



RESEARCH

FREIGHT PERFORMANCE MEASURES: APPROACH ANALYSIS

Final Report

RESEARCH ODOT/OTREC

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FREIGHT PERFORMANCE MEASURES: APPROACH ANALYSIS

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16. Abstract

This report reviews the existing state of the art and also the state of the practice of freight performance measurement. Most performance measures at the state level have aimed at evaluating highway or transit infrastructure performance with an emphasis on passenger transportation. Freight performance measurement ultimately requires evaluation of performance of the entire freight transportation system, which includes highways, waterways, rail, air, and modal connections. This requires considerable expansion of thinking beyond the traditional focus of state Departments of Transportation (DOTs) on highway performance.

This project builds upon past and current work in the area of freight performance measurement and incorporates recent literature on the development of these measures. A thorough review of state practices is conducted by surveying state DOT web sites and reporting on the measures most frequently recommended and used by individual states for planning purposes. The emphasis is on the application of performance measures to freight transportation, and the usefulness and limitations of these measures, is discussed.

Recommendations are made for potential freight performance measures for each freight mode (air, rail, trucking, and water/marine), including initial information on data availability, validity, and feasibility given existing data for Oregon.

Future research needs discussed include additional data collection and development required to support performance measures, what is needed to track system performance changes over time, and testing of measures for their sensitivity and usefulness for policy and decision-making.

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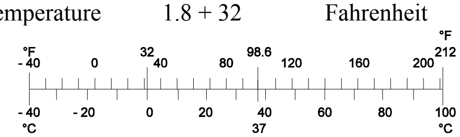
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

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DISCLAIMER

FREIGHT PERFORMANCE MEASURES: APPROACH ANALYSIS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Freight performance measures are tools used in transportation to judge the level of accountability efficiency and effectiveness throughout the various freight modes including air, rail, trucking and water/marine transportation. Performance measures provide a way to focus attention on the goals that an organization has defined and monitoring whether those goals are being attained. Analysis of freight performance measures are necessary for prioritization and selection of specific freight improvement projects in long-range transportation plans (LRTP), transportation improvement programs (TIP), and freight-specific investment programs. Various performance measure analyses have been proposed by different research groups.

1.1 BACKGROUND

Performance measurement has become an integral part of the way many state departments of transportation do business. An overall nationwide review of performance measures shows a clear increase in the use of performance measures over the past 20 years. In 1993, the Federal Government passed the Performance and Results Act which requires all federal agencies to develop and use performance measures. In addition, most states have developed some type of executive or legislative mandate for performance-based management. Several state transportation agencies have been using performance measures for a number of years (*Poister 2004*).

While performance measures have received increasing emphasis, there is often a large variance of perceptions in what exactly is meant by this term. Poister (*2004*) argues that most performance measures used by transportation agencies fall into one of the following three categories: agency performance, system performance, and the impact on broader social performance measures. Agency performance focuses on service delivery, projects completed, etc. System performance focuses on capacity and conditions of the transportation system as well as issues such as travel times, cost, safety, etc. Finally, performance measures also deal with broader societal concerns such as economic development and the environment.

This study does not focus on internal agency performance measures, but rather measures that enable the transportation agency to assess the performance of the freight transportation system and make informed decisions regarding the allocation of resources and effort between modes. However, to do this requires first defining the ultimate goals of the transportation agency which, are often broadly defined to include the impact of the transportation system on the economy, and on other things such as those included in the third category above. Thus, the review of the literature focuses on both performance measures and the ultimate goals or criteria (such as increased mobility, or impacts on economic development) for which each measure is developed.

1.1.1 The Importance of Freight Performance Measures Nationally

Most performance measures at the state level have aimed at evaluating highway or transit infrastructure performance with an emphasis on passenger transportation. Freight performance measures ultimately require evaluation of the performance of the entire freight transportation system, which includes highways, waterways, rail, air, and modal connections. This requires considerable expansion of thinking beyond the traditional focus of state Departments of Transportation (DOTs) on highway performance.

Nationally, the recognition of freight transportation systems as a key research area has been highlighted by the formation of the National Cooperative Freight Research Program (NCFRP), sponsored by the US Department of Transportation, and managed by the Transportation Research Board (TRB) (*ODOT 2009c*). Specific to performance measurement, NCFRP explains the importance of metrics in the following project description for (NCFRP 03), *Performance Measures for Freight Transportation*:

> A comprehensive, objective, and consistent set of measures of performance of the U.S. freight transportation system is important for assessing the condition of that system, identifying its problems, and setting priorities on actions to resolve those problems. Freight system performance measures are important to support decisions about investments, operations, and policies for both the public and private sectors, and for the system as a whole and its critical components–corridors, links, and nodes (terminals). Performance measures for the freight system that are applicable and comparable at various geographic levels will also help educate planners, decisionmakers, and the public about the importance of freight transportation to our economy and quality of life (*Schofield and Harrison 2007*).

While the development of performance measures at the national level is underway, it is also important to develop metrics specific to a state's freight transportation system. This is especially critical as economic growth in the future is predicted to place severe strains on the transportation system and policymakers need to be able to assess the impact of state multimodal investment decisions on the performance of the overall freight transportation system.

1.1.2 The Importance of Freight Performance Measures in Oregon

Performance measurement and investment criteria often go hand-and-hand, as performance data is frequently used to help optimize investments by providing information on the "greatest bang for the buck." Within Oregon, the Oregon Transportation Commission (OTC) makes decisions about investments on the highways and, to a lesser extent, for other freight-moving modes (e.g., through special funding programs for specific purposes such as rail spur improvements). The OTC uses a number of broad criteria for making investment decisions, which vary by funding program. For example, "projects that support freight mobility" is one of the prioritization factors established for the 2008-2011 Statewide Transportation Improvement Program (STIP). As used for the STIP, projects that support freight mobility are defined as modernization projects on freight routes of statewide or regional significance. These are projects that would remove identified barriers to the safe, reliable, and efficient movement of goods and/or would support multimodal freight transportation movements.

Separate criteria is used by the OTC for consideration of funding in the *Connect*Oregon program. The OTC has been charged by the Oregon Legislature with making decisions on state-authorized funding for aviation, marine, public transit, and rail projects through the *Connect*Oregon program. *Connect*Oregon I (ORS 367.080) resulted from the 2005 Oregon Legislative session and directed the OTC to consider factors such as transportation cost reduction, multi-modal connections, system efficiency, project costs, and economic benefits, in selecting projects to be funded via the *Connect*Oregon program (*ODOT 2009a*). The selection criteria for *Connect*Oregon II were revised to include consideration of access to jobs and sources of labor and remove consideration of multimodal connections. The *Connect*Oregon II application material also collected additional detail on job creation and associated wages, documented support of businesses that benefit from the funding request, and whether or not the affected region of the state could be categorized as economically distressed. *Connect*Oregon III further enhanced the selection process by creating an application scoring system based on quantifiable applicant responses. This method establishes a system of ranks, tiers, and priority levels for every application and provides a numerical score on which project funding requests are prioritized.

Separate from investment decision-making, freight is further emphasized in the 2006 Oregon Transportation Plan (OTP), which provides guidance on addressing freight's economic importance through an economic vitality goal, as well as calling for ongoing public information and education about transportation needs and funding alternatives (*ODOT 2009b*). ODOT has begun work on a statewide Freight Plan, "which will help shape freight policies and future investments in freight transportation systems." The Oregon Freight Plan will include further development of criteria and procedures for prioritizing multimodal projects.

Relevant to this study is the challenge of developing and accessing data for freight performance measures that can be monitored to meet the various criteria of interest.

1.2 RESEARCH OBJECTIVES AND REPORT ORGANIZATION

The purpose of this report is to review the existing state of the art and also the state of the practice of freight performance measurement. This project builds upon past and current work in the area of freight performance measurement and incorporates recent US literature on the development of these measures. A thorough review of state practices (Section 2), available literature (Section 3) on the application of performance measures to freight transportation, and the findings of others about the usefulness and limitations of these measures, is included. Section 4 includes an assessment of the availability, accuracy, and reliability of existing data for Oregon and identifies additional data collection and development needs required to support performance measures. In Section 5, recommendations of potential freight performance measures are provided for each freight mode (air, rail, trucking, and water/marine), including initial information on data availability, validity, and feasibility given existing data. Conclusions are presented in Section 6, along with a discussion of what is needed to track system performance changes over time and research necessary to assess whether these measures are sensitive to policy decisions.

2.0 PERFORMANCE MEASUREMENT: STATE OF THE PRACTICE

This chapter first provides a brief summary of transportation performance measurement for each state as listed on their DOT website. Other performance measures found in practice are then presented.

2.1 GOALS AND PERFORMANCE MEASURES FOR STATES

Information on goals and performance measures was attained through the review of state DOT (or equivalent state department) long range plans, publications on state websites, and from the Washington State Department of Transportation (WSDOT)'s *Performance Measurement Library* at http://www.wsdot.wa.gov/Accountability/Publications/Library.htm. An inventory of these resources is provided in Appendix A, and summaries of state level goals and performance measures are provided below.

In the following sections, goals are distinguished from performance measures. While the term "goals" is sometimes referred to interchangeably with the term "performance measures," goals are distinguished in this report as general criteria and performance measures as quantifiable data or measures that can be used to assess progress towards goals. Some states only list goals, others do not list either. In most cases, performance measures in practice are not specific to freight, but could reflect the performance of both passenger and freight transportation systems.

2.1.1 State Transportation Plan Goals

Most states provide general criteria, goals, or objectives in their long range plans rather than specific, quantifiable performance measures or targets. The general goals included here represent the most frequently mentioned goals and objectives for transportation policy.

Although many states have conducted an array of studies relevant to freight transportation and some have sponsored research papers on these topics, the state of the practice as reported here only includes the general goals or objectives listed for general state transportation planning purposes and freight performance measures that are actually being used by each state.
For many states, the only freight transportation mode considered is highway transportation. In others, there has been a serious effort to try and assess the freight transportation system and there is a clear interest in not only individual modes but also in the connectedness of these modes that is necessary to provide a seamless freight transportation system. Indeed, several states have, or are in the process of developing freight transportation plans. Most of the reports associated with these efforts provide a survey of the freight transportation modes used in the state (highway, air, water, and sometimes pipeline) but very few have designated any quantifiable performance measures (*Kale 2003*).

In the long range plans on various state DOT websites, a number of transportation policy goals are mentioned repeatedly. Table 2.1 summarizes the results using general categories, such as "accessibility" or "safety." In some cases, the exact title of a goal did not match the general category but was grouped within when it was apparent that the intent was similar. In some cases, such as "efficiency," only those states were included that referred to the efficiency of the transportation system rather than internal agency efficiency — however it is often difficult to interpret intent.

Table 2.1: Stated Goals for Transportation Policy

Goals	***# of states citing this as a goal***
Safety	42
Environmental stewardship/quality of life	32
Protection/maintenance of transportation investment	29
Mobility of people and/or goods (only 11 explicitly mentioned freight movement of goods)	28
Accessibility	21
System efficiency	18
Promotion of interconnectedness/multimodal system	16
Security	15
Economic vitality	15
Economics development	13
Revenue enhancement	12
Congestion management	8

The goal stated most frequently, on 42 state websites, was safety. Most of the time, safety was related to improvement of the transportation system however it was sometimes related to an internal agency goal, such as reducing agency work-related accidents. Security, a related issue, was named as another goal by 15 states.

Environmental stewardship, improving and enhancing the environment and quality of life, was the second most frequently stated goal for transportation policy (32 states). Although both of these goals can be affected by the actions of the public agency, they are also largely determined by factors out of the agency's control.

Protecting and maintaining the transportation infrastructure, both public and private, turned out to be the third most frequently cited goal, mentioned explicitly by 29 state DOTs. Unlike many of the other goals, the state DOTs have greater influence over the outcome, as they are the agencies typically responsible for building and maintaining the highway system.

Mobility (28 references) and accessibility (21 references) are traditionally at the heart of public transportation agency policies, especially when discussing the movement of people (auto and transit). Eleven of the twenty-eight references to mobility specifically mentioned freight.

At least 18 states made explicit mention of transportation system efficiency as a policy goal. However, as will be seen below, there were virtually no measures used to assess the efficiency of the transportation system. Rather, when efficiency measures were considered by state DOTs, they usually referred to an internal measure; such as the number of construction contracts that come in at or under budget.

The next most frequently mentioned goal was interconnectedness or the multimodal nature of the transportation system (16 states), referring explicitly to freight transportation. Four states specifically mentioned the importance of global competition.

Economic development was mentioned in 13 states and 15 states referred to economic vitality and the role of transportation in assuring economic health for the state.

Twelve states listed enhancing revenues for transportation as a major policy goal, although there were only a couple of examples given as to how the public agency could achieve this goal.

Eight states explicitly stated reducing congestion as a policy objective, and another four listed the reliability of the transportation system.

Other stated transportation policy goals included: accountability (5), system capacity enhancement/improvement (4), or some aspect of customer service, responsiveness, or satisfaction (12).

2.2 STATE PERFORMANCE MEASURES

In many cases, the only performance measures mentioned in state plans were internal measures such as the number of customers served at a motor vehicle office per day, time state contracted projects take to complete, cost containment on projects, or the time it takes to serve an average motor carrier division customer. These internal agency performance measures are not reported in the review below unless they appeared to somehow relate to the provision of freight transportation services by the state.

In other cases, performance measures listed in state plans applied only to passengers—such as measures of transit system performance. Most of these are omitted from this report as the focus is only on freight measures. With those exclusions, there were relatively few quantifiable performance measures that had been developed specifically for freight performance measurement. Many of the measures presented below could apply broadly to both passenger or freight transportation on the highway system, for example. Others, such as the number of passengers enplaning at an airport appear to be passenger related, but also probably give some indication of the accessibility/attractiveness of the airport location for air cargo, since freight is a derived demand.

Table 2.2-2.9 report performance measures and corresponding targets or benchmarks for some of the goals reported in Table 2.1. Performance measures are organized by goal. However, in some cases a measure could conceivably be listed under more than one goal, or may not clearly be aligned with any specific goal.

Efforts were made to identify those measures that were clearly freight related. However, it is important to note that many of the general measures may not be solely relevant to freight, but may be important to freight transportation system performance. For instance, under system maintenance, many states have developed measures that concern the structural integrity of bridges in the system. Although bridges carry passenger and freight vehicles, freight transportation is probably most affected when bridges must post lower weight limits and restrict traffic due to structural deficiencies. Thus, it could be argued that bridge measures, although applicable to system performance of all vehicles, should receive more weight when considering freight transportation system performance.

2.2.1 Safety

Safety was the most frequently listed policy goal by states there are as indicated in Table 2.2 While there were a vast array of different measures, "fatality rate" (fatalities per 100 million vehicle miles traveled (VMT)) was the most frequently mentioned (19 states). Although some states looked only at the number of fatalities and set targets accordingly, the fatality rate performance measure controls for the amount of vehicle traffic that actually occurs, and thus, theoretically, makes it a comparable measure across states. However, the variation in targets set by different states (e.g. .88 for New Mexico, compared to 2 for Wyoming), suggests that the measure may not be directly comparable. This probably reflects both differences in terrain, weather, and data availability across states.

Accident rates, crash rates, and personal injury rates are other measures used by states to access safety. Rates are often differentiated by categories such as alcohol related accidents/fatalities and those related to seat belt use. Many states use information on the location of accidents (work zones, signalized intersections, etc.) to plan for investments in safety improvements and to develop specific designs to address the safety issues. While these clearly have policy implications relevant to the state agencies, it is not clear that any are directly relevant for assessing freight performance.

Safety performance measures for each mode are specified below and shown in Table 2.2.

Highway

For highways, the fatality, injury, and crash rates that involve commercial vehicles or large trucks are the ones most obviously related to freight performance. Only four states (Nevada, Oregon, Missouri, and Pennsylvania) report that they use any of these rates in assessing highway safety performance. Notably missing is any reference to the value of loss or damage from accidents involving commercial vehicles and large trucks. From the shippers' perspective, a truck involved in a crash reduces freight system performance by increasing time in transit due to delay and also by the amount of loss and damage incurred by the accident.

Air

Air safety measures are cited much less frequently and often have to do with safety inspections or violations, runway accidents, or general aviation fatality rates. None of these apply specifically to freight.

Water/Port

The water/port measures do apply specifically to freight such as the number of containers inspected. It is not clear how general compliance with the Maritime Security Act of 2002 is measured although it obviously is relevant for the safety and efficiency of traffic flow through ports.

Rail

Rail safety measurement, when it is done, mostly applies to rail crossings safety or derailments – both of which can have impacts on either passenger or freight rail transportation performance. Only six states report any rail safety measures at all as seen in Table 2.2

Table 2.2: Performance Measures and Targets Used by States: Safety

Mode	Measure	States Using the Measure	Targets
Highway	Fatality Rate (per 100 million VMT in State)	AZ, CA, IL, KS, ME, MASS, MD, MO, MT, NE, NM, NY, OH, OR, RI, UT, VA, WA, WY	Reduce fatality rate by 2% (AZ) Reduce to below 1.0/100million VMT (NE) =.88 (NM) <1.63 (NC) =1.0 (OH, WA) To 1.0 by 2011 (RI) Five year average below 1.0 per year (UT) =2 (WY)
	Fatality Rate (per 100 million VMT on statewide system)	WY	2.53 (WY)
	Alcohol related fatality rate per 100 million VMT	IL, OR	
	Accident rate (per 100 million VMT)	TN	Rural roads: .44 (TN) Urban roads: 1.16 (TN)
	Crashes rate (crashes per 100 Million Vehicle Miles)	NC, WY	Less than 233.76 (NC) 174 total system; 153 state highway (WY)
	Frequency/number of crashes	OH,VT	Reduce by 10% (OH) Reduce to fewer than 350 by 2010 (VT)
	Rate of personal injury accidents (per 100,000 VMT)	MD, MO, MT, NC, OR	Less than 115.56 (NC)
	Preventable accident rate (Preventable accidents per 100,000 VMT	MD	
	Number of…		
	Fatalities related to drivers with revoked/suspended licenses	PA	
	Traffic fatalities	MD, MN, MO, MT, PA,UT, VA, WY	142 (WY)
	Rear end crashes	OH	Reduce by 25% (OH)

Mode	Measure	States Using the Measure	Targets
Highway	Number of… (cont.)		
	Personal injury accidents	MD, MO, MT, PA	
	Alcohol related fatalities	NM, PA, NV	<172 (NM)
			Reduce from 93 to 66 (NV)
	Non-alcohol related traffic fatalities	NM	<264 (NM)
	Average alcohol related repeat offender fatalities	NV	Reduce from 7 to 5 (NV)
	Driver impaired fatalities and disabling injuries	MO	
	Annual average unbelted fatalities	NV	Reduce from 164 to 116 (NV)
	Signalized intersection fatalities	NV, PA	Reduce from 41 to 29 (NV)
	Intersection red-light running and speed fatalities	NV	Reduce from 18 to 3 (NV)
	Running off the road fatalities	NV	Reduce from 135 to 96 (NV)
	Un-signalized intersection fatalities	NV	Reduce from 88 to 63
	Crashes in established safety corridors	NM	886 (NM)
	Work zone crashes	ME*	
	Fatalities and injuries in work zones	MO	
	Annual average lane departure failures	NV	Reduce from 186 to 132 (NV)
	Bridge inspections	FL	
	Bridge inspections contracted for repair or replacement	FL	
	Percent of…		
	Reduction in crash rates at improved sites	LA	
	Of drivers who drove safely by avoiding traffic violations and accidents during the past three years	OR	
	Statewide Safety Belt Usage	NC, OR, WY	90% or Greater (NC)
			77% all drivers;75% Wyoming drivers (WY)
	Front seat occupants using seat belt	KS, NM	90% (NM)
	Crash Costs	ME	
	Rate of nighttime crashes	MO	
Air	Percent compliance following IDOT safety inspection	ILL	
	Number of safety violations at airports	LA	
	Number of airports with lighting meeting standard	LA	
	Number of repeat discrepancies in the FAA inspection	MD	
	Rate of airfield ramp incidents and accidents per 1,000 operations	MD	

Mode	Measure	States Using the Measure	Targets
Air	General air service fatalities	MN	
	Percentage of airports participating in voluntary security certification	VA	
	Number of Individuals Participating in Aviation Safety/ Training Programs Sponsored by DOT	WY	
Water/Ports	Percent of port containers inspected	FL	
	Port of Baltimore compliance with Maritime Transportation Security Act of 2002	MD	
	Compliance with the Maritime Transportation Security Act (no exact measure)	VA	
Rail	Number of improved rail crossings/year	LA	
	Number of crashes/fatalities at railroad crossings	ME, MO, NE	
	Derailments	MN, OR	
	Number of public at-grade railroad crossings closed	NE	
	Number of highway-railroad at-grade incidents	OR	
	Number of at-grade crossings of freight lines by state-owned roads within strategic rail corridors	PA	Eliminate all by 2015 (PA)

2.2.2 Maintenance/Preservation

Maintenance and preservation of the transportation infrastructure has long been a primary function of state DOTs. In some states, the responsibility is only for highways; in others the state DOT also has responsibility for airports, waterways, and even pipelines. This in part, accounts for the fact that most states have not developed performance measures other than highways and bridges, which fall into the traditional functions of most DOTs. Performance measures related to maintenance and preservation for each mode are specified below and shown in Table 2.3.

Highway

When discussing the performance of highways, most states use some sort of pavement quality measure. The International Roughness Index (IRI) is the measure most frequently mentioned as a standard; however, different states set unique targets for IRI measures. Some distinguish between state roads and interstates and set unique standards for each (such as the percent of roads that are rated "good" or better) while other states have an overall standard.

In addition to using the IRI as an indicator of pavement quality, several states have developed their own indices of pavement or ride performance. It is not clear from reading through these plans how similar or dissimilar these measures are from one another or from the IRI. Similarly, for bridges two states use a Bridge Health Index (BHI) but it is not clear whether both states use the same measure. More common is a measure such as "the percent of deficient bridges" or the number of structurally deficient bridges by ownership category. Even then, it is not clear how the exact criteria for classification may vary from state to state.

It is difficult to assign any of the pavement or bridge performance measures specifically to freight, although as noted above, freight carriers operating on the highway system are apt to be more affected by deficiency in bridges than passenger vehicles. When weight restrictions are placed on bridges, trucks often have to use an alternate, more circuitous route that may have a significant adverse impact on the quality of the freight service provided. General performance measures for pavement and bridges may indirectly consider freight through design standards such as those that specify wider lanes for truck routes and bridges with a heavier load capacity.

Air

While none of the airport measures are specific to air cargo, obviously the service for both freight and passengers may be affected by the conditions of the runways.

Water/Ports

Since dredging of waterway has obvious impacts on ocean going cargo ships, the one measure suggested in Table 2.3 is relevant for freight.

Rail

Probably the most relevant freight measure presented in Table 2.3 is the rail measure used by only one state (Tennessee), the percentage of short line track miles with capacity over 286,000 pounds.

Table 2.3: Performance Measures and Targets Used by States: Maintenance/Preservation

Mode	Measure	States Using the Measure	Targets
Highway	Roads:		
	International Roughness Index (IRI)	AZ, MASS, MT, NE, NV, PA	Maintain IRI<171 on 97% of state highways (AZ)
			At least 84% of miles are rated good or better (NE)
			Percent in good or better condition (NV): 2010 = 92% 2015 = 100% 2020 = 100%
			Reduce percent rated poor by 2005 to: (PA) Interstates: <1% NHS: <5% Other: <15%
	Rut Index	MT	
	Alligator crack index	MT	
	Miscellany crack index	MT	
	Overall performance index (calculated as a weighted average of the others)	MT	

Mode	Measure	States Using the Measure	Targets
Highway	Roads: (cont.)		
	Nebraska Serviceability Index (NSI)	NE	At least 84% of miles are rated good or better (NE)
	Pavement Serviceability Index	MASS	
	Ride Quality Index (RQI)	MN, NM	4.3 (NM)
	Pavement Quality Index (scale 1 to 5)	TN	Interstates 90%>3.5, 10%<2 (TN) State routes 80%>3.5, 15%<2 (TN)
	Maintenance Rating Index	TN	Interstates: 90 (TN) State routes: 85 (TN)
	Percent state road in acceptable condition	ILL, MD	
	Percent of state roads in need of repair	ILL	
	Percent of distressed lane miles	CA	
	Percent of interstate pavement in highest rated condition	KS	
	Percent of Interstate Route Miles in Good Condition	NC	85% or Greater (NC)
	Percent of Primary Route Miles in Good Condition	NC	80% or Greater (NC)
	Percent of Secondary Route Miles in Good Condition	NC	75% or Greater (NC)
	Percent of non-interstate pavement in highest rated condition	KS	
	Percent of road pavements in good or excellent condition	WY	51% (WY)
	Percent rural miles with sufficient shoulder width	KS	
	Percent of major highways in good condition	MO	
	Percent of minor highways in good condition	MO	
	Percent of Interstate Highway System (HIS) in fair or better condition	LA	95% or greater
	Percent of National Highway System Miles (NHS) in fair or better condition	LA	93% or greater
	Percent of Highways of Statewide Significance (HSS) in fair or better condition	LA	90% or better
	Percent miles on the Regional Highway System (RHS) in fair or better condition	LA	80% or greater
	Percent state highway network in preferred maintenance condition	MD	
	Percent of all state maintained lane-miles meeting pavement conditions rating standards	OH	93% (OH)
	Percent of pavement centerline miles rated “fair” or better out of all such miles in state system	OR	
	Percent of travel on the NHS meeting pavement performance standards for good ride	RI	62 percent by 2011 (RI)

Mode	Measure	States Using the Measure	Targets
Highway	Roads: (cont.)		
	Percent of pavement in "fair or better " condition by road class	UT, WA	State highways : 90% (WA)
	Percentage of Interstate and Primary Road Pavement in Need of Repair	VA	
	Percent of roads with capacity deficiency	VA	
	Number of non-interstate miles rated good	NM	8,225 (NM)
	Number of Interstate Highway road surface miles rated Good	NM	1,190 (NM)
	Number of system wide state highway lane miles in deficient condition	NM	< 2500 (NM)
	Number of Statewide Improved Surface Lane Miles	NM	4,500 lane miles (NM)
	Level of service (LOS)	AZ	90% of state highway system maintained at min. stds (AZ)
	Number of distressed lane miles	CA	
	Average remaining service life for pavement by route type	SC	
	Statewide Maintenance Expenditures per lane mile for Combined Roadways	NM	3,500 (NM)
	Bridges:		
	Percent bridges with bridge health index (BHI<80)	KS	
	Bridge Health Index	MASS	85% or greater (MASS)
	Average highway bridge condition (scale 0-100)	TN	90 for state and interstate routes (TN)
	Weighted Score of all Highway Features, excluding Pavement and Bridges, in Acceptable Condition	NC**	84 or Greater (NC)
	Percent of bridges in acceptable condition (or rated not deficient)	ILL, OR	
	Percent of bridges in need of repair/rehabilitation	ILL, VA	
	Percent deficient bridges on state highways	MO	
	Percent deficient bridge deck area	LA, RI	19% on NHS bridges by 2011 (RI)
	Percent of state owned bridges categorized as structurally deficient or functionally obsolete	NV	2010 = reduce by 2.6% (NV)
	Percent of Bridges in Good Condition	NC	76% or Greater (NC)
	Percent of state maintained bridges meeting general appraisal standards	OH	97%
	Percent of state maintained bridges in fair or better condition	WA	97% (WA)
	Percent functionally obsolete bridges	TN	10%

Mode	Measure	States Using the Measure	Targets
Highway	Bridges: (cont.)		
	Number of structurally deficient bridges (sometimes by ownership group)	MA, MD, MO, MT, SC, VT	Interstate system < 21(7%) (VT State highway system <122 (16%)(VT) Town highway system <257 (16%)(VT) On-system "shorts" < 155 (12%)(VT)
	Number of deficient bridges replaced	SC	
	Number of closed bridges	MASS, PA	reduce by 50% by 2010 (PA)
	Number of bridges	MD, SC	
	Structural condition of bridges (bridge area in square feet in different conditions)	MN	
	Bridge inspection	MN, FL	
	Bridges structurally sound and adequate	NE, WY	95% of bridges meet this target(NE) 83% (NHS) (WY) 80% (non-NHS) (WY)
	Number of posted bridges	PA	
Air	Number of airports with pavement ratio > 70	LA	
	Percent of airport runway rated satisfactory or better	IA, NM	75% (NM)
	Percent of airport taxiways rated satisfactory or better	IA	
	Percent of airport aprons rated satisfactory or better	IA	
	Airport pavements at or above acceptable	WY	85% (WY)
Water / Ports	Freight-Specific		
	Dredge material replacement capacity remaining for harbor and bay maintenance dredging	MD	
Rail	Freight-Specific		
	Percentage of short line track miles with capacity over 286,000 pounds	TN	60% (TN)

2.2.3 Mobility

Several of the mobility metrics reported by state DOTs overlap with measures of congestion. Similarly, some of these measures also overlap with accessibility. For instance, freight tonnage by mode is a mobility measure, but can also be used as an accessibility measure, providing information on which modes are accessible to shippers. Table 2.4 lists the various mobility measures.

Highway

Many of the mobility measures listed have to do with travel times, some for selected corridors and others for the entire system. It is not always obvious exactly how the measures are calculated. The travel time index (TTI) developed by the Texas Transportation Institute and used by the state of Minnesota is one example of a measure applied to a specific corridor using a known methodology. For others such as Missouri's average travel index, it is less clear exactly how it is measured.

