Speed June 2009 (mph) | Operating Speed June 2010 (mph) |
|---|---|---|
| **Burlington Northern Santa Fe** | 25.97 | **25.0** |
| **Canadian Pacific** | 25.32 | **23.4** |
| **CSX Transportation** | 21.40 | **20.6** |
| **Kansas City Southern** | 27.73 | **26.6** |
| **Norfolk Southern** | 22.95 | **21.0** |
| **Union Pacific** | 26.40 | **25.9** |
| **Unweighted Average** | **24.96** | **23.75** |

interested state or local agency could easily automate the collection of the data each week as they are published.

The data are presented for different equipment categorizations, but only at the national level. Estimating speeds for a particular state or region may therefore be challenging.

## Rail Freight Market Share of Ton Miles

### Freight Performance Trend: Growing

The market share is defined as the tabulated amount of domestic railroad ton-miles in a particular year divided by the total number of ton-miles of freight transport in the United States. Figure A.15 charts the steady increase in rail freight market share from 1980 through 2006. In 2006, BTS tabulated a total of 1,852,833 tons of rail traffic, out of a total of 4,637,513 tons of traffic across all modes. Rail accounted for 39.95 percent of total traffic in 2006. By comparison, rail accounted for 27.4 percent of total traffic in 1980 and did not pass the 30 percent mark until 1993.

The increase in rail ton-miles as a percentage of all ton-miles shipped is credited to several trends. Since deregulation in 1980, the Class I railroads have posted significant increases in efficiencies, timeliness, and volumes. The development of low-sulfur Western coal fields provided significant new markets for the railroads. Also, imports from Asia through West

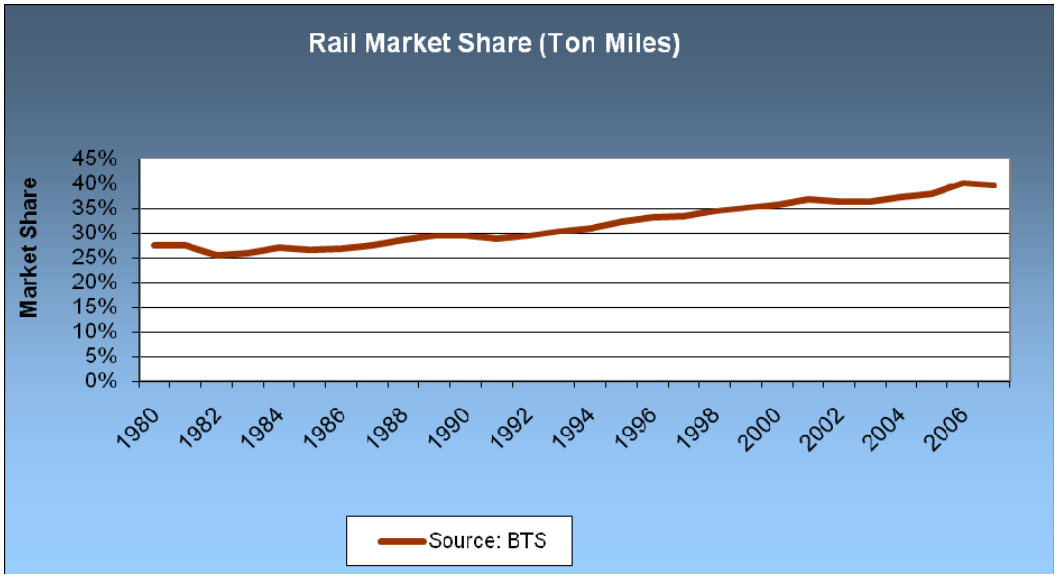



*Figure A.15. Rail freight market share.*

Coast ports provided significant new market opportunities for Class I railroads.

The current source for these data is the Bureau of Transportation Statistics.[12] BTS is developing more comprehensive and reliable estimates of ton-miles for the air, truck, rail, water, and pipeline modes. Improved estimates for 1960–1989, which will allow more comprehensive and reliable data for the entire period from 1960 to present, are still under development and will be reported when they are completed. It appears that the estimates will be provided on an annual basis, although some of the underlying data used to feed the estimates are not generated annually. The report generally presents information at the national level. The underlying data, however, come from sources with varying levels of granularity.

## Logistics as a Percentage of GDP

### Performance Indicator: Paradoxical

The cost of logistics as a percentage of GDP fell to the lowest level ever recorded in 2009.[13] This precipitous decline generally represents negative trends such as the rapid decline in manufacturing output, the unemployment of thousands of truck drivers, and a significant downturn in truck, rail, air, and water freight movement. As can be seen in Table A.6 and Figure A.16, logistics costs as a percentage of GDP had been generally declining since 1985. The gradual, long-term decline was generally viewed as a positive factor. It represented increased innovation and efficiencies in the logistics industry. That logistics costs were not rising as fast as GDP signaled increased productivity and lower relative costs for moving goods.

However, the severe recession of 2008 and 2009 caused logistics volume to fall significantly. The logistics costs decline was viewed as creating unsustainably low prices for goods movements, which were often below the costs of logistics firms. Layoffs, bankruptcies, and operating losses were prevalent in the logistics industry as a result.

### Forecast Trend Line: Uncertain

The decline in oil prices and extraordinary softness in the economy caused the cost of logistics in relation to GDP to decline in 2008 and 2009, but long-term trends could send the cost upward. After rising 50 percent in the previous five

**Table A.6. Logistics costs as percentage of GDP.**

| Year | Transport | Inventory | Total |
|---|---|---|---|
| **1986** | 6.3 | 4.9 | **11.6** |
| **1988** | 6.1 | 4.9 | **11.5** |
| **1990** | 6.1 | 4.9 | **11.4** |
| **1992** | 5.9 | 3.7 | **10** |
| **1994** | 5.9 | 3.7 | **10.1** |
| **1996** | 6.0 | 3.9 | **10.2** |
| **1998** | 6.0 | 3.7 | **10.1** |
| **2000** | 6.0 | 3.8 | **10.3** |
| **2002** | 5.6 | 2.9 | **8.8** |
| **2004** | 5.6 | 2.9 | **8.8** |
| **2006** | 6.1 | 3.4 | **9.9** |
| **2008** | 6.1 | 2.9 | **9.4** |
| **2009** | **4.9** | **2.5** | **7.7** |

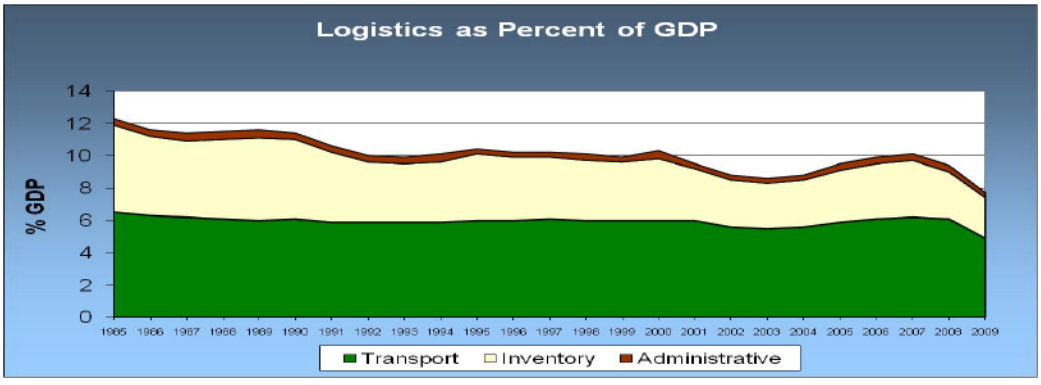



*Figure A.16. Logistics/GDP.*

years, total logistics costs fell in 2008 and fell further in 2009. Inventory carrying costs plunged primarily in 2008 because interest rates were more than 50 percent lower than they were in 2007. In 2009, transportation costs fell significantly to push logistics as a percentage of GDP to 7.7 percent. In the years leading up to the recession of 2001, logistics costs as a percentage of GDP had been rising until they passed the 10 percent mark. Greater efficiencies and innovations caused the rate to fall in the mid-2000s. The recession of 2008 caused overall freight movement to plummet, driving overall logistics costs further downward.

When the economy rebounds, there will be fewer trucks in service as the trucking industry has shed excess drivers and vehicles. Also, the recession softened demand for fuel. As the economy rebounds, these factors plus inventory costs could put upward pressure on logistics costs.

## Freight System Condition Indicators

Following are the summaries for the category of Freight System Condition.

## NHS Bridge Structural Deficiencies

### Performance Trend: Positive

As illustrated in Figure A.17, the performance trends for the NHS bridges have steadily improved since the early 1990s. Overall, structural deficiencies as a percentage of total bridge deck area on the NHS have dropped nearly 42 percent. In 1992, 13.32 percent of the national network as measured by bridge area was structurally deficient, but that number had declined to 7.7 percent by 2008. (Bridge area captures the size of the deficient inventory, not just the number of bridges.) The improvement in conditions began occurring during the era of increased spending resulting from the Intermodal Surface Transportation Efficiency Act of 1991 and continued through the next two subsequent transportation acts.

The primary considerations in classifying structural deficiencies are the bridge component condition ratings for the deck, superstructure, and substructure. These structural deficiencies are considered separately from "functional obsolescence," which measures geometric issues such as width, approach curvature, or other issues that may reflect current design standards and not the structural integrity of the bridge.

The data quality for the NHS bridge structural deficiencies is rated high because of the extensive data quality protocols in place for the national bridge inspection program. The data must be updated only every other year under federal bridge inspection standards. Bridge data can be accessed by structure but only as a result of manual effort. Changes over time also require additional data processing.

The future trend line of NHS bridge structural deficiencies is uncertain. After 15 years of improvement, significantly higher material prices starting in 2005 have greatly diminished state DOTs' purchasing power. Although the effects have not yet shown up in the annual inventories, the higher prices will make it more difficult to sustain the progress on bridge conditions.

## NHS Pavement Conditions

### Performance Indicator: Rising Conditions, Uncertain Future

As can be seen in Table A.7 and Figure A.18, pavement conditions on the NHS have steadily improved but the overall condition of the network remains mixed. As of 2004, 52 percent of the vehicle miles traveled (VMT) on the NHS occurred upon "good" pavements. Those are ones with an International Roughness Index of less than 95. The percentage of VMT occurring on "acceptable" pavements is much higher, 91 percent, in 2004.

Data for this measurement are compiled from FHWA's Highway Performance Management System (HPMS). States collect pavement condition data on a statistically valid sample of roadway sections. The condition data are compiled every two years and provide the basic input into the HPMS, which is used for national system monitoring.

The data are available biennially on a state and regional basis. Because the data are sample based, they are not avail-

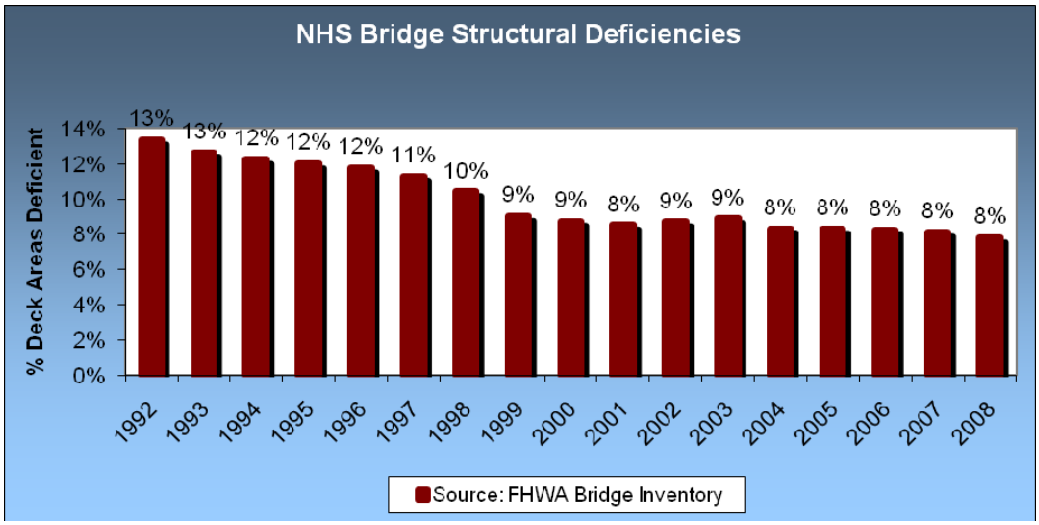



*Figure A.17. NHS bridge deficiencies.*

**Table A.7. NHS pavement conditions.**

| | *2002* | *2004* |
|---|---|---|
| Rural | | |
| Good | 66.6% | 68% |
| Acceptable | 96.9% | 97% |
| Urban | | |
| Good | 38.6% | 42.5% |
| Acceptable | 86.3% | 86.9% |
| Total | | |
| Good | 50% | 52% |
| Acceptable | 91% | 91% |

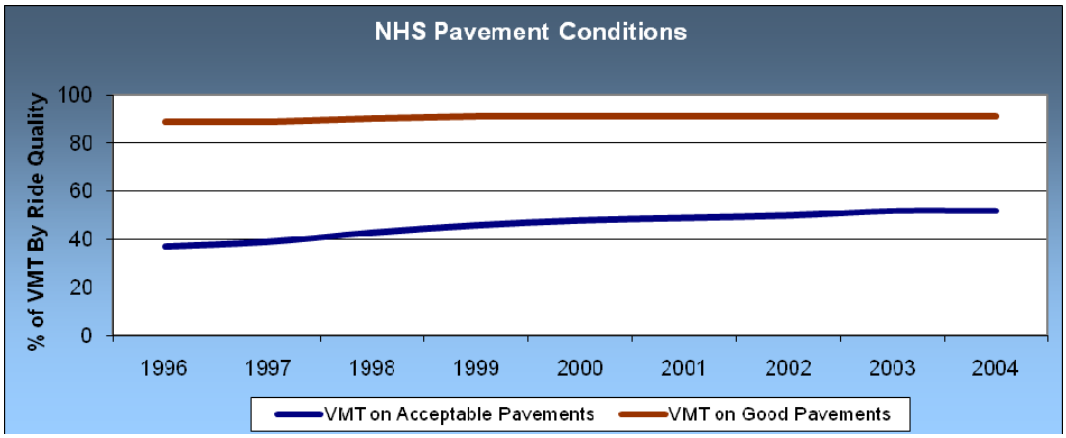



***Figure A.18. NHS pavement conditions.***

able for every roadway section. FHWA's biennial *Condition and Performance Report* was last updated in 2004. At that time, its modeling indicated that then-current levels of expenditures nationally were adequate to sustain system conditions into the future.[14] However, since that forecast, materials and construction prices have risen dramatically as a result of higher oil prices in 2005–2007. The higher prices will significantly affect forecast costs of sustaining the system. With the reauthorization of the federal highway programs on hold and with expenditure levels uncertain, the future condition of the NHS pavement conditions is also uncertain.

## Freight Environmental Measures

Following are the summaries for the category of Environmental performance measures.

### Truck Emissions

Over the last several decades the total amount and per-vehicle rates of emissions by large/heavy-duty trucks have declined overall, with the exception of greenhouse emissions. These declines may be attributed to the stricter emission standards, cleaner engines and fuel mandates, and voluntary industry efforts to reduce fuel consumption. Fuel consumption reduction efforts include motor carrier participation in EPA's SmartWay program and the increased use of technologies that reduce the need for drivers to idle trucks.

Trucks, cars, railroad locomotives, and marine vessels are defined by EPA as mobile pollution sources. These vehicles/vessels create emissions during the consumption of fossil fuels, namely, gasoline and diesel fuel. These pollutants are also emitted by stationary sources, including industrial facilities and power plants.

Air quality planners assign estimated volumes of pollutants, typically measured in tons or metric tons, to specific sources of emissions. Emissions included as performance measures for the freight transportation system include:

- Particulate matter (PM)
- Oxides of nitrogen ($NO_x$)
- Volatile organic compounds (VOCs)
- Ozone
- Greenhouse gas emissions (GHE)

### Future Trend Line: A Continued Decline in Overall Emissions

Emissions attributed to large/heavy-duty trucks for the majority of emission types have declined since 2002 (see Figure A.19) and are expected to continue to decline through at least 2020. The exception is for carbon emissions, which are predicted to increase. As a performance measure, emission rates/factors for PM, $NO_x$, and VOC are a more robust measure of future trend lines than is total tonnage of emissions. "Per truck" or "per unit" emission rates are not affected by external factors such as less freight transportation activities due to depressed economic environments. Emission rates/factors are commonly expressed in grams per brake-horsepower hour (g/bhp-hr), grams per mile, or pounds per gallon of fuel consumed.

As of October 10, 2007, air-quality data show that about 144 million people live in areas that violate air-quality standards for ground-level ozone, also called smog, and about 88 million people live in areas that violate air-quality standards from PM. These pollutants contribute to serious public health problems that include premature mortality, aggravation of respiratory and cardiovascular disease, and aggravation of existing asthma, acute respiratory symptoms and chronic bronchitis. Beyond the impact that diesel engines have on our nation's ambient air quality, exposure to diesel exhaust has been classified by EPA as being likely carcinogenic to humans. Children, people with heart and lung diseases, and the elderly are most at risk.[15]

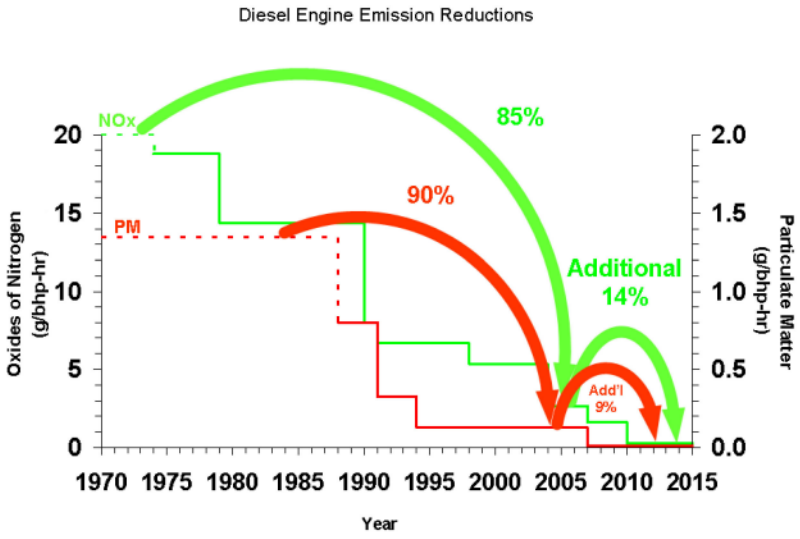



*Figure A.19. Truck emission reductions.*

## Particulates

There are two types of particulate matter: PM less than 2.5 microns in diameter (PM-2.5) and PM less than 10 microns in diameter (PM-10). Emission factors—the rates at which known sources emit pollutants—for PM-2.5 (commonly referred to as "fine particulates") are an emerging area of air-quality metrics.

As illustrated in Figure A.20, the performance trend for PM-10 produced by large trucks is positive in terms of pollutants being reduced. EPA estimates that total heavy-duty truck PM-10 emissions will have declined by nearly half (46 percent) between 2002 and 2010.[16] EPA further estimates that total emissions from these vehicles will decline by more than two-thirds (71 percent) by 2020 to 34,760 tons. This is the highest percentage decline in PM emissions for any freight transportation mode.

This decline is based on EPA's Mobile 6 model (v. 6.2), which assumes that by 2020 nearly all trucks engaged in freight transportation will have met the 2007 engine standards.[17] In addition, the introduction of low-sulfur diesel fuel contributes to particulate reductions.

EPA's National Emissions Inventory estimates that in 2005, the latest year for which data are available, heavy-duty diesel trucks produced 101,174 tons of Primary PM-10 and 87,306 tons of Primary PM-2.5.[18]

The increased use of newer, cleaner diesel engines and ultra-low sulfur diesel (ULSD) has reduced and will continue to reduce PM for diesel engines (Figure A.21)[19]. PM rate reductions were first mandated in the mid-1980s.

As shown in Figure A.21, the 2010 and 2020 total PM-10 emission factors for the three primary configurations of trucks, classified by EPA as heavy-duty trucks, are significantly lower than the 2002 factors.[20] For combination diesel

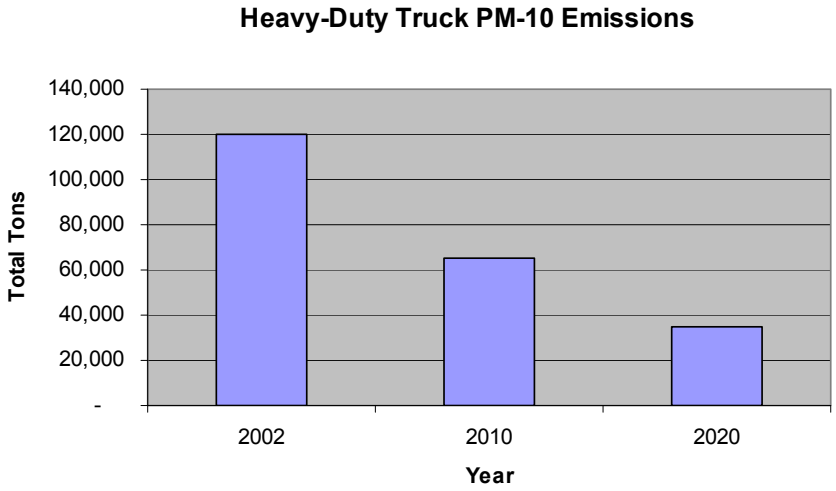



*Figure A.20. Particulate reductions.*

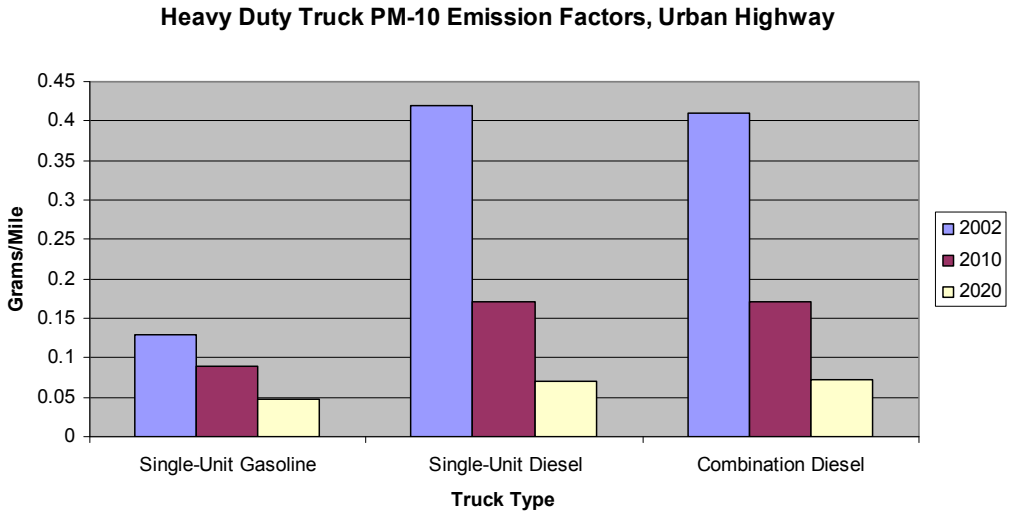



*Figure A.21. Total PM-10 truck emission factors.*

trucks, the emission rate in 2020 will be 82 percent lower than in 2002.

## Truck $NO_x$ Emissions

Oxides of nitrogen, $NO_x$, are a precursor, along with VOCs, of ground-level ozone. Ozone, informally known as smog, is a significant pollutant that has been attributed to thousands of premature deaths annually. It forms when $NO_x$ and VOCs interact with sunlight, particularly at higher temperatures.

The performance trends for truck-generated $NO_x$ are also positive and show significant decreases from 2002 to 2010 (Figure A.22). EPA estimates total $NO_x$ emissions from large trucks will decline from 3.78 million tons in 2002 to 2.19 million tons in 2010, a 42 percent decrease.[21] By 2020, $NO_x$ emissions from large trucks are expected to decrease 82 percent below 2002 levels to 662,600 tons. This is the highest percentage decline in total $NO_x$ emissions for any freight transportation mode. The reduction in $NO_x$ is attributable to the use of ULSD and the phase-in of cleaner diesel engines that must meet 2007 emission standards (see Figure A.23). As the current fleet is retired and new vehicles purchased, the emission reductions will increase.

## VOCs

### Volatile Organic Compounds

Similar to PM and $NO_x$ emission factors, VOC emission factors for the three main types of truck configurations are expected to decline significantly from 2002 to 2020 (Figure A.24).[22] These declines include an approximate decrease of 90 percent for single-unit gasoline vehicles, 36 percent for single-unit diesel vehicles, and a 53 percent for combination diesel vehicles.

Again, the reductions are attributable to cleaner fuels and cleaner vehicles.

## Greenhouse Emissions

Greenhouse emissions (GHE) consist of six types of pollutants, including carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and fluorinated gases. Of the GHE, $CO_2$ is the primary gas produced during fossil fuel consumption. At least some amounts of these gases are found in the atmosphere naturally. GHE are not currently regulated by the federal government, though EPA has recently proposed a rule mandating that large sources of GHE annually report amounts of GHE emitted.

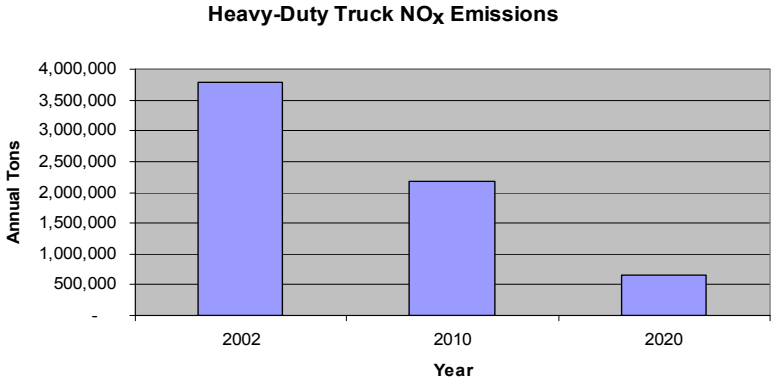



*Figure A.22. $NO_x$ reductions.*

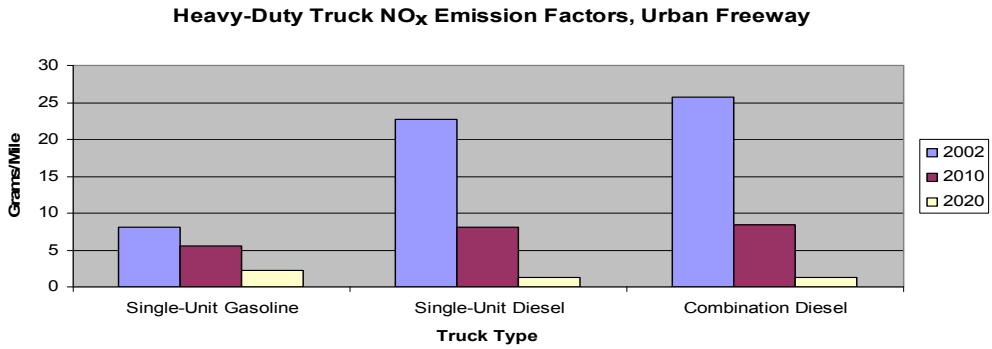



*Figure A.23. Heavy-duty $NO_x$ emission factors.*

Between 1990 and 2007, EPA estimates that $CO_2$ emissions, the primary GHE produced by medium- and heavy-duty trucks, increased significantly (Figure A.25).[23] EPA attributes this increase to growth in demand for freight movement by truck and the subsequent increase in miles traveled by these vehicles. In 2007, truck VMT in the United States was 318.8 billion miles.[24]

As shown in Figure A.26, EPA allocates the majority (61 percent) of transportation-related $CO_2$ to the consumption of gasoline by light-duty vehicles (cars, light trucks, SUVs).[25] Medium- and heavy-duty trucks are allocated nearly a quarter (22 percent) of total $CO_2$ transportation sector emissions.

Total GHE are typically measured in metric tons or teragrams[26] of $CO_2$ equivalent (Tg $CO_2$ Eq.). Between 1990 and 2007, the total amount of $CO_2$ emitted by all modes of transportation increased from 1,484.5 teragrams of $CO_2$ equivalent (Tg $CO_2$ Eq.) to 1,887.4 Tg $CO_2$ Eq.[27] EPA attributes this growth in $CO_2$ emissions to an increase in the demand for transportation, low fuel prices, and economic growth. During this same time period, total GHE from all sources (mobile and stationary) increased from 5,076.7 Tg $CO_2$ Eq to 6,103.4 Tg $CO_2$ Eq.

Future estimates of GHE attributed to "Freight Trucks," defined as trucks with a gross vehicle weight rating (GVWR) over 10,000 pounds, are provided by the U.S. Department of Energy, Energy Information Administration (EIA). EIA estimates that in 2009, these vehicles will emit 335.34 Tg $CO_2$ Eq., a lower amount than in 2007.[28] By 2030, EIA forecasts that these vehicles will emit 446.43 Tg CO2 Eq. (Figure A.27).

GHE estimates for mobile sources are based on the volumes of diesel and/or gasoline taxed and the estimated VMT in each state.[29] A common methodology for estimating truck-related GHE includes: determining/estimating total fuel

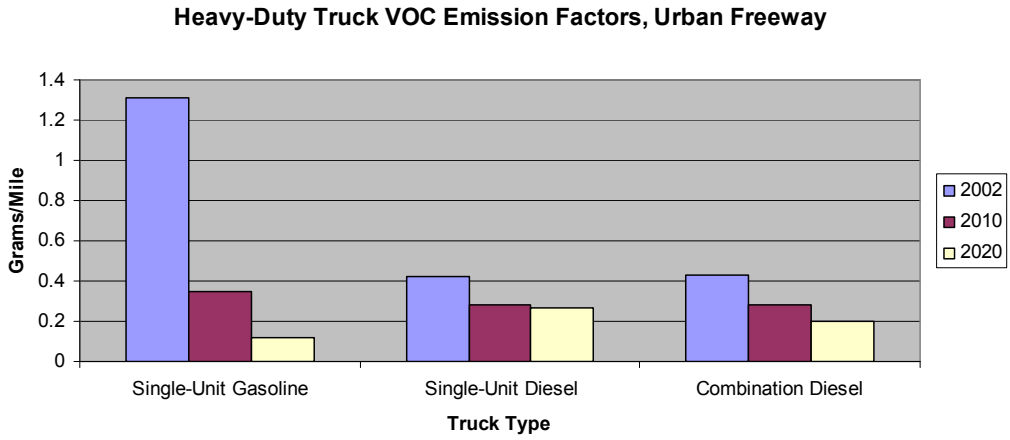



*Figure A.24. VOC reductions.*

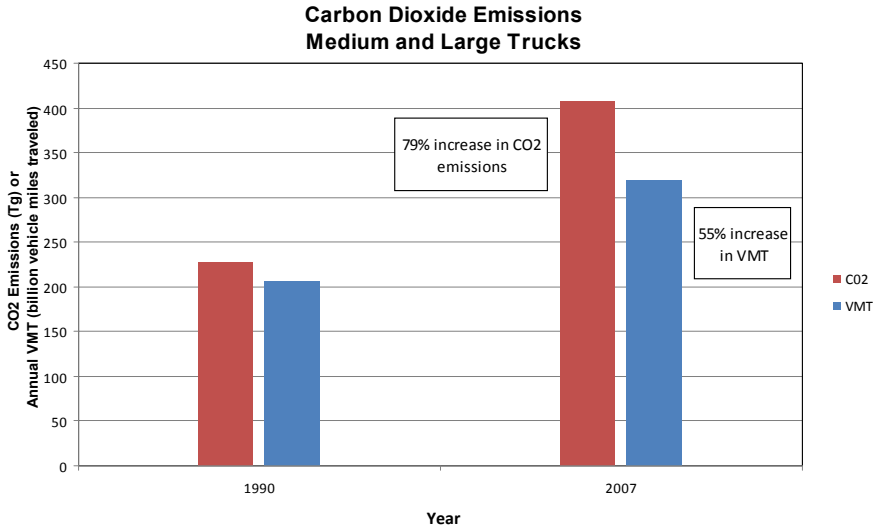



*Figure A.25. Truck carbon emissions.*

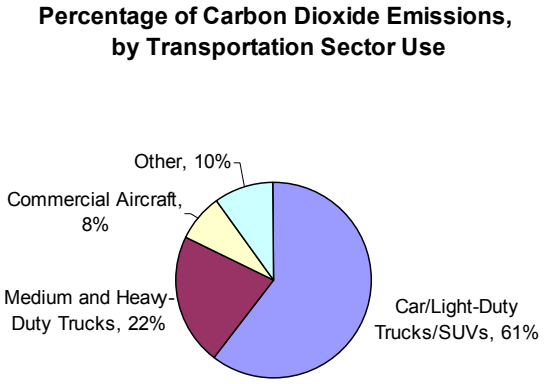



*Figure A.26. Greenhouse emission sources.*

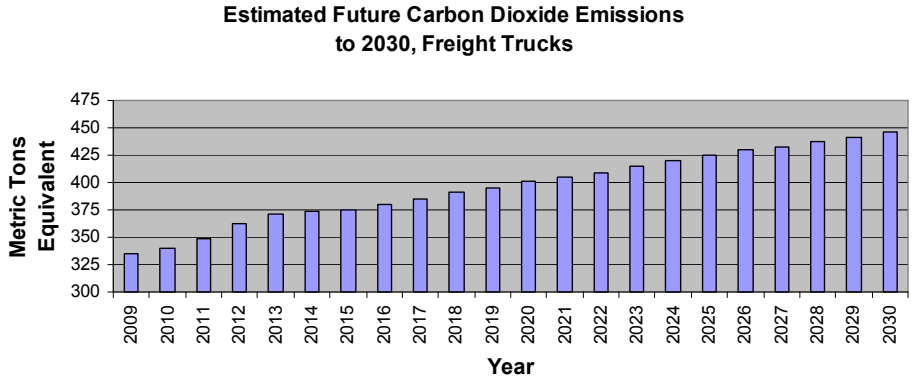



*Figure A.27. Forecast carbon emissions.*

consumption by fuel type and sector;[30] adjusting up these estimates based on VMT data; estimating $CO_2$ emissions; and allocating transportation emissions by vehicle type. In addition, these estimates may also be based on surveys of truck usage by motor carriers and vehicle-miles-per-gallon averages.

