JACOBS CONSULTANCY

In association with

HNTB Corporation
Alcantar & Associates, LLC
Cephas, Inc.
David Evans and Associates, Inc.
DKS Associates
NEXTOR
Parametrix
Synergy Consultants, Inc.
Zimmer Gunsul Frasca Architects, LLP

TECHNICAL MEMORANDUM NO. 2— AVIATION DEMAND FORECASTS

MASTER PLAN UPDATE
PORTLAND INTERNATIONAL AIRPORT

Prepared for
Port of Portland
Portland, Oregon

September 2008

JACOBS CONSULTANCY

TECHNICAL MEMORANDUM NO. 2—AVIATION DEMAND FORECASTS

MASTER PLAN UPDATE
PORTLAND INTERNATIONAL AIRPORT

Prepared for

Port of Portland

Portland, Oregon

September 2008

Chicago • Cincinnati • Dallas • London • New Delhi • Ottawa • San Francisco • Washington, D.C.

PREFACE

This technical memorandum summarizes the aviation demand forecasts prepared for the 2010 Portland International Airport Master Plan Update. This technical memorandum also provides historical data on the regional population and economy, aviation activity at PDX, and national aviation and economic trends—all of which were the basis for the aviation demand forecasts presented in this document. The PDX Master Plan forecast process was initiated in November 2007 and this technical memorandum was prepared in September 2008.

ACKNOWLEDGEMENTS

Jacobs Consultancy Inc. gratefully acknowledges the following organizations and staff that directed, participated in, and contributed significantly to this technical memorandum summarizing the aviation demand forecasts prepared for the 2010 Portland International Airport Master Plan Update.

Port of Portland

Chris Corich
Lise Glancy
Scott King
Sean Loughran

City of Portland

Jay Sugnet
Bronwyn Buckle

City of Portland Peer Review Consultant

Dr. Geoff Gosling

Planning Advisory Group Facilitator

Sam Imperati

U.C. Berkeley/NEXTOR

Dr. Mark Hansen
Chieh-Yu Hsiao
Megan Smirti
Irene Kwan

Planning Advisory Group Aviation Forecast Subcommittee

Stan Allison
Erwin Bergman
Jim Edelsen
Tom Gerharter
Alan Hargrave
Maryhelen Kincaid
Stuart Mathew
Dennis Mulvihill
Brian Nelson
Mary Olson
Bob Sallinger
Michael Sloan
Fred Stoval
John Weigant
Pia Welch
Travis Williams
Dennis Yee

CONTENTS

CONTENTS *(continued)*

CONTENTS *(continued)*

CONTENTS *(continued)*

CONTENTS *(continued)*

TABLES

TABLES *(continued)*

FIGURES

FIGURES *(continued)*

1. INTRODUCTION AND SUMMARY

This technical memorandum presents forecasts of aviation activity in support of the Master Plan for Portland International Airport (the Airport, or PDX). The forecasts presented in this memorandum are "unconstrained" and, therefore, do not include specific assumptions about the future capacity of the Airport. The forecasts are prepared for four future demand years: 2012, 2017, 2027, and 2035. The base year for the forecasts is 2006.

1.1 Forecast Process

The PDX Master Plan forecasts were prepared using a collaborative process which included (1) a review of the 1999 Master Plan and Federal Aviation Administration (FAA) Terminal Area Forecasts (TAF), (2) the collection and analysis of data related to the key issues and trends affecting future aviation demand at PDX, (3) the development of statistical models to define historical causal factors and to provide the logical structure for incorporating input from key stakeholders, (4) supplemental analyses to address technical issues and to reflect stakeholder and peer review input, (5) the preparation of probabilistic forecasts (described later), and (6) coordination with representatives of the Port of Portland (the Port), City of Portland (the City), Forecast Subcommittee and Planning Advisory Group (both described in the following paragraphs), FAA and the public. Figure 1 presents a diagram of the forecast process.

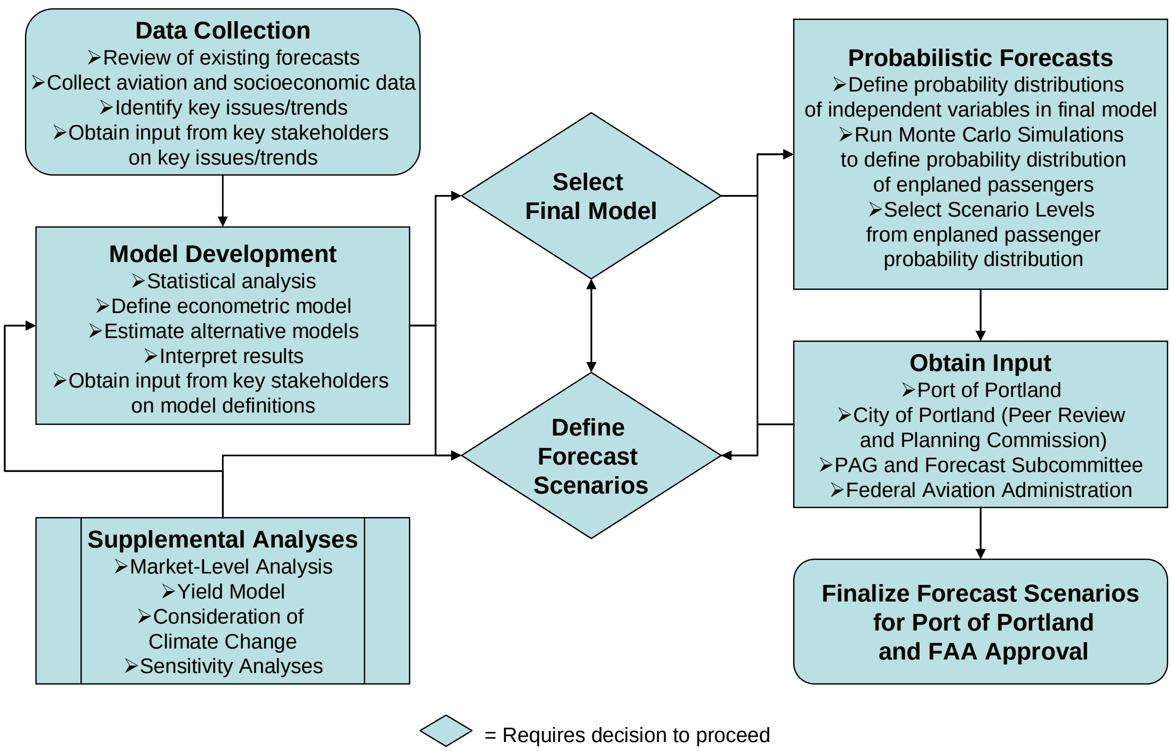
1.1.1 Forecast Subcommittee

The Forecast Subcommittee was formed to review and comment on the forecast process and included representatives from the Planning Advisory Group (PAG), Port of Portland Aviation Planning Department, City of Portland, Metro (the Portland-Vancouver region's Metropolitan Planning Organization or MPO), and members of the public. The Forecast Subcommittee was charged with assisting the Aviation Consultant and City Peer Review Consultant in reviewing the methodology, assumptions, and scenarios which formed the basis of the aviation forecasts and assisted in assembling the list of key issues and trends. The Forecast Subcommittee met five times to discuss and review the forecasts and made a final recommendation to PAG regarding the forecast results.

1.1.2 Planning Advisory Group

The Planning Advisory Group (PAG) serves as the advisory body to the City of Portland and Port of Portland and helps to guide and inform the joint planning process. Presentations to the PAG were made at five meetings to report on the forecast process and meetings with the Forecast Subcommittee. The PAG reviewed the forecast process, methodology, and forecast results and assisted in refining forecast assumptions and scenarios. The PAG unanimously recommended the forecast results be accepted on April 15, 2008.

Figure 1
Forecast Process Diagram



1.1.3 Peer Review

An independent peer review of the forecast process and technical results was conducted by Aviation System Consulting, LLC. The peer reviewer was retained by the City of Portland and was involved throughout the forecast process. The scope of work of the peer reviewer included (1) participation with the Port of Portland staff, the City of Portland staff, the PAG, and the Master Plan consultant in the creation, analysis, and adoption of the forecasts, and (2) preparation of an analysis of each forecast scenario, including the underlying assumptions and methodology.

1.2 Forecast Approach

The PDX Master Plan forecasts were developed using a variety of analytical tools, including trend analysis, econometric models, and probability (or risk) analysis, an innovative approach to evaluate the likelihood of future aviation activity. The key components of the forecast approach included (1) the definition and evaluation of key issues and trends affecting future aviation activity, (2) the creation of econometric models to provide a logical structure for testing the forecast scenarios and assumptions, (3) the preparation of probabilistic forecasts, (4) consideration of the price of oil forecasts, (5) the inclusion of future carbon costs related to the cost of travel, and (6) the translation of passenger and cargo demand generated by these analyses into future aircraft operations.

1.2.1 Key Issues and Trends

A list of key issues and trends affecting future aviation activity was created at the beginning of the forecast process and was the product of extensive public involvement including input obtained from the Forecast Subcommittee, PAG, the peer reviewer, and the public. The key issues and trends included five main categories: (1) aviation industry, (2) regional and economic, (3) technology, (4) global, and (5) external events, as shown in Table 1. As noted in Table 1, the forecast approaches for addressing each of the key issues and trends included (1) the incorporation of data for key variables in the econometric models, if available, and (2) the preparation of sensitivity tests of the forecast results.

1.2.2 Sources of Forecast Uncertainty

At the beginning of the PDX MP forecast process, it was recognized that "there are no facts about the future" and that there are many sources of uncertainty related to the preparation of aviation forecasts. Uncertainty is evident in the continuous restructuring of the airline industry and the related changes in service, the fluctuations in the price of oil and the resulting impact on airfares, and future policies related to greenhouse gas emissions and the potential effects on the aviation industry. There is also uncertainty related to how historical aviation demand relationships will be carried forward in the future. The question of whether demand remains unchanged over time or is changed by future events for which there is no available information today has been considered continuously throughout the forecast process.

1.2.3 Econometric Models

Econometric models of passenger and cargo activity were created based on data for 1976 through 2006. The independent variables in the passenger model included population, per capita income in 2006 dollars, a dummy variable for the effects of September 11, and PDX airline yield. In addition, a series of equations defining airline yield were created which (1) related PDX airline yield to U.S. domestic yield, (2) included the price of oil and future carbon costs as independent variables in the equations, and (3) allowed for the testing of alternative assumptions regarding oil and carbon costs in the forecast scenarios. The cargo model is a logistic model which relates PDX cargo tonnage to total personal income for the Portland-Vancouver region and is a measure of the cargo intensity of the Portland economy.

Table 1

KEY ISSUES AND TRENDS
Master Plan Update
Portland International Airport

Key issue/trend	Category
INCLUDED IN ECONOMETRIC MODELS OR OTHER ANALYSES	
Price of oil / Jet fuel costs	Aviation Industry
Fuel as a share of airline costs	Aviation Industry
Enplaned passenger load factors	Aviation Industry
Aircraft capacity (seats)	Aviation Industry
Airfares / yield (cost of travel)	Aviation Industry
Maturity of PDX markets (airline service)	Aviation Industry
Visitor vs. resident travel to PDX, domestic	Aviation Industry
Visitor vs. resident travel to PDX, international	Aviation Industry
Population	Regional / Economic
Nonagricultural employment	Regional / Economic
Personal income	Regional / Economic
Climate change	Global
SENSITIVITY TESTS OF THE ENPLANED PASSENGER FORECASTS	
Security concerns	Aviation Industry
Leakage to other airports (Oregon and Washington airports)	Aviation Industry
Leakage to other transport modes (high-speed rail and van shuttles)	Aviation Industry
New market / airline service development by Port	Aviation Industry
Airport fees	Aviation Industry
Congestion at other airports	Aviation Industry
Airline consolidation/merger	Aviation Industry
Population age distribution	Regional / Economic
Propensity to travel by age group	Regional / Economic
Population in-migration	Regional / Economic
Income distribution	Regional / Economic
Wealth (accumulated income)	Regional / Economic
Aircraft related	Technology
Fuel (biofuels, solar)	Technology
Video conferencing	Technology
Other new technologies	Technology
Currency exchange rates	Global
Foreign-country air travel patterns	Global
Terrorist event	External Event
Biological event	External Event
Global economic crisis	External Event
National economic recession	External Event
Oil shocks	External Event
Airline industry labor strikes / shortages	External Event
War	External Event

Note: A sensitivity analysis is conducted to test the sensitivity of the final passenger forecasts to changes in and specific assumptions about specific key issues and trends. For example, assumptions regarding the increased use of videoconferencing would be measured in terms of the potential reductions in the passenger forecasts in a given year.

1.2.4 Probabilistic Forecasts

Probabilistic forecasts express the likelihood of obtaining a future value in a given year and provide an indication of the uncertainty or risk associated with future values. For example, a probabilistic forecast would indicate that there is a 90% probability that the number of PDX passengers enplaned in 2035 would be equal to or less than 21 million. In contrast, traditional forecasting methods would provide a single value for 2035 but no indication of the likelihood of reaching that level. The probabilistic forecasts of passengers and cargo at PDX were prepared (1) using the econometric models described in 1.2.2, (2) probability distributions of the independent variables used in the models, and (3) Monte Carlo simulations used to randomly generate future values of PDX enplaned passengers. A detailed description of probabilistic forecasting is presented in Section 5.

1.2.5 Price of Oil Forecasts

From 2002 to 2006, the price of oil per barrel in 2006 dollars increased an average of 22% per year. According to the Air Transport Association (ATA), every penny paid for a gallon of jet fuel costs the U.S. passenger and cargo airline industry an additional $195 million annually. Throughout the PDX Master Plan forecast process, the potential future impact of rising oil prices on airline costs and the cost of passenger travel was considered and evaluated as a source of forecast uncertainty. As a result, additional research and analysis was conducted to (1) include the price of oil as an independent variable in the yield equations, (2) examine alternative forecasts of the price of oil, and (3) test the sensitivity of the passenger forecasts to changes in the future price of oil.

1.2.6 Carbon Emission Costs

According to the Environmental Protection Agency (EPA), the U.S. aviation industry currently accounts for about 3% to 4% of national greenhouse gas emissions. Although a U.S. policy regarding greenhouse gas emissions is not yet defined, a number of legislative proposals are under consideration and it is expected that a policy will be in place during the forecast period (through 2035). As a result, additional research and analysis was conducted to (1) include future carbon costs as an independent variable in the yield equations and (2) examine available research to define a range of future carbon costs.

1.2.7 Aircraft Operations

The probabilistic forecasts of passenger and cargo activity for the airport were translated into aircraft operations by (1) disaggregating the total demand into the components (i.e., domestic and international, mainline (air carrier) and regional affiliate) and (2) making future assumptions about average aircraft size in terms of seats per departure and average enplaned passenger load factors (percentage of seats occupied, on average). In addition, the future fleet plans of the airlines serving PDX were also considered based on available information.

1.2.8 Study Limitations

During the forecast process, a number of limitations were identified related to the reporting and composition of aviation data and the potential effects on the forecasts. To the extent that time and budget were available, every effort was made to address the issues raised by the Forecast Subcommittee, PAG, peer reviewer, and members of the public. A summary of the study limitations related to yield data, aircraft fuel efficiency, and air cargo activity are presented in Section 5.

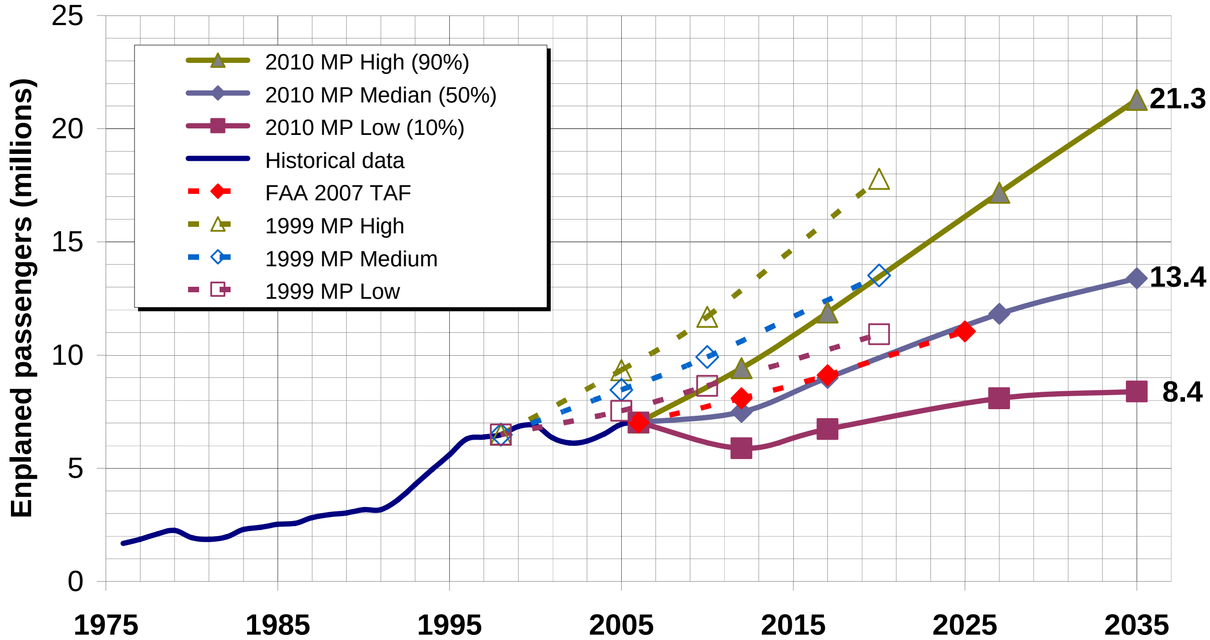
1.3 Review of Existing Forecasts

A review and comparison of the 1999 Master Plan forecasts and the FAA 2007 TAF was conducted at the beginning of and throughout the forecast process. The purpose of this review was to compare actual activity to the previous forecasts and to understand the reasons for any differences. A review of existing forecasts was conducted of enplaned passengers, cargo, and aircraft operations. For the purposes of comparison, the 2010 Master Plan forecasts are presented graphically in this section and will be discussed in detail in Section 5.

1.3.1 Enplaned Passengers

Figure 2 presents a graphical comparison of actual activity from 1976 through 2006 and PDX enplaned passengers forecasts for the 2010 Master Plan, the FAA 2007 TAF, and the 1999 Master Plan. The 1999 Master Plan forecasts tracked actual activity in 1999 and 2000 but were 9%, 20%, and 28% higher than actual in 2006 for the low, medium, and high growth scenarios, respectively. The differences between actual and the 1999 Master Plan forecasts are related to the events of September 11 and the resulting decrease in passenger traffic at PDX and in the nation as a whole. The 2010 Master Plan forecasts are based on 2006 data and are within 5.6% of the FAA 2007 TAF in 2011 and 2.6% in 2016. The enplaned passenger growth rate for the median scenario 2010 MP forecast (an average increase of 2.3% per year from 2006 to 2035) is lower than the annual growth rate forecast by the FAA in its 2007 Terminal Area Forecast (TAF) for the Airport—2.5% from Federal Fiscal Year (FFY) 2006 to FFY 2025. A detailed comparison of the 2010 Master Plan forecasts and the FAA 2007 TAF is presented in Section 5.8.

Figure 2
COMPARISON OF PDX ENPLANED PASSENGER FORECASTS

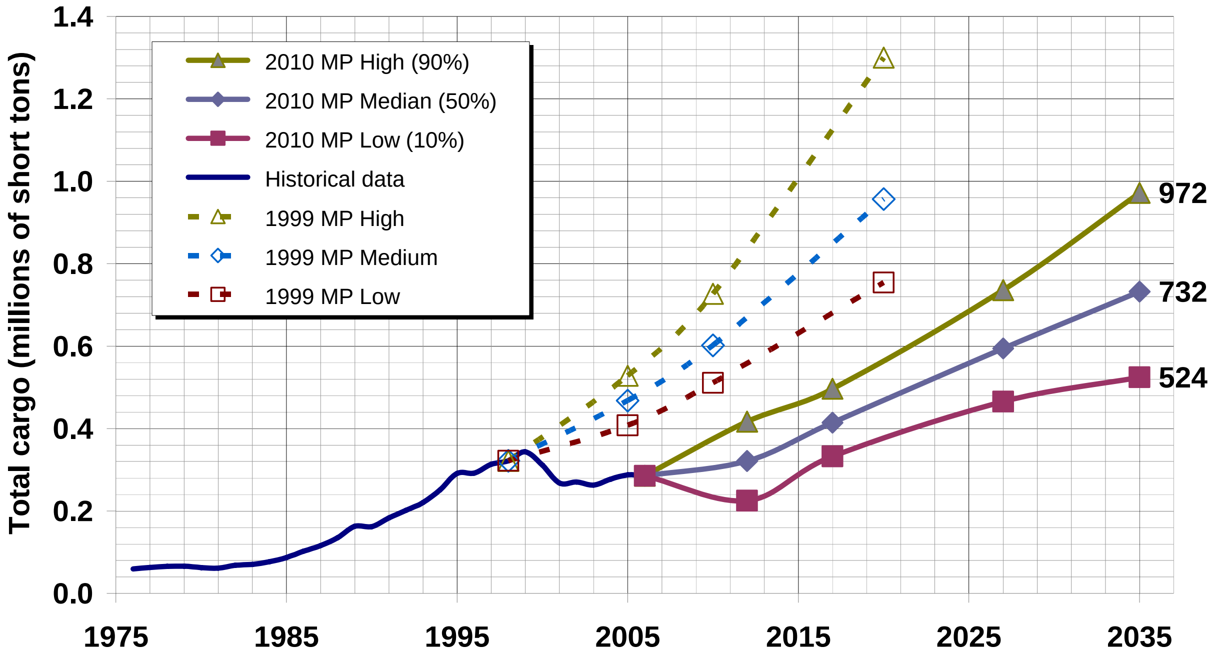


Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008. FAA 2007 TAF: U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecasts, online database. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

1.3.2 Cargo

Figure 3 presents a graphical comparison of actual activity from 1976 through 2006 and PDX total air cargo forecasts for the 2010 Master Plan and the 1999 Master Plan. (The FAA does not prepare cargo forecasts for individual airports as part of the TAF.) The 1999 Master Plan forecast tracked actual activity in 1999 but were 33%, 42%, and 49% higher than actual in 2006 for the low, medium, and high growth scenarios, respectively. The differences between actual and the 1999 Master Plan forecasts are related to the events of September 11, consolidation in the air cargo industry, and an increasing trend in the volume of cargo transported by truck. In the median scenario 2010 MP forecast, all-cargo airlines are forecast to account for an increasing share of total air cargo, from 85% in 2006 to 92% in 2035. The cargo transported on all-cargo airlines is forecast to increase an average of 3.8% per year from 2006 through 2035, compared with a forecast growth rate of 1.6% per for passenger airlines during the same period.

Figure 3
COMPARISON OF PDX TOTAL AIR CARGO FORECASTS

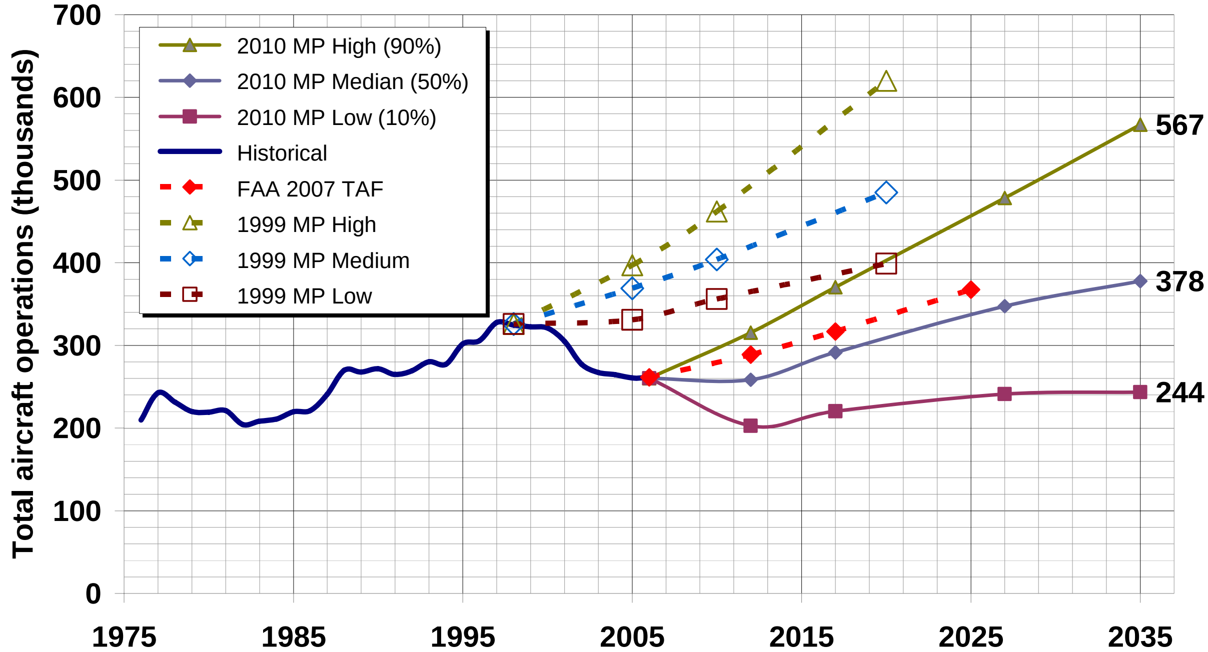


Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

1.3.3 Aircraft Operations

Figure 4 presents a graphical comparison of actual activity from 1976 through 2006 and PDX total aircraft operations forecasts for the 2010 Master Plan, the FAA 2007 TAF, and the 1999 Master Plan. The 1999 Master Plan forecasts tracked actual activity in 1999 but were 22%, 31%, and 36% higher than actual in 2006 for the low, medium, and high growth scenarios, respectively. The differences between actual and the 1999 Master Plan forecasts are related to the events of September 11, considerable increases in enplaned passenger load factors which contributed to slower growth in passenger airline operations, slower growth than forecast in the average aircraft size, slower growth than forecast in air cargo, and declines in general aviation and military activity. The 2010 Master Plan forecasts are based on 2006 data and are within 8.5% of the FAA 2007 TAF in 2011 and in 2016. In the median scenario 2010 MP forecast, total aircraft operations at PDX are forecast to increase from 260,386 in 2006 to 377,820 operations in 2035, an average increase of 1.3% per year. The total aircraft operations forecast growth rate for the median scenario forecast is lower than the annual growth rate forecast in the FAA 2007 TAF for the Airport—1.8% from 2006 to 2025. A detailed comparison of the 2010 Master Plan forecasts and the FAA 2007 TAF is presented in Section 5.8.

Figure 4
COMPARISON OF PDX TOTAL AIRCRAFT OPERATIONS FORECASTS



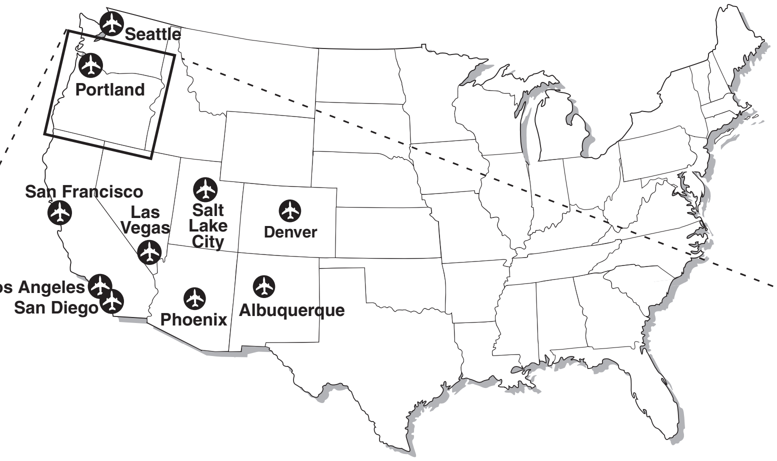
Sources: Historical: Port of Portland records. 2008 Master Plan forecasts (2008 MP): Jacobs Consultancy and NEXTOR, April 2008. FAA 2007 TAF: U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecasts, online database. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

1.4 Airport Service Region

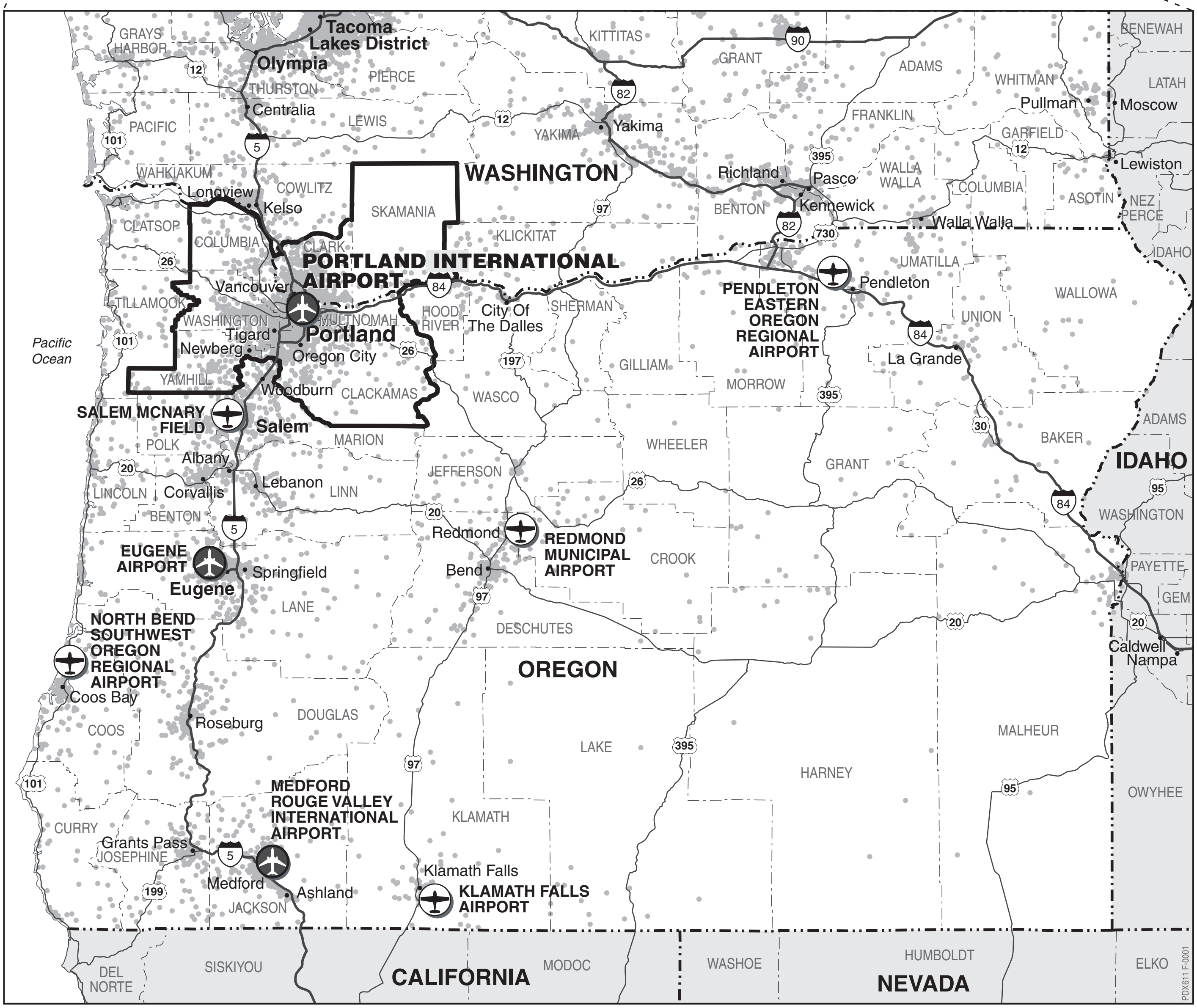
For purposes of the PDX Master Plan forecasts, the Portland-Vancouver Region is defined as the five-county planning region used by Metro in preparing its regional population and economic forecasts, including Clackamas, Multnomah, Washington, and Yamhill counties in Oregon and Clark county in Washington. The population densities for the five counties underline the importance of this region, as shown on Figure 5. The secondary region served by the Airport, which includes many of the counties surrounding the Portland-Vancouver region, is defined by the location of (and the airline service provided at) other commercial service air carrier airports. The nearest such airports are in Seattle (174 miles to the north) and Eugene (109 miles to the south).

1.5 Airport Role

Portland International Airport plays an important role in the national, state, and local air transportation systems. PDX is the primary commercial service airport for the State of Oregon, supports a large origin-destination passenger base, and serves as a secondary hub for Alaska and Horizon airlines.



Road miles from Portland to:	
Eugene	109
Klamath Falls	280
Medford	272
North Bend	219
Pasco	217
Pendleton	207
Redmond	145
Salem	47
Seattle	174
Spokane	352
Yakima	185



LEGEND

Portland-Vancouver-Beaverton MSA *(a)*

Population density: 1 dot equals 500 people

Passenger air carrier service

Commuter service airport

State boundary

County boundary

(a) Metro forecast region does not include Columbia County in Oregon and Skamania County in Washington.