While several of the measures may be used as internal agency performance measures, they also have an impact on freight mobility, such as the adverse impact of not timely issuing "single trip overdimensional vehicle permits issued within one day" or the number of "annual and special permits issued within 30 days." Thus, they are included here as an indicator of how easily carriers are able to get special permits needed to convey heavy or other non-standard loads.

Similarly, "the percent of trucks using advanced technology at weigh stations" may also be used as an indicator of internal agency efficiency in dealing with carriers at weigh stations. However, if it makes it easier for freight carriers to clear weigh stations, it saves them time and that increases the quality of freight performance.

Finally, "interstate motor carrier mileage" is an indicator of the volume of freight travel on the roads and is a gross indicator of freight mobility.

Air

The air service mobility measures are mostly related to passenger enplanements which may, in turn, be related to the area's population, and thus freight demand. One, "the percent of public-use airports connected to state traffic routes" seems particularly relevant for air cargo, as it usually requires intermodal movement, particularly on the highway system. No specific definition was provided for exactly how this is measured.

Water/Ports

For ports, the number of twenty foot equivalent units (TEUs) passing through the port may provide an indicator of freight mobility. This measure was only found for Maryland, with specific application to the port of Baltimore. As is discussed in the Section 3 (State of the Art), port-specific factors such as cargo type and container versus bulk shipments, may render inter-port comparisons inappropriate.

Rail

There are few mobility measures for rail and most usually apply to passengers. The exception is the state of Pennsylvania, which uses two measures related to double stack usage: "double stack clearance on strategic corridors" and "the number of strategic rail freight corridors considered adequately doubletracked and signalized."

Table 2.4: Performance Measures and Targets Used by States: Mobility

Mode	Measure	States Using the Measure	Targets
All	Freight tonnage by mode	MO	
Highway	Travel Time Index (developed by the Texas Transportation Institute (TTI)	MN	
	Average Annual Daily Traffic (AADT)	ME	KS
	Average daily hours of delay time (ADT)	CA	
	Average freeways speeds in key downtown corridor(SLC)	UT	
	Hours of travel delay per capita per year in urban areas	OR	
	Volume to capacity ratio (V/C)	OR	
	Growth in vehicle hours of delay	OH	reduce to 8% on state multilane divided system (OH)
	Service level	OH	D on urban state freeways(OH)
			B on rural freeways (OH)
	Travel time reliability (% variation from predicted time	CA	
	Average travel indices and speeds on selected freeways sections	MO	
	Average rate of travel on selected signalized routes	MO	
	Average daily hours of delay time/capacity	ME	
	Annual hours of delay per year per traveler	VA	
	Annual weekday hours of delay statewide on highways relative to maximum throughput	WA	
	Percent of vehicle hours traveled due to delay	ME	
	Percent single occupancy vehicles (SOVs) as a percent of total commute trips	CA	
	Percent of VMT on major highways in good condition	MO	
	Percent of VMT on minor highways in good condition	MO	
	Percentage of daily vehicle miles traveled at LOS E or worse	NV	2010 = 15% (NV)
	Number of lane-miles added	FL	
	Number of lane-miles on the state highway system	FL	
	Calls to state's 511 traveler information system	MASS	
	Number of miles under construction	FL	
	Freight-Specific		
	Percent of trucks using advanced technology at weigh stations	MO	
	Interstate motor carrier mileage	MO	
	Single trip overdimensional vehicle permits issued within one day (or same business day)	NV	2010 = 100%
			2015 = 100%
			2020 = 100%

Mode	Measure	States Using the Measure	Targets
Highway	Freight-Specific: (cont.)		
	Annual and special permits issued within 30 days	NV	2010 = 100% 2015 = 100% 2020 = 100%
	Average truck speeds along I-70	KS	
Air	Rural passenger enplanements	NV	2010 = 32,300,000 2015 = 38,200,000 2020 = 44,500,000
	Rural air carrier and taxi operations	NV	2010 = 780,000 2015 = 880,000 2020 = 990,000
	Public use airports aircraft operations	NV	2010 = 1,100,000 2015 = 1,200,000 2020 = 1,300,000
Air	Percent of public-use airports connected to state traffic routes or high-access transit systems	PA	65% by 2018
	Number of enplanements at air carrier airports	VA	
Water / Port	Freight-Specific		
	Twenty foot equivalent (TEUs) shipped through the Port of Virginia	VA	
Rail	Number of rail passengers in millions	CA	
	Freight-Specific		
	Double stack clearance on strategic corridors	PA	
	Number of strategic rail freight corridors considered adequately doubletracked and signalized	PA	

2.2.4 Congestion

Congestion performance measures and targets are presented in Table 2.5. While none of these measures apply specifically to either freight or passenger transportation, both types of transportation are affected by congestion. As will be seen in Section 3, most models seem to focus on passenger vehicles.

The ratio of volume to capacity (V/C) is explicitly mentioned only in a couple of state plans, but given the number of states that use something like "percent of congested miles", it appears that something like a V/C is used to make the classification of whether a road is congested or not. Note that in Oregon the V/C is considered to be a measure of mobility. Similarly, the Travel

Time Index (TTI) is used by some states (MN) as a mobility measure as well as a measure of congestion.

Congestion measures specific to transportation modes other than highway were not found. However, it is clear from reading through most of the state long-range plans, that reducing or ameliorating congestion is a very high priority for state transportation policy, and that appropriate measures and targets are being developed.

Table 2.5: Performance Measures and Targets Used by States: Congestion

Mode	Measure	States Using the Measure	Targets
Highway	Volume to capacity ratio (V/C)	CO*, MASS**	
	Travel Time Index (developed by the Texas Transportation Institute (TTI)	OR,MN	
	Percentage of congested lane miles by road type (from planning model)	TN	
	Percent of urban miles congested	KS	
	Percent of state maintained urban miles congested	TN	10%
	Percent of urban HIS in uncongested conditions	LA	
	Percent of urban NHS in uncongested conditions	LA	
	Percent of rural miles congested	KS, TN	5% (TN)
Highway	Percent of Strategic Highway Corridor Miles that have Little or No Recurring Congestion	NC	85% or Greater (NC)
	ADT on congested routes	KS	
	ADT on rural congested routes	KS	
	Non-recurring congestion (time to clear accidents)	KS, MO, NC, OH, UT,VA, WA	Less than 90 minutes (NC,OH)
			Reduction of 5% on Puget Sound roads (WA)

* *>85% considered congested (CO)*
** *estimated at 500 locations*

2.2.5 Accessibility

As stated in relation to many of the other policy goals, performance measures for accessibility overlap with measures for other goals. Measures often include the number of miles traveled by various classes of customers and, as such, could also be construed as mobility measures. The currently used measures for accessibility are presented in Table 2.6.

For freight, the relevant measures are either the number of commercial miles traveled in the state (e.g. by urban/rural class, used by Montana) or the number of vehicle miles driven in the state for heavy trucks. For air, the number of freight cargo tons was found for only one state, Iowa. Similarly, for water/ports and rail, the number of tons originating or terminating in the state is used as a measure of accessibility.

The only other freight related measure that may impart additional perspective regarding accessibility is "TEUs per acre (port capacity) of cargo per acre." This measure may better indicate accessibility in terms of port capacity—although future accessibility might better be indicated by a measure that refers to the excess capacity available.

Table 2.6: Performance Measures and Targets Used by States: Accessibility

Mode	Measure	States Using the Measure	Targets
Highway	Vehicle Miles Traveled (VMT) by functional road class	ME, MASS, MT, WA	
	VMT auto	IA	
	Annual average daily miles of traffic	ME	
	Average vehicle occupancy	ME	
	Freight-Specific		
	Commercial miles traveled by road class (urban/rural)	MT	
	VMT by heavy trucks	IA	
Air	Number of passenger enplanements	IA	
	Population within 60 minutes of airports with scheduled service	MN	
	Freight-Specific		
	Number of freight cargo tons	IA	
Water/Ports	Freight-Specific		
	Tons originating or terminating by water in state	IA	
	Dry cargo through port	ME	
	TEUs per acre (port capacity) of cargo per acre	VA	
Rail	Number of Amtrak passengers	IA	
	Freight-Specific		
	Tons originating or terminating by rail in state	IA	

2.2.6 Environment

None of the performance measures that were found for measuring the impact of various transportation activities on the environment or on sustainability/quality of life, were mode specific (Table 2.7). In almost every case where specific environmental measures were considered, they represented an overall measure for the state or region, such as listing: volatile organic compounds, nitrous oxides, carbon monoxide, ozone, particulates and greenhouse gases—some of which may originate from sources other than the transportation sector. Similar criticisms exist for such measures as "clear air days" and "fuel usage per capita." None are specific to freight.

The other type of environmental measure used by state DOTs relates to environmental impacts, such as facilities impacts on wetlands. While this is more under the control of the state agency, it is not clear how it affects freight performance unless mitigation of wetland loss has an impact on the infrastructure serving freight carriers.

Table 2.7: Performance Measures and Targets Used by States: Environmental

Mode	Measure	States Using the Measure	Targets
Non-Specific	Transportation-related emissions by region:	MD	
	Volatile Organic Compounds (VOCs) (tons/ day)	MD	For each region/dates (MD)
	Nitrous Oxides (NOx) (tons/day)	MD	For each region/dates (MD)
	Carbon Monoxide (CO) (tons/day)	MD	For each region/dates (MD)
	Particulate matter (PM) (ton/ day)	MD	For each region/dates (MD)
	Outdoor levels of ozone, nitrous dioxide, CO, and PM – percentage of the NAAQS	MN	
Non-Specific	Percentage change in (VMT) as proxy for greenhouse gas emission	MD	
	Acres of wetlands or wildlife habitat created, restored or improved since 2000	MD	
	Measurement of acres of wetlands habitat developed above and beyond present and past project replacement needs	NE	
	Ratio of wetlands created compared to the number of acres of wetlands impacted	MO	
	Percent state clean air days	MO	
	Number of gallons fuel consumed	MO	
	Fuel usage per capita	VA	
	Number of historical resources avoided or protected as compared to those mitigated	MO	
	Ozone Emission Standards Violations	NY	
	Petroleum consumption	NY*	
	Greenhouse gas emissions from fuel combustion	NY*, WA*	
	Tons of transportation related emissions	VA	
	Acreage of land preserved	VA	
	Number of DOT stormwater treatment facilities constructed or retrofitted	WA	
	Number of DOT fish passage barrier improvements constructed since 1980	WA	
	Number of high priority culverts remaining to be replaced or retrofitted to improve fish passage	OR	

**Unclear as to whether there is a precise measure specified*

2.2.7 Connectivity

Table 2.8 contains measures for connectivity. In many cases, these measures could easily serve also as accessibility, mobility, or congestion measures. For highway and air, the proposed measures could apply to either freight or passengers. For highway, freeways and interconnector road speeds are critical for intercity long-distance trucking activity although speeds are often viewed as a mobility measure as well. For airport, the number of non-stop markets served is an indicator of connectivity for both passenger and freight.

The connectivity measure for water/ports includes general cargo tonnage, which was also an accessibility measure, but in addition includes foreign cargo tons, which indicate global connections. The average truck turnaround time at the marine terminal is the only connectivity performance measure that directly targets intermodal transportation.

Note that the rail connectivity measure, "regional and short line rail with rating above 286,000 pounds," is similar to the one that was used by Tennessee for maintenance and preservation.

Table 2.8: Performance Measures and Targets Used by States: Connectivity

Mode	Measure	States using the Measure	Targets
Highway	Percent of freeway lane-miles and arterial lane-miles with AADT at or above congested levels	MD	
	Travel speed on state interregional connectors	MN	
Air	Number of non-stop airline markets served	MN, MD	
	Number of daily flights in and out of state	MN	
	Number of daily scheduled air flights	MO	
	Number of business capable airports	MO	
Water/Ports	Freight Related		
	Port of Baltimore foreign cargo tons	MD	
	General cargo tonnage	MD	
	Average truck turnaround time at key marine port	MD	
Rail	Freight Related		
	Regional and short line rail with rating above 286,000 pounds	TN	

2.2.8 Other Performance Measures

An assortment of performance measures not otherwise categorized by one of the policy goals above, is presented in Table 2.9. Several states conduct a variety of consumer rating surveys to rate satisfaction with a number of key transportation facilities and services such as airports, general transportation options, travel safety, road pavements, etc. None deal specifically with freight transportation providers or customers except the percentage of satisfied motor carrier customers and truck speeds along an interstate.

The rest of the miscellaneous performance measures are attempts to look at the overall health of the state's economy or economic vitality such as the unemployment rate and per capita income—these are measures that are primarily affected by factors other than transportation. Given the derived demand nature of freight transportation, the direction of causation is most likely to be in the reserve direction, from economic indicators such as income to transportation.

Table 2.9: Performance Measures and Targets Used by States: Other

Measure	States using the Measure	Targets
Illinois motorist rating of IDOT road construction (survey results)	IL	
Percent BWI customers rating the airport as good or better on key services	MD	
Percent of customers satisfied with transportation options	MO	
Percent of public satisfied with travel safety in Oregon	OR	
Perception of road pavements from consumer survey	WY	70%
Percentage of updated emergency, disaster, and evacuation plans	VA	
Freight-Specific		
Percent satisfied motor carrier customers	MO	
Per capita income	VA*	
Unemployment rate	VA*	
Annual percent change in unemployment rate	VA*	
Business climate (as ranked by Forbes Magazine)	VA*	

Note that these are general state economic health measures not specific to transport

2.3 OTHER MEASURES: HIGHWAY FREIGHT PERFORMANCE MEASURES

Most freight performance measures that are used in practice relate specifically to highway transportation. Some of these rely on data from the FHWA's Highway Performance Measurement System (HPMS), whereas others collect data directly from other technology. As the next two studies show, these measures require a much more detailed level of data and usually can only be measured for specific corridors or segments of the road system.

2.3.1 FHWA (*2006a*): Travel Time in Significant Freight Corridors

FHWA (*2006a*) reports travel times and reliability for five significant freight traffic corridors located on the U.S.: I-5, I-10, I-45, I-65, and I-70. Eventually FHWA plans to include 25 corridors that represent approximately 80 percent of the commodity freight being carried on the Interstate highway system.

For the corridors currently studied annual average daily traffic (AADT) and annual average daily truck traffic (AADTT) was used from the FHWA's Highway Performance Measurement System (HPMS) to assess performance of freight. They use average truck speeds on corridors as a freight performance measure. To measure reliability, they use a Buffer Index (BI) that is similar to the Travel Time Index measure developed by the Texas Transportation Institute and used in FHWA's urban congestion monitoring program. The BI describes how much more time needs to be budgeted at a given level of certainty. The BI is calculated using 95% on-time arrival rate (*2006a*).

In the future, this study suggests developing and using percent of on-time arrivals, average variability in point to point travel times, and average vehicle hours of delay as additional freight performance measures. There are also plans to extend the measures to include border time delays and reliability measures for five U.S. border crossings that account for 50% of inbound truck freight.

2.3.2 American Transportation Research Institute (ATRI) (*2009*): Freight Performance Measures Analysis of 30 Freight Bottlenecks

A study by ATRI (*2009*) used a congestion measure for freight highway performance to identify and rank 30 of the worst freight bottlenecks on the highway system in the U.S. The major focus was on congestion affecting freight vehicles, a factor considered to be of great importance to freight system users. The unique ATRI database contains GPS position location and timestamp collected from wireless technology installed in trucks for a subset of commercial vehicles that participate in the data collection effort.

For each location, the freight vehicle speeds were calculated. An average speed per hour was determined which was then subtracted from the free flow speed (assumed to be 55 mph). For each hour block, the total commercial vehicles in the data sample is multiplied by the speed difference to determine a "total freight congestion value." In hours where average speeds exceed free-flow speed, no freight congestion value is assigned (i.e. the value is 0). For all hours under study, the congestion value is summed to rank the relative congestion at each bottleneck.

2.3.3 Federal Motor Carrier Safety Administration (FMSCA): Large Truck Crash Facts 2005 (*2007*)

Growth in commercial motor carrier traffic on the U.S. highway system and increased threat to highway safety posed by many unsafe motor vehicle operations has resulted in an increase in funding for the development and/or strengthening of motor carrier safety programs, rules and regulations. The mission of FMCSA's Office of Analysis, Research and Technology is to reduce the number and severity of commercial motor vehicle (CMV) crashes and enhance the efficiency of commercial motor vehicles.

Although not referred to explicitly as performance measurement, the FMCSA publishes an annual volume of data on the number and rates for fatality accidents, injury accidents, and property damage accidents for large trucks.

2.4 OTHER MEASURES: RAIL FREIGHT PERFORMANCE MEASURES

The few rail performance measures that are available in the U.S. are not collected by a government agency. In the U.S. the Association of American Railroads (AAR) collects and publishes this data. In Australia, this is done by the Bureau of Transport and Regional Economics (BTRE).

2.4.1 Australian Rail Freight Performance Indicators

The Bureau of Transport and Regional Economics (*2007*) reports results for 11 railway indicators starting in 2005-06. These indicators of freight performance are categorized into three groups: train, track, and market.

For <u>train</u>, the three indicators are:

1. Scheduled intermodal transit time
2. Actual intermodal transit time3. Number of weekly intermodal direct city-to-city trains; total number of weekly intermodal trains on a line segment; and total number of weekly steel trains.

For <u>track</u>, the four indicators are:

1. Train length
2. Double-stacking capability
3. Track quality
4. Train flow patterns
    a. Dwell time
    b. Number of stops
    c. Average speed

For <u>market</u>, the four indicators are:

1. Access revenue yield indicator
2. Intermodal state-to-state market share
3. Total rail task, by line segment
4. Intercity line segment share in total rail task

3.0 FREIGHT PERFORMANCE MEASUREMENT: STATE OF THE ART

Despite a general movement towards use of performance measures in transportation planning, very few freight performance measures are usually included in the traditional transportation planning process. Practical performance measurement has generally been limited to less rigorous, less quantitative and more heuristic approaches.

In contrast, the state-of-the-art freight performance measures advocated by transportation researchers tend to be comprehensive, require good data availability and significant commitment by state DOTs or other agencies. In addition, the freight performance measures developed and suggested in various research projects often involve simplifying assumptions and calculations that need to be made using data that may or may not be available to analysts.

3.1 GENERAL FACTORS TO CONSIDER IN THE DEVELOPMENT OF FREIGHT PERFORMANCE MEASURES

Development of performance measures by transportation agencies involves three main stages: the first selects, then establishes performance measures and monitors progress, the second is real-time orientated and deals with using performance measures in the project planning and management process, and the third is future orientated and focuses on using a package of measures to optimize benefits (*TRB 2004*).

The key to identifying a performance indicator is that it is measurable, efficient, able to be forecasted, and easy to understand (*Harrison et al. 2006*). Specific challenges, identified by Poister (*2004*), in the development of effective and useful performance measures include:

- Agreement on common terminology
- Finding/developing improved measures for travel times, congestion, delay, etc.
- Developing measures that allow cross modal comparisons
- Developing improved performance measures for freight transportation
- Setting appropriate targets that are realistic but still aggressive
- Developing comparative performance measurement systems that can be used for benchmarking and process improvement
- Institutionalizing performance measurement in agencies to provide useful support rather than be derailed by changes in elected officials, funding, etc.

The challenge of "agreement on terminology" was noted during the perusal of state transportation plans, where long term goals, such as "mobility" or accessibility" were often listed as performance measures. In this report, however, these are called “objectives” or “goals” and the term “performance measure” are reserved for something that is quantifiable, either by using available data directly or through use of a calculation, such as an index.

Lessons learned regarding performance measures suggest that initially focusing on a few key measures is more important than selecting measures that have easily available data (*TRB 2004*). Selecting measures that best capture the important aspects of the problem at hand is ideal. This brings up the conceptual issue that performance measures should be based on the goals the agency is trying to accomplish rather than the data being collected (*TRB 2004*).

In many cases it seems that the technological side of data collection is developed without regard for the needed performance measure. Instead, it would be optimal to develop data collection technology to fulfill the needs of the performance measurement system. Schofield and Harrison (*2007*) argue that the general consensus is that states do not currently have the data necessary to build a comprehensive set of freight performance measures. Which is important, given that the success of performance measures rely largely on the availability of data needed to derive the measure (*Harrison et. al., 2006*).

NCHRP Report 551 (*Cambridge et. al., 2006*) stresses the need to tie performance measures to the broader planning and decision making process. The importance of identifying performance measures, engaging stakeholders, and establishing targets when using performance measures for asset management, is emphasized. Finding a straightforward way to communicate complex performance measures to the public, policy makers, etc. is important (*TRB 2004*).

While most existing performance measurement efforts have focused on performance from the supplier (agency) point of view, there has been growing interest in focusing on the customer point of view. This is reflected in the literature by frequent reference to consumer satisfaction and involvement of stakeholders in the transportation system as an important part of performance measure development.

The views of the stakeholders however are often very different from the agency, as many of the issues given top priority by the motor carrier industry such as insurance costs, hours of service rules, and volatile fuel prices are not under the control of the public agencies in charge of the transportation system. However, it could be argued that other motor carrier industry concerns are somewhat determined by agency decisions, such as urban congestion and travel time reliability and safety (*Schofield and Harrison 2007*).

As another example, a private motor carrier company may be able to increase profits (a typical internal measure) by filling empty backhauls or increasing average loads, which are things solely under the control of the private firm and have nothing to do with the public agency. The private motor carrier’s profits, however, could also be increased if travel times on the highway system were shorter (from less congestion) or more reliable, which could presumably be improved through decisions made by the public agency. These and other types of measures that are meaningful to the freight stakeholders in the private sector should be considered (*Jones and Sedor 2006*).

Thus, while it is important to include the customers of the transportation system in the decision making process, it is important to remember that the public agency can only focus on those things under its control (*Dahlgren 1998*).

Overall, most efforts at transportation performance measurement have been mode specific rather than multimodal. Indeed, most of the measures proposed and used to date have been focused on the highway component of the transportation system. The ultimate goal of many transportation agencies, however, is to develop freight performance measures so that they can approach capital investment decisions from a system or multi/intermodal perspective. Increasingly, states talk of "seamless" transportation systems and the importance of "connectivity." For freight transportation, intermodal links are important, such as the time from landing at the airport to getting to the ultimate destination via the highway system (getting into and out of ports is extremely important). For many commodities there exist alternative modes, and investment decisions need to be made using available information on all alternatives.

Once the factors mentioned above have been considered and freight performance measures chosen, the usefulness of such measures in planning will rely on setting targets or benchmarks and continuing to monitor over time to assess progress towards the stated targets and ultimate agency goals. The most relevant form of reporting performance measures is tracking changes over time and comparing actual measured performance to targeted performance (*Poister 2004*).

3.2 PAST STUDIES OF PROPOSED FREIGHT PERFORMANCE MEASURES

Over time there have been a plethora of performance measures proposed for use by governmental agencies. For instance, Czerniak, Gaiser, and Gerard (*1996*) surveyed 15 states, identified 20 goals related to intermodal freight movements, and then proceeded to identify 211 performance measures that were linked to those goals. Reiff and Gregor (*2005*) identified over 750 performance measures that have been used by various states.

Many of the performance measures considered in the literature will be listed and reviewed in the forthcoming NCFRP study (*NCFRP-03 2009a*) and thus we will not enumerate all of these here.

As the studies in the following subsections illustrate, there is still a long way to go between suggesting freight performance measures and implementing them. In many cases, the measures proposed may be related to freight, but it is not clear exactly how they impact the movement of freight on the transportation system. In some instances the measures are recommended for a specific corridor, in others the focus is on forecasting performance measures to use in a planning model. Finally, an effort is made to include some of the discussion regarding performance measures on modes other than highway.

3.2.1 NCHRP Synthesis 311 (*2003*) "Performance Measures of Operational Effectiveness for Highway Segments and Systems: A Synthesis of Highway Practice"

NCHRP (*2003*) is a study of highway segments and system performance measures that included a survey of state DOTs and Metropolitan Planning Organizations (MPOs). Overall, the report indicates the need for a national set of core performance measures that consider data quality and collection, system coverage, and the aggregation of results.

The study found over 70 different performance measures reported by various states and MPOs. Although none were specific to freight, the study makes observations regarding the need for future research. The results indicated the following areas in which further work is needed to make the performance measures of greater practical use:

1. Although the reliability of the transportation system is viewed as an important measure, there are a variety of different definitions of reliability being used by different states and MPOs. Where indices are used, they indicate a need to provide a complete explanation of the index and the data required to make the calculation.
2. There is no standard way to evaluate and collect information in an operational setting, making comparison of operational scenarios difficult.
3. There is a need to develop an effective way to present performance measure results
4. There has been relatively little work on forecasting performance measures and assessing their sensitivity to policy and changes in travel behavior.

3.2.2 Hagler Bailly Services, Inc (2000)

Recognizing the tendency for agencies and researchers to develop a "laundry list" approach to performance measures, Hagler Bailly Services, Inc (*2000*) screened previous studies and categorized performance measures relevant to freight into a list of thirteen "first tier" measures to recommend to the FHWA for national freight system performance measurement.

Measures that address the cost or quality of freight to shippers:

- Cost of highway freight per ton-mile
- Cargo insurance rates
- Fuel consumption of heavy trucks per ton-mile
- On-time performance for highway-freight deliveries

Measures that address travel time and reliability of highway performance as it relates to freight:

- Point-to-point travel times for selected freight-significant highways
- Hours of delay per 1000 vehicle-miles on freight-significant highways
- Ratio of peak period travel time to off-peak travel time at freight-significant nodes
- Ratio of variance to average minutes per trip in peak periods at freight-significant nodes

- Hours of incident-based delay on freight-significant highways

Other measures suggested were:

- Annual miles per truck (as a measure of freight equipment utilization affect by highway condition)
- Crossing time at international border crossings
- Performance on connectors between NHS and intermodal terminals
- Customer Satisfaction (measured through surveys)

This study argued that heavy truck fatality, or accident rates although are somewhat related to freight, really focus on human safety rather than freight transportation system performance Similarly, measures of general highway conditions were not considered especially relevant for freight unless the measures were specifically for freight-significant routes. They also argue that measures of job creation in building highway do not reveal anything about how freight movement is affected.

Hagler Bailly Services, Inc. (*2000*) does not recommend using measures frequently seen in state plans such as the number of at-grade railroad crossings, weight restricted bridges, etc. because, although they may be impediments to freight, the number of such occurrences says nothing about how much freight movement is affected.

Similarly, total costs of freight transportation do not provide information on whether the cost of freight is rising relative to other inputs or whether there is simply an overall increase in the price level. Spending on highways is again not necessarily reflective of freight movements.

What is particularly valuable about the Hagler Bailly Services, Inc. (*2000*) study is that it provides a general assessment of the strengths and weaknesses of each measure. For instance, it notes that travel time reliability, and congestion measures are all very important to freight shippers. A weakness of these measures is that when they are used in practice, they provide average values of time and reliability and do not separate freight from other traffic. Thus they may be of limited use for assessing the efficiency or productivity of the freight system.

This is consistent with surveys of both passenger and freight transportation users that congestion is a top priority for public policy (*Norager and Lyons 2002 and NCHRP Report 03 forthcoming 2009b*). There are conceptual and practical problems encountered when trying to determine how to measure the impact of congestion on freight transportation. Most studies do not distinguish between freight and passenger vehicles in the calculation of travel delay. Typically there is an implicit assumption that delays occur during peak morning and evening travel, when automobile delay is determined. Because much trucking activity occurs at non-peak travel times, actual truck delay may be significantly over or under-stated when vehicles are considered to be homogenous and use is assumed to be distributed over time in identical fashion by both freight and passenger users.

Indeed, Fepke et al. (*2002*) recognizes that truck travel patterns are fundamentally different from commuter travel patterns and thus it is necessary to determine the effects of truck travel on the network's capacity requirements for peak truck travel hours separately from commute peak hours. The study discusses how highway capacity provides performance measures on a particular link in the transportation network system and that some sort of aggregation may be necessary to identify congested highway links that are connected to seaports, border crossings, airports and other intermodal transportation flows.

3.2.3 Schofield and Harrison (2007)

This purpose of the Schofield and Harrison (*2007*) report was to summarize the status of freight performance measures used in DOTs nationally and suggest a universal set of performance measures for emerging users. The report refers to the work on freight performance measures going on in Colorado, Oregon, Florida, Minnesota, and California. However, these states have mostly focused on broad goals and objectives, rarely getting to the specifics of performance measures and addressing the data-collection requirements of freight performance measures.

The report suggests freight performance measure (Table 3.1) for evaluating the system for emerging highway users. However, these proposed measures are still fairly broad and not defined in detail For instance, trying to actually get data on truck emissions may prove difficult and as Hagler and Bailley Services (*2000*) point out, although the emissions are related to freight, it is not clear how they impact freight movements.

Table 3.1: Suggested Freight Performance Measures for an Emerging User (*Schofield and Harrison 2007*)

Mobility	Intercity Travel Times Average Speed on Freeways, by Route and Time of Day Major City Congestion Levels Compared to Other Metro Areas Volume/Capacity of All Vehicles on Freeway Segments
Reliability	Deviation of Travel Times or Speeds from the Average Frequency of Nonrecurring Delays Portion of On-Time Motor Carrier Arrivals
Economic	State Transportation Investment vs. Gross State Product
Safety/Environment	Emissions Freight Related Crash Rates
Infrastructure	Pavement and Bridge Quality Average Delay Time at Border Crossings

,

3.2.4 Reiff and Gregor (2005)

While the Oregon study by Reiff and Gregor (*2005*) does not concentrate exclusively on freight, it deserves mention because of its focus on the forecastability of performance measures and their use in the state planning process. The purpose of this study was to develop measures that could be forecasted and incorporated into long range planning models to predict the results of different scenarios.