Estimates of future amounts of GHE attributable to freight movement are based on assumptions of future economic activity (and subsequent freight volumes) as well as public policies that make an effort to curtail greenhouse gases. Though government agencies increasingly are making efforts to regulate GHE, the long-term impact of these policies is uncertain. Additionally, the future impact of industry efforts to reduce fuel consumption and GHE by participating in voluntary environmental programs and the increased use of idle-reduction technologies is also not easily quantified.

EPA annually updates the National Inventory of U.S. Greenhouse Gas Emissions and Sinks. Included in the update are new estimation methodologies and revised calculations of all previous years' estimates.

As compared to other truck-related emissions, GHE are typically a function of how much fuel is consumed in a specific jurisdiction. Unlike PM, $NO_x$, and VOC, the age of the truck's engine is less important than fuel economy. On the national level, the amount of fuel consumed (derived from the amount of fuel taxed or purchased) multiplied by the emission factor likely provides a reasonable estimate of the amount of GHE emitted by different vehicle types operating in the United States. This is based on the assumption that fuel taxed/purchased in this country is likely consumed here.

On the state level, interstate motor carriers track these activities on the individual truck level and can provide fuel consumption by state (though the reported figures are typically based on fleet averages). On the metropolitan/local level, however, the relationship between where fuel is purchased and where it is consumed is not known to an acceptable degree of certainty.

## Rail-Produced Greenhouse Gas Emission

Data available from EPA indicate that GHE from rail transport have steadily increased from 1990 (38.1 MMT) until 2006 (51.8 MMT), then dropped slightly in 2007 (50.8

MMT).[31] The increase was attributable to increased rail freight volume, and the decline was attributable to a reduction in train traffic. As shown in Figure A.28, this growth rate is approximately twice the growth rate of total national greenhouse gas emissions.[32]

EPA's annual inventory of U.S. Greenhouse Gas Emissions and Sinks does not distinguish between freight rail and passenger rail. For the purposes of this report, the entire GHE value is used as a proxy for freight rail GHE. Since 2005, data have been published on an annual basis. The information published in 2009 contained data through calendar year 2007.[33]

## Water-Produced Greenhouse Gas Emissions

### Freight Performance Trend: Mixed

EPA data indicate that greenhouse gases from water transport in 2005 (45.4 MMT) through 2007 (50.8 MMT) have decreased from a peak in 2000 (61.0 MMT). Figure A.29 shows how water-freight-based GHE have varied when compared to all national GHE. There have been three bands of relative performance: a growth period during the 1990s, a sharp decline early in the decade, and new growth over the past several years.

The EPA inventory information published in 2009 contained data through calendar year 2007.[34] Note that the analysis does not distinguish between freight water transport and passenger water transport such as ferries; for the purposes of this report the entire greenhouse gas value is used as a proxy for waterborne freight GHE.

## Rail VOCs and $NO_x$

### Freight Performance Trend: Decreasing

EPA standards adopted in 2008 are forecast to lead to a near 90 percent reduction in railroad locomotive emissions for the three primary pollutants, VOCs, $NO_x$, and particulates.[35] The standards will rely on a new generation of locomotive engine technology, with intermediate engine technology required for remanufactured locomotives.

EPA anticipates that these engines may account for an even greater share of overall emissions over the next few decades

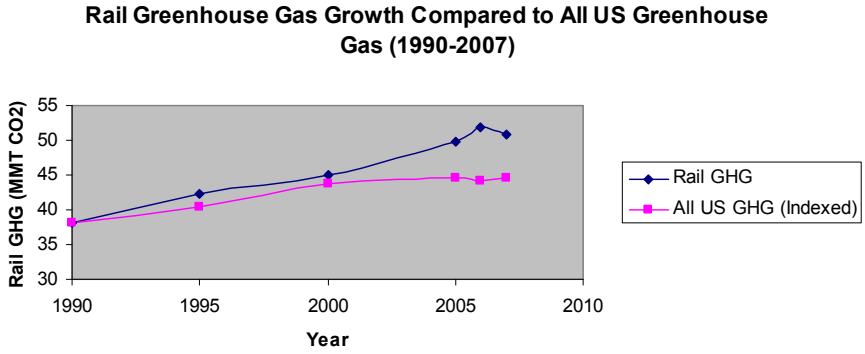



*Figure A.28. Rail greenhouse emissions.*

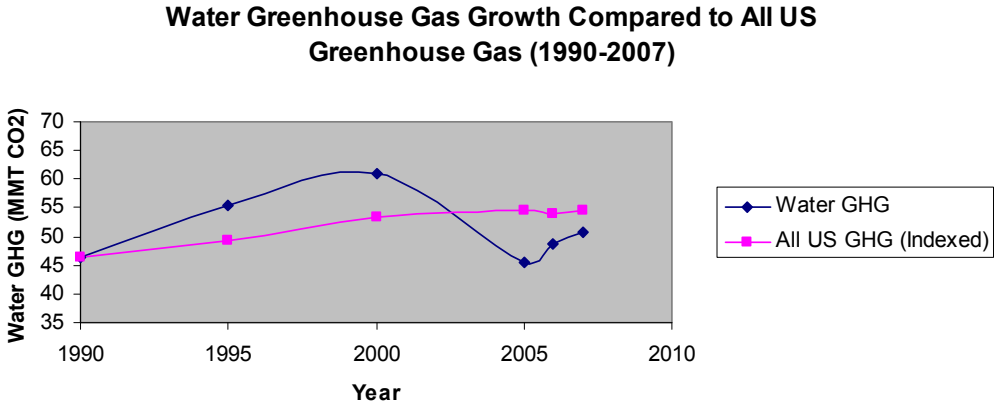



*Figure A.29. Water-freight greenhouse emissions.*

as other emission control programs take effect for cars and trucks and other nonroad emissions sources. Estimates show that, without the emission reductions, by 2030 locomotive and marine diesel engines would contribute more than 65 percent of national mobile-source diesel PM2.5, or fine particulate, emissions and 35 percent of national mobile-source $NO_x$ emissions, a key precursor to ozone and secondary PM formation.

According to the EPA 2005 National Emissions Inventory, rail equipment primarily engaged in freight transportation emitted 1,118,786 tons of $NO_x$.[36] The forecast trend, as demonstrated in Figure A.30,[37] is that these emissions will be largely eliminated within 30 years.

## Ship $NO_x$

### Freight Performance Trend: Decreasing

As with locomotives, EPA is developing new standards for ocean-going ships, which it estimates will by 2030 reduce $NO_x$ emission rates by 80 percent and PM emission rates by 85 percent, compared to the current limits applicable to these engines. EPA has finalized more stringent standards for marine transport.[39] EPA estimates that by 2030 the management of the program according to the revised standards will reduce annual emissions of $NO_x$ by about 1.2 million tons and PM emissions by about 143,000 tons.

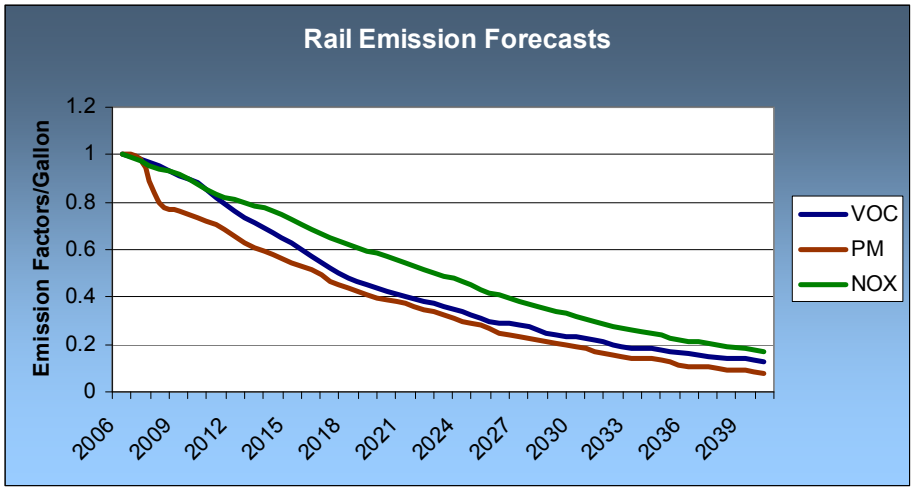



*Figure A.30. Forecast rail VOC and $NO_x$ emissions.*

## Freight Safety Measures

Following are the Safety performance measure summaries.

## Truck Injury and Fatal Crash Rates

### Freight Performance Trend: Positive

The performance trends for large-truck injury and fatal crash rates show significant improvement (Figures A.31 and A.32). Large trucks are defined as vehicles with a gross vehicle weight rating (GVWR) greater than 10,000 pounds. Crash rates are the number of crashes per 100 million vehicle miles of travel (VMT).

Between 1988 and 2007, the large-truck injury crash rate decreased from 67.9 to 31.8.[40] The 2007 rate is the lowest on record. The large-truck fatal crash rate has also declined. In 2007, this rate was 1.85, down from a peak of 5.21 in 1979.[41]

### Future Trend Line: Positive

Preliminary figures indicate that the number of large trucks involved in both injury and fatal crashes again declined in 2008.[42] FMCSA cautions, however, that these numbers may understate the actual number of large-truck crashes.

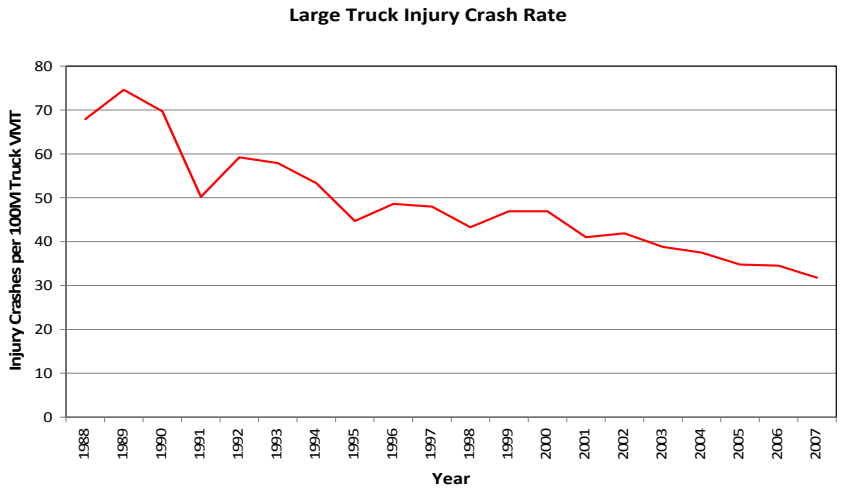



*Figure A.31. Truck injury crash rate.*

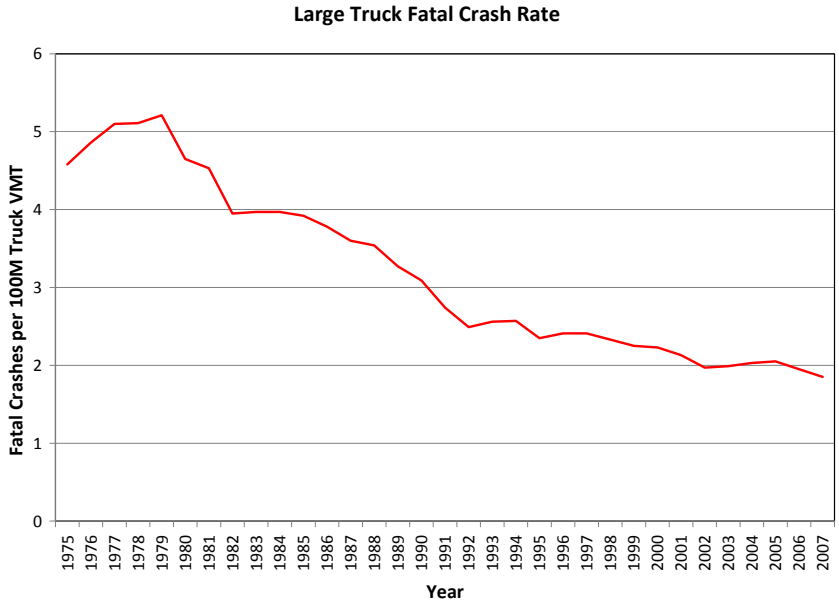



*Figure A.32. Truck fatal crash rates.*

Declines in large-truck crash rates may be attributed to several factors, including targeted enforcement of less safe motor carriers and high-risk truck drivers, national driver training/credentialing initiatives, increased use of onboard safety systems in large trucks, improvements in truck and car safety designs, and public outreach efforts to educate all roadway users on highway safety issues.

The data quality for large-truck injury crash rates is rated as inadequate, primarily because of FMCSA's determination that not all states report every "FMCSA-eligible" crash to the Motor Carrier Management Information System (MCMIS) Crash File. FMCSA-eligible crashes are defined as those that meet FMCSA's SAFETYNET definition of a reportable accident.[43] FMCSA has acknowledged the deficiency of data contained in MCMIS and is working with several states to improve data collection and reporting.

More reliable truck fatal crash statistics are collected by the National Highway Traffic Safety Administration (NHTSA) and entered into the Fatal Accident Reporting System (FARS). FARS is widely recognized as the most reliable source of fatal truck crash data.[44]

Truck VMT estimates can also affect the accuracy of vehicle crash rates. These estimates are reported by the states to FHWA and published annually in FHWA's *Highway Stats*. Since 1999, national truck VMT estimates generally show moderate annual growth. Conversely, some state-specific VMT estimates can fluctuate significantly from year to year. Additionally, because of the data collection methods used for determining VMT, some have questioned the accuracy of available VMT data sources.

The granularity of data used as inputs to crash-rate calculations is rated as adequate. These metrics are available at the state and national levels.

## Highway–Rail At-Grade Incidents

A highway–rail at-grade crash is any impact between a rail user and a highway user at a crossing site, regardless of severity. This includes motor vehicles and other highway, roadway, and sidewalk users at both public and private crossings.

The overall performance trend for highway–rail at-grade crashes in the United States has improved since 1998, most noticeably from 2000 to 2003 and from 2006 to 2008.[45] The frequency of these incidents declined significantly in 2008 (see Figure A.33).

Although the number of these incidents has decreased, FRA has named as a top research strategy the modernizing of grade crossings and the evaluation of public education and awareness strategies to reduce incidents on railroad rights-of-way.[46] Railroads operating in the United States are required to submit monthly accident reports to FRA. This report must include any collision between an on-track piece of equipment and any user of a public or private crossing.[47] Data quality is further bolstered by the required use of a standardized form for reporting these types of incidents. In addition, FRA provides an online tool for railroads and states to compare and reconcile crossing location inventories with the USDOT National Crossing Inventory File.[48]

Crash data updates are published monthly. An FRA website allows users to query the incident database with a wide range of filters, including railroad, state, county, public and/or private crossings, and start/end date.

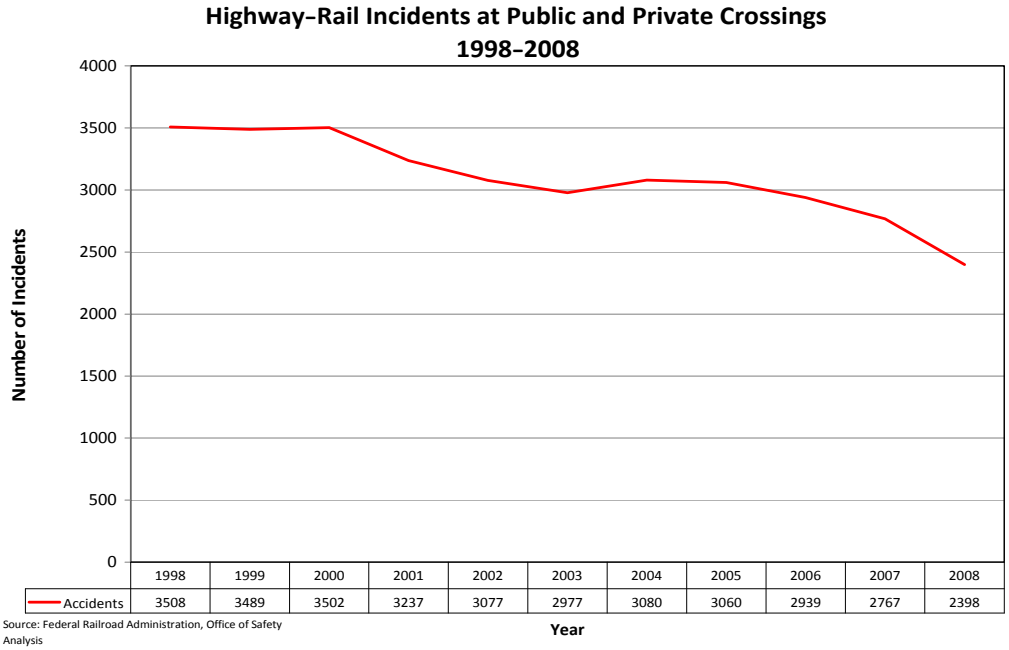



*Figure A.33. RR crossing incidents.*

# Freight Investment Measures

These are the summaries for the Investment measures.

## Investment to Sustain NHS

### Freight Performance Trend: Increasing

The key indicator of the highway system's future condition is the ratio of the total estimated national investment in the NHS over the next 10 years to the amount necessary to sustain current performance.

The source of the national investment amounts in NHS is the *Conditions and Performance Report* that FHWA prepares and submits biannually to the Congress. The currently available analysis uses the 2004[49] and 2006[50] *Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance Report*. Both reports contain data from two years before the report date: The 2004 report uses 2002 data, and the 2006 report uses 2004 data. Highway rehabilitation and system expansion investments are modeled by the Highway Economic Requirements System (HERS), whereas the National Bridge Investment Analysis System (NBIAS) model analyzes rehabilitation and replacement investment for all bridges, including those on the NHS.

Approximately $12.3 billion was spent on NHS rural arterials and collectors in 2004, and another $22.3 billion on NHS urban arterials and collectors. Reported state government spending on NHS routes functionally classified as rural local or urban local was negligible in the year 2004. It is not currently possible to identify spending by local governments on these routes, which would mainly consist of intermodal connectors and Strategic Highway Network (STRAHNET) Connectors. STRAHNET is a national set of roadways that provide access to defense facilities. Of the total $34.6 billion spent by all levels of government for the capital improvements to the NHS in 2004, approximately 45.0 percent was used on the interstate component of the NHS.

Average delay and average travel time costs on rural NHS routes would be maintained at an average annual investment level of $5.4 billion, while $22.2 billion would be required to maintain the same performance on urban NHS routes.

The biannual report is theoretically available every two years, but in some cases three years have passed between reports. The underlying data are at the local level. FHWA has versions of both systems that can be used by agencies to generate forecasts for varying geographic regions.

### Future Trend Line: Uncertain

As can be seen from the last line of Table A.8, the ratio of total funds expended to sustain the NHS was positive in both 2002 and 2004 overall. However, in 2002, only 95 percent of what was necessary to sustain urban NHS conditions was spent and in 2004 the ratio of what was spent compared to what was required was exactly 1.0. As noted above, these figures for 2004 were calculated in 2006. Since 2004, highway construction cost inflation has risen significantly, in many regions by more than 50 percent between late 2004 and early 2009. Declining oil prices caused by the recession have moderated construction price increases, but they remain substantially above 2004 levels. Therefore, it is uncertain, given the severely constrained purchasing power of the past several years (2008–2010), whether recent expenditures on the NHS have been sufficient to sustain both condition and performance of the system.

## Rail Industry Cost of Capital

### Performance Trend: Improving but Incomplete

Earning more than the cost of capital is a basic measure of financial health in any industry. The Surface Transportation Board calculates annually the cost of capital for the U.S.

**Table A.8. NHS investment level adequacy.**

| | 2002 | | | 2004 | | | Trend (annual percentage) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rural | Urban | Total | Rural | Urban | Total | Rural | Urban | **Total** |
| **Total NHS Investment ($B)** | $14.9 | $20.4 | $35.3 | $12.3 | $22.3 | $34.6 | -9.1% | 4.6% | **-1.0%** |
| **Average Investment Needed to Maintain Average Delay and Travel Time Costs** | $7.0 | $21.5 | $28.5 | $5.4 | $22.2 | $27.6 | -12.2 | 1.6% | **-1.6%** |
| **Ratio of Total vs. Average Needed** | **2.13** | **.95** | **1.24** | **2.28** | **1.0** | **1.25** | **3.4%** | **2.9%** | **.6%** |

Class I railroads. For 2008, STB estimated that the railroad's cost of capital was 11.75 percent[51] (see Figure A.34). The railroads are a very capital-intensive industry because of their need for tracks, locomotives, train cars, and related equipment and facilities. If they do not earn more than their cost of capital, it is an indicator that investments in rail capital are economically inefficient and that other investments would earn a higher economic return.

Despite significant gains in productivity and profitability since the 1980s Staggers Act deregulation, the Class I railroads still struggle to earn their cost of capital; railroads earn only about 8 percent on net capital, according to the FRA.[52] This is a modest rate of return compared to some other industries. For decades, American railroads earned the lowest rates of return of any major U.S. industry. Between 1960 and 1979 the average annual return on shareholder equity was 2.3 percent.[53] U.S. railroads have estimated that up to 40 percent of their revenues are devoted to capital assets, a percentage that is significantly higher than most industries. The high cost of maintenance for track, rolling stock, and yards requires substantial capital investments, which are not liquid or mobile. Investing in capital represents a significant long-term investment for a railroad.

If national policy develops that seeks to expand railroad capacity so that rail absorbs a larger percentage of national freight traffic, the cost-of-capital calculation can be an important metric to assess the industry's ability to finance its capital expansion. This metric may be defined as the required return necessary to make the capital budgeting projects worthwhile in the rail freight industry. Cost of capital is the weighted average computed using proportions of debt and equity as determined by their market values and current market rates.[54]

STB annually determines the cost of capital (with input from AAR) and uses it in evaluating the adequacy of individual railroads' revenues each year. The figure is also used in maximum rate cases, feeder-line applications, rail-line abandonments, trackage rights cases, rail-merger reviews, and more generally in the STB's Uniform Rail Costing System. The railroad cost of capital determined here is an aggregate measure. It is not intended to measure the desirability of any individual capital investment project.

Although the cost of debt is observable and readily available, the cost of equity (the expected return that equity investors require) can only be estimated. How best to calculate the cost of equity is the subject of a vast amount of literature covering the fields of finance, economics, and regulation. In each case, however, because the cost of equity cannot be directly observed, estimating the cost of equity requires adopting a financial model and making a variety of simplifying assumptions.

As noted above, the 2008 composite after-tax cost of capital for the railroad industry was 11.75 percent. The procedure used to develop the composite cost of capital is consistent with the Statement of Principle established by the Railroad Accounting Principles Board: "Cost of capital shall be a weighted average computed using proportions of debt and equity as determined by their market values and current market rates." The 2008 cost of capital was 0.42 percentage points higher than the 2007 cost of capital (11.33%).[55]

Although the methodology has been recently updated and the cost of debt is observable, the abundance of literature regarding variations in calculating the cost of equity is a source of potential concern. The analysis is conducted each year to support existing financial decision-making processes. It is unlikely that the frequency of this analysis will decline.

The analysis is conducted only at the national level. It may be impossible to identify and quantify significant variations for specific localities.

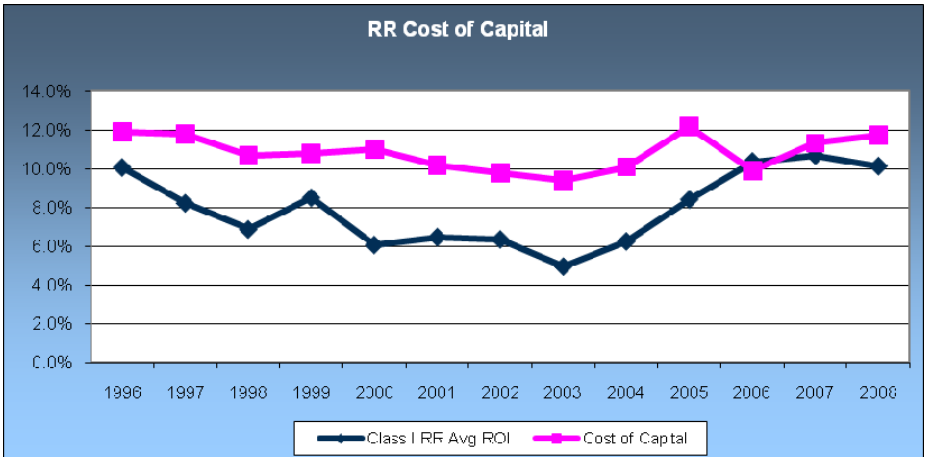



*Figure A.34. Rail cost of capital.*

## Estimated Capital to Sustain Rail Market Share

### Freight Performance Trend: Increasing

The estimated rail capital investment to sustain market share has not traditionally been a publicly calculated value. However, it represents an estimate based on a definitive study of what level of investment is needed for Class I railroads to sustain their current market share in the face of rising freight volumes.

The National Surface Transportation Policy and Revenue Study Commission, charged by Congress to develop a plan of improvements to the nation's surface transportation systems to meet the needs of the twenty-first century, requested that AAR commission a study[56] to estimate the system's long-term capacity needs.

The study, released in 2007, identified that the investment will have to increase over the study's planning horizon of 28 years if Class I railroads are to keep up with expected freight demand. The total investment required is $148 billion, or a straight-line average investment of $5.3 billion per year. The study also identified that this amount was increasing as time passed without higher investment levels. The AAR reported that between 2005 and 2007 Class I railroads invested an average of $1.5 billion annually for expansion, leaving an annual investment gap of $3.3 billion. The railroads estimated that through increased revenues and productivity, they could generate $3.4 billion annually of the $4.8 billion needed to invest in capacity. That leaves an "investment gap" of $1.4 billion annually to be funded from railroad investment tax incentives, public-private partnerships, or other sources. Tracking the investment gap would provide an ongoing metric of the sufficiency of investment in the nation's rail network.

The network used in the methodology is corridor based, with corridors being specified by the Class I railroads participating in the study. The beginnings and ends of the corridors are major urban areas corresponding with the USDOT Freight Analysis Framework Version 2.2 (FAF2.2) zones, major rail traffic generators such as the Powder River Basin coal fields, port complexes, and major rail traffic junctions. The number of trains on the network is based on the 2005 Surface Transportation Board Carload Waybill Sample.

The 2007 report was the first of its type. It is unclear if the AAR intends on replicating the study calculations on a periodic basis. However, the framework proposes investigating if the AAR would assist in reporting the annual investment gap.

## Investment to Sustain Inland Waterway System

The inland waterway system comprises 12,000 navigable miles connecting 41 states, including all states east of the Mississippi River. On this system are 230 locks, which had an average age in 2007 of 56.7 years.[57] Many were built in the 1930s with an expected design life of 50 years. Seven of the locks were built in the 1800s, and the oldest operating lock is from 1839. USACE reports that locks were available 92 percent of the time in calendar 2007[58] and that lock downtime created 157,430 hours of delay.

Although inland water volumes have been relatively stable in the past decade overall, the inland system is important to many bulk commodities. The marine transportation and inland waterway system moves an estimated 60 percent of grain exports and an estimated 95 percent of soybean exports.[59] It also is disproportionately important for ore, chemicals, and mining products.

The suggested performance metric for the inland waterway system is proposed to be the average age of the locks. Based upon current levels of investment in lock replacement, the average age of the inland locks has increased annually, with no reduction in average age in many years. Although age alone may not be an indicator of lock performance, it is proposed as the initial metric for the performance of the inland waterway system.

The data quality of this measure is high because of the fixed and static nature of the waterway system. The data also are highly granular, because age and performance data are available for every lock. That would allow any region to track the age of the waterway system in its area

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APPENDIX B

# Statewide and Metropolitan Freight Performance Metrics Examples

## CONTENTS

## Introduction

The following section depicts selected metrics from the Freight System Report Card that are populated with local and regional data. In this case, the State of Washington and the metropolitan Puget Sound region are selected. The statewide data represent data for the entire state, while the Puget Sound data reflect metrics from within the boundaries of the Puget Sound Regional Council, which encompasses metropolitan Seattle.

These metrics are not intended to be definitive but rather illustrative of how the measures from the report card could be replicated locally. One of the many purposes of the Freight System Report Card is to provide a template of freight performance measures that can be replicated at the state and metropolitan levels. As states and metropolitan regions adopt the framework's template, the ability to drill down into state and local freight performance will increase. Examples of comparative analysis that could be possible would be to develop a Top 25 list of congested freight bottlenecks nationally, as well as Top 25 lists within each state or even within each region. As the metrics are tracked over time, the rate of change or the effect of improvement strategies could be measured on the bottlenecks.

Not all measures have local or state counterparts. Measures that are based on inventories, such as the National Bridge Inventory, can be replicated at the state or metropolitan levels. Measures based on surveys and estimates, such as the Cost of Logistics as a Percentage of Gross Domestic Product, tend not to allow granular deconstruction down to the state or local level.

## Washington State Measures

The measures shown in this section represent the application of a representative sample of the national measures to a statewide system, in this case, the State of Washington.

## Washington State Freight Forecast

The national Freight Analysis Forecast 2 (FAF2) predicts a 5 percent annual rate of growth for overall freight in Washington State between 2008 and 2035, one of the higher growth rates in the country. Such a large and steady rate of growth forecasts a near tripling of overall freight volumes, from 261 million tons annually to 975 million tons annually moved within, into, or out of the state (see Figure B.1). Trucking has the highest forecast increase, with a forecast rate of growth of 6 percent. As trucking represents the largest freight sector in Washington, its higher rate of growth has a disproportionate effect on this forecast. However, all modes are expected to grow significantly, with water freight predicted to grow at 4.5 percent (see Figure B.2) and rail at 3.5 percent annually.

## Statewide Freight Growth for Trucks

The forecast rate of truck freight growth can be defined as the estimated percentage increase in tonnage hauled in future years by trucks. Tons[1] shipped include the total weight of all freight transported within or between regions, and tonnage is counted each time the goods are transported.[2]

The forecast estimates that freight shipments that originate outside of Washington and are destined to the state will quadruple from 2002 to 2035.[3] Freight shipments being transported within the state are expected to rise from approximately 190 million tons in 2002 to 350 million tons in 2035, while freight shipments originating within the state but are destined out of the state are projected to remain static during this time frame (see Figure B.3).