Source: U.S. 2000 Census data.

Figure 5
AIRPORT SERVICE REGION
Portland International Airport
September 2008

JACOBS CONSULTANCY

1.5.1 Primary Commercial Service Airport in Oregon

Of the eight commercial service airports in Oregon, the Airport accounted for 87% of the passengers enplaned in the State and is the primary commercial service airport in Oregon, as shown earlier on Figure 5 and in Table 2. Eugene Airport, a non-hub airport 109 miles south of the Airport, is the second largest commercial service airport in Oregon. Approximately 387,628 enplaned passengers were accommodated at Eugene Airport and 27 scheduled average daily aircraft departures were provided at Eugene Airport in 2007, compared to 7.3 million enplaned passengers and 265 scheduled average daily aircraft departures at Portland International Airport in the same year.

Table 2

OREGON COMMERCIAL SERVICE AIRPORTS IN 2007

Oregon airports	Aircraft type providing service to Portland	Enplaned passengers
Portland International	--	7,332,478
Eugene	Turboprop	387,628
Medford	Regional jet/turboprop	317,326
Redmond	Turboprop	249,610
North Bend	Turboprop	37,984
Klamath Falls	Turboprop	28,902
Pendleton	Turboprop	16,841
Salem	--	12,960
Total Oregon airports		8,383,729

Sources: Port of Portland records, U.S. Department of Transportation, Form T-100 Domestic; Official Airline Guides, Inc., online database.

1.5.2 Large Origin-Destination Passenger Base

The Airport's large origin-destination passenger base reflects the strength of the Portland-Vancouver regional economy. A total of 5.9 million passengers originated from the Portland-Vancouver Region in 2006, i.e., enplaned passengers whose flight originated at the Airport and who have not connected from another flight. According to the Port's Terminal User Survey, about 85% of total Airport passengers in 2006 were originating, with the remaining 15% of Airport passengers connecting between flights.

1.5.3 Secondary Hub for Alaska and Horizon

Portland International Airport accounted for 11% of the combined seating capacity of Alaska and Horizon Airlines in 2007, second only to its primary hub operations at Seattle International Airport with 30% of system seating capacity. Alaska provided service from PDX to 18 airports in 2007 and Horizon provided service to 26 airports, with overlapping service by Alaska and Horizon to 10 destination airports. In 2007, Alaska and Horizon together accounted for 35% of enplaned passengers at PDX.

2. ECONOMIC BASIS FOR AVIATION DEMAND

Growth in the economy of the region served by an airport is a major factor affecting long-term airline traffic growth at the airport serving the region. Generally, regions with larger populations, higher levels of employment, and higher average incomes will generate a greater demand for air travel. At airports primarily serving origin-destination passengers, such as Portland International Airport, the demographics and economy of the service region—as measured by population, employment, and per capita income—and airline service levels and airfares are typically the most important factors affecting airline traffic. Based on the historical trend, it is expected that the majority of the Airport's passenger traffic will be generated within the Portland-Vancouver Region because of the size of the Region's population, the level of economic activity in the Region, and the distance to alternative air carrier airports.

As mentioned previously, for purposes of the PDX Master Plan forecasts, the Portland-Vancouver Region is defined as a five-county planning region, including Clackamas, Multnomah, Washington, and Yamhill counties in Oregon and Clark county in Washington, as shown in Figure 5. The five-county planning region was used in Metro's 2002 regional forecasts of population, employment, and income, the most recent socioeconomic forecasts available when the aviation demand forecasts were prepared.* Since then, Metro began the process of revising its regional forecasts and has broadened its study area to include the Portland-Vancouver-Beaverton Primary Metropolitan Statistical Area (PMSA). The PMSA consists of seven counties, including the five-county planning region noted above, Columbia County in Oregon, and Skamania County in Washington.

2.1 Population, Nonagricultural Employment, and Personal Income

Table 3 presents comparative trends in population, nonagricultural employment, and per capita income in the Portland Region, the State of Oregon, and the United States from 1976 through 2007. Since 1976, four national economic recessions have occurred, according to the National Bureau of Economic Research (NBER), a private, nonprofit research organization which defines start and end dates for U.S. national economic recessions. As shown on Figure 6, the most recent economic downturn affecting the Portland-Vancouver Region, the State, and the United States began in 2001. Between 2001 and 2003, the Portland-Vancouver Region experienced a downturn in employment that exceeded that of the State and the nation. From 2003 to 2007, the Portland-Vancouver Region and the State experienced a recovery in employment growth exceeding that of the United States.

*Metro, Economic Report to the Metro Council, *2000 – 2030 Regional Forecast for Portland-Vancouver Metropolitan Area*, Released March 2002, Revised September 2002.

Table 3

HISTORICAL AND PROJECTED SOCIOECONOMIC DATA

Portland-Vancouver Region, State of Oregon, and United States

1976-2035

	Population (thousands)			Nonagricultural employment (thousands)			Per capita personal income, in 2006 dollars		
	Portland-Vancouver Region (a)	State of Oregon (b,c)	United States (d,e)	Portland-Vancouver Region (a)	State of Oregon (c)	United States (f)	Portland-Vancouver Region (a)	State of Oregon (g)	United States (e,g)
Historical									
1976	1,172	2,387	217,563	474	879	79,502	28,362	24,307	23,931
1977	1,204	2,452	219,760	502	937	82,593	28,584	24,926	24,634
1978	1,235	2,522	222,095	542	1,009	86,826	29,296	25,897	25,493
1979	1,266	2,584	224,567	571	1,056	89,932	28,807	25,789	25,396
1980	1,298	2,633	227,225	573	1,045	90,528	27,814	24,818	24,746
1981	1,315	2,661	229,466	563	1,019	91,289	27,591	24,074	24,942
1982	1,326	2,656	231,664	538	961	89,677	27,423	23,338	24,933
1983	1,317	2,635	233,792	536	967	90,280	28,679	24,189	25,539
1984	1,330	2,660	235,825	564	1,007	94,530	30,102	25,056	26,953
1985	1,342	2,676	237,924	578	1,030	97,511	30,481	25,345	27,651
1986	1,355	2,662	240,133	598	1,059	99,474	31,392	26,239	28,405
1987	1,369	2,690	242,289	621	1,100	102,088	32,252	26,388	28,819
1988	1,399	2,741	244,499	655	1,153	105,345	33,563	27,011	29,535
1989	1,428	2,791	246,819	690	1,206	108,014	34,505	27,716	30,110
1990	1,478	2,842	249,623	715	1,256	109,487	34,715	27,956	30,043
1991	1,502	2,928	252,981	718	1,254	108,375	34,267	27,430	29,443
1992	1,552	2,991	256,514	731	1,277	108,726	33,833	27,650	29,966
1993	1,597	3,059	259,919	758	1,318	110,844	34,051	27,979	29,780
1994	1,643	3,120	263,126	792	1,372	114,291	34,472	28,661	30,160
1995	1,681	3,183	266,278	831	1,428	117,298	35,484	29,506	30,526
1996	1,724	3,245	269,394	869	1,485	119,708	35,936	30,082	31,062
1997	1,773	3,302	272,647	907	1,537	122,776	36,633	30,755	31,822
1998	1,812	3,350	275,854	923	1,563	125,930	37,168	31,613	33,249
1999	1,845	3,393	279,040	936	1,586	128,993	36,911	32,049	33,809
2000	1,874	3,421	282,217	961	1,618	131,785	39,042	32,987	34,938
2001	1,923	3,472	285,226	954	1,606	131,826	38,087	32,468	34,790
2002	1,959	3,505	288,126	932	1,585	130,341	36,780	32,577	34,510
2003	1,984	3,542	290,796	922	1,574	129,999	35,950	32,534	34,476
2004	2,005	3,583	293,638	942	1,607	131,435	36,287	32,684	35,296
2005	2,038	3,631	296,507	971	1,655	133,703	36,653	32,605	35,804
2006	2,078	3,691	299,398	1,003	1,704	136,086	37,137	33,304	36,635
2007	2,115	3,745	301,621	1,023	1,732	137,623	n.a.	33,839	37,542
Projected									
2012	2,296	4,004	316,983	1,090	1,837	144,632	39,139	36,249	39,454
2017	2,462	4,270	333,265	1,162	1,978	152,061	41,749	38,985	41,480
2027	2,852	4,810	370,951	1,282	2,184	169,257	47,975	44,799	46,171
2035	3,156	5,249	405,110	1,387	2,364	184,843	52,778	49,284	50,423
	Average annual percent increase								
1976-1986	1.5%	1.1%	1.0%	2.4%	1.9%	2.3%	1.0%	0.8%	1.7%
1986-1996	2.4%	2.0%	1.2%	3.8%	3.4%	1.9%	1.4%	1.4%	0.9%
1996-2006	1.9%	1.3%	1.1%	1.4%	1.4%	1.3%	0.3%	1.0%	1.7%
2006-2007	1.8%	1.5%	0.7%	2.0%	1.6%	1.1%	n.a.	1.6%	2.5%
1976-2007	1.9%	1.5%	1.1%	2.5%	2.2%	1.8%	0.9%	1.1%	1.5%
2007-2012	1.6%	1.3%	1.0%	1.3%	1.2%	1.0%	0.9%	1.4%	1.0%
2012-2017	1.4%	1.3%	1.0%	1.3%	1.5%	1.0%	1.3%	1.5%	1.0%
2017-2027	1.5%	1.2%	1.1%	1.0%	1.0%	1.1%	1.4%	1.4%	1.1%
2027-2035	1.3%	1.1%	1.1%	1.0%	1.0%	1.1%	1.2%	1.2%	1.1%
2007-2035	1.4%	1.2%	1.1%	1.1%	1.1%	1.1%	1.2%	1.4%	1.1%

Notes: The Portland-Vancouver Region consists of Clackamas, Multnomah, Washington, and Yamhill counties in Oregon and Clark county in Washingt
The base year for the aviation demand forecasts is 2006.
n.a. = Not available.

(a) Metro Data Resource Center, Economic Report to Metro Council, 2000-2030, revised September 2002. The 2007 estimates is form the U.S. Department

(b) Historical data from Population Research Center, Portland State University, March 2008.

(c) Projected data from State of Oregon, Office of Economic Analysis, *Oregon Economic and Revenue Forecast*, Volume XXVIII, No. 3, September 2008.

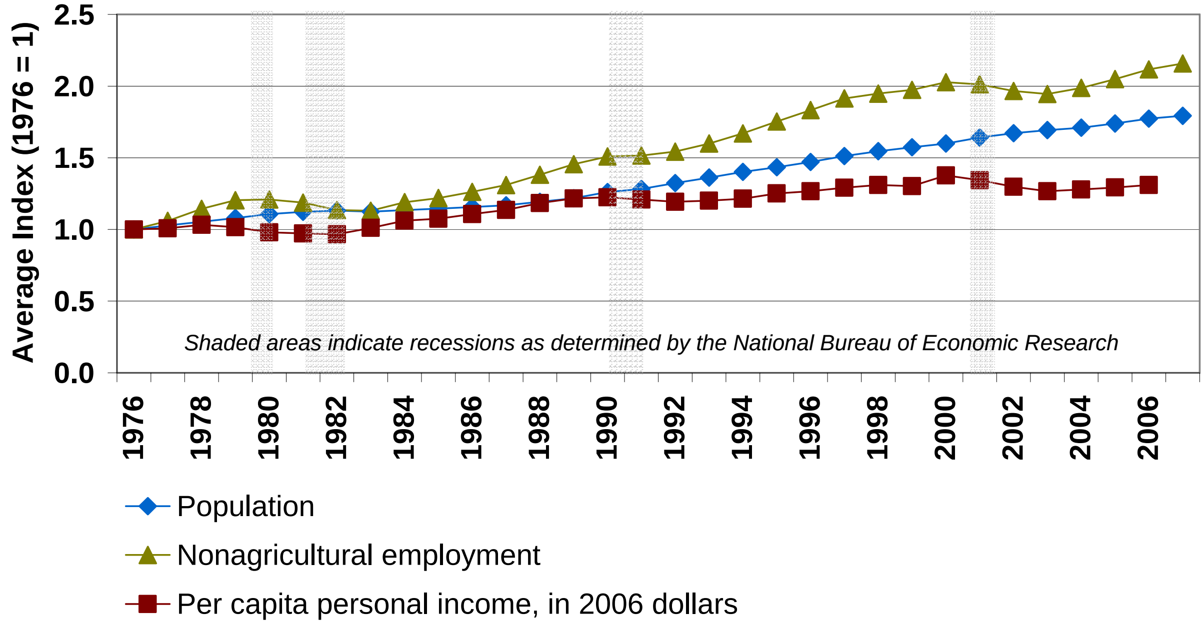
(d) Historical data from U.S. Department of Commerce, Bureau of the Census, Population Estimates Program, Population Division, Washington, D.C., on-line c

(e) National Planning Association, Data Services, Inc., *Key Indicators of County Growth*, *1970-2030* 2007 Edition. Extrapolated to 2035 by Jacobs Consultanc

(f) Historical data from U.S. Department of Labor, Bureau of Labor Statistics from www.bls.gov.

(g) Historical data from U.S. Department of Commerce, Bureau of Economic Analysis, www.bea.gov.

Figure 6
SOCIOECONOMIC TRENDS IN THE PORTLAND-VANCOUVER REGION



Sources: Portland-Vancouver Region population, employment, and income--Metro Data Resource Center, Economic Report to Metro Council, 2000-2030, revised September 2002. .U.S.GDP--U.S. Department of Commerce, Bureau of Economic Analysis,

Historically, population, employment, and per capita income in the Portland-Vancouver Region have (1) typically moved in the same direction over time, and (2) generally grown at similar or higher rates than those for the State and the nation overall.

2.1.1 Population

From 1976 to 2007, the population of the Portland Region increased an average of 1.9% per year, compared with 1.5% per year in the State and 1.1% per year in the nation as a whole. In 2007, Multnomah County was the largest county in the State in terms of population, accounting for approximately 19% of the population of the State and approximately 33% of the population of the Portland Region. In 2007, the Oregon counties in the Portland-Vancouver Region accounted for approximately 45% of the population of the State of Oregon. Table 4 presents 2007 population for the counties in the Portland-Vancouver Region.

Metro projects that population in the Portland-Vancouver Region will increase an average of 1.4% per year from 2007 to 2035, higher than the projected average growth rates of 1.2% per year for the State and 1.1% per year for the nation.

Table 4

DISTRIBUTION OF POPULATION BY COUNTY
Portland-Vancouver Region
2007

State / County	Population	Percent of total
Oregon		
Clackamas	376,251	17.8%
Multnomah	701,986	33.2
Washington	522,514	24.7
Yamhill	96,573	4.5
	1,697,324	80.2%
Washington		
Clark	418,070	19.8%
Portland-Vancouver Region	2,115,394	100.0%

Note: In 2007, the Portland-Vancouver-Beaverton PMSA population totaled 2,175,113, including the five-county Portland-Vancouver region noted above and Columbia County in Oregon and Skamania County in Washington with populations of 48,996 and 10,723, respectively. Together, Columbia and Skamania counties accounted for less than 3% of the PMSA 2007 population.

Source: U.S. Department of Commerce, Bureau of the Census, www.census.gov.

Because regions with larger populations, as well as higher levels of employment and income, have historically generated greater demand for airline travel, as has been the case for the Portland-Vancouver Region, continued growth in the Portland-Vancouver Region's population is expected to contribute to growth in airline traffic at the Airport.

2.1.2 Nonagricultural Employment

From 1976 to 2007, nonagricultural employment in the Portland-Vancouver Region and the State increased an average of 2.5% and 2.2% per year, respectively, compared with 1.8% per year in the nation. From 2000 to 2003 (a period of national and regional economic downturn), the Portland-Vancouver Region experienced employment losses that exceeded those of the State and the nation. Specifically, between 2000 and 2003, the Portland-Vancouver Region experienced an average annual decrease in employment of 1.4%, compared with average annual decreases of 0.9% in the State and 0.5% in the nation. From 2003 to 2007, the Portland-Vancouver Region and the

State experienced a recovery in employment growth with average annual increases of 2.6% and 2.4%, respectively, exceeding that of the United States (1.4%).

Metro projects that nonagricultural employment in the Portland-Vancouver Region will increase an average of 1.1% per year between 2007 and 2035, the same as that for the State and the nation.

2.1.3 Personal Income

As shown in Table 3, from 1976 to 2006 (the most recent year for which data are available), per capita income in the Portland-Vancouver Region, in 2006 dollars, increased an average of 0.9% per year, slower than the growth in the State (1.1%) and the nation (1.5%) over the same period. As also shown in Table 3, the Portland-Vancouver Region has historically had a higher per capita income than both the State and the nation. Metro projects that per capita income in the Portland-Vancouver Region will increase an average of 1.2% per year between 2007 and 2035 compared with an average increase of 1.4% per year in the State and 1.1% per year in the nation.

2.2 Industry Sectors

Figure 7 demonstrates the diversity of employment in the Portland-Vancouver Region, showing the overall percentage distribution of nonagricultural employment by industry sector in 1990, 2000, and 2007*. The figure also shows a comparison to the distributions of nonagricultural employment in the State and the nation in 2007.

Table 5 lists the largest employers in the Portland-Vancouver Region by number of employees in 2007, illustrating the diversity of the Region's economy. Eight of the listed employers are Fortune 500 companies, and 13 employers are headquartered in the Portland Region. The companies listed accounted for 14.6% of total nonagricultural employment in the Portland Region in 2007, with the remaining 85.4% accounted for by smaller businesses and organizations.

The services sector increased its share of the Portland-Vancouver Region's employment from approximately 35% in 1990 to approximately 41% in 2007. The trade, government, construction and mining, finance, and transportation and utilities sectors maintained approximately similar shares of the Portland Region's nonagricultural employment between 1990 and 2007. The manufacturing sector's share decreased from about 17% in 1990 to about 12% in 2007, maintaining similar shares to that for the State and the nation, respectively.

*Data for the Portland-Vancouver-Beaverton PMSA were used to represent the shares of employment by industry sector for the Portland-Vancouver Region.

Table 5

LARGEST EMPLOYERS IN THE PORTLAND-VANCOUVER REGION
2007

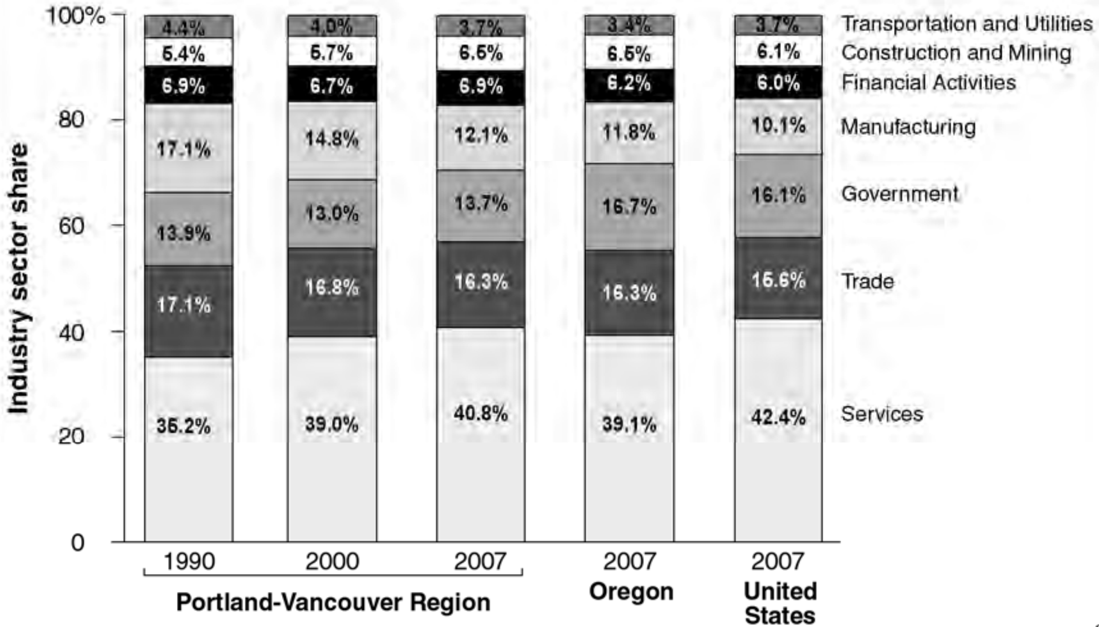
Rank	Company	Headquartered in Portland Region	Fortune 500 Company	Principal industry	Number of employees
1	Intel Corp.		✓	Computer products	16,740
2	Providence Health System			Health care	14,639
3	Safeway Inc.		✓	Grocery retail	13,453
4	Oregon Health & Science University	✓		Hospital and university	11,500
5	Fred Meyer Stores			Retail merchandising	8,500
6	City of Portland	✓		Municipal government	8,000
7	Kaiser Foundation Health Plan of the Northwest			Health care	8,221
8	Legacy Health System	✓		Nonprofit health care	8,196
9	Nike Inc.	✓	✓	Athletic equipment	7,648
10	State of Oregon			Government	6,700
11	Wells Fargo		✓	Financial institution	4,873
12	U.S. Bank		✓	Financial institution	3,725
13	Shari's Restaurants	✓		Restaurant chain	3,725
14	Beaverton School District	✓		Education	3,533
15	Hewlett-Packard Co.		✓	Global technology company	3,500
16	Freightliner LLC			Diesel trucks	3,500
17	Albertsons Food Centers		✓	Grocery retail	2,500
18	Portland Community College	✓		Community college	3,410
19	United Parcel Service		✓	Parcel delivery service	3,400
20	Evergreen School District	✓		Education	3,300
21	Southwest Washington Medical Center	✓		Health care	3,286
22	Portland State University	✓		College	3,266
23	Bonneville Power Administration	✓		Utility	2,959
24	Vancouver School District	✓		Education	2,770
25	Portland General Electric	✓		Electric energy service	2,750

Note: The Portland Region consists of Clackamas, Columbia, Multnomah, Washington, and Yamhill counties in Oregon and Clark and Skamania counties in Washington.

Source: Portland Development Commission, Portland Metropolitan Region Fact Book, July 2007 and Business Journal, 2007 Book of Lists; Portland Business Alliance, Largest Employers 2007.

Figure 7

COMPARATIVE DISTRIBUTION OF NONAGRICULTURAL EMPLOYMENT



Note: Data for the Portland-Vancouver-Beaverton Metropolitan Statistical Area were used to represent the Portland-Vancouver Region.

Source: U.S. Department of Labor, Bureau of Labor Statistics, www.bls.gov.

2.2.1 Services

Companies such as Providence Health System, Oregon Health & Science University, and Legacy Health System in the education and health services subsector and Wells Fargo and U.S. Bank in the business services subsector account for a major portion of employment in the services sector in the Portland-Vancouver Region. Although the sector was affected by the 2001 economic recession, the information and professional and business services subsectors were the only subsectors to experience losses in employment. Moreover, the Portland-Vancouver Region's services sector employment and share of total nonagricultural employment grew, largely as a result of an approximately 3% average annual increase in the Region's education and health services subsector from 2000 to 2007. Employment in leisure and hospitality grew 3.4% between 2003 and 2007.

2.2.2 Trade (Wholesale and Retail)

In 2007, trade was the second largest nonagricultural employment sector in the Portland-Vancouver Region, representing approximately 16% of total nonagricultural employment. Safeway Inc., Fred Meyer Stores, and Nike Inc. are the largest trade sector employers in the Portland-Vancouver Region.

2.2.3 Government and Military

The Portland-Vancouver Region's public sector employs approximately 142,400 people who work for federal, State, and local government agencies in the Region; the Port of Portland; the cities of Portland, Vancouver, and Beaverton; and smaller city and town governments in the Region. Between 2000 and 2007, the government sector added approximately 11,900 jobs.

2.2.4 Manufacturing

As mentioned earlier, the Portland-Vancouver Region's manufacturing sector was the sector most adversely affected by the recent economic recession, particularly high technology and other durable goods manufacturing. However, the manufacturing sector still accounted for almost 12% of the Portland Region's employment in 2007. High technology, metals and machinery, wood products, and transportation equipment manufacturing represent the most significant industries in the Portland Region's manufacturing sector. The Portland Regional Partners for Business list high technology manufacturing, specifically nano- and micro-technology, cyber-security, and health and medical information technology manufacturing, as an emerging sector in the Portland-Vancouver Region's economy. Intel is the largest employer in the both the manufacturing sector and the Portland-Vancouver Region, with about 16,740 employees in the Region in 2007.

2.2.5 Finance

The finance sector in the Portland-Vancouver Region grew in absolute terms between 2000 and 2007, while maintaining a roughly constant share of total nonagricultural employment. From 2000 to 2003, the Portland-Vancouver Region experienced employment gains in the finance sector, notwithstanding a period of national and regional economic downturn. Employment in the finance sector decreased 0.5% in 2004 and has increased each year since then. From 2004 to 2007, finance sector employment increased an average of 2.7% per year, with slower growth in 2007 (1.3%).

2.2.6 Construction

Employment in construction in the Portland-Vancouver Region increased an average of approximately 7% between 2003 and 2007, with growth slowing to about 4% in 2007. Continuing growth in the construction sector has been facilitated by office, industrial, and public projects.

2.2.7 Transportation and Utilities

The Portland-Vancouver Region's multimodal transportation system includes the Seaport and the Airport operated by The Port of Portland, three interstate highways, two of the nation's largest transcontinental railroads (BNSF Railway and Union Pacific

Railroad), and a regional mass transit network. TriMet provides a system of buses, a streetcar, and light rail. TriMet's light rail system connects downtown Portland, North Portland, Gresham, Beaverton, Hillsboro, and the Airport. The streetcar connects River Place in southwest Portland to Portland State University and Legacy Good Samaritan Hospital in northwest Portland, and most of the area served by the streetcar is in a zone that is free to the public. TriMet's 8.3-mile extension into Clackamas County and along a new alignment in downtown Portland will open September 2009. TriMet also has expansion plans that include extending the light rail south to connect Tigard, Wilsonville, and Milwaukie to the existing system. There is also a bus system in Clark County called C-Tran that connects downtown Portland to much of Clark County. City of Portland Utilities provides water services for residents, and Portland General Electric and others provide electricity.

2.3 Economic Outlook Summary

As discussed earlier, the economy of the Portland-Vancouver Region, similar to the State and much of the United States, experienced a slowdown between 2000 and 2003. From 2003 through 2007, the Region has been characterized by a positive economic growth trend. Metro projects that population, employment, and per capita income in the Portland Region will increase slightly faster than or equal to that in the State and the United States between 2007 and 2035.

- **Population**—Metro projects that the Portland-Vancouver Region's population will increase 1.4% per year between 2007 and 2035, compared to 1.2% per year in the State and 1.1% per year in the United States as a whole.

- **Nonagricultural employment**—Metro projects that the Portland-Vancouver Region's nonagricultural employment will increase 1.1% per year between 2007 and 2035, the same as that for the State and the nation.

- **Per capita income**—Metro projects that real per capital income in the Portland-Vancouver Region will grow 1.2% per year between 2006 and 2035, compared to growth of 1.4% per year in the State and 1.1% per year in the United States as a whole.

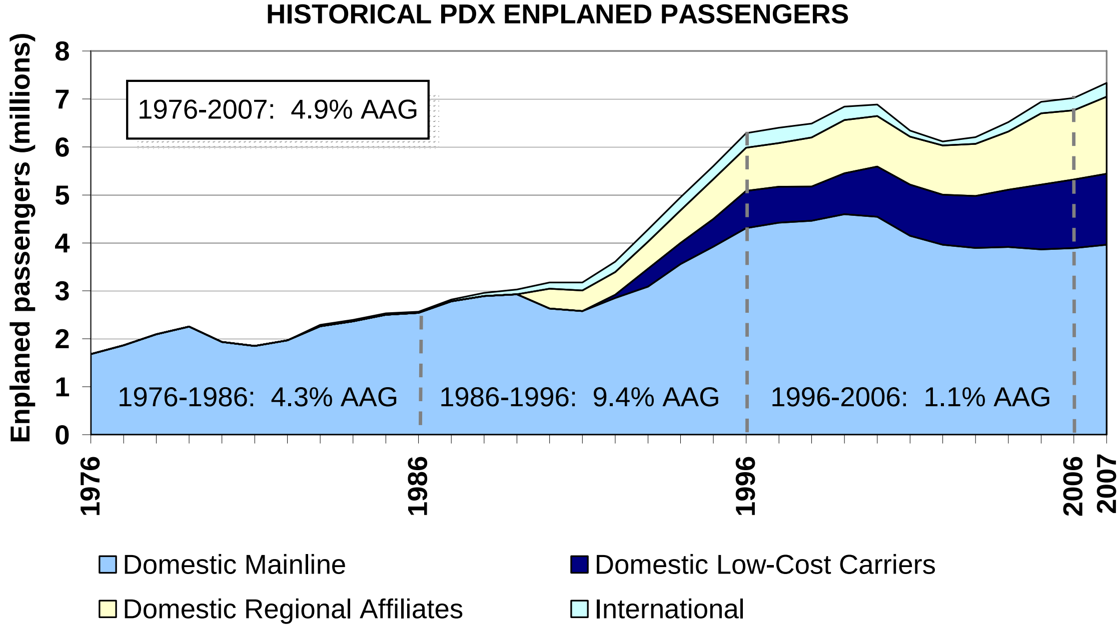
3. HISTORICAL PASSENGER DEMAND

PDX was the 31st busiest airport in the United States, in terms of calendar year 2007 enplaned passenger data provided by the FAA. The Airport is designated as a medium-hub airport by the FAA (i.e., enplaning more than 0.25% and less than 1.0% of U.S. airport systemwide enplaned passengers), and was the busiest medium hub in calendar year 2007 in terms of enplaned passengers.

The Airport principally serves origin-destination passengers, which are estimated by the Port from a Terminal User Survey conducted four times between March and October 2006 to account for about 85% of total Airport passengers in 2006, with the remaining 15% of Airport passengers connecting between flights. U.S. Department of Transportation data from the Origin-Destination Survey (a 10% sample of all tickets issued) in 2006 are consistent with the Port's Terminal User Survey results.

From 1976 to 2006 (the base year of the PDX MP forecasts), the number of PDX enplaned passengers increased an average of 4.9% per year, with the strongest growth occurring from 1986 to 1996 (an average increase of 9.4% per year) principally as a result of strong regional economic growth and the development of low-fare and other airline service at the Airport, as shown on Figure 8. In 2007, the number of PDX enplaned passengers increased 4.4%.

Figure 8
HISTORICAL PDX ENPLANED PASSENGERS



AAG = Average annual growth
Source: Port of Portland records. Domestic mainline includes charter airline passengers.

3.1 Airlines Serving PDX

As shown in Table 6, as of August 2008, 14 U.S.-flag and 3 foreign-flag passenger airlines provided scheduled passenger service at the Airport. In addition, 3 airlines provided charter passenger service, and 13 airlines provided all-cargo service. In August 2008, the passenger airlines at the Airport were scheduled to provide an average of 270 daily departures to 45 destinations in the United States. In addition, the passenger airlines were scheduled to provide an average of 12 daily departures to five international destinations.

Table 6

AIRLINES SERVING PORTLAND INTERNATIONAL AIRPORT
August 2008

Scheduled passenger service	Charter passenger service
U.S.-flag Airlines	Allegiant Air, Inc.
Alaska Airlines	MN Airlines
American Airlines	XTRA Airways
Continental Airlines	
Delta Air Lines	**All-cargo service**
Delta Connection *(a)*	ABX Air
Frontier Airlines	Air Cargo Carriers
Hawaiian Airlines	Air China
Horizon Air	Air Transport International
JetBlue Airways	Airpac Airlines
Northwest Airlines	Ameriflight
Southwest Airlines	Empire Airlines
United Airlines	FedEx
United Express/SkyWest Airlines	Kalitta Charters
US Airways *(b)*	Kitty Hawk Air Cargo
	Martinaire Partners
Foreign-flag airlines	UPS Air Cargo
Air Canada Jazz	Western Express Air Lines
Lufthansa German Airlines	
Mexicana de Aviacion *(c)*	

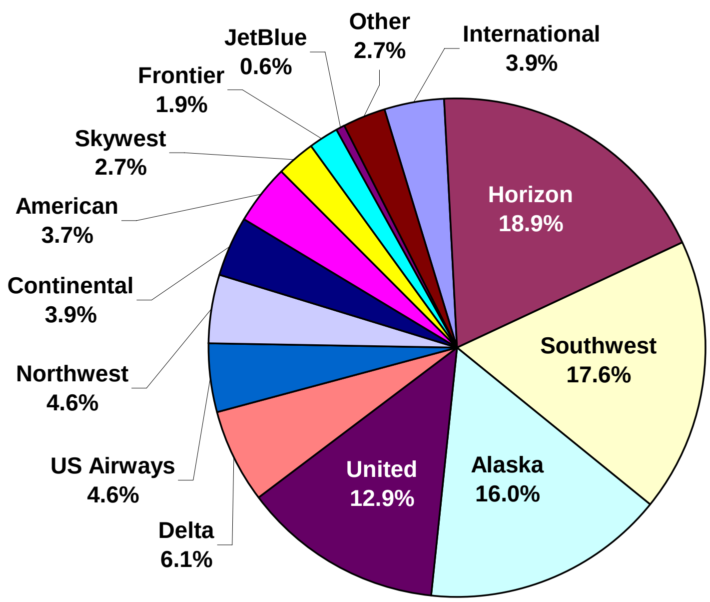
(a) Includes SkyWest Airlines and Expressjet.
(b) America West Airlines merged with US Airways in July 2005.
(c) Mexicana plans to discontinue service at PDX on September 2, 2008.