The report includes an appendix with over 750 transportation performance measures, of which 175 were obtained from various Oregon state transportation plans. Of these, it was noted that many were only tangentially related to the goals that they were listed under. Emphasis was given on the need to select performance measures where there is a clear relationship between the measure and the policy goal.

The report argues that many measures that were (or are still) in use, such as the level of service (or volume to capacity) measures typically found in metropolitan plans, are aimed mostly at planners and engineers rather than policymakers and the general public. Recommendations are made to use measures such as those developed for the Urban Mobility Report (UMR) by the Texas Transportation Institute (TTI). The TTI measures seem to provide an assessment of urban mobility that resounds with the public. The UMR system relies on observed data derived from the Highway Performance Monitoring System (HPMS) and involves some simplifying assumptions such as the use of a national average vehicle occupancy rate of 1.25 passengers for all calculations.

The advantage of the UMR measures are that they use travel volumes and congested speeds that can be calculated either using observed data or model simulations—they are also conducive to setting specific benchmarks that can be used to monitor progress over time.

Reiff and Gregor (*2005*) suggest the UMRs travel time and buffer (reliability) indices (see the following section for details), as well as recommend developing a transportation cost index.

Another index suggested, which would be more relevant for the reliability of the freight system, is the road network concentration index which measures how evenly traffic is spread over a regional arterial network. Presumably, the less evenly traffic is distributed over the system, the greater the chance of traffic disruptions and the delay associated with incidents.

Finally, this study gives serious consideration to the use of the economic concept of consumer surplus in addressing questions of social and economic benefits that are often discussed in the literature, but which are difficult to measure, such as general economic impacts from transportation investment.

3.2.5 Gosling (1999) Aviation System Performance Measures

Gosling (*1999*) emphasizes the need to develop not just modal, but intermodal performance measures to support decisions by transportation policymakers. He also expresses the concern that many performance measures that are used have been shaped by the ease of data collection rather than by how well the measure indicates progress towards stated goals.

The report focuses on the aviation sector and its role in the intermodal system. It stresses the need to include the perspective of users in selecting performance measures. Airport accessibility is largely determined by the local highway system, especially in ground access to the airport. Although shippers are known to be concerned with cost, service frequency, and accessibility, these are difficult to assess for air cargo, especially given the recent growth of integrated express package carriers such as UPS and FedEx.

A total of 74 potential aviation system performance measures are presented in the report that correspond to outcomes indicated as desired by the California Transportation Commission. Most are not fully developed, but emphasize the same factors deemed important in the highway studies: mobility, reliability, and access.

3.2.6 California DOT (*1999*)

This study was performed for the California DOT by Booz-Allen and Hamilton, Inc. and contains a section specifically devoted to the evaluation of performance measure indicators for goods movement. In this study, explicit attention is given to both truck and rail traffic and the development of performance measures for each to help meet goals of equity, safety, reliability, mobility/accessibility, the environment and economic well-being. This study is notable as it was one of the first to specifically address freight, although this report seems to suggest that with a little change, indicators that have been used for highway and transit can be extended to deal with freight either on highways or rail.

Indicators suggested in this study were not detailed; things were listed such as accident rates, travel time and standard deviation of travel time, delay, and general environmental indicators provided by the Environmental Protection Agency (EPA). While accessibility to intermodal terminals is mentioned, the report is mostly concerned with parking restrictions and hours of operation rather than any indicators of the interface between modes.

3.2.7 Talley (*2006*)

Talley (*2006*) provides a theoretical discussion of the economics of ports. He suggests several relevant performance measures that can be used by port managers to monitor performance. Various ports may cater to different types of ocean going vessels (bulk or containership) thus inter-port comparisons need to be made with care. Talley (*2006*) provides some suggested port measures that cover the safety, mobility and congestion goals for which freight performance measures are usually developed. Table 3.2 is reproduced from Talley (*2006*) and shows "operating options," which are similar to freight performance measures, as well as the desired direction of change for each.

Table 3.2: Port Performance Measures from Talley (*2006*)

Operating Option	Directional Change
Loading Service Rate for Bulk Ships (SL_b)	Increase
Unloading Service Rate for Bulk Ships (SU_b)	Increase
Loading Service Rate for Container Ships (SL_c)	Increase
Unloading Service Rate for Container Ships (SU_c)	Increase
Loading Service Rate for Bulk Vehicles (VL_b)	Increase
Unloading Service Rate for Bulk Vehicles (VU_b)	Increase
Loading Service Rate for Container Vehicles (VL_c)	Increase
Unloading Service Rate for Container Vehicles (VU_c)	Increase
Port Channel Accessibility (PCA)	Increase
Port Channel Reliability (PCR)	Increase
Port Berth Accessibility (PBA)	Increase
Port Berth Reliability (PBR)	Increase
Entrance Gate Reliability (EGR)	Increase
Departure Gate Reliability (DGR)	Increase
Probability of Ship Damage (SDAM)	Decrease
Probability of Ship Property Loss (SLOS)	Decrease
Probability of Vehicle Damage (VDAM)	Decrease
Probability of Vehicle Property Loss (VLOS)	Decrease
Probability of Port Cargo Damage (CDAM)	Decrease
Probability of Port Cargo Loss (CLOS)	Decrease

3.2.8 Barber and Grobar (*2001*)

Although many states mention intermodal connections as an important aspect of their transportation system, there are few that have actually tried to evaluate the performance of their maritime port facilities and their interaction with the highway and rail systems. In California, the obvious problems with congestion and dealing with the intermodal interface has led to practical research on this topic.

The purpose of research by Barber and Grobar (*2001*) was to devise ways to deal with capacity problems in intermodal corridors of economic significance in the ports of Long Beach-Los Angeles. Included in the research was the identification of performance measures that could be used to measure desirable outcomes identified in the movement of goods in California, these included: mobility and accessibility, reliability, sustainability, and environmental quality. A combination of data available from the ports and other agencies such as the EPA was used, along with surveys and proprietary data from trucking firms, to calculate several performance indicators.

Indicators/performance measures suggested for each of these goals were as follows:

Mobility/Accessibility

1. Average wait time for trucks inside the port complex
2. Throughput per acre as a measure of port productivity
3. Dwell time: the average amount of time a container spends in the port

4. The ratio of wheeled to grounded containers (wheeled containers are on a chassis, grounded containers need to be place on a chassis.
5. Average number of times a container is handled in the port
6. Lifts per hour of containers by cranes

Most of the data were available to calculate these measures for the Long Beach/Los Angeles ports where congestion has been a problem.

Reliability

1. Average length of time for cargo containers to pass customs
2. Percentage of cases in which a crew arrives on time to service an arriving vessel
3. How often chassis equipment is rejected by truckers, delaying container movement

Primary data were not available on these measures, rather survey results informed the research team on their relevance and some general estimates were made on the basis of the survey responses.

Sustainability

1. Predicted future freeway constraints
2. Predicted future port capacity constraints

These forecasts were generally available from planning models and then an effort must be made to translate them into implications for the ports.

Environmental

1. Pollution caused by trucks queuing in the port complex
2. Temporal distribution of trucks in the port

Value for truck idle time are then used in conjunction with EPA estimates of NOx, CO, HC, and CO2 to come up with the impact of these activities on the region's air quality.

This research is probably the first to carefully develop and apply performance measures to maritime ports.

3.3 INDEXES

As the number of performance measures used has grown along with an increase in the categories tracked (mobility, accessibility, environmental, etc.), there has been interest in use of indices. An index can provide a simplified way to review performance as a single number that provides a summary of multiple outputs (performance measures in this case.) An index number can only tell whether overall performance is going up or down; to identify the source of the overall change still requires measurement of the index's component performance measures.

Research by FHWA found average speed and buffer time index to be among the best performance measures for highways (*Jones and Sedor 2006*). Targets for performance measures are also being used at the state level. Rather than just focusing on improvement over time, agencies are setting specific numerical performance measures to be reached by a specified date. These targets can be difficult to set and realistic goal numbers and time frames can be difficult to determine (*Poister 2004*).

The indexes referred to most frequently in the literature are related to time and reliability/congestion, such as the travel time and buffer indexes covered in the following subsection.

3.3.1 Travel Time Index

The Travel Time Index (TTI) is calculated by the Texas Transportation Institute (*TTI 2007*) in their Urban Mobility Report (*2007*) as the ratio of peak travel time divided by free-flow travel time:

TTI = Peak Travel Time/Free-Flow Travel Time

This measure is reported for different functional classes and is unitless so that comparisons can be made between conditions on different road segments. See the publication by Shrank and Lomax (*2007*) for more details.

3.3.2 The Buffer Index

The Buffer Index (BI) is the extra amount of time that a traveler needs to allot in order to be on time a certain percent of the time. For a 95% buffer, the buffer index is explained as follows:

> The buffer index represents the extra buffer time (or time cushion) that most travelers add to their average travel time when planning trips to ensure on-time arrival. This extra time is added to account for any unexpected delay. The buffer index is expressed as a percentage and its value increases as reliability gets worse. For example, a buffer index of 40 percent means that, for a 20-minute average travel time, a traveler should budget an additional 8 minutes (20 minutes × 40 percent = 8 minutes) to ensure on-time arrival most of the time. In this example, the 8 extra minutes is called the buffer time. The buffer index is computed as the difference between the 95th percentile travel time and average travel time, divided by the average travel time (*FHWA 2006b*).

Thus, the Buffer Index is calculated as:

BI = (95% Percentile Travel Rate-Average Travel Rate)/ Average Travel Rate

Where the travel rates referred to are minutes per mile (average times/mile).

3.3.3 Overall System Efficiency Measurement

One of the problems inherent in measuring system performance is that there are numerous goals and objectives with performance measures for each that are specified by public agencies. As mentioned above, sometimes these goals are in conflict. One way to try and compare different systems and their collective efficiency in attaining multiple goals, is through the use of a non-parametric approach such as that used by Nolan et al (*2002*) and

McMullen and Noh (*2007*) to provide rankings for the efficiency of bus transit systems throughout the U.S. These studies used variants of data envelope analysis (DEA) to incorporate multiple goals and outputs into the measure of transit bus system efficiency. DEA provides an efficiency benchmark for an agency that shows the agency performance relative to the most efficient possible output, which is defined as the maximum output for a given set of inputs. A major advantage of DEA is that it is able to provide an efficiency measure when there are multiple inputs and outputs. The related Malmquist Index (calculated from multiperiod DEA analysis) allows calculation of productivity over time.

This approach has not yet been explored for the evaluation of freight systems and would be more of a "macro" look at system efficiency rather than a "micro" approach that permits evaluation of individual projects.

3.4 CONCLUSIONS

Although there has been great progress and recognition of the need for freight performance measures, there is still no real standard for measurement, especially of the freight system as a whole. By far, the most work in both theory and practice has been on travel time and reliability measures dealing primarily with congestion at bottlenecks or in key urban corridors on the highway system. There needs to be similar work done in regard to modes other than highway and on the interface between the modes (highway-to-port, airport-to-highway, etc.)

The focus of past studies on highway traffic can be justified in large part because of the dominant role that motor carriers play in the surface freight transportation system (*McMullen 2001*). However, to measure the performance of the freight transportation system as a whole requires the development of measures for all freight modes and, if possible, for the multi-modal system rather than individual modes. This is because ultimately the goal for transportation planners is to evaluate alternative ways of providing service which requires the ability to evaluate investment in different kinds of infrastructure and to determine the ultimate impact of different kinds of investment on freight system performance.

The level of analysis tends to differ considerably from case to case. For instance, some performance measures look at a short road segment while others look at the total tons of freight carried in a state during a year. Neither of these is apt to provide a very meaningful or useful measure for use in system planning, especially when trying to make decisions regarding where in the transportation system to invest. To include both the system dimension as well as the intermodal/multimodal nature of freight transportation system performance, it might be necessary to define a freight significant corridor and then develop intermodal/multimodal measures and benchmarks for that corridor.

Even within government, various levels of government may need different performance measures to meet their desired objectives. A recent survey of private and public stakeholders and state, local, and national government agencies found that state respondents ranked freight performance measures highest if they were regional or local, whereas private sector respondents were more concerned with international and intercontinental supply chains. Further, at least two states strongly opposed the use of any national performance measures—presumably because they did not want to be held to a national standard (*NCFRP Report 03, 2009b*).

There are bound to be problems with data availability depending on the geographic region of interest. In fact, data availability seems to be a major driver in the development of time and reliability indices as technologies have been developed and implemented to monitor performance on highways in congested areas. As mentioned in this literature review, the American Transportation Research Institute (ATRI) has developed and collected freight performance measures for 30 of the worst identified freight bottlenecks in the U.S (*ATRI 2007 and various years*). They collect detailed data via sensors and monitor performance. However, such data is usually available only for a few very congested urban areas and really does not provide much information about traffic flows in areas other than major metropolitan areas. While there is a national concern with urban road congestion, comparable data is not available for smaller metropolitan or rural roads at this time.

In summary, there is evidence that different stakeholders in the freight transportation system often have varying goals and objectives and may find different performance measures useful or relevant. There is a need to identify the scope of freight system measurement, such as a short segment, a corridor, or the entire state. Data availability also plays an important role in the practical application of freight performance measures. Finally, there is a conceptual gap in the literature when it comes to trying to deal with intermodal or multi-modal transportation systems.

4.0 SUMMARY OF POTENTIAL DATA SOURCES

There are a number of freight data resources, both quantitative and qualitative, that can be used to analyze freight performance. The primary challenges with freight data for performance measurement are: 1) the lack of publicly available data; and 2) the proprietary nature of the data often requiring spatial and temporal aggregations that make detailed measurement difficult. These have long been identified as problems for public-sector freight planning and monitoring (*TRB 2003*).

The following chapter begins by defining the freight system and connections between modes. The subsections identify data sources (both public and private) that relate to the major performance measures categories identified in Chapter 2.0, including: safety, maintenance and preservation, mobility, congestion and reliability, accessibility and connectivity, and environment.

4.1 DEFINING THE FREIGHT SYSTEM

While many performance measures were identified in the previous chapters, most of the measures that were found had a limited relationship to freight activities. However, as suggested in the literature review, some identified measures may be adapted to freight if the following conditions are met: 1) freight-specific corridors or links are identified; and 2) the volume of freight-specific activity can be quantified.

In the analysis for this project, the first step in brainstorming freight-specific measures was to identify the location, physical parameters, and intermodal connections of the freight system. The freight transportation infrastructure cartography has been fairly robust for the state of Oregon. A map of the major transportation facilities in Oregon is shown in Figure 4.1. This figure shows the general location of the marine facilities (ports), airports, and highways (note that intermodal connection locations are not shown).

To separate out freight-critical links or corridors from all vehicle traffic it was necessary to identify which links or facilities are freight-related. For highways, a subset of the highway system has been designated as the freight system in *The Oregon Highway Plan* (*2005*). This highway network is shown in Figure 4.2 and is referred to as the "designated freight routes".

For railroads, the main distinction is between track operated by Class I carriers and those tracks operated by regional or "short-line" railroads. Figure 4.3 shows the railroad infrastructure in the state. The Class I railroads Union Pacific (UP) and Burlington Northern Santa Fe (BNSF) are shown in red and green lines respectively, all other railroads are shown in blue. There are 2,864 miles of railroad track which is comprised of 1,400 miles of Class I carrier track, 982 miles of regional railroad, 308 miles of local track, and 134 miles of switching railroad track.

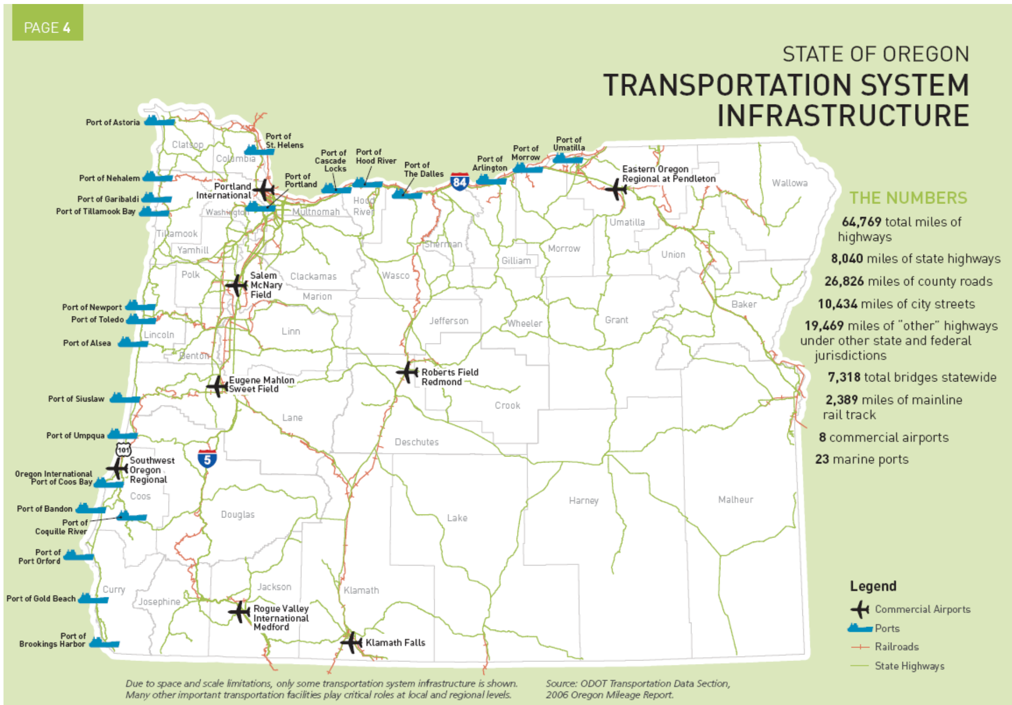


Figure 4.1: Oregon Transportation System Infrastructure

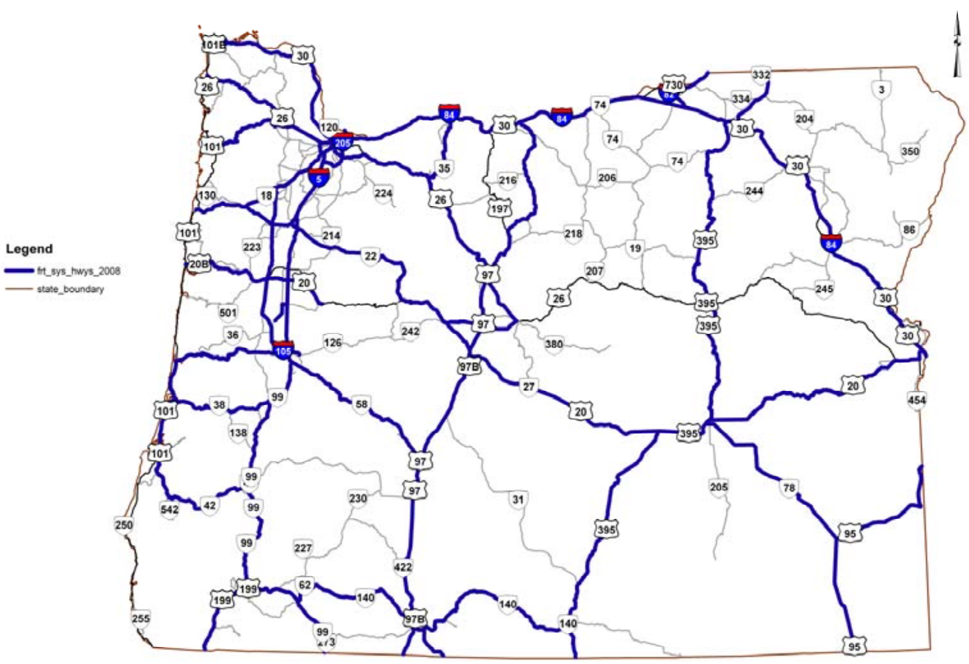


Figure 4.2: State Highway Freight System

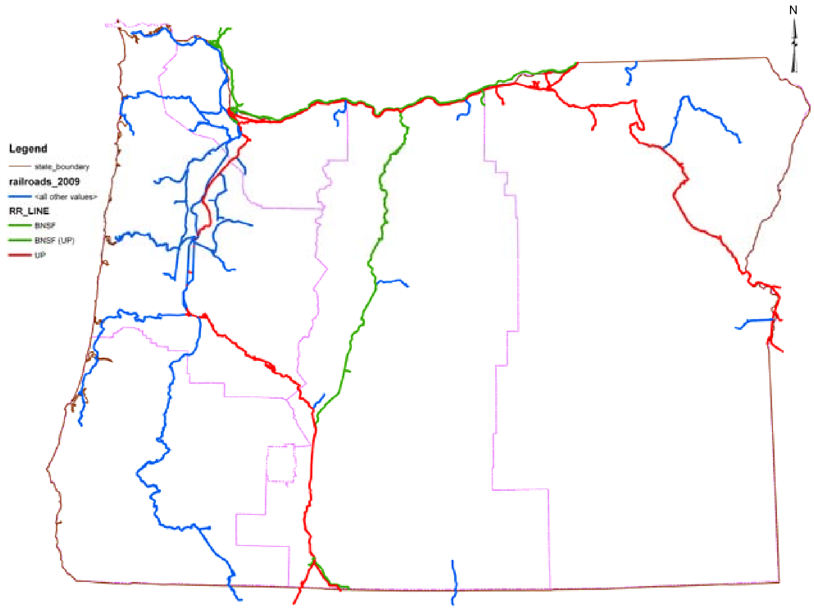


Figure 4.3: Railroads in Oregon, 2009

Figure 4.4 shows the location of the major water transportation infrastructure including deep-water ports and the locations of the four major locks on the Columbia River system (Bonneville, The Dalles, John Day, and McNary). Also inventoried and available, but not shown for clarity, is the detailed information about ports provided by the U.S. Army Corps of Engineers in their Waterways Facilities data. These data identify each wharf/berth at the ports along navigable waterways and describes depth alongside berth, total berthing space, and intermodal connections at each location.

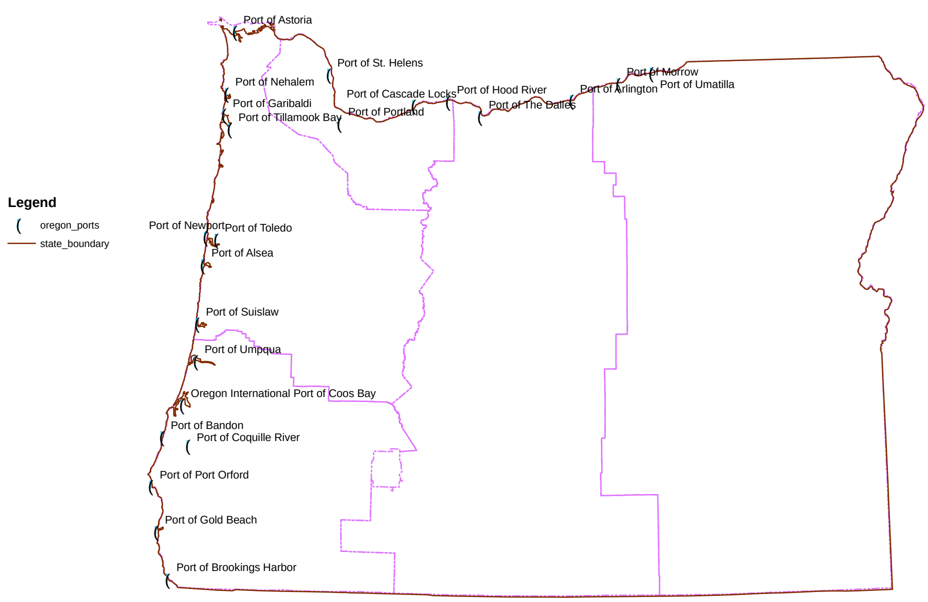


Figure 4.4: Water Transportation Infrastructure, 2009

Finally, Figure 4.5 shows the location of intermodal connections (truck-to-rail, truck-to-air, and truck-to-ship). These data are provided by the Bureau of Transportation Systems National Transportation Atlas and updated annually. Also shown on the figure are highway links that have been identified as "Intermodal Connectors" by the Oregon DOT.

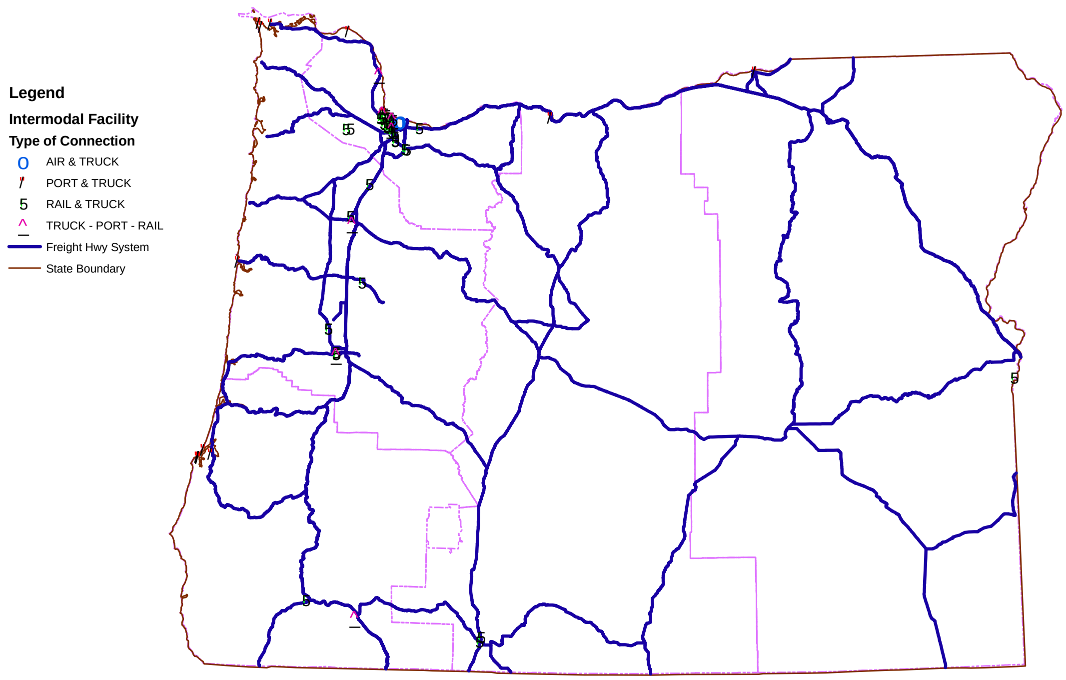


Figure 4.5: Intermodal Connections and Facilities, 2009

4.2 SAFETY

Through the literature review research it was found that states frequently listed safety as a policy goal, but primarily in the context of passenger safety. Freight-specific measures of safety can be extrapolated by filtering for those "accidents" or "events" that involve freight vehicles. For freight shippers, loss and damage of cargo in transit is a significant issue that can affect the mode choice of shippers. Thus, for freight accidents, it is desirable to capture this "value lost" which, while not downplaying the importance of human safety, may be a metric that can be communicated to the freight industry (since presumably it has some relationship to cargo insurance or claims payments).

Vehicle-level accident data are primarily available for the highway, railroad and water modes. Data for air safety exist but crashes are rare and might not relate to air freight.

4.2.1 Highway

4.2.1.1 Oregon Traffic Crash Data

Two units in ODOT have responsibility and oversight for crash reporting, these include the Driver and Motor Vehicles (DMV) Services Division, and the Crash Analysis and Reporting (CAR) Unit. Currently, private citizens are required to file an Oregon Traffic Accident and Insurance Report within 72 hours if they are involved in a crash that results in injury, death, more than $1,500 damage to their vehicle, or more than $1,500 damage and towing of another vehicle. These reporting thresholds changed in 1998 from $500 to $1000 and in 2004 from $1000 to $1500. The crash data contains information on vehicle type, making it possible to select freight-involved vehicles. Crashes on state highways can also be geo-located allowing for the generation of specific metrics for the designated freight system of highways. An example of this can be seen in Figure 4.6 which shows motor vehicle crashes involving at least one-truck on state highways for 2006-2007 with the designated freight system in dark blue (heavy) line. Most truck crashes occur on the designated freight-route system.