The most recent forecast utilizes the FAF2.2 Commodity Origin–Destination database, which estimates tonnage moved to, from, and within 114 areas in the United States, as well as several international regions.[4] Tonnage is estimated by both commodity type and mode of transport. The FAF 2002 base

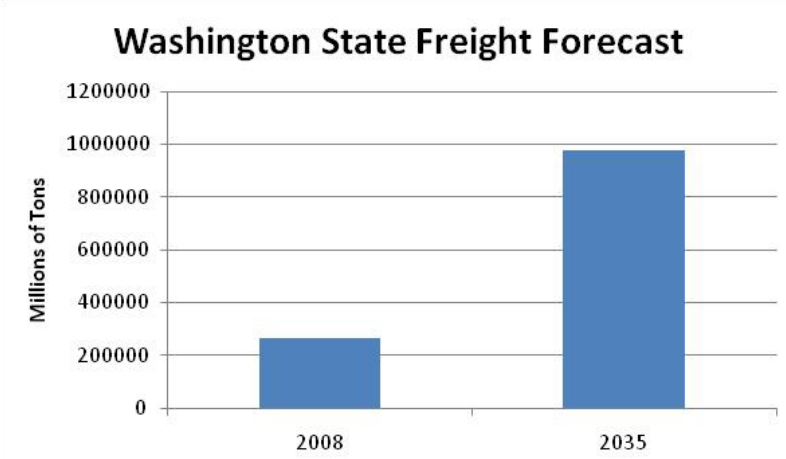



*Figure B.1. Washington freight volumes.*

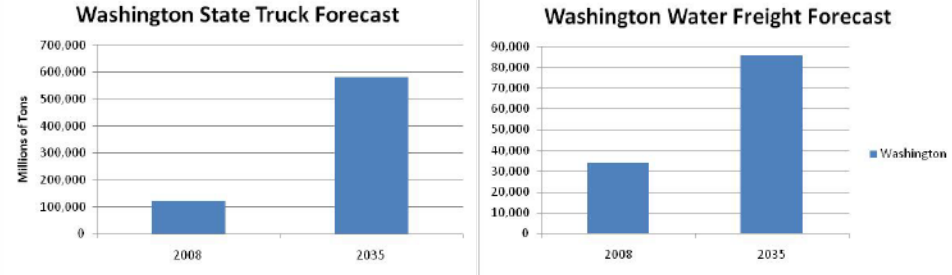
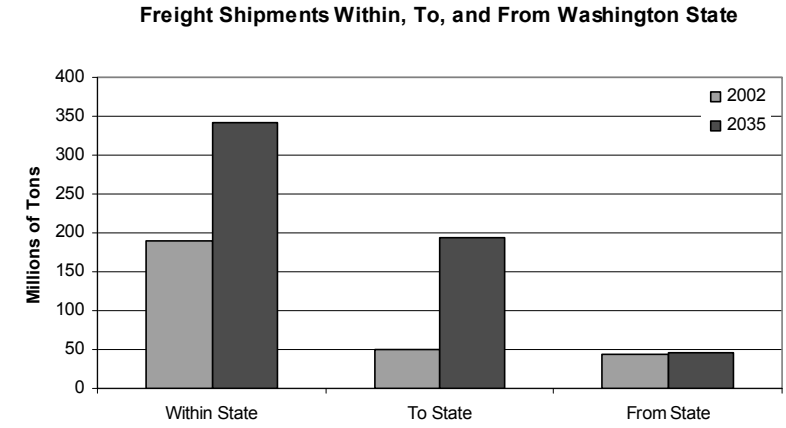



*Figure B.2. Washington truck and water freight forecasts.*




Source: Freight Analysis Framework

*Figure B.3. Washington truck freight forecast.*

year database was constructed from a wide variety of public sources, primarily the Commodity Flow Survey, while future projections are based on Global Insights' economic models.[5]

## Statewide Corridor Truck Travel Speeds

Figure B.4 displays the average travel rates along the Interstate 5 and Interstate 90 corridors in Washington during the month of October 2009 by three-mile segments. As is shown in Figure B.4, average travel speeds are less than 50 mph in several areas, including the Seattle metropolitan area and the U.S./Canada border crossing. Travel rates in the Seattle area are significantly affected by the I-5 and I-90 junction as well as by rush-hour passenger car traffic.

Figure B.5 displays the I-5 average truck travel rates (by 3-mile segment) in Washington during October 2009. As can be seen, travel rates deviate at several locations, including points within and north of the Seattle metropolitan region and at the U.S./Canada border crossing (mile markers 0–160 on this chart).

Figure B.6 displays the I-90 truck travel rates by 3-mile segment in Washington. The areas with lower average speeds are urban (Puget Sound region and Spokane).

Figure B.7 shows the average speeds for Washington data by month in 2009. Overall average truck speeds are lowest in January, July, and December.

Figure B.8 represents the average truck speed along the I-90 corridor in Washington by month in 2009. As can be seen, averages remained fairly constant across the year, with the exception of the December and January travel period, which may be weather related.

Figure B.9 represents the average speed by day of the week for Washington along the I-5 corridor. As can be seen, average travel rates decreased slightly during the week and rebounded over the course of the weekend.

## Statewide Truck-Involved Injury and Fatal Crashes

Injury crashes involved large trucks have declined, as seen in Figure B.10. It displays the number of large trucks[6] that

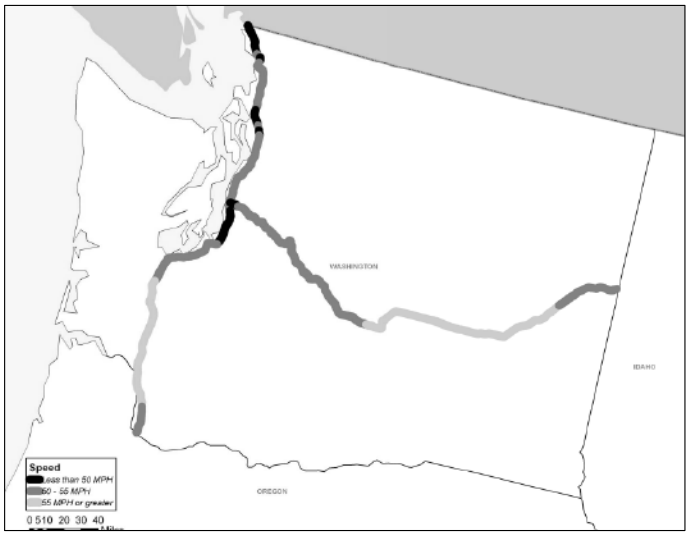



*Figure B.4. Average Interstate speeds statewide.*

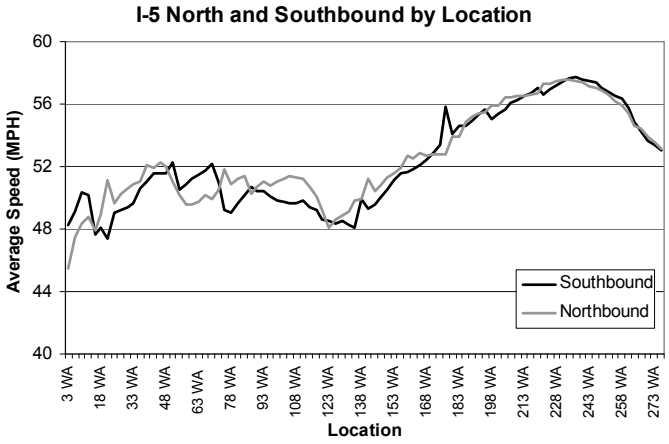



*Figure B.5. I-5 speeds, north and southbound statewide.*

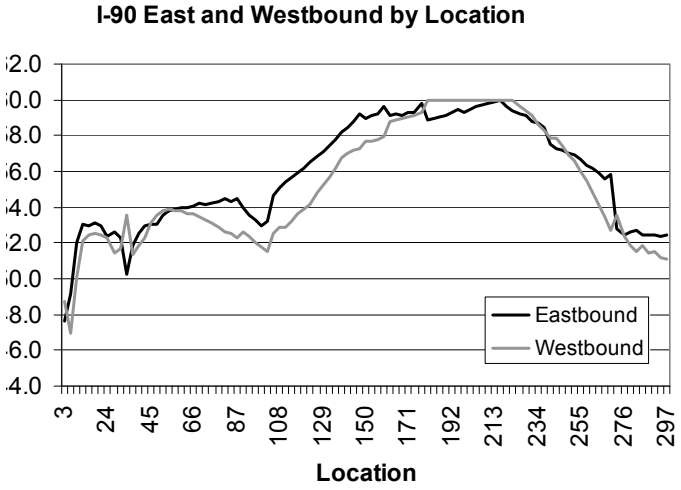



*Figure B.6. I-90 speeds.*

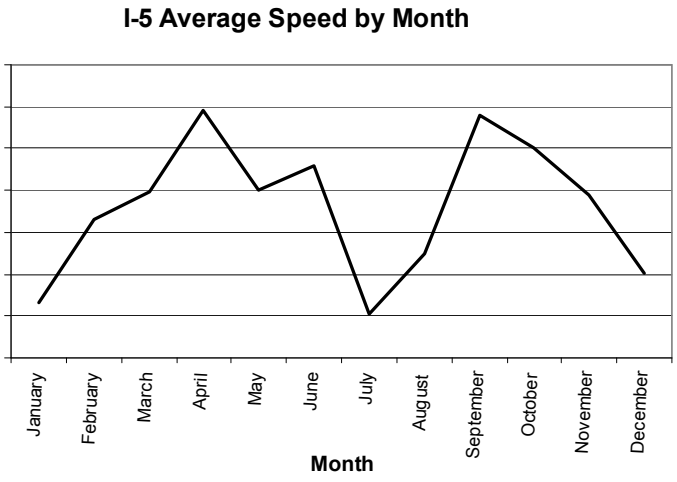



*Figure B.7. I-5 speeds.*

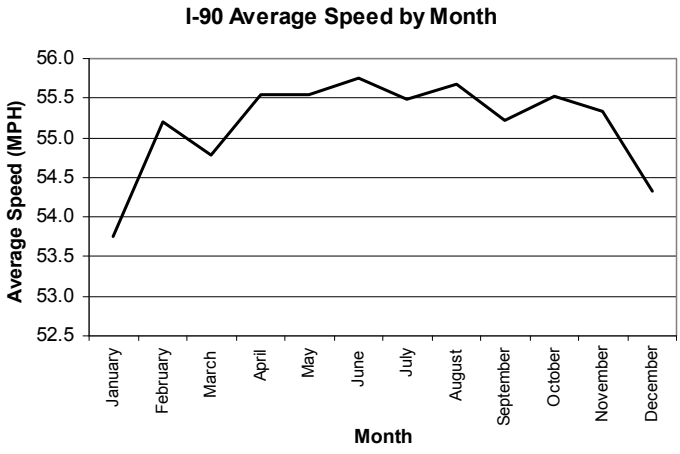



*Figure B.8. I-90 monthly trends, truck speeds.*

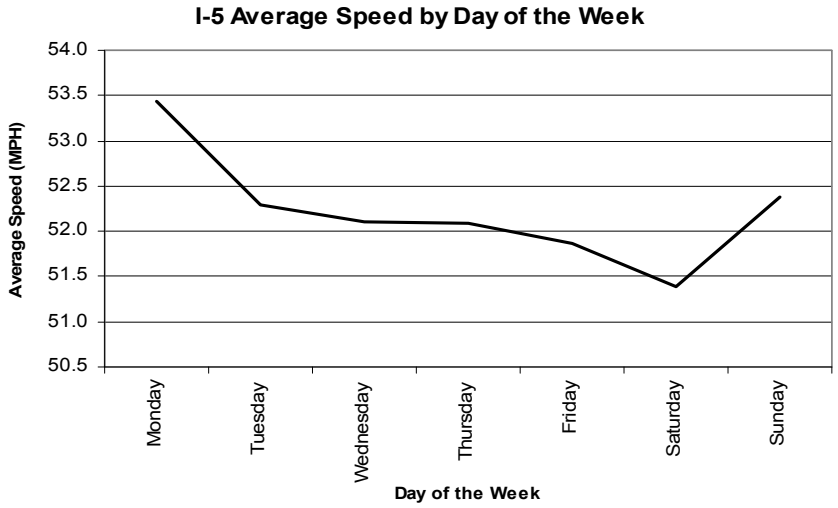



*Figure B.9. Speeds by day of the week.*

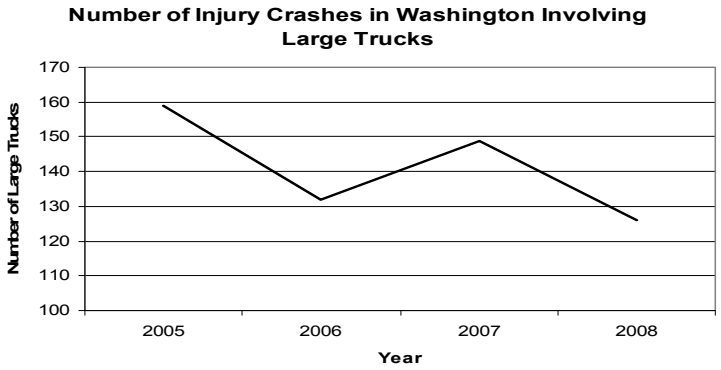



*Figure B.10. Injuries involving trucks.*

were involved in accidents that resulted in at least one injury in Washington. Injury crashes involving large trucks have declined slightly from the high of 159 accidents in 2005 to 126 accidents in 2008.

The number of large trucks involved in fatal crashes in Washington State is shown in Figure B.11. In 2008, there were 54 large trucks involved in fatal crashes in Washington. This number is reported by FMCSA but is generated using the Fatality Analysis Reporting System (FARS). The FARS database is maintained by NHTSA and includes data on all vehicle crashes in the United States that occur on a public roadway and involve a fatality.

Figure B.12 displays the number of fatalities resulting from crashes involving large trucks in Washington. In 2008, there were 55 fatalities resulting from large-truck-involved crashes. This number is generated using the FARS database and reported by FMCSA.

## Statewide Highway–Rail At-Grade Crashes

The Federal Railroad Administration (FRA) maintains records on highway–rail grade crossings and crossing accidents. A highway–rail incident is any impact between a rail user and a highway user at a crossing site, regardless of severity. This includes motor vehicles and other highway, roadway, and sidewalk users at both public and private crossings.

The FRA Office of Safety Analysis collects data on the number of highway–rail incidents. Data are collected on the county, state, and regional levels, date back to 1975, and are updated monthly.[7]

In the past fifteen years, the number of highway-rail at-grade incidents that have occurred in Washington has declined by approximately 50 percent (Figure B.13). In 2009, the number of incidents in the state was at its lowest point in over 10 years, with 32 incidents being reported.

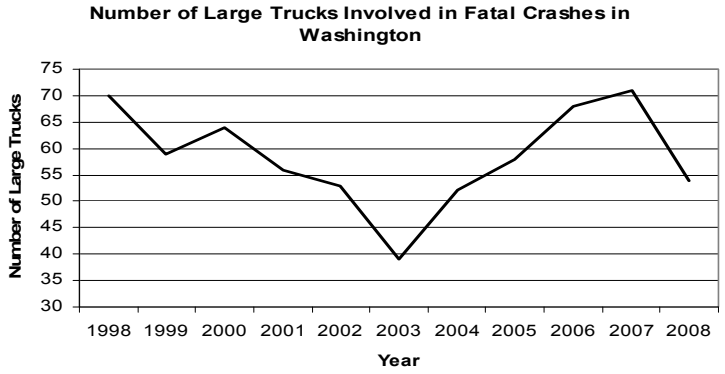



*Figure B.11. Washington State fatal crashes involving large trucks.*

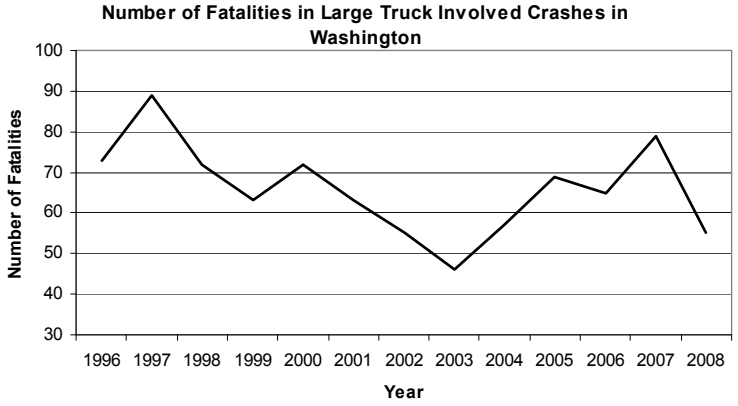



*Figure B.12. Number of fatalities involving truck crashes.*

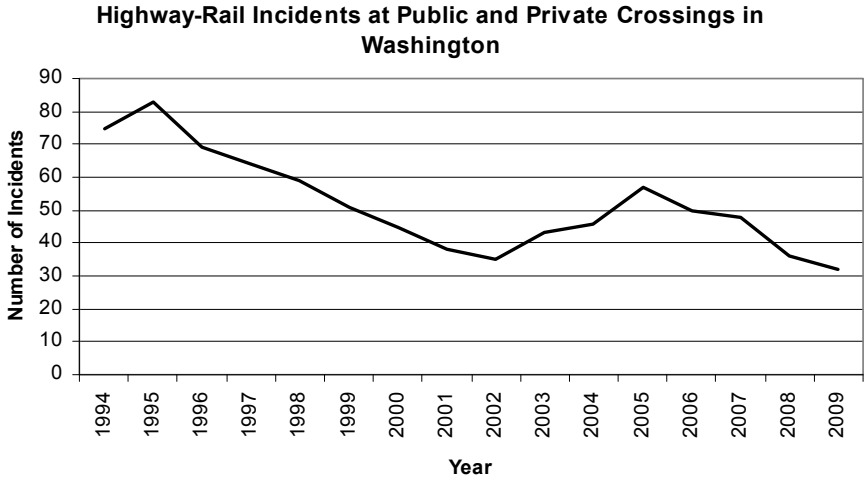



*Figure B.13. Highway–rail incidents in Washington.*

## Puget Sound Metropolitan Area Measures

The measures shown in this section represent the application of a representative sample of the national measures to a local area, in this case the Puget Sound Regional Council.

## Puget Sound Truck Corridor Travel Speeds

The same American Transportation Research Institute (ATRI) technology and methodology that was used in the national case study was applied to the Puget Sound region to measure truck travel times on major corridors. The intent is to allow the region's transportation officials to measure travel time performance on their major routes. Routes within the region could be compared to one another or compared to national performance. Figures B.14 to B.20 illustrate how travel time performance could be plotted by location, direction, time of day, day of the week, or month of the year. Projects and countermeasures could be deployed to address the locations and times of slowest truck travel times. Performance over time also could be tracked to measure rates of change, or the effect of countermeasures or projects.

Figure B.14 maps the average travel rates along the Interstate 5 and Interstate 90 corridors in Washington during the month of October 2009 by 3-mile segments. As is shown in Figure B.14, average travel speeds are less than 50 mph in several areas, including the Seattle metropolitan area and the U.S./Canada border crossing. Travel rates in the Seattle area are significantly affected by the I-5 and I-90 junction as well as peak-hour passenger car traffic.

The charts below, including Figure B.15, display the average truck travel rates (by 3-mile segment) in the Puget Sound region during October 2009. As can be seen, travel rates deviate at several locations, including points within and north of the Seattle metropolitan region and at the U.S./Canada border crossing.

Figure B.15 displays the I-5 truck travel rates by 3-mile segment in the Puget Sound region while Figure B.16 illustrates I-90's travel times. The areas with lower average speeds are urban.

Figure B.17 shows the average speeds for the Puget Sound Region by month in 2009. Overall average truck speeds are lowest in January, July, and December but vary by less than two miles an hour.

Figure B.18 represents the average truck speed along the I-90 corridor in the Puget Sound region by month in 2009. As can be seen, averages remained fairly constant throughout the year, with the exception of the December and January travel period, which is probably weather related.

Figure B.19 represents the average speed by day of the week for the Puget Sound region along the I-5 corridor. As can be seen, average travel rates decreased slightly during the week and rebounded over the course of the weekend.

Figure B.20 represents the average speed by day of the week along the I-90 corridor in the Puget Sound region in 2009.

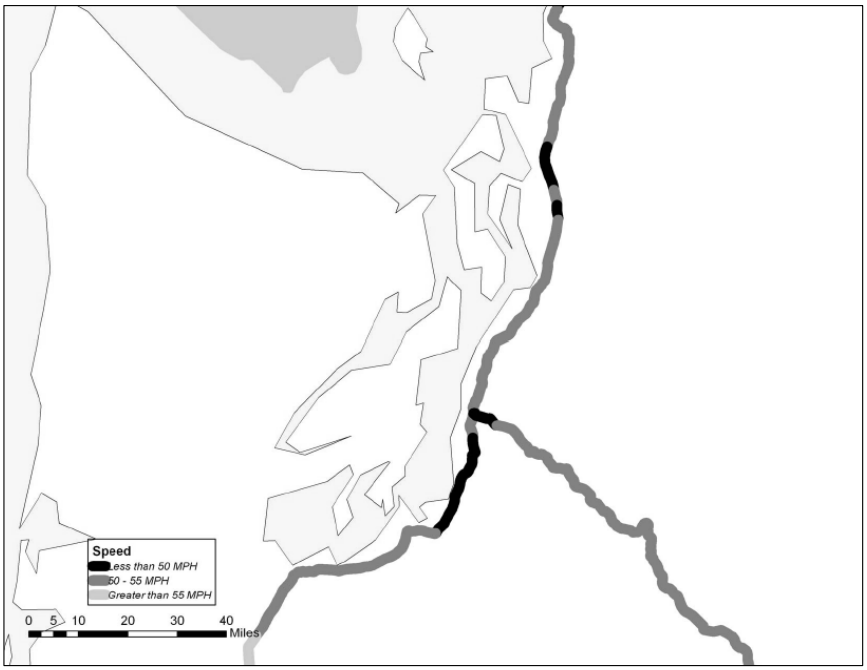



*Figure B.14. Travel speeds on the I-5 and I-90 Puget Sound corridors.*

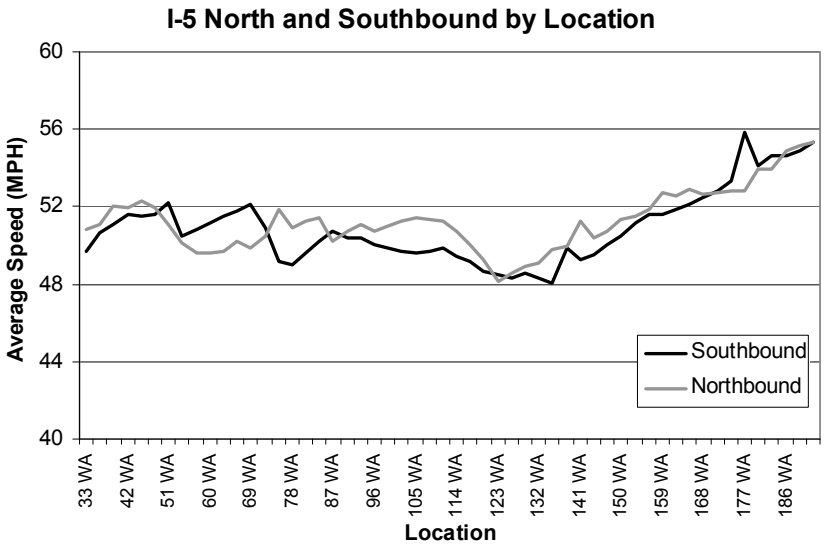



*Figure B.15. I-5 northbound and southbound average speed by location.*

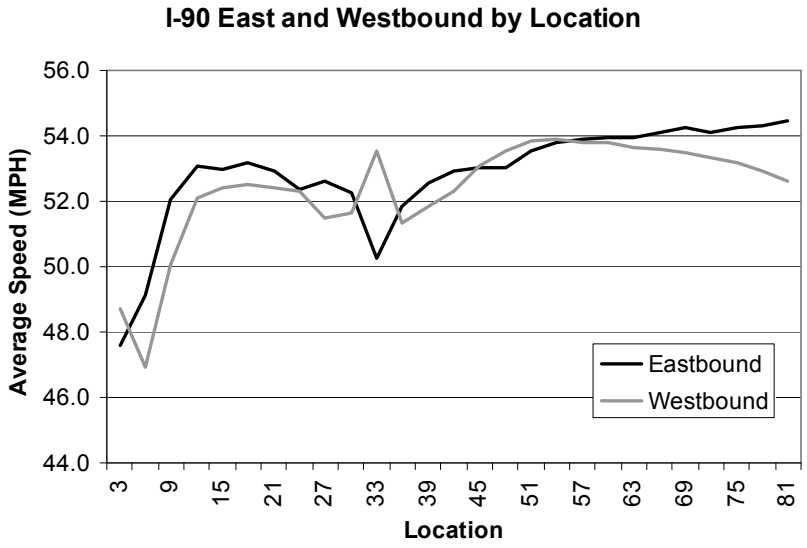



*Figure B.16. I-90 eastbound and westbound average speeds by location.*

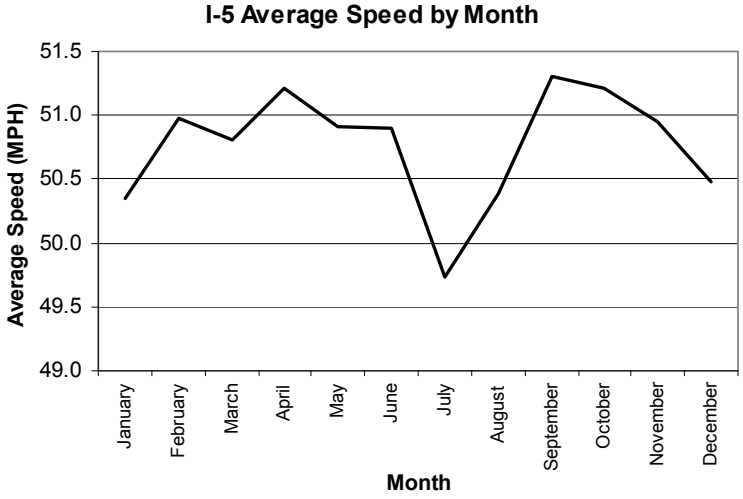



*Figure B.17. I-5 average speed by month.*

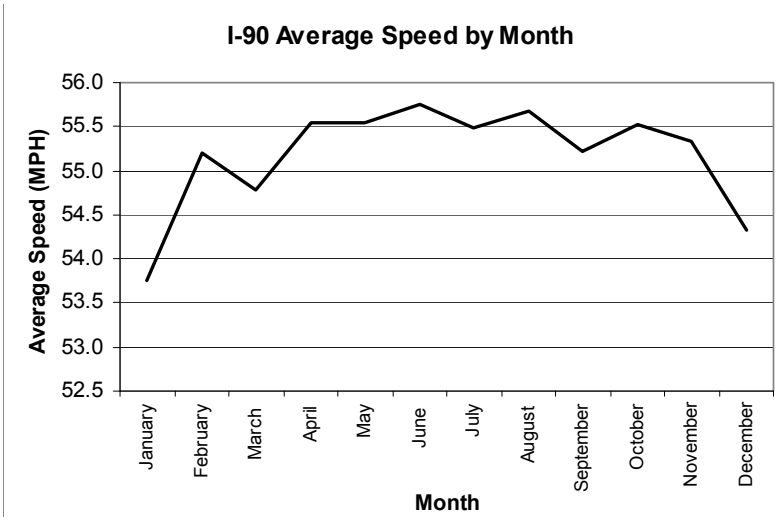



*Figure B.18. I-90 average travel speed by month.*

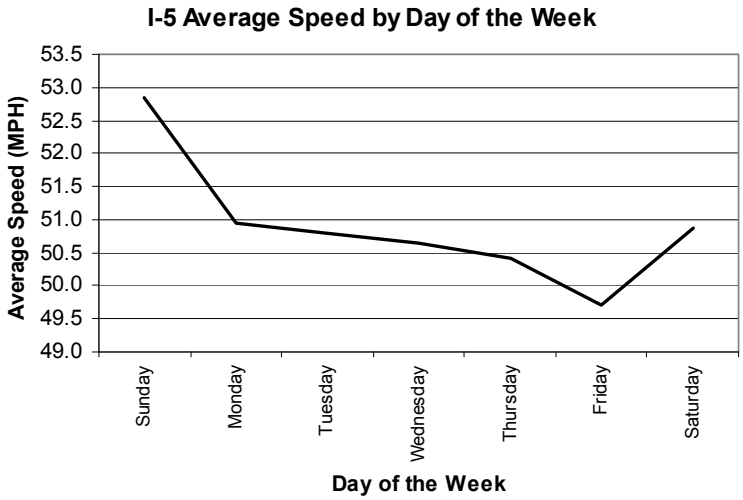



*Figure B.19. I-5 average speed by day of week.*

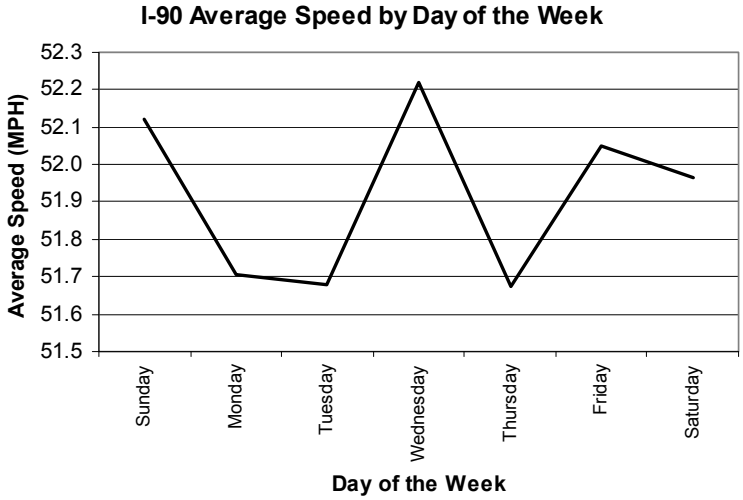



*Figure B.20. I-90 average speed by day of the week.*

## Localized Bottleneck Analysis

The following indicators quantify the severity of interstate congestion at locations within Washington. This is done through a calculation of the average speed of trucks operating in potentially high-congestion areas during 24 one-hour time periods during all weekdays in 2009.

FHWA, in partnership with ATRI, measured the average speed of trucks along selected Interstate corridors through the Freight Performance Measures (FPM) initiative. For this analysis, FPM researchers conducted an in-depth analysis using truck position and speed data that were derived from wireless onboard communications systems used by the trucking industry. The four basic steps in this analysis are as follows:

- Identification of study population: This step consists of extraction of data for commercial vehicles during all of 2009 at a specific location from a large, anonymous database;
- Application of data quality tools and techniques;
- Application of a four-step analysis process that utilizes vehicle time, date, and speed information; and
- Final production of total freight congestion values and ranking.

Figure B.21 and Table B.1 illustrate the travel times, ratio of peak to nonpeak speeds, and a congestion index. The index represents a multiplier of delay times the number of trucks.

The I-5/I-90 interchange in Seattle, Washington, is currently monitored by the FPM program; this location has a significant level of traffic congestion. The average speed for trucks at this location is 41 mph for weekday travel, and the peak hour speed falls to 35 mph.

The I-90/I-405 interchange, located in the Seattle, Washington, metropolitan area, is currently monitored by the FPM program; this location has a significant level of traffic congestion. The average speed during non-peak travel periods is 50 mph for trucks, and average speed during peak travel periods is 36 mph (see Figure B.22 and Table B.2).

The Seattle area I-90 "Floating Bridge" is currently monitored by the FPM program; this location has a moderate level of traffic congestion. Of the four freight bottlenecks identified in the Oregon–Washington region, the Floating Bridge has the lowest level of congestion (see Figure B.23 and Table B. 3).