Source: Portland International Airport records.

3.2 Airline Market Shares of Enplaned Passengers

Airline market shares of enplaned passengers at the Airport in 1990, 2000, and 2007 are shown in Table 7. In 2007, approximately 96.1% of passengers were enplaned on domestic flights at PDX, and the remaining 3.9% were enplaned on international flights. Horizon Air accounted for the largest share of passengers in 2007 (18.9%), followed by Southwest Airlines with 17.6%, Alaska Airlines with 16.0%, and United Airlines with 12.9%, as shown on Figure 9. Alaska Airlines and Horizon Air, which operate in concert as the Alaska Air Group although they are separately certificated airlines, together accounted for 35.7% of PDX enplaned passengers (domestic and international) in 2007.

Figure 9
PDX ENPLANED PASSENGER MARKET SHARES IN 2007



Note: International share includes passengers enplaned by Alaska (0.2%), Horizon (0.6%) and Northwest (1.0%).
Source: Port of Portland records.

Table 7
ENPLANED PASSENGERS BY AIRLINE
Master Plan Update
Portland International Airport
1990, 2000, and 2007

Carrier	Enplaned passengers			Percent of total		
	1990	2000	2007	1990	2000	2007
Domestic						
Mainline						
Alaska Airlines	503,548	1,339,842	1,172,367	15.9%	19.5%	16.0%
American Airlines	385,800	313,513	269,638	12.2%	4.6%	3.7%
Continental Airlines	89,872	135,993	282,657	2.8%	2.0%	3.9%
Delta Air Lines	416,796	857,955	448,100	13.1%	12.5%	6.1%
Eastern Airlines	43,668	--	--	1.4%	--	--
Northwest Airlines	168,992	301,470	333,849	5.3%	4.4%	4.6%
Trans World Airlines	67,370	149,035	--	2.1%	2.2%	--
United Airlines	739,429	1,114,570	943,469	23.3%	16.2%	12.9%
US Airways	212,893	221,198	335,079	6.7%	3.2%	4.6%
	2,628,368	4,433,576	3,785,159	82.8%	64.4%	51.6%
Low cost carriers						
Frontier Airlines	--	68,625	142,754	--	1.0%	1.9%
JetBlue Airways	--	--	45,012	--	--	0.6%
Southwest Airlines	--	974,814	1,293,134	--	14.2%	17.6%
	--	1,043,439	1,480,900	--	15.2%	20.2%
Regional affiliates						
Horizon Air	291,557	876,641	1,387,126	9.2%	12.7%	18.9%
SkyWest Airlines	--	178,575	196,547	--	2.6%	2.7%
United Express	121,611	--	--	3.8%	--	--
Other airlines	-	3,167	21,447	0.0%	0.0%	0.3%
	413,168	1,058,383	1,605,120	13.0%	15.4%	21.9%
Other airlines	2,268	110,444	173,488	0.1%	1.6%	2.4%
Subtotal--Domestic	3,043,804	6,645,842	7,044,667	95.9%	96.5%	96.1%
International						
U.S. flag airlines						
Alaska Airlines	--	--	18,263	--	--	0.2%
Delta Air Lines	108,350	134,066	--	3.4%	1.9%	--
Horizon Air	4,609	49,140	40,455	0.1%	0.7%	0.6%
Northwest Airlines	--	--	74,946	--	--	1.0%
SkyWest Airlines	--	13,683	--	--	0.2%	--
	112,959	196,889	133,664	3.6%	2.9%	1.8%
Foreign-flag airlines						
Air Canada Jazz	17,591	42,796	43,822	0.6%	0.6%	0.6%
Lufthansa German Airli	--	--	74,850	--	--	1.0%
Mexicana Airlines	--	--	35,475	--	--	0.5%
	17,591	42,796	154,147	0.6%	0.6%	2.1%
Subtotal--International	130,550	239,685	287,811	4.1%	3.5%	3.9%
Total	3,174,354	6,885,527	7,332,478	100.0%	100.0%	100.0%

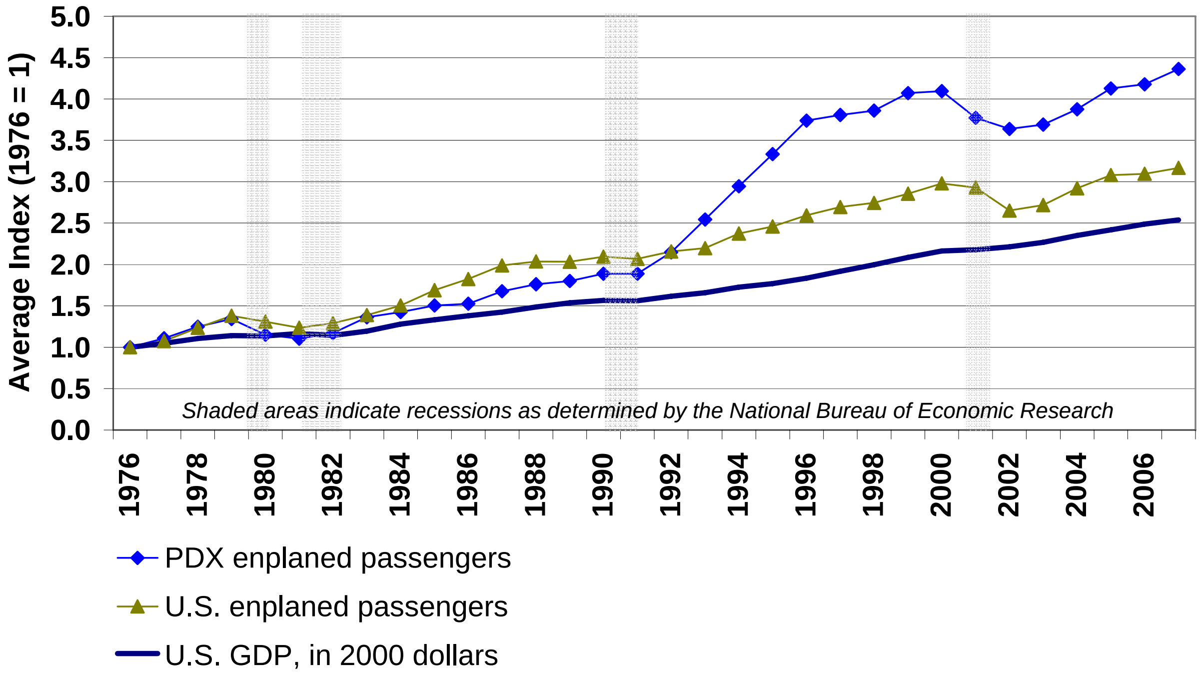
Source: Port of Portland records.

3.3 Historical Enplaned Passengers

Table 8 presents historical data on enplaned passengers at the Airport from 1976 through 2007. Over the past three decades, the Airport's traffic has increased significantly faster than the national average for enplaned passengers and U.S. economic growth, as shown on Figure 10. Strong growth in PDX passenger traffic reflects (1) the growth in the economy of the Portland-Vancouver Region, (2) airline service development at the Airport by the Alaska Air Group (Alaska Airlines and Horizon Air), and (3) the increase in low-fare airline service, including that of Southwest Airlines. The Alaska Air Group operates its primary hub at Seattle-Tacoma International Airport, with its second largest operation, as measured by number of available seats, at Portland International Airport, providing the ability to offer connecting service.

Through the four national economic downturns that have occurred since 1976, the number of enplaned passengers at the Airport increased each year except in 1980, 1981, 1991, 2001, and 2002, indicating a strong overall market for airline service. As shown on Figure 10, PDX passenger traffic tracked the trends in U.S. GDP and U.S. enplaned passengers until 1992, with the expansion of airline service, and exceeded national trends since then.

Figure 10
PDX AND U.S. ENPLANED PASSENGER TRENDS



Sources: PDX enplaned passengers--Port of Portland records. U.S. enplaned passengers--U.S. Department of Transportation, Federal Aviation Administration, www.faa.gov. U.S.GDP--U.S. Department of Commerce, Bureau of Economic Analysis, www.bea.gov.

Table 8

HISTORICAL ENPLANED PASSENGERS

Master Plan Update

Portland International Airport

1976 - 2007

Year	Domestic passengers	Increase (decrease)	International passengers	Increase (decrease)	Total enplaned passengers	Increase (decrease)
1976	1,680,870	--%	--	--%	1,680,870	--%
1977	1,863,808	10.9%	--	--	1,863,808	10.9%
1978	2,095,679	12.4%	--	--	2,095,679	12.4%
1979	2,254,443	7.6%	--	--	2,254,443	7.6%
1980	1,931,573	-14.3%	--	--	1,931,573	-14.3%
1981	1,853,116	-4.1%	--	--	1,853,116	-4.1%
1982	1,968,018	6.2%	--	--	1,968,018	6.2%
1983	2,263,821	15.0%	26,299	--	2,290,120	16.4%
1984	2,363,376	4.4%	32,367	23.1%	2,395,743	4.6%
1985	2,502,480	5.9%	26,922	-16.8%	2,529,402	5.6%
1986	2,541,774	1.6%	23,992	-10.9%	2,565,766	1.4%
1987	2,777,169	9.3%	39,086	62.9%	2,816,255	9.8%
1988	2,890,403	4.1%	68,153	74.4%	2,958,556	5.1%
1989	2,928,916	1.3%	97,761	43.4%	3,026,677	2.3%
1990	3,043,804	3.9%	130,550	33.5%	3,174,354	4.9%
1991	3,007,360	-1.2%	164,548	26.0%	3,171,908	-0.1%
1992	3,390,628	12.7%	219,953	33.7%	3,610,581	13.8%
1993	4,023,417	18.7%	252,687	14.9%	4,276,104	18.4%
1994	4,679,384	16.3%	272,462	7.8%	4,951,846	15.8%
1995	5,326,897	13.8%	275,367	1.1%	5,602,264	13.1%
1996	5,983,877	12.3%	302,634	9.9%	6,286,511	12.2%
1997	6,080,139	1.6%	319,400	5.5%	6,399,539	1.8%
1998	6,197,567	1.9%	289,659	-9.3%	6,487,226	1.4%
1999	6,560,948	5.9%	282,154	-2.6%	6,843,102	5.5%
2000	6,645,842	1.3%	239,685	-15.1%	6,885,527	0.6%
2001	6,214,579	-6.5%	126,023	-47.4%	6,340,602	-7.9%
2002	6,027,297	-3.0%	88,431	-29.8%	6,115,728	-3.5%
2003	6,063,626	0.6%	140,297	58.7%	6,203,923	1.4%
2004	6,321,708	4.3%	194,970	39.0%	6,516,678	5.0%
2005	6,701,989	6.0%	236,595	21.3%	6,938,584	6.5%
2006	6,763,514	0.9%	258,670	9.3%	7,022,184	1.2%
2007	7,044,667	4.2%	287,811	11.3%	7,332,478	4.4%
	Average annual percent increase (decrease)					
1976-1986	4.2%		--		4.3%	
1986-1996	8.9%		28.9%		9.4%	
1996-2006	1.2%		-1.6%		1.1%	
1976-2006	4.8%		--		4.9%	
1996-2000	2.7%		-5.7%		2.3%	
2000-2002	-4.8%		-39.3%		-5.8%	
2002-2006	2.9%		30.8%		3.5%	
2006-2007	4.2%		11.3%		4.4%	

Source: Port of Portland records.

From 1996 to 2006, PDX passenger traffic increased an average of 1.1% per year, slower than growth during the previous 10 years which were characterized largely by an expansion of airline service. The number of passengers enplaned at PDX increased an average of 2.3% per year between 1996 and 2000, with slower growth in 2000 as regional economic growth began to slow.

Between 2000 and 2002, the number of enplaned passengers at the Airport decreased, principally as a result of (1) the effects of the terrorist attacks on September 11, 2001, (2) the national economic downturn, which particularly affected the Portland Region, a national center for the information technology industry, with employment reductions in that industry, and (3) the withdrawal of international service by Delta Air Lines in 2001, which reduced the number of international enplaned passengers and the number of domestic enplaned passengers connecting from that international service. At that time, Delta reorganized its international hub network to reach Asian destinations from other U.S. hubs using longer-range aircraft.

The number of enplaned passengers increased an average of 3.7% per year between 2002 and 2007, reflecting (1) significant growth in the Portland Region economy during this period, (2) the adjustment of passengers to the effects of September 11, 2001, such as increased security requirements, (3) reductions in average airfares at the Airport, and (4) the introduction of international service to Frankfurt, Guadalajara, and Tokyo.

3.4 Origin-Destination Passenger Markets

As discussed earlier, the Airport has historically served primarily origin and destination passengers. According to data from the Portland International Airport Terminal User Survey, approximately 85% of passengers enplaned at the Airport in 2005 were origin and destination passengers. According to U.S. DOT data, the number of originating enplaned passengers grew from about 2.5 million in 1990 to about 5.6 million in 2007, representing an average annual increase of 4.9%. (Complete and reliable origin-destination data are not available for the period from 1976 through 1990.)

Table 9 presents the top 25 domestic passenger origin and destination markets (those markets accounting for 1% or more of domestic origin and destination passengers) for the Airport in 2007. Of the top 25 markets, only five—Boise, Reno, Sacramento, Seattle, and Spokane—were short-haul destinations (less than 500 miles). Of these five short-haul routes, Reno and Sacramento were at the high end of this range—444 and 479 miles, respectively. Alternative travel modes such as road and rail are less attractive for medium- and long-haul trips than for short-haul trips. All of the top 25 markets had nonstop daily scheduled airline service, except Boston and Orlando. In addition, 51 daily nonstop scheduled departures served other domestic destinations. There are major traffic flows between the Airport and domestic markets across the United States, including major cities on both coasts.

Table 9
TOP DOMESTIC ORIGIN AND DESTINATION MARKETS AND AIRLINE SERVICE
Portland International Airport
2007

Rank	Market *(a)*	Air miles from Portland *(b)*	Share of market	Domestic scheduled departing seats *(c)* Number	Domestic scheduled departing seats *(c)* Share of total	Average daily nonstop domestic departures *(c)*
1	Los Angeles *(d)*	834	10.7%	74,052	8.4%	24
2	San Francisco *(e)*	550	10.4	123,866	14.1	32
3	Las Vegas	762	4.7	47,764	5.4	11
4	Phoenix	1,009	4.6	47,829	5.4	11
5	Sacramento	479	4.4	41,901	4.8	12
6	Denver	992	3.3	50,930	5.8	13
7	New York *(f)*	2,433	3.2	24,168	2.7	5
8	San Diego	933	3.0	17,732	2.0	4
9	Chicago (g)	1,739	2.9	47,120	5.4	10
10	Washington, D.C. *(h)*	2,358	2.5	5,272	0.6	1
11	Boise	344	2.4	23,762	2.7	8
12	Salt Lake City	630	2.4	30,548	3.5	8
13	Spokane	279	2.2	27,375	3.1	9
14	Honolulu	2,603	1.8	15,128	1.7	2
15	Dallas/Fort Worth *(i)*	1,616	1.8	17,360	2.0	4
16	Seattle-Tacoma	129	1.8	52,266	5.9	38
17	Reno	444	1.7	18,734	2.1	5
18	Minneapolis/St. Paul	1,426	1.4	27,670	3.1	5
19	Atlanta	2,172	1.3	25,509	2.9	5
20	Orlando	2,534	1.3	--	--	--
21	Houston *(j)*	1,825	1.2	20,303	2.3	4
22	Kahului	2,559	1.3	8,184	0.9	1
23	Boston	2,529	1.2	--	--	--
24	Philadelphia	2,398	1.0	7,200	0.8	2
25	Detroit	1,947	1.0	4,962	0.6	1
	Subtotal		73.4%	759,635	86.3%	214
	All other markets		26.6%	86,663	13.7	51
	Total		100.0%	846,298	100.0%	265

(a) Cities with 1% or more of domestic origin and destination passengers at Portland International Airport.
(b) U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information.
(c) Official Airline Guides, Inc., online database for August 2007, for domestic destinations. An additional 34,045 seats and an average of 12 nonstop departures were provided to international destinations.
(d) Los Angeles International, Bob Hope (Burbank), John Wayne (Orange County), Ontario International, and Long Beach airports.
(e) San Francisco, Oakland, and Mineta San Jose international airports.
(f) John F. Kennedy and Newark Liberty international airports.
(g) Chicago O'Hare and Midway international airports.
(h) Washington Dulles International and Reagan Washington National airports.
(i) Dallas/Fort Worth International Airport and Love Field.
(j) Bush Intercontinental Airport/Houston and William P. Hobby Airport.

Source: U.S. Department of Transportation, Survey of Origin-Destination Passenger Traffic, Domestic, except as noted.

Table 10 presents international passenger origin and destination market shares by region in the Airport for 2007, based on U.S. DOT data. International origin and destination passengers accounted for approximately 9% of total origin and destination passengers. The principal international traffic flows from the Airport are to Europe, Mexico and Central America, Canada, and East Asia. Each of these regions has nonstop service from the Airport. In total, approximately 12 international departures are scheduled per day from the Airport as of August 2007, including service to Frankfurt (since April 2003), Guadalajara (since May 2003), Tokyo (since June 2005), and Vancouver (British Columbia).

Table 10

INTERNATIONAL ORIGIN AND DESTINATION MARKETS AND AIRLINE SERVICE
2007

Market	Share of international market *(a)*	Share of Airport total	Average daily nonstop departures *(b)*
Europe	29.9%	2.8%	1
Mexico and Central America	28.9	2.7	1
Canada	14.7	1.4	9
East Asia	17.4	1.6	1
South America	2.8	0.3	--
Middle East/Central Asia	1.4	0.1	--
Caribbean, Bahamas, and Bermuda	2.1	0.2	--
Australia and Oceania	1.9	0.2	--
Africa	0.9	0.1	--
Total	100.0%	9.4%	12

Note: Columns may not add to totals shown because of rounding.

(a) U.S. Department of Transportation, Airline Passenger Origin and Destination Survey for U.S.-flag airline passengers; U.S. Department of Transportation T-100 onboard database for foreign-flag airline passengers.

(b) Official Airline Guides, Inc., online database for August 2007.

Three of the 12 departures shown in Table 10—to Europe (Frankfurt), East Asia (Tokyo), and Mexico (Guadalajara)—are served by narrowbody or widebody aircraft, with the remaining 8 being served by regional/commuter aircraft.

3.5 Connecting Passenger Markets

As discussed earlier, the Airport has historically served primarily origin and destination passengers. Connecting passengers account for approximately 15% of passengers enplaned at the Airport. The Airport serves as a regional hub serving the northwestern United States, including the State of Alaska, principally by the Alaska Air Group. Given its geographic location and the relatively longer trip stage lengths and lower population densities in the northwestern United States, the Airport is expected to continue to serve as a regional hub. If the Alaska Air Group were to reduce connecting passenger activity at the Airport, such activity would not necessarily be replaced by other airlines, although reductions in service by either airline (Alaska or Horizon) would create business opportunities for other airlines.

3.6 Scheduled Passenger Airline Service

Table 11 shows daily scheduled nonstop departures by passenger airlines from the Airport in August 2008. As of August 2008, the Airport was served by 11 mainline U.S. airlines, 3 regional and commuter airlines, and 3 foreign-flag airlines. As with numbers of enplaned passengers, the Alaska Air Group accounts for the most departures from the Airport. Southwest Airlines and United Airlines/United Express also have substantial numbers of departures from the Airport.

Table 11
SCHEDULED AVERAGE DAILY NONSTOP DEPARTURES FROM THE AIRPORT BY AIRLINE
August 2008

Airline	Mainline jet	Regional jet	Turboprop	Total
Alaska Airlines	30	--	--	30
Horizon Air	--	39	50	90
Alaska Air Group	30	39	50	120
American Airlines	7	--	--	7
Air Canada Jazz	--	--	5	5
Continental Airlines	7	--	--	7
Delta Air Lines	10	--	--	10
Delta Connection *(a)*	--	6	--	5
Hawaiian Airlines	2	--	--	2
US Airways *(b)*	11	--	--	11
Lufthansa German Airlines	1	--	--	1
Mexicana de Aviacion *(c)*	2	--	--	2
Northwest Airlines	9	--	--	9
United Airlines	20	--	--	20
United Express/SkyWest Airlines	--	4	21	25
Southwest Airlines	42	--	--	42
Frontier Airlines	5	--	--	5
JetBlue Airways	1	--	--	1
Total	145	49	76	270

(a) SkyWest Airlines and Expressjet.
(b) America West Airlines merged with US Airways in July 2005.
(c) Mexicana discontinued service at PDX in September 2008.
Source: Official Airline Guides, Inc., online database.

As discussed earlier, the Airport is located in the northwestern United States where (1) trip stage lengths are longer in comparison to those at many other airports, and (2) the population densities are lower. The Airport has significantly less regional jet service than many other airports as a result of (1) the airlines' preference to serve the smaller communities using smaller turboprop aircraft, and (2) Southwest Airlines' presence in many regional destinations—including Boise, Las Vegas, Oakland, Reno, Sacramento, Salt Lake City, San Jose, and Spokane. These cities could be candidates for regional jet service provided by other airlines.

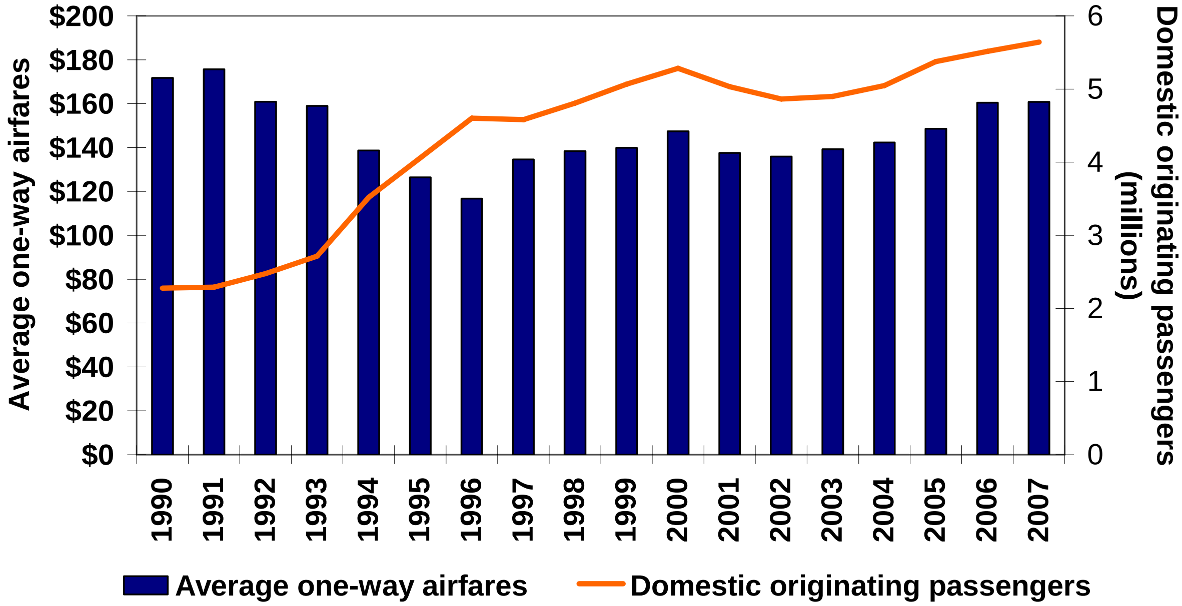
Since 2001, Alaska Airlines' partner, Horizon Air, has acquired new 70-seat regional jet aircraft to replace aging Fokker-28 aircraft of a similar size. Horizon's regional jets fly a variety of medium-haul routes where there is not sufficient demand for Alaska Airlines' larger narrowbody aircraft. In 2007 and 2008, Horizon Air replaced its DH8 aircraft (37 seats) with the Q400 aircraft (74 seats).

3.7 Airfares

Figure 11 shows trends in historical airline fares and numbers of domestic originating (enplaned) passengers at the Airport. There have been four distinct trends in airfares and numbers of passengers at the Airport since 1990. First, fares declined from 1991 to 1996 along with the introduction of low-fare airline service and the competitive response of other airlines. The decline in fares led to high growth in numbers of passengers. Second, from 1996 to 2000, fares increased and numbers of passengers grew at a slower rate than between 1991 and 1996. Third, in 2001 and 2002, fares and numbers of originating passengers decreased as a reaction to the terrorist attacks on September 11, 2001, the wars in Afghanistan and Iraq, the national economic recession, and continuing weak economic conditions. Fourth, between 2002 and 2007, airline fares and numbers of originating passengers increased, consistent with the regional and national economic recovery. The increase in airline fares since 2002 reflect continued increases in world oil prices.

Additional information on PDX airfares and yields (revenue per passenger mile) is presented in Section 5, "Aviation Demand Forecasts."

Figure 11
PDX DOMESTIC ORIGINATING PASSENGERS AND AVERAGE AIRFARES

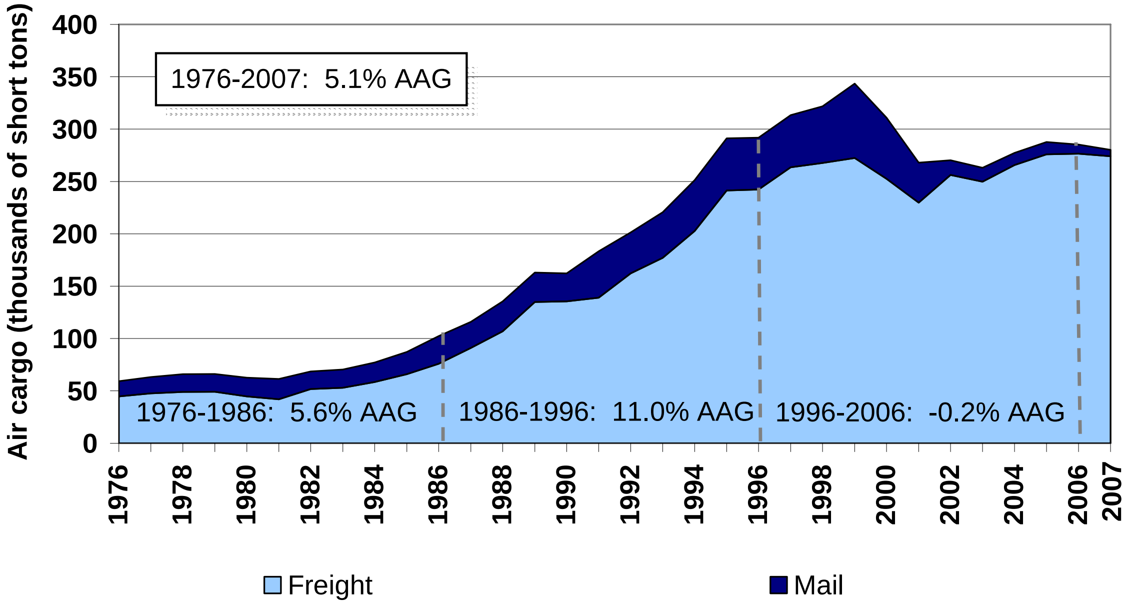


Source: U.S. Department of Transportation, Federal Aviation Administration, *Origin-Destination Survey of Airline Passenger Traffic, Domestic* , OD1A online database.

4. HISTORICAL AIR CARGO DEMAND

PDX was the 24th busiest airport in the United States, in terms of calendar year 2007 air cargo data provided by the Airports Council International, North America. From 1976 to 2007, PDX air cargo tonnage increased an average of 5.1% per year, with the strongest growth occurring from 1986 to 1996 (an average increase of 11.0% per year) principally as a result of strong regional economic growth and the development of cargo airline service at the Airport, as shown on Figure 12. From 1996 to 2006, PDX air cargo tonnage decreased an average of 0.2% per year, with positive growth between 1996 and 1999 (an average increase of 5.6% per year), decreases between 1999 and 2001 (an average decrease of 11.7% per year), and slow growth between 2001 and 2006 (an average increase of 1.3% per year), including a 2.6% decrease in 2003. In 2007, PDX cargo tonnage decreased 1.8%. The fluctuations in air cargo at PDX during the last 11 years reflect overall changes in the cargo industry, including (1) the consolidation of cargo companies such that fewer companies control increasing amounts of air cargo, (2) the increasing use of consolidation points by freight forwarders to channel shipments through one gateway for better corporate rates, (3) the increasing use of trucks to transport cargo to consolidation points, even though the airport in the region may have cargo service, and (4) the increasing market presence of integrated carriers such as FedEx and UPS who have expanded their overall services to increase their market share.

Figure 12
HISTORICAL PDX AIR CARGO



AAG = Average annual growth
Source: Port of Portland records. Includes enplaned and deplaned cargo, measured in short tons. (A short ton is equal to 2,000 pounds.)

4.1 Cargo Airlines Serving PDX

As shown in Table 12, as of August 2008, 13 airlines provided all-cargo service at the Airport, including 3 integrated carriers, 3 all-cargo carriers, and 7 regional feeders.

Table 12

ALL-CARGO AIRLINES SERVING PORTLAND INTERNATIONAL AIRPORT
August 2008

Integrated carriers	Regional feeders
ABX Air	Air Cargo Carriers
FedEx	Ameriflight
UPS Air Cargo	Airpac Airlines
	Empire Airlines
All-cargo carriers	Kalitta Charters
Air China	Martinaire Partners
Air Transport International	Western Express Air Lines
Kitty Hawk Air Cargo	

Source: Port of Portland records.

The air cargo industry includes a diverse collection of companies and services, with differing business strategies, market roles, and abilities to respond to changes in the economic and operating environment. The following is a basic overview of the key participants, their respective customer base, and the various types of modal competition that exists within the industry. The information assists in understanding how the air cargo industry responds to the shifts in economic cycles and shipping patterns. Table 13 provides a summary of the different types of cargo airlines and their associated cargo capacities.

In addition to the various air cargo carriers summarized on Table 13, there are other operators that participate in the transportation of cargo, including freight forwarders and motor carriers. Figure 13 presents an illustration of the services provided by the various types of operators, and depicts how these key components conduct business as they transport cargo from the shipper to consignee.

Table 13

AIR CARGO CARRIER TYPES AND THEIR BUSINESS CHARACTERISTICS

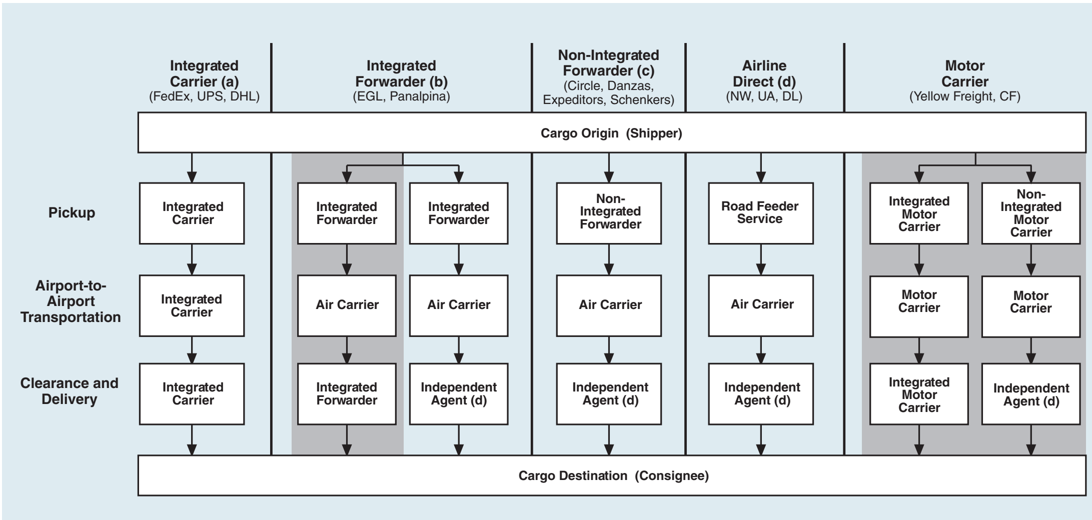
Air cargo carrier types	Characteristics	Illustrative carriers	Customers	Desired airport characteristics
Belly	Baggage holds of passenger aircraft	Delta, Continental, US Airways	Wholesale, mail, retail	Passenger airport
Mixed	Baggage holds of passenger aircraft and main decks of all-cargo aircraft	Northwest, Lufthansa, Cathay Pacific	Wholesale, mail, retail	Passenger airport
Integrated	Main decks of all-cargo aircraft	FedEx, UPS, DHL	Retail	Airport near population
All-cargo	Main decks of all-cargo aircraft	Cargolux, Evergreen Airlines, Atlas Air	Wholesale	Airport near population

4.1.1 Integrated Carriers

The integrated carriers (DHL, FedEx, and UPS) have continued to dominate the domestic express market and to expand their market share in the international cargo market since the early 1990's. At PDX, FedEx, UPS, and ABX Air (provides airlift support and sort facility staffing for DHL) accounted for 79% of total air cargo in 2007, greater than their combined share in 2000 (51%) and 1990 (48%). These companies employ sophisticated sorting equipment, closed-loop business strategies, and precisely choreographed networks of local stations and regional sorting hubs to ensure the delivery of shipments to virtually every address in the domestic United States overnight and most worldwide destinations in two days. These companies continue to grow in size with a surge of corporate acquisitions (e.g., freight forwarding and trucking companies) over the past several years that effectively increased their service offerings to a much wider base of potential customers.