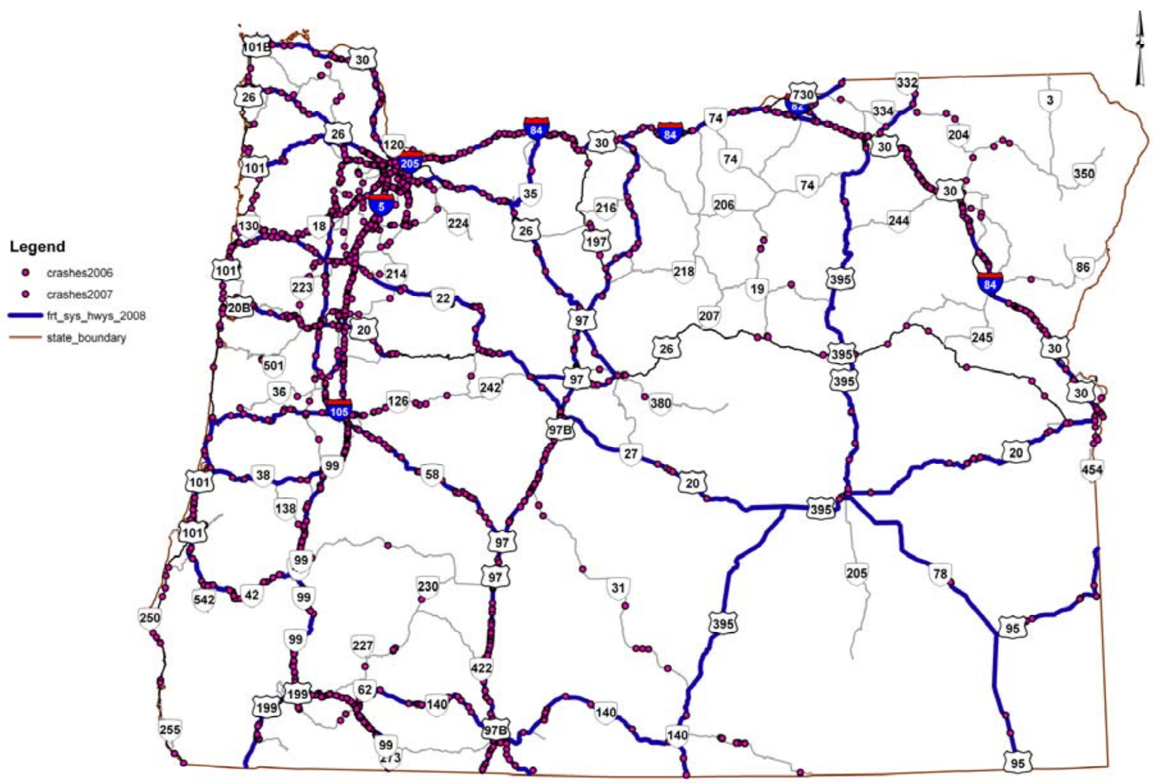


Figure 4.6: Reported Motor Vehicle Crashes Involving a Truck, 2006-2007

Annually, the CAR Unit generates summaries for the state overall and for each highway that reports motor carrier crash rates. Statewide motor carrier VMT is estimated from weight-mile tax records while highway-level truck volumes are generated from other counting programs. Crash rates for all motor carriers, truck-at-fault crashes, fatal motor carrier crashes, and triple crash rates are summarized for 1997-2008 in Table 4.1. Also included CAR publication is a table of *Estimated Societal Costs of Truck Crashes in Oregon 1976 – 2007*. This table (shown as a time-series in Figure 4.7, is generated by assigning a value to each motor carrier crash by severity (the value is indexed to the CPI). While it is not clear if the property-damage only values include the value of cargo, it might provide a method to communicate safety in a measure that directly targets the freight community.

Table 4.1: Truck Crash Rates, per Million VMT, 1997-2008

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
All Motor Carrier	1.07	1.00	1.06	1.22	1.04	1.08	1.11	0.99	1.08	1.17	1.09	1.21
Truck At-Fault	0.64	0.60	0.63	0.72	0.62	0.64	0.67	0.58	0.61	0.67	0.63	0.68
Fatal Motor Carrier	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.02	0.02
Triples	0.40	0.58	0.44	0.56	0.76	0.61	0.61	0.50	0.49	0.43	0.29	0.31

Source: *Oregon Department of Transportation, Crash Analysis and Reporting Unit, 2009c*

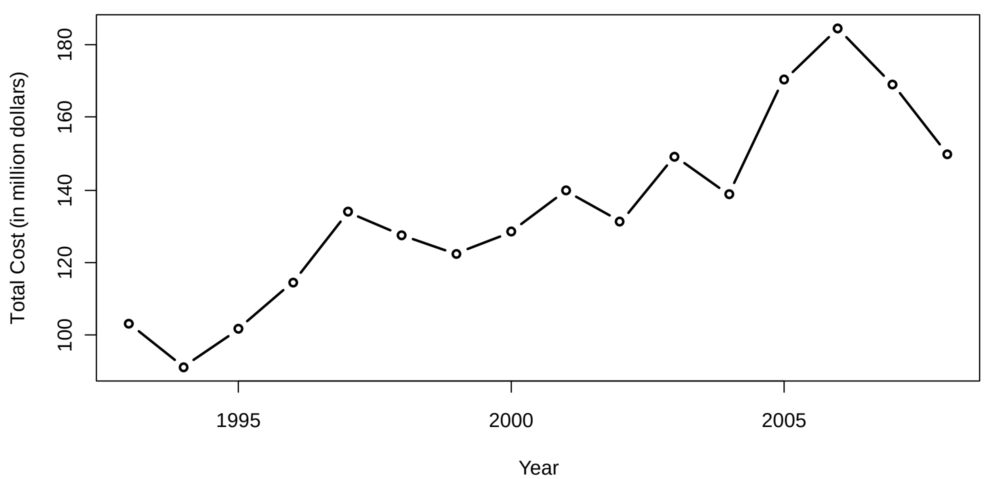


Figure 4.7: Estimated Societal Cost of Truck Crashes in Oregon, 1976-2008

A second source of motor carrier crash data is also managed by CAR. As part of the Federal Motor Carrier Safety Administration (FMCSA) process, motor carriers must submit an accident form for any incident that occurs. These forms contain information that is not presently contained in the statewide crash file such as commodity carried and property damage estimates. With additional research, this information could be used to estimate of a value of cargo lost.

4.2.1.2 Truck Safety Inspection Records

Motor carrier safety inspections are a potential data source. States report most of their inspection activities to the Federal Motor Carrier Safety Administration (FMCSA) as part of the Safety and Fitness Electronic Records (SAFER) System. The Commercial Vehicle Safety Alliance provides standardized inspection procedures and training through the North American Standard Inspection (NASI) program. The inspections are targeted at violations that are more likely to cause a crash, although some argue that the link has not been established definitively. Motor carrier safety inspections are categorized by the depth of inspection, with Level 1 inspections being the most complete. Data on the number of inspections conducted in Oregon for 2006-2009 are shown in Table 4.2.

Table 4.2: Motor Carrier Inspection Activity by Inspection Level (Oregon)

Inspection Level	2006	2007	2008	2009
I. Full	18,607	15,662	10,917	8,361
II. Walk-Around	29,400	29,114	27,004	26,515
III. Driver Only	11,326	15,757	21,356	20,794
IV. Special Study	3	633	67	1
V. Terminal	1,017	771	722	775
VI. Radioactive Materials	10	12	15	2
Total	**60,363**	**61,949**	**60,081**	**56,448**

4.2.2 Railroad

4.2.2.1 FRA State Freight Rail Safety Statistics

There is an extensive and detailed accident reporting system for railroads that includes highway-rail grade crossings, derailments, worker injuries and other data provided by the Federal Railroad Administration (FRA) Office of Safety Analysis. These data are generated from information filed with the Federal Railroad Administration (FRA) as required in Title 49 of the Code of Federal Regulations (CFR), Part 225 (2009). These data include very detailed information on accident rates per train mile, raw data, number of injuries, location of injuries, type of accident (e.g. incidents involving trespassers or employees, derailments), time of day, etc. These data are available by railroad and can be aggregated by track class, region, state, and county. Raw data are available from 1975 (including Oregon). Like motor vehicle crashes, the minimum accident reporting threshold can change over time; in 2008 it was $8,500. Data that might potentially generate useful metrics include number of accidents on the mainline (likely a source of delay to other trains), derailments, hazmat spills, and value of accident loss (to equipment and track structure). A sample 10 year summary of the total reported accident damage (to track and rail equipment) is shown for Class I and all other railroads in Figure 4.8.

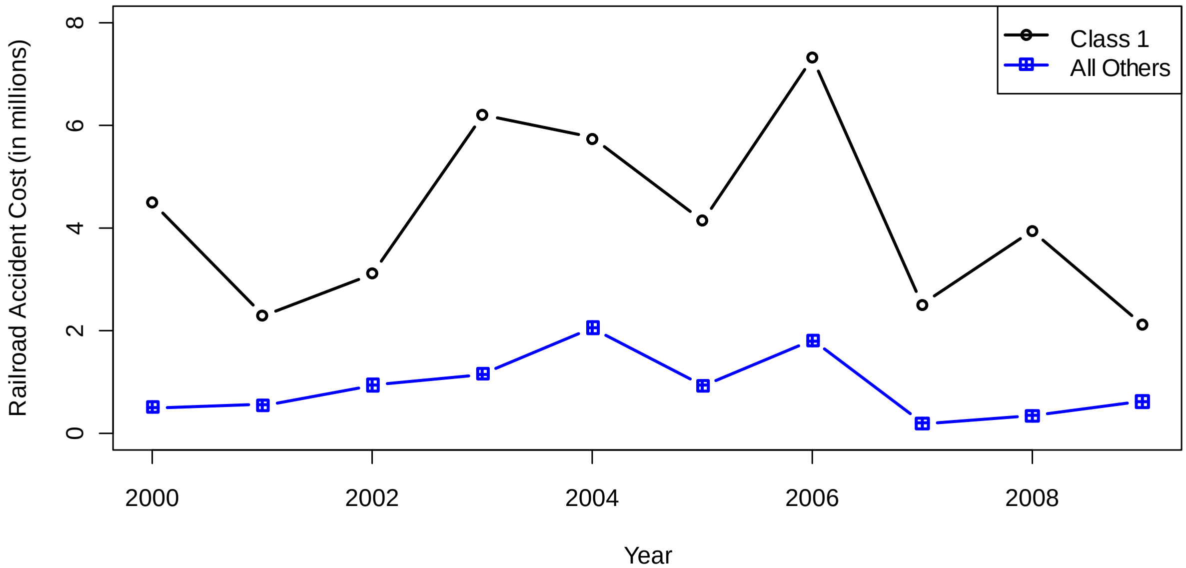


Figure 4.8: Total Reported Accident Damage, Railroads 2000-2009

4.2.3 Air

4.2.3.1 Aviation Safety Information Analysis and Sharing (ASIAS) System

The Federal Aviation Administration (FAA) provides a number of aviation safety related data systems including the Accident/Incident Data System (AIDS) database (for accidents that do not meet the National Transportation Safety Board (NTSB) threshold), the Aviation Safety Reporting System (ASRS), the Near Midair Collision System (NMACS), and the Runway Safety Office Runway Incursion database. Most of these data sources can be queried by state, airport, and other related fields. Very few incidents relate to cargo-specific aircraft (most are general aviation). Tracking air-related safety for freight performance measurement would seem to have little benefit.

4.2.4 Ports/Marine

4.2.4.1 Marine Information for Safety and Law Enforcement (MISLE)

The United States Coast Guard (USCG) maintains data on “marine casualty or accident” that occur on navigable waterways in the United States in the Marine Information for Safety and Law Enforcement (MISLE) combines all operational missions of the USCG in one system. Prior to 2001, these data were housed in MINMod (Marine Investigation Module) and prior to 1991 in CASMAIN (Casualty Maintenance) (*Dobbins and Abkowitz, 2010*). Marine casualty or accident are defined by 46 CFR Subpart 4.03 the term “marine casualty or accident" applies to events caused by or involving a vessel and includes persons overboard or diving accidents and incidents that result in grounding; stranding; foundering; flooding; collision; allision; explosion; fire; reduction or loss of a vessel's electrical power, propulsion, or steering capabilities. For freight performance measure purposes allusions (a collision between a vessel and fixed object such as a bridge pier) and collisions would be most relevant. MISLE data can be made available to state agencies but not does not appear to be available without a request. In a recent paper, Dobbins and Abkowitz (*2010*) show how the data can be used to tabulate and display waterway accidents.

4.3 MAINTENANCE/PRESERVATION

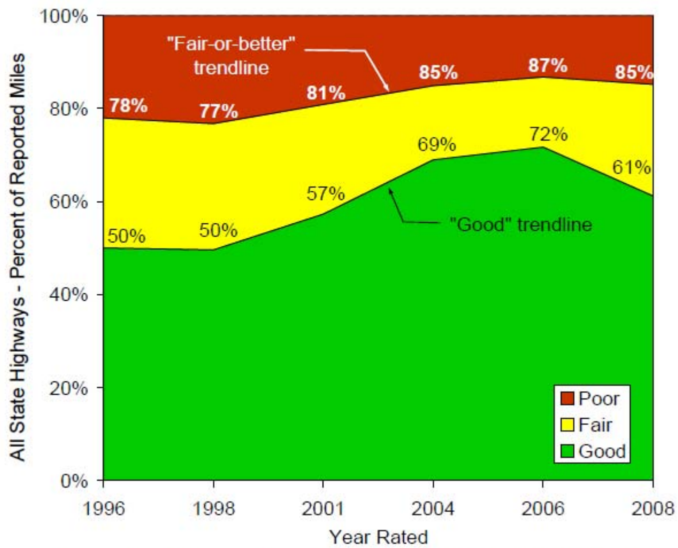
Performance of transportation system can be impacted by the quality of the available infrastructure. Deficient bridges, tracks, or runways can limit capacity by creating bottlenecks and/or costly rerouting of freight. In extreme cases, complete loss of service from a mode might occur (e.g. such as that that occurred on the Central Oregon and Pacific's Coos Bay line after the owner RailAmerica decided that aging tunnels were too costly to repair). The following section summarizes the available data related to maintenance of the system.

4.3.1 Highway

Transportation infrastructure maintenance and preservation is another primary function of state DOTs. ODOT systematically monitors the condition of its two primary assets: pavements and bridges. The Highway Division provides bridge and pavement data; and the Motor Carrier Transportation Division provides data on over-dimensional restrictions on roadways.

4.3.1.1 Pavement Management System

State highways are evaluated every two years by the ODOT Pavement Management Unit using pavement condition surveys. Highways that are part of the National Highway System (NHS) are rated by a distress survey method, while non-NHS highways are typically rated by the Good-Fair-Poor (GFP) approach. Reports are available from the following years: 1998, 1999, 2001, 2003, 2004, 2006, and 2008. Figure 4.9 shows a time-series of pavement rating for all evaluated sections. Since these data are compiled by highway and milepoint, it would be possible to report pavement conditions for the designated freight route system or a specific corridor. An example of this is shown in Figure 4.10. This map shows the pavement condition data for 2008 for Oregon state highways and the designated freight highway system.



Source: 2008 Pavement Condition Report, ODOT

Figure 4.9: Pavement Condition Trends (All State Highways)

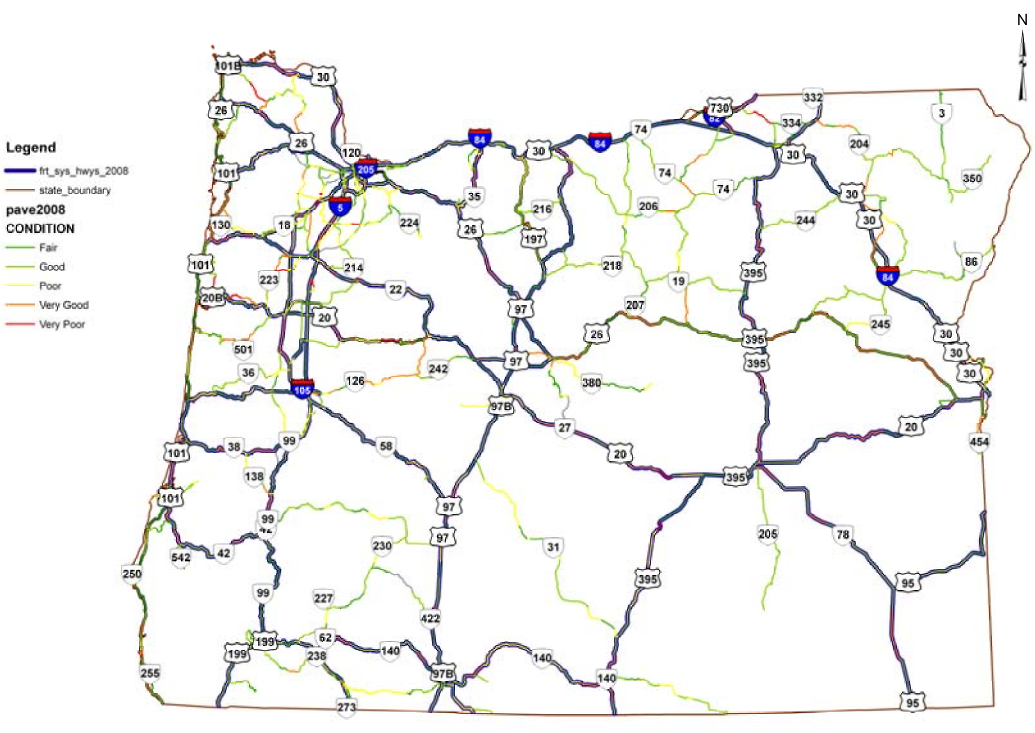


Figure 4.10: Road Pavement Condition and Freight Routes, 2008

4.3.1.2 Bridge Log and Bridge Management System

ODOT's Bridge Engineering Section maintains an extensive and detailed record of structures. The Bridge Log, first compiled in 1924, includes data on all significant structures. This data includes bridge location by highway number and milepoint, name and number of structure, description of type of structure, span lengths, vertical and horizontal clearances, design loading, and years built and modified. The Bridge Management System recently began publishing the *Bridge Condition Report* (*2007; 2009*) which summarizes the results of ODOT's submittal for the FHWA's National Bridge Inventory. For bridges under ODOT's jurisdiction (about 2,600), the report describes overall conditions and provides listings of condition ratings. These listings are organized by district, highway, and milepoint. Structurally deficient bridges on the Interstate Highway and the National Highway System (NHS) are given separate listings in addition to their listings in the district-level reports. The report provides summary graphs, including those showing percentage of bridges that are structurally deficient, functionally obsolete, and not deficient. An overall structural rating, ranging from very good to very poor, is provided for each bridge. Another example of the detailed bridge management system is shown in Figure 4.11 which maps all bridges and the load-restricted bridges (the red dots) in Oregon and the designated freight system for 2005

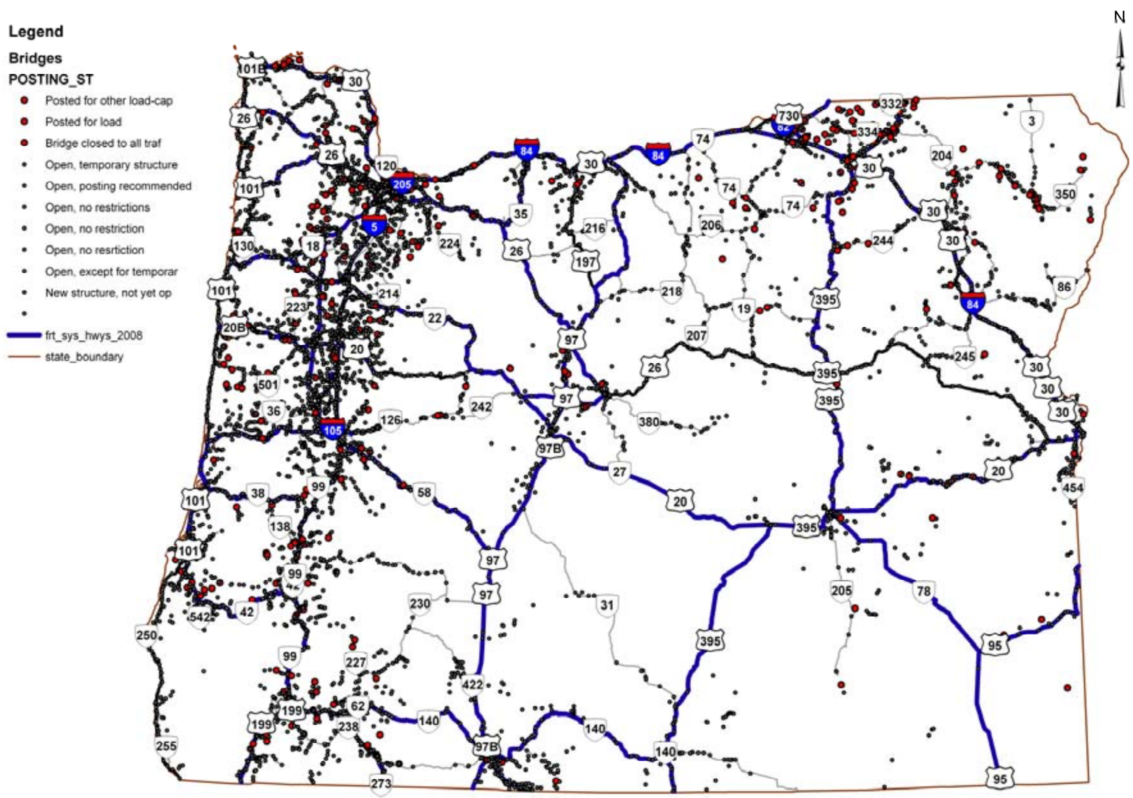


Figure 4.11: Example of Posted (Weight-Restricted) Bridges and Freight Routes

4.3.1.3 *Over-dimensional Restrictions*

The Motor Carrier Transportation Division provides and records information on horizontal and vertical restrictions including the MCTD Freight Mobility Map (Figure 4.12), which shows routes that are restricted.

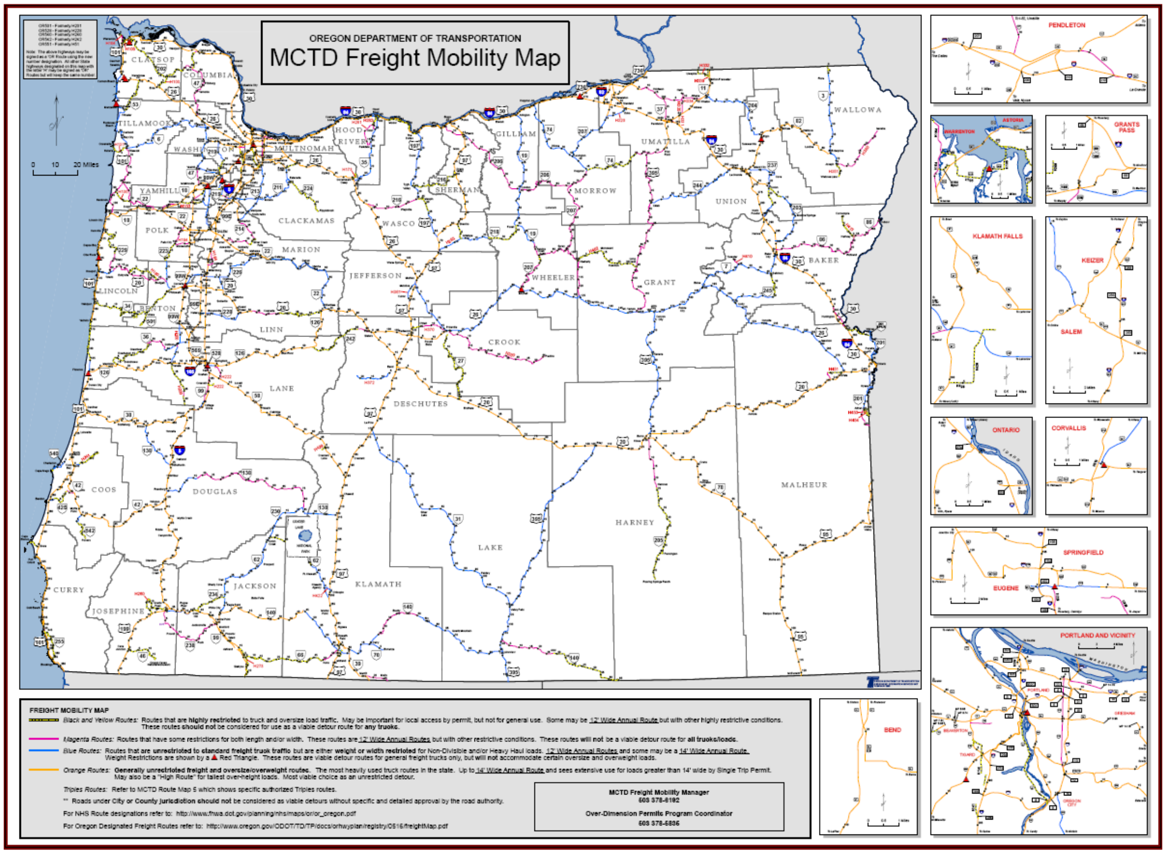


Figure 4.12: Motor Carrier Freight Mobility Map

4.3.2 Railroad

4.3.2.1 *ODOT Rail Division*

ODOT’s Rail Division monitors the condition of tracks, tunnels, and vertical restrictions on the State’s rail network. Data on FRA class of track, track rail weight (in lbs/ft), welded rail or not, whether the line is capable of handling carloads up to 286,000 pounds, and tunnel restrictions. FRA class of track dictates the maximum allowable speed for freight trains, shown in Table 4.3. While these track data are not published regularly, communication with the Rail Division indicates that it would be possible to produce and that there are some changes in the system that could be monitored. The Rail Division has recently completed an assessment of the rail system (focusing primarily on the short line system (not the major Class I carriers)) that will be published in the near future. Preliminary data indicates that about 41% of the non-Class I track (or 20% of the entire system) in the State has a maximum allowable speed of 10 mph (rate expected or FRA Class 1). Further, about 330 miles of railroad network cannot accommodate 286,000 pound railcars (the standard car capacity on the Class I network).

Table 4.3: Maximum Allowable Speed by FRA Class of Track

Class of Track	Maximum Allowable Speed for Freight Trains
Excepted Track	10 mph
Class 1	10 mph
Class 2	25 mph
Class 3	40 mph
Class 4	60 mph
Class 5	80 mph
Class 6	N/A
Class 7	N/A
Class 8	N/A
Class 9	N/A

4.3.3 Air

4.3.3.1 Airport Pavement Management System

The Oregon Department of Aviation monitors airport pavement through its pavement management system. This includes information on all airports, many of which are general airports and serve little freight traffic. The data appears to be produced annually as part of the Oregon Department of Aviation's performance measurement. Condition data on other assets such as the air traffic control system or runway lighting were not identified.

4.3.4 Ports/Marine

4.3.4.1 US Army Corps of Engineers (USACE) Navigation Data Center

The USACE collects and provides detailed information on port facilities, dredging information and lock use, performance, and other characteristics. For the lock and dam system, detailed operational data are collected (see description in following sections). Another key maintenance issue is adequate depth for navigation. While dredging information is tracked and provided by contract amount and material removed, a data source indicating current navigation depth was not found.

4.4 MOBILITY, CONGESTION, AND RELIABILITY

Mobility measures are closely aligned with congestion and reliability measures. This section presents data that could be used to monitor travel times and the reliability of those travel times as well as congestion.

Congestion occurs when the demand for a particular asset exceeds the available throughput. For highway segments, it is common to measure congested road segments based on volume-to-capacity ratios (v/c). The ratio is typically calculated using peak-period traffic volumes (expressed as the highest 15 minute flow rate) and the estimated capacity. Capacity of a facility can be measured empirically or estimated using deterministic methods in the Highway Capacity Manual. Interrupted-flow (arterials and surface streets) and uninterrupted flow (freeways and expressways) facilities have separate calculation methods but both require data on the number of lanes, signal timing and type, lane width, presence of parking, and a number of other variables. Thus, to calculate a volume capacity ratio, data are needed on traffic and highway characteristics. For facility planning, ODOT has adopted v/c standards that are higher (less congestion tolerated) for State freight system routes than for other highways, and which vary by location, ranging from 0.70 to 0.85 for metropolitan and nonmetropolitan areas outside the state's largest metro area, Portland, and 0.85 to 0.95 inside the Portland area (see Appendix B in the Oregon Highway Plan).

Volume-to-capacity ratios approaching 1.0 are indicative of congestion. However, unlike probe-based measures where performance is actually measured over time, v/c ratios are typically only calculated measures. Further, in severely congested conditions v/c measures can be meaningless as they do not capture either the duration of congestion or the variability in traffic conditions. Closely analogous to v/c ratios is the calculation of a level-of-service (LOS) qualitative measure. LOS values range from A-F (A being the "best").

4.4.1 Highway

4.4.1.1 PORTAL

Portland Transportation Archive Listing (PORTAL) is the official Archived Data User Service (ADUS) for the Portland metropolitan area as specified in the Regional ITS Architecture. PORTAL provides a centralized, electronic database that facilitates the collection, archiving, and sharing of information/data for public agencies within the region. Data from the freeway monitoring system (approximately 500 inductive loop sensors) report speed, count, and occupancy (a measure of density) every 20 seconds. Presently no distinction is made between passenger cars and trucks, so all reported data apply to the entire traffic stream. Observed travel speeds at each point location can be extrapolated with some manipulation to travel speeds between links, which can then be converted to travel times. Data are also kept on weather, incidents, and data quality.

With this rich data source freeway mobility measures including: average travel times, 95th percentile travel time, and standard deviations can be calculated. In addition, common indices such as the travel time index, planning time index, or the buffer index can be calculated. An example is shown in Figure 4.13 for I-5 North from Wilsonville, OR to the Washington state line (approximately 23.5 miles) which shows the distribution of travel times in five minute intervals for all of 2005. The chart shows that the corridor's free-flow speed was defined as 60 mph, thus the free flow travel time was 23.5 minute. The mean travel time was 27.3 minutes, the standard deviation was 5.75 minutes, the coefficient of variation was 21%, and the 95th percentile travel time was 41.0 minutes. Thus, the Buffer Index is calculated at 0.50.