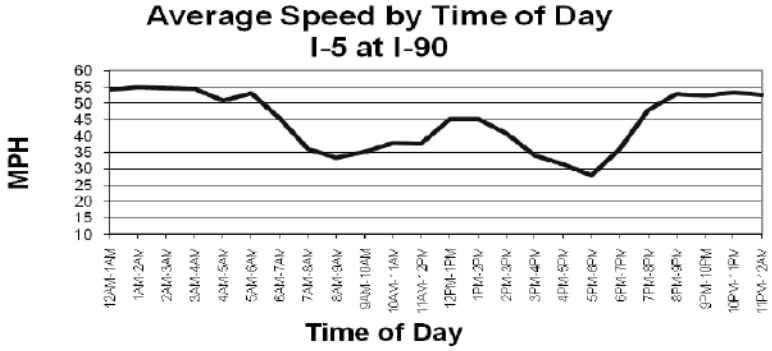



***Figure B.21. Time-of-day speed variability at the I-5/I-90 interchange.***

**Table B.1. I-5/I-90 bottleneck speeds.**

| I-5/I-90 Bottleneck Summary | |
|---|---|
| Average Speed | 41 |
| Peak Average Speed | 35 |
| Nonpeak Average Speed | 44 |
| Nonpeak/peak ratio | 1.25 |
| Congestion Index | 407,504 |

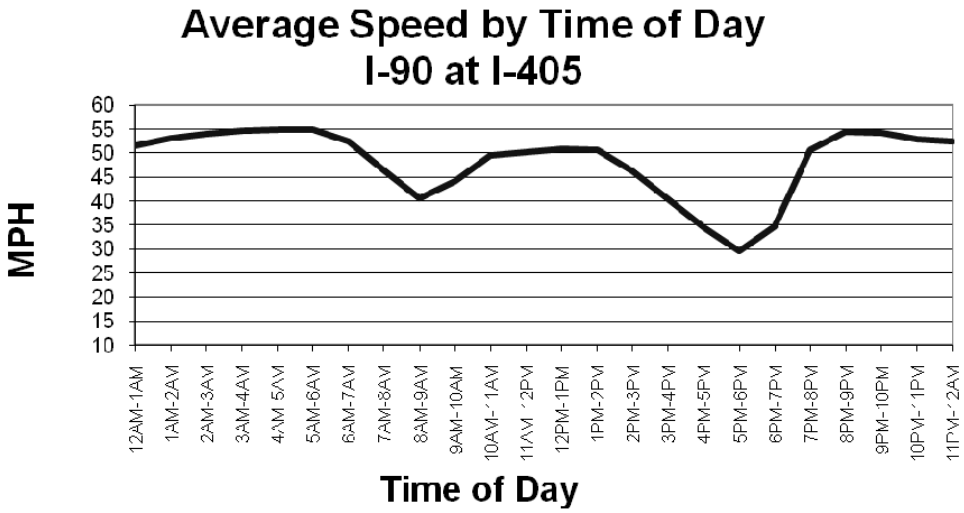



*Figure B.22. Puget Sound I-90/I-405 bottleneck.*

**Table B.2. I-90/I-405 bottleneck speeds.**

| I-90/I-405 Bottleneck Summary | |
|---|---|
| Average Speed | 46 |
| Peak Average Speed | 39 |
| Nonpeak Average Speed | 50 |
| Nonpeak/peak Speed Ratio | 1.27 |
| Congestion Index | 222,359 |

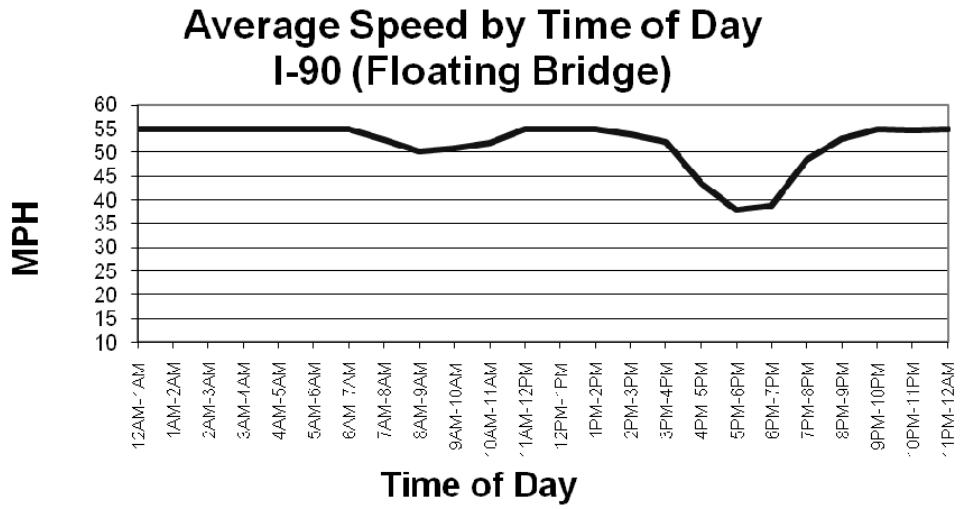



*Figure B.23. Puget Sound I-90 hourly travel time.*

**Table B.3. I-90 Floating Bridge bottleneck speeds.**

| I-90 Floating Bridge Bottleneck Summary | |
|---|---|
| Average Speed | 51 |
| Peak Average Speed | 46 |
| Nonpeak Average Speed | 53 |
| Nonpeak/peak Speed Ratio | 1.16 |
| Congestion Index | 19,052 |

Source: FHWA and ATRI, 2009 Bottleneck Analysis of 100 Freight Significant Highway Locations, Puget Sound Air Quality Measures.

## Localized Air-Quality Measures

The Puget Sound region's air-quality emission forecast mirrors national trends, with overall levels of transport-generated emissions expected to fall well below mandated levels, except for carbon dioxide ($CO_2$), which is the primary greenhouse emission (GHE). This trend reflects long-standing federal, state, and local efforts to control traditional air pollutants that generate smog, carbon monoxide, and particulates. However, government efforts to reduce GHE are only beginning.

The Puget Sound region is a "non-attainment" area for CO and PM 2.5. CO is carbon monoxide, a pollutant that tends to be localized, forming to harmful levels at locations such as depots and intersections where large numbers of vehicles idle or travel at low speeds. PM 2.5 are particulates smaller than 2.5 micrometers, or far less than the width of a human hair. They form from soot and other particles, particularly from diesel engine exhaust. The Puget Sound area is also an "attainment area" for the pollutants volatile organic compounds (VOCs) and nitrogen oxides ($NO_x$), which are the primary precursors of ground-level ozone or smog. Although VOCs and $NO_x$ levels are reported in Figure B.26, the Puget Sound region does not need to perform "conformity" analysis on its transportation programs to demonstrate that the VOCs and $NO_x$ generated by the transportation projects will comply with the region's emissions budget. The region does have to perform conformity analysis for CO and PM 2.5. The VOC and $NO_x$ emission numbers come from an environmental impact statement for the region's long-range transportation plan.

As seen in Figure B.24, the transportation programs for the three counties within the region are forecast to produce PM emissions well below the acceptable "emissions budget."[8]

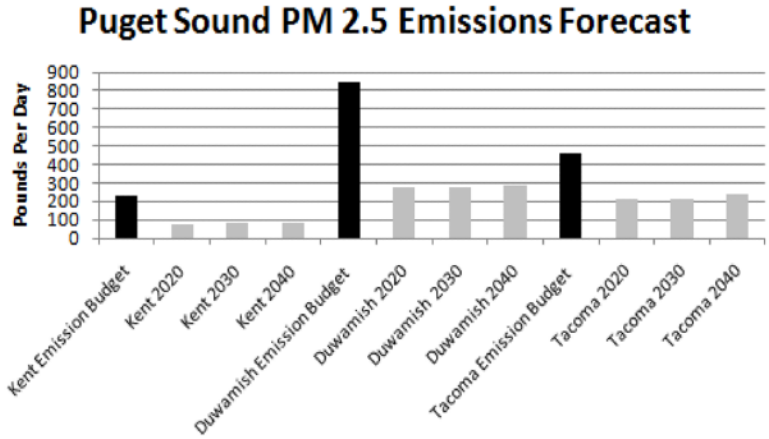



*Figure B.24. Particulate forecast.*

The black bar represents the budget for each county and the subsequent values are of the transportation PM emissions forecast for 2020, 2030, and 2040. The emission forecasts are derived from the travel outputs from the region's travel demand model, then used as input to EPA's emission model.

Similar procedures are used to model CO emissions. While the PM emissions are highly localized, the CO emissions are forecast and regulated on a county level. As seen in Figure B.25, CO levels are expected to be well below the emissions budget.[9] The emissions do rise measurably beyond 2016 because of forecast increases in vehicle miles of travel. Although CO emissions on a per-mile basis have fallen significantly, they are expected to rise somewhat because of overall travel growth although remaining well below the emissions budget.

As seen in Figure B.26, $NO_x$ and VOC emissions are expected to decline considerably as cleaner vehicles and cleaner fuels are incorporated into the region.[10] As vehicles in the fleet are replaced with newer ones, the per-vehicle emissions fall significantly and produce the forecasts seen in Figure B.26. The $NO_x$ emissions are produced disproportionately by diesel engines. Significant improvements in $NO_x$ emissions are largely attributed to much tighter $NO_x$ standards for newer diesel engineers and from low-sulfur diesel fuel which has been required. As a result, per-mile $NO_x$ emissions from the diesel fleet are declining dramatically.

In contrast to the reductions forecast and modeled for the traditional pollutants of CO, PM, VOCs, and $NO_x$, emissions for $CO_2$, which is a primary greenhouse gas, are expected to increase. The State of Washington has enacted an aggressive statute to significantly reduce vehicle miles traveled by 2050, but to date the statute has not resulted in mandatory long-term or interim milestone targets that are

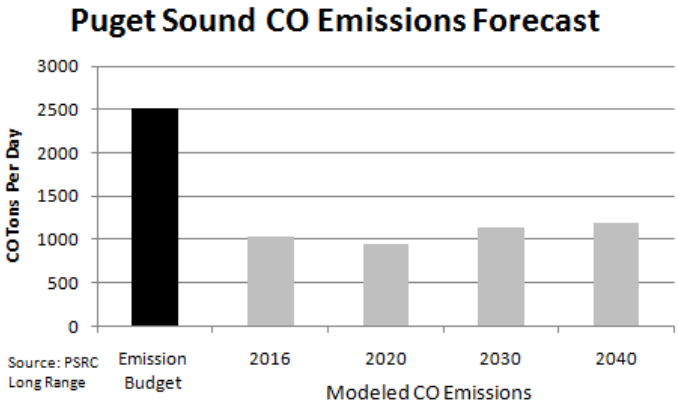



*Figure B.25. Transportation CO trends.*

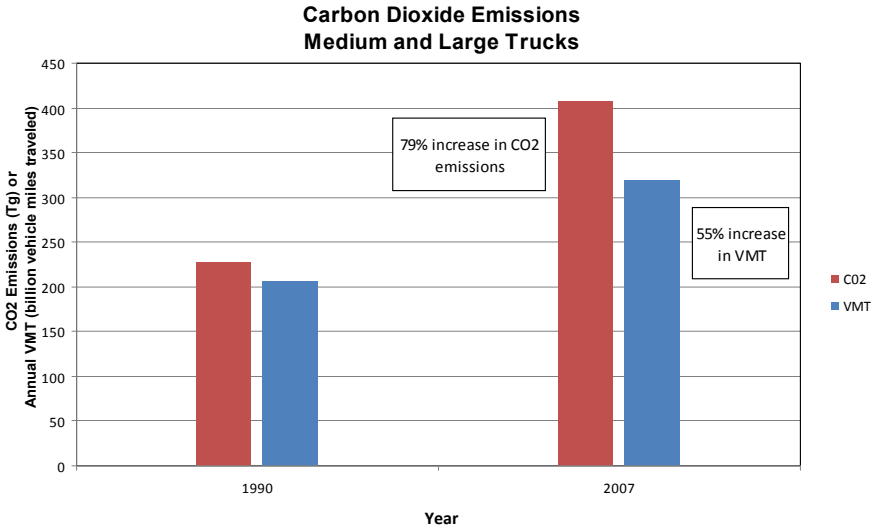



*Figure B.26. Transportation VOC and $NO_x$ trends.*

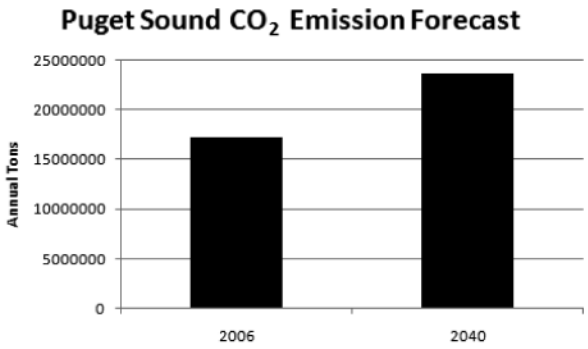



*Figure B.27. Rising carbon emissions.*

enforceable. Because carbon emissions are not yet controllable from current internal combustion engines, the rate of $CO_2$ production is forecast to increase as vehicle miles of travel increase. In the forecast in Figure B.27, the total VMT for the Puget Sound region is predicted to increase about 9 percent by 2040, resulting in a commensurate increase in $CO_2$.[11]

The above emission levels are for highway emissions only. There are no comparable conformity analyses for aviation, water, or rail modes. Within the emission burdens and budgets, freight emissions are not isolated for the conformity analyses. Freight's contribution to the overall emissions varies by pollutant. Diesel engines were disproportionate producers of $NO_x$ and particulates, with the automotive fleet producing most of the CO and VOCs emissions. However, stringent new controls on new diesel engines and the removal of sulfur from diesel fuel has contributed to the significant reduction in those emissions produced by trucks.

## Puget Sound Region Highway–Rail At-Grade Crashes

FRA maintains records on highway–rail grade crossings and crossing accidents. A highway–rail incident is any impact between a rail and a highway user at a crossing site, regardless of severity. This includes motor vehicles and other users of highways, roadways, and sidewalks at both public and private crossings.

The FRA Office of Safety Analysis collects data on the number of highway–rail incidents. Data are collected on the county, state, and regional levels, date back to 1975, and are updated monthly.[12]

In the last 15 years, the number of highway–rail at-grade incidents that have occurred in Washington State has declined significantly (Figure B.28) from a high of 81 incidents in 1995. In 2008 and 2009, the number of incidents in the area was at its lowest point in over 10 years.

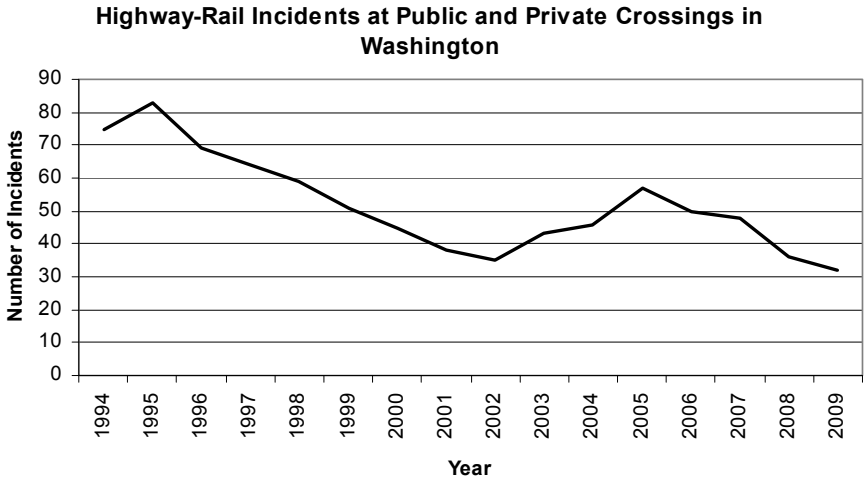



*Figure B.28. Highway–rail incidents in the Puget Sound region.*

## Endnotes

1 Tons are defined as short tons (2,000 pounds) in the FAF.
2 The tonnage of freight can be, and often is, counted multiple times depending on the production and consumption cycle of the freight (Source: FAF2.2).
3 FAF2.2, Origin–Destination Data and Documentation.
4 FAF2.2, Origin–Destination Data and Documentation. http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_com.htm.
5 IHS Global Insight used proprietary tonnage estimates coupled with proprietary economic and freight models to calculate future growth rates and tonnage increases.
6 Large trucks are defined as trucks with a gross vehicle weight rating (GVWR) of 10,000 pounds or more.
7 FRA, Office of Safety Analysis. http://safetydata.fra.dot.gov/OfficeofSafety/Default.aspx.
8 Figure B.24 is based on "Table 2-$PM_{10}$ Analysis Results," Puget Sound Regional Council, "Appendix E: Air Quality Conformity." *Transportation 2040: The Long-Range Metropolitan Transportation Plan of the Central Puget Sound Region*, March 4, 2010, p. 9.
9 Figure B.25 is based on "Table 1-CO Analysis Results," Puget Sound Regional Council, "Appendix E: Air Quality Conformity." *Transportation 2040: The Long-Range Metropolitan Transportation Plan of the Central Puget Sound Region*, March 4, 2010, p. 9.
10 Figure B.26 is based on "Exhibit 6-8. Emissions (annual tons)," Puget Sound Regional Council, "Appendix E: Air Quality Conformity." *Transportation 2040: The Long-Range Metropolitan Transportation Plan of the Central Puget Sound Region*, March 4, 2010, pp. 6–21.
11 Figure B.27 is based on "Exhibit 6-8. Emissions (annual tons)," Puget Sound Regional Council, "Appendix E: Air Quality Conformity." *Transportation 2040: The Long-Range Metropolitan Transportation Plan of the Central Puget Sound Region*, March 4, 2010, pp. 6–21.
12 FRA, Office of Safety Analysis. http://safetydata.fra.dot.gov/OfficeofSafety/Default.aspx.

APPENDIX C

# State-Level Freight Performance Measures: State of Practice

## Freight-Specific Performance Measurement

State departments of transportation's (DOTs') use of freight performance metrics generally has lagged significantly behind the use of metrics for other aspects of the transportation system. State DOTs generally use measures that are easily obtained from existing data sources, such as travel time (in heavily traveled freight corridors), safety (including tracking truck crashes), and pavement condition (in heavily traveled freight corridors). A common strategy for state DOTs that have used freight performance measures is to focus on a "vital few" tied to a broader planning and decision-making processes, or to use surrogates, such as travel time in freight corridors. The travel time measured is often for all vehicles, and not specifically trucks.

Depending upon the definition used, it is debatable whether many of the freight metrics that state DOTs report actually are performance measures or are more generic indicators. The General Accountability Office (GAO) definition of performance measures considers them to be metrics relating to a specific government program or target, as opposed to indicators of trends. Many of the metrics reported by the state DOTs related to freight include both measures related to specific programs or targets and others that are indicators of overall system trends, such as increases in freight volumes.

Early in the past decade, the few state DOTs that attempted to measure freight performance relied on measures of transportation industry productivity that are not clearly linked to the performance of the highway system or on measures of highway system performance that are important to highway users in general but not specifically linked to freight.[1] A report for the FHWA Office of Freight Operations and Management identified 13 potentially valuable indicators using the following evaluation criteria:

- **Descriptive value.** Is the indicator clear and understandable for a range of audiences? Does it communicate clearly, or does it require a detailed explanation in order to be understood?
- **Technical appropriateness.** How useful is the indicator in describing the productivity of freight movement in the United States? Is it conceptually appropriate as a measure of productivity or a measure of FHWA's contribution to productivity?
- **Data availability.** Are data available in existing databases? If data are available, are they easy to collect, or are there difficulties in obtaining the data? Are there new ways to develop or collect the data?
- **Data cost.** How expensive would it be to collect the appropriate data?

The results of this screening are shown in Table C.1.

The screening and evaluation led to recommendation of the following seven indicators for further development by FHWA:

1. Cost of highway freight per ton-mile;
2. Cargo insurance rates;
3. Point-to-point travel times on selected freight-significant highways;
4. Hours of delay per 1,000 vehicle miles on selected freight-significant highways;
5. Crossing times at international borders;
6. Condition of connectors between the National Highway System (NHS) and intermodal terminals; and
7. Customer satisfaction.

No rigid scoring methodology was used for the selection of recommended indicators. These measures were selected in an evaluation process that balanced the inherent value of an indicator as a measure of performance against the difficulty and cost of obtaining the necessary data. In general, the measures that were recommended are those that ranked highest in terms of descriptive value and technical appropriateness.

A literature review from this project identified more than 360 potential freight performance measures. The large majority of them were only suggested measures in research projects. A smaller number were measures in use by state DOTs, by a federal modal agency, or by a federal agency that regulates some aspect of freight externality, or they were measures reported by a freight trade association. Typical of measures suggested in the research literature were the 277 potential measures suggested in NCHRP Project 8-32(2), entitled *Multimodal Transportation: Development of a Performance-Based Planning Process.*[2] They were grouped into categories such as accessibility, mobility, travel time, safety, and economic development.

## Freight Performance Measures Guide

Performance-based planning uses quantitative or qualitative indicators that rely on data or information to explain the influence of freight on safety, the environment, and other transportation factors. The Freight Performance Measures Guide[3] identifies Texas, Minnesota, and New Jersey as states that have made notable progress in using freight performance measures by developing detailed freight plans with goals and objectives that are evaluated on the basis of the information derived by freight performance measures. Oregon and California have included freight performance measures in their general transportation plans. Examples of measures that exist today include freight volumes measured by trucks per day or percentage of trucks in daily traffic counts. The Minnesota DOT uses freight performance measures to describe travel reliability, safety, and infrastructure performance. The measures are used to support planning efforts.

**Table C.1. Examined measures.**

| Indicator | Descriptive Value | Technical Suitability | Data Availability | Data Cost |
|---|---|---|---|---|
| Cost per Ton-Mile | 3 | 3 | Easy | Low |
| Fuel Consumption of Heavy Trucks per Ton-Mile | 1 | 2 | Easy | Low |
| Cargo Insurance Rates | 2 | 2 | Easy | Low |
| On-time Performance | 3 | 1 | Difficult | High |
| Point-to-Point Travel Times on Freight-Significant Highways | 2 | 3 | Not easy | Medium to High |
| Hours of Delay on Freight-Significant Highways | 2 | 3 | Not easy | Medium to High |
| Incident Delay on Freight-Significant Highways | 2 | 3 | Not easy | High |
| Ratio: Peak Travel Time to Off-Peak Travel Time | 1 | 2 | Not easy | High |
| Ratio: Variance to Average for Peak Trip Times | 1 | 2 | Not easy | High |
| Annual Miles per Truck | 2 | 1 | Easy | Low |
| Border Crossing Times | 3 | 2 | Not easy | Medium |
| Conditions on Intermodal Connectors | 2 | 2 | Not easy | High |
| Customer Satisfaction | 2 | 3 | Difficult | High |

Source: Hagler Bailly, Inc.

Minnesota has incorporated freight performance measures into its statewide transportation plan and statewide freight plan.[4] It includes freight performance measures for trucking, rail, waterways, air cargo, and intermodal facilities. The plan summarizes both existing performance measures identified in the statewide transportation plan and new measures identified for the freight plan. Rail performance measures identified include percentage of major generators with appropriate rail access, total crashes at at-grade rail crossings (three-year average), number of truck-related fatalities at at-grade rail crossings (three-year average), percentage of rail track-miles with track speeds greater than 25 mph, and percentage of rail track-miles with 286,000-pound railcar capacity rating. Measures for air cargo, waterways, and intermodal facilities are also identified. Performance measures related to trucking include:

- Percentage of miles of highway that meet "good" and "poor" ride quality targets;
- Percentage of townships, counties, and municipalities along interregional connectors whose adopted local plans and ordinances support interregional corridor (IRC) Management Plans and Partnership studies;
- Percentage of interregional connectors and bottleneck removal projects identified in the 10-Year Program for which right-of-way needs have been protected;
- Clearance time for incidents, crashes, or hazardous material incidents;
- Snow and ice removal clearance time;
- Percentage of major generators with appropriate roadway access to IRCs and major highways;
- Peak-period travel time reliability on IRCs and other high-use truck roadways;
- Ratio of peak to off-peak travel time;
- Miles of peak-period congestion per day;
- Heavy-truck crash rate;
- Number of heavy-truck-related fatalities (three-year average); and
- Benefit of truck weight enforcement on pavement service life.

The Iowa DOT freight-related performance measures include highway crash rate per million vehicle miles for large trucks, total crashes at rail–highway crossings, and railroad derailments per million ton-miles.[5] Freight efficiency measures include the percentage of Iowa rail carriers earning a reasonable return on investment and average rail revenue per ton-mile. The quality-of-life performance measures identify approximate travel times to major external markets in the Midwest Region, percentage of railroad track-miles able to handle 286,000-pound cars, percentage of railroad track-miles able to operate at 30 mph or more, and rail fuel use per ton-mile.

Washington State DOT's *Grey Book* includes a handful of freight performance measures. It reports on truck volumes on state highways, number of truck border crossings, rail freight tonnage, and container shipments through state ports.

The Missouri DOT *Tracker* includes 111 measures, of which five relate to freight: freight tonnage by mode; percentage of trucks using advanced technology at weigh stations; interstate motor carrier mileage; percentage of satisfied motor carriers; and customer satisfaction with timeliness of Motor Carrier Services response. The customer satisfaction ratings focus upon users' satisfaction with service received from the Motor Carrier Services office.

## Summary of State Measures

Although the research literature identified hundreds of potential freight performance measures, in practice the minority of states that have freight performance measures use only a handful. Mature performance measurement states such as Washington, Missouri, and Minnesota use between 5 and 10 measures. It was noticeable that no two states had the same measures, and in most cases there were wide differences in the metrics. Although states reported freight performance metrics, most of the metrics were not used to calibrate performance of specific state programs. Exceptions were customer satisfaction with Missouri's motor carrier office. Generic measures such as travel time in freight-significant corridors were likely a contributing factor to state efforts to improve overall travel times. However, it appeared to be rare that any state DOT freight performance measure was used to make frequent decisions. Most of the measures appear to be indicators of broad trends of overall transportation system performance.

## Endnotes

1 FHWA, Office of Freight Management and Operations. *Measuring Improvements in the Movement of Highway and Intermodal Freight*, prepared by Hagler-Bailly, 2000. http://ops.fhwa.dot.gov/freight/freight_analysis/measure_rpt.htm (accessed May 20, 2010).

2 Cambridge Systematics, Inc. *NCHRP Web Document 26: Multimodal Transportation: Development of a Performance-Based Planning Process*, Transportation Research Board, National Research Council, Washington, D.C., 1999.

3 R. Harrison, M Schofield, L. Loftus-Otway, D. Middleton, J. Harrison, 2006, *TxDOT Project 0-5410: Developing Freight Highway Corridor Performance Measure Strategies in Texas*, pp. 19–25.

4 Minnesota DOT, Office of Freight and Commercial Vehicle Operations. *Minnesota Statewide Freight Plan*, prepared by Cambridge Systematics, Inc. and SRF Consulting Group, Inc., 2005.

5 Iowa DOT. *Performance Measures for Iowa Transportation Systems*, prepared by Iowa State University, Center for Transportation Research and Education, 2006.

APPENDIX D

# National-Level Performance Measures: State of Practice

## RITA's Key Transportation Indicators

The Bureau of Transportation Statistics (BTS) within the Research and Innovative Technology Administration (RITA) produces a monthly report entitled *Key Transportation Indicators.* The report includes both passenger and freight information derived from RITA's and BTS' extensive data sources, as well as sources from other federal agencies. The full list of indicators is in Table D.1

## Transportation Services Index

Among the monthly indicators is the Transportation Services Index (TSI), which tracks both passenger and freight volumes as part of a moving index pegged to January 2000 as a base year. The TSI allows the observation of total freight and passenger services nationally from that base point, back to 1990 and forward to present. An expanded discussion of the TSI occurs later in this appendix. TSI is used as a case study because it is analogous to the effort envisioned for the freight performance measurement research project.

Five of the measures are directly related to freight: the TSI freight volume index, rail freight revenue ton-miles, U.S.-Canada-Mexico surface trade, inland waterway delay, and freight rail yields. Others, such as gasoline and diesel prices and transportation employment, are indirectly related.

Figure D.1 captures the operating yield, or revenue, per ton-mile of rail freight. This is a way of showing the average price paid by freight rail users. Yields break down into costs (such as fuel and labor) and profits associated with rail operations, which may vary by commodity hauled and geography. Its source is RITA.[1] In Figure D.2 are continental surface trade statistics.[2]

**Table D.1. RITA indicators.**

| RITA Key Transportation Indicators | | |
|---|---|---|
| Transportation Services Index | Air Travel Price Index | Jet Fuel Prices |
| Major US Carrier On-Time | Retail Diesel Prices | Gasoline Prices |
| Vehicle Miles Travelled | Amtrak Ridership | Railroad Fuel Prices |
| Rail Freight Revenue Ton Miles | Amtrak On-Time | Amtrak Revenue |
| US-Canadian-Mexico Surface Trade | Personal Spending on Transportation | Transportation Employment |
| Inland Waterway Delay | Transit Ridership | Airline Passengers |
| US Airline Revenue-Passenger Miles and Load Factor | Amtrak Ticket Prices and Yields | Freight Rail Yields |

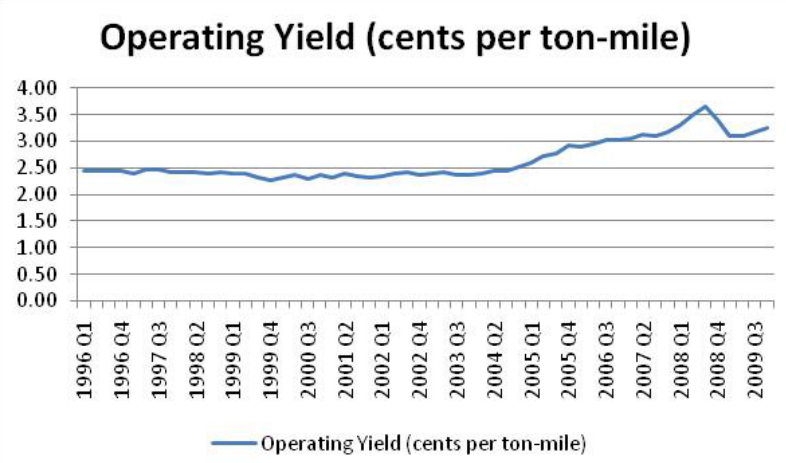



***Figure D.1. Railroad yields.***

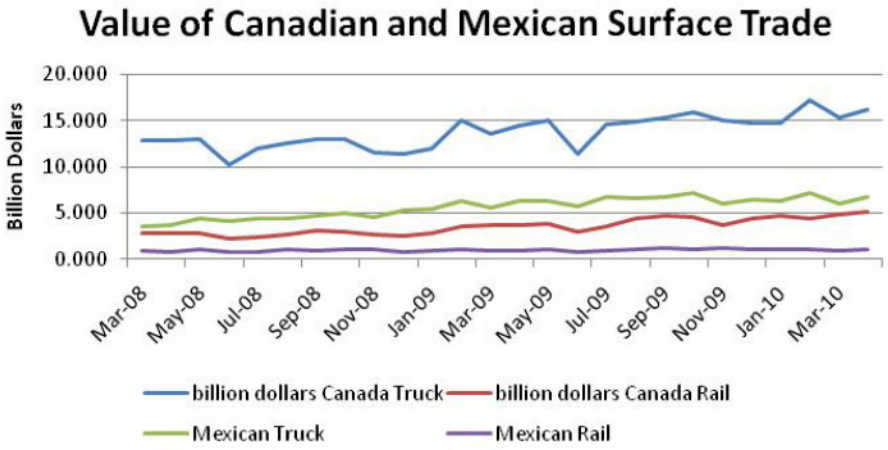



***Figure D.2. Canadian and Mexican trade figures.***

## Endnotes

1 BTS. Calculations based on Surface Transportation Board, Office of Economics, Environmental Analysis, and Administration, *Quarterly Earnings Reports*, http://www.stb.dot.gov/ (accessed April 2010).

2 USDOT, RITA, BTS. *TransBorder Freight Data*, http://www.bts.gov/ntda/tbscd/prod.html (accessed April 2010).

APPENDIX E

# Modal Freight Performance Measures: State of Practice

## Mode-Specific Performance Measures

At the national level, significant volumes of data are collected to measure many aspects of freight system performance. Collecting freight-related data are all of the modal agencies of the U.S. Department of Transportation, including the FHWA, the Federal Railroad Administration (FRA), the Federal Motor Carrier Safety Administration (FMCSA), the Maritime Administration (MARAD), the FAA, the National Highway Transportation Safety Administration (NHTSA), and the Surface Transportation Board (STB). The U.S. Army Corps of Engineers (USACE) collects performance data on the national marine transportation system. The U.S. Environmental Protection Agency (EPA) tracks and regulates mobile emissions, including those of trucks, ships, railroads, and aircraft. The U.S. Department of Commerce monitors imports, exports, and many categories of commercial output. The complexities of using data from these different sources are discussed below in the data quality of this appendix.

### Highway Infrastructure Condition Measures

The Highway Performance Monitoring System provides data that reflect the extent, condition, performance, use, and operating characteristics of the nation's highways. It was developed in 1978 as a national highway transportation system database and includes limited data on all public roads, more detailed data for a sample of the arterial and collector functional systems, and certain statewide summary information. The data are sample based and therefore do not provide data regarding every highway link. Also, speed and reliability data are estimated, making the data unsuitable for examination of individual links.

The National Bridge Inventory compiles bridge inspection data on the nation's bridges as reported by the state and local governments. It reports conditions in terms of Functional Obsolescence and Structural Deficiencies. The National Bridge Inventory is bridge specific.