Figure 13

AIR CARGO SERVICES AND SERVICE PROVIDERS



LEGEND

North American market

Notes: (a) Integrated carriers are all-cargo air carriers that own and operate all the equipment and services necessary to provide complete door-to-door customer services.

(b) Integrated forwarders are companies that provide all the services necessary to provide complete door-to-door customer services, typically using air carriers for airport-to-aiport transportation.

(c) Non-integrated forwarders are companies that consolidate freight and arrange complete transportation services using air carriers for airport-to-airport transportation and other comparies for pickup and/or clearance and delivery.

(d) Independent agents are comparies providing only cargo clearance and/or delivery services to air carriers and non-integrated forwarders.

Source: Jacobs Consultancy, July 2008.

PDX611 F-0002

However, while delivery speed and reliability—two strengths of integrated carriers—are important aspects of daily shipping requirements, other modes of transport (e.g., truck, rail) are increasingly providing competitive shipping services at a cost below that of air cargo. For example, trucking is estimated to be 10 to 12 times less expensive than air transportation, and therefore every major U.S. integrated carrier has invested heavily in the development of time-definite regional and transcontinental surface distribution networks. Over the past decade, FedEx acquired American Freightways and Caliber Group (RPS and Caliber Logistics), two of the largest independent trucking companies in the nation, and UPS expanded its Supply Chain Services (SCS) activity through additional infrastructure investments. DHL has also responded to these trends by recently acquiring two of the world's largest freight forwarders, Danzas and Exel, in order to respond to recent customer demand.

4.1.2 All-Cargo Carriers

The all-cargo carriers serving PDX—Air China, Air Transport International, and Kitty Hawk Air Cargo—accounted for 16% of total air cargo in 2007. These carriers operate air carrier aircraft, including the DC-8 Freighter, B-727, B-737, and B-767 aircraft. Air China initiated service at PDX in November 2002.

4.1.3 Regional Feeders

The seven regional feeders serving PDX accounted for 4% of total air cargo in 2007. These carriers operate commuter aircraft, including the ATR aircraft, Caravan 208 aircraft, Embraer Brazilia aircraft, Beechcraft 99 and 1900 aircraft, and the Shorts 360 aircraft.

4.2 Airline Market Shares of Air Cargo

Airline market shares of air cargo at the Airport in 1990, 2000, and 2007 are shown in Table 14. In 2007, all-cargo airlines accounted for approximately 89% of air cargo at PDX, and the remaining 11% was carried as belly-cargo on passenger flights. FedEx accounted for the largest share of air cargo in 2007 (44%), followed by UPS with 24%, ABX Air with 11%, and Air Transport International with 4%, as shown on Figure 14.

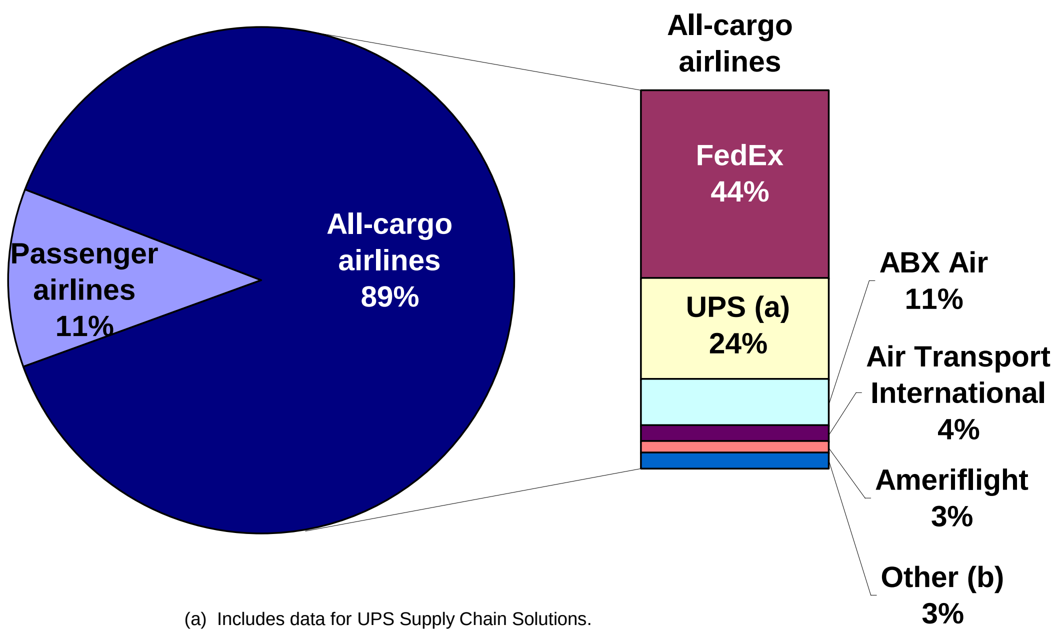
From 1990 to 2007, the share of PDX air cargo carried on passenger aircraft decreased from 41% to 11%, reflecting the overall reduction in cargo capacity on passenger aircraft, especially in the U.S. domestic market, due to the rapid growth in low cost carriers (that specialize in quick gate turnaround times) and use of regional jet aircraft that have minimal to no cargo capacity.

Table 14
AIR CARGO BY AIRLINE
Master Plan Update
Portland International Airport
1990, 2000, and 2007

	Total air cargo (in short tons) (a)			Percent of total		
	1990	2000	2007	1990	2000	2007
All-cargo airlines						
FedEx	18,033	90,622	124,162	11.1%	29.1%	44.3%
UPS *(b)*	60,407	68,778	66,412	37.3%	22.1%	23.7%
ABX Air	0	0	30,232	0.0%	0.0%	10.8%
Air Transport International	0	0	10,784	0.0%	0.0%	3.8%
Ameriflight	1,391	8,313	7,558	0.9%	2.7%	2.7%
Empire	2,330	3,584	3,388	1.4%	1.2%	1.2%
Air China	0	0	2,693	0.0%	0.0%	1.0%
Kitty Hawk	0	17,242	2,170	0.0%	5.5%	0.8%
Air Cargo Carriers	0	0	553	0.0%	0.0%	0.2%
MartinAire Aviation, LLC	0	0	269	0.0%	0.0%	0.1%
Western	0	0	158	0.0%	0.0%	0.1%
Airpac	295	248	156	0.2%	0.1%	0.1%
Kalitta Charters	0	0	12	0.0%	0.0%	0.0%
Other	13,783	48,069	-	8.5%	15.5%	0.0%
	96,238	236,855	248,546	59.4%	76.2%	88.7%
Passenger airlines						
Lufthansa German Airlines	--	--	7,054	--	--	2.5%
Southwest Airlines	--	5,938	5,405	--	1.9%	1.9%
Northwest Airlines	6,699	4,832	5,055	4.1%	1.6%	1.8%
Hawaiian Airlines	--	3,426	2,943	--	1.1%	1.1%
United Airlines	14,842	11,203	2,391	9.2%	3.6%	0.9%
Alaska Airlines	6,727	4,923	2,058	4.2%	1.6%	0.7%
Delta Air Lines	21,576	33,382	2,030	13.3%	10.7%	0.7%
Continental Airlines	1,732	1,259	1,347	1.1%	0.4%	0.5%
Horizon Air	2,263	3,942	1,323	1.4%	1.3%	0.5%
Other	11,928	5,148	2,082	7.4%	1.7%	0.7%
	65,768	74,052	31,690	40.6%	23.8%	11.3%
Total air cargo	162,007	310,908	280,235	100.0%	100.0%	100.0%

(a) Includes enplaned and deplaned freight and mail.
(b) Includes activity for UPS Supply Chain Solutions.
Source: Port of Portland records.

Figure 14
PDX AIR CARGO MARKET SHARES IN 2007

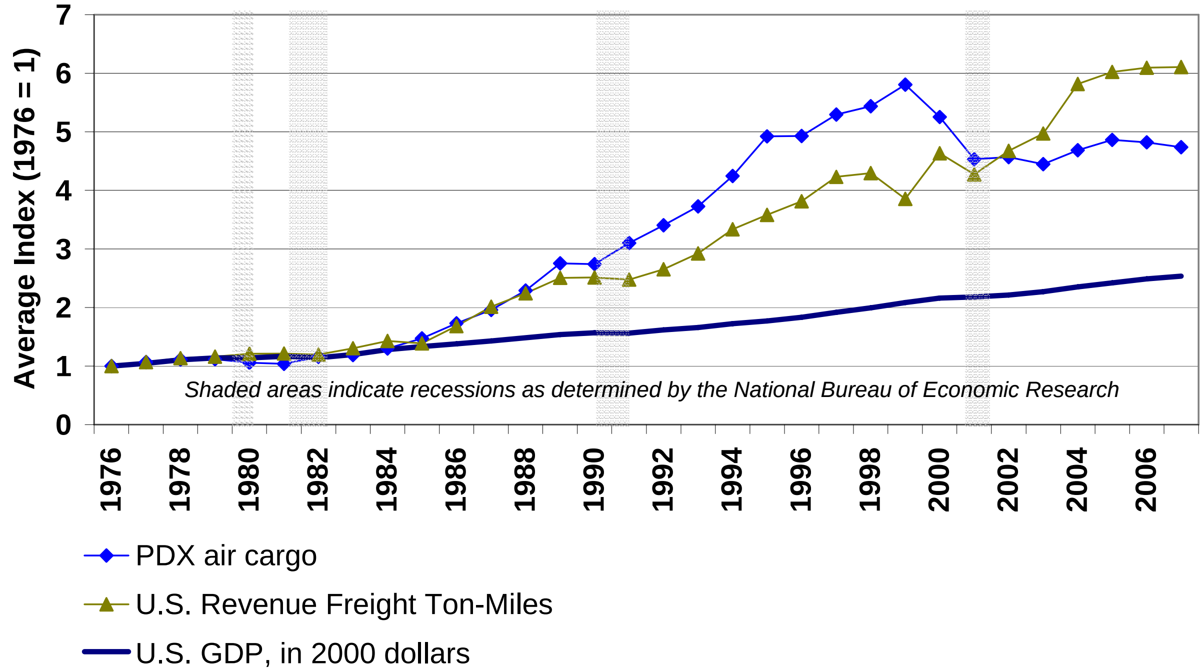


(a) Includes data for UPS Supply Chain Solutions.
(b) Includes activity for other all-cargo airlines reported in Table 12.
Source: Port of Portland records.

4.3 Historical Air Cargo

Many events have affected the air cargo industry growth pattern over the past 30 years. Worldwide economic recession, the threat of terrorism and increased security requirements, as well as regional military/political unrest have all resulted in a short-term reduction in air tonnage levels. However, the long-term trend in U.S. cargo activity (as measured by U.S. revenue freight ton-miles) shows a continual increase, averaging almost 5% per year, as shown on Figure 15. Temporary periods of decline in U.S. cargo activity have historically been followed by a resumption of growth. In contrast, PDX air cargo activity has not recovered from its decline in 1999, although cargo tonnage has stabilized at 2001 levels.

Figure 15
PDX AND U.S. AIR CARGO TRENDS



Sources: PDX enplaned passengers--Port of Portland records. U.S. Revenue Freight Ton-Miles--U.S. Department of Transportation, Bureau of Transportation Statistics, www.bts.gov. U.S.GDP--U.S. Department of Commerce, Bureau of Economic Analysis, www.bea.gov.

Table 15 presents historical data on air cargo at the Airport from 1976 through 2007. Through the four national economic downturns that have occurred since 1976, air cargo tonnage at the Airport increased each year except in 1980, 1981, 1990, 2000, and 2001, indicating a strong overall market for air cargo. However, since 2001, air cargo traffic at PDX has decreased in 3 of the last 6 years, reflecting consolidation in the cargo industry, the increasing use of consolidation points by freight forwarders, the increasing use of trucks to transport cargo to consolidation points, and the increasing market presence of integrated carriers, as discussed earlier.

Table 15

HISTORICAL AIR CARGO

Master Plan Update

Portland International Airport

1976 - 2007

Year	Freight	Increase (decrease)	Mail	Increase (decrease)	Total	Increase (decrease)
1976	44,616	--%	14,552	--%	59,168	--%
1977	47,737	7.0%	15,337	5.4%	63,074	6.6%
1978	48,999	2.6%	16,795	9.5%	65,794	4.3%
1979	49,239	0.5%	16,824	0.2%	66,063	0.4%
1980	44,754	-9.1%	17,820	5.9%	62,574	-5.3%
1981	41,979	-6.2%	19,413	8.9%	61,392	-1.9%
1982	51,780	23.3%	16,753	-13.7%	68,533	11.6%
1983	52,898	2.2%	17,452	4.2%	70,350	2.7%
1984	58,427	10.5%	18,572	6.4%	76,999	9.5%
1985	65,808	12.6%	21,352	15.0%	87,160	13.2%
1986	75,918	15.4%	26,458	23.9%	102,376	17.5%
1987	91,027	19.9%	24,879	-6.0%	115,906	13.2%
1988	106,851	17.4%	28,565	14.8%	135,416	16.8%
1989	134,852	26.2%	28,061	-1.8%	162,913	20.3%
1990	135,527	0.5%	26,705	-4.8%	162,007	-0.6%
1991	139,066	2.6%	44,323	66.0%	183,389	13.2%
1992	162,189	16.6%	39,139	-11.7%	201,328	9.8%
1993	177,110	9.2%	43,532	11.2%	220,642	9.6%
1994	202,688	14.4%	48,611	11.7%	251,299	13.9%
1995	241,346	19.1%	49,818	2.5%	291,164	15.9%
1996	242,258	0.4%	49,527	-0.6%	291,785	0.2%
1997	263,528	8.8%	49,792	0.5%	313,320	7.4%
1998	267,730	1.6%	54,071	8.6%	321,801	2.7%
1999	272,353	1.7%	71,134	31.6%	343,487	6.7%
2000	252,535	-7.3%	58,368	-17.9%	310,903	-9.5%
2001	229,863	-9.0%	38,146	-34.6%	268,009	-13.8%
2002	256,333	11.5%	13,936	-63.5%	270,269	0.8%
2003	249,880	-2.5%	13,309	-4.5%	263,189	-2.6%
2004	265,626	6.3%	11,654	-12.4%	277,280	5.4%
2005	275,798	3.8%	11,823	1.5%	287,621	3.7%
2006	276,473	0.2%	8,852	-25.1%	285,325	-0.8%
2007	274,156	-0.8%	6,079	-31.3%	280,235	-1.8%

Average annual percent increase (decrease)

	Freight	Mail	Total
1976-1986	5.5%	6.2%	5.6%
1986-1996	12.3%	6.5%	11.0%
1996-2006	1.3%	-15.8%	-0.2%
2006-2007	-0.8%	-31.3%	-1.8%
1976-2007	6.0%	-2.8%	5.1%
1996-1999	4.0%	12.8%	5.6%
1999-2001	-8.1%	-26.8%	-11.7%
2001-2006	3.8%	-25.3%	1.3%

Note: Includes enplaned and deplaned cargo, measured in short tons. (A short ton is equal to 2,000 pounds.)

Source: Port of Portland records.

5. AVIATION DEMAND FORECASTS

An update of the aviation demand forecasts for the Airport over the period 2006 through 2035 has been prepared as described in this section. This update included a review of the previous forecasts prepared for the 1999 Airport Master Plan and the most recent FAA Terminal Area Forecast (the FAA 2007 TAF). Calendar year 2006 was selected as the base year since it is the most recent full year for which aviation activity statistics were available when the forecast was developed. However, actual activity for 2007 became available during the time the forecasts were prepared.

The forecasts were prepared for four future demand years, 2012, 2017, 2027, and 2035, and are based on unconstrained demand which assumes that there are no physical, regulatory, environmental or other impediments to aviation activity growth. This analysis focuses on the future levels of enplaned passenger demand since it is the key determining factor in planning terminal and other landside facilities. In addition to forecasts of passenger activity, this analysis also includes forecasts for air cargo tonnage and aircraft operations. Forecasts of aircraft operations are provided for passenger, all-cargo, general aviation, and military operations.

5.1 Forecast Methodology

The methodology for the forecasts of enplaned passengers, air cargo, and aircraft operations is summarized in the following sections. The forecasts were developed after considering (1) a number of standard industry forecasting techniques including trend analysis, market share analysis, econometric modeling, airline schedule analysis and professional judgment and (2) probabilistic forecasting, an innovative technique used to evaluate the probability of a level of activity in a given forecast year. Although the results of these multiple forecasting techniques were considered, the primary forecasting methodology applied used econometric modeling and probabilistic forecasting. In addition, sensitivity tests of the forecasts were prepared (defined by the list of key issues and trends presented earlier) and are described in Section 6.

5.1.1 Econometric Modeling

Econometric modeling (also referred to as linear regression) compares the historical relationship between a dependent variable, in this case, enplaned passengers and air cargo, and an independent or "predictor" variable. The predictor variable is eventually used to project future levels of the dependent variable. In aviation demand forecasts the predictor variable is typically represented by an economic or demographic metric such as population, employment, or personal income. Econometric analyses produce a mathematical equation that identifies the strength or reliability of the historical correlation between the dependent variable (enplaned passengers) and predictor variables. The statistical reliability of this equation is typically measured by a regression statistic known as "R-squared." An R-squared of 1.0 would represent a perfect historical correlation between the dependent and predictor variable and suggest that the measurement of this historical relationship will be a reliable predictor of future results.

Two econometric models were defined during the forecast process to represent passenger and air cargo demand. In addition, a system of equations was developed to define yield (fare revenue per passenger mile), a measure of the cost of travel, and to provide for the ability to test the impact of changes in the price of oil on passenger and cargo demand. The passenger and air cargo models and the yield equations are summarized in Table 16.

5.1.2 Air Travel Demand Elasticity

The elasticity of a demand variable measures the sensitivity of demand for air travel to changes in that variable when other influences on demand are held constant. It is defined as the percentage change in demand resulting from a given percentage change in the demand variable. For example, if a 1% increase in airfare results in a 1.2% decrease in passenger demand, the fare elasticity of demand is 1.2. In this case, since the percentage decrease in demand is greater than the percentage increase in airfare, the demand is said to be “elastic” or sensitive to changes in airfare. If, on the other hand, a 1% increase in airfare causes a smaller percentage decline in passenger demand, the fare elasticity will be less than one, and demand is said to be “inelastic” or insensitive to changes in airfare.*

During the tests of econometric models for passenger demand, it was discovered that:

- The fare elasticity, the coefficient for yield, was considerably less than 1.0 in aggregate or total enplaned passenger models based on a 31-year data series and using U.S. domestic yield as a cost of travel independent variable. This suggested that PDX passenger demand was relatively inelastic or insensitive to changes in airfare.

- In aggregate passenger models based on a 17-year data series and using PDX specific yield, the fare elasticity was somewhat higher than those for the 31-year models but also less than one. The 17-year model results were unacceptable (i.e., variable coefficients were insignificant or unreasonable).

As a result of these findings, tests of fare elasticity by market were conducted to determine whether the fare elasticity for PDX passenger markets is higher than that obtained from the aggregate models of total enplaned passengers. The results of this analysis are described in the following section.

*Gillen, David W., Morrison, William G., and Stewart, Christopher, “Air Travel Demand Elasticities: Concepts, Issues, and Measurement”, Final Report, December 2002.

Table 16
ECONOMETRIC MODELS
Master Plan Update
Portland International Airport

PASSENGER MODEL	
Dependent variable = ln(PDX total enplaned passenger, thousands)	
Independent variables / coefficients	
ln(mixed yield, cents per pax-mile in 2006 dollars) *(a)*	-1.1475
ln(mixed yield)*dummy before 1990	0.5998
ln(Portland-Vancouver region population, thousands)	0.8878
ln(Portland-Vancouver region per capita personal income, in thousands of 2006 dollars)	1.0422
dummy for years before 1990 (=1, if year<1990)	-1.8281
dummy for year 2001 (=1, if year =2001)	-0.2931
dummy for Sept. 11 (=1, if year >=2002)	-0.3871
Constant	1.3933
Observations	31
Adjusted R-squared	0.9910
CARGO LOGISTIC MODEL	
Dependent variable = (PDX cargo / Portland-Vancouver region total income)	
(PDX cargo/Portland-Vancouver region total income)=0.0147*exp(-329*dummy)(=1 if year >1999)*(price of oil^-.164)/(1+exp(1.53-0.079*(year-1976))	
Observations	31
Adjusted R-squared	0.9400
YIELD EQUATIONS	
1 Dependent variable = ln(PDX yield, cents per passenger mile in 2006 dollars)	
Independent variables / coefficients	
ln(US domestic yield, cents per passenger mile in 2006 dollars)	1.0479
dummy for Southwest (=1, if year >=1994)	-0.1840
Constant	-0.1452
Observations	17
Adjusted R-squared	0.9660
2 Dependent variable = US domestic yield, cents per passenger mile in 2006 dollars	
Independent variables / coefficients	
Predicted US domestic yield, cents per passenger mile in 2006 dollars *(b)*	1.0968
Constant	-3.4750
Observations	31
Adjusted R-squared	0.9440
3 Dependent variable = fuel cost, cents per available seat mile (ASM) in 2006 dollars	
Independent variables / coefficients	
Oil price, dollars per barrel in 2006 dollars	0.0455
Constant	0.3927
Observations	17
Adjusted R-squared	0.8730

(a) Mixed yield includes U.S. domestic yield from 1976 through 1989 and PDX yield from 1990 through 2006. A consistent data series for PDX yield was not available from 1976 through 2006.

(b) Predicted U.S. domestic break-even yield, in 2006 dollars = (U.S. domestic non-fuel cost/asm + U.S. domestic fuel cost/asm) / load factor, where asm = available seat miles.

Sources: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

5.1.3 Market Models

Market model tests were conducted using panel models or cross-sectional time series models which evaluated a cross-section of PDX passenger markets from 1990 to 2005. Using city-pair market data, including PDX originating passengers, socioeconomic variables, and yield, the objectives of the market model tests were to:

- Investigate if the relatively low fare elasticity found in the aggregate passenger models would also be found in a market-level model.
- Evaluate whether the market model statistics would be appropriate benchmarks for an aggregate model.

Market model tests were conducted of the top 20, 40, 60, 80, and 100 PDX originating passenger markets. Comparable aggregate models of originating passengers were also prepared for the purpose of comparison with the market model results. Evaluations of cross-elasticity were also conducted to capture the extent to which air travelers substitute trips in low fare markets for trips in high fare markets. The primary findings of the market model tests were:

- Fare elasticity (the yield coefficient) is higher in the passenger market models than in the aggregate models.
- Fare elasticity in the market model tests is consistently about 1.0, whereas fare elasticity in the aggregate models varies greatly.
- Fare elasticity increased as more markets are included in the tests (from the top 20 to top 100 markets), while the income coefficient decreased in magnitude.
- Cross-elasticity (the substitution effect) becomes insignificant when more markets are included in the tests.

Fare elasticity is an important issue from a forecasting standpoint because of the potential for future yields to increase substantially as a result of higher fuel price and other factors. The findings of the market model tests show that, in fact, fare elasticity is higher in a market-level model. This implies that aggregate models with fare coefficients of magnitude much below 1.0 should not be used for forecasting.

5.1.4 Forecast Scenarios

Forecast scenarios are intended to provide a framework for thinking about future aviation activity and the factors that affect it. For example, a high growth scenario of enplaned passengers might be characterized in terms of strong economic growth—regionally and nationally, relatively low oil prices and a corresponding low cost of travel, and the absence of any major external events that might adversely affect future passenger traffic.

The scenarios used in the PDX MP forecasts were defined by (1) the list of key issues and trends presented earlier, (2) the variables included in the econometric models, and (3) input on the future parameters of those variables. The input on the future values of the variables considered came from numerous sources, including published long-term forecasts from Metro (the Portland-Vancouver region's Metropolitan Planning Organization or MPO), the Department of Energy (DOE), the International Energy Administration (IEA), the World Bank, and the Federal Aviation Administration, as well as short-term forecasts prepared by financial institutions such as Deutsche Bank, Lehman Brothers, and Morgan Stanley. In addition, input was also provided by the members of Forecast Subcommittee and Planning Advisory Group (through a Forecast Scenario Survey conducted in February 2008), the Port of Portland, the City of Portland, and the peer reviewer.

The forecast parameters of the independent variables used in the probabilistic forecasting are discussed in the following section. Table 17 presents a summary of the parameters.

5.1.5 Probabilistic Forecasting

Standard industry forecasting techniques, including econometric modeling, typically produce point estimate forecasts (e.g., enplaned passengers will total 3.5 million in 2020). These estimates oftentimes neglect the sources of uncertainty associated with the forecasts or are incapable of assessing the level of uncertainty. In contrast, probabilistic forecasts express the likelihood of obtaining a future value in a given year and provide an indication of the uncertainty or risk associated with future values. Although probabilistic forecasting is not yet widely used in the preparation of aviation forecasts, recent studies suggest that it can be an invaluable tool in assessing the uncertainty associated with future aviation demand.*

*Bhadra, Dipasis and Schaufele, Roger, "Probabilistic Forecasts for Aviation Traffic at the Federal Aviation Administration's Commercial Terminals: A Suggested Methodology and an Example", The Mitre Corporation, June 2006.
Hardison, Matthew F., Mudge, Richard R., and Lewis, David, "Using Risk Assessment for Aviation Demand and Economic Impact Forecasting in the Minneapolis-St. Paul Region", Transportation Research Board, Record 1274.

Table 17
FORECAST PARAMETERS
Master Plan Update
Portland International Airport

Variable	Year	Minimum	Mode	Maximum
Portland-Vancouver region Income per Capita (in thousands of 2006 dollars)	2012	34.58	41.30	44.12
	2017	34.89	44.90	49.21
	2027	36.36	53.60	60.04
	2035	36.66	62.00	69.34
Oil price after carbon tax (dollars per barrel, in 2006 dollars)	2012	42.2	56.3	79.1
	2017	35.5	57.8	101.8
	2027	38.8	71.7	126.8
	2035	43.9	89.7	155.6
Non-fuel cost (cents per available seat mile (ASM), in 2006 dollars)	2012	8.25	9.57	11.05
	2017	7.65	9.34	11.29
	2027	6.27	9.01	12.54
	2035	4.99	8.83	14.36
U.S. domestic load factor	2012	72.7	76.7	81.5
	2017	74.0	78.7	85.0
	2027	76.0	81.9	90.3
	2035	77.1	83.9	93.2
Oil price before carbon tax (dollars per barrel, in 2006 dollars) *(a)*	2012	42.2	56.3	79.1
	2017	33.7	50.5	83.2
	2027	36.0	59.0	98.9
	2035	39.5	66.7	114.5
Passed on carbon tax (dollars per barrel, in 2006 dollars)	2012	0.00	0.00	0.00
	2017	1.83	7.32	18.57
	2027	2.77	12.71	27.84
	2035	4.43	22.96	41.06
Price of carbon emissions (in 2006 dollars per metric ton)	2012	0.00	0.00	0.00
	2017	14.64	29.28	49.52
	2027	22.15	50.83	74.23
	2035	35.46	91.84	109.48
CO2 emissions from one barrel of oil (metric tons / barrel)		0.5	0.5	0.5
Fraction of carbon tax passed on to airlines		0.250	0.500	0.750

Variable	Year	Mean	Standard deviation
Portland-Vancouver region population	2012	2,402,382	27,149
	2017	2,604,874	45,093
	2027	2,933,505	79,797
	2035	3,156,034	109,885

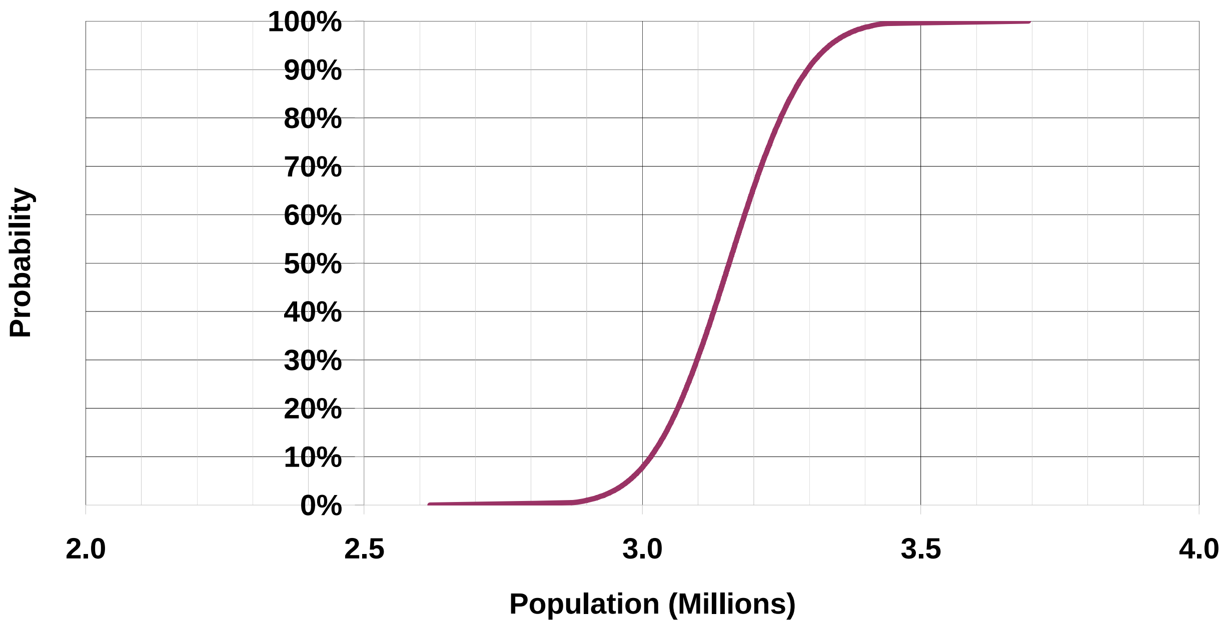
(a) Represents the acquisition cost to refiners.

Sources: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

In probabilistic forecasting, probability distributions of the independent variables included in the econometric modeling of aviation demand are defined and used to generate a range of probable future values. The probability distributions represent the range of potential future values for a particular variable. Figure 16 presents a cumulative distribution function of population, one of the independent variables used in the passenger model.

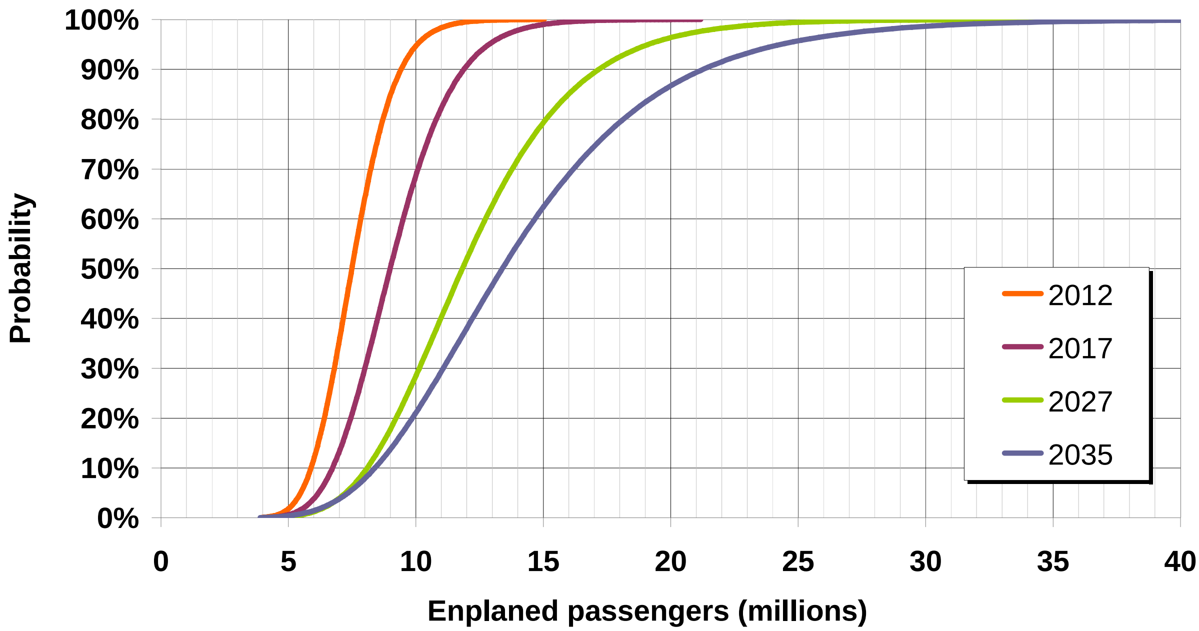
Monte Carlo simulation is used to simulate a probability distribution for total passenger demand based on the probability distributions of the independent variables, together with the econometric model used to define the underlying causal relationships. In Monte Carlo simulation, values from each independent variable's probability distribution are randomly selected and used to generate values of total enplaned passengers based on the passenger model. Approximately 10,000 trials are conducted to create a probability distribution of total enplaned passengers. For the PDX MP forecasts, the cumulative probability distributions of total enplaned passengers created for the four future demand years—2012, 2017, 2027, and 2035—are presented on Figure 17.