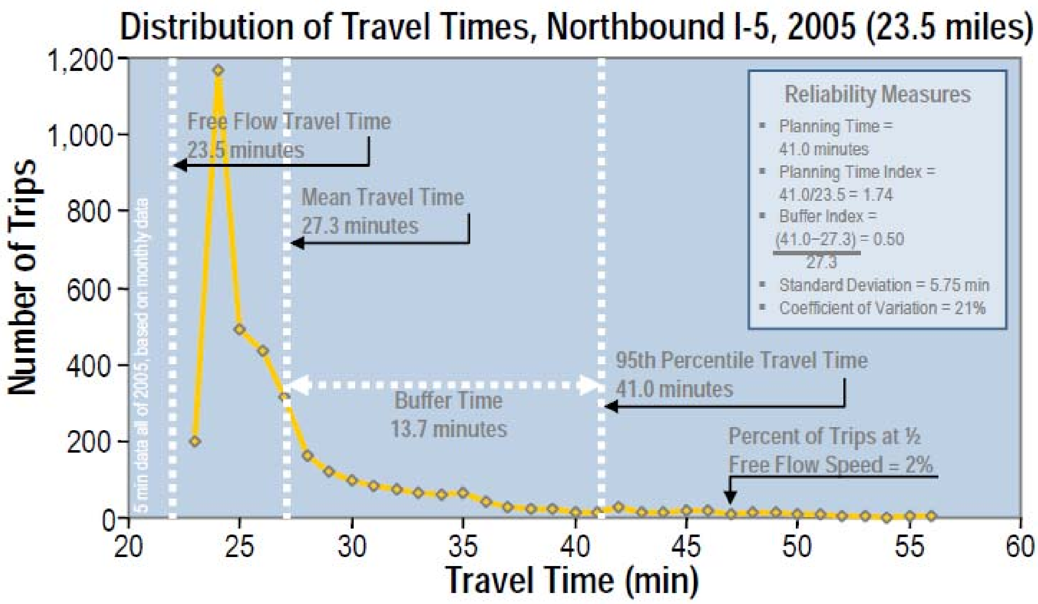


Figure 4.13: Northbound I-5 travel time distribution for 2005 (*Lyman and Bertini 2008*).

Presently, the PORTAL database only contains this information for freeways in the Portland, Oregon/Vancouver, Washington metropolitan area. Work is underway to incorporate key arterial measures in a systematic manner as well as to modify detection stations to identify long and short vehicles (i.e. trucks). No other area of the state has a comparable monitoring system.

4.4.1.2 Probe-Based Data

The primary disadvantage of point-sensor data like the freeway monitoring system is that sensor coverage (e.g. spacing) can limit the accuracy of the estimated travel times. An alternative is to use probe data which can provide more detail about the conditions experienced by individual vehicles. Further, since GPS-equipped probe vehicles are limited to a set of specific facilities there is an opportunity to capture performance at bottlenecks or intermodal connectors that are not currently instrumented by sensors. The disadvantage of probe data is that the temporal resolution is usually lower (freeway sensor data reports every 20-seconds). However, if the penetration of the probe technology is sufficiently large, adequate performance measures can be developed.

4.4.1.2.1 American Transportation Research Institute Truck Probe Data

As discussed earlier in Section 2.3.2, ATRI has been developing freight performance measure tools for FHWA. Various trucking fleets provide ATRI with GPS data from wireless communication systems. These data uniquely identify a truck and provide a position (latitude and longitude) and timestamp. These data are desirable because they are freight-specific. ATRI recently released a report that used these data to quantify performance at the nation's 30 worst identified bottlenecks. An example of this analysis is shown in Figure 4.14. These position data also exist outside of urban areas and off freeways. In research (underway at the time of this report publication) at Portland State University suggests that the PORTAL data compares well with the ATRI measurements but under predicts truck-specific congestion measures. Confidentiality agreements prohibit additional disclosure about the analysis. Negotiations between ATRI, FHWA and ODOT would be required to use these data.

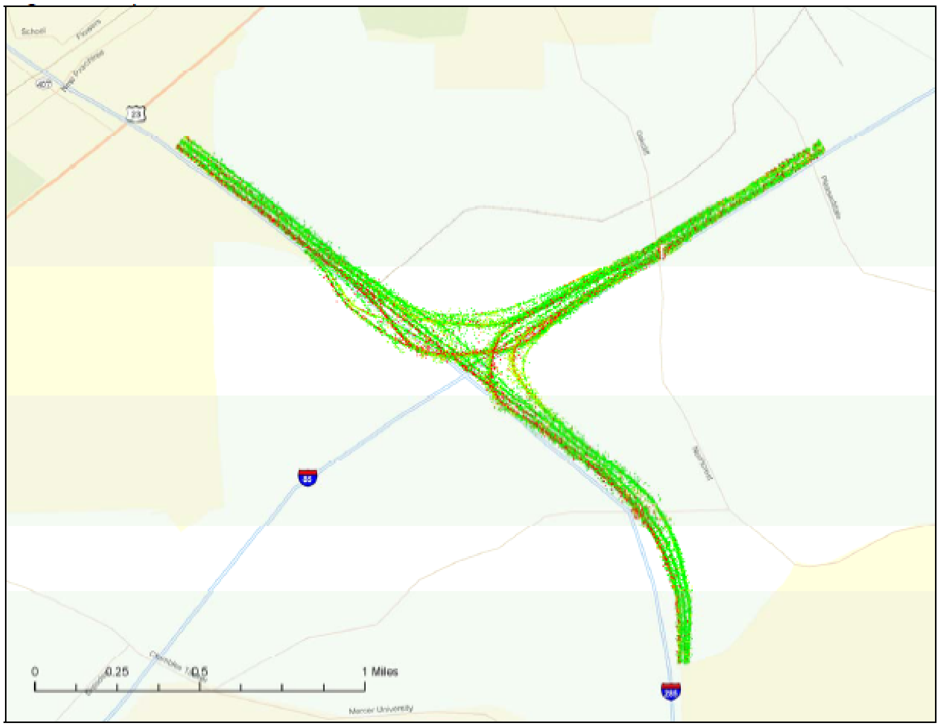


Figure 4.14: ATRI Analysis of Atlanta, Georgia; Interstates 85 and 285 Bottleneck

4.4.1.2.2 INRIX Probe Vehicle Data

INRIX is a private company based in the Seattle area and provides real-time, historical, and predictive traffic speed information for major freeways, highways and arterials in every major metropolitan area in the U.S. and Canada. INRIX acquires data from "GPS-enabled probe vehicle reports from vehicles traveling the nation's roads – including taxis, airport shuttles, service delivery vans, long haul trucks, and consumer vehicles" (*INRIX 2010*). These data can be used to produce similar speed and travel-time performance measures as described previously. INRIX has also published a "freight intensity" map based on these same data as shown in Figure 4.15. This analysis shows relative truck volumes but does not show travel speeds. To date, they have not produced freight-specific travel times or measures, though that appears completely feasible (if the fleet penetration is sufficient). These data are not publicly available, but can be purchased by DOTs.

Figure 4.15: INRIX Freight Corridor Data Real-Time Map Example

4.4.1.2.3 WIM Data

In a recent ODOT research project, data from each of the 22 Green Light equipped weigh stations in Oregon were assembled, processed, and uploaded to a data archive housed under the Portland Transportation Archive Listing (PORTAL) umbrella at Portland State University's Intelligent Transportation Systems Lab (*Monsere et al. 2009*). The data include axle weight and spacing, truck speed, timestamp, total length, gross vehicle weight, axle count, and transponder identification (this is a unique aspect of Oregon's system). The data archive includes adequate security measures to address privacy issues.

Since transponder-equipped vehicles can be uniquely identified at two stations, estimates of the vehicle's travel time can be made. Two separate algorithms were scripted, tested, and validated. The first algorithm matched transponders of all vehicles in a time window between the upstream and downstream stations for all possible pairs. The second algorithm filtered these matches to identify through trucks. This step was necessary because the long distances between stations mean that not all trucks travel between the stations without stopping.

Though the penetration rate of transponder-equipped trucks varies by station, overall it is relatively high (40%). Application of the search algorithms identified 1.3 million through-travel time observations. An example of corridor-level performance metrics that can be generated from these data is given in Figure 4.16. The plot shows the average speed (solid line) and +/- one standard deviation (dashed line) for the route between the Klamath Falls to Lowell stations (US-

97NB to OR-58WB). This route traverses the Cascade mountain range and the effects of winter weather on both travel time and reliability (larger standard deviations) can be seen.

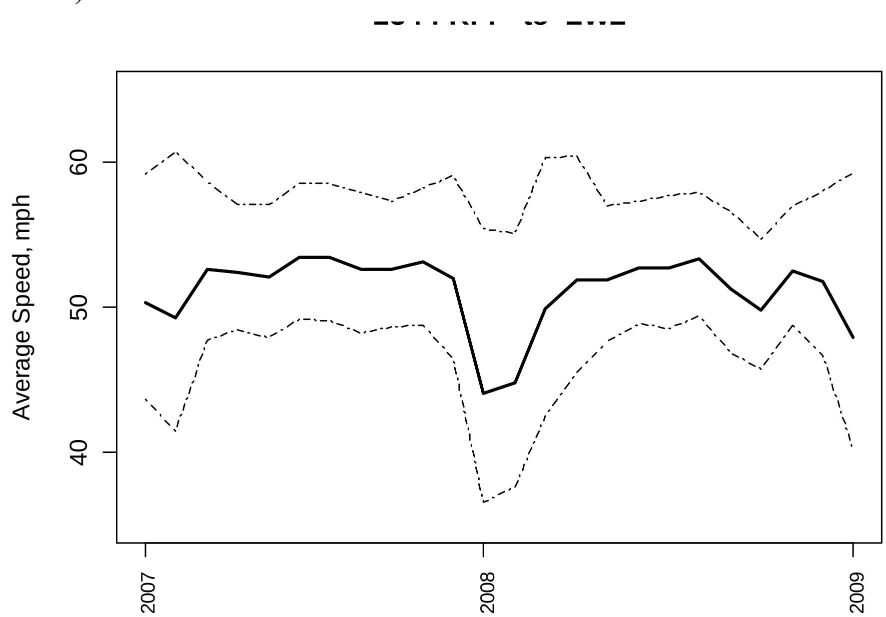


Figure 4.16: Average Truck Travel Speed, Klamath Falls WS to Lowell WS (US-97NB to OR-58WB)

These data cover the key rural interstate and freight corridors in the state (I-5, I-84, US-97, and US-26 (from Madras to Portland)). Placement of additional transponder readers could improve travel time estimates (as done in Washington State) as well as data quality monitoring.

1.1.1.1.1 Other Probe-Data

In Portland, transit buses are equipped with automated vehicle location (AVL) technology and can be used to estimate arterial level travel-times with some assumptions. In addition, there is a deployment of a number of Media Access Control (MAC) address reading/matching projects on arterials in Portland (and Eugene) that would serve to generate similar data. It is possible that key freight connectors could be monitored with these technologies.

4.4.1.3 Oregon Highway Traffic Volume

Oregon highway traffic volumes are provided in ODOT's transportation volume tables. An extensive network of Automated Traffic Recorders (ATR) provide data on ADT volumes for the last 10 years, average weekday traffic volumes by month, and percentage of vehicles by 14 vehicle classifications. The tables are published annually and contain annual average daily traffic (AADT) volumes on state highways by mile point at selected locations along state highways. These and other data are reported to the FHWA as part of the Highway Performance Monitoring System (HPMS).

The ATR tables enable the estimation of truck volumes at selected locations. By applying an average weight per truck, tonnage estimates can be derived. Tonnage estimates based on data from ATR tables can be combined with estimates from other sources to develop truck tonnage estimates for corridors.

4.4.1.4 Integrated Transportation Information System (ITIS) Data

ITIS is the official source of state highway information and provides mileage statistics and status of features related to the highway system. Data are provided through a series of reports on topics, such as the following: lanes, vertical grade, horizontal curve, pavement, capacity, traffic volumes, vehicle classification, bikeways, sidewalks, and crosswalks. The data are collected to support the development and maintenance of transportation management systems, the Highway Performance Monitoring System submittal, the Federal functional classification and National Highway System, planning, straightline charts, and the video log.

4.4.2 Railroad

4.4.2.1 AAR

The Association of American Railroads (AAR) began collecting and publishing weekly performance measures for railroads in 1999. In 2005 they changed their methodology somewhat and warn that inter-railroads comparisons may not be appropriate due to differences in operation procedures, freight type, terrain, etc. However, year to year comparisons can be made for the same railroad over time.

Results are reported for the following major North American railroads: BNSF Railway Company, Canadian Pacific Railway, CSX Transportation, Kansas City Southern, Norfolk Southern, and the Union Pacific Railroad. Data reported include cars on line by owner (railroad system, private or foreign), and type of car (box car, hopper, intermodal, etc.). The average train speeds are provided for each railroad for intermodal, grain trains, coal trains, etc. The hours of terminal dwell time are provided for specific terminals in the system as well as a railroad system average.

Performance data from non-Class I railroads are not available, nor is it clear if data could be provided for a subset of the one of the carrier’s network. The terminal dwell and delay information is only reported for Hinkle, OR on the Union Pacific system.

4.4.2.2 Railroad Capacity

Railroad capacity is typically measured by the number of trains per day that can reasonably be accommodated. Similar to highways, capacity can be estimated if track, control, train mix, and other factors are known. In a recent study for the American Association of Railroads titled *National Rail Freight Infrastructure Capacity and Investment Study*, Cambridge Systematics developed a practical method for estimating the current and forecasted level of congestion on the Class I rail system in the United States. In consultation with the major railroads, a "practical maximum" number of trains per day were developed based on the number of tracks, type of signal control, and the mix of train types. The practical maximum allows for "possible disruptions, maintenance, human decisions, weather, possible equipment failures, supply and demand imbalances, and seasonal demand variations." These volumes are shown in Table 4.4.

Table 4.4: Practical Maximum Trains per Day

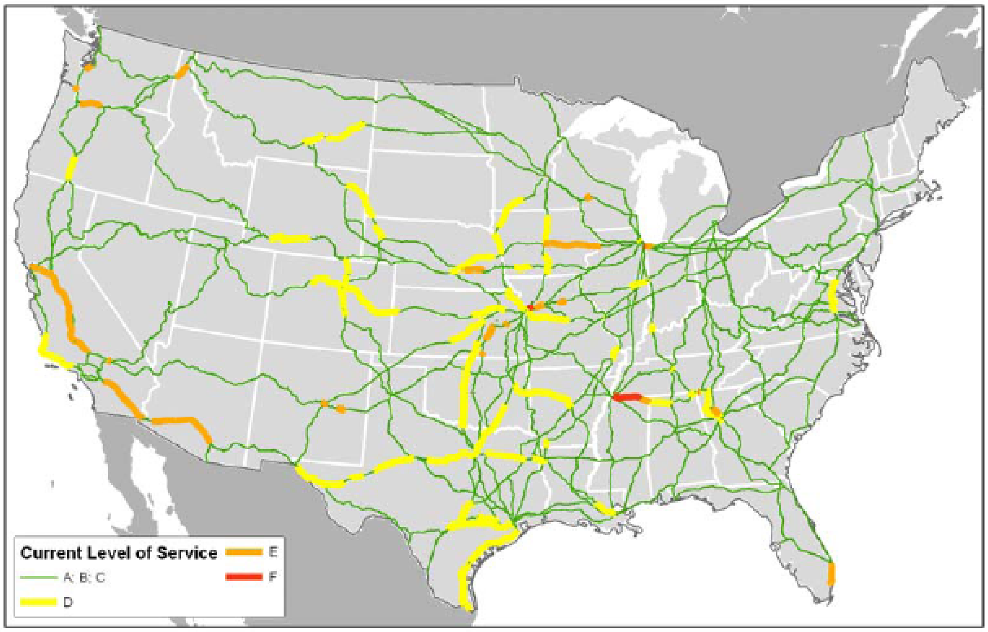
		Trains per Day	
Number of Tracks	Type of Control	Practical Maximum If Multiple Train Types Use Corridor*	Practical Maximum If Single Train Type Uses Corridor**
1	N/S or TWC	16	20
1	ABS	18	25
2	N/S or TWC	28	35
1	CTC or TCS	30	48
2	ABS	53	80
2	CTC or TCS	75	100
3	CTC or TCS	133	163
4	CTC or TCS	173	230
5	CTC or TCS	248	340
6	CTC or TCS	360	415

Key: N/S-TWC – No Signal/Track Warrant Control.
ABS – Automatic Block Signaling.
CTC-TCS – Centralized Traffic Control/Traffic Control System.

Notes: * For example, a mix of merchandise, intermodal, and passenger trains.
** For example, all intermodal trains.

Source: Class I railroads' data aggregated by Cambridge Systematics, Inc.

Train traffic per day was then estimated using the Surface Transportation Board's Waybill sample and the Uniform Rail Costing System (URCS) to include empty car returns. Based on commodity types and operational characteristics, these car volumes were converted to trains. The estimated train volumes were then compared to the practical maximum for each track section and a Level of Service A-F rating was assigned. To account for seasonal trends in train traffic the 85th percentile daily volume was used. The resulting level of service values are shown in Figure 4.17. Two sections of Class I track were identified as having LOS E and D in Oregon (the Columbia River Gorge, and the Union Pacific line to California south of Bend).



Source: Cambridge Systematics, Inc.

Note: Volumes are for the 85th percentile day.

Figure 4.17: Level of Service for Current Train Volumes Compared to Current Train Capacity

4.4.3 Air

4.4.3.1 Bureau of Transportation Statistics BTS, Airline Service Quality Performance

Freight-specific reliability data sources were not found; however, BTS monitors on-time performance of air carriers and produces summary data. Data are available for each major airport in Oregon for arrival and departure statistics. Air cargo on passenger aircraft would certainly be measured by these metrics but all-cargo aircraft may or may not experience the same delays. A sample of on-time arrival performance for 2009 at Eugene is shown in Figure 4.18.

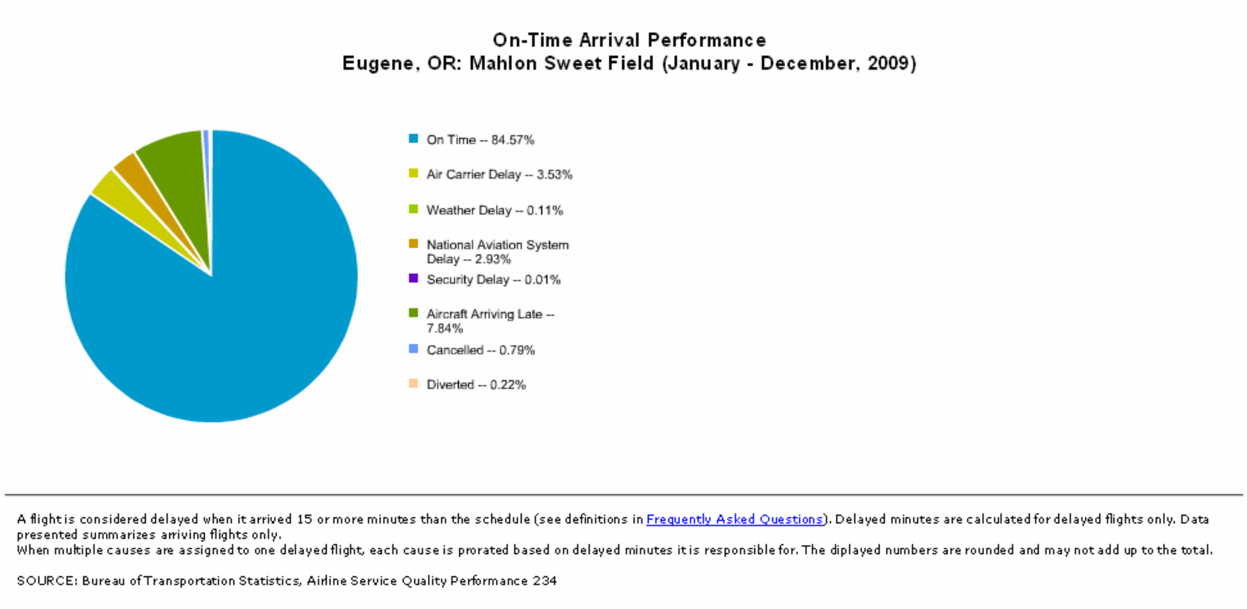


Figure 4.18: On-Time Arrival Performance, Mahlon Sweet Field, Eugene, OR January-Dec 2009

4.4.4 Ports/Marine

4.4.4.1 US Army Corps of Engineers Lock Performance Measurement System

The USACE data source tracks the performance of each lock in the Columbia River system. Data are reported for each lock and aggregated for the system. Data are recorded on the total number of vessels, tonnage by commodity type, percent of vessels delayed, average delay (for all vessels and for tows) and lock closures (both scheduled and unscheduled). Since freight traffic is nearly all barge tows, it is helpful to have separate measures for barge tows. Most data are available on a monthly basis. Figure 4.19 shows the average delay per barge tow in hours from 1993-2008 on the Columbia River System. Scheduled and unscheduled time (in hours) that the lock was unavailable is also reported. Figure 4.21 shows unscheduled lock closure time (in hours) over the same period.

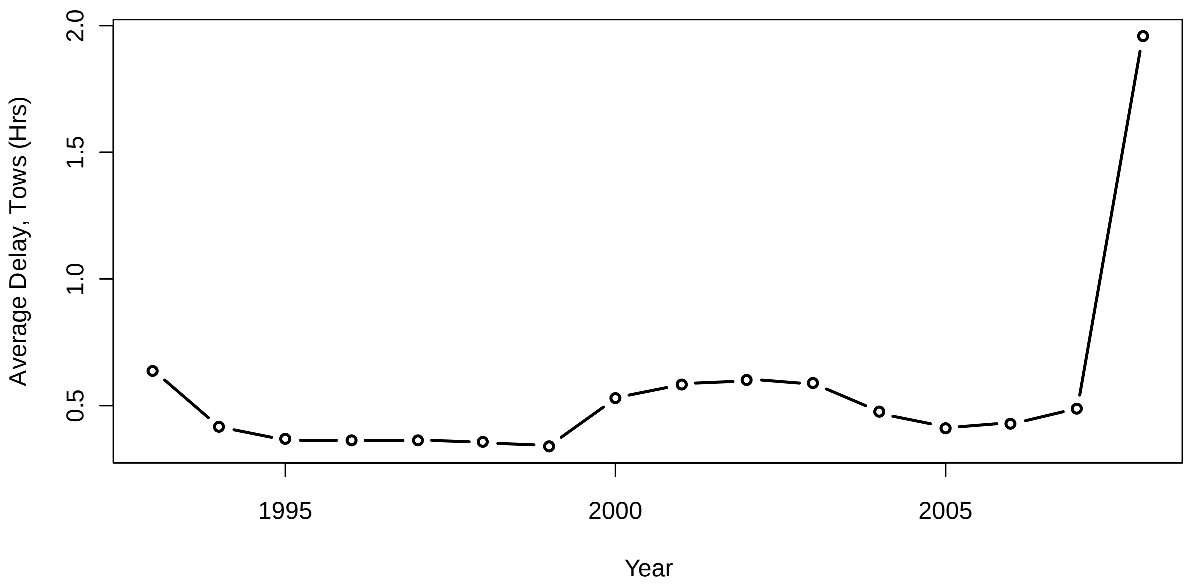


Figure 4.19: Average Delay for Tows (Hrs) on the Columbia River Lock and Dam System

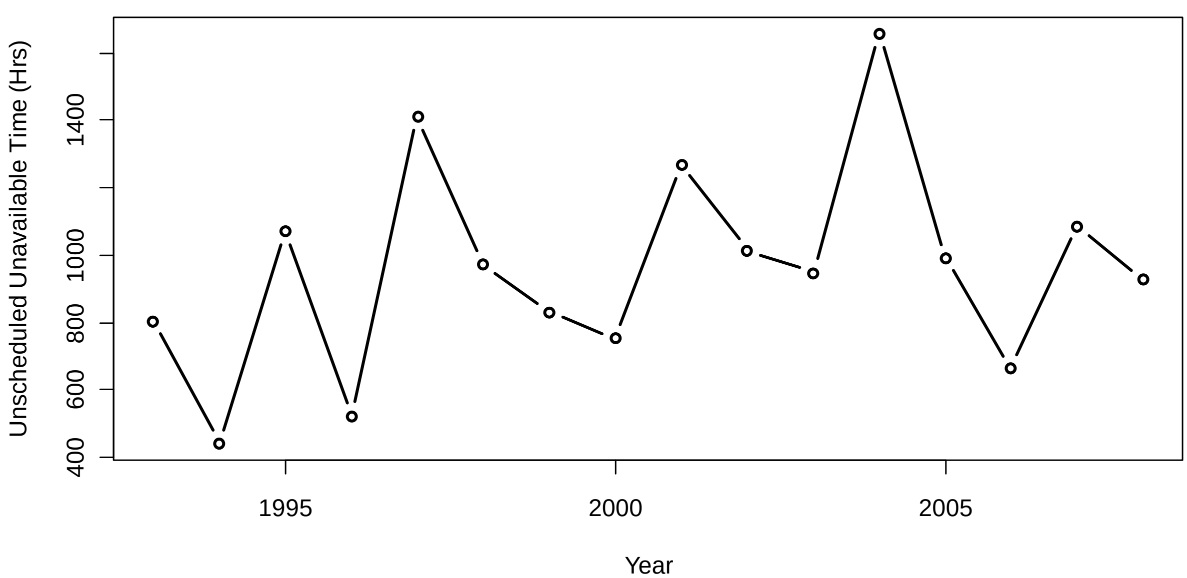


Figure 4.20: Unscheduled Lock Closure Time (Hrs) on the Columbia River Lock and Dam System

4.4.4.2 Port of Portland Gate Tracking

The Port has installed a cargo tracking system and gate monitoring technologies at the container import/export facility at Terminal 6 (Figure 4.22). These could potentially generate truck turn times and cargo delays.

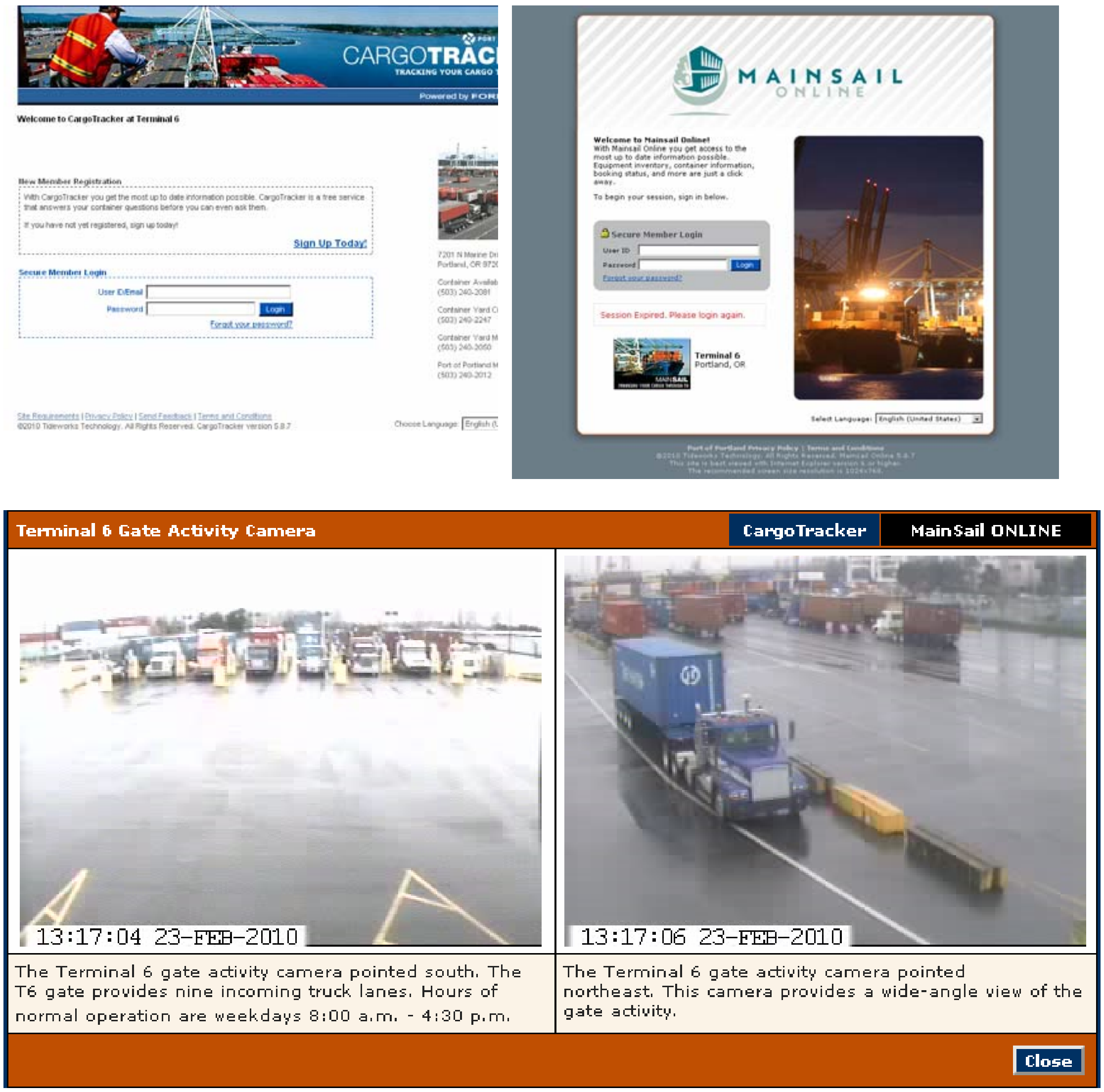


Figure 4.21: Port of Portland Gate and Cargo Monitoring Technologies

4.4.4.3 Maritime Safety and Security Information System (MSSIS)

The Volpe Center developed the MSSIS system to provide tracking of maritime vessels equipped with an Automatic Identification System (AIS) beacon. The primary purpose of the system is to support collision avoidance, but because positional data (latitude and longitude), attributes (such as speed, name, size, type, etc.), and time are available for ocean-going vessels it is conceivable that performance measures could be calculated. For example, Columbia River transit times from the Pacific Ocean and other measures could be generated.