The Fatality Analysis Reporting System includes state-by-state data on crashes by type, including those involving trucks.

### Trucking Performance Measures

Trucking-specific performance data in the public domain remain insufficient for many policy, investment, and operational decisions, according to some.[1] State transportation agencies usually generate actual or estimated average daily traffic volumes for trucks, but other important information, such as truck origins and destinations, remains expensive and intrusive for them to collect. Traditional means for gathering such information have involved stopping trucks and interviewing drivers or giving them a questionnaire. Often such surveys were conducted only once a decade, or less frequently.

A need for improved truck freight performance data has led to efforts to use existing commodity-flow data and to exploit emerging technologies. The Freight Analysis Framework (FAF), a FHWA-led initiative, analyzes commodity-flow information to produce estimates of overall freight volumes, as well as estimated origins and destinations. An FAF guidebook[2] describes several means by which capacity-related measures could be estimated, including:

- Traffic volume,
- Capacity,
- Volume-to-capacity ratios,
- Average speed,
- Travel time, and
- Link delay.

Efforts to use GPS data to improve truck-movement information began in 1999 with an investigation of the use of onboard devices to monitor the trucking industry's use of roadways.[3] This research was limited, however, to the number of participating drivers and companies, and by equipment costs.

To further research the idea of using wireless truck position data to determine metrics related to demand for roadways, Short and Jones[4] analyzed several million truck movements across the U.S. interstate system. It was shown that a ranking of demand for groupings of 3-mile segments (i.e., hundreds of segments falling across entire interstate corridors) could be determined, thus identifying a potential complement to the FAF information described earlier. The research has produced robust travel-time and travel-reliability information on the Interstate Highway System (IHS) and has identified major truck-freight bottlenecks.[5]

Using this source, the following methods for producing freight performance measures have been developed:

*Use of Multiple Unique Truck Positions to Measure Speed:* Using this method, truck position pairs for individual/unique vehicles are matched, and a time/distance calculation is made to determine average travel rates. The end results are calculations along broad corridors (e.g., Interstate 10 from Jacksonville, FL, to Santa Monica, CA). A database of such calculations is updated monthly and measures 27 U.S. interstate corridors. Measurements can focus on specific regions, times of day, and days of the week.

*Measuring Border Crossing and Bottleneck Delay:* Delay is measured at border crossings and other points, such as highly congested bottlenecks, by measuring travel time across such points.

*Spot Speed Measures:* Speeds can also be measured for specific urban areas and highway intersections that are highly congested. The end result includes measures such as average speed in a geographic location by hour of day, which identifies peak times of freight congestion/delay.

The rate at which trucks move and thus the time it takes to travel given distances is a common indicator of issues such as congestion and delay. Measuring such issues through the use of travel-time and travel-rate information can produce the following types of metrics:[6]

- Travel time or difference in travel times (minutes or seconds)
- Travel rate (travel time divided by travel distances)
- Delay rate (minutes per mile)
- Total delay (person hours, vehicle hours)
- Relative delay rate (delay rate divided by acceptable travel rate
- Delay ratio (delay rate divided by actual travel rate)
- Miles of congested roadway
- Miles of congested travel

## Reliability

Reliability of truck movement, as the term implies, is an indicator of how likely a roadway will perform in a certain way during a given period of time. As would be expected, trucking companies often prefer roadways that perform in a reliable manner so that they can plan routes/deliveries and accurately estimate costs. Such factors can play a role in meeting delivery windows and scheduling required hours of service and rest periods.

Three methods are commonly used for determining reliability of travel: statistical range, buffer time measures, and tardy trip indicators:[7]

> Statistical Range: This can be described as a Travel Time Window, Percent Variation, or Variability Index, all of which can be applied to freight movement.
>
> Buffer Measures: These can be considered as "time allowance," and measures include Buffer Time, Buffer Time Index, and Planning Time Index.
>
> Tardy Trip Indicators: These indicators measure "the unreliability impacts using the amount of late trips." Included in this category are the Florida Reliability Method, which measures travel time during the peak, On-Time Arrival measures, and the Misery Index, which measures the most-congested 20 percent of travel periods.

FHWA[8] offers two methods for measuring reliability. The first, shown in Figure E.1, is named the Travel Time Index, which compares peak period and free-flow travel conditions.

The second method is the Buffer Time Index, which "expresses the amount of extra 'buffer' time needed to be on-time 95 percent of the time (late one day per month)."[9]

FHWA defines travel time reliability "as how much travel times vary over the course of time." Thus, when measuring the reliability of truck movements, truck-specific information can be analyzed to determine similar travel-time variability (over a specific time period) for all or part of the trucking industry.

The calculation of reliability measures specifically for trucks is demonstrated as shown in Figure E.2.[10] The buffer time was "calculated for travel across entire corridors [e.g., Interstate 10], for each of the 100-mile segments of the corridor, and travel across every combination of each of the 100-mile segments of a corridor."

## Operational Costs

Beyond speed, delay, and reliability, several performance measures look at the cost of production. A first measure is cost per mile. The American Trucking Associations (ATA) 2003 *Motor Carrier Annual Report*[11] lists the key elements of a cost-per-mile calculation for trucking. This includes the following in approximate order of magnitude:

- Other wages and benefits
- Equipment rents and purchased transportation
- Driver wages
- Miscellaneous
- Fuel and fuel taxes

$$\text{Travel Time Index} = \frac{\left(\frac{\text{Freeway Travel Rate}}{\text{Freeway Free - flow Rate}} \times \text{Freeway Peak Period VMT}\right) + \left(\frac{\text{Principal Arterial Street Travel Rate}}{\text{Principal Arterial Street Free - flow Rate}} \times \text{Principal Arterial Street Peak Period VMT}\right)}{\left(\text{Freeway Peak Period VMT} + \text{Principal Arterial Street Peak Period VMT}\right)}$$

*Figure E.1. Travel Time Index.*

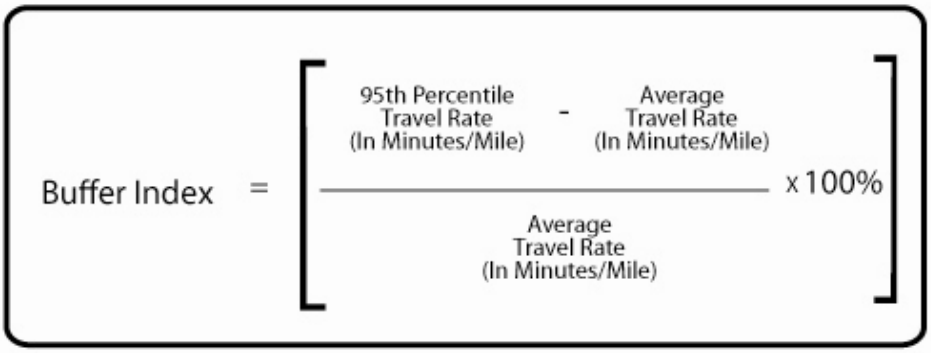



*Figure E.2. Buffer Index from Freight Performance Measures Initiative.*

- Depreciation
- Insurance
- Outside maintenance
- Tax and license
- Tires

## Measurement of Safety Performance for Trucks

Truck safety measures can be calculated in several ways. ATA[12] identifies the number of fatal crashes annually as a safety measurement for the entire industry and places the measure into two categories:

- Total Annual Large-Truck Fatal Crashes
- Large-Truck Fatal Crash Rate Per 100 Million VMT

Such statistics are typically sourced from reports such as the FMCSA *Large Truck Crash Facts 2005*, which develops measures from data sources such as FARS, NHTSA's General Estimates System (GES), and FMCSA's Motor Carrier Management Information System (MCMIS).[13] FMCSA organizes crash statistics into four sections, which are described as follows:

- Number of crashes;
- Number of vehicles involved in crashes;
- Number of people involved and resulting fatalities and injuries; and
- Number of drivers involved.

FMCSA addresses the cost of highway crashes that involve medium and heavy trucks with estimates for the following measures:

- Cost of crashes involving longer combinations;
- Cost of straight truck crashes;
- Cost of "property damage only" crashes;
- Cost per crash involving a nonfatal injury; and
- Cost per crash involving a fatality.

## Economic Measures, Forecasting, and Other Private-Sector Trucking Performance Measures

Although much of the truck-specific economic forecasting that is produced is related to growth in truck tonnage and other freight sectors, the trucking industry does follow the economic forecasts for a variety of non-freight industries, especially manufacturing. ATA's *U.S. Freight Transportation Forecast* tracks trends and forecasts in manufacturing, construction, agricultural commodities, mining, and non-oil merchandise imports.

## Private-Sector Summary

Key private-sector performance measures are produced by ATA and listed in *Trucking Trends*. These measurements include the following:

Commodity/ Commodity Flow Information: The statistics followed by the industry in this category focus mainly on how freight is moved (i.e., percentage by truck, rail, air), as well as the value of and type of goods shipped.

Trucking Company Failures: The number of trucking company failures that occur in a given time period is an indicator of industry performance. Trends in the number of failures can help measure the impact of other forces on the trucking industry, such as high fuel prices or an economic slowdown.

Tonnage Growth: ATA has a For-Hire Truck Tonnage Index that measures the decline or growth in freight hauled by the industry on an annual basis, as well as percent changes in the tonnage index itself.

Revenue Growth: For-Hire Trucking Revenue is also measured as an index, as well as the percentage change in the index itself.

Revenue per Mile and Revenue per Ton: Both revenue per mile and per ton of freight shipped are indexed on an annual basis.

Trucking Producer Price Indices: The Producer Price Index for segments of trucking are used to track the change in prices for trucking services in general, and specifically for truckload carriers, less-than-truckload carriers, local delivery, and long-distance trucking (as well as other segments).

Other Financial and Operating Statistics: USDOT typically releases financial and operating data collected through Form M, which is a required reporting document for carriers with $3 million or more in annual revenue. These data and the performance measures derived from the data have not been released by USDOT since 2003.

## Rail Performance Measures

The American Association of Railroads (AAR) has since 1999 published performance measures for the Class I railroads. On its website (http://www.railroadpm.org/) it reports weekly updates on train travel speeds, cars on line, and dwell times of Norfolk Southern, CSX, Union Pacific, BNSF, Kansas City Southern, and Canadian Pacific Railway. It notes that, despite using common methodology, one railroad's performance metrics should not be compared to another's. It notes that performance can be affected by differences in network terrain, railroad design, the mix of traffic, the effect of passenger operations, and external factors such as weather and port operations. It also notes that each railroad's calculation methodology of each measure also can vary.

The performance measures allow train speeds to be measured by train type, such as intermodal, grain, coal, or double stack. It allows dwell times to be observed at major yards. It also tracks cars on the system by the various types of cars such as box, intermodal, or hopper cars. Historical performance data are available for the past 53 weeks.

AAR reports that the railroads agreed over a series of years to consolidate their performance reporting for public convenience. AAR states that it is unaware of the cost to the railroads of generating the measures because each railroad contributes its data from its internal reporting mechanisms.

### Surface Transportation Board Data

STB requires voluminous reporting data from the U.S. railroads, much of which could be used to develop performance measures at the national level. The data generally are aggregated from proprietary sources and are therefore not available at a local or regional level. Some of the data sources are described below.

### Waybill Data

STB requires U.S. railroads to report sample waybill data, which is reported in a public form that has been purged of proprietary information. It contains information regarding origin and destination of cargo, types of commodities shipped, numbers of cars, tons and revenue, and length of haul. These data could be translated into various performance measures of rail volume, commodity shipment types, or other measures.[14]

### Railroad Earnings

The economic health of railroads is measurable from the earnings reports that the publicly traded and publicly regulated railroads must report. These reports track gross revenues, net operating revenues, revenue ton-miles, and net income. In addition, the corporate annual reports required by the Securities and Exchange Commission provide detailed information on the economic performance of the railroads.[15]

### Railroad Statistics

More than 1,500 categories of statistics are reported for each of the Class I railroads in the *Statistics of Class I Freight Railroads* report. These data, required by STB, include uniform reporting of income, expenses, investments in track, equipment investments, and depreciation by various categories. These data were last published in 2004.[16]

### Cost of Capital

STB[17] makes an annual calculation of whether the Class I railroads have earned income that exceeds their cost of capital, which for 2007 was determined to be 11.3 percent. For 2008, it determined that the NS and Soo Line, or Canadian Pacific, railroads earned more than their cost of capital. All other Class I railroads were found to be either revenue "adequate" or "inadequate."

### Rail Safety Data

The Federal Railroad Administration Office of Safety Analysis[18] website (http://safetydata.fra.dot.gov/officeofsafety/) provides search and query tools to conduct analyses of railroad crashes. The query tools link to federal crash databases that allow for analysis of crashes by railroads, state, crash types, and localities. Links to individual crash reports are provided.

## Aviation Performance Measures

The air transportation industry has been measure-intensive for decades, with both private carriers and the FAA carefully evaluating key measures of reliability, safety, and service. Annually, beginning in FY 2004, FAA developed an

aggressive strategic plan to help manage and measure performance. Its *Flight Plan* provides the framework to match resources with initiatives for long-term change. This report sets forth goals and the performance measures to assess progress in meeting them and is tightly aligned with the mission, vision, goals, and performance measures outlined in the DOT Strategic Plan.

The *Flight Plan* highlights performance measures, and conducts analysis on each measure to determine whether the data were complete and reliable enough to measure appropriately. Within this report performance measures are grouped in the broad categories of Safety, Capacity, International Leadership, and Organizational Excellence.

Table E.1 provides an overview of measures used by FAA and highlights whether or not the performance measures were met.

## Waterborne Freight Performance Measures

MARAD produces an annual *Statistical Snapshot*[19] that provides nearly 20 categories of water-freight-related statistics. The statistics address freight volumes, ports of entry and export, commodity trends, numbers of ships and containers involved, measures of trade, measures of employment in the industry, and measures of the economics of waterborne shipping. It is useful to assess general trends in port volumes and activity (Table E.2).

Analogous to the highway mode, in which data exist for traffic volumes but not for highway performance to the same extent, there are little available data on port performance. Port volumes are measured, but information is not available as to how ports have accommodated the growth in container volume in past decades.

In its *Report to Congress on the Performance of Ports and the Intermodal System*[20] MARAD noted that a lack of common performance measures and the lack of a reporting process have stymied its attempts to measure the efficiency of major U.S. ports. It informed Congress that it was unable to assess congestion levels at ports or to assess the performance of the nation's intermodal system overall:

> MARAD was unable to provide the requested comparison of the most congested ports in terms of operational efficiency due to a lack of consistent national port efficiency data. Given the diverse characteristics of U.S. ports, comparing port efficiency

**Table E.1. FAA statistics.**

| Table 10 Measure | Actual | Target | |
|---|---|---|---|
| | Data | Data | Index Range |
| **10S1 Commercial Air Carrier Fatality Rate (FAA)** | - | - | Green |
| **10S2 General Aviation Fatal Accident Rate (FAA)** | 0.0 | 8.1 | Green |
| **10S2 General Aviation Fatal Accident Rate (FAA)** | 1.09 | 1.02 | Red |
| **10S3 Alaska Accident Rate (FAA)** | 2.55 | 1.70 | Red |
| **10S4 Runway Incursions (Category A and B) (FAA)** | 0.12 | 0.45 | Green |
| **10S6 Commercial Space Launch Accidents (FAA)** | 0 | 0 | Green |
| **10S7 Operational Errors (FAA)** | 3.24 | 2.05 | Red |
| **10S59 Safety Management System (FAA)** | 3 | 3 | Green |
| **10S105 Total Runway Incursions (FAA)** | 409 | 446 | Green |
| **GREATER CAPACITY 10 (FAA)** | - | - | Green |
| **10C1 Average Daily Airport Capacity (35 OEP Airports) (FAA)** | 101.354 | 102,648 | Yellow |
| **10C2 Airport Average Daily Capacity (7 Metro Areas) (FAA)** | 42.494 | 39,484 | Green |
| **10C3 Annual Service Volume (FAA)** | 3 | 3 | Green |

Table E.1. Continued.

| Table 10 Measure | Actual | Target | |
|---|---|---|---|
| 10C4 Adjusted Operational Availability (FAA) | 398.78 | 99.7 | Green |
| 10C5 NAS On-Time Arrivals (FAA) | -99.78 | 88.00 | Yellow |
| 10C6 Noise Exposure (FAA) | 089.69 | 3 | Green |
| 10C7 Aviation Fuel Efficiency (FAA) | 3 | 3 | Green |
| INTERNATIONAL LEADERSHIP 10 (FAA) | 3 | - | Green |
| 10I2 CAST Safety Enhancements (FAA) | 1- | 4 | Red |
| 10I7 International Aviation Development Projects (FAA) | 3 | 3 | Green |
| 10I23 NextGen Technology (FAA) | 2 | 1 | Green |
| 10I40 Aviation Leaders (FAA) | 1 | 1 | Green |
| ORGANIZATIONAL EXCELLENCE 10 (FAA) | - | - | Green |
| 10E2 Cost Control (FAA) | 3 | 3 | Green |
| 10E3 Critical Acquisitions on Budget (FAA) | 100 | 90 | Green |
| 10E4 Critical Acquisitions on Schedule (FAA) | 96 | 90 | Yellow |
| 10E5 Information Security Program (FAA) | 3 | 3 | Green |
| 10E6 Customer Satisfaction (FAA) | 3 | 3 | Green |
| 10E61 OPM Hiring Standard (FAA) | 3 | 3 | Green |
| 10E102 Reduce Workplace Injuries (FAA) | 3 | 3 | Green |
| 10E104 Unqualified Audit Opinion (FAA) | 2 | 3 | Yellow |
| 10E107 Grievance Processing Time (FAA) | 3 | 3 | Green |
| 10E108 ATC Positions Workforce Plan (FAA) | 15,812 | 15,639 | Green |
| 10E226 Continuity of Operations (FAA) | 0 | 0 | Green |
| 10E231 Aviation Safety Positions Workforce Plan (FAA) 7 | 7,171 | 7,195 | Green |
| *STRATEGIC OBJECTIVES (FAA) | 0 | 0 | Green |

Source: FAA 2010 Performance Targets, http://www.faa.gov/about/plans_reports/performance/quarter_scorecard/media/FY10%202nd%20Quarter%20Scorecard.pdf.

would require the creation of new methodologies and the collection of data that were not available for this report.

To generate its report for Congress on port performance, MARAD formed four teams of researchers who interviewed officials and representatives at 23 major U.S. ports. It stressed that, to assess port operations, it needed to interview port officials, port labor representatives, shippers, ship operators, and truckers, and it had to assess the infrastructure related to highways, rail, water, and the intermodal transfer points between the modes.

The MARAD report noted a wide variety of issues—both operational and infrastructure related—that can influence efficient port operations:

**Table E.2. Port volumes.**

| Port | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | % Change 2003-08 |
|---|---|---|---|---|---|---|---|
| LA/LB | 47.8 | 53.6 | 57.1 | 66.5 | 69.7 | 69.8 | 46 |
| New York | 22.1 | 23.6 | 26.8 | 27.8 | 29.9 | 31.9 | 44.3 |
| Savannah | 10.5 | 11.6 | 13.6 | 14.5 | 17.1 | 18.7 | 78.1 |
| Houston | 15.9 | 14.6 | 15.3 | 16.3 | 17.6 | 18.4 | 15.7 |
| Seattle/Tacoma | 12.6 | 14.5 | 18.3 | 17.6 | 18.9 | 17.9 | 42.1 |
| Norfolk | 10.2 | 10.1 | 10.9 | 11.9 | 12.3 | 12.9 | 26.5 |
| S. Francisco | 8.4 | 9.6 | 10.9 | 11.4 | 11.7 | 11.8 | 40.5 |
| Charleston | 9.9 | 10.8 | 12.1 | 11.2 | 11.3 | 10.9 | 10.1 |
| Miami | 7.7 | 8.5 | 9.7 | 9.3 | 8.8 | 8.3 | 7.8 |
| N. Orleans | 4.1 | 5.0 | 4.6 | 5.5 | 6.0 | 5.7 | 39.0 |
| Top 5 | 109.0 | 117.8 | 131.0 | 142.7 | 153.2 | 156.7 | 43.8 |
| Top 10 | 149.2 | 161.8 | 179.1 | 192.2 | 203.2 | 206.2 | 38.2 |
| Total | 174.0 | 187.6 | 205.8 | 220.6 | 231.6 | 235.1 | 35.1 |
| *Source: US Bureau of Census, Foreign Trade Division www.census.gov/foreign-trade* | | | | | | | |

Source: US Bureau of Census, Foreign Trade Division, www.census.gov/foreign-trade.

The greatest concerns for both commercial operations and military deployments were the surge in cargo flows into the ports, the adequacy of cargo staging areas in the ports, port rail infrastructure, and communications. Additional issues that dominated commercial operations were landside access to ports, highway signage, channel and port dredging, increasing cargo volumes, financing, and intermodal connectivity. Two additional major concerns specific to military deployments were training and coordination among ports and shippers.

While there were a wide variety of themes in response to MARAD's questions, there was much agreement on the most urgent congestion and infrastructure issues facing the MTS [Maritime Transportation System]. About half the ports cited specific reasons for congestion that cause infrastructure overload. One fourth of the ports described their infrastructure impediments as "severe." The responses mirror the concerns raised in recent DOT, Government Accountability Office (GAO), and non-government studies on MTS issues.

MARAD advised Congress that, although a variety of potential port efficiency performance measures could be adopted, few of the potential measures had universal acceptance because of the large diversity in port operations:

> In preparing this report, MARAD reviewed articles and studies from the academic and scientific communities that set forth methodologies for measuring port efficiency. The literature reviewed supported MARAD's finding that there is no widespread agreement on an approach to measuring the efficiency of a port as a link in the logistics chain. A 2004 article in Maritime Policy & Management states: "Measures of port efficiency or performance indicators use a diverse range of techniques for assessment and analysis, but although many analytical tools and instruments exist, a problem arises when one tries to apply them to a range of ports and terminals. Ports are very dissimilar and even within a single port the current or potential activities can be broad in scope and nature, so that the choice of an appropriate tool of analysis is difficult. Organizational dissimilarity constitutes a serious limitation to enquiry, not only concerning what to measure but also how to measure. Furthermore, the concept of efficiency is vague and proves difficult to apply in a typical port organization extending across production, trading and service industries.[21]

MARAD listed the following considerations that influence a port's efficiency and could skew an attempt to make comparisons between ports:

- Type of cargoes handled by the port (specialization);
- Location of port relative to shippers' markets (regional demand);
- Price of port services relative to shippers' alternative ports;

- Waterside access limitations;
- Carrier investment in port infrastructure;
- Quality of port services;
- Business realignment to increase purchasing power; and
- Availability of national government subsidies.

MARAD noted "Factors That Affect Port Efficiency":

- Labor efficiency (cargo moved per unit of labor);
- Land use efficiency (cargo storage per unit of land);
- Waterside access limitations;
- Capacity of port road and rail connections;
- Inland transportation availability; and
- Cargo handling capability.

It went on to say that the diversity of factors prevents the general measurement of port efficiency. It quoted Cullinane[22] as saying that there is even a lack of standard terminology between ports as to how define measures, with different ports using different terminology to describe similar functions. It quoted Robinson[23] as saying that port efficiency measures "will always have a national tendency to be terminal specific." It quoted De Monie[24] as saying that the following factors impede measurement of port efficiency:

- The sheer number of parameters involved;
- The lack of up-to-date, factual, and reliable data, collected in an accepted manner and available for dissemination;
- The absence of generally agreed and acceptable definitions;
- The profound influence of local factors on the data obtained; and
- The divergent interpretation given by various interests to identical results.

## MARAD Strategic Plan and Performance Measures

MARAD has a strategic plan with embedded performance measures for the years 2008–2015.[25] Its measures support its five basic strategic goals, which are:

- Improve maritime policies and programs to enrich and secure the nation.
- Expand reliable private and public investment funding mechanisms to support the growth of the Marine Transportation System.
- Revitalize the partnerships between the Maritime Administration and the Marine Transportation System's private and public stakeholders.
- Enhance the U.S. intermodal transportation system.
- Maximize the potential of each employee to achieve the agency's mission.

Its Strategic Plan includes a cascading series of outcomes, strategies, key performance indicators, and performance measures. The performance measures are included in the agency budget documents and link expenditures with effectiveness. Two examples are the number of out-of-service ships that are dismantled in an environmentally sustainable way and the number of communities MARAD engages to enlist their help in improving the Maritime System. The MARAD measures evaluate internal agency performance and not the performance of ports, intermodal links, or actual shipments.

Its more extensive lists of key performance indicators do relate to many aspects of national concern regarding shipping performance and security. However, it notes they are not quantitative, nor do they have a measurement system related to them. They are of a more qualitative nature. They include issues such as increased outreach to public and private sectors, increased private investment in the Maritime System and adoption of best practices in managing port facilities to maximize throughput.

## Inland Waterways

USACE's Navigation Economics Technology Program[26] produces a suite of analytic tools for the Corps to evaluate possible investments in the inland waterways system. It has produced a report, *An Overview of the U.S. Inland Waterway System*, that provides baseline information on the domestic inland system. It includes statistics on the size and characteristics of the waterways, locks, ports, and commodity flows on the system. The data are extensive but static and are not subject to regular updates. The Corps also produces a website with significant amounts of performance data regarding waterborne commerce and the conditions of locks and dams[27] (Figure E.3).

RITA produces in its *Key Transportation Indicators* monthly report a moving average of delay on the inland waterway system.[28]

## Time Series Analysis of U.S. Inland Waterways Trade

BTS[29] publishes monthly trend data on the shipment of commodities on U.S. inland waterways. Aggregate data are normalized to adjust for seasonal variations but do not provide granularity as to types of commodities shipped, or by origins and destinations.

## European Union Transport Policy for 2010

The European Union has not adopted freight performance measures per se but it has adopted firm goals that arise from

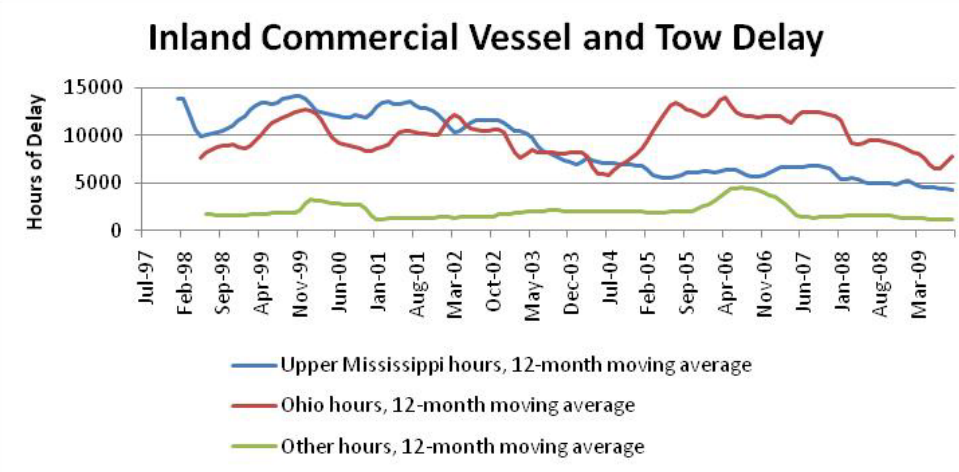



***Figure E.3. Inland waterway volumes.***

its freight-transport policies. The EU example represents a clear case of performance goals selected specifically to achieve a formal, official transportation policy.[30] Its 2001 White Paper proposed approximately 60 measures to develop a transport system capable of shifting the balance between modes by reducing the growth in truck freight, revitalizing rail transport, encouraging in-land and short sea shipping, and controlling the rate of growth in air travel.

In a 2006 assessment of the 2010 White Paper goals, the EU noted mixed progress. Highway freight still carried 44 percent of freight tonnage, compared to 8 percent for rail and 4 percent for inland waterways. For passengers, 79 percent of travel was on roads, compared to 6 percent for rail and 5 percent for air. The number of cars trebled between 1970 and 2000 and continues to grow, particularly in the former Eastern Bloc members, which are rapidly developing. Between 1995 and 2004, highway freight grew 35 percent compared to 6 percent for rail freight.[31]

A recent European research program conducted for the Dutch Ministry of Transport, Public Works and Water Management has shown that the EU so far has not succeeded in achieving its passenger mode-shift goals and has had only partial success on its freight goals. The Dutch study proposed a renewed emphasis on pricing to discourage highway travel and increase travel on rail and water modes. It also proposed the acceleration of biofuels and hydrogen to achieve air quality and greenhouse gas emissions goals that have not been achieved so far by the mode-shift strategy.[32]

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APPENDIX F

# Environmental Freight Performance Measures: State of Practice

## Introduction

The environmental impacts of freight performance can be captured in several ways. Air-quality emissions can be estimated for trucking, rail, air, and waterborne freight through several extrapolations and interpolations conducted by EPA. Hazardous material releases attributed to trucking and rail accidents or spills are tracked through FMCSA and FRA. The energy use by sector is captured by several agencies. From federal energy use data a "carbon footprint" can be calculated. Localized impacts, such as petrochemical runoff from depots or contaminated ballast releases from ships, are not subject to standardized national reporting and will not as easily lend themselves to calculating national performance measures until new reporting mechanisms are established.

## Greenhouse Gas Emissions Measures

Presently there are no national performance measures for freight-related greenhouse gas emissions (GHE). However, there are estimates that could be monitored as general measures of the trends related to GHE generated by the freight sector. EPA generates these estimates by multiplying fuel-use data by the emission factors generated from several sources.[1] These factors are developed by EPA and then used by the states and metropolitan planning organizations when they conduct "conformity" analyses. A conformity analysis is a modeled estimate of whether the emission burden generated by transportation sources is within, or "conforms" to, the total allowable transportation emissions allowed for that region. The conformity models used by states and metropolitan planning organizations (MPOs) were not developed to produce estimates of GHE emissions but were developed for estimating ozone-related emissions of volatile organic compounds (VOCs) and nitrogen oxides ($NO_x$). Because there are still no national standards for GHE, the models do not produce a conformity estimate for those emissions. However, EPA has used components of the models to produce estimates of greenhouse emissions such as carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$). It uses different methodology to estimate hydrofluorcarbons (HFC), which escape from air-conditioning and refrigeration units. Using slightly different methodology, it has produced comparable estimates for rail, aviation, and water freight modes. These other modal estimates are produced by multiplying total fuel use attributable to that mode by estimated emission factors.

These estimates are available from EPA at an aggregated national level. It relies on FHWA and the U.S. Energy Information Administration (USEIA) for the fuel estimates. Those fuel estimates come from the refineries, not from the local retailers. This process greatly simplifies the estimates of fuel production for federal taxation purposes. However, it requires an estimation of how much fuel is attributable to each state for purposes of allocating federal fuel tax receipts. EPA does not produce local or regional GHE emissions data for freight transport. However, because fuel use is estimated by state, the same methodology EPA uses nationally could be estimated on a state basis. Also, because each metropolitan planning organization must produce conformity forecasts, it probably would be possible to estimate from their existing models some regional GHE forecast similar to that produced nationally by EPA. The models would not cover rural "attainment" areas, which are not required to conduct conformity analyses.

As shown in Table F.1,[2] the EPA report notes that the 77 percent increase in truck-related GHE resulted from a doubling of diesel fuel consumption by trucking during the time period. It reported diesel consumption by medium- to heavy-duty trucks increased from 18.5 billion gallons to 36.0 billion between 1990 and 2008. Gasoline usage for passenger purposes rose 21 percent during the same period. [3]

**Table F.1. Greenhouse gas emissions.**

| Greenhouse Gas Emissions from Domestic Freight Transportation ($CO_2$ Megatons) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Mode** | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | % Change 1990–2006 |
| **Truck** | 228.6 | 272.5 | 344.3 | 343.6 | 357.9 | 354.4 | 367.4 | 395.2 | 404.6 | 77% |
| **Rail Freight** | 34.1 | 39.6 | 44.9 | 45.5 | 45.6 | 47.0 | 49.8 | 50.4 | 51.5 | 51% |
| **Ships, Boats** | 32.8 | 40.1 | 50.6 | 29.8 | 47.8 | 20.7 | 29.5 | 33.2 | 30.2 | -8% |

Source: EPA.

Transportation generates about 33 percent of all U.S. GHE.[4] About 66 percent of the transport-related GHE comes from passenger travel, about 25.3 percent from freight, and the remaining from off-road sources such as agriculture or mining.[5]

USEIA predicts a gradual continued rise in transportation-section energy use and a gradual rise in transport-related GHE.[6] It predicts that annual tons of $CO_2$ related to transportation will rise from 1,948 million tons in 2005 to 2,145 million tons in 2030, or an approximate 10 percent increase. The increase is about .4 percent a year compared to an expected energy-use increase of .7 percent. The lower rate of emission is attributed to improved emission-reduction technology.