Figure 16
CUMULATIVE DISTRIBUTION OF POPULATION IN 2035



Source: Metro, the Portland-Vancouver region's Metropolitan Planning Organization.

Figure 17
CUMULATIVE DISTRIBUTIONS OF PDX ENPLANED PASSENGERS



Source: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

5.1.6 Aircraft Operations Forecasting

The aircraft operations forecasts are prepared in two parts: (1) the forecasts of passenger and cargo airline aircraft departures and (2) the forecasts of general aviation and military activity. The forecasts of passenger airline aircraft departures are based on the enplaned passenger forecasts and assumptions regarding average aircraft size and enplaned passenger load factor. For example, a forecast of 1 million enplaned passengers at an airport with an average aircraft size of 100 seats and an enplaned passenger load factor of 80% would generate 12,500 annual departures (or approximately 25,000 aircraft operations, arrivals and departures). The forecasts of all-cargo airline aircraft departures are based on future assumptions about cargo tonnage enplaned per departure for air carrier and regional feeder aircraft.

The forecasts of general aviation and military aircraft operations are defined by the number of aircraft based at an airport, the average daily utilization of those aircraft, and assumptions regarding aircraft utilization in the future. For example, the average utilization, in terms of general aviation operations per based aircraft, for an airport with 200 based aircraft and 100,000 annual general aviation aircraft operations would be 500 average daily operations. If the number of based aircraft increased to 250 and utilization is expected to increase to 600 operations per day, the forecast of annual general aviation operations would be 150,000 for that future year. Data for the number of passengers and/or cargo carried on general aviation are not collected and, therefore, are not available as a metric for forecasting future operations.

5.2 Sources of Forecast Uncertainty

There are a number of sources of uncertainty related to the econometric modeling of aviation forecasts that have also been identified during the forecast process, including:

- Model predictive error. There is no such thing as a "perfect" regression model. A model that fits the historical data well may not fully reflect all the relevant factors that will influence demand in the future.

- Error-in-the-variable bias. The data for the independent variables is subject to random errors of measurement.

- Coefficient estimation error. The coefficients are estimates and will not exactly equal the true coefficients. These errors take two forms:

  – Errors in the historical coefficient values

  – Uncertainty in how the coefficients may change in the future

- Independent variable forecast error. The aviation demand forecasts require forecasts of the independent variables such as yield, population, etc, which are themselves uncertain.

5.3 Study Limitations

During the forecast process, a number of limitations were identified related to the reporting and composition of aviation data and the potential effects on the forecasts. To the extent that time and budget were available, every effort was made to address the issues raised by the Forecast Subcommittee, PAG, peer reviewer, and members of the public. This section presents a summary of the limitations related to yield data, aircraft fuel efficiency, and air cargo activity.

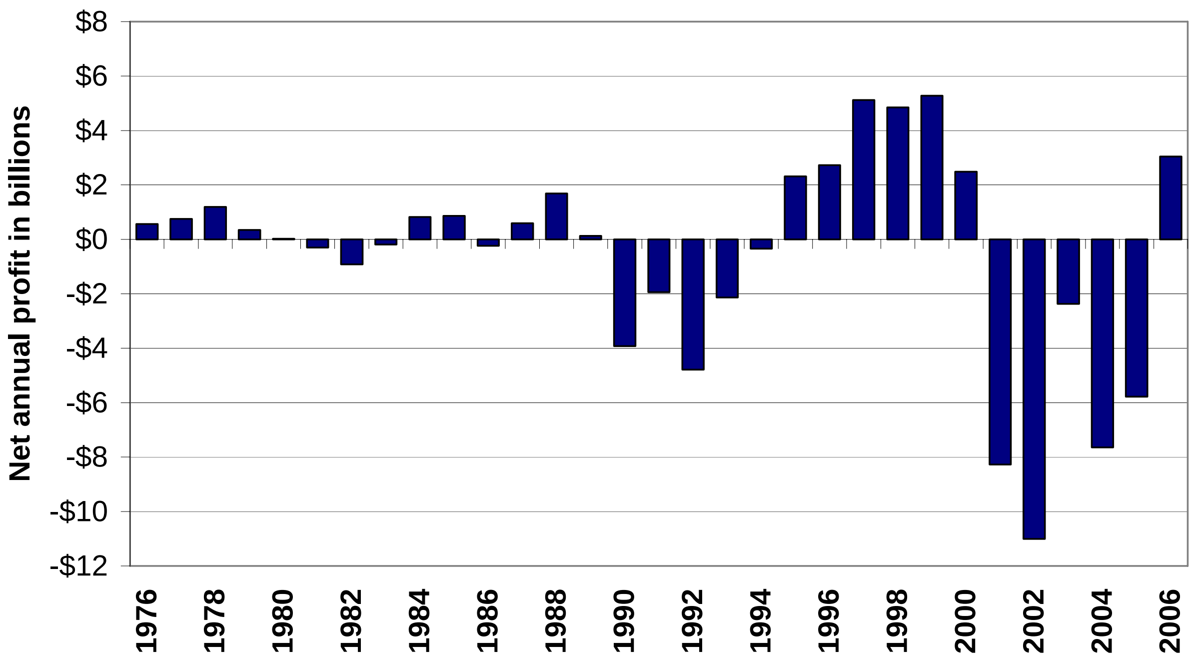
5.3.1 Yield Data

In many respects, the uncertainty and challenges faced by the airline industry are reflected in yield data. As a result, the analysis of yield data is limited by the extent to which it can be used as a reliable indicator of the future. Three issues were identified that affect the interpretation of yield data, including: (1) airline profitability, (2) the relationship between PDX yield and U.S. domestic yield, and (3) data reporting and measurement.

Airline Profitability

From 1976 to 2006, U.S. airlines collectively recorded losses, in terms of net annual profits, for 14 of 31 years (or 45% of the time), according to Air Transport Association (ATA).* Since 1990, U.S. airlines have been unprofitable for 10 of 17 years (or 59% of the time), with some of the largest losses reported during the years since 2000, as shown on Figure 18.

Figure 18
U.S. AIRLINE NET ANNUAL PROFITS



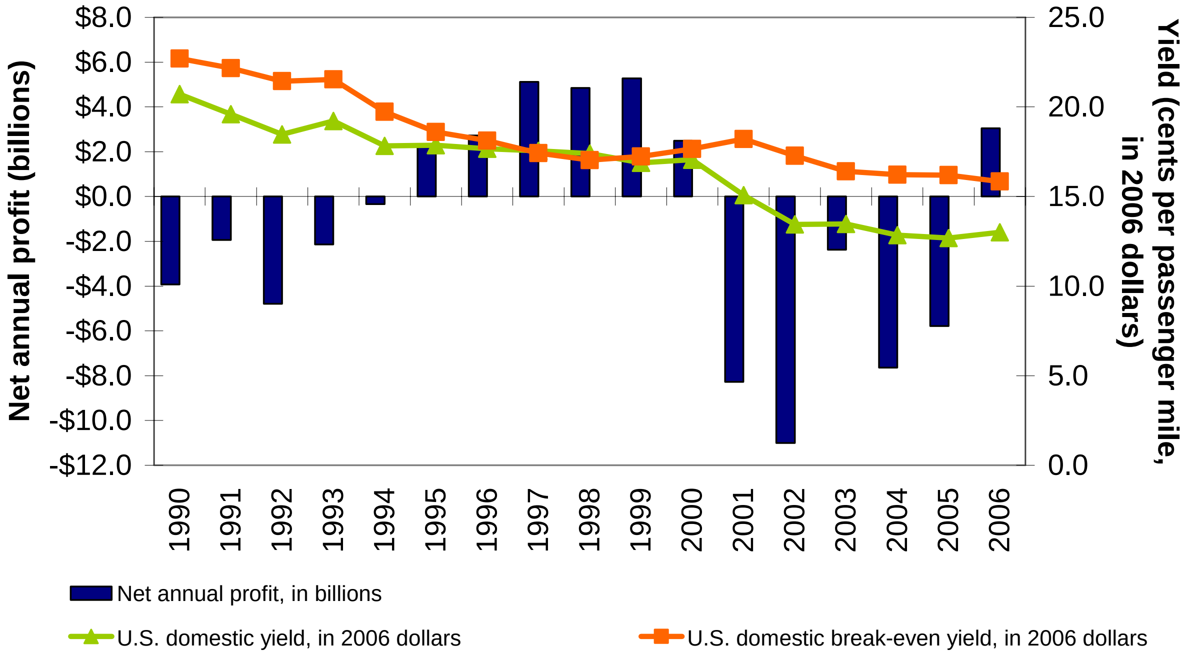
Source: Air Transport Association, online database, as reported from U.S. Department of Transportation, Form 41 financial reports.

In addition to the annual net losses reported since 1990, U.S. airlines have operated at less than break-even yields** during this period, as shown on Figure 19. From 1990 to 2006, break-even yields for U.S. airlines were greater than actual yields for 15 of 17 years (or 88% of the time). That is, U.S. airline unit costs exceeded unit revenue for most of the last two decades.

*ATA data are derived from U.S. Department of Transportation Form 41 financial reports.

**Break-even yield = U.S. domestic non-fuel cost/asm + U.S. domestic fuel cost/asm) / load factor, where asm = available seat miles.

Figure 19
U.S. AIRLINE ACTUAL AND BREAK-EVEN DOMESTIC YIELD



Break-even yield = (U.S. domestic non-fuel cost/asm + U.S. domestic fuel cost/asm) / load factor), where asm = available seat miles.
Source: Air Transport Association, online database, as reported from U.S. Department of Transportation, Form 41 financial reports.

The fact that U.S. airlines could operate unprofitably and at below break-even yields for such an extended period is most likely related to the following factors:

- U.S. airline reported costs are more than their actual out-of-pocket expenses, reflecting tax deductions for depreciation and other adjustments to income.

- Airlines have other sources of revenue such as cargo, regional affiliate agreements, and miscellaneous sources such as airline frequent flyer programs. Many airlines now earn hundreds of millions of dollars per year by selling miles to partners such as credit card companies and hotel chains.* For example, in 2006, American Airlines reported $0.8 billion in cargo revenue and $1.4 billion in miscellaneous revenue, for a total of approximately $2.2 billion (or 10% of its total revenues).** These revenues are not included in the calculation of yield.

---

*The New York Times, "Award Plans Earn Cash for Airlines", April 1, 2008, www.nytimes.com.

**United States Securities and Exchange Commission, *Form 10-K/A*, American Airlines, Inc., for the fiscal year ended December 31, 2006, www.sec.gov.

- U.S. airline Chapter 11 bankruptcy filings, particularly since 2000, have resulted in extraordinary airline losses. During the preparation of the PDX MP forecasts, four U.S. airlines filed for Chapter 11 protection—Aloha Airlines, ATA Airlines, Frontier Airlines, and Skybus, with two of the four (ATA and Skybus) subsequently terminating operations.

- Predatory pricing, particularly among new entrant airlines, has contributed to airlines operating below break-even yields. The most recent example is the Chapter 11 bankruptcy filing by Aloha Airlines (the second such filing in the airline's past five years) in response to predatory pricing by Go Jet!, a new entrant airline and subsidiary of Mesa Airlines. Aloha announced on March 30, 2008 that it would cease operations on April 1, 2008.

Given the history of airline losses and below break-even operating performance, it is not surprising that an econometric analysis of the past 31 years would suggest that airlines will continue to operate unprofitably. Although the idea that U.S. airlines will choose to operate unprofitably in the future seems unlikely, it is also equally unlikely, based on the reported data, that airlines, as a group, will always be profitable.

A more complete understanding of the extent to which airline reported costs differ from their actual out-of-pocket expenses would require a substantial investment of time and effort which are beyond the scope of this study. It is also uncertain whether a further investigation of airline costs will substantially improve the forecast results. Therefore, for the purposes of the PDX MP forecasts, it is assumed that the probabilistic forecasts provide for a range of profitable and unprofitable airline scenarios in the future, given the data upon which this analysis was based.

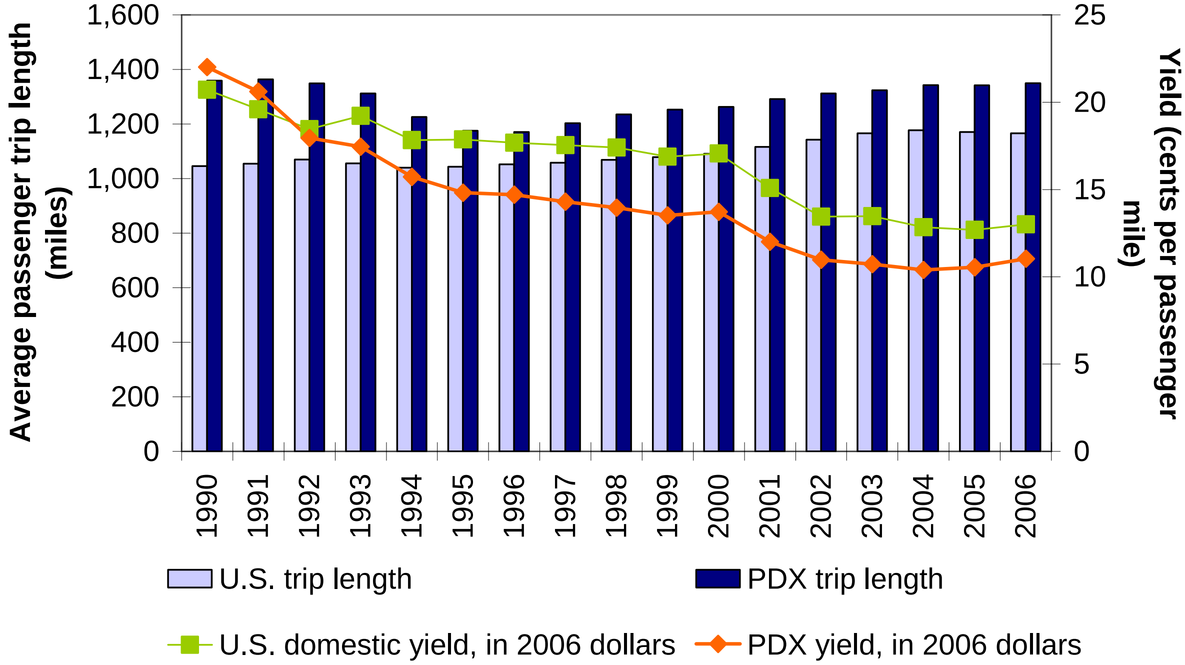
PDX Yield and U.S. Domestic Yield

The relationship between PDX and U.S. domestic yield from 1990 to 2006 is shown on Figure 20. The yield data and the PDX yield equation* imply that the difference between PDX yield and U.S. domestic yield will continue in the future. There are a number of factors that suggest that PDX yield will continue to remain lower than U.S. domestic yield including: (1) the market presence of low cost carriers at PDX** and Alaska and Horizon which all together account for nearly 60% of PDX passenger traffic and (2) the geographic location of PDX and an average passenger trip length that has consistently remained greater than that for the nation. Typically, the yield for a long airline trip is less than that for a trip of shorter length.

---

*PDX yield equation: ln (PDX yield, 2006 dollars) = -0.145 + 1.048*ln(U.S. domestic yield, 2006 dollars) -0.184*dummy for Southwest (=1, if year >=1994)
**Includes Frontier, Jet Blue, and Southwest.

Figure 20
PDX AND U.S. DOMESTIC YIELD



Sources: Air Transport Association, online database, as reported from U.S. Department of Transportation, Form 41 financial reports and U.S. Department of Transportation, Origin-Destination Survey of Airline Passenger Traffic, online database.

However, it is important to note that a number of conditions could result in a convergence of PDX and U.S. domestic yield, including (1) a continued decline in non-fuel costs that could occur if the low cost carrier business model became the predominant one for the U.S. airline industry or, conversely, (2) an increase in low cost carrier costs and a restructuring of operations that could occur if the traditional network carrier business model was predominant.

Data Reporting and Measurement

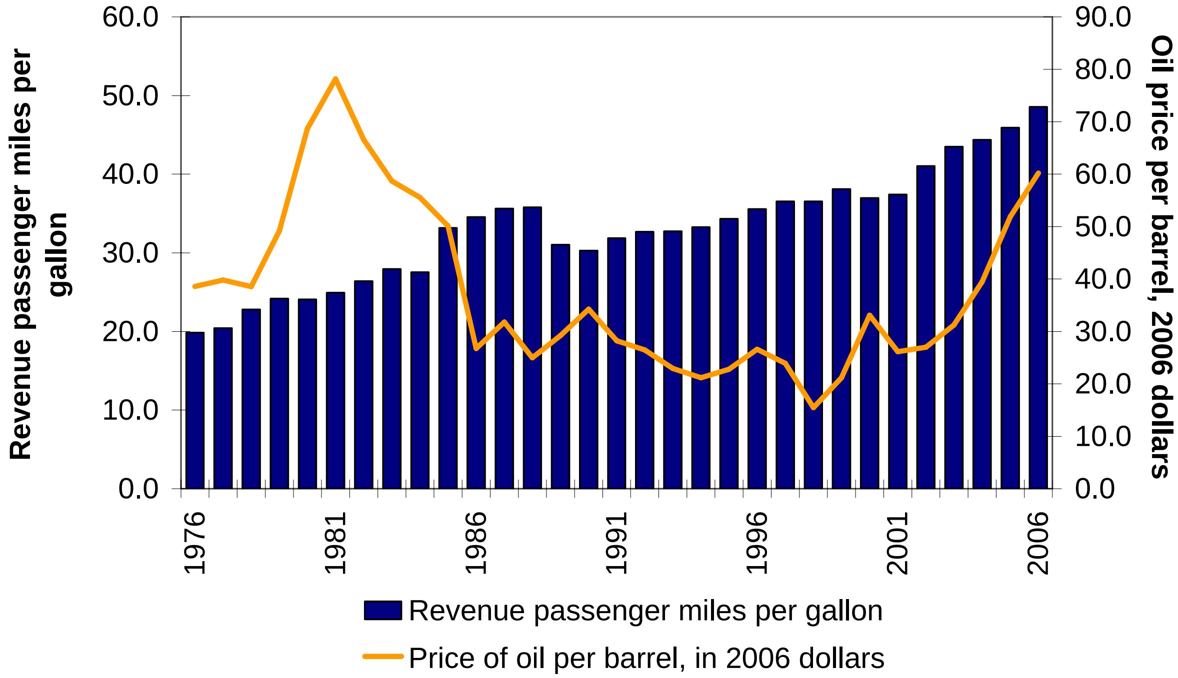
During the process of evaluating PDX and U.S. domestic yield, the following data reporting and measurement limitations were noted:

- A reliable and consistent data series for PDX yield was not available before 1990 due to inconsistent reporting by airlines, particularly regional and commuter airlines.
- Data for U.S. domestic yield are not perfectly correlated with PDX yield, reflecting error-in-variables bias or measurement error in the reporting of yield data.

5.3.2 *Aircraft Fuel Efficiency*

From 1976 to 2006, the fuel efficiency of the U.S. airline industry has more than doubled, as measured by the average number of revenue passenger miles (RPMs) per gallon shown on Figure 21. During most of the same period, real oil prices averaged about $20 to $30 per barrel, suggesting that factors other than the price of oil contributed to the gains in aircraft fuel efficiency. These factors included (1) the modernization of aircraft fleets which incorporate new fuel efficient technology and lighter designs, (2) improvements in the operational efficiencies of airline hubs, and (3) significant increases in average passenger load factors.

Figure 21
AIRCRAFT FUEL EFFICIENCY



Sources: Air Transport Association, online database, as reported from U.S. Department of Transportation, Form 41 financial reports and U.S. Department of Energy, Energy Information Administration, online database.

In addition, in recent years, airlines have employed other strategies to either increase RPMs per gallon or decrease their costs of fuel, including:

- The creation of airline fuel hedging programs. According to the Air Transport Association, Southwest and Alaska Airlines hedge approximately 70% and 40%, respectively, of their fuel costs.
- The adoption of operational procedures to reduce fuel burn, such as single-engine taxi procedures during normal operations, selective engine shutdown

during ground delays, cruising longer at higher altitudes, and employing shorter, steeper approaches.

- The reduction and more accurate measurement of onboard weight while redistributing belly cargo.
- The tankering of extra fuel on certain flights to avoid refueling at more expensive locations.
- The addition of fuel efficient technology, such as winglets, to existing fleets.
- The use of ground power rather than onboard auxiliary power units (APUs) when at the gates.

The combined contribution of the strategies that airlines have taken to increase aircraft fuel efficiency is difficult to measure and assess, particularly when there are no reported data on many of these efforts. The fuel cost equation* employed in the evaluation of PDX yield relates the fuel cost per available seat mile (asm) to the cost of oil per barrel which includes the cost of carbon futures. The objective of the fuel cost equation was to provide a mechanism for testing the sensitivity of PDX passenger traffic to changes in the price of oil. The fuel cost equation, as well as any analysis of aircraft fuel efficiency, is limited by the data available to understand the causal factors affecting the RPMs per gallon. Therefore, for the purposes of the PDX MP forecasts, it is assumed that airlines will continue to improve aircraft fuel efficiency, as they have done in the past, and that these measures will be captured in the trends of RPMs per gallon.

5.3.3 Air Cargo Activity

An assessment of the demand for air cargo activity is challenged by a number of factors, including:

- The market for cargo (air and ground transported) is larger than the cargo activity handled at an airport. Therefore, air cargo activity reported at an airport is a subset of the total cargo market and is difficult to relate to regional population and economic trends.
- The transfer of cargo between air and ground transport modes is controlled by the corporations who demand and purchase cargo services from a variety of cargo operators. As a result, no one cargo operator has a complete picture of total demand for any one corporation.

*Fuel cost equation = U.S. domestic fuel cost, cents per asm, in 2006 dollars = 0.393 + 0.0455 * oil cost, dollars per barrel, in 2006 dollars, where oil cost = market price of oil per barrel + carbon emission costs per barrel, in 2006 dollars * share of the carbon tax passed on to industry and consumers.

- Cargo operators have prearranged agreements for distribution points and volume price shipments which affect the flow of cargo at airports and increase the difficulty of evaluating air cargo demand.

- All-cargo airlines such as FedEx report activity in aggregate for air and ground components, which makes it difficult to compare all-cargo airline shares of labor and fuel costs with those for passenger airlines. For example, the fuel share reported in FedEx's annual report was 11% in 2007*, compared with 28% for Southwest Airlines**.

5.4 Probabilistic Passenger Forecasts

The probabilistic passenger forecasts for PDX are presented in Table 18 and illustrated on Figure 22 in terms of a future distribution of total passenger activity ranging from 8.4 million (10th percentile or 10%) to 21.3 million (90th percentile or 90%) in 2035. (The 0% and 100% ranges typically capture extreme values and therefore are not shown.) For the purposes of the PDX Master Plan forecasts, the range of future passenger activity for the median, high and low growth scenarios is defined by the 50th, 90th, and 10th percentile probabilistic forecasts, respectively, as summarized in the following sections.

The probabilistic forecasts of total enplaned passengers were disaggregated into two additional categories which include (1) domestic and international and (2) mainline and regional affiliate enplaned passengers. These categories are also summarized in the following sections.

5.4.1 Median Scenario Forecasts

The median scenario forecasts of total enplaned passengers correspond to the 50th percentile, as shown in Table 18. The 50th percentile range implies that there is a 50% probability that the total number of passengers associated with a given future year will be equal to or less than that number. For example, in 2035, there is a 50% probability that the total number of passengers enplaned at PDX will be equal to or less than 13.4 million.

*FedEx Corporation, 2006 Annual Report, www.fedex.com.

**United States Securities and Exchange Commission, *Form 10-K/A*, Southwest Airlines Co., for the fiscal year ended December 31, 2007, www.sec.gov.

Table 18

PROBABILISTIC FORECASTS OF ENPLANED PASSENGERS
Master Plan Update
Portland International Airport
2006 - 2035

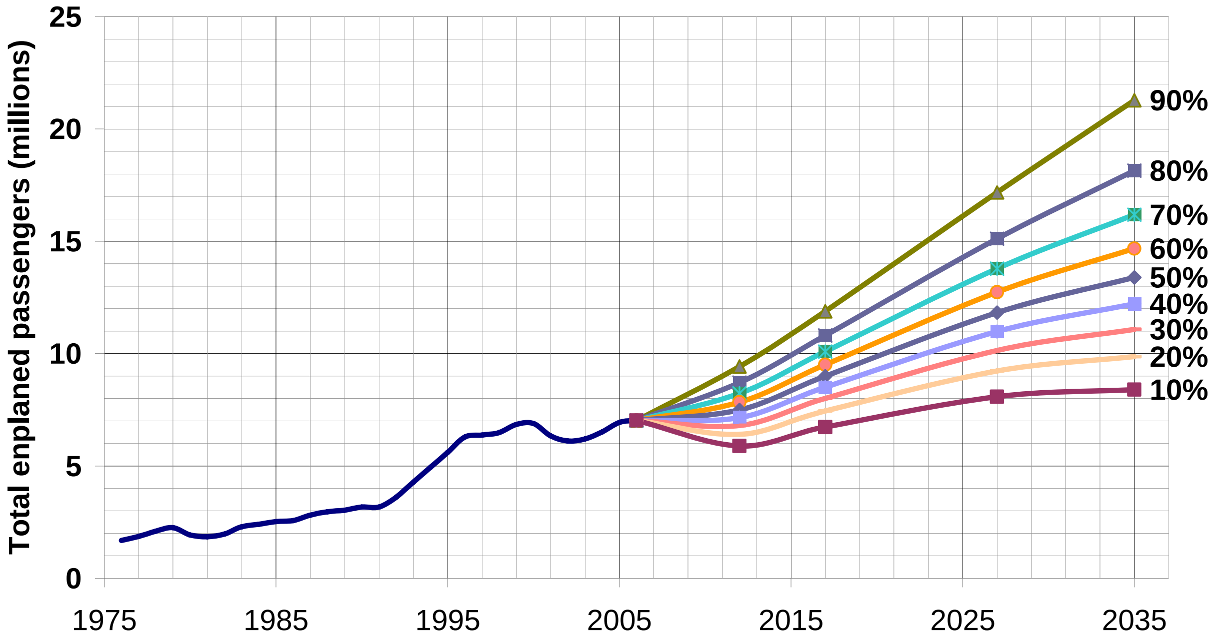
The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

	Historical		Scenario 1 (Median, 50th percentile)				Scenario 2 (High, 90th percentile)				Scenario 3 (Low, 10th percentile)			
	2006 (a)	2007	2012	2017	2027	2035	2012	2017	2027	2035	2012	2017	2027	2035
ENPLANED PASSENGERS (thousands)														
Domestic														
Mainline	5,321	5,440	5,498	6,582	8,577	9,589	6,914	8,699	12,458	15,254	4,260	4,857	5,791	5,956
Regional affiliate	1,443	1,605	1,644	1,967	2,561	2,864	2,084	2,621	3,752	4,594	1,286	1,467	1,749	1,800
	6,764	7,045	7,142	8,549	11,138	12,453	8,998	11,320	16,210	19,848	5,546	6,324	7,540	7,756
International														
Mainline and Foreign Flag	182	204	265	338	524	717	318	425	726	1,073	261	311	418	489
Regional affiliate	77	84	82	105	163	223	105	141	241	356	80	95	128	150
	259	288	347	443	687	940	423	566	967	1,429	341	406	546	639
TOTAL AIRPORT--ENPLANED PASSENGERS (thousands)	**7,022**	**7,332**	**7,489**	**8,992**	**11,825**	**13,393**	**9,421**	**11,886**	**17,177**	**21,277**	**5,887**	**6,730**	**8,086**	**8,395**
Average annual percent change	--	4.4%	0.4%	3.7%	2.8%	1.6%	5.1%	4.8%	3.8%	2.7%	-4.3%	2.7%	1.9%	0.5%
ANNUAL PASSENGER AIRLINE AIRCRAFT DEPARTURES														
Domestic														
Mainline	48,793	49,574	50,700	58,500	73,700	80,500	62,200	77,000	106,500	127,200	38,900	43,300	50,200	49,400
Regional affiliate	40,535	42,300	36,000	41,000	46,000	50,000	47,000	55,000	68,000	81,000	29,000	31,000	31,000	32,000
	89,328	91,874	86,700	99,500	119,700	130,500	109,200	132,000	174,500	208,200	67,900	74,300	81,200	81,400
International														
Mainline and Foreign Flag	1,066	1,275	1,500	1,900	2,800	3,700	1,800	2,400	3,900	5,700	1,500	1,800	2,300	2,600
Regional affiliate	2,668	2,628	2,000	2,100	2,800	3,300	2,500	2,800	4,100	5,200	1,900	1,900	2,200	2,200
	3,734	3,903	3,500	4,000	5,600	7,000	4,300	5,200	8,000	10,900	3,400	3,700	4,500	4,800
TOTAL AIRPORT--ANNUAL PASSENGER AIRLINE AIRCRAFT DEPARTURES	**93,062**	**95,777**	**90,200**	**103,500**	**125,300**	**137,500**	**113,500**	**137,200**	**182,500**	**219,100**	**71,300**	**78,000**	**85,700**	**86,200**
Average annual percent change	--	2.9%	-1.2%	2.8%	1.9%	1.2%	3.5%	3.9%	2.9%	2.3%	-5.7%	1.8%	0.9%	0.1%
DAILY PASSENGER AIRLINE AIRCRAFT DEPARTURES (b)														
Domestic														
Mainline	134	136	139	160	202	217	170	211	292	348	107	119	138	135
Regional affiliate	111	116	99	112	126	141	129	151	186	222	79	85	85	88
	245	252	238	273	328	358	299	362	478	570	186	204	222	223
International														
Mainline and Foreign Flag	3	3	4	5	8	10	5	7	11	16	4	5	6	7
Regional affiliate	7	7	6	6	8	9	7	8	11	14	5	5	6	6
	10	10	10	11	16	19	12	14	22	30	9	10	12	13
TOTAL AIRPORT--DAILY PASSENGER AIRLINE AIRCRAFT DEPARTURES	**255**	**262**	**247**	**284**	**343**	**377**	**311**	**376**	**500**	**600**	**195**	**214**	**235**	**236**

(a) The base year for the forecasts is 2006.
(b) Totals may not add due to rounding.

Sources: Historical: Port of Portland records. Forecast: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

Figure 22
PERCENTILES OF PDX ENPLANED PASSENGERS



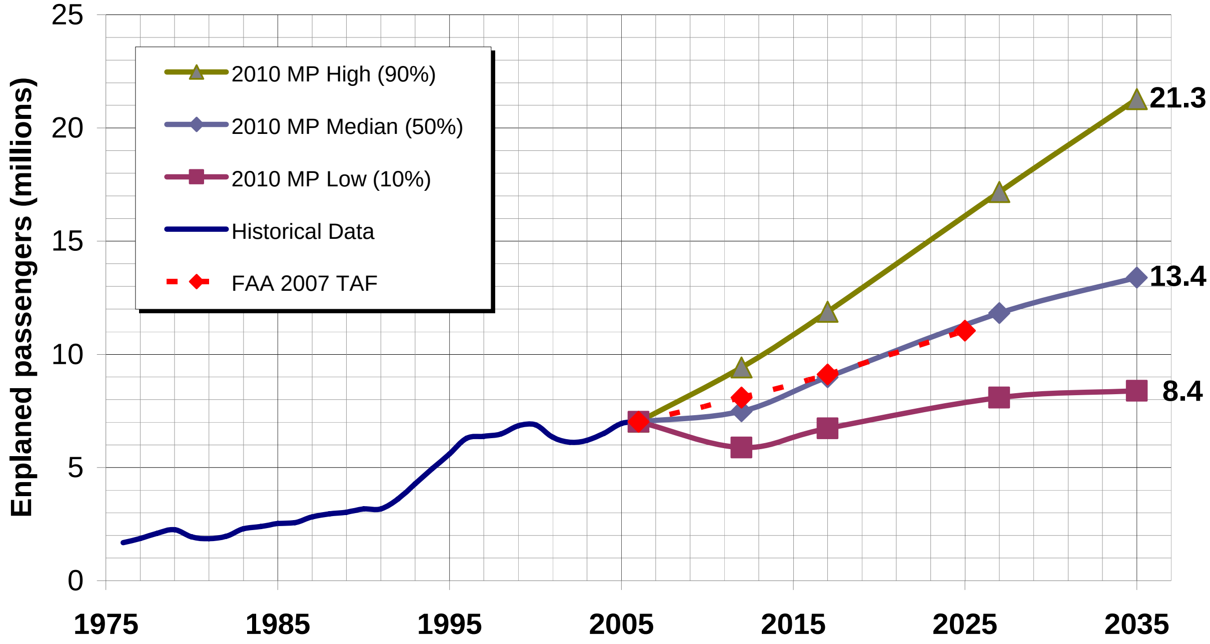
Source: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

The enplaned passenger growth rate for the median scenario forecast (an average increase of 2.3% per year from 2006 to 2035) is lower than the annual growth rate forecast by the FAA in its 2007 Terminal Area Forecast (TAF) for the Airport—2.5% from Federal Fiscal Year (FFY) 2006 to FFY 2025. The Terminal Area Forecast is prepared by the FAA each year, and includes a forecast of passengers and aircraft operations for each towered airport in the United States. A comparison of the median forecast and the FAA 2007 TAF is presented on Figure 23.