4.5 ACCESSIBILITY AND CONNECTIVITY

Accessibility refers to the shippers' access to the transportation mode. In general, the highway mode is accessible for all locations where shippers originate or terminate shipments. Other modes, such as railroad, require the shipper have access to a terminal within some reasonable distance. To generate measures of accessibility, supplementary data sources such as employment, population, or economic data would be needed (these are generally described in last section of the chapter).

4.5.1 Highway

4.5.1.1 Oregon Weight-Mile Tax Records

Oregon's weight-mile tax system is a potential data source to estimate truck activity. ODOT already uses the data to estimate truck vehicle-miles and triple mileage traveled as shown in Figure 4.23. It may also be possible to estimate vehicle utilization measures (how many miles reported per vehicle).

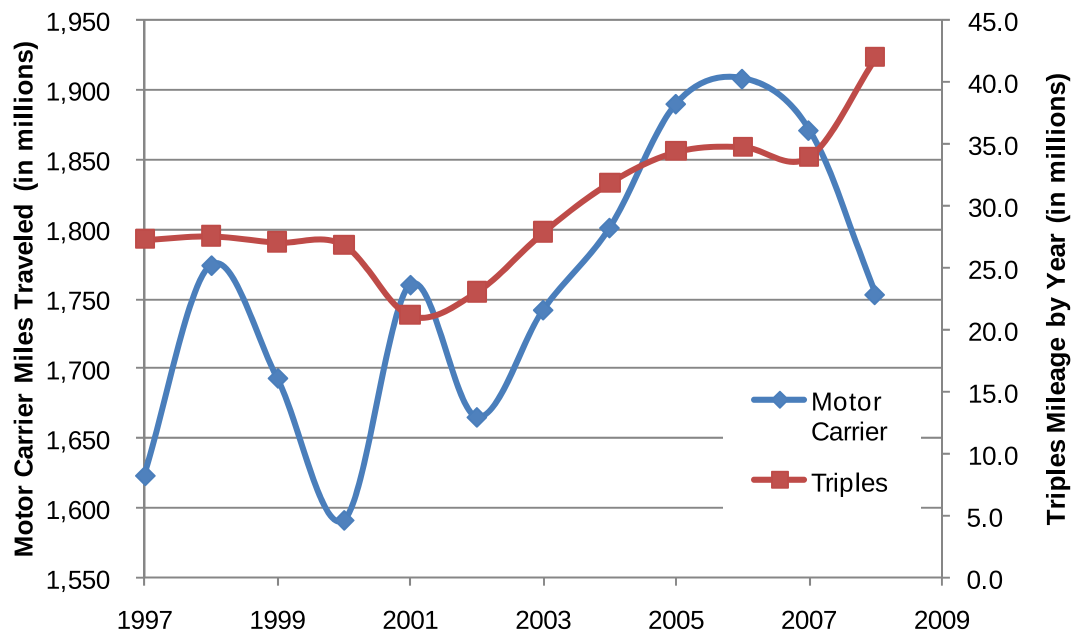
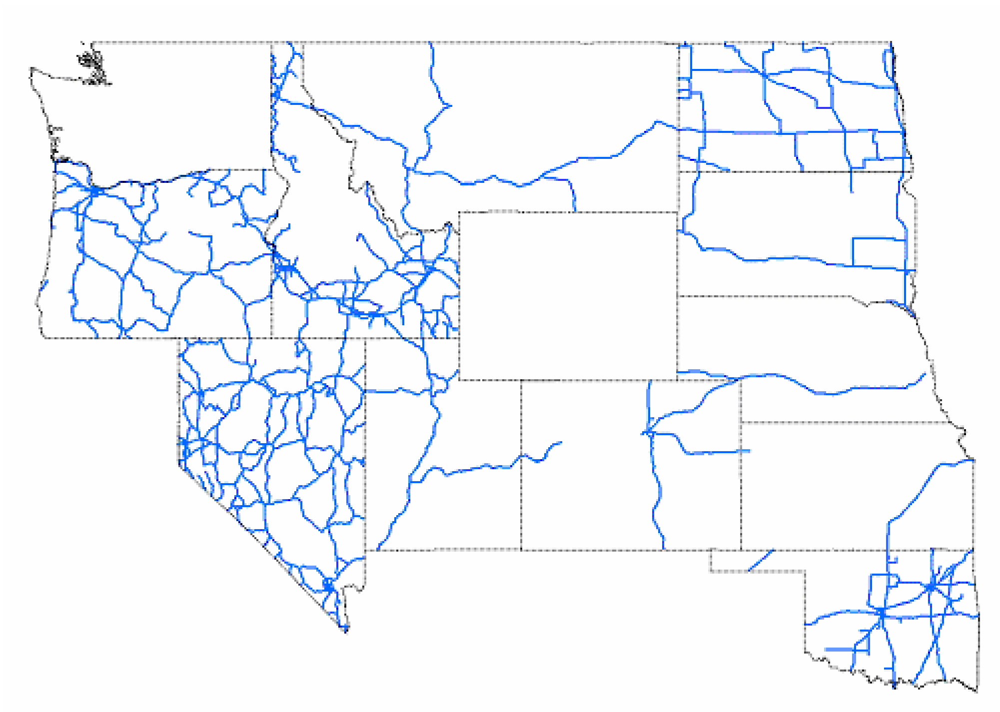


Figure 4.22: Motor Carrier and Triple VMT Generated from Weight-Mile Tax Records

4.5.1.2 Longer Combination Vehicle Network

All shippers may not have equal access to triple trailers or other longer combination vehicles (LCVs), for instance, unless they are located near one of the roads where these vehicles are allowed. The network for LCVs was frozen in Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 to the type of vehicles in use on or before June 1, 1991. The highway network available for triple tractor trailers is shown in Figure 4.23. Oregon MCTD produces Route Map 5 which provides more detail on the triple-permitted routes in Oregon (including holiday travel restrictions). One potential measure of accessibility would be to consider the percent of freight originating or terminating within a certain number of miles of these freight corridors. Unfortunately, shipment origin or destination data does not contain that level of specificity. Population may be a good proxy for freight activity.



Source: Western Uniformity Scenario Analysis (*FHWA 2004*)

Figure 4.23: Triple-Trailer Network, Western US

4.5.2 Railroads

For rail accessibility the basic access issue is how close the railroads are to shippers and whether the railroads provide a viable transportation alternative. Also, another issue is whether the railroads are located near roads in major corridors to allow intermodal transfers. As shown in Figure 4.5, there are limited numbers of locations where rail-truck intermodal connections can be made. It is possible to estimate shipment origin-destinations from the STB's waybill sample as described below.

4.5.2.1 Surface Transportation Board Carload Waybill Sample

The Surface Transportation Board (STB) Carload Waybill Sample data are most useful in rail studies and for future freight rail planning purposes. This database provides a rich and detailed source of rail-based commodity flows and detail rail traffic in the state. Geographic and commodity level information about freight rail flows information are available from the data, as well as information on the railroad carrier, weight (tons), value, type of commodity, and general route, displaying which commodities are moving to, from, within, or through the State. Due to sensitive shipping and revenue information, access to the data is restricted (though a public use version is available that does not allow individual shippers to be identified).

4.5.3 Ports/Marine

4.5.3.1 US Army Corps of Engineers Lock Performance Measurement System

As described previously, the USACE Lock Performance Measurement System monitors commodity and barge traffic on the Columbia River System. Figure 4.24 shows the number of loaded barges annually from 1993-2008.

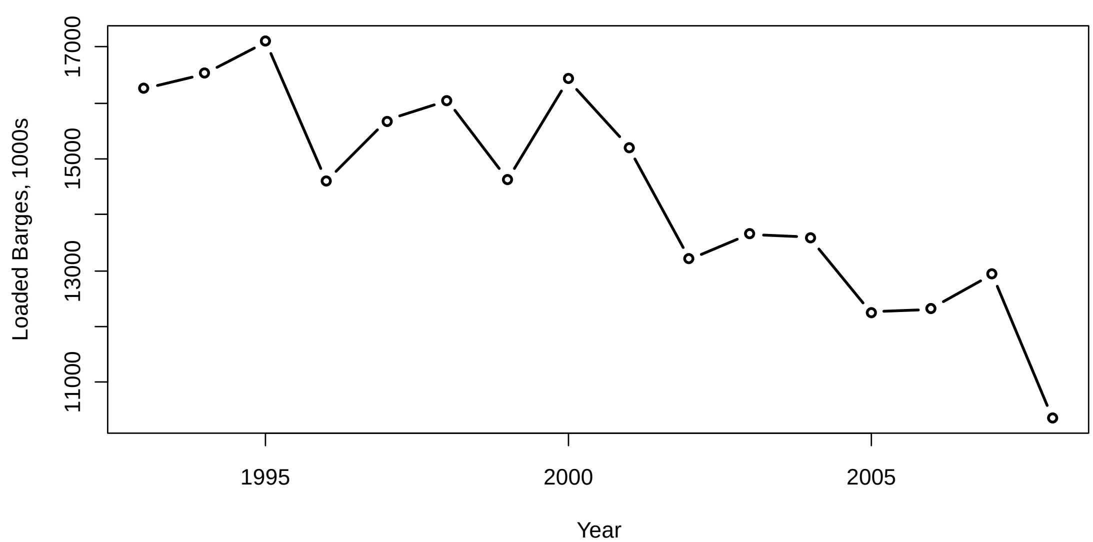


Figure 4.24: Loaded Barges on the Columbia River System

4.5.3.2 Port of Portland Statistics

The Port of Portland provides annual statistics on the movement by tons, import and export container, and auto units. These data have been recorded since 1978 and are shown in Figure 4.25 indexed to movements in 1978.

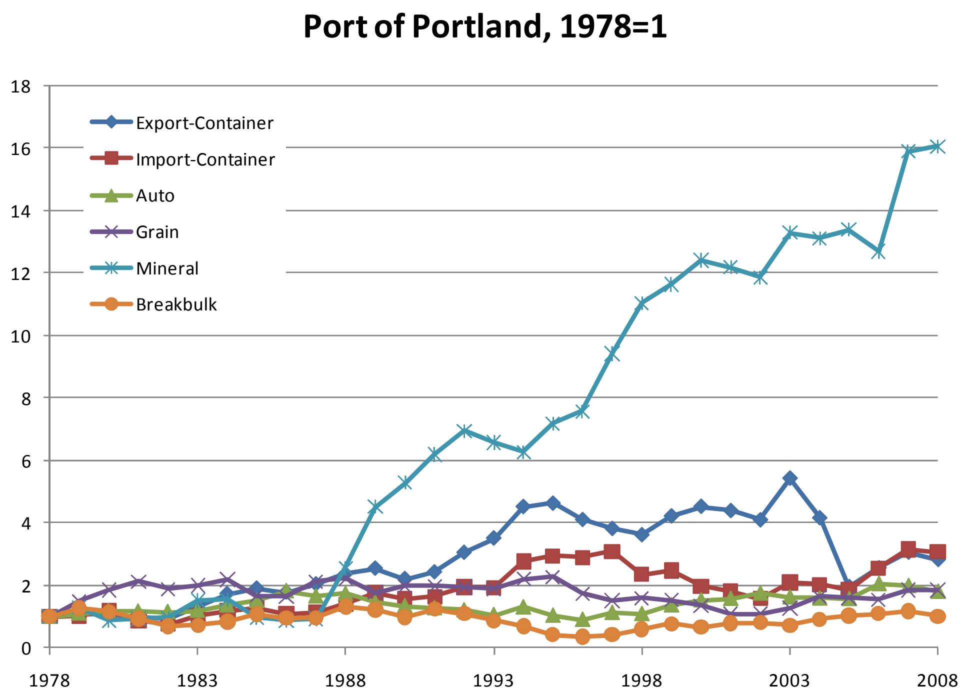


Figure 4.25: Port of Portland Annual Statistics

4.5.4 Air

4.5.4.1 Frequency of Air Cargo Service

For air freight, a likely measure of accessibility would be frequency of service. Published timetables are available for commercial passenger carriers that carry some freight, but package-delivery carriers United Parcel Service (UPS) and FedEx do not have published schedules. Presently, the Port of Portland lists seven air cargo carriers with operations: Air China Cargo, AmeriFlight, Bax Global (now DB Schenker), Empire Airlines, FedEx, United Parcel Service, and Western Air Express.

As part of noise impacts of small planes (less than 12,500 pounds) at the Port of Portland, frequency and time of the arrival and departure of cargo feeder aircraft were collected (*Port of Portland 2010*). These smaller aircraft connect the state's regional airports (e.g. Salem, Corvallis, Klamath Falls, Bend, and Medford) with the main cargo carriers at Portland International Airport. As shown in Figure 4.26, cargo feeder operations peak in the morning (shipments outbound) and the afternoon (shipments returning to PDX for next-day delivery by major carriers to other U.S. destinations). Major cargo carriers, such as UPS and FedEx, also follow this schedule (arrivals in the morning and departures in the late afternoon/early evening). While these data were not found to be published publicly, it should be possible to collect the information from the airports or air carriers themselves.

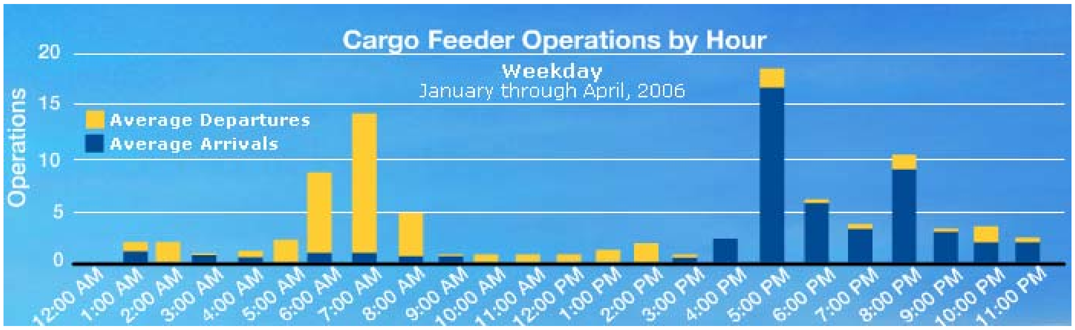


Figure 4.26: Cargo Feeder Operations at Portland International Airport

4.5.5 Commodity Flow Data

Accessibility measures require information on how much freight is flowing from where to where. There are a number of data sources available. Note the STB Waybill sample could be included here but was described previously.

1.1.1.2 Oregon Commodity Flow Data

For Oregon, commodity flow work was developed using base year (1997) estimates and forecasts at five-year intervals from 2000 to 2030 for the following: tonnage and value of shipments; 38 Standard Transportation Commodity Classifications; modes (truck, rail carload, rail intermodal, water, air, and pipeline); geographical areas (statewide, six metropolitan areas, 10 Area Commission on Transportation areas, and four selected counties); and movements into, out of, within, and through each geographical area by mode and commodity classification.

4.5.5.1 Freight Analysis Framework

The Freight Analysis Framework (FAF) estimates commodity flows and related freight transportation activity among states, sub-state regions, and major international gateways. It also forecasts future flows among regions and relates those flows to the transportation network. The newer version FAF2.2 projected commodity flow data ranging from 2010 to 2035 in five-year intervals as well as corrected 2002 base case data. It also includes an origin-and-destination database of commodity flows among regions (includes local and long distance trucking), and a network database in which flows are converted to truck payloads and related to specific routes.

Commodities are described and reported via the Commodity Flow Survey (see Section 4.5.5.4) using a five-digit Standard Classification of Transported Goods (SCTG) code for the major commodity contained in the shipment. Regional transportation modes, tonnage for each shipment, and value of commodities transported for different types of commodity are available from FAF. Based on definition from 2002 Commodity Flow Survey, commodities are products that an establishment produces, sells, or distributes; however excess or byproducts of establishment's operation are excluded.

4.5.5.2 TRANSEARCH Database

Global Insight's TRANSEARCH data provides U.S. county-level freight-movement data by commodity group and mode of transportation for state freight planning purposes. This data combines information from public sources and data for primary shipments from major carriers. Data are available for 38 commodity groups for truck, rail, and water freight. Shipments of manufactured goods and selected non-manufactured goods, rail shipments, waterborne and air freight shipments, U.S./Mexico and U.S./Canada shipments for selected transportation modes are all available from this database. The data set is commercial and is available for purchase only. Historical data are also available (these data were previously created by Reebie Associates).

4.5.5.3 Commodity Flow Survey

The Commodity Flow Survey (CFS) is a shipper-based survey that is conducted by the Bureau of Transportation Statistics and the U.S. Census Bureau every five years. It provides comprehensive information of national freight flows, estimating shipping volumes (value, tons, and ton-miles) by different commodity level and mode of transportation at varying levels of geographic details (state and region). Commodities are coded by the Standard Classification of Transported Goods (SCTG) list. The 2007 survey (the most recent) sampled over 100,000 establishments with paid employees that were located in the United States and were classified, using the 2002 North American Industry Classification System (NAICS) in mining, manufacturing, wholesale trade, and select retail trade industries (electronic shopping, mail-order houses, and fuel dealers). The CFS does not include establishments classified in forestry, fishing, utilities, construction, or transportation. Most retail and services industries, farms and government-owned entities (except government-owned liquor stores) were also excluded.

4.6 ENVIRONMENT

The construction and operation of the entire transportation system produces significant environmental impacts and other externalities. The freight system also has significant impacts, though it would be difficult in most cases to assign the incremental contribution of the freight system. All freight modes primarily use carbon-based fuels; emissions of greenhouse gases and other criteria pollutants (e.g. nitrogen oxide) for air quality are of primary concern. Actual emissions are nearly impossible to measure (direct measurement of criteria pollutants is done at only a handful of locations statewide); values would have to be calculated from empirical models using traffic, speed, fuel type, and other simplifying assumptions. Estimates could be made from models (such as those described below) if sufficient data and information were available.

In addition to emissions, other environmental impacts include water quality (from dredging and runoff), noise impacts (from trucks, trains and airplanes), and fish habitat (lock system). Data sources on these impacts are not presented.

4.6.1.1 MOVES2010–EPA

For the highway mode, MOVES2010 is the new upgrade to EPA's modeling tools for estimating emissions from highway vehicles, based on analysis of millions of emission test results and considerable advances in the Agency's understanding of vehicle emissions. This model can be used to estimate air pollution emissions from cars, trucks, motorcycles, and buses, and it is the best tool for quantifying criteria pollutant and precursor emissions, as well as for other emissions analyses of the transportation sector.

4.6.1.2 Oregon DOT's GreenSTEP Model

ODOT's Transportation Planning and Analysis Unit is developing a greenhouse gas Statewide Transportation Emissions Planning model (GreenSTEP) for the purpose of implementing a statewide strategy for managing greenhouse gas emissions from transportation sources. It includes models of household travel, vehicle ownership, and vehicle characteristics at the household level. It also includes simple truck, fuels and emissions models to estimate the effect of land use, transportation pricing, and other policies on GHG emissions. The model outputs include fuel consumption, electric power consumption, and greenhouse gas emissions, which is the last step for all models. Fuel consumption (in gasoline equivalent gallons) by vehicle type can be calculated from the respective estimates of VMT and fuel economy. These estimates are then split into fuel types. The model addresses five fuel types: gasoline, ultra low-sulfur diesel (ULSD), ethanol, biodiesel, and compressed natural gas (CNG). Presently the model is only for the highway system.

4.7 SUPPLEMENTAL DATA SOURCES

There are additional datasets that may be useful as proxies or for normalizing freight measures. These data include economic and demographic data. At the federal level, Employment and Gross Regional Product (GRP) information is available from the Bureau of Economic Analysis; and International Importer/Exporter information is available from the U.S. Department of Commerce. Additional economic data may be downloaded from various federal websites, including:

- the U.S. Department of Commerce's Bureau of Economic Analysis (http://www.bea.gov/),
- the U.S. Census Bureau (http://www.census.gov/),and
- the transportation-specific website, U.S. BTS' TranStats (http://www.transtats.bts.gov/).

Specific industry information is available from various state agencies, including the Oregon Office of Economic Analysis, Department of Agriculture, Department of Forestry, and Department of Geology and Mineral Industries. The Oregon Office of Economic Analysis provides data useful for understanding the overall economic and demographic structure of the state, including future forecasts. Furthermore, Oregon's Department of Employment provides a wealth of information regarding businesses in Oregon. One of the more robust data sources is the Oregon Labor Market Information System, available on-line, from the Department of Employment.

These data sources are listed in Appendix D.

5.0 IDEAL AND RECOMMENDED PERFORMANCE MEASURES

There are several levels on which freight performance measures could be considered: state or system-wide, on individual corridors, or on individual routes. The correct level to use may depend on the purpose for which policymakers are considering the measure.

If the desire is to increase overall freight system efficiency through investing wisely in public infrastructure, then measures would be needed that predict the impact of the investment on transportation flows through the entire state or system-wide and potential modal shifts. This would require performance measures for multiple modes since investment in one mode may affect performance of other modes. For instance, investment in rail infrastructure that allows more reliable rail service and availability of flat cars would likely impact rail but also secondarily impact trucking firms, which provide trailer-on-flat-car (TOFC) intermodal services. Investment that increases efficiency of one mode could have the impact of decreasing service on another mode. One clear example would be bridge improvements that remove load or width restrictions, which might increase truck traffic at the expense of rail or barge if shippers were previously using those modes.

At this point in time, there is not an aggregate index available. One possible way to do this would be to calculate a data envelope analysis (DEA) index of efficiency for all of the state systems using measures of highway, water, rail, and air infrastructure and vehicles as inputs and ton-miles as output for each mode. This effort would allow a multi-state examination of the relative efficiency of freight transportation systems across states. Over time, calculation of Malmquist indices (numbers enabling productivity comparisons between transportation network systems) would show efficiency and productivity gains and allow comparison of policies in states that are more efficient with those that are not. The challenge is defining freight system inputs and outputs in a meaningful way that could help guide policy decisions. This is very difficult at such an aggregate level and for such a complicated system.

At the corridor or route level, it is easier to identify relevant freight modes and those routes or corridors that are freight significant. While there are often extensive data available for highways in metropolitan areas, much of the data relate to overall traffic on those routes and are not specific to freight. Where data are available, it is often only on a segment of a major route in the area (such as a section of I-5). While this sort of data can provide information on a specific facility that may be useful for decision making, it usually does not provide information necessary to evaluate the overall efficiency of the freight transportation system.

In locations outside major metropolitan areas, the data available relate more to the quality of the facility (say road or bridge quality) that again are relevant for all traffic, not just freight. Further, those measures examine the quality of the infrastructure (which does have an impact on freight) rather than the performance of the freight transportation system.

Given the current state of the practice in performance measurement, many measures currently being used and suggested are based primarily on the available data. In other words, the available data is driving the measures used. Often these measures are not very good proxies for the underlying issues that policymakers are trying to address. In many cases, a performance measure for one goal may impact multiple goals. For instance, truck accidents may be something that policymakers would like to reduce in order to increase safety, but a reduction in truck accidents also reduces delay from incidents and increases travel time and reliability—which are consistent with increases in mobility. These possible interactions will be mentioned below as ideal measures and available data for each category are considered.

In order to better evaluate the performance of the freight transportation system, data that relate to each of the major policy goals for freight by mode are required. Obtaining this data is a first step in developing metrics that are useful to decision-makers for policy analysis. Below, ideal freight performance measures for each category and mode are discussed. Information is then provided on which can be easily calculated with existing data, which would require further analysis of existing data (calculations, use of simulation models, etc.), and those that would be possible pending further development of data sources. Distinctions are made between measures that are observed (e.g. travel time) and those which are only estimated from data (e.g. pounds of carbon dioxide emissions). Finally, a discussion is presented on the future need to test the success of these measures in achieving the underlying policy goals.

A summary of all measures to be discussed in the subsections of this chapter are presented in Table 5.1. Asterisks are used to signify the availability of data sources as follows:

- * Data available to collect metric. No manipulation of data source needed.
- ** Data available but manipulation or analysis is needed.
- *** Data could be generated from simulation or model.
- **** Data are not available, requires collection.

Table 5.1: Summary of Recommended Performance Measures

Category		Measure	Observed	Estimated	Data Availability
		SAFETY			
Highway	a	Motor Carrier Crash Rate and Triple Trailer Crash Rate	X		*
	b	Motor Carrier Truck At-Fault Crash Rate	X		*
	c	Total Cost of Freight Loss and Damage from accidents/VMT		X	**
Railway	a	Total Loss and Damage from accidents per route-mile	X		*
	b	Total Loss and Damage from accidents per tons moved		X	*
	c	Train derailments per tons moved		X	**
Water	a	Value of Cargo Lost or Damaged per Tons or Value of Cargo Moved		X	****
	b	Containers Damaged or Lost Per Containers Handled /Total Containers		X	****
Air	a	Total Loss and Damage from accidents/Value of freight		X	****
	b	Incidents per 1,000 operations at freight-significant airports	X		*

Category		Measure	Observed	Estimated	Data Availability
MAINTENANCE AND PRESERVATION					
Highway	a	Percent of Pavement in Good Condition (or unacceptable, etc) on Freight Significant Highways	X		**
	b	Number of Weight Restricted Bridges/ Total Number of Bridges	X		*
Railway	a	Miles of track in expected or FRA Class 1 divided by total miles of Class I track	X		*
	b	Number of Double-Stack Tunnel Restrictions/Number of Tunnels	X		*
Water	a	Percent of tons on river moving though locks with constraints	X		**
	b	Unscheduled lock closure time (hours)			
	c	Channel depths at the port divided by depths at competitive ports (e.g. Seattle/Tacoma)	X		**
Air	a	Percent of Pavement in Fair or Poor Condition at Freight-Significant Airports	X		*
MOBILITY, RELIABILITY AND CONGESTION					
Highway	a	Urban: Hours of congested conditions per day	X	X	**
	b	Urban: Average Hours of delay per day for freight vehicles on freight-significant links	X	X	**
	c	Urban: Travel Time Index (TTI) on freight-significant links (ratio of the peak travel time to free-flow travel time)	X	X	**
	d	Urban: Buffer Index on freight-significant links (ratio of the 95th percentile travel time – average travel time to average travel time)	X	X	**
	e	Rural: Average hours of delay per day for freight vehicles on freight-significant links	X	X	**
	f	Rural: Average travel time on freight-significant links	X		***
Railway	a	Tons or ton-miles of freight over relevant period		X	**
	b	Average terminal dwell time train-hours of delay	X		***
	c	Railroad Corridor Level of Service	X		***
Water	a	Tons of traffic arriving at Port of Portland by barge	X		*
	b	TEUs passing through port (port throughput)	X		*
	c	Gate Reliability or Truck Turn Time	X		**
	d	Ship Unload Rate (Time per Container)	X		****
	e	Ship Load Rate (Time per Container)	X		****
	f	Average delay per barge tow on Columbia River	X		*
Air	a	Flight frequency by airlines with cargo capacity (number per day)	X		**
	b	Average time between flights by airlines with cargo capacity (minutes)	X		**
	c	Percent of On-Time Departures at Freight Significant Airports	X		*
	d	Percent of On-Time Arrivals at Freight Significant Airports	X		*
ACCESSIBILITY AND CONNECTIVITY					
Highway	a	Triple trailer VMT as a percent of total freight VMT	X	X	*
	b	Percent of Shippers with Access to Triple Network		X	***
Railway	a	Class I: Ratio of unit train carloads(or tons) / total carloads(or tons)		X	****
	b	Percent of shippers within 50 miles of intermodal trailer-on-freight-car (TOFC) facility		X	**
	c	Number or capacity of intermodal facilities	X		*
Water	a	Shippers within 50 miles of river port (for barge accessibility)		X	****
Air	a	Flight frequency by airlines with cargo capacity (number per day)	X		**
	b	Average time between flights by airlines with cargo capacity (minutes)	X		**
	c	Average travel time delay for on airport access roads	X		**
	d	Number of docks or acres of cargo-handling facilities	X		*
ENVIRONMENTAL					
All	a	Pounds of Greenhouse Gas Emissions		X	****

5.1 SAFETY

Measures used for safety frequently involve the number of accidents or fatalities from incidents involving freight vehicles or related infrastructure. For the freight shippers, accidents of any kind involve losses, these may include lost time in transit, delay time or loss, and damage to the goods being carried. To the carrier, there may be loss in terms of equipment lost or damaged. Simply measuring the number of accidents or fatalities or even accident or fatality rates, while important, does not get at the impact on transportation costs.

Accordingly, an ideal freight relevant measure would provide an indication of the amount of loss and damage from accidents and fatalities. This measure of loss and damage would ideally include loss and damage to the shippers, carriers, and to others on the system, as accidents result in delay. It should also be scaled in some way to control for the scope of operations. These measures can often be estimated from existing data with additional research.

5.1.1 Highway: Safety

For highways, the ideal performance measure would be the total cost of freight loss and damage from accidents divided by total freight vehicle miles traveled. Total cost would include both the cost of lost and damaged equipment, the value of the lost and damaged cargo, and the delay that the accidents impose on other freight carriers on that highway or corridor.

In addition to being a measure of safety that is relevant for freight system performance, this measure (total cost of freight loss and damage / total freight VMT) also provides an indicator of the reliability of the transportation mode. Carriers and modes that are more prone to accidents and losses will be perceived by shippers as less reliable. This is of greater concern to shippers of higher valued commodities, which have higher values of time.