Again, these data can be used to produce GHE performance measures for the freight system at a gross, national level. Additional calculations could break out these estimates for state and regions.

## Other Transport Emissions

Since approximately 1970, various amendments to the Clear Air Act have promulgated a series of emission-reduction strategies for the national vehicle fleet and its fuel. These strategies have been focused upon six primary emissions, VOC, $NO_x$, CO, lead, $SO_2$, and particulates (PM). Lead was removed from fuel in the 1970s both because it was a public health hazard and because it interfered with the vehicular catalytic converters that were an important emission-control strategy. $NO_x$ and VOCs are the precursors of ground-level ozone, or smog, which has been the focus of significant emission-reduction efforts. Sulfur dioxide also is a pollutant that contributes to "acid rain" and to the formation of particulates. Particulates are controlled because of their ability to penetrate deep into the lungs and create negative health effects. Carbon monoxide is a toxin particularly in high-congestion locations. The effects of the control strategies have been significant, with reductions of up to 80 percent in some of these transport-produced pollutants as shown in Figure F.1.

These data provide a potential air-quality performance measure for these six pollutants. Performance measures using these data can be produced regionally as part of the conformity analyses or they can be aggregated nationally. In addition, 20-year forecasts for these emissions are produced for each non-attainment area's air-quality conformity analyses.

Many air-quality measures can be calculated from basic fuel data as shown in Table F.2, below. The EPA Emission Factors web page[7] notes that emission levels are generally calculated by a formula of :

$$E = A \times EF \times (1\text{-}ER/100)$$

Where: E = Emissions
A = Activity Rate
EF = Emission factor
ER = Overall emission reduction efficiency, %

## Energy Use in Freight Transportation

USEIA produces a forecast of energy use for the transportation sector through 2030.[8] This forecast serves, in effect, as a leading indicator of fuel usage that can be used to extrapolate a carbon footprint, emissions, and other related factors. The forecast for transportation addresses petroleum, natural gas,

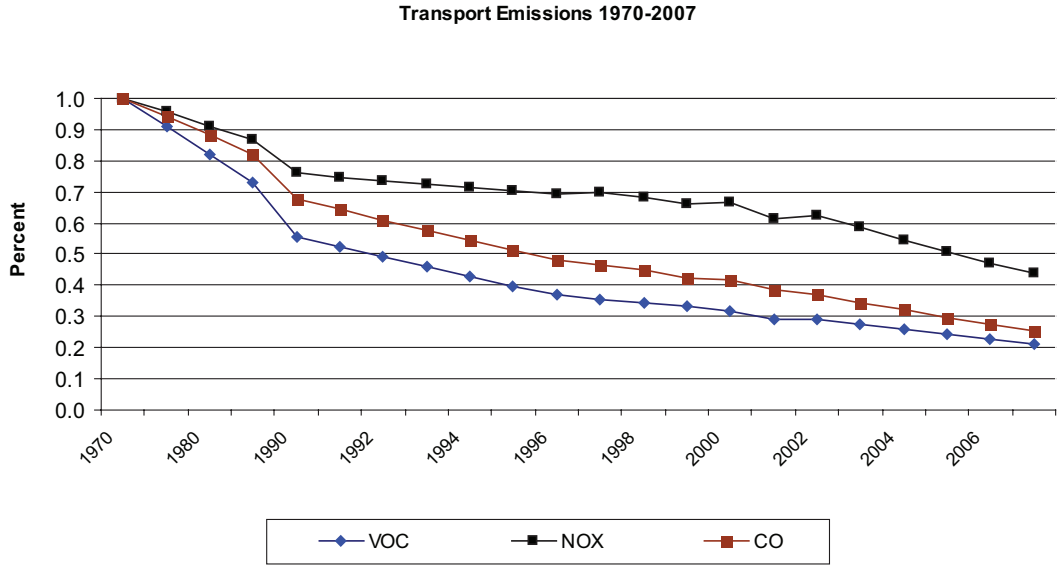


*Figure F.1. Emission trends.*

**Table F.2. Petroleum use for freight.**

| Petroleum Use by Mode | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mode | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | % Change |
| Heavy Trucks | 18,557 | 23,149 | 30,074 | 30,077 | 31,421 | 31,539 | 32,772 | 35,139 | 36,013 | 94 |
| Rail | 3.460 | 3,863 | 4,105 | 4,119 | 4,088 | 4,176 | 4,406 | 4,446 | 4,538 | 31 |

Source: EPA, Table A-72, in Methodology for Estimating Emissions of $CH_4$, $N_2O$, and Indirect Greenhouse Gases, 2008.

and electricity usage for the transportation sector. Again, as with other measures, it does not specifically address freight but does so indirectly. The indirect forecast comes from forecasts for diesel usage, which can be assumed to be used primarily for freight transport. USEIA predicts that transportation sector energy consumption will increase at an average annual rate of 0.7 percent through 2030, which is significantly lower than the 1.4 percent historic average annual rate from 1980 to 2006. It attributes the lower rate of growth to vehicle fuel economy standards, slower economic growth, higher fuel prices, and lower demand.

Although light-duty passenger cars and trucks remain the largest consumers of energy, the largest rate of growth is among heavy trucks. Heavy vehicles' use of energy will grow from 18 percent of all transportation energy today to 20 percent of all transport energy in 2030, according to USEIA.

## Energy Price and Efficiency Measures

Energy is a large percentage of freight movement costs and is intuitively a greater cost as prices increase. Fuel prices are particularly important to the trucking and aviation modes, although they are not insignificant to rail or water modes. either. For this reason, the trucking industry's consumption of fuel is an important element at both the national level and within individual trucking operations. Two examples of such measures are the calculation of the quantity of diesel and gasoline consumed annually by the industry as a whole and the basic analysis of energy performance (e.g., measures such as miles per gallon [mpg]). In fact, some trucking firms are so cognizant of energy performance that drivers are rewarded with fuel bonuses for attaining specific mpg levels, and drivers are trained to shift gears in a more fuel-efficient manner.

The ATA publication *Trucking Trends* offers basic industry statistics related to fuel consumption, such as billions of gallons of diesel and gasoline used per annum as well as comparisons of fuel consumption and vehicle miles traveled. Fuel efficiency is considered through freight performance measures on the national level as well.[9] Estimates can be made of fuel consumption for several types of U.S. commercial truck operations through a national level analysis of factors such as:

- The effect of cargo tons per truck on fuel consumption;
- The effect of long-haul mileages driven by heavy trucks on fuel consumption.

The results of this analysis over a 20-year time period show an improvement in efficiency measured in gallons-per-cargo of ton-miles traveled.

Finally, industry-wide performance measures for emissions are calculated in *Trucking Trends* (thousands of short-tons) and address the following emissions types:

- Sulfur dioxide
- Nitrogen oxide
- Volatile organic compounds
- Particulate matter (PM-10)

EPA produces fuel-use estimates for the major modes that are derived from FHWA, USEIA, and other sources (see Table F.2).

## Hazardous Materials Releases

Local and state governments are required to have systems in place to respond to hazardous material incidents because such events often necessitate specialized equipment and greater expertise than standard highway incidents. Government regulations also aim to decrease the number and severity of hazmat incidents on highways. Public-sector program goals therefore relate specifically to decreasing incidents and the effectiveness of incident preparedness and response; several measures of the performance of public-sector entities to meet these goals are listed in the literature.

Regarding state-level activities, FMCSA[10] identified several outcome-based performance measures through a survey of

state agencies that have authority over hazardous materials transport, including:

- Measurement of Hazardous Materials Violations and Enforcement Actions;
- Measurement of Severe Incident Trends;
- Measurement of Hazardous Materials Carrier/Shipper Inspection Trends;
- Total Number of Hazardous Materials Incidents; and
- Budget/ Resources Record Trends.

At the federal level, USDOT's FY 2004 Performance Plan assesses hazardous materials transportation safety through one key measure: "the number of serious hazardous materials incidents in transportation." [11]

Additional measures are also employed by the federal government for program assessment purposes; USDOT's *Hazardous Materials Transportation Safety—Emergency Preparedness Grants* program, which aids local hazmat responders,[12] is evaluated using the following measures (in addition to the number of serious hazmat incidents):

- Number of Hazmat Responders Trained;
- Number of Emergency Plans Completed;
- Number of Local Emergency Planning Committees Supported; and
- Number of Training Exercises Conducted.

Finally, in response to federal regulations requiring hazmat security, FMCSA[13] produced guidelines for the development of comprehensive security plans for hazmat trucking operations. Within these guidelines, it is suggested that performance measures are put in place to assess hazmat carrier vulnerability levels as security plans are established and improved. Examples of such measures that are offered in the guidelines include changes in theft and property damage rates. Likewise, trucking companies that haul hazardous materials have internal performance measures that rate the outcomes of safety-related plans and procedures.

## Endnotes

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APPENDIX G

# Stakeholder Perspectives

## Introduction

Substantial effort was expended to determine stakeholder preference for freight performance measures, including surveys and interviews with public- and private-sector stakeholders. The responses are summarized below.

## Categorizing Stakeholder Preference

One way to categorize stakeholders who could be served by a freight performance measurement system is to divide them between public and private sectors. The public sector is largely responsible for building highways, airports, ports, inland waterways, and many of the connections between them and for regulating many aspects of freight operations. The private sector provides railways, rolling stock, trucking companies, ships, barges, the air freight industry, and the goods that move across these networks, and it provides the substantial intellectual capital that manages the logistics networks. The project approach, therefore, was to examine the perspectives of both the public and the private sector (see Table G.1).

**Table G.1. Public and private perspectives.**

| Interests in Freight Performance | Public Stakeholder Interests | Private Stakeholder Interests |
|---|---|---|
| System Condition | Bridge, Pavement Conditions<br>Railroad Network Condition<br>Age of shipping fleet<br>Adequacy of Airports | Do system conditions increase operating costs? |
| System Performance | Highway speeds<br>Highway Reliability<br>Rail speed, reliability<br>Rail access<br>Port throughput<br>Harbor, Channel Dimensions | Reliability of deliveries<br>Availability to needed modes<br>Direct and indirect costs of congestion, reliability |
| Policy Implications | Emissions<br>Hazardous Material Releases<br>Operator Safety<br>Licensing, Taxation | Concern of regulatory cost<br>Concern of regulatory fairness<br>Concern of regulatory predictability |

## Private-Sector Perspectives

The great diversity of private-sector stakeholders is evident from earlier tables and descriptions of the substantial diversity that exists across the U.S. economy. Nearly every category of firm would have some interest in freight system performance. Those interests, however, would be quite diverse, even within similar categories of industries. A very localized small manufacturer's interests will be different from those of a multinational manufacturer who relies upon tightly strung global supply chains. Likewise the real-time high-value-package focus of UPS is quite different from that of an upper Midwest grain shipper barging corn to New Orleans. Their scales of timeliness, cost, waste, and reliability are significantly different.

NCHRP 8-70, *Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies,*[1] notes that there are divergent ways in which a private-sector company might view freight movement performance. To some companies, freight movement is simply a cost center, and the corporate goal is to reduce cost of shipment to the lowest level, even if it sacrifices some quality. To other companies, reliable delivery is a key corporate principle, and to these companies freight movement quality is a key corporate value. Other companies are not primarily transport oriented but try to make transport a profit center or value-added activity and source of revenue.

Still others outsource all transport to focus instead on core manufacturing or production capabilities. Finally, some companies view transport through labor agreement perspectives and outsource it to avoid expanding the purview of labor agreements. Therefore, even within a similar category of industry, the key metrics for freight transport could vary, depending on the corporate strategy and corporate structure.

Further complicating the "private-sector" perspective on freight performance measures is that "freight movement" in a modern logistics system is part of a much larger web of logistics activities that extend beyond the highway, railway, port, or terminal. For a large company, freight movement is part of the larger logistics cycle that involves sophisticated systems for predicting inventory needs, timing manufacturing outputs, minimizing warehouse times, maximizing turnaround times, tracking inventory, and billing customers promptly. Only one part of the logistics chain is the actual shipment of

goods along public highways, on private railways, on private air freight carriers, and through publicly owned but privately operated water port terminals. To private-sector logistics professionals, a set of comprehensive freight performance measures would extend not only across the entire network of transport facilities but also across the network of private-sector producers, shippers, carriers, warehouses, information systems, and customers with whom they interact.

## Public-Sector Perspectives

The research has identified stakeholder interests that are either explicit or implicit. The explicit interests are those expressed in the surveys and interviews. The implicit measures are those that have been captured through earlier statutes or government regulatory actions. It could be argued that the implied stakeholder interest may be stronger than the expressed interest because the implied interest has in the past led to concrete government action to measure, manage, and regulate some aspect of freight performance. Such examples would be in policy areas such as emissions affecting air quality, hazardous materials releases, truck crashes, truck size and weight, import and export records, railroad competitiveness, import security, or railroad–highway crossing safety. Each of these regulatory frameworks arose because of acute interest on behalf of some group of stakeholders, often the public at large.

As noted, public-sector transportation stakeholders tend to express interest in performance measures closely aligned with the government function for which they are responsible. Public-sector freight stakeholders tend to further differentiate their interest in the transportation system to those links and nodes that carry the most freight. Freight volumes are highly concentrated. As noted, the Interstate Highway System (IHS) is only 1 percent of all public road miles, but it carries 49 percent of truck vehicle miles of travel (VMT). The National Highway System (NHS) carries another 26 percent of truck VMT. Together these two networks carry 75 percent of all truck VMT, although they comprise only 4 percent of all public road miles. Likewise, the Class I railroads comprise only 1 percent of U.S. railroad companies, but they generate 93 percent of rail revenue. Similarly, the top 10 U.S. container ports handle more than 86 percent of all container volume.

Although the nation lacks an explicit set of national freight performance indicators, it does contain an implicit set of indicators. These indicators, however, are not clearly articulated as performance information but tend to be obscured within the data captured by various state and federal agencies for their use within their own statutory purview. For instance, Congress and FHWA differentiate the data they gather on system condition and performance to allow analysis of the IHS and the NHS because of its disproportionate importance to national freight movement. The Surface Transportation Board (STB) and the Federal Railroad Administration (FRA) produce voluminous data on the safety, performance, competitiveness, and service levels of the Class I railroads. The U.S. Army Corps of Engineers (USACE) has a lock and dam performance measurement system to track the volume and condition of inland waterways. The U.S. Department of Commerce monitors daily the imports and exports from ports. The Federal Motor Carrier Safety Administration (FMCSA) produces monthly data on truck crashes, truck company safety, and the adequacy of on-the-road vehicles. EPA is closely monitoring and regulating truck emissions. Crash data are gathered for all surface modes, with significant geographic and temporal specificity. To capture a broader range of stakeholder interests, the research effort examined both the stated preference of private- and public-sector stakeholders and the implied preference that exists in federal regulatory systems.

The effort to identify stated stakeholder preference for freight performance measurement relied primarily upon surveys and questionnaires. Surveys were deployed to: (1) all 50 state DOT planning departments and freight offices; (2) 4,000 private-sector members of the Council of Supply Chain Management Professionals (CSCMP); (3) 10 national trade associations; (4) three Class I railroads; (5) a representative sample of trucking firms; (6) four ports; and (7) five relevant federal agencies. The results of these surveys, questionnaires, and interviews are summarized below.

## State Perspectives

Surveys were distributed to all 50 state DOTs. Targeted were officials within the state freight offices, of which approximately 22 exist. In state transportation agencies that do not have freight offices, the surveys were sent to the DOT's planning officials.

The state DOTs generally expressed a keen desire for freight performance measures, with some strong exceptions. State officials overall expressed greatest interest in measures that captured information regarding the performance of local and regional freight networks, such as highway, railway, and port systems, with lesser interest expressed in aviation and inland waterway systems. This probably is attributable to their lack of responsibility for those systems and their lack of eligible funds to invest in them.

The states generally indicated that they would use the performance measures as one input for a wide array of purposes, including project selection, funds allocation, legislative communication, system monitoring, and long-range planning. For the most part, the states indicated a higher interest in performance measures at the regional and local levels, and on

an annual or quarterly basis. Performance measures regarding the national freight network and daily freight system performance generally were not as highly ranked by the states. The exception was for travel-time data, which some indicated they would like on a daily basis. Because the states indicate they would use the performance measures for planning and project-selection purposes, the need for daily operational measures probably is less acute for them than it would be for logistics providers who are concerned about daily freight routing decisions.

The states were asked to rate potential measures on a simple scale of 0–3, with 3 indicating they would find a potential measure to be "very" important to them. They also were asked to indicate any difference in preference if the measure was available at a local, regional, or national level. The highest overall scores were for measures addressing congestion and reliability at the local and regional level. Both were scored at a value of 2.5 or higher out of a possible highest score of three. As can be seen in Figure G.1, the lowest overall scores were for the cost of logistics (as a percentage of GDP), for train speeds nationally, and for environmental performance regarding the emissions, pollution, and energy impacts of freight. The measures for cost of logistics had an overall value of only 1.2 from the state respondents, while the environmental and energy measures scored 1.8. However, the states indicated a higher interest in the energy and environmental measures if they were available at the local level. The cost-of-logistics measure may also have been affected by its availability only at a national level. The score for that measure was notable because that category was among the highest rated by the private-sector respondents. It should be noted that respondents were commenting upon their need for and use of specific freight performance measures. They were not asked to comment upon the importance of national freight data sets, from which they could pull local freight data.

The difference in the importance of local versus national measures was clear-cut between the state respondents and the later private-sector respondents. The state respondents gave high ranking to all local or regional measures. The private sector ranked most measures highly as long as they were national. The private sector appeared to be influenced by its involvement with long international and intercontinental supply chains. The state officials were influenced by their local and state responsibilities.

One strong sentiment emerging from at least two states was opposition to any national set of performance measures. Some state respondents expressed strong concern that any set of measures might be used to inaccurately measure states and to make arbitrary national fund-allocation decisions. This concern has been strongest among some of the Great Plains states, whose respondents stated that their low populations and large distances create unique transportation conditions. When national statistics for congestion, crashes, and other traditional indicators of "need" are examined, the some states

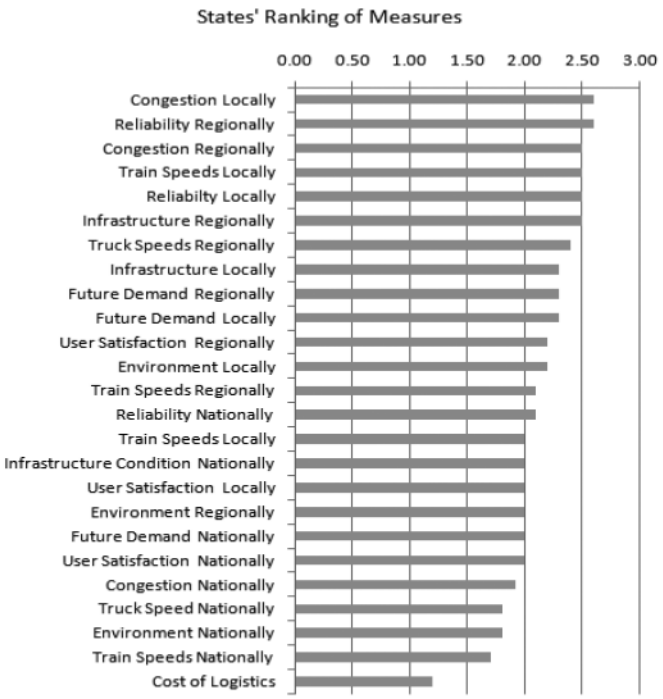


***Figure G.1. States' ranking of potential measures.***

can appear to have little need and may therefore not receive adequate federal investment. Accordingly, they have strongly urged that any performance measures be state specific and developed by the states in a fashion that best meets their individual needs. AASHTO has incorporated these sentiments in its official positions regarding performance measures. AASHTO advocates that no national targets be set, instead allowing states to set targets that meet their needs.

## AASHTO Perspective on Measuring Freight Performance

AASHTO has spent considerable effort on examining its membership's perspective and need for national performance measures. It also has developed a formal position on how the nation should develop national freight investments. Although the organization has not formally proposed a specific set of freight performance measures, it has described to a much greater degree than many national organizations the type of freight performance measure that should be considered and how such measures could be used.

Freight-specific measures are only a small component of AASHTO's recommendation on performance measures. However, the issues surrounding AASHTO's recommendation are representative of the overall concerns and priorities AASHTO has for national performance measurement, including freight performance measurement. AASHTO's position, not only on which measures to identify but also on how those measures should be used, has been drafted to incorporate the concerns of states mentioned above. AASHTO and the states have focused their comments more on how measures will be used—or misused—than they have focused on the details of individual measures.

AASHTO's consensus position on performance measures is that national goals should be established in six areas:

- Safety
- Preservation
- Congestion
- System Operations
- Freight
- Environment

Its position is that the next transportation authorization legislation should require AASHTO to work with other stakeholder groups such as the American Public Transit Association, metropolitan planning organizations (MPOs), and others to establish national goals for each of the six areas. AASHTO does not support federal rule making to adopt the goals, other than a conforming rule making to accommodate the changes in statute.

AASHTO recommends that after national goals are established, each state would adopt its own performance measures to account for how it is achieving the national goals. AASHTO recommends that each state, MPO, and transit agency adopt a planning and programming process to focus federal funding on meeting the federal goals for the system under that entity's jurisdiction. In turn, each state would adopt performance targets for each of the six key national goals. It recommends commensurate changes to the federally required planning factors to focus those planning factors on achievement of the national goals. AASHTO recommends that each state be asked to develop a process to track progress toward the goals. AASHTO would be required to recommend a process by which states self-define targets that would work in their unique context rather than have measures and targets imposed through federal statute, federal regulation, or funding distribution. AASHTO also recommends a "carrot" rather than a "stick" approach to the performance measures. It recommends a Performance-Oriented Pilot Program for the states or MPO regions that meet the goals. They would be rewarded with regulatory relief, relaxed engineering requirements, or federal 4(f) avoidance relief in exchange for having achieved the goals.

AASHTO's position has not progressed to the point where it has proposed formal national strategic goals or formal performance measures. It has, however, discussed and presented general concepts for the types of goals and performance measures it believes should be included. The goals and nested performance measures it has discussed are:

- **Safety:** Reduce the number of fatalities by 50 percent over 20 years.
  - Number of fatalities
  - Number of serious injuries
  - Accident rates

- **Preservation:** Reduce the percentage of pavement in poor condition on the IHS and NHS by an agreed percentage in 10 years; reduce the number of structurally deficient bridges on the IHS and the NHS by an agreed percentage in 10 years; keep the transit fleet in a state of good repair by maintaining the average age of fleet at an agreed age and the rail fleet at an agreed age.
  - Pavement roughness
  - Bridge condition
  - Age of transit fleet

- **Congestion:** Immediate goals would be established to move toward a consistent method for measuring and tracking congestion levels (total delay) for all urban areas above a certain population. Once those goals are in place, a

national goal to reduce total delay by an agreed percentage over 10 years could be established.
  – Hours of delay
  – Travel times
  – Transit load factors

- **System Operation:** An initial goal would be to establish a consistent approach to measuring incident clearance times on the IHS (and potentially other systems). Once consistent measurement is obtained, a national goal to reduce incident clearance time by an agreed amount within 10 years could be established.
  – Travel time index
  – Incident clearance times
  – Lane closures

- **Freight/Economic Development:** The suggested goal would be to increase the average speed on the freight-significant Interstate and National Highway systems by an agreed amount.
  – Average IHS and NHS operating speed
  – Border crossing time
  – Bridge clearance for double-stacked containers
  – Container throughput at ports

- **Environment:** Reduce the growth in greenhouse gas emissions (GHE) from transport by an agreed percentage by an agreed horizon year.
  – GHE
  – Agency use of recycled products
  – Agency use of energy
  – Carbon footprint

AASHTO notes a number of challenges to the development of a national set of transportation performance measures. First, all parties must agree on the national goals. Second, decisions must be made as to whether to establish the same targets for all state and urban areas or to have varying targets. Third, AASHTO insists that states and regions must drive the target-setting process. Fourth, how the setting of goals and targets changes the federal versus state versus metropolitan area relationships must be determined. Currently, the federal transportation role is to monitor state processes in the use of federal funds. Moving to a performance-based system could involve federal transportation agencies monitoring how states choose projects or adopt operational strategies. The FHWA and FTA could be in a position of reviewing and approving state, MPO, and transit agency decisions much more closely if the federal role is to ensure that state and local agencies achieve predetermined federal target levels. The movement to a performance-based federal program holds potentially major implications for changes in the federal-state-local relationships. Thus, AASHTO and its member states are proceeding cautiously in suggesting a set of performance metrics and a measurement system.

## Federal Agency Perspectives

Interviews were conducted with five federal agencies to assess the agencies' use and need for freight performance measures. The interviews sought to obtain perspectives on the agencies' need for performance indicators beyond the indicators that they already compile to satisfy federal statutes. The five interviewees were either current or former employees of one of the following entities:

- USDOT, Federal Highway Administration (FHWA)
- USDOT, Federal Motor Carrier Safety Administration (FMCSA)
- U.S. Department of Commerce (DOC), International Trade Administration
- EPA, Office of Transportation and Air Quality
- U.S. Army Corps of Engineers (USACE)

The interviews were not intended to be comprehensive assessments of the agencies' performance measurement needs but rather to be indicative of the types of performance issues relevant to the agencies. The literature review included discussion of federal freight performance data because the data collected by the agencies reflects generally the agencies' interest in freight performance. One agency representative from the U.S. Army noted in a separate interview that it would require an exhaustive analysis to determine all of the logistical performance measures that are important only to the U.S. Army, not to mention the other diverse branches of the military. The Army representative noted that U.S. military logistics concerns within the continental United States are much different from the logistics needs of battlefield commanders. He noted that any stated preference for military-related freight performance measures would be very generalized. The same sentiments are likely to be true for the other agencies interviewed.

## Data Collection and Analysis

The interview participants were asked 18 questions related to freight performance measures. All indicated that their agencies had expressed a need for freight-related performance measures. Next, participants were asked to give the motivations for specific organizations to use freight performance measures and to highlight specific measures that were currently used. The following responses were given:

### *U.S. Department of Transportation, Federal Highway Administration*

- *Motivation: Uses freight performance measures to align/allocate resources to areas of greatest need.*
  - Key measurement category: highway measures
    - Travel time
    - Speed
    - Congestion level
    - Reliability
    - SmartWay Transport program measures
      - Overall efficiency of fleets
      - Aerodynamics
      - Engine model year
      - Rolling resistance of tires
      - Use of idling control devices
      - Trailer size
      - Measures of program effectiveness
        - Participants versus total registered trucks
        - Participant VMT versus total truck VMT

### *U.S. Department of Transportation, Federal Motor Carrier Safety Administration*

- *Motivation: Uses freight performance measures to ensure compliance with federal mandates and to monitor the safety of FMCSA-regulated motor carriers/motor coaches.*
  - Key measurement categories: safety and compliance
    - Number of large-truck crashes
    - Number of large-truck inspections
  - Specific databases produced/utilized
    - Motor Carrier Management Information System (MCMIS)
      - Roadside inspection results
      - Motor carrier census
      - Crashes
      - Compliance review results
      - Enforcement
    - Licensing and Insurance

### *U.S. Department of Commerce, International Trade Administration*

- *Motivation: Uses freight performance measures to monitor the competitiveness of the U.S. economy with other countries, as well as to monitor various elements of the U.S./international supply chain.*
  - Key measurement categories: export/import volumes

### *Environmental Protection Agency, Office of Transportation and Air Quality*

- *Motivation: Uses freight performance measures to provide insight on how fleet operational changes can reduce emissions and/or reduce fuel consumption rates.*
  - Key measurement category: vehicles emissions
    - GHE
    - $NO_x$
    - Particulates
  - Key measurement category: energy consumption
    - Efficiency/miles per gallon (mpg)

### *U.S. Army Corps of Engineers*

- *Motivation: Facilitates compliance with Office of Management and Budget (OMB) requirements and aids in determining that projects are included in funding requests (and prioritizes the funding of such projects).*
  - Key measurement categories: coastal and inland waterway
    - Lock usage
    - Tonnage moved
      - By facility
    - Vessel size
    - Port access depth
    - Cost of operations
    - Docking time

Of the five agencies represented in the interviews, three were aware of additional measures that would be produced internally in the future.

FMCSA discussed several initiatives to improve or develop current or future performance measures. Improvement of data collection techniques was mentioned as a first activity, with an example being the future deployment of remote computers to vehicle inspectors so that data can be transmitted and assessed in real time. Other future freight performance measures, identified within the scope of the CSA-2010 program, will help FMCSA prioritize compliance review resources by identifying company and driver behaviors that are deemed high risk.

A second agency, EPA (specifically the SmartWay Transport program), is currently transitioning to a broader set of metrics to measure the operational efficiency of fleets and will focus on emission rates per ton-mile.

Finally, the Department of Commerce is consulting with stakeholders to discuss the needs and benefits of freight performance measures. It will focus on the competitiveness of U.S. transportation and trade networks compared with those in other countries.

The interviewees were next asked the following question: *If a national set of freight performance measures were to be produced, what measures should be included?* Participants offered a variety of insightful responses.

A first opinion was that metrics should measure performance across each element of the entire supply chain and U.S. transportation network. The resulting outputs should be input into transportation infrastructure investment formulas.

Another opinion was that a national system of measurement should focus on fleet efficiency and specifically take into account actual costs and benefits. A respondent named miles per gallon (mpg) as an example of a current measure that does not consider cost/benefit accurately and suggested that a better measure of fuel efficiency would be the amount of goods hauled per energy unit consumed.

A third interviewee suggested that a more accurate and consistent truck VMT measurement was required nationally.

A fourth opinion was that measurements should include the cost of moving freight within each mode.

Finally, four specific measures, according to one respondent, should be included in a national freight performance measurement data set:

- Travel time
- Travel time reliability
- Freight-related highway improvement expenditures
- Intermodal connector assessments

Participants were next asked how frequently freight performance measures should be reported; of those who answered, two said annually, one said quarterly, and one said monthly.

Generally speaking, those interviewed thought that agencies would be willing to spend funds to produce freight performance measurements specifically useful to them.

Next, a series of four-level Likert scale questions were asked. Participants ranked specific freight performance measurement categories with one of the following classifications:

- Not at all valuable
- Somewhat valuable
- Moderately valuable
- Very valuable

The overall results of the Likert scale questions are shown in Figure G.2 as average scores, with 1 being the lowest score possible (this would occur if all participants state that a measure is "not at all valuable"), and 4 being the highest possible score (this would occur if all participants state that a measure is "very valuable").

The first question related to the usefulness of an annual report that outlined the cost of logistics as a percentage of the GDP. Four of the respondents indicated that this would be "somewhat valuable"; FMCSA stated that this would be "not at all valuable."

The second question asked interviewees to rank the value of measurements of congestion on the nation's major freight transportation facilities (i.e., highways, ports, rail, and waterways). There were three indications that such measures would be "somewhat valuable." EPA and FHWA, however, stated that such measures would be "very valuable."

A next question asked how valuable measures of truck travel time and operating speeds on major U.S. corridors would be. Three participants (FHWA, DOC, and EPA) stated that such measures would be "very valuable."

The fourth question asked: *How valuable to you would be a national survey of the satisfaction of logistics users in the*

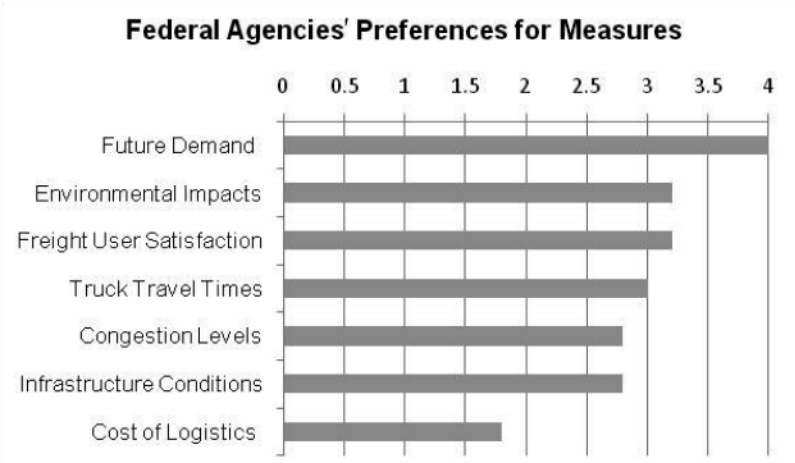


***Figure G.2. Federal agencies' performance measure preferences.***

*nation's freight system?* The results leaned toward "moderately" to "very" valuable.