Domestic and International Passengers

Domestic enplaned passengers have historically represented about 96% of total enplaned passengers at the Airport. In the median scenario forecast, domestic passengers are forecast to account for a slightly decreasing share, from 96% in 2006 to 93% in 2035, reflecting strong growth assumptions for international passenger traffic—an average increase of 4.5% per year through 2035. The forecast growth in international passenger traffic through 2035 translates into an additional nine international flights (seven mainline and foreign-flag and two regional affiliate), as shown in Table 18. The FAA 2007 TAF of international enplaned passengers at PDX is for an average increase of 5.8% per year from 2006 through 2025, faster than the FAA's

Figure 23
PDX PROBABILISTIC FORECASTS OF ENPLANED PASSENGERS



Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008. FAA 2007 TAF: U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecasts, online database.

national forecasts of international passenger traffic on U.S. airlines (an average increase of 4.8% per year from 2006 to 2025).

Mainline and Regional Affiliate Passengers

The share of regional affiliate enplaned passengers at PDX (domestic and international) increased from 14% of total enplaned passengers in 1990 to 23% in 2005 and has remained at that level in recent years. In the median scenario forecast, domestic regional affiliate passenger traffic is forecast to increase an average of 2.4% per year from 2006 though 2035, slightly faster than the growth in domestic mainline passenger activity—an average increase of 2.1% per year. International regional affiliate passenger activity, which is entirely service to Canada, is forecast to increase an average of 3.7% per year from 2006 through 2035, slower than the growth in international mainline and foreign-flag passenger traffic—an average increase of 4.8% per year. The FAA 2007 TAF of regional affiliate (commuter) enplaned passengers at PDX is for an average increase of 2.9% per year from 2006 through 2025, slower than the FAA's national forecasts of commuter passenger traffic on U.S. regional airlines (an average increase of 3.7% per year from 2006 to 2025).

5.4.2 High Scenario Forecasts

The high scenario forecasts of total enplaned passengers correspond to the 90th percentile, as shown in Table 18. The 90th percentile range implies that there is a 90% probability that the total number of passengers associated with a given future year will be equal to or less than that number. (Alternatively, there is a 10% probability that the level of passengers in a given future year will be greater than that number.) For example, in 2035, there is a 90% probability that the total number of passengers enplaned at PDX will be equal to or less than 21.3 million.

The enplaned passenger growth rate for the high scenario forecast (an average increase of 3.9% per year from 2006 to 2035) is faster than the annual growth rate forecast in the FAA 2007 TAF for PDX—2.5% from 2006 to 2025, as noted earlier. A comparison of the high scenario forecast and the FAA 2007 TAF is presented earlier on Figure 23.

Domestic and International Passengers

In the high scenario forecast, domestic passengers are forecast to account for a slightly decreasing share, from 96% in 2006 to 93% in 2035, reflecting strong growth assumptions for international passenger traffic—an average increase of 6.1% per year through 2035. The forecast growth in international passenger traffic through 2035 translates into an additional twenty international flights (thirteen mainline and foreign-flag and seven regional affiliate), as shown in Table 18. The high scenario forecast growth rate in international passengers is consistent with the FAA 2007 TAF of international enplaned passengers at PDX noted earlier (an average increase of 5.8% per year from 2006 through 2025) and faster than the FAA's national forecasts of international passenger traffic on U.S. airlines (an average increase of 4.8% per year from 2006 to 2025).

Mainline and Regional Affiliate Passengers

In the high scenario forecast, domestic regional affiliate passenger traffic is forecast to increase an average of 4.1% per year from 2006 though 2035, slightly faster than the growth in domestic mainline passenger activity—an average increase of 3.7% per year. International regional affiliate passenger activity, which is entirely service to Canada, is forecast to increase an average of 5.4% per year from 2006 through 2035, slower than the growth in international mainline and foreign-flag passenger traffic—an average increase of 6.3% per year. The high scenario forecast growth rate in regional affiliate passengers is faster than that in the FAA 2007 TAF of regional affiliate (commuter) enplaned passengers at PDX noted earlier (an average increase of 2.9% per year from 2006 through 2025) and the FAA's national forecasts of commuter passenger traffic on U.S. regional airlines (an average increase of 3.7% per year from 2006 to 2025).

5.4.3 Low Scenario Forecasts

The low scenario forecasts of total enplaned passengers correspond to the 10th percentile, as shown in Table 18. The 10th percentile range implies that there is a 10% probability that the total number of passengers associated with a given future year will be equal to or less than that number. (Alternatively, there is a 90% probability that the level of passengers in a given future year will be greater than that number.) For example, in 2035, there is a 10% probability that the total number of passengers enplaned at PDX will be equal to or less than 8.4 million.

The enplaned passenger growth rate for the low scenario forecast (an average increase of 0.6% per year from 2006 to 2035) is slower than the annual growth rate forecast in the FAA 2007 TAF for PDX—2.5% from 2006 to 2025, as noted earlier. A comparison of the low scenario forecast and the FAA 2007 TAF is presented earlier on Figure 23.

Domestic and International Passengers

In the low scenario forecast, domestic passengers are forecast to account for a slightly decreasing share, from 96% in 2006 to 92% in 2035, reflecting moderate growth assumptions for international passenger traffic—an average increase of 3.2% per year through 2035. The forecast growth in international passenger traffic through 2035 translates into a net gain of three additional international flights (four mainline and foreign-flag and a loss of one regional affiliate), as shown in Table 18. The low scenario forecast growth rate in international passengers is slower than the FAA 2007 TAF of international enplaned passengers at PDX noted earlier (an average increase of 5.8% per year from 2006 through 2025) and slower than the FAA's national forecasts of international passenger traffic on U.S. airlines (an average increase of 4.8% per year from 2006 to 2025).

Mainline and Regional Affiliate Passengers

In the low scenario forecast, domestic regional affiliate passenger traffic is forecast to increase an average of 0.8% per year from 2006 though 2035, faster than the growth in domestic mainline passenger activity—an average increase of 0.4% per year. International regional affiliate passenger activity, which is entirely service to Canada, is forecast to increase an average of 2.3% per year from 2006 through 2035, slower than the growth in international mainline and foreign-flag passenger traffic—an average increase of 3.5% per year. The low scenario forecast growth rate in regional affiliate passengers is slower than that in the FAA 2007 TAF of regional affiliate (commuter) enplaned passengers at PDX noted earlier (an average increase of 2.9% per year from 2006 through 2025) and the FAA's national forecasts of commuter passenger traffic on U.S. regional airlines (an average increase of 3.7% per year from 2006 to 2025).

5.5 Probabilistic Air Cargo Forecasts

The range of probabilistic air cargo forecasts for PDX are presented in Table 19 and illustrated on Figure 24 in terms of a future distribution of total air cargo activity ranging from 526,000 tons (10th percentile or 10%) to 972,000 tons (90th percentile or 90%) in 2035. (The 0% and 100% ranges typically capture extreme values and therefore are not shown.) For the purposes of the PDX MP forecasts, the range of future air cargo activity for the median, high and low growth scenarios is defined by the 50th, 90th, and 10th percentile probabilistic forecasts, respectively, as summarized in the following sections.

The probabilistic forecasts of total air cargo were disaggregated into three additional categories which include (1) enplaned and deplaned cargo, (2) all-cargo and passenger (belly) airline cargo, and (3) domestic and international air cargo. From 1990 to 2006, the share of enplaned air cargo has varied slightly but has generally remained in the range of 48% to 49%. For the purposes of the PDX MP forecasts, the shares of enplaned and deplaned cargo are assumed to be evenly split (50% each). The other two categories are summarized in the following sections.

5.5.1 Median Scenario Forecasts

The median or preferred forecasts of total air cargo correspond to the 50th percentile, as shown in Table 19 and on Figure 25. The 50th percentile range implies that there is a 50% probability that total air cargo associated with a given future year will be equal to or less than that number. For example, in 2035, there is a 50% probability that total air cargo at PDX will be equal to or less than 732,000 tons.

The total air cargo growth rate for the median scenario forecast is for an average of 3.3% per year from 2006 to 2035. The FAA does not prepare airport-specific forecasts of air cargo activity so there are no comparable PDX specific forecasts of air cargo. The FAA's national forecasts of domestic air cargo (revenue ton miles) are for an average increase of 3.2% per year from 2006 through 2025. The Boeing Company projects domestic air cargo growth rates within a range of 3.3% and 4.2% for the period 2005 through 2025 (an average increase of 3.8% per year in its base forecast).

Table 19

PROBABILISTIC FORECASTS OF TOTAL AIR CARGO
Master Plan Update
Portland International Airport
2006 - 2035

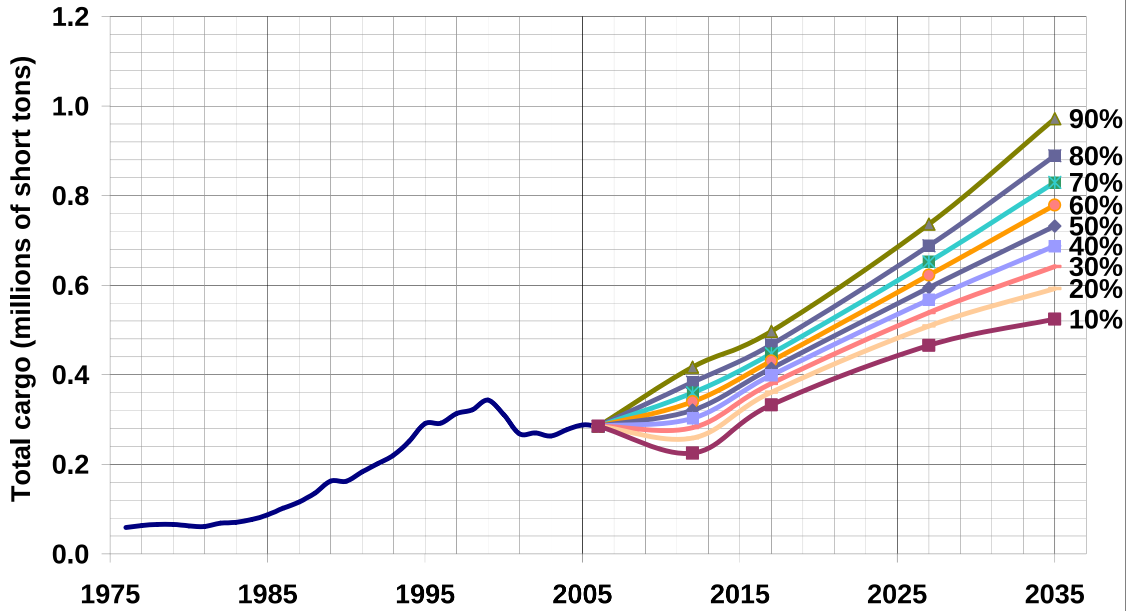
The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

	Historical		Scenario 1 (Median, 50th percentile)				Scenario 2 (High, 90th percentile)				Scenario 3 (Low, 10th percentile)			
	2006 (a)	**2007**	**2012**	**2017**	**2027**	**2035**	**2012**	**2017**	**2027**	**2035**	**2012**	**2017**	**2027**	**2035**
TOTAL AIR CARGO (thousands of short tons)														
ENPLANED AIR CARGO														
Passenger airlines														
Domestic	14	11	12	12	14	15	12	13	16	19	7	10	10	11
International	5	6	6	8	12	16	8	10	14	19	4	5	6	6
	20	17	18	20	26	31	20	23	31	39	11	15	16	17
All-cargo airlines														
Domestic	109	119	141	183	265	325	185	221	331	440	100	148	214	243
International	5	2	3	4	6	9	3	4	6	8	2	3	3	3
	114	122	144	187	271	335	188	225	337	448	102	151	217	246
TOTAL ENPLANED AIR CARGO	134	138	161	207	297	366	208	248	368	486	113	166	233	263
TOTAL DEPLANED AIR CARGO	152	142	161	207	297	366	208	248	368	486	113	166	233	262
TOTAL AIRPORT--AIR CARGO	**285**	**280**	**322**	**414**	**594**	**732**	**417**	**496**	**736**	**972**	**225**	**332**	**466**	**526**
Average annual percent change	--	-1.8%	2.8%	5.2%	3.7%	2.6%	8.2%	3.6%	4.0%	3.5%	-4.3%	8.1%	3.4%	1.5%
ALL-CARGO AIRLINE AIRCRAFT DEPARTURES														
Domestic														
Air carrier	4,162	4,041	4,700	5,600	6,900	7,900	6,200	6,700	8,700	10,800	3,300	4,500	5,600	5,900
Air taxi	12,274	12,534	14,200	14,900	17,300	18,000	16,400	17,100	19,400	21,800	9,500	10,500	12,100	12,900
	16,436	16,575	18,900	20,500	24,200	25,900	22,600	23,800	28,100	32,600	12,800	15,000	17,700	18,800
International	156	87	90	120	180	260	100	120	170	170	60	80	90	100
TOTAL AIRPORT--ALL CARGO AIRLINE DEPARTURES	**16,592**	**16,662**	**18,990**	**20,620**	**24,380**	**26,160**	**22,700**	**23,920**	**28,270**	**32,770**	**12,860**	**15,080**	**17,790**	**18,900**
Average annual percent change	--	0.4%	2.7%	1.7%	1.7%	0.9%	6.4%	1.1%	1.7%	1.9%	-5.0%	3.2%	1.7%	0.8%

Note: Totals may not add due to rounding.
(a) The base year for the forecasts is 2006.

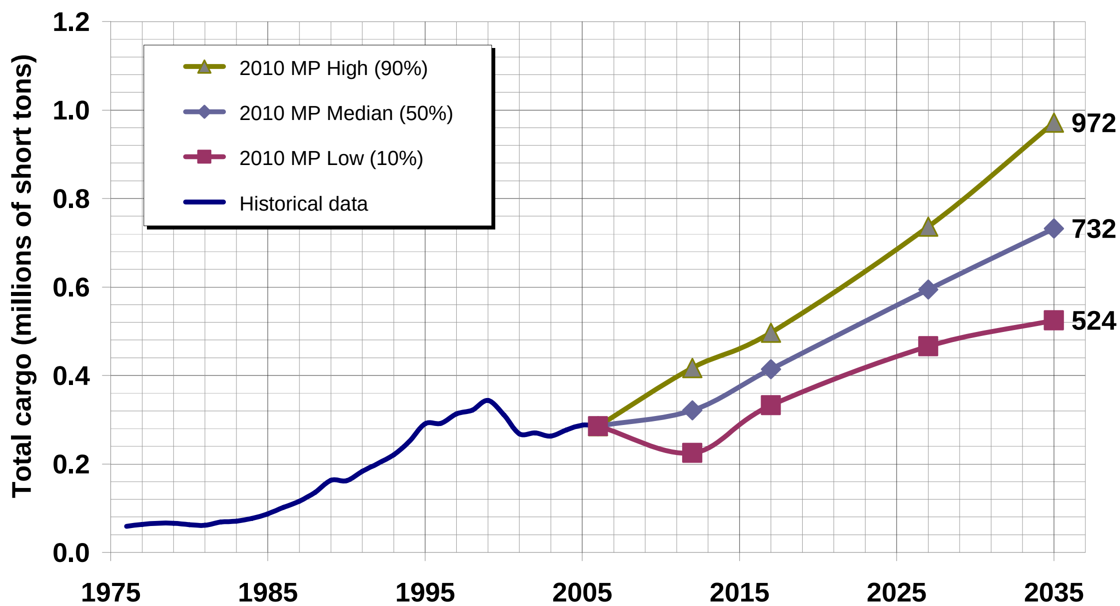
Sources: Historical: Port of Portland records. Forecast: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

Figure 24
PERCENTILES OF PDX TOTAL AIR CARGO



Source: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

Figure 25
PDX PROBABILISTIC FORECASTS OF TOTAL AIR CARGO



Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008.

All-Cargo and Passenger Airline Cargo

Air cargo tonnage is cargo that is transported in the belly hold of aircraft flown by passenger airlines and in aircraft flown by airlines dedicated to the exclusive transportation of cargo, known as "all-cargo" carriers. In 2006, approximately 85.0% of the Airport's air cargo tonnage was carried by all-cargo airlines and the remaining 15.0% was carried in the belly hold of passenger airlines. The all-cargo airline share of total PDX air cargo increased to 89% in 2007.

In the median scenario forecast, all-cargo airlines are forecast to account for an increasing share of total air cargo, from 85% in 2006 to 92% in 2035. The cargo transported on all-cargo airlines is forecast to increase an average of 3.8% per year from 2006 through 2035, compared with a forecast growth rate of 1.6% per for passenger airlines during the same period.

Domestic and International Cargo

Domestic air cargo accounted for 92% of total air cargo tonnage at the Airport in 2006, with about 88% of domestic air cargo transported by the all-cargo airlines. In the median scenario forecast, domestic air cargo tonnage is forecast to increase an average of 3.6% per year from 2006 through 2035 and account for a slightly increasing share of total air cargo tonnage (93% in 2035).

5.5.2 High Scenario Forecasts

The high forecasts of total air cargo correspond to the 90th percentile, as shown in Table 19. The 90th percentile range implies that there is a 90% probability that total air cargo associated with a given future year will be equal to or less than that number. For example, in 2035, there is a 90% probability that total number air cargo at PDX will be equal to or less than 972,000 tons. The total air cargo growth rate for the high forecast is for an average of 4.3% per year from 2006 to 2035.

All-Cargo and Passenger Airline Cargo

In the high scenario forecast, all-cargo airlines are forecast to account for an increasing share of total air cargo, from 85% in 2006 to 92% in 2035. The cargo transported on all-cargo airlines is forecast to increase an average of 4.8% per year from 2006 through 2035, compared with a forecast growth rate of 2.4% per year for passenger airlines during the same period.

Domestic and International Cargo

Domestic air cargo accounted for 92% of total air cargo tonnage at the Airport in 2006, with about 88% of domestic air cargo transported by the all-cargo airlines. In the high scenario forecast, domestic air cargo tonnage is forecast to increase an average of

4.6% per year from 2006 through 2035 and account for a slightly increasing share of total air cargo tonnage (94% in 2035).

5.5.3 Low Scenario Forecasts

The low forecasts of total air cargo correspond to the 10th percentile, as shown in Table 19. The 10th percentile range implies that there is a 10% probability that total air cargo associated with a given future year will be equal to or less than that number. For example, in 2035, there is a 10% probability that total air cargo at PDX will be equal to or less than 526,000 tons. The total air cargo growth rate for the low forecast is for an average increase of 2.1% per year from 2006 to 2035.

All-Cargo and Passenger Airline Cargo

In the low scenario forecast, all-cargo airlines are forecast to account for an increasing share of total air cargo, from 85% in 2006 to 93% in 2035. The cargo transported on all-cargo airlines is forecast to increase an average of 2.7% per year from 2006 through 2035, compared with a forecast for an average decrease of 0.5% per year for passenger airlines during the same period.

Domestic and International Cargo

Domestic air cargo accounted for 92% of total air cargo tonnage at the Airport in 2006, with about 88% of domestic air cargo transported by the all-cargo airlines. In the low scenario forecast, domestic air cargo tonnage is forecast to increase an average of 2.5% per year from 2006 through 2035 and account for a slightly increasing share of total air cargo tonnage (96% in 2035).

5.6 Total Aircraft Operations Forecasts

Total aircraft operations includes the sum of passenger airline, all-cargo airline, general aviation, and military operations. The forecasts of total aircraft operations are derived from the probabilistic forecasts of passenger and cargo demand described earlier and an evaluation of general aviation and military operations based on standard FAA methodology. In the median scenario forecast, total aircraft operations at PDX are forecast to increase from 260,386 in 2006 to 377,820 operations in 2035, an average increase of 1.3% per year, as shown in Table 20. The total aircraft operations forecast growth rate for the median scenario forecast is lower than the annual growth rate forecast in the FAA 2007 TAF for the Airport—1.8% from 2006 to 2025. A comparison of the median scenario forecast and the FAA 2007 TAF is presented on Figure 26.

Table 20

TOTAL AIRCRAFT OPERATIONS FORECASTS
Master Plan Update
Portland International Airport
2006 - 2035

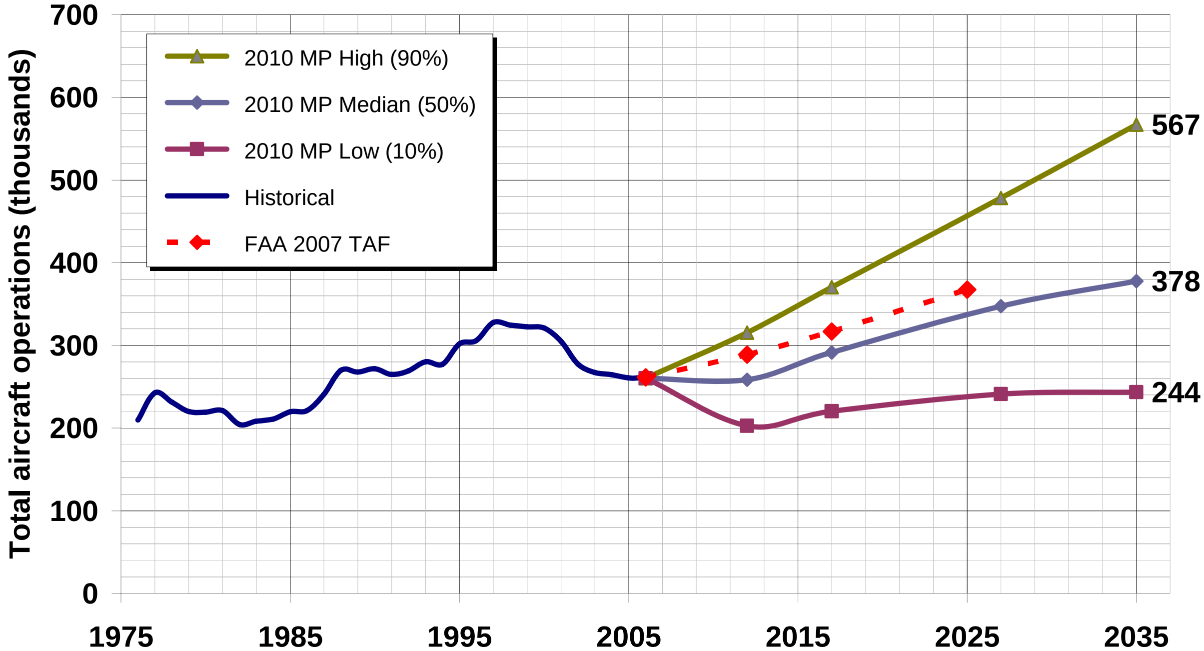
The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

	Historical		Scenario 1 (Median, 50th percentile)				Scenario 2 (High, 90th percentile)				Scenario 3 (Low, 10th percentile)			
	2006 (a)	2007	2012	2017	2027	2035	2012	2017	2027	2035	2012	2017	2027	2035
PASSENGER AIRLINE AIRCRAFT OPERATIONS	186,124	191,554	180,400	207,000	250,600	275,000	227,000	274,400	365,000	438,200	142,600	156,000	171,400	172,400
ALL-CARGO AIRLINE AIRCRAFT OPERATIONS	33,184	33,324	37,980	41,240	48,760	52,320	45,400	47,840	56,540	65,540	25,720	30,160	35,580	37,800
GENERAL AVIATION	28,230	27,623	26,100	28,200	30,900	32,500	27,000	30,300	35,200	39,000	22,200	21,300	20,300	19,400
MILITARY	5,017	3,707	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
OTHER ACTIVITY (a)	7,831	8,310	8,000	9,100	11,100	12,000	10,100	11,800	15,600	18,400	6,200	6,900	7,800	8,000
TOTAL AIRPORT--AIRCRAFT OPERATIONS	**260,386**	**264,518**	**258,480**	**291,540**	**347,360**	**377,820**	**315,500**	**370,340**	**478,340**	**567,140**	**202,720**	**220,360**	**241,080**	**243,600**
Average annual percent change	--	1.6%	-0.5%	2.4%	1.8%	1.1%	3.6%	3.3%	2.6%	2.2%	-5.2%	1.7%	0.9%	0.1%

Note: Aircraft operations include departures and arrivals.
(a) Includes nonscheduled and empty flights.

Sources: Historical: Port of Portland records and U.S. Department of Transportation, Federal Aviation Administration, ATADS online database. Forecast: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

Figure 26
COMPARISON OF PDX TOTAL AIRCRAFT OPERATIONS FORECASTS



Sources: Historical: Port of Portland records. 2008 Master Plan forecasts (2008 MP): Jacobs Consultancy and NEXTOR, April 2008. FAA 2007 TAF: U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecasts, online database. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

The high scenario forecast is for an average increase of 2.7% per year in PDX total aircraft operations from 2006 to 2035, reaching 567,140 operations in 2035. In the low scenario forecast, total aircraft operations at PDX are forecast to decrease an average of 0.2% per year from 2006 to 2035, for a total of 243,600 operations in 2035.

5.6.1 Passenger Airline Aircraft Operations

Passenger aircraft operations include total departures and arrivals performed mainline and regional affiliate aircraft in the service of transporting passengers. A detailed breakout of passenger airline aircraft operations by category discussed earlier is presented in Table 21. The assumptions used for the forecasts of passenger airline aircraft departures are shown in Table 22.

Passenger airline aircraft operations were calculated by dividing the enplaned passenger forecasts by category (e.g., domestic and international, mainline and regional affiliate) by the estimated number of passengers enplaned per departure. In 2006, the average number of passengers enplaned per departure for the Airport as a

Table 21

FORECASTS OF TOTAL AIRCRAFT OPERATIONS BY TYPE
Master Plan Update
Portland International Airport
2006 - 2035

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

	Historical		Scenario 1 (Median, 50th percentile)				Scenario 2 (High, 90th percentile)				Scenario 3 (Low, 10th percentile)			
	2006 (a)	2007	2012	2017	2027	2035	2012	2017	2027	2035	2012	2017	2027	2035
PASSENGER AIRLINE AIRCRAFT OPERATIONS														
Domestic														
Mainline	97,586	99,148	101,400	117,000	147,400	161,000	124,400	154,000	213,000	254,400	77,800	86,600	100,400	98,800
Regional affiliate	81,070	84,600	72,000	82,000	92,000	100,000	94,000	110,000	136,000	162,000	58,000	62,000	62,000	64,000
	178,656	183,748	173,400	199,000	239,400	261,000	218,400	264,000	349,000	416,400	135,800	148,600	162,400	162,800
International														
Mainline and Foreign Flag	2,132	2,550	3,000	3,800	5,600	7,400	3,600	4,800	7,800	11,400	3,000	3,600	4,600	5,200
Regional affiliate	5,336	5,256	4,000	4,200	5,600	6,600	5,000	5,600	8,200	10,400	3,800	3,800	4,400	4,400
	7,468	7,806	7,000	8,000	11,200	14,000	8,600	10,400	16,000	21,800	6,800	7,400	9,000	9,600
TOTAL PASSENGER OPERATIONS	**186,124**	**191,554**	**180,400**	**207,000**	**250,600**	**275,000**	**227,000**	**274,400**	**365,000**	**438,200**	**142,600**	**156,000**	**171,400**	**172,400**
Average annual percent change	--	2.9%	-1.2%	2.8%	1.9%	1.2%	3.5%	3.9%	2.9%	2.3%	-5.7%	1.8%	0.9%	0.1%
ALL-CARGO AIRLINE AIRCRAFT OPERATIONS														
Domestic	32,872	33,150	37,800	41,000	48,400	51,800	45,200	47,600	56,200	65,200	25,600	30,000	35,400	37,600
International	312	174	180	240	360	520	200	240	340	340	120	160	180	200
TOTAL ALL-CARGO OPERATIONS	**33,184**	**33,324**	**37,980**	**41,240**	**48,760**	**52,320**	**45,400**	**47,840**	**56,540**	**65,540**	**25,720**	**30,160**	**35,580**	**37,800**
Average annual percent change	--	0.4%	2.7%	1.7%	1.7%	0.9%	6.4%	1.1%	1.7%	1.9%	-5.0%	3.2%	1.7%	0.8%
GENERAL AVIATION OPERATIONS														
Itinerant	27,448	27,160	25,700	27,700	30,400	32,000	26,500	29,800	34,600	38,300	21,800	20,900	20,000	19,100
Local	782	463	400	500	500	500	500	500	600	700	400	400	300	300
TOTAL GENERAL AVIATION OPERATIONS	**28,230**	**27,623**	**26,100**	**28,200**	**30,900**	**32,500**	**27,000**	**30,300**	**35,200**	**39,000**	**22,200**	**21,300**	**20,300**	**19,400**
Average annual percent change	--	-2.2%	-1.1%	1.6%	0.9%	0.6%	-0.5%	2.3%	1.5%	1.3%	-4.3%	-0.8%	-0.5%	-0.6%
MILITARY OPERATIONS														
Itinerant	4,800	3,666	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Local	217	41	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
TOTAL MILITARY OPERATIONS	**5,017**	**3,707**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**	**6,000**
OTHER ACTIVITY (a)	**7,831**	**8,310**	**8,000**	**9,100**	**11,100**	**12,000**	**10,100**	**11,800**	**15,600**	**18,400**	**6,200**	**6,900**	**7,800**	**8,000**
TOTAL AIRPORT--AIRCRAFT OPERATIONS	**260,386**	**264,518**	**258,480**	**291,540**	**347,360**	**377,820**	**315,500**	**370,340**	**478,340**	**567,140**	**202,720**	**220,360**	**241,080**	**243,600**
Average annual percent change	--	1.6%	-0.5%	2.4%	1.8%	1.1%	3.6%	3.3%	2.6%	2.2%	-5.2%	1.7%	0.9%	0.1%

Note: Aircraft operations include departures and arrivals.
(a) Includes nonscheduled and empty flights. Other operations accounted for 3.7% of commercial airline (passenger and all-cargo) operations in 2007 and are assumed to account for this share in future years.

Sources: Historical: Port of Portland records and U.S. Department of Transportation, Federal Aviation Administration, ATADS online database. Forecast: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

Table 22

ASSUMPTIONS FOR PASSENGER AIRLINE AIRCRAFT DEPARTURE FORECASTS
Master Plan Update
Portland International Airport
2006 - 2035

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

	Historical		Scenario 1 (Median, 50th percentile)				Scenario 2 (High, 90th percentile)				Scenario 3 (Low, 10th percentile)			
	2006 (a)	2007	2012	2017	2027	2035	2012	2017	2027	2035	2012	2017	2027	2035
ENPLANED PASSENGERS PER DEPARTURE														
Domestic														
Mainline	109	110	108	113	116	119	111	113	117	120	110	112	115	121
Regional affiliate	36	38	46	48	56	57	44	48	55	57	44	47	56	56
	76	77	82	86	93	95	82	86	93	95	82	85	93	95
International														
Mainline and Foreign Flag	170	160	177	178	187	194	177	177	186	188	174	173	182	188
Regional affiliate	29	32	41	50	58	68	42	50	59	68	42	50	58	68
	69	74	99	111	123	134	98	109	121	131	100	110	121	133
TOTAL AIRPORT--ENPLANED PASSENGERS PER DEPARTURE	**75**	**77**	**83**	**87**	**94**	**97**	**83**	**87**	**94**	**97**	**83**	**86**	**94**	**97**
SEATS PER DEPARTURE														
Domestic														
Mainline	145	146	144	144	146	148	143	142	145	147	144	142	146	150
Regional affiliate	47	51	62	63	71	73	60	63	71	72	60	62	72	72
	100	101	108	110	117	119	108	110	117	118	107	110	117	118
International														
Mainline and Foreign Flag	186	171	208	211	217	222	207	209	215	220	208	211	217	222
Regional affiliate	50	50	60	71	79	90	60	71	79	90	60	71	79	90
	94	92	125	138	150	161	122	135	146	158	125	138	150	161
TOTAL AIRPORT--SEATS PER DEPARTURE	**99**	**101**	**109**	**111**	**119**	**121**	**109**	**111**	**119**	**120**	**108**	**112**	**119**	**121**
ENPLANED PASSENGER LOAD FACTOR														
Domestic														
Mainline	75%	75%	76%	78%	80%	80%	78%	80%	81%	82%	76%	79%	79%	80%
Regional affiliate	75%	75%	74%	76%	78%	79%	74%	76%	78%	79%	74%	76%	78%	79%
	76%	76%	76%	78%	79%	80%	76%	78%	79%	80%	76%	77%	79%	80%
International														
Mainline and Foreign Flag	92%	93%	85%	84%	86%	87%	85%	85%	86%	85%	84%	82%	84%	85%
Regional affiliate	58%	64%	69%	71%	74%	75%	70%	71%	74%	76%	71%	71%	74%	76%
	74%	80%	80%	81%	82%	84%	81%	81%	83%	83%	80%	80%	81%	83%
TOTAL AIRPORT--ENPLANED PASSENGER LOAD FACTOR	**76%**	**76%**	**76%**	**78%**	**79%**	**81%**	**76%**	**78%**	**79%**	**81%**	**76%**	**77%**	**79%**	**81%**

Note: The numbers as shown are rounded.
(a) The base year for the forecasts is 2006.