For highways, the existing motor carrier crash file (not the statewide Crash Data System) provides information on property damage and commodities being carried by incident and vehicle. It could be used to develop an estimate of the value of losses from crashes involving trucks in Oregon. These data, combined with a crash rate for each highway segment (also available from crash summary data), could be used to produce a loss and damage rate that would be more meaningful for the evaluation of freight system performance than just the motor carrier crash rate alone. The crash data alone do not include value of cargo, only the property damage and loss to the equipment. However, an average value of cargo loss could be implied by average value of cargo carried by trucks in Oregon and an average cargo loss and damage estimate could be obtained. Further, because information on the severity and type of crash is also recorded, one could envision analysis that results in damage estimates that vary (i.e. a rollover crash would likely cause more cargo loss than a minor rear-end collision).

Finally, it should be noted that the available crash loss data do not include value of delay time caused by the accident which may be imposed on other carriers. Given the difficulty of obtaining ideal measures, especially in the short run, some indicators are included in the recommended measures below that are more readily available and can serve as gross proxies for safety performance.

The recommended performance measures for highway safety include the following:

a. Motor Carrier Crash Rate and Triple Trailer Crash Rate
b. Motor Carrier Truck At-Fault Crash Rate
c. Total Cost of Freight Loss and Damage from Accidents per VMT

The first two measures are readily available from existing data sources and published annually. The third would require a considerable amount of additional work but would be closer to the ideal measure (not including delay).

These measures could be made for the statewide system as well as for freight-significant corridors, highways, or route segments. The goal would be to identify where safety performance is weakest and initiate policies designed to reduce loss and damage from accidents. Monitoring over time would help policymakers determine where to make safety investments and improvements. Other public sector policies could include increasing enforcement and inspection efforts on safety deficient corridors and increased on-site audits of carriers. Private carriers can influence safety by providing incentives to drivers that help improve the safety culture of the firm and by instituting various safety programs.

5.1.2 Rail: Safety

Ideal safety measures for rail would be analogous to those mentioned above for highway. However, there is not a rail measure comparable to VMT, as different trains are of substantially different sizes and there may be a conceptual issue as to how to define a vehicle. Tons or ton-miles is another way to get at the scope of railroad operations, however this information may not be available for all rail lines. Route-mile (RM) of track may be the closest proxy available in most cases.

Again, for rail there is an extensive and detailed accident reporting system. To make this measure for rail comparable to the measure for trucking, would require a dollar amount of loss and damage for each incident. At the present time the available rail statistics provide only loss and damage to the equipment and track. As in the case for highway freight, an estimate of the value of cargo loss and damage would have to be made using estimates for the average value of rail cargo and size of rail shipments.

Again given the difficulty of obtaining ideal measures, especially in the short run, the recommended measure below include some indicators that are more readily available and can serve as gross proxies for safety performance.

Accordingly, the recommended performance measures for rail include:

a. Total Loss and Damage from Accidents per Route-mile
b. Total Loss and Damage from Accidents per Tons Moved
c. Derailments per Tons Moved

For all three measures, data are readily available at a detailed level (by railroad, county, month, year). The exposure measure of route-mile is easily calculated. Tons movement data are estimated in the aggregate; route or corridor level would require more analysis of the data.

These measures could be made at the statewide level or for freight-significant corridors. Data would also allow for calculation by railroad, though the most logical grouping is to consider Class I carriers or other railroads. The goal would be to identify sections of the system with poor performance (high measures) and to adopt policies or regulations to help decrease these ratios. Public sector policies designed to improve rail safety could include increased track inspections, rolling stock inspections or other regulatory effort. Track improvements aimed at reducing accidents could be made either by private rail companies or through public-private partnerships.

Note that another possible indicator of safety for rail would be the miles of track not in expected or FRA Class 1 condition (see maintenance section below).

5.1.3 Water and Ports: Safety

Again, what would be ideal would be a measure of loss and damage per unit of output going through the port or down the river such as the Total Cost of Freight Loss and Damage from accidents/Tons.

For the Port of Portland, there are measures of tons being exported, and tons of traffic arriving at the Port by barge. In this instance, tons is a reasonable scale for the scope of operations or port/waterway output. The USACE lock performance measurement system also provides ton movements on the Columbia River system.

However, for this area as well as port activities, there does not seem to be data available either on incidents or dollar values of loss and damage. This is due largely to the fact that freight services by barge or ocean going vessel are performed by private companies that do not share this information on their operations.

Again given the difficulty of obtaining ideal measures, especially in the short run, we include in recommended measure below some indicators that are more readily available and can serve as gross proxies for safety performance.

Recommended Safety Performance Measure(s) for Ports:

a. Value of Cargo Lost or Damaged per Tons or Value of Cargo Moved
b. Containers Damaged or Lost Per Containers Handled /Total Containers

At this point it is unclear that data are available for either of these measures. The most readily available data would be for the denominator of these measures: tons moving through the port or arriving at the port from the river (for barges) and total containers handled.

It is difficult formulating public policy to help improve safety without more information. Suggestions include: improvements in navigational aids and tools, port improvements, lock improvements (for travel down the river), and possibly vessel safety programs. However, to the extent that cargo loss and damage may be observed on the port side of water operations, working closely with longshoreman safety practices and handlings may be warranted.

5.1.4 Air: Safety

Air freight represents a very small fraction of all freight transportation in Oregon. In addition, most freight going by air to or from Oregon is intermodal in nature and almost always requires a truck movement. Given the very light weight and high value of commodities traveling by air, a loss and damage per ton measure would not probably be very meaningful or comparable across modes. Further, accidents involving aircrafts are rare; those involving freight only are even rarer.

Here the relevant measure might be the Total Cost of freight loss and damage divided by the value of all shipments going by air or total freight revenue (value).

However, there does not appear to be data available for this measure for freight, although there are federal data available on aviation accidents including runway incursions, near midair collisions, none of these report any data on loss.

The proposed safety performance measures are:

a. Total Loss and Damage from Accidents / Value of Freight
b. Incidents per 1,000 Operations at Freight-significant Airports

As mentioned, data for calculating the first measure are not presently available. Similar efforts as discussed for highways and railroads could be undertaken to develop average value loss per accident. The second measure can be calculated from existing Federal Aviation Administration (FAA) data, though there is no guarantee that the incidents observed affect freight movements.

For air as for the other modes, it is problematic to obtain cost for loss and damage other than by developing a model to estimate these values. Given the relatively small share of air freight constitutes and the lack of clearly identifiable policies at the state level that could affect commercial air freight operations, the cost of such an effort may not be warranted.

5.2 MAINTENANCE/PRESERVATION

Lack of maintenance and preservation may have an impact on freight performance, especially if the quality of the facility makes it impossible for freight traffic to pass, resulting in loss of service. Bridge restrictions or lock outages, for instance, may mean that truck traffic has to be diverted to more circuitous routes that involve longer travel times, or it could mean that traffic has to be diverted to other modes. Low quality infrastructure (such as poor roads or track quality) may impact freight transportation by reducing speeds at which transit can occur, increasing vehicle wear and maintenance (thereby increasing freight rates), and in very poor conditions, even result in cargo damage.

5.2.1 Highway: Maintenance/Preservation

Information on road quality would be most useful if made available for specific freight corridors as the overall quality of the road system may reflect quality on routes that are relatively unimportant for freight. However, all measures could be calculated at the statewide, corridor, or route segment level.

One such measure for highways is the percentage of pavement on the relevant system that is rated in “good” (or unacceptable, etc.) condition on freight-significant highways. Additional research is needed to determine exactly which measure (miles unacceptable, miles rated good, or miles rated fair-or-better) would be the best measure of road quality relevant for freight transportation performance.

The other factor that will affect freight transportation performance is whether trucks can use existing bridges. Accordingly, a system-wide measure such as the percent of bridges that are weight or width restricted might give an overall perspective of the system.

However, this does not really consider the impact on freight performance when trucks are diverted to an alternate route when faced with an impassable bridge. The impact on system efficiency and thus overall freight system performance is likely to be quite different depending on the route and freight corridor. Thus, an ideal indicator would be an index constructed to measure the impact of structurally deficient or restricted bridges on system or corridor freight efficiency. The first step would be to categorize freight-significant truck volume by corridor or link; next determine the length of the possible or feasible detour; calculate the value of the loads being diverted (delay time, value of time) and determine the cost of delay per ton mile of freight shipment passing over that corridor. The exact method is a topic for future research.

Given data constraints and the need for more research on developing the ideal measures, it is recommend that the following be used as highway freight performance measures for maintenance and preservation:

a. Percent of Pavement in Good Condition (or unacceptable, etc.) on Freight-Significant Highways
b. Number of Weight Restricted Bridges / Total Number of Bridges on Freight-Significant Highways

Data to produce both of these measures is readily available (with some additional manipulation to extract freight-significant corridors).

Public policy (investment) to help improve pavement and bridge quality would be best directed toward freight-significant corridors, highways, and route segments where these measures indicate there is the greatest need for improvement.

5.2.2 Rail: Maintenance/Preservation

In a manner analogous to highway infrastructure, rail infrastructure may either impact the speeds and reliability of the traffic that goes by rail or severe deficiencies such as tunnel and vertical restrictions may force potential rail traffic to alternate modes by reducing rail's competitive advantage. The large percentage of intermodal freight movements that utilize rail make the intermodal connections between rail and other modes an important factor affecting performance of the freight transportation system. For some commodities this may not make much of a difference but for others, such as intermodal TOFC traffic (which is usually higher valued), slow rail speeds may divert traffic to roads, increasing congestion and losing the cost advantage shippers are able to gain by utilizing rail for part of the trip.

Thus, a reasonable measure of the quality of the rail system would be the percent of track on which the maximum allowable speed for freight trains is less than 25 miles per hour. The Federal Railroad Administration (FRA) defines "miles of track in expected or FRA Class 1 condition" as that track with a maximum speed of 25 miles per hours. Accordingly a good measure would be the miles of track in expected or FRA Class 1 divided by total miles of Class 1 track. This measure applies nearly exclusively to the non-Class 1 railroads.

Rail has a cost advantage relative to truck especially for long distances. The ability to achieve these lower costs depends largely on the ability to move heavy carloads over the track. Thus, another infrastructure factor relevant to the efficiency of the freight system might be the percent of miles of track capable of handling carloads up to 286,000 pounds.

Finally, there should be some measure that indicates the percent of the track that is inaccessible to certain trains (especially double stacks) due to either vertical restrictions or tunnels. This is a proxy for the ability of freight to move efficiently through the existing transportation system. The number of double-stack tunnel restrictions affects both the accessibility and mobility for rail shippers. To get the real impact on the system would require looking at the tons of traffic or miles of track affected by restriction as a percent of total miles of track to see how the freight system performance is affected by these restrictions.

Given these considerations and data availability, we recommend the following performance measures for rail:

a. Miles of Track in Expected or FRA Class 1 Divided by Total Miles of Class 1 Track
b. Number of Double-Stack Tunnel Restrictions / Number of Tunnels

Data for both of these measures are available

5.2.3 Water and Ports: Maintenance and Preservation

The inland waterway on the Columbia/Snake River system is built and maintained by the Army Corps of Engineers. Unlike the railroad or highway systems, there are no alternate routes should one of the locks be unavailable. Unscheduled maintenance issues can shut down the barge system. Maintenance activities can be scheduled to avoid peak freight times (e.g. harvest) to limit impacts on the freight system. Thus, ideal measures would report on unscheduled lock closures and weight those based on historical or actual barge traffic. For the Port of Portland, measures such as port channel depths and ability to serve deep draft container ships would be relevant maintenance issues. Another physical constraint on ports is storage space availability and the presence of container loading facilities.

Possible recommended measures include:

a. Percent of Tons on River moving Though Locks with Constraints (delays)
b. Unscheduled Lock Closure Time (hours)
c. Channel Depths at the Port or River Channel Divided by Depths at Competitive Ports (perhaps Seattle/Tacoma)

Data from the USACE lock performance system can be used to generate the second measure and possibly the first. Data on channel depths were not found, though are likely measured and monitored. This measure would require finding these data sources.

5.2.4 Air: Maintenance/Preservation

There are airport pavement condition measures available. Airport runway conditions may place constraints on the size and weight of airplanes able to use the facility. Runway length is probably the biggest physical constraint on the type of aircraft that can operate at an airport. Thus, some system-wide measure such as the percent of system runways that are not able to handle a minimum size cargo plane (or jet) might be appropriate here. Of course, smaller planes might be able to transport cargo into smaller airports that might not be able to generate the demand necessary to require a larger plane. A measure such as the percent of runways capability to operate standard passenger or cargo jet might give an idea of the quality of the infrastructure for freight.

Another important factor for airports is whether the airport has the infrastructure for instrument landings or just visual landings—as this greatly affects whether planes are able to get in and out of the airport under adverse weather conditions.

It is difficult to distinguish between overall infrastructure maintenance and preservation and that which is specific to freight. This is because such a small portion of air traffic is freight and also because some of the freight traffic travels on aircraft that also carry passengers.

Given the small percent of freight that uses air, a simple measure is suggested in the short run. Also, it is suggested that performance measures be developed for air freight after further study of the kind of planes air freight uses and identification of freight-significant airports

Recommended measure:

a. Percent of Pavement in Fair or Poor Condition at Freight-Significant Airports

5.3 MOBILITY, CONGESTION AND RELIABILITY

Mobility measures are closely related to reliability and congestion measures. As mentioned above, even safety measures may be related as accident delays may impede mobility and reduce reliability of the transportation system.

In general, mobility suggests that traffic should move easily throughout the transportation system. At the statewide level, the mobility performance for each mode and the statewide freight system could be indicated by the total traffic over the system (ton-miles, or tons traveled) and by individual mode such as that indicated in Table 5.2, which shows actual flows in 1998 and those predicted in the future (2010 and 2020).

Table 5.2: Oregon Freight by Mode

	Tons (millions)		
	1998	**2010**	**2020**
By Mode			
Air	<1	<1	1
Highway	220	323	420
Other	2	3	4
Rail	53	81	109
Water	16	20	24
Grand Total	291	428	557
By Destination/Market			
Domestic	258	372	477
International	33	55	81
Grand Total	291	428	557

Source: *FHWA 2003* ("Freight Transportation Profile - Oregon")

Table 5.2 presents the freight transportation profile for Oregon as identified and forecasted by the FHWA. As shown, freight transportation is dominated by truck movement followed by rail and water.

5.3.1 Highway: Mobility, Congestion, and Reliability

It is difficult to get measures of freight mobility separate from overall traffic flows. The ATRI and INRIX data sets follow truck activity, but to date have only produced measures for a few major routes in the Portland metropolitan area. The limitation is not technical (the freight vehicles travel on other facilities and the data are captured) but is limited by the number of probe samples that would be obtained on these other facilities. The PORTAL data also provides information on the Portland system, but for all traffic, not just freight. Recent research at PSU (*Figliozzi et al. 2010*) found a close correlation between the ATRI data and the PORTAL information, suggesting that the PORTAL data might be used as a proxy for freight flows. However, this is only for freeways and does not cover the other key freight arterials in the Portland metropolitan area.

These data sources only provide VMTs traveled over the freight system. Ideally there would be data on ton-miles of freight being transported over the highway system. In the absence of ton-miles, overall VMT of freight per mile of the relevant highway, corridor, or route segment provides a good proxy for freight mobility throughout the highway system. Setting 2010 levels as a base year would allow measurement of mobility over time.

Travel time is often suggested as a measure of mobility. This measure must be calculated and collected for individual route segments since different distances, terrains, as well as congestion, can affect travel time. As an overall measure of mobility, average travel speeds (miles per hour) are a measure that could be compared across routes and corridors. This would provide a measure of freight mobility that could help both shippers and policymakers with decision-making.

Information on segments/routes with slower average travel times per mile could result in carriers selecting alternate routes or shippers using alternate modes.

Finally, shippers are concerned not only with average travel times but with the variance of travel (reliability of the existing freight system). Even if travel times are known to be lengthy due to congestion, if they are predictable, shippers can plan around peak times with long average delays. However, if times are unpredictable (or have a large variance) this presents an even greater problem for shippers.

While the total hours of congested conditions per day is a measure of general congestion, it provides valuable information for freight transportation shippers and carriers that have to making routing decisions.

Congestion pricing is a much discussed and debated option that would reduce, although not necessarily eliminate congestion. Monitoring the TTI and the Buffer Index are very important for testing whether the pricing system is working to meet the desired reduction in congestion and for deciding on changes in an existing system and pricing. This is important as congestion pricing, although precise in theory, is usually implemented by setting prices that are based on political rather than solid economic evidence. Part of the reason is that price elasticities of demand for VMTs may differ considerably by location so that a price imposed in one place may not be the right one to meet traffic reduction goals elsewhere. More research needs to be done on this to facilitate congestion pricing, but unless there are good performance measures that can be monitored as a system is implemented, there will be no analytical evidence on which to base pricing decisions. Most discussion regarding congestion does not distinguish between freight and passenger vehicles. To the extent that congestion may affect freight users in different ways than passengers, pricing may have a different impact on the behavior of freight users. Thus, there is a need to develop freight specific congestion measures.

Other options include increasing transit options, investing in high-occupancy toll (HOT) lanes, meter ramping, etc.

Recommended Measure(s) for Mobility, Congestion, and Reliability are:

a. Urban: Hours of Congested Conditions per Day
b. Urban: Average Hours of Delay per Day for Freight Vehicles on Freight-significant Links
c. Urban: Travel Time Index (TTI) on Freight-significant Links (Ratio of the Peak Travel Time to Free-flow Travel Time)
d. Urban: Buffer Index on freight-significant links (ratio of the 95th percentile travel time – the average travel time) to the average travel time).
e. Rural: Average Hours of Delay per Day for Freight Vehicles on Freight-significant Links
f. Rural: Average Travel Time on Freight-significant Links

For the most part, data are available to calculate the above metrics. A decision would need to be made whether to use probe-based data or estimates of these measures from count stations.

5.3.2 Rail: Mobility, Congestion, and Reliability

General mobility in rail would be shown by some measure of tons or ton-miles of freight traffic per mile over the system, corridor, or route segment being studied.

Average travel speed per mile is a measure that could be compared across routes and corridors and is a factor that affects transit times important to shippers. It would be important to characterize performance for different train types since higher priority intermodal trains may not have the same performance experience as lower priority mixed freight trains. There have been concerns raised lately regarding the capacity of the rail system in the Northwest to deal with future demand (*Cambridge Systematics 2004*). Thus, some measure of the current traffic relative to the maximum traffic flows possible over the rail system would be desirable. In the absence of such a measure, decision-makers may need to rely on simulation models of rail flows to make such a calculation. Ideally, these measures would be actual measurements of train performance and include average speed by train, train hours of delay (system and corridor) and terminal delay operations. Lacking access to internal railroad performance data, it may be possible to develop models to produce these measures. Their complexity can vary substantially; ranging from highly sophisticated operational simulation models to more simplistic deterministic models as used in the Cambridge Systematics study for AAR. This will become increasingly important if passenger rail services grow and continue to operate on the same track as freight. In addition to time in transit for rail traffic, there may be delays at terminals and in switching trains.

Finally, there is some concern that rail mobility is impaired due to contracts restricting access to lines when shippers' origin and destination points would involve using track owned by more than one company. Some measure such as the percent of traffic that is diverted from rail due to this sort of carrier non-cooperation is a barrier to mobility and the efficient use and performance of the freight transportation system. Developing a measure to determine how significant this problem is in affecting freight performance is a topic for future research as most contact information is confidential.

There are few public policies to deal with rail mobility, reliability, and congestion as railroads are privately owned and operated. Investment in track (especially double stack track), sidings and other facilities have traditionally been made by railroads. In the future public-private partnerships are one way to address some of the massive investment that may be required to insure an acceptable level of freight system performance.

Private companies may be able to reduce delay at terminals and switching yards through adoption of more efficient scheduling of operations.

Again, performance measures are needed to monitor rail system performance and provide private firms and policymakers information of where there are the greatest impediments to freight performance.

Recommended Measure(s)

a. Tons or Ton-miles of Freight Over Relevant Period
b. Average Terminal Dwell Time Train-Hours of Delay

c. Total Train Hours of Delay (Average Daily per Train)
d. Average Train Speed Over Freight-significant Corridor

Data for the first measure (tons or ton-miles) are available and can be generated. The remaining measures will require either obtaining the information from the railroads themselves or using models or methods to estimate these values based on the first measure.

5.3.3 Water and Ports: Mobility, Congestion, and Reliability

For ports, mobility is indicated by the amount of traffic passing through the port. Tons of traffic arriving at the port by barge is probably the best indicator of mobility down the Columbia/Snake River system. For container traffic, TEUs passing through the port would be an indicator of traffic flows.

Much of the traffic through the Port of Portland consists of bulk natural resource based commodities rather than container traffic. For these loads, congestion at ports is usually not as much of an issue given the low per unit value of the commodities. Container shipments typically consist of higher valued commodities, where time is of the essence. Accordingly, the focus is on measures of delay and turn-around times for containers through the port as measures of port congestion and reliability.

In Oregon, congestion is primarily an issue for highways, but forecasts of future freight system demand in the northwest indicate that the rail system is nearing capacity and may experience congestion at some times and locations. Given the fact that containers arrive at the Port of Portland both by rail and truck, the focus on container traffic for delays is appropriate there. Given that the other ports in the Oregon system do not handle container traffic, those measures would not apply.

For the traffic on the Columbia/Snake River system some measure of volume-to-capacity would be helpful in determining whether there are capacity constraints. Delay measures are tabulated per barge tow. This might become more of an issue in the future if upstream dams (on the Snake River system) are breached and lock capacity is affected. This is a topic for future research and would be best coordinated with the Corps of Engineers, who is responsible for the inland waterway system.

Recommended Measure(s):

a. Tons of Traffic Arriving at Port of Portland by Barge
b. TEUs Passing Through Port (Port Throughput)
c. Gate Reliability or Truck Turn Time
d. Ship Unload Rate (Time per Container)
e. Ship Load Rate (Time per Container)
f. Average delay per barge tow

5.3.4 Air: Mobility, Congestion, and Reliability

Air freight typically consists of high valued, low weight commodities. As such, by weight it constitutes a small percent of intercity ton-miles, but a larger percent of intercity freight revenues. Air freight is a relatively small, but important part of the freight transportation system and will become more important in the future as trends towards production of high valued commodities, such as electronics and computers, grow. Delay and service reliability are very important to these shippers. If the air system is experiencing delay, shippers may choose to ship time sensitive cargo by truck. This is especially true for shipments where overnight or one day service is guaranteed.

Two types of measures are thus relevant for air shippers. One is the frequency of scheduled service: the more frequent scheduled service, the lower the schedule delay (the time when flights are available and when the shipper needs the service). The other delay is caused by late arrivals and departures.

Note that these factors are usually not easily affected by public policy as flight frequency and operation decisions are the domain of the private airline firms.

Accordingly, following are recommended as relevant performance measure(s) for air freight:

a. Flight Frequency by Airlines with Cargo Capacity (number per day)
b. Average time Between Flights by Airlines with Cargo Capacity (minutes)
c. Percent of On-Time Departures at Freight Significant Airports
d. Percent of On-Time Arrivals at Freight Significant Airports

Data are available to generate c) and d). The first measures would require either obtaining data from airports or carriers themselves.

5.4 ACCESSIBILITY AND CONNECTIVITY

Defining accessibility is somewhat problematic. These measures are often based on the number of miles traveled by various classes of customers and, as such, could also be construed as mobility measures.

More meaningful would be the nearness of shippers to the various components of the infrastructure. This is likely to be different for each shipper. A measure such as the percent of shippers (or percent of tons of traffic) within a certain number of miles of a freight-significant highway, corridor, railroad, port facility, or intermodal connection, would be ideal. In general this information is not available and would require an extensive study of freight-significant shippers.

Other things affecting access and connectivity are the existence of regulatory factors that might restrict access and connectivity between routes or modes. Examples could be different truck or rail size and weight limits on different sections of freight-significant highways. Interstate movements of freight are affected by different state size and weight limits. For instance, triple trailers are allowed in Oregon, but not in California or Washington, creating impediments to seamless interstate freight system performance.

As discussed previously, private rail contracts often preclude interlining rail traffic and thus may make rail a less attractive option to freight shippers. Also, coordination of schedules between rail and truck firms and reliability of rail service is necessary if intermodal shipments by TOFC are to be a viable option for shippers.

Many of these factors are difficult to quantify and data to measure them are only available internally to the carriers involved.

5.4.1 Highway: Accessibility and Connectivity

While all shippers must be located on or have access to some sort of road, their market access usually will be better if they are near a high-speed, freight-significant highway or corridor. As mentioned previously, the number of shippers within a certain number of miles of a freight–significant highway would give an idea of how well the freight transportation system is serving all state shippers. In particular, for shippers to take advantage of economies associated with longer combination vehicles, they must have access to a road where such vehicles are allowed. Triple trailers are one such longer combination vehicle that is allowed in Oregon only on certain parts of the road system. Shippers without access to those roads are unable to take advantage of the increased efficiencies such vehicles provide.

Accordingly, recommended access measure(s) that could have relevance for policy include the following:

a. Triple Trailer VMT as a Percent of Total Freight VMT
b. Percent of Shippers with Access to Triple Network

5.4.2 Rail: Accessibility and Connectivity

For rail shippers access may not be simply proximity to a rail line. Indeed, since the 1980 Staggers Act when railroads were allowed increased rate making flexibility and the ability to engage in contracts, much of the rail traffic has moved from single carload shipments to unit trains. If a shipper does not have the volume to fill a unit train or the necessary unit train loading facilities, the proximity of a rail line is not a good indicator of access. An indicator of this lack of access would ideally be some measure that shows the percent of shippers of the relevant commodity (such as wheat) who are located on a rail line, who do not have car-loading facilities and thus do not have access to unit trains. Anecdotal evidence in the Willamette Valley indicates that small wheat shippers use trucks rather than rail since the rail service is sporadic and not dependable and the railroads do not give their shipments priority.

An indicator of overall accessibility to rail unit trains is the percent of rail shipments that go by unit train. The higher this ratio, the more freight may go through the system. However, this may mean reduced access to those shippers who do not have volumes or facilities necessary to ship by unit train.

Finally, an increasing amount of rail traffic is intermodal (TOFC or COFC), making connections with trucks and/or ships as part of the intermodal freight transportation system.

Recommended Measure(s) include:

a. Class I: Ratio of Unit Train Carloads(or tons) / Total Carloads(or tons)
b. Percent of Shippers Within 50 Miles of Intermodal TOFC facility
c. Number or Capacity of Intermodal Facilities

Data on unit trains may not be available and shipper data (location and commodities) is difficult or impossible to obtain. Data are available on the number of intermodal facilities.

5.4.3 Port and Water: Accessibility and Connectivity

Again, proximity to a river terminal is a major issue in access to barge transportation. All traffic going out through the Port of Portland or another maritime Port is intermodal in nature, meaning that some connection has been made between modes. Whether the maritime port is considered a viable alternative is dependent on the distance from the shipper to the port, relative to the distance to the nearest alterative export port. This is not a performance measure as it will not change over time (unless shippers relocate).

Recommended Measure:

a. Shippers within 50 miles of river port (for barge accessibility)

5.4.4 Air: Accessibility and Connectivity

Air freight is usually high valued commodities where time is very valuable. Access to the airport for shippers depends on travel times between point of shipment origination and the airport (or the airport and ultimate destination). Thus, the average hours of delay on roads leading to the airport may play an important role in determining whether air is a viable a transportation mode for the shipper. Thus, there is a strong relationship between highway and air modes. If shippers perceive the congestion in roads surrounding airports to be a factor that will cause delay, they may decide to use truck and go by another, less congested route.

Frequency of scheduled air service probably is the most important factor affecting access to air service as discussed above. This is a case where some of the measures suggested for mobility, congestion, and reliability for air and highways may also provide indicators of accessibility. One additional factor is the airport capacity for loading cargo which may affect the ability of the airport to serve shippers.

Recommended Measure(s):

a. Flight Frequency by Airlines with Cargo Capacity (number per day)
b. Average Time Between Flights by Airlines with Cargo Capacity (minutes)
c. Average Travel Time Delay for on Airport Access Roads
d. Number of Docks or Acres of Cargo-handling Facilities

5.5 ENVIRONMENTAL FREIGHT PERFORMANCE MEASURES

Measuring the environmental impact/performance of the various transportation modes is increasingly an important and controversial issue. In the absence of any consistent method for calculating the impact for any mode, let alone across modes, it is suggested that a model be used such as the GreenStep model now being developed by ODOT, to obtain benchmark measure. Those measures could then be used to evaluate the environmental impacts of various policies. Though this only applies to highways, a similar approach could be applied to other modes. From an environmental perspective, modal shifts may be desirable (i.e. barge is more fuel efficient than truck or rail).

Recommended Measure(s):

a. Pounds of Greenhouse Gas Emissions per Tons Moved
b. Amounts of Other Criteria Pollutants Emitted per Tons Moved

6.0 CONCLUSIONS AND NEXT STEPS IN IMPLEMENTATION OF FREIGHT PERFORMANCE MEASURES

At this point, the development and use of freight performance measures is in its infancy. The first step is to identify and develop measures that are meaningful and can be measured. The focus of this study has been on the identification process.