The fifth question asked how valuable performance measures that assessed the condition of the nation's infrastructure would be. Results were mixed, with three indications that such measures would be "very valuable" and two entities stating that such measures would be "not at all valuable."

The next question asked participants to value measures of the environmental impact of freight systems. As indicated in Figure G.2, most participants felt that this type of measure was "moderately" to "very" valuable.

Asked if a measure of future demand for freight shipments would be valuable, all participants stated that such a measure would be "very valuable."

Also, the interviewees were asked what modal and/or infrastructure measures were desired. Highway, Intermodal, and Intermodal Connector measures were selected by all participants. The remaining modes were selected by three out of five participants.

## Private-Sector Responses

To capture private-sector stakeholder preference, the research team collaborated with CSCMP to conduct a Web-based survey of its membership. CSCMP has approximately 8,000 members, approximately 4,000 of whom were solicited for the survey via an e-mail request from CSCMP. It was explained to the membership that the survey results would influence the report's final recommendations and that their opinions were solicited to gain insight into the private sector's perspective regarding potential freight performance measures. Two follow-up notices were sent to members who had not responded.

The CSCMP membership represents a cross section of the private-sector logistics industry. Among its largest groups listed in approximate order by category are: 1,985 logistics and management planning firms; 1,938 manufacturers; 1,061 third-party logistics providers; 630 food and beverage providers; 420 consulting firms; 411 transportation management firms; 400 educators; 398 warehouse operators; 307 pharmaceutical and toiletry producers; 222 auto and transportation equipment producers; and 206 department store or general merchandise firms. These, of course, are only the largest categories, while more than 2,324 members list themselves as "Other" firms. The remaining members listed themselves among nearly 40 smaller categories.

For the survey, not all members were solicited. The intent was to get private-sector logistics practitioners' opinions as to which performance measures would be of greatest import to them. Non-practitioners such as academics, other trade associations, and consultants were deleted from the survey list. The remaining 4,000 included groups such as retailers, manufacturers, third-party logistics firms, warehouse operators, and other groups who are involved in day-to-day movement of freight.

The response rate was not high. Out of 4,000 firms e-mailed, only 73 responses were received. Clearly, such a low rate does not provide a statistically valid number of responses, but it does provide a useful convenience sample. A reason for the low response rate was suggested by the comment from two-thirds of the respondents that they had never sought publicly provided measures.

The responses, however, did provide consistency in several informative areas. Primarily, the results appeared to indicate that, although most respondents had never expressed a desire for government-produced freight performance measures, they had clear preferences regarding what they would want to measure: timeliness, reliability, and the costs of shipping freight. This apparent trend will be further explained.

The following analysis and charts illustrate the survey respondents and their opinions. CSCMP members were allowed to note whether several measures would be valuable to them at national, regional, or local levels. They could note that a particular measure was important to them at one, two, or all three levels. This granularity was sought to produce insight into whether certain types of measures had more value to them based upon the measure's geographic.

As can be seen in Figure G.3, the large majority of respondents were engaged in providing logistics services, with the second largest category being retailers and the third largest, wholesalers/distributers. Few of the respondents were involved primarily with only state or local logistics (Figure G.4). The large majority were either involved in national or international supply chains. This population was desired as survey respondents because of the interest in measures that could be used at international, national, regional or local levels.

Two-thirds of the respondents rated as "very" or "moderately" high their interest in the CSCMP's measure of the cost of logistics as a percentage of gross domestic product, as seen in Figure G.5. This report tracks a variety of logistics cost indicators and compiles them into an annual report that uses GDP as a denominator. Twenty-seven percent rated it as "somewhat" useful, and only 5 percent said it was not useful at all. As was seen earlier, this interest in the cost of logistics was not shared by the state DOT respondents, who rated it among the least important measures. Another difference noted was that the private-sector respondents' role in national and international supply chains caused them to be more consistently interested in national and international measures, as opposed to local or regional ones.

As seen in Figure G.6, a significant majority of respondents listed as "very" important potential measures of changes in logistics costs. The CSCMP survey breaks down logistics costs into labor, inventory, overhead, fuel, and other major catego-

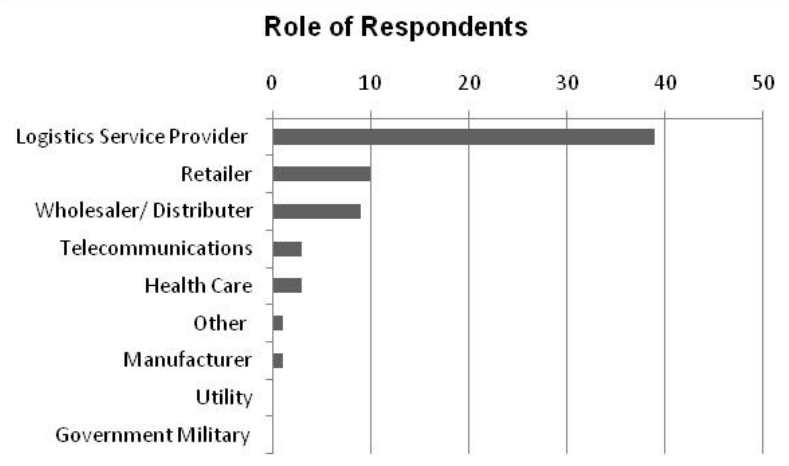


*Figure G.3. Role of respondents.*

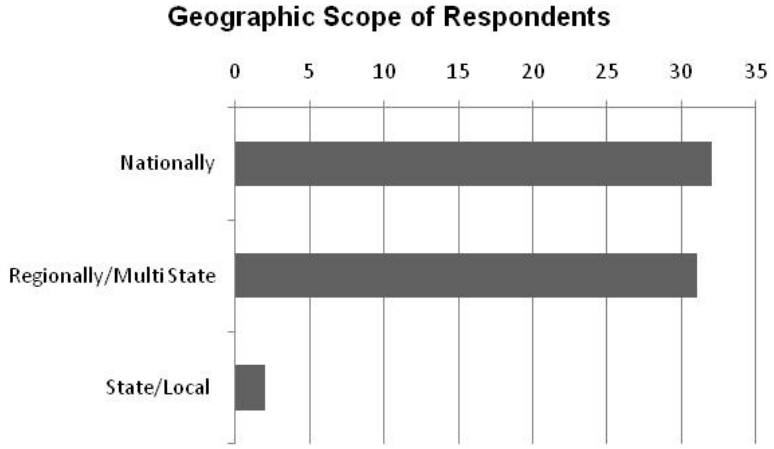


*Figure G.4. Geographic scope of respondents.*


*Figure G.5. Importance of cost of logistics as percentage of GDP.*

ries. When asked if such categories were important, the clear majority answered in the affirmative. They also rated highly the usefulness of the cost-related performance measures at national, local, and regional levels.

In regard to truck travel speeds on major corridors, Figure G.7, a plurality of respondents rated the potential of such a measure as "very" important to them and gave near equal weight to such measures at the local, regional, and national levels. Fewer than 14 percent indicated the measure would be of no value to them. Open-ended comments also revealed considerable interest in operating speed data to be available daily, as opposed to monthly or annually.

Travel-time reliability, Figure G.8, was another highly rated measure. In responses to questions about performance measures regarding congestion, slightly higher preference was shown for state and local measures. Local granularity was desired. One trade association reported that 20 percent of its members reported that they lost or risked losing a customer during the past five years because of a freight bottleneck.

Slightly less interest was stated for measures that reported on environmental issues, such as air pollution, energy use, or GHE related to freight, Figure G.9. There was a slightly smaller majority who rated such measures "very" or "moderately" important to them. As was seen earlier, these measures appeared to be of more interest to the public-sector respondents than to those from the private sector. The public-sector respondents face many environmental compliance requirements that create a strong interest in such data.

The respondents also gave high scores to potential measures regarding the satisfaction of the logistics users with the national freight system. Slight preference was given for that potential measure at the national, rather than local, level (Figure G.10).

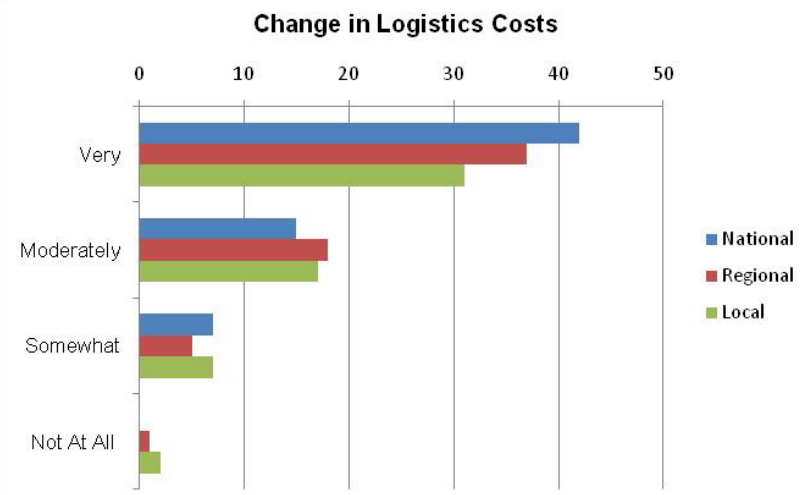


*Figure G.6. Importance of changes in logistics costs.*

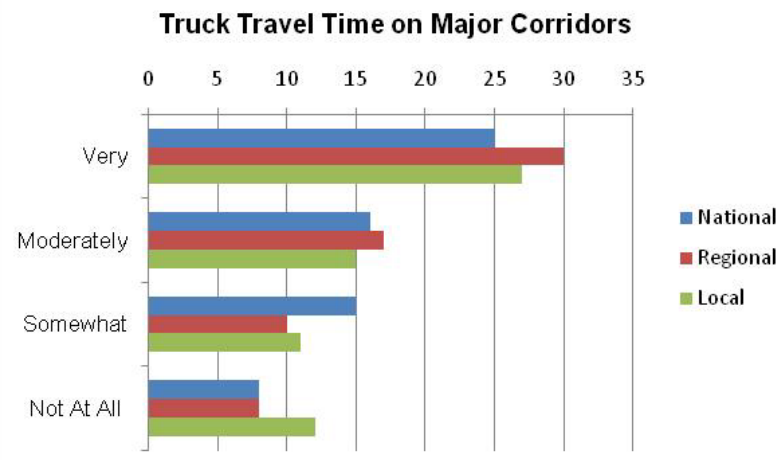


*Figure G.7. Rating of measures of travel time.*

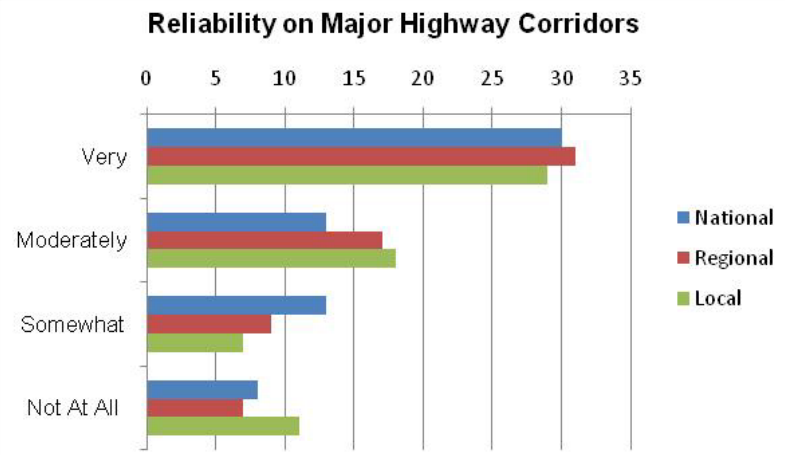


*Figure G.8. Rating of reliability measures.*

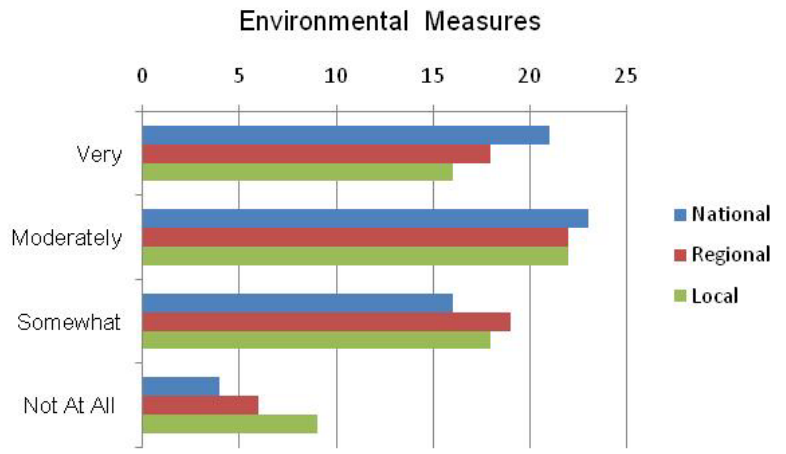


*Figure G.9. Rating of environmental measures.*

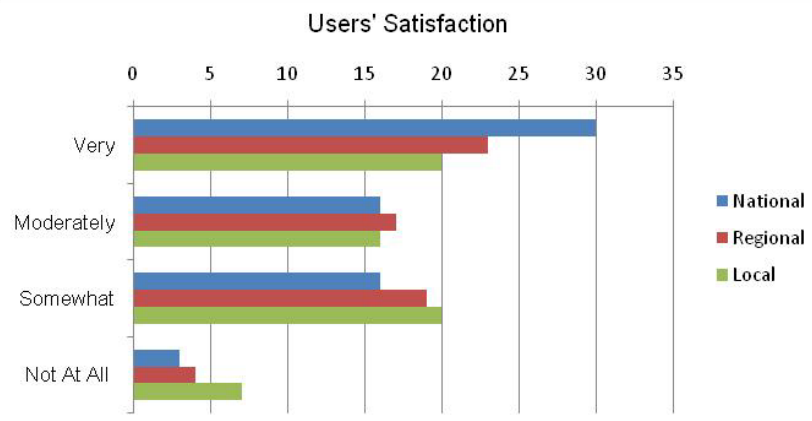


*Figure G.10. Preference for user satisfaction measure.*

The condition of infrastructure, Figure G.11, was a highly scored measure by the private-sector respondents. Nearly 82 percent of respondents said measures of national infrastructure condition were very or moderately important.

By a fairly wide margin, the respondents reported that they had never desired freight performance measures that would be produced by the public sector (Figure G.12). Sixty-three percent of respondents said they had never desired such measures, while approximately 36 percent indicated that they had. Also, the respondents reported little certainty as to how they would use such measures if provided. As can be seen in Figure G.13, the majority of respondents did not report a specific use for such measures, beyond approximately 30 respondents who said they would use such data for budgeting and planning purposes.

## Open-Ended Comments

In an open-ended comment section related to the uses of freight performance measures, no dominant consensus of opinion was evident, either. No two comments were the same, although it was clear that issues of on-time delivery and transport costs were of overall importance, as would be predictable in the highly competitive logistics industry. "We pass many of these requirements off to our freight carriers but it's very important for us to be knowledgeable about these issues when we're negotiating our annual contracts and fees. These issues are critical for us to be able to leverage our shipments," said one respondent.

"It would be great to have accurate freight volumes by major corridor as well as impact factors (congestion, emissions, safety, etc.)," said another.

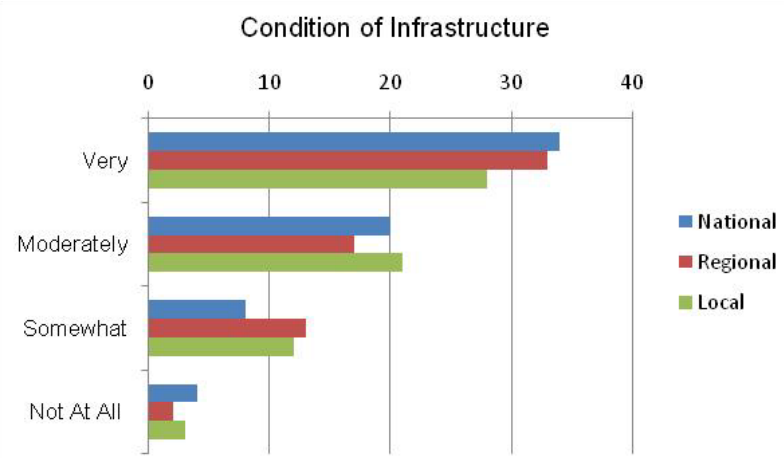


*Figure G.11. Preference for infrastructure condition measure.*

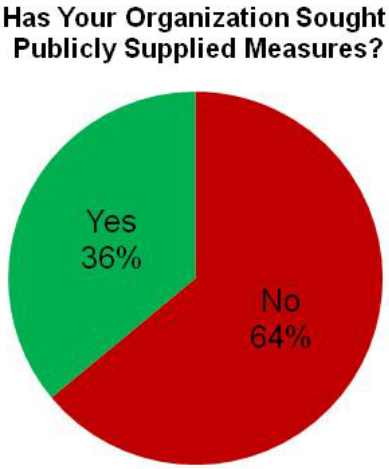


*Figure G.12. Those who sought measures.*

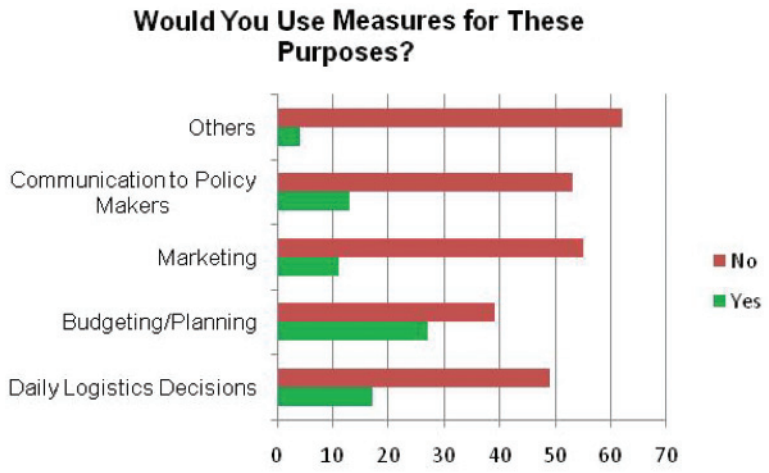


***Figure G.13. Uses of measures.***

Several of the comments indicated that the most important measures involve company-specific and trip-specific measures that are relevant to individual supply chains. As one succinctly said, they wanted:

> "On time pick up—Monthly with over year comparison;
> On time delivery—Monthly with over year comparison;
> Average Highway Delays—Monthly with year over year comparison;
> Congestion Index—Monthly with year over year comparison."

Several other responses focused upon the companies' intense need for the highly specific information on which their competitive position depends. "Perfect order: on time, complete, damage free, billed accurately," wrote one respondent. Another asked for measures regarding, "on-time performance—delivery windows adherence in relationship to cost." Another wanted access to the number of drivers with commercial driver's licenses in their area. Another wanted fuel cost surcharge data weekly. Another wanted to know what future freight volume will be.

The focus on cost, timeliness, and reliability also was clearly evident from responses to questions regarding the internal measures that respondents use in their operations. One hundred open-ended comments were received. Thirty said some measure of timeliness or reliability was used as their most important measures, while 28 indicated some measure of shipping cost. In other words, 58 percent of the internal measures cited related to either timeliness or cost as the most important performance measure used in the internal company operations. Other measures cited include customer satisfaction, or variations on costs, such as return on investment.

Respondents were asked what the most important measures would be for informing public decision makers about the condition and performance of the nation's freight system. Of 101 responses, 22 were related to factors about the cost of freight movement, while 21 were related to factors of shipping speed or reliability. Again, those two issues were viewed by the limited number of private-sector respondents as being most important for policy makers to understand.

From a regulatory standpoint, the most important issue that respondents cited as being important was the Hours of Service regulations. Out of 46 responses as to what is the single most important regulatory issue facing their operations, Hours of Service was rated first 22 times. Other issues sometimes cited were Customs requirements, size and weight, or environmental regulation.

## Contrast with Public-Sector Interests

Some clear contrasts in the interests of private-sector respondents compared with the state agency respondents were apparent (see Figure G.14 for private-sector ranking of measures). The private-sector respondents placed logistics cost performance measures as their highest priority, whereas they were the lowest priority for the public-sector agency respondents. Also, the public-sector respondents consistently rated as highest local and regional measures, while the private sector tended to rate national measures of more importance. Both groups rated infrastructure condition and travel information as important, although, again, the public-sector respondents were more interested in local measures, while the private-sector respondents gave more weight to regional measures in those categories. Local congestion was the highest-ranked measure for the state respondents; that measure was 13th for the private-sector respondents.

The responses indicate that for a performance measurement system to be of interest to both public and private sec-

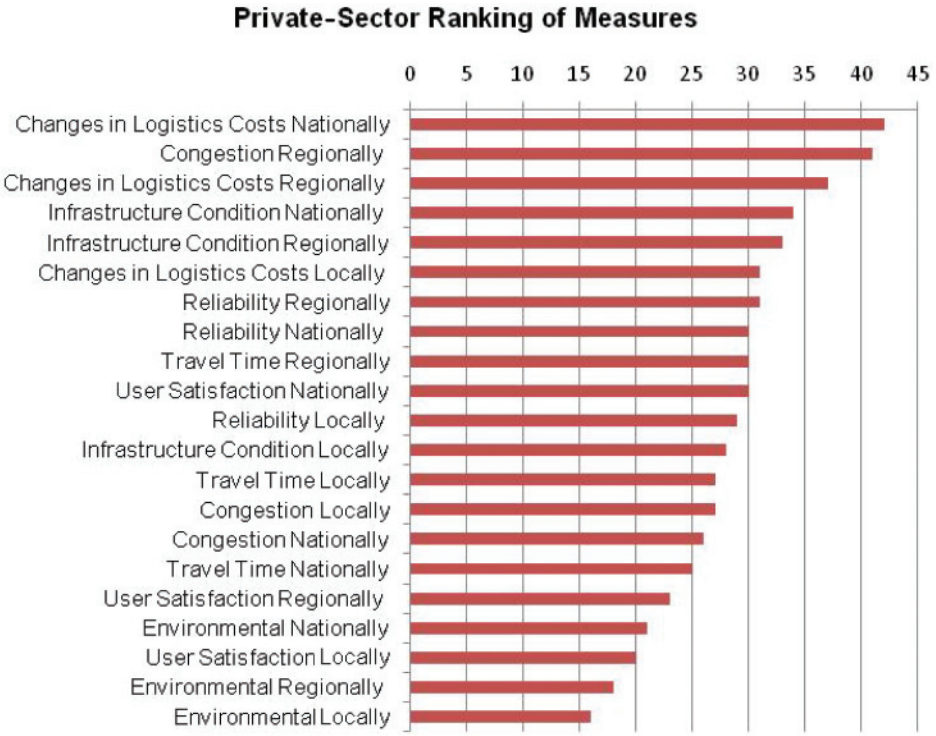


***Figure G.14. Selected private-sector ranking of measures, excluding open-ended comments.***

tor users it will need to include performance information at national, regional, and local levels.

## Additional Practitioners

In an effort to solicit additional responses from the private sector and from researchers who have worked with the private sector, nine additional practitioners who have been active in NCFRP programs were contacted. Seven of them responded to the survey and provided additional insight into the freight-performance measure issue. They were a mix of private-sector logistics professionals, researchers, and government officials.

As can be seen in Figure G.15, this group gave consistently higher scores to all of the proposed performance measures than did the state officials. This may reflect a self-selection influence, in that these individuals were specifically selected because of their interest in freight research. This group ranked all measures with an average score of 3.05, whereas the state officials' average score was 2.14 for the value of all the measures, on a scale of 0–4.

Also perhaps reflecting the national perspective of this group, the national measures were consistently ranked higher than they were by the state officials. In fact, the ranking of national versus local measures was the inverse between the two populations. For this group, national measures were ranked highest in six of the top eight highest-ranked measures. For the state officials, national measures did not appear even in the top 10. All the top measures ranked for state officials consisted of local or regional measures.

As can be seen, the top performance measures for this group were related to congestion, infrastructure condition, and environmental externalities of freight. However, it should be noted that eight categories were listed, and three choices—national, regional, or local—were available for each category for that measure. In nearly all cases, this group rated the national measure as more valuable than the same measure provided at the regional or local level. Again, this emphasizes this population's national perspective.

When asked the open-ended question of what regulatory issues were most important, no two respondents identified the same issue. The issues cited were: funding for the highway trust fund; open access to rail lines; supply chain security; greenhouse gas emissions; California Air Board legislation; truck size and weight; hours of service; and wetland regulations.

Likewise, when asked what additional measures they would like to have, there were no two similar needs noted except for two who cited vehicle miles traveled by major corridor. Other performance measures cited as being needed include cost of

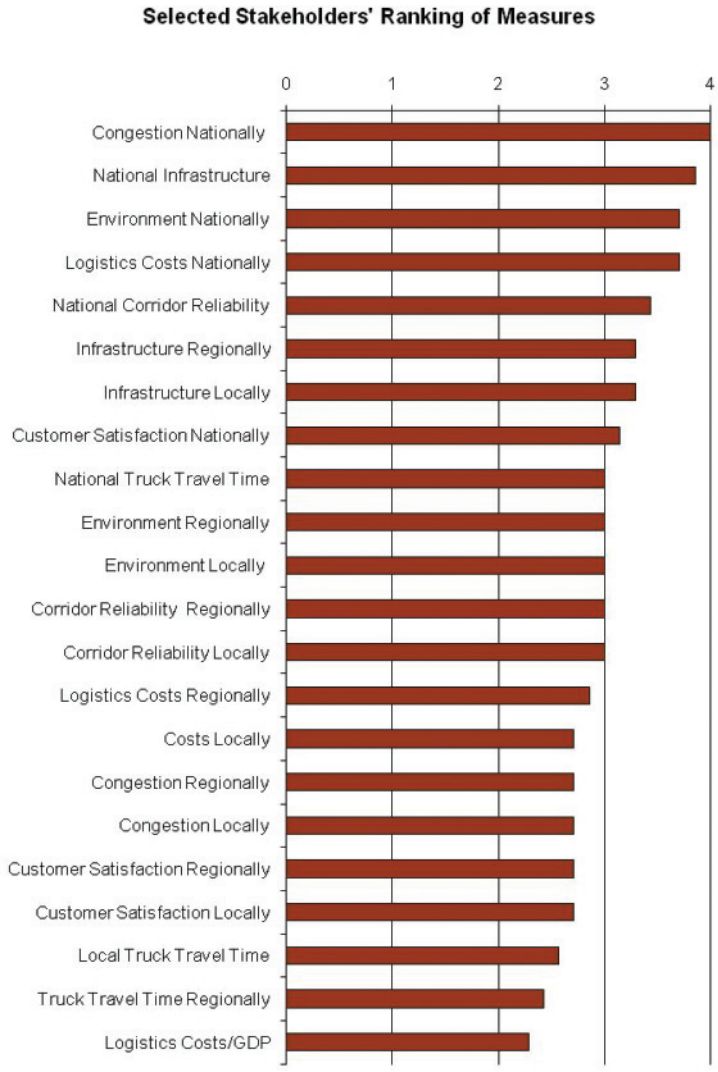


***Figure G.15. Practitioners' preferences.***

highway expansion, highway speeds, highway reliability, container lift volumes and port tonnage reports, highway congestion, and rail line velocity. In addition, one cited the need for national data to help a trade association advocate for freight projects of national significance.

The respondents did report generally similar measures that were most important to their internal operations. Most of the cited measures were generally related to speed or reliability. In addition, safety was also mentioned as a highly ranked internal measure.

When asked what measures policy makers need in order to understand the freight system, out of the top measures cited, two respondents cited measures related to rail speed, one to port throughput, three to congestion, and one to the length of time it takes to deliver public projects.

Again, although this was a small population, the responses are consistent with what has been discerned from other stakeholder groups. These findings are that:

- Practitioners prefer measures that are scaled to their operations, be their operations national, regional, or local;
- Great diversity in interest exists;
- Measures of speed and reliability consistently rate highest; and
- Interest in several modes is apparent.

## Trade Association Perspectives

To further understand the needs of the private sector for freight performance measures, efforts were made to interview

or survey major trade associations. Responses were mixed. Out of 10 trade associations that were contacted, five eventually responded after repeated requests. Responses from the trade associations were limited but consistent. The associations generally reported that members were concerned with transportation costs and reliability. "We've never expressed a need for freight-related performance measures, but an understanding of system-wide performance is important to our membership," said the representative of one national association. "Delay and congestion along the most heavily traveled interstate corridors would be a useful performance measurement," said the representative whose membership relies primarily on trucking.

One association that is highly focused upon international supply chains reported that its members rely on all modes and therefore would be interested in all aspects of international freight performance. That industry trade group rated as "most important" forward-looking measures that would help predict future demand for freight. All other potential measures were rated as only "somewhat" or "moderately" important.

One retail-focused association rated as "most important" measures related to infrastructure condition and future freight demand. The representative wrote on the questionnaire,

> Developing a set of national freight performance measures is critical as we continue to ask the federal government to develop a National Freight Policy that will help to identify the future needs of the goods movement system within the United States. The current infrastructure will not be able to meet the future demands of the system. It is important that we have as much information as possible to develop a system that will be able to handle the future needs of the system.

Another major national trade association representative said that national freight performance measures would be important,

> . . . to help make the case for direct public sector investment, tax incentives for private investment, and removal of barriers to private investment in freight-related infrastructure. I expect we will need updated information on system performance and return on investment to advocate for Federal policies that target investments (rather than "spread the peanut butter" formulas). . . . A single, authoritative source of information that allows for annual comparisons—even if it in part consolidates the work already being done by associations—would be very useful.

## Trucking Industry Perspectives

Eight interviews with trucking company managers and executives were conducted to ascertain that industry's perspective on measures. Insights were sought on both the measures they use and their interest in potential publicly provided measures. Such a small sample size was not intended to be representative of the entire industry but rather to be illustrative of how a small cross section of the industry used performance measures (see Figure G.15).

Company representatives noted that they rely heavily on performance measures but on ones that provide specific and highly granular insight into the operations of their company, their suppliers, their fleets, and their employees.

All eight indicated that their company relies on performance measures, with the primary use of them being in this order of frequency:

- Efficiency, profitability, and cost savings (13)
- Customer service (5)
- Competitiveness (3)
- Compliance (1)
- Pricing (1)
- Routing (1)

The use of performance measures to make business practices more "efficient" was by far the strongest motivator. Thirteen of the top motivators fell into the "Efficiency, Profitability and Cost Savings" category and included rationales such as:

1. To improve efficiency and bottom-line return on resources;
2. To increase operational efficiency;
3. To increase productivity;
4. To control costs;
5. To increase and measure profitability; and
6. To measure employee performance.

The most important measures used by the companies were:

- Labor productivity;
- On-time pickup and delivery;
- Revenue yield by shipment or by mile;
- Shipments per truck/ truck productivity;
- Fuel economy;
- Profit or loss per truck;
- Equipment utilization;
- Maintenance costs;
- Out-of-route and loaded miles;
- Loading and unloading times; and
- Border crossing time/delays.

### Current Measures

Respondents were asked: *Are there currently measures that your organization intends to produce but has not yet developed?*

Five of the eight companies indicated that new performance measures were or would be under development, including:

1. Out-of-route miles;
2. Maintenance cost per mile;
3. Driver- and vehicle-based operations via engine control module (ECM) data;
4. Revenue generated per square foot within facilities (this measure is specific to freight warehousing);
5. Cost of regulatory compliance, with a focus on hazardous materials;
6. Cost of operating in Canada; and
7. Cost of transportation worker identification credential (TWIC) deployment.

Interview participants were asked about utilization of trucking performance measures developed by other companies or organizations. Although all respondents indicated that performance measures from other individual trucking companies were not used, aggregated data were accessed and used for benchmarking purposes. The sources of such data were indicated to be the following:

- Industry association publications and statistics;
- U.S. Department of Transportation publications and statistics;
- Trade magazines;
- Productivity/ modeling software; and
- Consultants and universities.

## Needed Measures

In the final open-ended question, interviewees were asked what performance measures were needed in the future. Respondents indicated that the following would be beneficial:

- Performance measures based on ECM data;
- Delay at fueling locations;
- Delay at weigh stations;
- Delay at roadside inspections;
- Accounts receivable collection times;
- Infrastructure performance measures (to support national freight mobility);
- Urban congestion measures (to support freight mobility); and
- Accident/congestion ratios.