Sources: Historical: Port of Portland records. Forecast: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

whole was approximately 75. This number is expected to increase slowly over the forecast period based on an estimated increase in the average number of seats per aircraft and an estimated load factor, or percentage of available seats filled with passengers. In the median scenario forecast, the average number of passengers enplaned per departure is expected to reach approximately 97 in 2035. Dividing the enplaned passenger forecasts by the forecast number of passengers enplaned per departure yields passenger airline aircraft departures. The forecast departures were then multiplied by two to yield passenger airline aircraft operations for each category of activity.

In the median scenario forecast, passenger airline aircraft operations at PDX are forecast to increase from 186,124 in 2006 to 275,000 operations in 2035, an average increase of 1.4% per year, as shown in Table 20. The total aircraft operations forecast growth rate for the median scenario forecast is lower than the annual growth rate forecast in the FAA 2007 TAF for the Airport—1.8% from 2006 to 2025. A comparison of the median scenario forecast and the FAA 2007 TAF is presented on Figure 27.

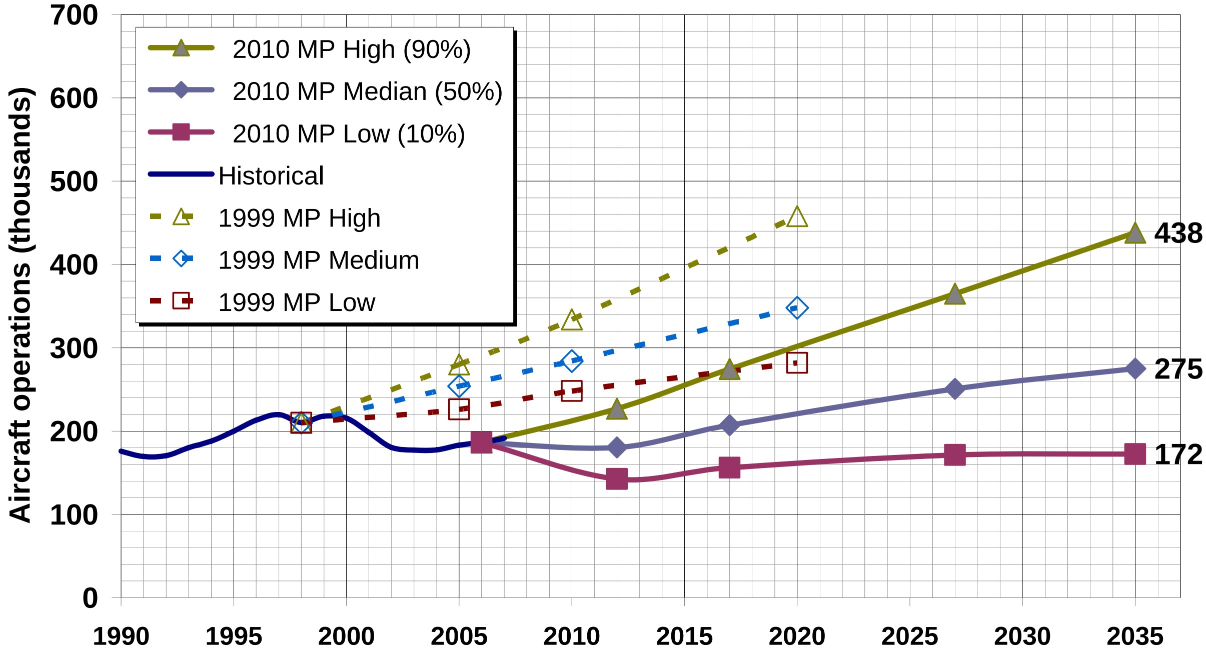
The high scenario forecast is for an average increase of 3.0% per year in PDX passenger airline aircraft operations from 2006 to 2035, reaching 438,200 operations in 2035. In the low scenario forecast, passenger airline aircraft operations at PDX are forecast to decrease an average of 0.3% per year from 2006 to 2035, for a total of 172,400 operations in 2035.

5.6.2 All-Cargo Airline Aircraft Operations

All-cargo operations include the flight activity by airlines dedicated exclusively to the transportation of freight such as FedEx and UPS. All-cargo operations are performed by both air carrier and commuter/regional size aircraft. Air carrier size aircraft that perform all-cargo operations at the airport include aircraft models such as the Boeing 727, 757 and 767, in addition to other narrowbody and widebody jet aircraft. Commuter or regional aircraft that perform all-cargo operations at the airport include small turboprop aircraft such as the Beechcraft 99 and 1900. In 2006, there were 33,184 all-cargo operations at the Airport and approximately 24,548 or 74% were performed by commuter/regional aircraft and the remaining 8,636 operations were by air carrier-size aircraft.

The forecast of all-cargo operations was developed by first estimating the share of future cargo tonnage expected to be carried by air carrier and commuter aircraft. In 2006, approximately 94% of the cargo carried by all-cargo carriers was on air carrier-size aircraft. This cargo tonnage distribution ratio was increased slightly over the forecast period 2006 through 2035.

Figure 27
PDX PASSENGER AIRLINE AIRCRAFT OPERATIONS FORECASTS



Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008. FAA 2007 TAF: U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecasts, online database. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

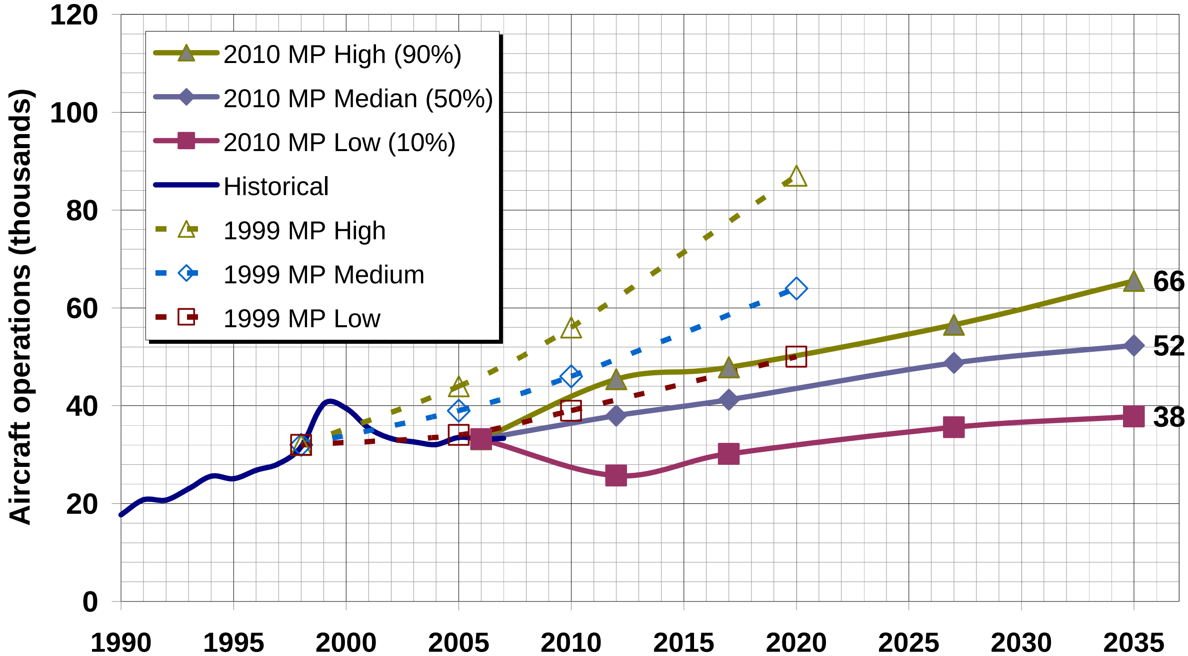
The cargo tonnage expected to be carried by all-cargo carriers was then divided by an estimated cargo tons per departure ratio to yield total air carrier cargo operations. In 2006, air carrier all-cargo aircraft carried approximately 27.7 tons per departure. Similarly, in 2006, commuter all-cargo aircraft carried approximately 0.58 tons per operation. This ratio of tons per departure is expected to increase gradually over the forecast period to account for larger aircraft entering the fleet of all-cargo carriers and to reflect an increase in the cargo tonnage carried by regional feeders to outlying, developing markets.

In the median scenario forecast, all-cargo airline aircraft operations at PDX are forecast to increase from 33,184 in 2006 to 52,320 operations in 2035, an average increase of 1.6% per year, as shown in Table 21. A comparison of the median scenario forecast and the 1999 Master Plan forecasts is presented on Figure 28.

The high scenario forecast is for an average increase of 2.4% per year in PDX all-cargo airline aircraft operations from 2006 to 2035, reaching 65,540 operations in 2035. In the low scenario forecast, all-cargo airline aircraft operations at PDX are forecast to increase an average of 0.5% per year from 2006 to 2035, for a total of 37,800 operations in 2035.

Figure 28

PDX ALL-CARGO AIRLINE AIRCRAFT OPERATIONS FORECASTS



Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

5.6.3 General Aviation Forecasts

General aviation (GA) activity includes all flight operations by aircraft other than scheduled or charter passenger aircraft and military aircraft. GA includes not only pilot training and recreational flights on small single engine or multi-engine propeller driven aircraft, but also operations on larger corporate or business jet aircraft.

On a nationwide basis, the number of general aviation aircraft operations has been in slow decline due to factors such as increases in aircraft, fuel, and insurance costs, as well as increased avionic instrument requirements. For the future, the FAA expects general aviation traffic to recover slowly. One notable development is the emergence of new Very Light Jet (VLJ) general aviation aircraft. These aircraft began to receive FAA type certification at the end of 2006 and the relatively low price for these high performance aircraft could potentially drive new growth in general aviation activity. However, at the writing of this report, there were no VLJs based at PDX and occasional itinerant operations by only one VLJ aircraft.

The flight operations of GA aircraft are categorized as local or itinerant operations. Local operations are flights that operate within visual range or close proximity of the airport. Itinerant operations typically include those flights that leave the airport destined for another airport and require the filing of flight plans with the local air traffic control authorities. Historically, itinerant operations have represented the majority of GA operations at the airport and in 2006 and 2007 accounted for approximately 97.0% and 98.0%, respectively, of total GA operations. Local operations accounted for the remaining 2.0% to 3.0%. Each touch and go training pass is counted as two operations. The total number of general aviation operations at the Airport decreased 2.2% between 2006 and 2007.

The current distribution of GA operations between itinerant and local operations is anticipated to remain constant over the 2006 through 2035 forecast horizon. In the median scenario forecast, the total number of general aviation operations is forecast to increase an average of 0.5% per year from 2007 through 2035, which includes a period of continued decline between 2006 and 2012, as shown in Table 23. The median scenario forecast of GA operations is consistent with the level of GA activity at other similar size medium-hub commercial service airports. The GA aircraft operations forecast growth rate for the median scenario forecast is lower than the annual growth rate forecast in the FAA 2007 TAF for the Airport—1.4% from 2006 to 2025. A comparison of the median scenario GA aircraft operations forecast and the FAA 2007 TAF is presented on Figure 29.

The high scenario forecast is for an average increase of 1.1% per year in PDX GA aircraft operations from 2006 to 2035, reaching 39,000 operations in 2035. In the low scenario forecast, GA aircraft operations at PDX are forecast to decrease an average of 1.3% per year from 2006 to 2035, for a total of 19,400 operations in 2035.

5.6.4 Military Forecasts

Military operations at the Airport have generally been in the range of approximately 4,000 to 6,000 operations per year during the last five years. In 2007, military operations decreased to 3,707, reflecting the temporary suspension of flying by the F-15 aircraft. Military operations are expected remain at a level of about 6,000 operations from 2007 through 2035, as shown earlier in Table 21 and Figure 30. It should be noted that military operations will increase and decrease with geopolitical trends and therefore this activity may vary in a given year.

Table 23

FORECASTS OF GENERAL AVIATION ACTIVITY
Master Plan Update
Portland International Airport
2006 - 2035

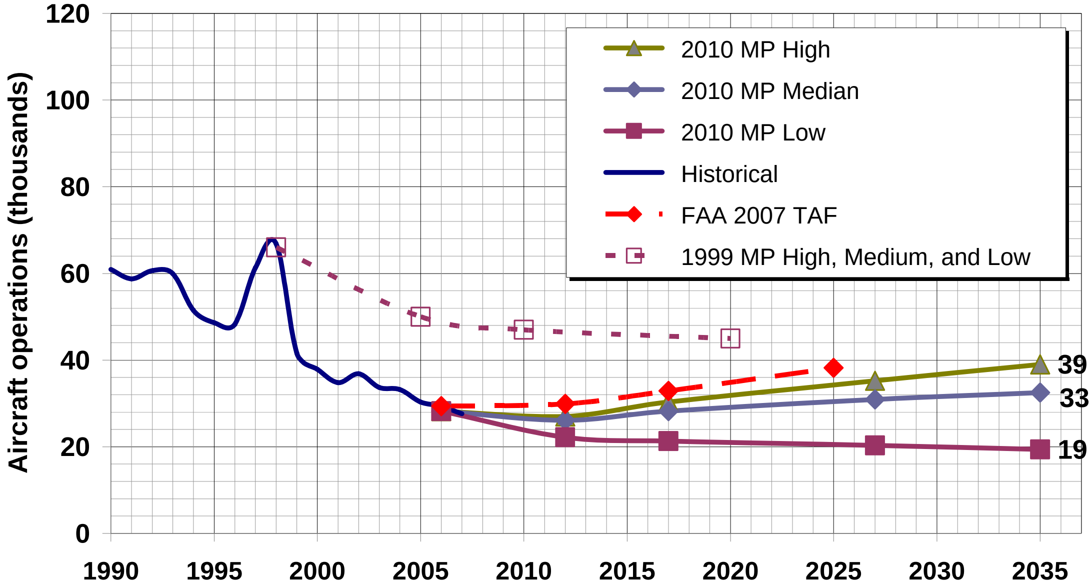
The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

	Historical		Scenario 1 (Median, 50th percentile)				Scenario 2 (High, 90th percentile)				Scenario 3 (Low, 10th percentile)			
	2006 (a)	2007	2012(a)	2017	2027	2035	2012(a)	2017	2027	2035	2012(a)	2017	2027	2035
GENERAL AVIATION OPERATIONS														
Itinerant	27,448	27,160	25,700	27,700	30,400	32,000	26,500	29,800	34,600	38,300	21,800	20,900	20,000	19,100
Local	782	463	400	500	500	500	500	500	600	700	400	400	300	300
GENERAL AVIATION OPERATIONS	**28,230**	**27,623**	**26,100**	**28,200**	**30,900**	**32,500**	**27,000**	**30,300**	**35,200**	**39,000**	**22,200**	**21,300**	**20,300**	**19,400**
Average annual percent change	--	-2.2%	-1.1%	1.6%	0.9%	0.6%	-0.5%	2.3%	1.5%	1.3%	-4.3%	-0.8%	-0.5%	-0.6%
BASED AIRCRAFT														
Single Engine (Nonjet)	39	39	24	22	20	18	24	23	22	21	24	21	18	15
Multi Engine (Nonjet)	14	14	15	16	17	18	15	16	17	18	14	13	12	11
Jet Engine	24	24	28	32	35	37	29	34	39	42	24	25	26	27
Helicopter	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Other (b)	18	18	18	18	18	18	18	18	18	18	18	18	18	18
TOTAL BASED AIRCRAFT	**98**	**98**	**88**	**91**	**93**	**94**	**89**	**94**	**99**	**102**	**83**	**80**	**77**	**74**
Average annual percent change	--	0.0%	-2.1%	0.7%	0.2%	0.1%	-1.9%	1.1%	0.5%	0.4%	-3.3%	-0.7%	-0.4%	-0.5%
GENERAL AVIATION OPERATIONS PER BASED AIRCRAFT	**288**	**282**	**296**	**310**	**332**	**346**	**304**	**322**	**356**	**382**	**268**	**267**	**264**	**262**
Average annual percent change	--	-2.2%	1.0%	0.9%	0.7%	0.5%	1.5%	1.2%	1.0%	0.9%	-1.0%	-0.1%	-0.1%	-0.1%

Note: Aircraft operations include departures and arrivals.
(a) Reflects a reduction of 15 aircraft related to the removal of 18 hangars in 2008 for road realignment.
(b) Other includes military, gliders, and ultralight aircraft.

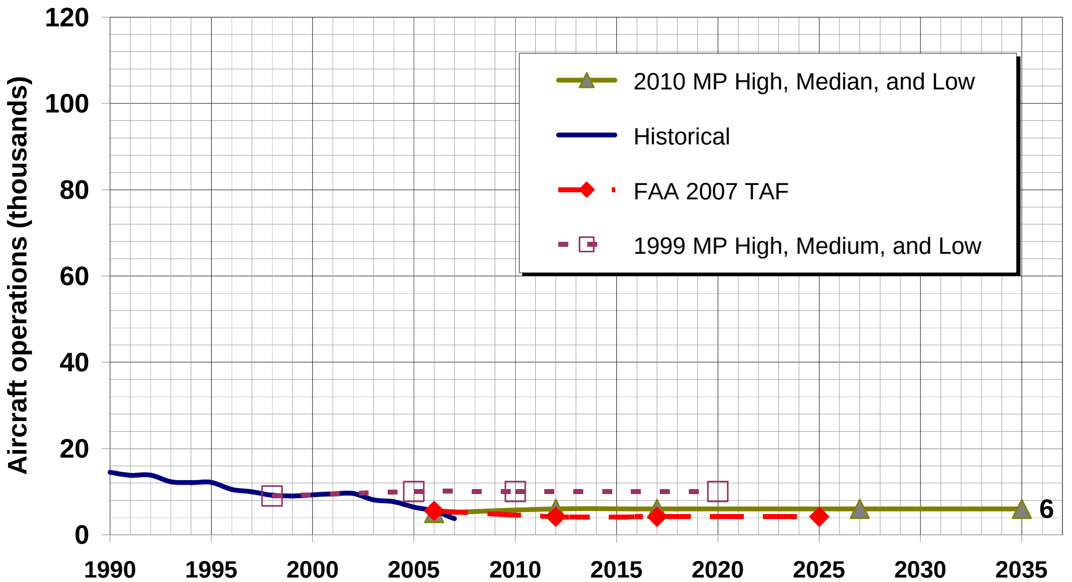
Sources: Historical: Port of Portland records and U.S. Department of Transportation, Federal Aviation Administration, ATADS online database. Forecast: Jacobs Consultancy and U.C. Berkeley NEXTOR, April 2008.

Figure 29
PDX GENERAL AVIATION AIRCRAFT OPERATIONS FORECASTS



Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008. FAA 2007 TAF: U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecasts, online database. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

Figure 30
PDX MILITARY AIRCRAFT OPERATIONS FORECASTS



Sources: Historical: Port of Portland records. 2010 Master Plan forecasts (2010 MP): Jacobs Consultancy and NEXTOR, April 2008. FAA 2007 TAF: U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecasts, online database. 1999 Master Plan forecasts (1999 MP): P&D Aviation, 2000.

5.7 Based Aircraft Forecasts

In 2006, a total of 98 aircraft were based at the Airport, including 39 single-engine, 14 multi-engine, 24 jet, 3 helicopters, and 18 other aircraft, including the F-15 aircraft based at PDX, as shown in Table 23. In 2008, the number of single engine aircraft was reduced by 15 aircraft as a result of the removal of 18 aircraft hangars for road realignment. In the median scenario forecast, the total number of based aircraft at the Airport is forecast to decrease an average of 0.1% per year between 2006 and 2035. The high scenario forecast is for an average increase of 0.1% per year in PDX based aircraft from 2006 to 2035, totaling 102 based aircraft in 2035. In the low scenario forecast, the number of aircraft based at PDX is forecast to decrease an average of 1.0% per year from 2006 to 2035, for a total of 74 based aircraft in 2035.

5.8 FAA TAF Forecast Comparison

Table 24 presents a comparison of the aviation activity forecasts prepared for the PDX Master Plan and the Federal Aviation Administration's 2007 Terminal Area Forecast (2007 FAA TAF) for the Airport. The forecasts are compared for the components of total enplaned passengers, commercial aircraft operations and total aircraft operations. The format of Table 24 is based on the template provided by the FAA for the comparison of airport planning forecasts and the FAA TAF.* As required, the results are presented for the base year of 2006 and forecast horizons years which are equal to the base year, plus 1, 5, 10 and 15 years (2007, 2011, 2016, and 2021). The 2010 MP forecasts have been compared graphically with the 2007 FAA TAF forecasts in figures throughout this report, including Figures 2 and 4 in Section 1.

The forecast of enplaned passengers under the PDX Master Plan forecast is generally lower than the TAF. The variance between the PDX Master Plan forecast and the 2007 FAA TAF is 5.6% in 2011 and 2.6% in 2016, as shown in Table 24.

The forecast of commercial operations under the PDX Master Plan forecast also varies from the TAF projections. The variance between the two forecasts for 2007, 2011, and 2016 for commercial operations is less than 10.0%.

The variance between the forecasts of total aircraft operations is less than that between commercial operations and also never exceeds a difference of 10%. In general, the PDX Master Plan forecast of total operations is lower than the 2007 FAA TAF projections in each of the compared forecast years.

*U.S. Department of Transportation, Federal Aviation Administration., *Forecasting Aviation Activity by Airport,* July 2001, and *Revision to Guidance on Review and Approval of Aviation Forecasts*., Memorandum from Director of Airport Planning and Programming, APP-1, December 23, 2004, http://www.faa.gov.

Table 24
FAA TAF FORECAST COMPARISON
Master Plan Update
Portland International Airport
2006-2021

	Forecast Year (a)	PDX Master Plan Update (b)	2007 FAA TAF	% Variance PDX MPU vs. 2007 TAF
PASSENGER ENPLANEMENTS				
Base year	2006	7,022,184	6,927,043	1.4%
Base year + 1 year	2007	7,332,478	7,137,355	2.7%
Base year + 5 years	2011	7,457,430	7,898,924	-5.6%
Base year + 10 years	2016	8,669,020	8,896,206	-2.6%
Base year + 15 years	2021	10,033,080	10,027,275	0.1%
		Annual compound growth rates		
2006-2011		1.2%	2.7%	
2007-2011		0.4%	2.6%	
2011-2016		3.1%	2.4%	
2016-2021		3.0%	2.4%	
COMMERCIAL OPERATIONS				
Base year	2006	227,139	226,543	0.3%
Base year + 1 year	2007	233,188	232,115	0.5%
Base year + 5 years	2011	227,730	250,159	-9.0%
Base year + 10 years	2016	250,830	274,640	-8.7%
Base year + 15 years	2021	277,400	301,582	-8.0%
		Annual compound growth rates		
2006-2011		0.1%	2.0%	
2007-2011		-0.6%	1.9%	
2011-2016		2.0%	1.9%	
2016-2021		2.0%	1.9%	
TOTAL OPERATIONS				
Base year	2006	260,386	261,442	-0.4%
Base year + 1 year	2007	264,518	263,763	0.3%
Base year + 5 years	2011	259,680	283,686	-8.5%
Base year + 10 years	2016	284,610	311,066	-8.5%
Base year + 15 years	2021	312,700	341,196	-8.4%
		Annual compound growth rates		
2006-2011		-0.1%	1.6%	
2007-2011		-0.5%	1.8%	
2011-2016		1.9%	1.9%	
2016-2021		1.9%	1.9%	

(a) The PDX Master Plan Update was prepared on a calendar year basis and the FAA TAF was prepared on a federal fiscal year ending
(b) PDX Master Plan Update figures for 2006 and 2007 are actual results and 2011 through 2021 are forecasts.
(c) Commercial operations include operations by passenger airlines, all-cargo airlines, and air taxi operators.
(d) Total operations include commercial operations plus operations by general aviation and military.

Sources: Actual PDX results--Port of Portland records. PDX MPU Forecasts--Jacobs Consultancy and U.C. Berkeley NEXTOR. FAA 2007 TAF for PDX--U.S. Department of Transportation, Federal Aviation Administration, online database.

Table 25 presents a summary of the PDX Master Plan forecasts using a second template provided by the FAA.

5.9 Peak Period Demand Forecasts

The forecast of peak period demand includes: peak month activity, average day peak month activity (ADPM), and average day peak month flight schedules. Peak period demand was derived from the annual demand forecasts using the methodology and assumptions described in the following sections.

5.9.1 Peak Month

The forecast of peak month activity was derived from the forecast of annual activity using assumptions regarding peak month "factors"—the peak month as a percentage of the annual total.

Enplaned Passengers

Table 26 presents historical enplaned passengers by month at PDX in 1990 and from 2000 through 2007. August has consistently been the peak month since 1990. The peak month share of annual enplaned passengers can vary somewhat depending on service or demand changes throughout the year. For example, in 2001, August accounted for 10.9% of annual enplaned passengers, the largest historical share from 1990 through 2007. The large peak month share in 2001 reflects reductions in service and reduced demand related to the September 11 terrorist events that affected monthly passenger levels in September through December 2001 and for the year as a whole. It is important, therefore, to look at the peak month share of annual for a number of years, rather than for a single year. During the last 5 years, the peak month share of total annual passengers enplaned at PDX was similar, ranging from 9.9% to 10.4%, as shown on Figure 31.

The peak month of activity for an airport generally occurs in July or August and coincides with the summer travel season. Figure 32 shows a monthly distribution of enplaned passengers at PDX, selected airports, and all U.S. airports in 2007. Although each of the selected airports represents a different level of passenger activity, the peak month occurs in either July or August and the peak month share of annual enplaned passengers was similar, ranging from 9.4% to 10.4% of total.

Table 25

SUMMARY OF PDX MPU FORECASTS USING FAA TEMPLATE

Master Plan Update

Portland International Airport

2006-2021

	Forecast Levels and Annual Compound Growth Rates (a)								
	Base year 2006	Base year + 1 year 2007	Base year + 5 years 2011	Base year + 10 years 2016	Base year + 15 years 2021	Base year to +1 year 2006-2007	Base year to +5 years 2006-2011	Base year to +10 years 2006-2016	Base year to +15 years 2006-2021
PASSENGER ENPLANEMENTS									
Air Carrier (b)	5,502,240	5,643,081	5,738,810	6,671,360	7,721,460	2.6%	0.8%	1.9%	2.3%
Commuter (c)	1,519,944	1,689,397	1,718,620	1,997,660	2,311,620	11.1%	2.5%	2.8%	2.8%
TOTAL ENPLANEMENTS	7,022,184	7,332,478	7,457,430	8,669,020	10,033,080	4.4%	1.2%	2.1%	2.4%
OPERATIONS									
Itinerant									
Air carrier	139,419	148,756	166,050	191,380	221,290	6.7%	3.6%	3.2%	3.1%
Commuter/air taxi	87,720	84,432	61,680	59,450	56,110	-3.7%	-6.8%	-3.8%	-2.9%
Total Commercial Operations	227,139	233,188	227,730	250,830	277,400	2.7%	0.1%	1.0%	1.3%
General aviation	27,448	27,160	25,700	27,700	30,400	-1.0%	-1.3%	0.1%	0.7%
Military	4,800	3,666	5,000	5,000	5,000	-23.6%	0.8%	0.4%	0.3%
Local									
General aviation	782	463	400	500	500	-40.8%	-12.5%	-4.4%	-2.9%
Military	217	41	1,000	1,000	1,000	-81.1%	35.7%	16.5%	10.7%
TOTAL OPERATIONS	260,386	264,518	259,680	284,610	312,700	1.6%	-0.1%	0.9%	1.2%
INSTRUMENT OPERATIONS	262,258	263,990	259,160	284,040	312,070	0.7%	-0.2%	0.8%	1.2%
Peak Hour Operations	40	42	44	47	50	5.0%	1.9%	1.6%	1.5%
CARGO/MAIL (ENPLANED + DEPLANED TONS)	285,325	280,235	313,080	393,700	478,430	-1.8%	1.9%	3.3%	3.5%
BASED AIRCRAFT									
Single Engine (Nonjet) (d)	39	39	24	22	20	0.0%	-9.3%	-5.6%	-4.4%
Multi Engine (Nonjet)	14	14	15	16	17	0.0%	1.4%	1.3%	1.3%
Jet Engine	24	24	28	32	35	0.0%	3.1%	2.9%	2.5%
Helicopter	3	3	3	3	3	0.0%	0.0%	0.0%	0.0%
Other	18	18	18	18	18	0.0%	0.0%	0.0%	0.0%
TOTAL BASED AIRCRAFT	98	98	88	91	93	0.0%	-2.1%	-0.7%	-0.3%

	Operational Factors				
	Base year 2006	Base year + 1 year 2007	Base year + 5 years 2011	Base year + 10 years 2016	Base year + 15 years 2021
Average aircraft size (seats)					
Air Carrier (b)	145.4	145.4	146.5	148.4	151.3
Commuter (c)	48.5	61.6	63.5	71.7	73.9
Average enplaning load factor					
Air Carrier (b)	75.9%	76.9%	78.9%	79.8%	81.3%
Commuter (c)	72.5%	73.9%	75.7%	78.0%	78.5%
GA operations per based aircraft	288	282	297	310	332

Note: The PDX Master Plan Update was prepared on a calendar year basis and the FAA TAF was prepared on a federal fiscal year ending September 30th.
(a) PDX Master Plan Update figures for 2006 and 2007 are actual results and 2011 through 2021 are forecasts.
(b) Includes domestic and international mainline airline activity as summarized in the earlier tables in this report.
(c) Includes domestic and international regional affiliate airline activity, which includes flights using regional aircraft with more than 60 seats.
(d) Reflects a reduction of 15 aircraft related to the removal of 18 hangars in 2008 for road realignment.

Sources: Actual PDX results--Port of Portland records. PDX MPU Forecasts--Jacobs Consultancy and U.C. Berkeley NEXTOR. FAA 2007 TAF for PDX--U.S. Department of Transportation, Federal Aviation Administration, online database.