Testing the identified measures involves seeing if they can be measured in a cost effective manner. In some cases, the measure itself may not give a good indication of freight performance, especially at the system level. For instance, if increasing performance of one mode ends up reducing performance of another, there is no net gain for the freight transportation system. Thus, further research needs to be conducted to examine possible interactions/interdependencies between the measures for various modes.

Accordingly, further development is needed for systemwide measures that indicate how changes in one mode's performance impacts the entire freight system. As discussed in Section 3.3.3, measures of systemwide performance may require additional techniques and models to provide information that will be of use to statewide planners.

Once measures are identified and data collected on a regular basis, then policymakers will be able to test whether the policies they adopt to meet policy goals, are effective. For instance, an improvement made to help meet a target such as reducing accidents by 10 percent, may not impact safety as planned, but will provide information needed to formulate more effective policy.

Another example is if congestion pricing is implemented and prices are set with a goal of reducing VMT by 10 percent and the actual VMT reduction is 20 percent, then policymakers would know that the price had been set too high and they would have information needed to adjust price to meet the target VMT reduction. Over time with growth in traffic, prices would need to be continually adjusted.

While increasing overall freight performance is the goal, there are usually limited resources available that require decisions to be made regarding alternative policies. For instance, increasing freight system performance may be achieved by reducing highway accidents, increasing track quality so trains can travel faster, or building an intermodal terminal facility. Each of these alternatives will have different costs and presumably benefits. Tracking performance measures over time, especially as policies change, will help provide decision-makers with information on how much freight system performance can be affected by policies that impact different components of the system.

With experience over time it may be found that some of the measures serve as better overall indicators of freight performance than others. A test of which measures are the best can only be designed after the measures have been collected on a regular basis so that policymakers can determine which are providing useful information for designing policy and making decisions regarding choices of alternative policies.

Thus, the next steps in implementing freight performance measurement are:

- Collect and assemble data for measures chosen.
- Select models in cases where estimation is required; perform estimations.
- Calculate measures.
- Compile a time series of the freight performance measures selected by collecting data and performing required estimation and calculations on a regular basis

These actions are necessary to produce a database of freight performance measures. Future researchers will then be able to begin to empirically and analytically examine interactions between measures (e.g. if one measure changes, does it impact another?) and to assess the impact that policy changes have on freight performance.

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Schofield M., and Harrison R., 2007. *Developing Appropriate Freight Performance Measures for Emerging Users.* Publication Southwest Regional University Transportation Center, SWUTC/07/473700-00073-1.

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Talley, W.K., 2006. An Economic Theory of the Port. *Port Economics, Research in Transportation Economics*. In Cullinane, K. and, W.K Talley (eds.). Elsevier Press, 2006.

TTI (Texas Transportation Institute), 2007. *2007 Annual Urban Mobility Report*. Accessed on June 8, 2009 at: http://mobility.tamu.edu/ums/.

TRB (Transportation Research Board), 2004. *Performance Measures to Improve Transportation Systems: Summary of the Second National Conference*. TRB Conference Proceedings 36, 2004. Accessed on June 1, 2009 at: https://secure.engr.oregonstate.edu/wiki/transportation/uploads/ODOT-Multimodal/TRB_Conference%20Proceedings_36.pdf.

TRB, 2003. *A Concept for a National Freight Data Program*. Publication Transportation Research Board, Special Report 276. Accessed on June 1, 2009 at: http://trb.org/publications/sr/sr276.pdf.

* References are to preliminary reports, not ready for public access.

APPENDIX A:
WEBSITE LOCATIONS FOR STATE LONG-RANGE PLANS AND OTHER DOCUMENTS

The following list provides web addresses for the long range plans found on each state's DOT web site. In some cases, there was nothing called the "long-range plan," in these cases, documents which seemed to serve that purpose were used. Many states had MPO level plans, but only those that had state plans are included. A few states had a separate performance measure report or a "dashboard" or "balanced scorecard" indicator of a few key performance measures. These were used as cited below. There were three states for which no documents found on the DOT website provided the requisite information.

Alabama
Alabama Statewide Transportation Plan, Alabama Department of Transportation, 2000. (http://www.dot.state.al.us/NR/rdonlyres/5E4F8847-CB03-4CB4-8A70-3EA19E65B491/0/stateplan.pdf)

Alaska
Performance (http://www.gov.state.ak.us/omb/results/view.php?p=157)

Arizona
The Arizona DOT Strategic Plan for 2010-2014
(http://www.azdot.gov/Inside_ADOT/PDF/StrategicPlan.pdf)

Arkansas
Arkansas Statewide Long-Range Intermodal Transportation Plan, 2007 Update, Planning and Research Division, Arkansas State Highway and Transportation Development, 8/21/2007 (http://www.arkansashighways.com/planning/F%20&%20E/Final%202007%20Statewide%20Long%20Range%20Plan.pdf).

California
Caltrans Strategic Plan 2007-2012, The California Department of Transportation, December 17, 2007 (http://www.dot.ca.gov/docs/StrategicPlan2007-2012.pdf)

Colorado
Linkage of Mobility Performance Measures to Resource Allocation: Survey of State DOTs and MPOs Jeremy Klop and Erik Guderian, Colorado DOT, 2008.
Colorado Department of Transportation Planning and Research Web page (http://www.cotrip.org/its/planningResearch.html).

Connecticut
On the Move: Performance Metric Report, Connecticut Department of Transportation, January 2009
(http://www.ct.gov/dot/lib/dot/documents/dpublications/ctdot_on_the_move_performance_measures_report_011409.pdf)

Delaware
Delaware Freight and Goods Movement Plan , DelDOT, Parsons, 2004
(http://www.deldot.gov/information/pubs_forms/freight_plan/pdf/technical_report.pdf)

Florida
Florida Performs, Florida DOT,
2007(http://www.floridaperforms.com/Area_Transportation.aspx)
2025 Florida Transportation Plan, Florida DOT
(http://www.dot.state.fl.us/planning/FTP/2025FTP-LowRes.pdf)

Georgia
2005-2035 Georgia Statewide Freight Plan , Cambridge Systematics, Georgia DOT, 2006
(http://www.dot.state.ga.us/informationcenter/programs/transportation/Documents/swtp/2005_to_2035_ga_freightplan_oct06.pdf)

Hawaii
Hawaii Statewide Transportation Plan (http://www.state.hi.us/dot/stp/hstp.htm)

Idaho
2006 Annual Report, Idaho DOT (http://www.state.hi.us/dot/stp/hstp.htm)

Illinois
Illinois State Transportation Plan 2007Summary
(http://www.illinoistransportationplan.org/info_center/index.html)
Public Accountability Report Fiscal Year 2006, Illinois Office of the Comptroller
(http://www.apps.ioc.state.il.us/ioc-pdf/PAP2006.pd)

Indiana
None.

Iowa
Iowa Department of Transportation Strategic Plan: January 2003-December 2006, Iowa DOT, June 2004 (http://publications.iowa.gov/1691/1/dot_strategic_plan_rev.pdf)

Kansas
Kansas Making Progress: Our Transportation Performance 2007 Annual Report, Kansas DOT
(http://www.ksdot.org:9080/publications.asp)

Kentucky
Kentucky Statewide Transportation Plan 1999
(http://transportation.ky.gov/planning/stp/stp2002.asp)

Louisiana
Five Year Strategic Plan: Fiscal Years 2006-2010, Louisiana Department of Transportation and Development, July 2004 (http://www.dotd.state.la.us/strategicplan.pdf)
In addition, the Louisiana Department of Transportation web site has a direct link to key performance measures (http://www8.dotd.la.gov/administration/metrics/)

Maine
Maine State of the System Report, November 2002 (http://www.maine.gov/mdot/planning-documents/state-of-system.php)
2004-2025 Long-Range Transportation Improvement Plan: Keeping Maine Moving, Maine Department of Transportation, Bureau of Planning, January 2004, 90p. (http://www.state.me.us/mdot/pubs/pdf/lrip20032025.pdf)

Maryland
2009 Maryland transportation Plan, Maryland Department of Transportation, January 2009(http://www.mdot.state.md.us/Planning/Plans%20Programs%20Reports/Reports/MTP/09MTP.pdf)
2009 Annual Attainment Report on Transportation System Performance, Maryland DOT, January 2009

Massachusetts
You Move Massachusetts Interim Report , Massachusetts Executive Office of Transportation, January 2009 (http://youmovemassachusetts.org/youMoveMassachusettsInterimReport.pdf)
Mass Highway Scorecard, January 2009 (http://www.eot.state.ma.us/scorecard/downloads/ScoreCard/ScoreCard0209.pdf)

Michigan
Key Findings, Michigan Transportation Plan Moving Michigan Forward: 2005-2030 State Long Range Transportation Plan prepared for the Michigan Department of Transportation by Wilbur Smith Associates, March 2007 (http://www.michigan.gov/documents/mdot/MDOT_SLRP_Key_Findings-3-27-07_191398_7.pdf).

Minnesota
Minnesota Statewide Transportation Plan 2008-2029, Minnesota Department of Transportation, January 2009 (http://www.dot.state.mn.us/planning/stateplan/download.html)

Mississippi
Mississippi Department Web site listing goals: (http://www.gomdot.com/Home/AboutMDOT/Mission.aspx)

Missouri
Tracker Data: Measures of Departmental Performance, Missouri Department of Transportation (http://www.modot.org/about/general_info/documents/Tracker_Jan09/CoverIntroTOC.pdf)

Montana
TransPlan 21 (http://www.mdt.mt.gov/publications/brochures.shtml#tranplan21

Nebraska
Nebraska Long Range Transportation Plan (http://www.nebraskatransportation.org/lrtp/docs/9-2006/LRTP-final.pdf)
Performance Measures: A Performance Based Transportation Agency, Nebraska Department of Roads, September 2008. (http://www.nebraskatransportation.org/performance/docs/9-2008-Report.pdf)

Nevada
Statewide Transportation Plan–-Moving Nevada through 2028, Nevada Department of Transportation, September 2008. (http://www.nevadadot.com/planning/pdfs/NevPlan_TOC.pdf)

New Hampshire
None

New Jersey
New Jersey Long Range Plan: Transportation Choice 2030 for public discussion, October 2008 (http://www.state.nj.us/transportation/works/njchoices/pdf/2030plan.pdf)

New Mexico
Good to Great: Performance Measures Report., New Mexico Department of Transportation, FY 09 Quarter 1, July 1-September 30, 2008 (http://www.nmshtd.state.nm.us/upload/images/GTG/Good_To_Great_FY09Q1.pdf)

New York
Strategies for a New Age: New York State's Transportation Plan for 2030, New York State Department of Transportation, Summer 2006 (https://www.nysdot.gov/main/transportation-plan/transportation-plan)

North Carolina
2008 NCDOT Performance Report: Executive Summary, NCDOT (http://www.ncdot.gov/_templates/download/external.html?pdf=http%3A//www.ncdot.org/programs/dashboard/content/download/08_ExecSummary_Organizational_Performance_Rpt.pdf)

North Dakota
TransAction II North Dakota's Statewide Strategic Transportation Plan , North Dakota Department of Transportation 2007, (http://www.dot.nd.gov/manuals/planning/TrActII-07.pdf)

Ohio
Access Ohio 2004-2030, Final Document, Ohio Department of Transportation (http://www.dot.state.oh.us/Divisions/Planning/ProgramMgt/ACCESSOHIO/Pages/FinalDocument.aspx)

Oklahoma
*Oklahoma's 2005 - 2030 Statewide Intermodal Transportation Plan,*ODOT (http://www.okladot.state.ok.us/hqdiv/p-r-div/25yearplan/index.htm)

Oregon
Oregon Transportation Plan adopted September 20, 2006, Oregon Department of Transportation (http://www.oregon.gov/ODOT/TD/TP/docs/ortransplanupdate/06otp/06otpVol1sep.pdf)
Annual Performance Progress Report (APPR) for Fiscal Year 2005-06, Oregon Department of Transportation , September 2006 (http://www.oregon.gov/ODOT/CS/PERFORMANCE/docs/2006_ANNUAL_PERFORMANCE_REPORT.pdf)

Pennsylvania
Pennsylvania Long Range Transportation Plan 2000-2025: PennPlan Moves!, Pennsylvania Department of Transportation (ftp://ftp.dot.state.pa.us/public/pdf/ExecutiveSummary/ExecutiveSummary.pdf)

Rhode Island
Transportation 2030, Rhode Island Statewide Planning Program, Department of Administration, August 2008 (http://www.planning.ri.gov/transportation/trans2030.pdf)

South Carolina
South Carolina Statewide Comprehensive Multimodal Transportation Plan: Executive Summary, NCDOT, 2008 (http://www.scdot.org/inside/multimodal/pdfs/MultimodalPlanExecutiveSummary.pdf)

South Dakota
Statewide Intermodal Long Range Plan, South Dakota Department of Transportation, Office of Planning and Programs (http://www.sddot.com/docs/reports/longrangeplan.pdf)

Tennessee
Final Report: Tennessee Long Range Transportation Plan: Transportation System Performance Measures: PlanGo: A Long- Range Multimodal Strategy, TDOT, December 2005 (http://www.dot.state.tn.us/plango/pdfs/plan/PerfMeasures.pdf)

Texas
TxDOT Has a Plan: Strategic Plan for 2007-2011, Texas Department of Transportation (ftp://ftp.dot.state.tx.us/pub/txdot-info/lao/strategic_plan2007.pdf)

Utah
Utah Performance Elevated Web site (http://performance.utah.gov/agencies/udot.shtml)
UDOT's Long Range Transportation Plan 2007–2030, Utah Department of Transportation (http://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:1843)

Vermont
Vermont Long Range Transportation Business Plan, Vermont Agency of Transportation, March 2009 (http://www.aot.state.vt.us/planning/Documents/Planning/LRTBPfinalMarch2009.pdf)
Vtrans Annual Report 2006 (http://www.aot.state.vt.us/AnnualReports/Documents/AnnualReport06/AnnualReport2006.pdf)

Virginia
Virginia's 2006 Transportation Performance Report (http://www.vtrans.org/)

Washington
Transportation Benchmarks, Washington DOT (http://www.wsdot.wa.gov/Accountability/Publications/Benchmarks.htm#Goals)
The Grey Notebook, Washington State Department of Transportation, February 27, 2009 (http://www.wsdot.wa.gov/NR/rdonlyres/EFA555E7-4B17-4640-B85A-16FD190F4BD5/0/GrayNotebookDec08.pdf).

West Virginia
None

Wisconsin
Connections 2030: Long Range Multimodal Transportation Plan, Draft Executive Summary, Wisconsin Department of Transportation
(http://www.dot.wisconsin.gov/projects/state/docs/2030-exec-summ.pdf)

Wyoming
Balanced Scorecard of Performance Measures:
(http://www.dot.state.wy.us/webdav/site/wydot/users/JFARRA/public/WYDOT%20Overall%20BSC%20-2009.pdf).
Long Range Transportation Plan, Wyoming Department of Transportation, 2005
(http://www.dot.state.wy.us/webdav/site/wydot/users/JFARRA/public/Long%20Range%20Transportation%20Plan.pdf)

APPENDIX B:
DATA SUMMARY TABLES

Safety

Oregon Traffic Crash Data

Source	ODOT, Transportation Data Section, Crash Analysis & Reporting
Type of Data	All reported motor vehicle crashes on public roadways
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	Annual
Link	http://www.oregon.gov/ODOT/TD/TDATA/car/CAR_Publications.shtml

Truck Safety Inspection Record

Source	Federal Motor Carrier Safety Administration (FMCSA)
Type of Data	Motor carrier safety inspections data source
Modes	Trucks
Spatial	State
Frequency of Data	Annual
Link	http://ai.fmcsa.dot.gov/safetyprogram/home.aspx

FRA State Freight Rail Safety Statistics

Source	Federal Railroad Administration (FRA)
Type of Data	Extensive and Detail accident reporting system for railroads
Modes	Railroads
Spatial	State
Frequency of Data	Annual
Link	http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/on_the_fly_download.aspx?itemno=7.01

Aviation Safety Information Analysis and Sharing (ASIAS) System

Source	Federal Aviation Administration (FAA)
Type of Data	Aviation safety related data
Modes	Air
Spatial	State
Frequency of Data	Annual
Link	http://www.asias.faa.gov/portal/page/portal/ASIAS_PAGES/ASIAS_HOME

Maintenance/Preservation

Pavement Management System

Source	ODOT, Construction Section

Type of Data	Overall rating of pavement conditions for state highways
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	1998, 1999, 2001, 2003, 2004, 2006, and 2008
Link	http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/pms_reports.shtml

Bridge Log and Bridge Management System

Source	ODOT, Construction Section
Type of Data	Bridge engineering section maintains and extensive and detailed records of structures
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	2007 and 2009
Link	ftp://ftp.odot.state.or.us/Bridge/2007_br_condition_report/

Over-dimensional Restrictions

Source	ODOT, Motor Carrier Transportation Division
Type of Data	Information about over-dimensional restrictions on state highways
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	Road and bridge are regularly updated automatically. Weight are updated every few month
Link	http://www.oregon.gov/ODOT/MCT/OD.shtml

ODOT Rail Division

Source	ODOT, Rail Division
Type of Data	Condition of tracks, tunnels and vertical restriction on the state's rail network
Modes	Rails
Spatial	State
Frequency of Data	Data are not published regularly
Link	http://www.oregon.gov/ODOT/RAIL/

Airport Pavement Management System

Source	ODOT, Department of Aviation
Type of Data	Information about airport pavement in state
Modes	Air
Spatial	State
Frequency of Data	Annual

Link	http://www.aviation.state.or.us/Aviation/index.shtml

US Army Corps of Engineers Navigation Data Center

Source	US Army Corps of Engineers
Type of Data	Information on port facilities, dredging information and lock use, performance and others.
Modes	Ports/Marine
Spatial	State
Frequency of Data	Annual
Link	http://www.ndc.iwr.usace.army.mil/lpms/lpms.htm

Mobility, Congestion and Reliability

PORTAL

Source	ODOT, Region 1, ITS
Type of Data	Data from freeway monitoring system, report speed, count and occupancy every 20 seconds
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	Every 20 seconds
Link	http://portal.its.pdx.edu/

Probe-Based Data

American Transportation Research Institute Truck Probe Data

Source	FHWA
Type of Data	Various trucking fleets travel data from GPS data device system
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	
Link	

INRIX Probe Vehicle Data

Source	INRIX private company
Type of Data	Real-time, historical and predictive traffic speed information
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	
Link	

WIM

Source	ODOT, Traffic Count Management System (Weight-in-Motion Data)
Type of Data	Axle weight and spacing, truck speed, timestamp and all characteristics for traveling trucks
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	Every truck passing 22 WIM Stations
Link	

Other Probe Data

Source	Oregon Transit Buses
Type of Data	AVL technology and estimate arterial level travel times with some assumptions
Modes	Transit buses
Spatial	Corridors
Frequency of Data	NA
Link	

Oregon Highway Traffic Volume

Source	ODOT, Transportation Data Section
Type of Data	ADT volumes for last 10 years, average weekday traffic volume and 13 vehicle classifications
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	Annual
Link	http://www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml

Integrated Transportation Information System

Source	ODOT
Type of Data	Mileage statistics and status of features related to the highway systems
Modes	Trucks
Spatial	State and Corridors
Frequency of Data	Monthly
Link	http://www.oregon.gov/ODOT/TD/TDATA/otms/OTMS_Highway_Reports.shtml

AAR

Source	Association of American Railroad
Type of Data	Reported cars on line, broken down by owners, and type of car. Average speed and dwell time
Modes	Rail

Spatial	State and Corridors
Frequency of Data	Weekly
Link	http://www.aar.org/Homepage.aspx

Railroad Capacity

Source	Surface Transportation Board, Uniform Rail Costing System
Type of Data	Daily train traffic
Modes	Rail
Spatial	State and Corridors
Frequency of Data	Annual
Link	http://www.stb.dot.gov/stb/industry/urcs.html

BTS, Airline Service Quality Performance

Source	Bureau of Transportation Statistics,
Type of Data	On time performance of air carriers and summary data
Modes	Air
Spatial	State
Frequency of Data	Monthly
Link	http://www.transtats.bts.gov/OT_Delay/OT_DelayCause1.asp

US Army Corps of Engineers Lock Performance Measure System

Source	US Army Corps of Engineers
Type of Data	Tracking the performance of each lock in the Columbia River system
Modes	Ports/Marine
Spatial	State
Frequency of Data	Annual
Link	http://www.ndc.iwr.usace.army.mil/lpms/lpms.htm

Maritime Safety and Security Information System (MSSIS)

Source	VOLPE, MSSIS
Type of Data	Positional data, attributes and time for ocean-going vessels
Modes	Marine
Spatial	State
Frequency of Data	

Link	https://mssis.volpe.dot.gov/Main/home/].

Accessibility and Connectivity

Oregon Weight-mile Tax Records

Source	ODOT, Oregon Weight-mile tax system
Type of Data	Truck vehicle-miles and triple mileage traveled
Modes	Truck
Spatial	State
Frequency of Data	Annual
Link	

Longer Combination Vehicle Network

Source	Oregon MCTD
Type of Data	Highway network available to LCV
Modes	Truck
Spatial	State and corridors
Frequency of Data	Updated when needed
Link	http://www.oregon.gov/ODOT/MCT/OD.shtml

Surface Transportation Board Carload Waybill Sample

Source	STB's Carload Waybill Sample data
Type of Data	Rail-based commodity flows and detail rail traffic in state
Modes	Rail
Spatial	State and corridors
Frequency of Data	Annual
Link	http://www.stb.dot.gov/stb/industry/econ_waybill.html

US Army Corps of Engineers Lock Performance Measure System

Source	US Army Corps of Engineers
Type of Data	Tracking the performance of each lock in the Columbia River system
Modes	Ports/Marine
Spatial	State
Frequency of Data	Annual
Link	http://www.ndc.iwr.usace.army.mil/lpms/lpms.htm

Port of Portland Statistics

Source	Port of Portland
Type of Data	Annual statistics on the movement by tons, import and export container and auto units
Modes	Port/Marine
Spatial	State
Frequency of Data	Annual
Link	http://www.portofportland.com/Marine_Stat.aspx

Frequency of Air Cargo Service

Source	Port of Portland
Type of Data	Timetable for commercial passenger carrier for freight usage
Modes	Air
Spatial	State
Frequency of Data	Daily
Link	Not published routinely

Commodity Flow Data

Oregon Commodity Flow Data

Source	ODOT, Freight Mobility Section
Type of Data	Estimate and forecast commodity flow in 5 year interval
Modes	Truck, rail, water and air
Spatial	State
Frequency of Data	5 year intervals
Link	http://www.oregon.gov/ODOT/TD/FREIGHT/Publications.shtml

Freight Analysis Framework

Source	Freight Analysis Framework
Type of Data	Estimates commodity flow and related fright transportation activity among state, sub-state region, and major international gateway
Modes	Truck
Spatial	State and corridors
Frequency of Data	5 year intervals
Link	http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm

TRANSEARCH Database

Source	Global Insight's TRANSEARCH
Type of Data	County-Level fright movement data by commodity group and modes
Modes	Truck, rail, water and air

Spatial	State and corridors
Frequency of Data	Annual
Link	http://www.ihsglobalinsight.com/ProductsServices/ProductDetail1024.htm

Commodity Flow Survey

Source	BTS, U.S. Census Bureau
Type of Data	Shipper-based survey
Modes	Truck, rail, water and air
Spatial	State and corridors
Frequency of Data	1993, 1997 and 2002
Link	http://www.bts.gov/help/commodity_flow_survey.html

Environment

MOVES2010- EPA

Source	EPA
Type of Data	Estimate emissions form highway vehicles based on emission test results and others.
Modes	Truck
Spatial	State and corridors
Frequency of Data	NA
Link	http://www.epa.gov/otaq/models/moves/

Oregon DOT’s GreenSTEP Model

Source	ODOT
Type of Data	Managing greenhouse emissions from transportation sources
Modes	Truck
Spatial	State
Frequency of Data	NA
Link	NA

APPENDIX C:
MAXIMUM V/C RATIOS IN OHP

MAXIMUM VOLUME TO CAPACITY RATIOS OUTSIDE METRO [A, B, C, 14]							
Highway Category	**Inside Urban Growth Boundary**					**Outside Urban Growth Boundary**	
	STA[D]	**MPO**	**Non-MPO Outside of STAs where non-freeway posted speed <= 35 mph, or a Designated UBA**	**Non-MPO outside of STAs where non-freeway speed > 35 mph**	**Non-MPO where non-freeway speed limit >= 45 mph**	**Unincorporated Communities**	**Rural Lands**
Interstate Highways [E]	N/A	0.80	N/A	0.70	0.70	0.70	0.70
Statewide Expressways	N/A	0.80	0.70	0.70	0.70	0.70	0.70
Freight Route on a Statewide Highway	0.85	0.80	0.80	0.75	0.70	0.70	0.70
Statewide (not a Freight Route)	0.90	0.85	0.85	0.80	0.75	0.75	0.70
Freight Route on a Regional or District Highway	0.90	0.85	0.85	0.80	0.75	0.75	0.70
Expressway on a Regional or District Highway	N/A	0.85	N/A	0.80	0.75	0.75	0.70
Regional Highways	0.95	0.85	0.85	0.80	0.75	0.75	0.70
District / Local Interest Roads	0.95	0.90	0.90	0.85	0.80	0.80	0.75

Table 6: Maximum volume to capacity ratios for peak hour operating conditions

MAXIMUM VOLUME TO CAPACITY RATIOS INSIDE METRO[A]		
Location	**Standard**	
	1st hour	**2nd hour**
Central City Regional Centers Town Centers Main Streets Station Communities	1.1	.99
Corridors[B] Industrial Areas Intermodal Facilities Employment Areas Inner Neighborhoods Outer Neighborhoods	0.99	.99
Banfield Freeway *(from I-5 to I-205)*[C]	1.1	.99
I-5 North[C] *(from Marquam Bridge to Interstate Bridge)*	1.1	.99
Highway 99E[C] *(from Lincoln Street to Highway 224 Interchange)*	1.1	.99
Sunset Highway[C] *(from I-405 to Sylvan Interchange)*	1.1	.99
Stadium Freeway[C] *(from I-5 South to I-5 North)*	1.1	.99
Other Principal Arterial Routes I-205[C] I-82 *(east of I-205)* I-5 *(Marquam Bridge to Wilsonville)*[C] Highway 217[C] US 26 *(west of Sylvan)* Highway 30 Tualatin Valley Highway *(Cedar Hills Blvd to Brookwood Avenue)*[C] Highway 224[C] Highway 47 Highway 213 242nd/US 26 in Gresham	.99	.99
Areas of Special Concern[D] Beaverton Regional Center Highway 99W *(I-5 to Tualatin Road)*	 1.0 .95	D

Table 7: Maximum Volume to Capacity Ratios Within Portland Metropolitan Region

APPENDIX D:
SUPPLEMENTAL DATA SOURCES

Supplemental Data Sources

Employment and Gross Regional Product (GRP)

Source	Bureau of Economic Analysis
Type of Data	Employment and gross regional product information
Spatial	State
Frequency of Data	Monthly
Link	http://www.bea.gov/interactive.htm

International Import/Exporter

Source	U.S. Department of Commerce
Type of Data	Importer and exporter information
Spatial	State
Frequency of Data	Annual
Link	http://www.ita.doc.gov/TD/Industry/OTEA/trade_data_basics.html

U.S. Department of Commerce's Bureau of Economic Analysis

Source	U.S. Department of Commerce
Type of Data	National, regional, international and industrial economic account data
Spatial	State
Frequency of Data	Annual/Monthly
Link	http://www.bea.gov/

U.S. Census Bureau

Source	U.S. Department of Commerce
Type of Data	Including population, economic, industry, and geography studies data
Spatial	State
Frequency of Data	10 year intervals
Link	http://www.census.gov/

U.S. BTS TranStats

Source	Research and Innovative Technology Administration
Type of Data	Providing transportation statistics by modes and subjects
Spatial	State
Frequency of Data	Annual/Monthly
Link	http://www.transtats.bts.gov/

Oregon Office of Economic Analysis

Source	Research and Innovative Technology Administration
Type of Data	provides objective forecasts of the state's economy, revenue, population, corrections population, and Youth Authority population
Spatial	State
Frequency of Data	Annual/Monthly
Link	http://www.oregon.gov/DAS/OEA/index.shtml

Oregon Agricultural Products Database

Source	Oregon Department of Agriculture
Type of Data	Oregon's agricultural suppliers and products grown, processed, or distributed from the State
Spatial	State
Frequency of Data	Unknown
Link	http://oda.state.or.us/dbs/search.lasso

Department of Forestry

Source	Oregon Department of Forestry
Type of Data	Provide the GIS information on Oregon forests geographic information
Spatial	State
Frequency of Data	Unknown
Link	http://www.oregon.gov/ODF/GIS/gis_home.shtml

Department of Geology and Mineral Industries

Source	Oregon Department of Geology and Mineral Industries
Type of Data	Providing digitally compile geologic data for state and mine Data
Spatial	State
Frequency of Data	Unknown
Link	http://www.oregongeology.org/sub/default.htm

Oregon Department of Employment

Source	Oregon Employment Department
Type of Data	A wealth of information regarding businesses in Oregon
Spatial	State
Frequency of Data	Annual/Monthly
Link	http://www.employment.oregon.gov/

Oregon Labor Market Information System

Source	Research and Innovative Technology Administration
Type of Data	Providing detailed information on occupations, employment and labor force, business and employers and education data.
Spatial	State
Frequency of Data	Annual/Monthly
Link	http://www.qualityinfo.org/olmisj/OlmisZine