The final seven questions were quantitative in nature, and respondents were asked to select from the following four value rankings (see Figure G.16 for trucking industry responses to these seven questions):

- No, Not Valuable;
- Somewhat Valuable;
- Moderately Valuable; or
- Yes, Very Valuable.

Interviewees were first asked the following quantitative question: *Would measures of congestion on major U.S. highways be valuable to your company?* The majority (50 percent) indicated that such measures would be "Somewhat Valuable." No interviewees indicated that this information was not valuable.

To the question: *Would measures of highway travel time or operating speed on major national corridors be valuable to your company?* three respondents indicated "Very Valuable," while another three indicated "Somewhat Valuable."

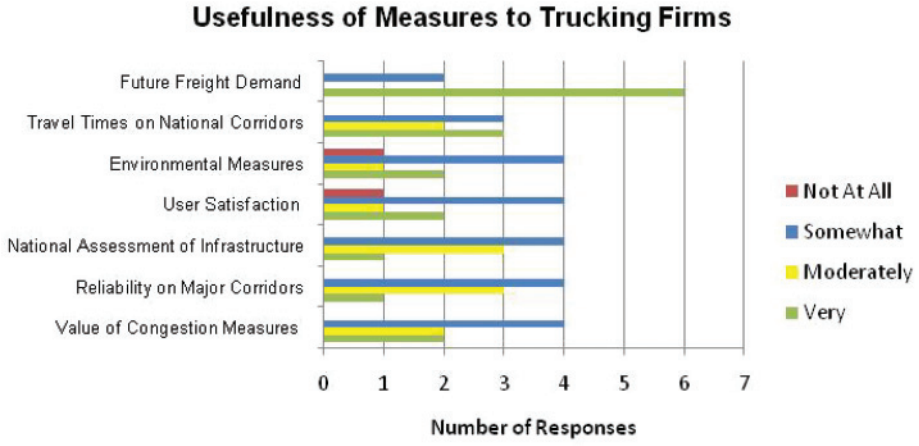


*Figure G.16. Trucking industry responses.*

To the question: *Would measures of the reliability of travel on major national corridors be valuable to your company?* nearly all participants indicated a "middle-ground" answer, with four stating "Somewhat Valuable" and three stating "Moderately Valuable."

To the question: *Would a national assessment of the condition of the nation's public infrastructure, including highways, bridges, ports and airports, be valuable to your company?* Fifty percent of interviewees stated that such measures/assessments would be "Very Valuable," and none indicated "not at all."

To the question: *Would a national survey of users' satisfaction with the performance of the nation's freight system including highways, railroads, ports, and the intermodal connections be valuable to your company*? answers fell in all four categories, with the most answers given to "Somewhat Valuable."

To the question: *Would performance measures on the amount of air pollution, fossil fuel use and other environmental impacts produced by the freight system be valuable to your company?* answers also fell into all four categories, with the most answers given to the "Somewhat Valuable" category.

Finally, to the question: *Would a measure of the level of future demand for freight shipments be valuable to your company?* all respondents saw value in this measure, with an overwhelming 75 percent indicating that such a measure was "Very Valuable."

In summary, the trucking industry respondents—although representing a very small sample population—indicated a greatest perceived utility for measures that relate to future freight demand, condition of public infrastructure, and the travel speeds on major national corridors.

## Railroad Industry Perspectives

Railroad stakeholders, their goals and objectives, and their subsequent interest in railroad freight performance measures have evolved over the more than 150 years that railroads developed, were regulated, and then were largely deregulated. As a result, a rich array of railroad freight performance data is available, particularly at the national or corporate level. The basic data available that already are used for performance or statistical measurement include:

- Data on overall rail volumes, both for passenger and freight, by railroad and by type of commodity on a weekly, monthly, and annual basis;
- Extensive information on rail safety, including not only highway–rail crashes but also injuries and fatalities to trespassers, railroad employees, and others on railroad property;
- Information on hazardous material cargos, in terms of volumes and releases—including various categories of releases caused by accidental spills or crash-caused releases;
- Environmental and energy data, including the volume of fuel used, that can then be extrapolated into GHE and other air pollutants; and
- Extensive financial data including not only total revenues, profits, return on income, and return on equity but also whether railroads have earned their Cost of Capital.

The Cost of Capital analysis is a formal measure conducted by the STB and is used for consideration in decisions regarding rate disputes. In addition to the regulatory financial data provided to the government, the seven large Class I railroads are publicly traded companies that produce extensive filings required by the Securities and Exchange Commission.

With respect to safety, the railroads in many states are still partially governed by forms of public utilities commissions that house vast data regarding local safety and crossing issues. Additionally, because state DOTs, state public utilities commissions, FHWA, and FRA are all active in highway–rail crossing safety issues, extensive information is available to state agencies about to the location, configuration, safety record, and safety-countermeasure deployment at virtually every railroad crossing of a public road.

In addition to the large volume of railroad performance data that is produced through governmental processes, each of the major railroads provides extensive websites that regularly report on issues such as their on-time delivery, their rate structures, and their shipment policies (Table G.2). AAR also produces a significant volume of performance data including:

- Operating speeds by railroad and by class of cargo train;
- Dwell times for trains at major terminals;
- Statistical information on the volume of rail cars, locomotives, and other rolling stock in operation;
- The miles of track in service;
- Total wages paid;
- Number of employees;
- Revenue and financial performance; and
- Revenue per ton-mile of freight.

Table G.2 illustrates only a portion of the overall financial and operating data produced by the AAR. Taken over time, such reporting data can produce insightful trend lines of performance or performance measures for a variety of issues regarding the financial viability of the railroads and their role in the national freight network.

In addition, AAR and the individual railroads are increasingly involved in the public debate about transportation and regularly produce statistics and analyses regarding individual policy issues. One recent analysis addressed the optimized amount of capital investment necessary for railroads to maximize the movement of freight; a second analysis addressed

**Table G.2. AAR-produced statistics.**

| **Traffic** | 2006 | 2007 | 2008 |
|---|---|---|---|
| Carloads Originated (millions) | 32.11 | 31.46 | n.a. |
| Intermodal units | | | |
| Containers | 9.40 | 9.43 | 9.03 |
| Trailers | 2.88 | 2.60 | 2.48 |
| Total | 12.28 | 12.03 | 11.52 |
| Tons Originated (billion) | 1.957 | 1.940 | n.a. |
| Ton-miles (trillion) | 1.772 | 1.771 | n.a. |
| **Operating Statistics** | | | |
| Average Revenue per Ton Mile | 2.840¢ | 2.990¢ | n.a. |
| Average tons per carload | 60.9 | 61.7 | n.a. |
| Average tons per Train | 3,163 | 3,274 | n.a. |
| Average Length of Haul (miles) | 905.6 | 912.8 | n.a. |
| **Financial** | | | |
| Freight revenue (billion) | $50.3 | $52.9 | n.a. |
| Operating revenue (billion) | $52.2 | $54.0 | n.a. |
| Operating Expenses (billion) | $41.0 | $42.7 | n.a. |
| Net income (billion) | $6.5 | $6.8 | n.a. |
| Operating ratio | 78.6% | 78.3% | n.a. |
| Return on Average Equity | 11.3% | 11.49% | n.a. |
| Number of employees | 167,581 | 167,216 | n.a. |
| Average wages | $68,141 | $69,367 | n.a. |
| Average total compensation plus benefits | $94,607 | $97,401 | |

rail safety after a commuter train crash; and a third addressed rail's contribution to GHE reductions.

As a result of all this data and statistical information, it would be possible—and often done—to produce a wide array of rail freight performance measures that assess issues relating to policy, investment, safety, environmental, and other key issues at a national, regional, or railroad level. As shown in Figure G.17, train accidents by type are tracked, as are rail volumes and revenue by commodity type in Figure G.18, and deaths by type of train accident in Figure G.19.

What is not as readily available is information at a local level or at an individual producer level. For instance, Class I

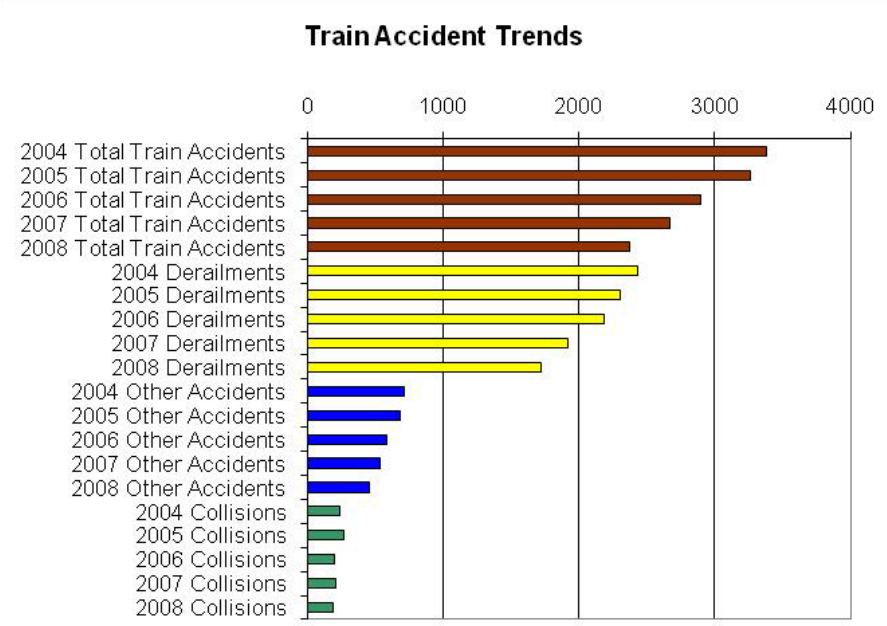


*Figure G.17. Rail accident statistics.*

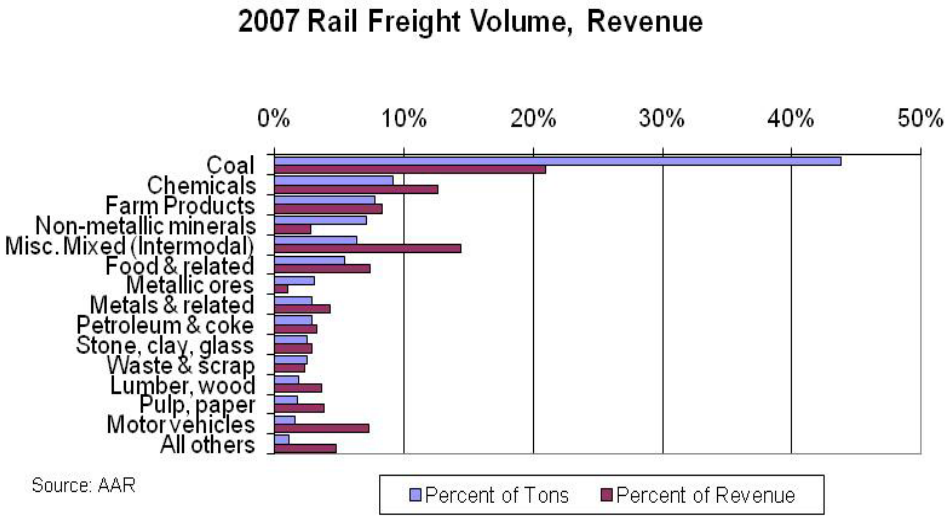


*Figure G.18. Rail volume by shipment categories.*

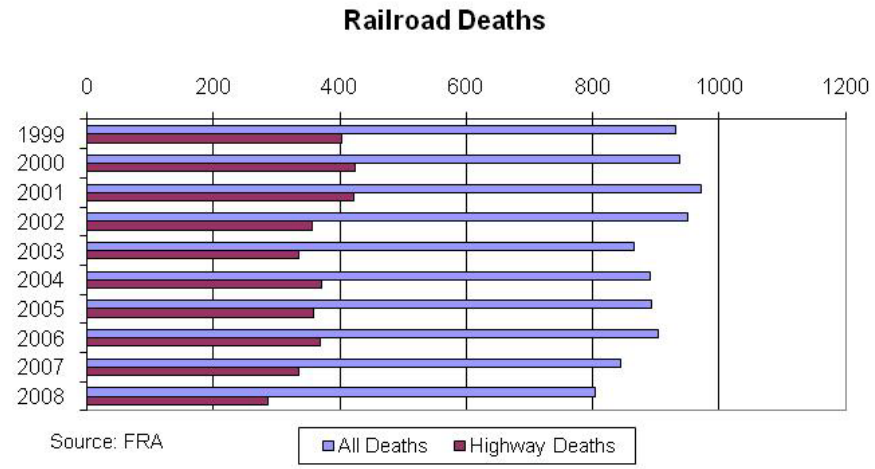


*Figure G.19. Railroad deaths.*

railroads have significantly increased their revenue and profitability by hauling larger volumes over longer distances to improve their efficiencies and economies of scale. Just between 2006 and 2007, average length of haul rose from 905.6 miles per train to 912.8 miles,[2] a trend that has been evident for several decades. This reflects their increased hauling of massive volumes of coal from Wyoming and their increased movement of high-valued intermodal containers containing Asian imports. These relatively long-haul movements may have reduced the volume of long-haul truck moves on highways, with commensurate savings in fuel, emissions, infrastructure deterioration, and crashes. However, the increased model of "hook and haul" of large-unit trains has resulted in some loss of service to local shippers. This has become a significant issue in some markets, such as among grain producers in isolated eastern Washington State. Local producers of commodities such as grain, timber, ethanol, chemicals, and minerals often desire rail service as an alternative to truck or to water. Although extensive data exist regarding what railroads haul, less information is available about what service they have discontinued, particularly at the local, regional, or individual producer level. This type of local service information is of acute interest to many public officials, as well as to the private producers who desire rail service.

Likewise, local transportation planners have complained about a lack of information regarding very localized rail operations that may affect passenger rail service, commuter rail service, highway–railroad crossings, and other local transportation planning issues. Highway designers have voiced repeatedly the need for information regarding the railroad's long-term track-expansion plans and how those plans may affect the repair or construction of highway–railroad overpasses.[3]

Thus, although extensive performance and statistical data exist regarding national and regional railroad performance, the information needs of individual shippers and local stakeholders are less well met. It should be noted, however, that the same is true regarding the other modes. The service patterns, prices, and frequencies of inland barge companies, air freight carriers, and truckers likewise is proprietary information and is seldom shared with the public and local policy makers.

Highway-related train deaths are approximately one-third of all train deaths. Most fatalities are trespassers, and the remainder are employees of either the railroad or of companies working on the tracks.

**Table G.3. Marine Transportation System dimensions.**

| Waterway Type | Description | Key Metrics |
|---|---|---|
| Great Lakes | Includes lakes Superior, Michigan, Huron, Erie, and Ontario, their connecting waterways, and the St. Lawrence Seaway. Great Lakes waterways are mostly deep draft. | 9,292 total system miles<br>97 million tons domestic traffic<br>63 million tons international traffic<br>Key commodities: ores and other crude materials, coal |
| Shallow Draft Inland and Intracoastal Waterways | Includes shallow-draft (12 feet or less) segments of rivers, inland waterways, and intracoastal waterways. Ports on these waterways accommodate barges and other limited-draft vessels. Leading subsystems include the Mississippi River and its tributaries; the Gulf of Mexico (including the Gulf Intracoastal Waterway, Black Warrior, and Tombigbee rivers, Tennessee-Tombigbee waterway, et al.); the Atlantic Intracoastal Waterway; and the Columbia River system. | 29.382 total system miles<br>628 million tons domestic traffic<br>Key commodities: coal, petroleum products, aggregates, food and farm products |
| Deep Draft Coastal and Rivers | Includes deep-draft (more than 12 feet) international trade lanes to and from ports on the Pacific, Atlantic, and Gulf of Mexico coasts; also includes coastwise trade lanes outside of the intracoastal waterways; also includes deep-draft segments of rivers and inland waterways. | 23,670 total system miles<br>202 million tons domestic traffic<br>1,502 million tons international traffic<br>Key commodities: crude petroleum, petroleum products, food and farm products, manufactured goods, chemicals (international); petroleum products, crude petroleum (domestic) |

## Port Industry Perspectives

The U.S. Marine Transportation System (MTS) is a vast, diverse system of waterways and ports that stretch along all U.S. coasts, Hawaii, and Puerto Rico and deep into the continental interior along the Mississippi, Missouri, and Ohio river systems (Table G.3). The physical network consists of more than 1,000 harbor channels; 25,000 miles of inland, intercoastal, and coastal waterways; 300 ports; and 3,700 terminals.[4] This system is responsible for approximately $673 billion worth of goods movement or 5.2 percent of the nation's total value of freight and 8.6 percent of all tons shipped.[5]

In addition to its physical diversity, the MTS involves multiple stakeholders—private ship owners, public and private terminal operators, labor unions, the owners of modal connections into port facilities, and local, state, and federal government agencies that regulate and promote waterborne traffic. In recent years, the government network has been substantially augmented by security forces concerned about drugs, terrorism, and immigration. These governmental functions are in addition to the historic national regulatory function of capturing import duties and tariffs.

Several major constituencies and policy issues surround the Maritime System in addition to the traditional economic issues.

- Economically the marine system is critically important, because deep-water seaports comprise 11 of the nation's top 25 foreign trade gateways. Foreign trade has more than doubled as a percentage of the overall GDP in recent decades;
  - Out of 300 total ports, the top 10 handle 86 percent of the high-value container goods that have grown disproportionately important in the global economy; and
  - The inland waterway system carries disproportionate amounts of the nation's heavy commodities such as chemicals, aggregates, and agricultural products. It is an aging system, with more than 45 percent of inland locks and dams more than 50 years old.
- From a national security standpoint, the water ports are invaluable for large-scale military deployments;
- The security of imports has become an increasing concern in an era focused upon chemical and nuclear terrorism threats;
- In recent years, the environmental effects of the marine trade have become a source of increasing focus.
  - The air-quality impacts of idling ships, trains, and trucks have created air-quality concerns surrounding ports;
  - The inadvertent transfer of invasive species from ships' ballast water into inland lakes and waterways has been a concern; and
  - The disposal of dredging materials created from deepening harbors and channels likewise is an ongoing issue.
- Until the recession of 2008, growing freight volumes at major seaports created growing landside congestion concerns on local streets, interchanges, railroads, and the crossings between them;
  - The trend of steadily increasing ship size allows for greater economies of scale at sea but creates additional throughput and surge issues at terminals and local streets, railroads, and pipelines; and
  - Expansion of the Panama Canal will mean an increase in large ships on the East Coast and possible diversion of West Coast container traffic to East Coast ports.
- Improving technology at the ports to improve cargo handling, tracking, billing, taxation, and monitoring for security has received continuous attention by private- and public-sector members; and
- Land use concerns in areas adjacent to ports can be a significant local issue. Coasts, harbors, channels, rivers, and intercoastal waterways are finite environmental resources that spur interest in both preservation and residential/commercial development. These efforts to preserve water resources or to develop them for other residential and commercial uses can conflict with marine freight operations.

It is also important to recognize that the many different types of ports further complicate measurement and comparison efforts. Ports that primarily handle containers have different equipment, operations, and facilities than do ports or terminals that handle bulk commodities such as petroleum, chemicals, grain, aggregates, minerals, or coal. Inland waterway ports tend to be commodity specific to serve local industries such as steel production, mining, grain production, or mineral extraction. The size and scale of ports differ considerably, as do the ports' connections to local highways, railroads, and pipelines. The geographic locations of ports vary considerably, with some of them on the coasts and others miles inland on river channels. These variations compound the differences in issues such as port throughput, port connectivity, port efficiency, and port costs per unit shipped.

### Port and Waterway Performance Measurement

While many individual stakeholders regularly apply performance metrics to their particular function within the MTS, to date there has been no successful effort to characterize or measure the performance of the system as a whole. For example, a report by MARAD concluded that the federal agency could not apprise Congress of the nation's ports' abil-

ity to handle a large military deployment because of a lack of common measures.[6] It noted that the significant diversity in ports, the types of cargo they handle, their inland connections, and the geographic configuration of their harbors and channels all created great diversity. The ports as an industry have a few common denominators but none that are uniformly monitored or reported, MARAD observed:

> In preparing this report, MARAD reviewed articles and studies from the academic and scientific communities that set forth methodologies for measuring port efficiency. The literature reviewed supported MARAD's finding that there is no widespread agreement on an approach to measuring the efficiency of a port as a link in the logistics chain. A 2004 article in Maritime Policy & Management states: "Measures of port efficiency or performance indicators use a diverse range of techniques for assessment and analysis, but although many analytical tools and instruments exist, a problem arises when one tries to apply them to a range of ports and terminals. Ports are very dissimilar and even within a single port the current or potential activities can be broad in scope and nature, so that the choice of an appropriate tool of analysis is difficult. Organizational dissimilarity constitutes a serious limitation to enquiry, not only concerning what to measure but also how to measure. Furthermore, the concept of efficiency is vague and proves difficult to apply in a typical port organization extending across production, trading and service industries.

MARAD concluded in its Congressional report:

> MARAD was unable to provide the requested comparison (to Congress) of the most congested ports in terms of operational efficiency due to a lack of consistent national port efficiency data. Given the diverse characteristics of U.S. ports, comparing port efficiency would require the creation of new methodologies and the collection of data that were not available for this report.

Internally, port operations have generated some standards measures, but these are mainly of interest to the internal, business operations of the port. They tend to regard how efficient port crews operate, whether labor rules restrict efficiency in loading and unloading, and whether internal configuration of ports, parking lots, cranes, and storage areas are efficient.[7] These measures are unlikely to be appropriate for a national set of performance measures because they tend to be proprietary, would be difficult to collect, and may not influence public policy but rather internal port and terminal operations. Each port is a unique business, operating over unique infrastructure, and a measure appropriate for one may not be relevant to another. Ultimately, ports are providers of transportation services, and the fundamental common metric is "customer satisfaction." The American Association of Port Authorities addresses this issue on its website.

> AAPA continuously receives requests on how ports rank nationally and internationally. The question is ambiguous, however, since ports can be compared in many different ways—by volume or value of trade, number of cruise passengers, revenues, and storage capacity, as examples. Moreover, sheer size of a port, in terms of traffic flow, says nothing about productivity, efficiency, or responsiveness to customers. These are just some of the criteria that a shipper might consider in evaluating port performance.

As mentioned, periodic studies and reports have attempted to identify potential port and marine measures.

NCHRP Web Document 26 (Project B8-32(2)A): *Multimodal Transportation: Development of a Performance-Based Planning Process* (by Cambridge Systematics, December 1999), recommended the following as potential marine performance measures:

- Number of ports with railroad connections
- Lift capacity of ports, in annual volume
- Number of dockage days per ship
- Accidents or injuries caused by waterborne transportation
- Shipping accidents occurring on waterways
- Transfer time between modes
- Number of users of intermodal facilities

Measures of overall volume through ports are captured or estimated from several sources such as the U.S. Department of Commerce, the USACE, and USDOT's Freight Analysis Framework (FAF). Potential measures from FAF or USACE volume data could include:

- Water ton-miles shipped annually
- Value of water freight shipped annually
- Value of waterborne exports, imports
- Forecast demand for waterborne freight, both inland and maritime

Throughout the United States, but particularly in southern California, environmental concerns about ports have become significant. There are concerns that local populations are exposed to significant air pollution from idling ships, trucks, and trains congregating at ports. The ports of Long Beach and Los Angeles have adopted air-quality goals that are somewhat like performance measures. Using cleaner fuels, less idling, and cleaner vehicles, they proposed to reduce, by 2010, particulates by 47 percent; $NO_x$ by 45 percent; and sulphur oxides by 52 percent. Other environmental measures could address issues such as release of contaminated ballast water (this has led to zebra mussels and other invasive species in the Great Lakes) and localized water-quality concerns due to petroleum and chemical releases near ports. No doubt, such environmental measures would be difficult to measure and would require significant localized testing.

## Port Responses

The Multimodal Transportation project distributed 19 questionnaires to port authorities and state DOT water officials. Only four responses were received despite repeated follow-up efforts. The limited number of responses appears to be indicative of significant differences in interest regarding port-related performance measures. The American Association of Port Authorities (AAPA) reported that it had never expressed a need for freight-related performance measures, nor does it produce any. AAPA reported that it believed the development of performance measures related to ports would be very difficult because of the significant diversity among U.S. ports. It listed as the most important measures for policy makers to understand to appreciate port performance would be:

- Container lifts per hour;
- Container dwell time;
- Highway–rail congestion outside of gates; and
- Available land for expansion.

It expressed concern, however, that if such measures were produced nationally they could be misused as a competitive marketing tool. AAPA officials indicated that the lack of response from ports regarding the survey could be indicative of port officials' skepticism that measures would be meaningful. Some port officials also have concerns that measures would be used and misused as marketing tools to portray competitor ports as being costly or inefficient.

Two ports did respond to the survey, as did one state DOT water department planner and the AAPA.

One major East Coast port authority reported that it tracks 22 performance measures and would be very interested in additional measures to help assess local, regional, national, and international freight performance. Among the measures it produces for its own use are:

- The number of crashes on marine terminal highways;
- Injuries;
- Reduction in crime;
- Facilities maintained as structurally sound;
- Number of containers handled;
- Cost savings of vessels using deepened channel;
- Air emissions per ton of cargo; and
- Customer satisfaction.

It reports it uses such measures to measure its corporate goals, to advance safety and security, to improve economic opportunity, and to improve customer service and the environment.

The port also indicated that developing a comparable set of national port performance measures would be very difficult, rated as an 8 out of a complexity scale of 10. It reported that some aspects of port performance are relatively straightforward, such as trade statistics and port throughput. Difficulties arise on the land side in terms of measuring the effects of the port on congestion compared with general congestion on the urban road networks. Measurement becomes even more complex when attempts are made to isolate and measure national and international aspects. The respondent stated, "If we don't understand the value and net impacts of the system we hope to measure, we won't be able to measure it very well. In sum, there are complexities in port-related supply chains that make measuring, managing and supporting its disparate elements for the achievement of national goals difficult."

The port officials indicated that their concerns that could arise from the development of port-related measures would be:

- Are the supporting data robust?
- Do they fairly allow port-to-port comparisons?
- Will they support an equitable distribution of federal aid?
- Will there be conflicts between national goals and local or regional impacts?
- Will they be used for political ends that don't ensure the safety, capacity, and environmental and economic development needs of the ports?

The port officials indicated that if national policy makers are to understand the major issues facing the nation's ports, the top measures that should be compiled would be:

- Measurement of individual and collective port terminal capacity;
- Volume-to-capacity ratios of major highways and railroads serving marine terminals;
- The number of truck turns per day on trips between ports and the first point of rest for imports and the last point of embarkation for exports;
- Metrics for pollutants produced per container; and
- The economic impact of port-related activities on the national, regional, and local economies.

One of the West Coast ports also supported the development of port performance measures. Several of its cited reasons corresponded with those of its East Coast counterpart but with some significant differences. The West Coast port recommended that, if national policy makers were to develop a few key, insightful measures, the most important should be to understand the difference between actual versus shortest-distance routes from domestic origins and destinations to points of export or import. In other words, if the available capacity of ports were better understood, incentives could be provided to export or import from the closest

geographic port—the logic being that the more direct routes could reduce miles traveled by truck and rail, reduce energy use, reduce emissions, and lessen surface congestion.

Related to that measure, the port official recommended measures to evaluate volume-to-capacity ratios for marine terminals and airports and to provide:

- The percentage of local versus discretionary cargo, to highlight how ports in gateway cities play a national role and provide national benefits;
- The ratio of maintenance budgets to actual maintenance needs, or other forms of deferred investment measurement; and
- Local system reliability and delay data, to highlight performance of the off-port service system as a first or last link in the international supply chain.

This port official was slightly more optimistic about the complexity of developing a set of port performance measures nationally and rated the complexity as a 5 out of a scale of 10. The official suggested that such measures could be simplified if they were stratified by the size and functions of ports.

One state port authority official rated the complexity of a national set of port performance measures as being 7 out of 10. He also noted the dissimilarities between ports and terminals that are designed to handle different types of freight and commodities. If national policy makers are to understand key issues related to the health of the nation's ports, he recommended measures that capture:

- The volume of cargo moving through terminals currently;
- How much excess terminal capacity remains; and
- What terminals handle commodities that are nationally critical and in what condition are those terminals.

He said that his concern over misuse of such measures would be in inaccurate interpretation of the data that could adversely affect allocation of federal funds for needs such as port dredging.

## Private Port Performance Data

IHS Global Insight produced the *Port Tracker*, which used short-term econometric forecasting to predict volume through the major U.S. ports. Its reports provided shippers insight into possible congestion or delay at ports not only caused by freight volumes but also due to localized issues such as trade disputes. It reported freight trends through ports on a monthly basis for the preceding four years compared to predicted current volumes. The *Port Tracker* incorporated data from both public and private sources. It provides forecast trade data by 77 commodity groups, value and volume and mode of transport for 54 countries and 16 global regions.

A similar service is Lloyds Register–Fairplay. It produces and sells a variety of ship travel data, including real-time ship location and travel information. These data come from internationally required on-board GIS transmitters. The data are similar to the ATRI travel-time data derived from GIS transmissions from trucks. The difference is that the Lloyds data track individual ships, both at sea and at port. With such data the location of a ship and the cumulative on-time performance over time can be assessed. The company reports that its users include port authorities, ship agents, brokers, charters, port service suppliers, ship owners, and civil authorities. Its promotional information indicates that it provides real-time information in more than 100 countries and 2,000 ports and terminals internationally. It reports that it tracks and displays the live position of 27,000 vessels a day and is updated every three minutes. Individual vessels can be tracked as to their location, course, speed, and next port.

Another private source of voluminous shipping data is the Port Import Export Reporting Service (PIERS), which is owned by the *Journal of Commerce*. It captures import/export data required to be reported by ships traveling to and from the United States. It synthesizes the data into reports that are purchased by more than 6,000 public- and private-sector data users. It reports that its data not only can measure shipping volumes by commodity type but also can be used for a variety of analytical and modeling purposes.

## Endnotes

1 Cambridge Systematics, Inc. *NCHRP Web-Only Document 154: Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies Volume III: Case Studies.* Transportation Research Board of the National Academies, 2010, pp. 1–4, 5–9, 35–42 (accessed Feb. 18, 2011).

2 AAR Statistics, http://www.aar.org/~/media/AAR/Industry%20Info/Statistics.ashx (accessed Feb. 27, 2009).

3 Strategic Highway Research Program 2, Project R16, "Railroad-DOT Institutional Mitigation Strategies," unpublished study.

4 MARAD. *An Assessment of the U.S. Marine Transportation System*, 1999.

5 RITA/BTS. *Freight in America*, 2006, p. 7.

6 MARAD *Report to Congress on the Performance of Ports and the Intermodal System, 2005.*

7 Chung, Kek Choo. Port Performance Indicators, in *Infrastructure Notes*, for the Transportation, Water and Urban Development Department of the World Bank, December 1993, http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1119275973157/td-ps6.pdf (accessed May 24, 2010).

*Abbreviations and acronyms used without definitions in TRB publications:*

| | |
|---|---|
| AAAE | American Association of Airport Executives |
| AASHO | American Association of State Highway Officials |
| AASHTO | American Association of State Highway and Transportation Officials |
| ACI–NA | Airports Council International–North America |
| ACRP | Airport Cooperative Research Program |
| ADA | Americans with Disabilities Act |
| APTA | American Public Transportation Association |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| ATA | Air Transport Association |
| ATA | American Trucking Associations |
| CTAA | Community Transportation Association of America |
| CTBSSP | Commercial Truck and Bus Safety Synthesis Program |
| DHS | Department of Homeland Security |
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FHWA | Federal Highway Administration |
| FMCSA | Federal Motor Carrier Safety Administration |
| FRA | Federal Railroad Administration |
| FTA | Federal Transit Administration |
| HMCRP | Hazardous Materials Cooperative Research Program |
| IEEE | Institute of Electrical and Electronics Engineers |
| ISTEA | Intermodal Surface Transportation Efficiency Act of 1991 |
| ITE | Institute of Transportation Engineers |
| NASA | National Aeronautics and Space Administration |
| NASAO | National Association of State Aviation Officials |
| NCFRP | National Cooperative Freight Research Program |
| NCHRP | National Cooperative Highway Research Program |
| NHTSA | National Highway Traffic Safety Administration |
| NTSB | National Transportation Safety Board |
| PHMSA | Pipeline and Hazardous Materials Safety Administration |
| RITA | Research and Innovative Technology Administration |
| SAE | Society of Automotive Engineers |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005) |
| TCRP | Transit Cooperative Research Program |
| TEA-21 | Transportation Equity Act for the 21st Century (1998) |
| TRB | Transportation Research Board |
| TSA | Transportation Security Administration |
| U.S.DOT | United States Department of Transportation |