Table 26

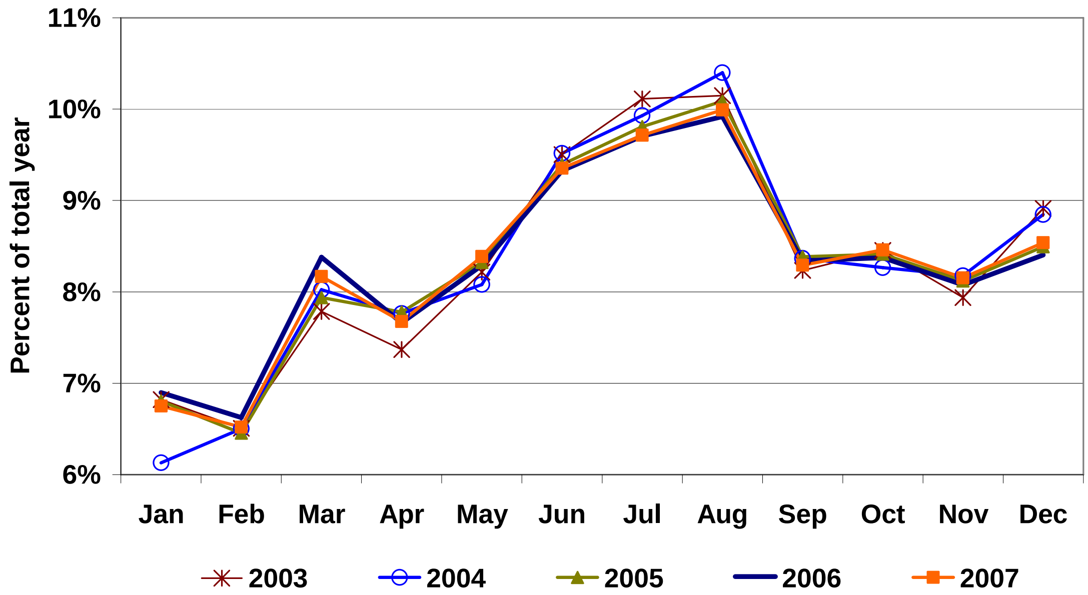
HISTORICAL ENPLANED PASSENGERS BY MONTH
Master Plan Update
Portland International Airport
1990 and 2000 - 2007

	Month												
Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1990	228,572	203,040	258,739	227,157	251,856	311,224	305,858	343,638	271,721	262,984	243,673	265,892	3,174,354
2000	462,853	479,983	577,316	534,264	573,885	646,460	658,350	693,031	557,312	569,877	557,355	574,841	6,885,527
2001	470,468	457,544	578,598	498,912	543,180	618,751	650,411	693,520	387,051	475,567	469,756	496,844	6,340,602
2002	410,625	403,508	509,627	469,999	504,543	575,677	595,030	639,636	494,457	493,843	468,263	550,520	6,115,728
2003	423,160	403,714	482,948	457,187	509,721	589,489	627,329	629,625	510,853	524,450	492,453	552,994	6,203,923
2004	399,507	423,764	522,818	505,937	526,559	620,103	647,068	677,701	545,251	538,616	532,904	576,450	6,516,678
2005	472,182	447,755	550,783	539,766	577,474	651,744	680,595	699,915	581,727	583,810	563,450	589,383	6,938,584
2006	484,403	465,185	588,467	537,995	582,117	654,957	681,607	696,495	585,657	588,039	567,128	590,134	7,022,184
2007	494,946	478,012	598,966	562,731	614,881	685,847	712,337	732,664	608,015	620,201	597,766	626,112	7,332,478

	Percent of total												
	Month												
Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1990	7.2%	6.4%	8.2%	7.2%	7.9%	9.8%	9.6%	10.8%	8.6%	8.3%	7.7%	8.4%	100.0%
2000	6.7%	7.0%	8.4%	7.8%	8.3%	9.4%	9.6%	10.1%	8.1%	8.3%	8.1%	8.3%	100.0%
2001	7.4%	7.2%	9.1%	7.9%	8.6%	9.8%	10.3%	10.9%	6.1%	7.5%	7.4%	7.8%	100.0%
2002	6.7%	6.6%	8.3%	7.7%	8.2%	9.4%	9.7%	10.5%	8.1%	8.1%	7.7%	9.0%	100.0%
2003	6.8%	6.5%	7.8%	7.4%	8.2%	9.5%	10.1%	10.1%	8.2%	8.5%	7.9%	8.9%	100.0%
2004	6.1%	6.5%	8.0%	7.8%	8.1%	9.5%	9.9%	10.4%	8.4%	8.3%	8.2%	8.8%	100.0%
2005	6.8%	6.5%	7.9%	7.8%	8.3%	9.4%	9.8%	10.1%	8.4%	8.4%	8.1%	8.5%	100.0%
2006	6.9%	6.6%	8.4%	7.7%	8.3%	9.3%	9.7%	9.9%	8.3%	8.4%	8.1%	8.4%	100.0%
2007	6.8%	6.5%	8.2%	7.7%	8.4%	9.4%	9.7%	10.0%	8.3%	8.5%	8.2%	8.5%	100.0%

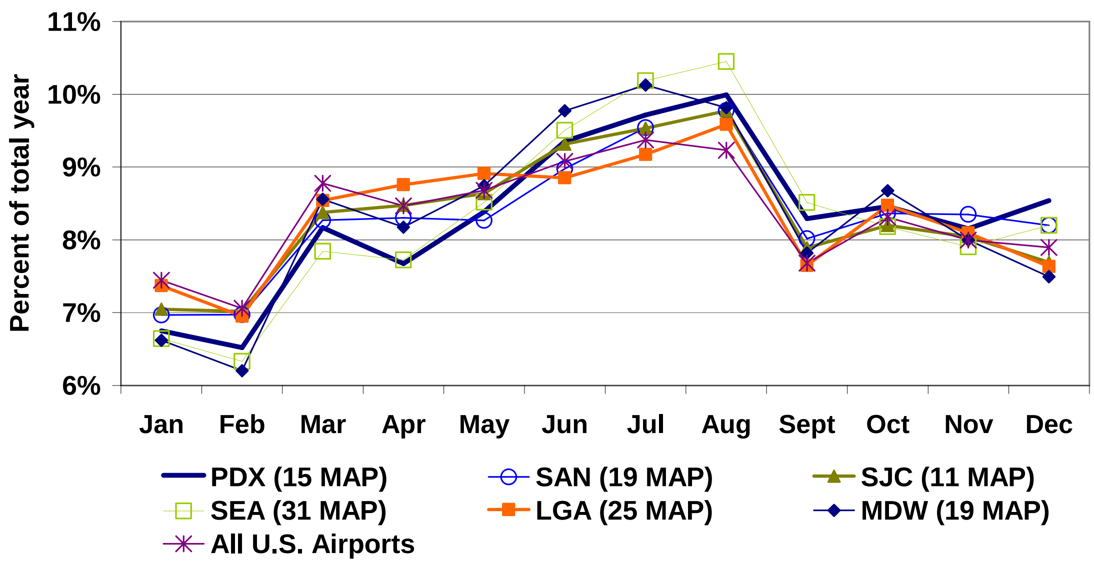
Note: Data include domestic and international passengers enplaned on mainline and regional passenger airlines.
Source: Port of Portland records.

Figure 31
MONTHLY SHARES OF PDX ANNUAL ENPLANED PASSENGERS



Source: Port of Portland records.

Figure 32
MONTHLY SHARES OF ANNUAL ENPLANED PASSENGERS AT PDX AND SELECTED U.S. AIRPORTS IN 2007



Note: MAP = Million Annual Passengers (enplaned and deplaned)
Sources: PDX: Port of Portland records. Other airports: U.S. Department of Transporation, Federal Aviation Administration, Schedule T100, domestic and international, online database.

Based on a review of historical data, it was determined that a peak month factor of 10.0% was appropriate for the forecasts of peak month enplaned passengers, as shown in Table 27. The peak month factor for enplaned passengers is higher than the peak month factor for aircraft operations because in the peak month there are typically higher boarding load factors and larger average aircraft.

Passenger Airline Aircraft Operations

Table 28 presents historical passenger airline landings by month at PDX in 1990 and from 2000 through 2007. August has consistently been the peak month, with July accounting for a similar but slightly smaller share of passenger airline operations. During the past five years, the peak month share of PDX passenger airline aircraft operations was similar, ranging from 8.9% to 9.1%, as shown on Figure 33.

Figure 34 shows a monthly distribution of passenger airline operations at PDX, selected airports, and all U.S. airports in 2007. Although each of the selected airports represents a different level of passenger activity, the peak month occurs in either July or August and the peak month share of annual passenger airline operations is similar, ranging from 8.6% to 9.3% of total.

Based on a review of historical data, it was determined that a peak month factor of 9.1% was appropriate for the forecasts of peak month passenger airline operations, as shown previously in Table 27. The ADPM operations shown in Table 27 correspond to (1) the annual forecasts of passenger airline operations and (2) the total flights (arrivals and departures) in the future schedules for each forecast year presented in the following sections.

Table 27

HISTORICAL AND FORECAST PEAK PERIOD DEMAND
Master Plan Update
Portland International Airport
2006 - 2035

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

	Historical		Scenario 1 (Median, 50th percentile)				
	2006 (a)	2007	2012	2017	2022 (b)	2027	2035
ENPLANED PASSENGERS							
Annual passengers	7,022,000	7,332,000	7,489,000	8,992,000	10,312,000	11,825,000	13,393,000
Peak month (c)	695,180	733,200	748,900	899,200	1,031,200	1,182,500	1,339,300
Peak month percent of annual	9.9%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Average day peak month (ADPM)	22,425	23,652	24,158	29,006	33,265	38,145	43,203
PASSENGER AIRLINE AIRCRAFT OPERATIONS							
Annual operations (d)	186,124	191,554	180,400	207,000	228,000	250,600	275,000
Peak month (c)	16,940	17,050	16,420	18,840	20,750	22,800	25,030
Peak month percent of annual	9.1%	8.9%	9.1%	9.1%	9.1%	9.1%	9.1%
Average day peak month (ADPM)	546	550	530	608	669	735	807
TOTAL AIRCRAFT OPERATIONS (e)							
Annual operations	260,386	264,518	258,480	291,540	318,440	347,360	377,820
Peak month (c)	24,480	24,340	23,780	26,820	29,300	31,960	34,760
Peak month percent of annual (f)	9.4%	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%
Average day peak month (ADPM)	790	785	767	865	945	1,031	1,121

(a) The base year for the forecasts is 2006.
(b) Interpolated from the forecasts for 2017 and 2027.
(c) Estimated using the peak month percent of annual and the annual totals.
(d) Includes other activity such as nonscheduled and empty flights. As a result, the totals reported for passenger airline aircraft operations in this table are greater than twice the landings reported in Table 15.
(e) Includes passenger, cargo, general aviation, and military operations.
(f) Based on actual data from FAA Tower records.

Sources: Historical: Port of Portland records and Federal Aviation Administration, Air Traffic Activity System (ATADS), online database. Forecast: Jacobs Consultancy, July 2008.

Table 28

HISTORICAL PASSENGER AIRLINE LANDINGS BY MONTH

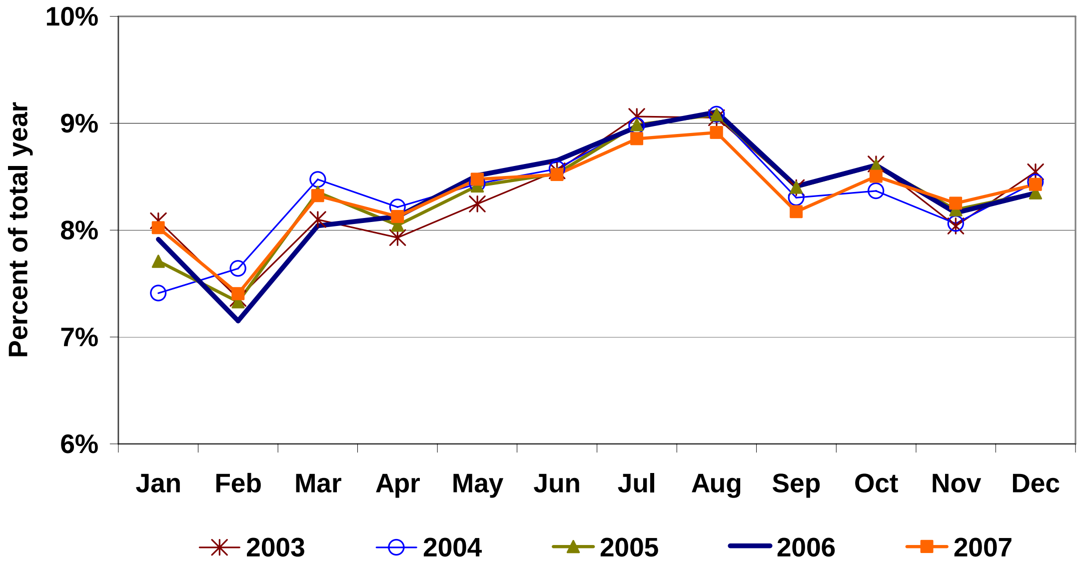
Master Plan Update
Portland International Airport
1990 and 2000 - 2007

	Month												
Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1990	6,923	6,160	7,141	6,859	7,311	7,158	7,488	7,726	7,202	7,469	6,934	6,926	85,297
2000	7,794	8,414	9,324	9,055	9,304	9,156	9,360	9,561	9,102	9,273	8,660	8,727	107,730
2001	8,855	7,934	8,816	8,503	8,819	8,859	9,280	9,445	6,735	7,507	7,095	7,369	99,217
2002	7,404	6,878	7,604	7,554	7,931	7,628	7,978	8,071	7,258	7,479	7,063	7,297	90,145
2003	7,168	6,525	7,178	7,028	7,307	7,581	8,033	8,022	7,442	7,639	7,124	7,573	88,620
2004	6,572	6,777	7,516	7,287	7,482	7,605	7,963	8,057	7,365	7,421	7,151	7,495	88,691
2005	7,043	6,698	7,633	7,353	7,689	7,793	8,211	8,296	7,676	7,862	7,485	7,629	91,368
2006	7,328	6,621	7,444	7,525	7,880	8,010	8,301	8,430	7,786	7,969	7,556	7,727	92,577
2007	7,645	7,057	7,930	7,745	8,078	8,119	8,439	8,493	7,787	8,102	7,863	8,031	95,289

	Percent of total												
	Month												
Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1990	8.1%	7.2%	8.4%	8.0%	8.6%	8.4%	8.8%	9.1%	8.4%	8.8%	8.1%	8.1%	100.0%
2000	7.2%	7.8%	8.7%	8.4%	8.6%	8.5%	8.7%	8.9%	8.4%	8.6%	8.0%	8.1%	100.0%
2001	8.9%	8.0%	8.9%	8.6%	8.9%	8.9%	9.4%	9.5%	6.8%	7.6%	7.2%	7.4%	100.0%
2002	8.2%	7.6%	8.4%	8.4%	8.8%	8.5%	8.9%	9.0%	8.1%	8.3%	7.8%	8.1%	100.0%
2003	8.1%	7.4%	8.1%	7.9%	8.2%	8.6%	9.1%	9.1%	8.4%	8.6%	8.0%	8.5%	100.0%
2004	7.4%	7.6%	8.5%	8.2%	8.4%	8.6%	9.0%	9.1%	8.3%	8.4%	8.1%	8.5%	100.0%
2005	7.7%	7.3%	8.4%	8.0%	8.4%	8.5%	9.0%	9.1%	8.4%	8.6%	8.2%	8.3%	100.0%
2006	7.9%	7.2%	8.0%	8.1%	8.5%	8.7%	9.0%	9.1%	8.4%	8.6%	8.2%	8.3%	100.0%
2007	8.0%	7.4%	8.3%	8.1%	8.5%	8.5%	8.9%	8.9%	8.2%	8.5%	8.3%	8.4%	100.0%

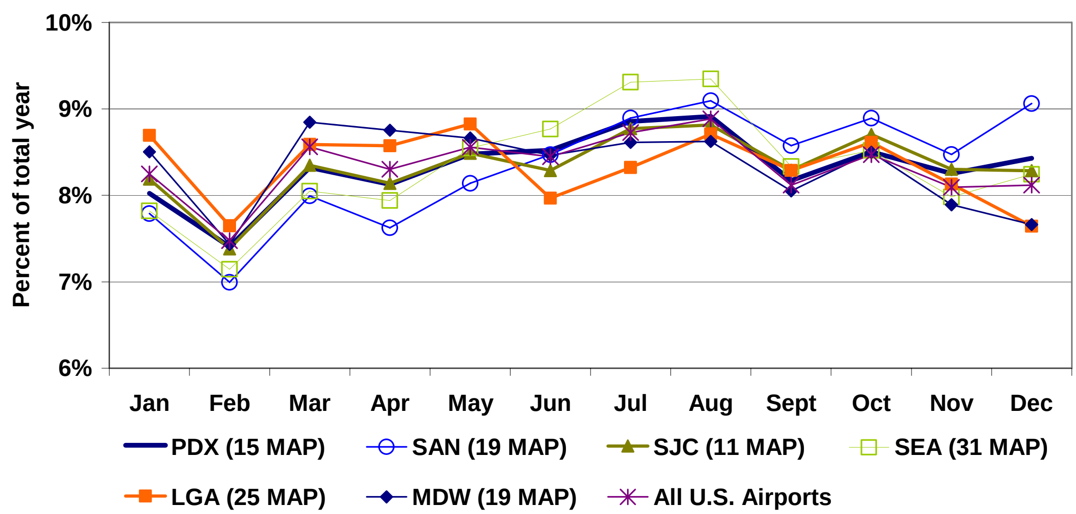
Note: Data include domestic and international landings by mainline and regional passenger airlines.
Source: Port of Portland records.

Figure 33
MONTHLY SHARES OF
PDX ANNUAL PASSENGER AIRLINE AIRCRAFT OPERATIONS



Source: Port of Portland records, based on passenger airline landings.

Figure 34
MONTHLY SHARES OF ANNUAL PASSENGER AIRLINE OPERATIONS
AT PDX AND SELECTED U.S. AIRPORTS IN 2007

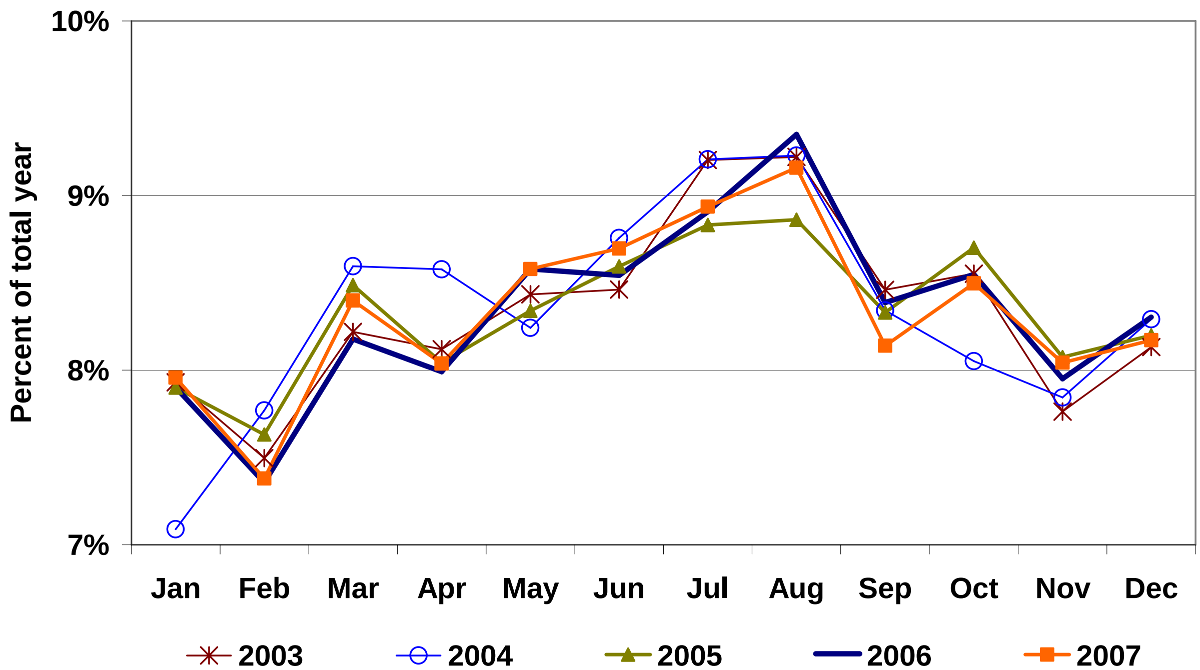


Note: MAP = Million Annual Passengers (enplaned and deplaned)
Sources: PDX: Port of Portland records. Other airports: U.S. Department of Transporation, Federal Aviation Administration, Schedule T100, domestic and international, online database.

Total Aircraft Operations

Table 29 presents historical total PDX aircraft operations by FAA category from 1980 through 2007. Table 30 presents historical total PDX aircraft operations (including passenger and cargo airline, general aviation, and military) by month in 1990 and from 2000 through 2007. August has consistently been the peak month, with July accounting for a similar but slightly smaller share of total aircraft operations. During the past five years, the peak month share of PDX total aircraft operations was similar, ranging from 8.9% to 9.4%, as shown on Figure 35. As shown earlier in Table 27, it was assumed that a peak month factor of 9.2% was appropriate for the forecasts of peak month total aircraft operations.

Figure 35
MONTHLY SHARE OF PDX TOTAL AIRCRAFT OPERATIONS



Sources: Port of Portland records and U.S. Department of Transportation, Federal Aviation Administration.

Table 29

HISTORICAL AIRCRAFT OPERATIONS
Master Plan Update
Portland International Airport
1976-2007

Year	Air carrier	Air taxi	General aviation	Military	Total	Percent change
1990	98,208	97,070	59,739	14,633	269,650	--
1991	91,521	100,419	58,596	13,764	264,300	-2.0%
1992	89,368	107,119	60,719	13,217	270,423	2.3%
1993	95,069	114,704	58,660	12,396	280,829	3.8%
1994	102,202	119,333	50,085	12,304	283,924	1.1%
1995	114,431	127,631	48,436	11,505	302,003	6.4%
1996	122,644	127,205	49,501	10,274	309,624	2.5%
1997	120,400	135,514	63,666	10,210	329,790	6.5%
1998	94,158	157,375	65,946	8,780	326,259	-1.1%
1999	157,520	117,906	37,789	9,232	322,447	-1.2%
2000	152,372	118,900	37,320	8,885	317,477	-1.5%
2001	138,211	112,354	33,486	9,851	293,902	-7.4%
2002	122,226	108,816	37,911	9,453	278,406	-5.3%
2003	122,314	102,848	32,985	8,041	266,188	-4.4%
2004	129,320	93,760	33,199	7,216	263,495	-1.0%
2005	135,552	89,791	30,487	6,523	262,353	-0.4%
2006	139,419	87,720	28,230	5,017	260,386	-0.7%
2007	148,756	84,432	27,623	3,707	264,518	1.6%
	Average annual percent increase (decrease)					
1990-2000	4.5%	2.0%	-4.6%	-4.9%	1.6%	
2000-2007	-0.3%	-4.8%	-4.2%	-11.7%	-2.6%	
2000-2002	-10.4%	-4.3%	0.8%	3.1%	-6.4%	
2002-2007	4.0%	-4.9%	-6.1%	-17.1%	-1.0%	

Sources: Port of Portland records and Federal Aviation Administration, Air Traffic Activity System (ATADS), online database.

Table 30

HISTORICAL TOTAL AIRCRAFT OPERATIONS BY MONTH
Master Plan Update
Portland International Airport
1990 and 2000 - 2007

	Month												
Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1990	20,956	19,380	22,554	22,198	23,110	23,791	24,483	26,038	22,837	22,871	20,691	20,731	269,640
2000	24,680	23,955	26,989	25,683	26,593	27,480	28,019	28,643	26,096	26,463	24,729	25,048	314,378
2001	25,349	23,079	25,946	24,066	26,242	26,036	27,574	27,541	20,144	22,528	20,847	21,765	291,117
2002	21,254	20,605	22,778	22,966	24,657	24,427	25,586	26,017	23,181	23,148	20,823	21,435	276,877
2003	21,180	20,020	21,953	21,684	22,525	22,599	24,578	24,626	22,594	22,842	20,732	21,719	267,052
2004	18,649	20,439	22,611	22,565	21,681	23,036	24,219	24,278	21,944	21,181	20,633	21,810	263,046
2005	20,800	20,090	22,342	21,173	21,957	22,626	23,250	23,331	21,933	22,908	21,257	21,586	263,253
2006	20,586	19,167	21,304	20,818	22,349	22,256	23,205	24,358	21,850	22,270	20,714	21,633	260,510
2007	21,050	19,521	22,218	21,262	22,693	23,003	23,637	24,228	21,534	22,478	21,276	21,618	264,518

Percent of total

	Month												
Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1990	7.8%	7.2%	8.4%	8.2%	8.6%	8.8%	9.1%	9.7%	8.5%	8.5%	7.7%	7.7%	100.0%
2000	7.9%	7.6%	8.6%	8.2%	8.5%	8.7%	8.9%	9.1%	8.3%	8.4%	7.9%	8.0%	100.0%
2001	8.7%	7.9%	8.9%	8.3%	9.0%	8.9%	9.5%	9.5%	6.9%	7.7%	7.2%	7.5%	100.0%
2002	7.7%	7.4%	8.2%	8.3%	8.9%	8.8%	9.2%	9.4%	8.4%	8.4%	7.5%	7.7%	100.0%
2003	7.9%	7.5%	8.2%	8.1%	8.4%	8.5%	9.2%	9.2%	8.5%	8.6%	7.8%	8.1%	100.0%
2004	7.1%	7.8%	8.6%	8.6%	8.2%	8.8%	9.2%	9.2%	8.3%	8.1%	7.8%	8.3%	100.0%
2005	7.9%	7.6%	8.5%	8.0%	8.3%	8.6%	8.8%	8.9%	8.3%	8.7%	8.1%	8.2%	100.0%
2006	7.9%	7.4%	8.2%	8.0%	8.6%	8.5%	8.9%	9.4%	8.4%	8.5%	8.0%	8.3%	100.0%
2007	8.0%	7.4%	8.4%	8.0%	8.6%	8.7%	8.9%	9.2%	8.1%	8.5%	8.0%	8.2%	100.0%

Note: Data include passenger, cargo, general aviation, and military operations.
Sources: Port of Portland records and Federal Aviation Administration, Air Traffic Activity System (ATADS), online database.

5.9.2 Average Day Peak Month

The ADPM is the mathematical average of peak month activity (i.e., the peak month number of operations divided by 31 days in the peak month). The ADPM level of activity serves as the "control total" for the ADPM flight schedules which are used as input to detailed technical analyses such as facility requirements, noise modeling, and demand-capacity modeling. The ADPM forecasts of enplaned passengers, passenger airline aircraft operations, and total aircraft operations are presented in Table 27.

5.9.3 Forecast of ADPM Flight Schedules

Detailed flight schedules of PDX passenger airline aircraft operations were prepared for 2017, 2027, and 2035 for the 50th percentile forecasts. In addition, a flight schedule for 2022 was prepared based on an interpolation of 2022 activity from the forecasts for 2017 and 2027. These detailed future flight schedules include individual arriving and departing flights, with information on airline, origin/destination, equipment type, and arrival/departure time. The key assumptions used to develop the flight schedules are described in the following section.

Key Assumptions

Actual airline flight schedules for PDX in August 2008 were obtained from BACK Aviation Solutions to evaluate airline scheduling practices and the distribution of ADPM aircraft operations by airline, equipment type, origin/destination, and time of day. Schedules for August 2008 were used because they reflect the most recent mix of passenger airline fleet at PDX. Flight schedules were prepared which matched arrivals and departures to reflect the complete routing or turn of an aircraft at PDX. The key assumptions used to develop the ADPM flight schedules included:

- Peak Month Shares of Annual Activity—The peak month shares of annual activity reported in Table 27 were assumed to represent future peak demand and were used as the control totals for the future schedules in each forecast year.

- Passenger Airline Aircraft Fleet—Airline aircraft fleet orders were reviewed to determine the anticipated evolution of the fleet to newer-generation aircraft with increased fuel efficiency. The average seating capacity of regional aircraft is expected to increase with the replacement of Horizon's DH8 aircraft (37 seats) with the Q400 aircraft (74 seats) and the replacement of less fuel efficient regional jets. The average seating capacity of narrowbody aircraft is expected to increase gradually with the replacement of MD80 aircraft (140 seats) with the B-737-800 (157 seats) by Alaska and American, the continued use of the B-737 aircraft (137 seats) by Southwest Airlines, and replacement of B-757 aircraft (170 seats) with smaller narrowbody aircraft such as the A-320 (150 seats) and the B-737-800 (150 seats).

- Market Growth—Overall market growth was applied to individual markets in order to determine likely increases in service frequency and up-gauging of aircraft size on specific routes.

- Hourly Distribution of Operations—The hourly distribution of operations from the flight schedules obtained for August 2008 was assumed to remain relatively unchanged during the forecast period. The peak periods of passenger airline aircraft operations are substantially determined by passenger preferences for flight times as well as the geographical location of PDX in the northwestern United States, the large communities of interest between Portland and metropolitan areas in the western United States, and acceptable travel windows for long-haul flights from Portland to the eastern United States, Hawaii, and international destinations. At the time this report was prepared, there were no demand management practices in place or anticipated that would significantly impact the hourly distribution of operations at PDX.

Methodology

The future flight schedules for PDX were constructed using the actual arrivals and departures published in the August 2008 baseline schedule. Additional flights (arrivals and departures) were added to the August 2008 schedule to reflect: (1) the ADPM operations for each forecast year (the “control totals” mentioned earlier) which relate directly to the annual forecasts, as summarized in Table 27, (2) the hourly percentage distribution of arrivals and departures represented by the August 2008 schedule and summarized later in Table 31, (3) the fleet mix of the airlines serving PDX and their future fleet plans, and (4) the markets currently served at PDX and the potential for new markets.

Hourly Distribution of Passenger Airline Aircraft Operations

Table 31 presents the hourly distribution of passenger airline aircraft operations for the August 2008 (baseline) schedule and each of the ADPM future flight schedules and a summary of arrivals and departures by hour. The key findings from analyzing the baseline schedule are:

- The peak hour for total aircraft operations (arrivals and departures) at PDX in August 2008 was the 10 a.m. hour, accounting for approximately 8% of ADPM total operations.

- The peak hour for aircraft departures at PDX in August 2008 was the 6 a.m. hour, accounting for approximately 10% of ADPM departures.

- The peak hour for aircraft arrivals at PDX in August 2008 was the 12 noon hour, accounting for approximately 9% of ADPM arrivals.

Table 31

HISTORICAL AND FORECAST HOURLY DISTRIBUTION OF PASSENGER AIRLINE AIRCRAFT OPERATIONS

Master Plan Update

Portland International Airport

2006-2035

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and

	Departures					Arrivals					Total operations				
Hour of the day	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035
0	2	2	2	3	3	3	3	3	3	3	5	5	5	6	6
2	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1
5	2	2	2	2	2	1	1	1	1	1	3	3	3	3	3
6	29	31	34	35	39	6	5	5	5	5	35	36	39	40	44
7	24	23	28	28	32	11	10	11	13	14	35	33	39	41	46
8	16	18	18	22	24	12	14	14	16	16	28	32	32	38	40
9	12	14	14	17	18	18	19	21	22	26	30	33	35	39	44
10	25	25	29	30	33	21	20	24	25	31	46	45	53	55	64
11	18	19	21	22	29	14	18	18	20	23	32	37	39	42	52
12	12	14	14	17	18	26	28	30	33	35	38	42	44	50	53
13	25	27	29	33	35	16	17	18	21	22	41	44	47	54	57
14	20	22	24	26	29	13	13	16	19	23	33	35	40	45	52
15	13	13	14	16	18	11	14	15	18	18	24	27	29	34	36
16	19	21	23	26	26	22	24	25	26	27	41	45	48	52	53
17	17	19	21	23	24	11	11	13	17	17	28	30	34	40	41
18	9	9	11	15	17	21	18	20	24	27	30	27	31	39	44
19	14	14	15	16	18	20	20	22	20	21	34	34	37	36	39
20	16	14	17	20	21	18	18	22	24	25	34	32	39	44	46
21	10	8	10	8	8	17	18	21	22	26	27	26	31	30	34
22	5	5	5	5	5	16	18	20	23	26	21	23	25	28	31
23	4	4	4	4	5	13	14	14	15	17	17	18	18	19	22
Total	292	304	335	368	404	291	304	334	368	404	583	608	669	736	808

Table 31 (page 2 of 2)

HISTORICAL AND FORECAST HOURLY DISTRIBUTION OF PASSENGER AIRLINE AIRCRAFT OPERATIONS

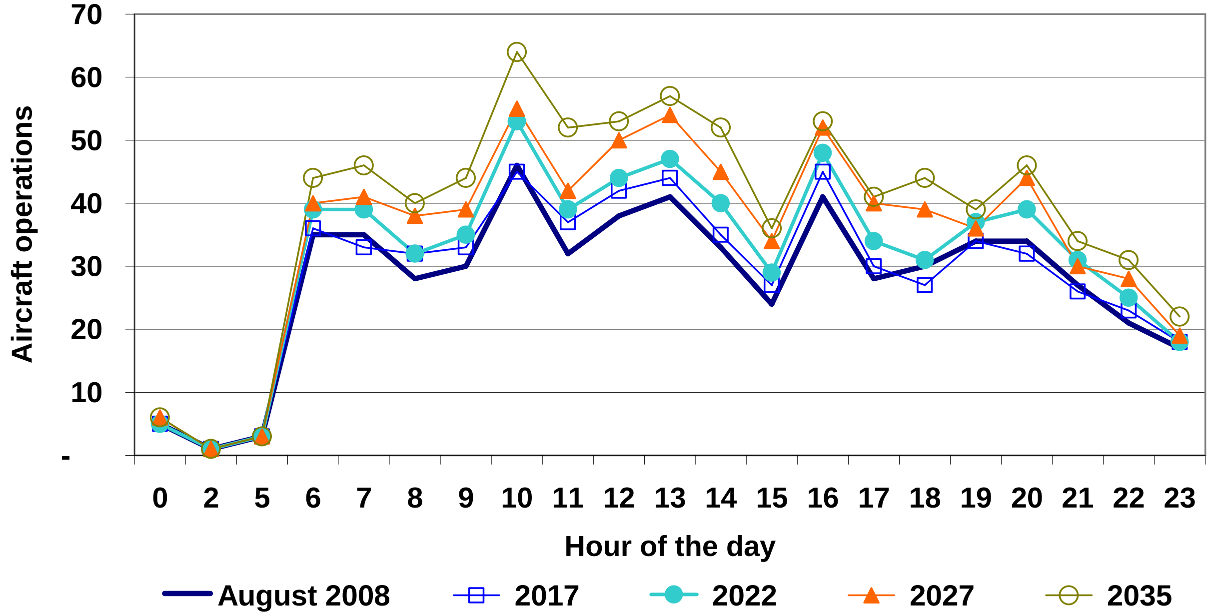
Master Plan Update
Portland International Airport
2006-2035

	Percent distribution														
	Departures					Arrivals					Total operations				
Hour of the day	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035
0	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
6	10%	10%	10%	10%	10%	2%	2%	1%	1%	1%	6%	6%	6%	5%	5%
7	8%	8%	8%	8%	8%	4%	3%	3%	4%	3%	6%	5%	6%	6%	6%
8	5%	6%	5%	6%	6%	4%	5%	4%	4%	4%	5%	5%	5%	5%	5%
9	4%	5%	4%	5%	4%	6%	6%	6%	6%	6%	5%	5%	5%	5%	5%
10	9%	8%	9%	8%	8%	7%	7%	7%	7%	8%	8%	7%	8%	7%	8%
11	6%	6%	6%	6%	7%	5%	6%	5%	5%	6%	5%	6%	6%	6%	6%
12	4%	5%	4%	5%	4%	9%	9%	9%	9%	9%	7%	7%	7%	7%	7%
13	9%	9%	9%	9%	9%	5%	6%	5%	6%	5%	7%	7%	7%	7%	7%
14	7%	7%	7%	7%	7%	4%	4%	5%	5%	6%	6%	6%	6%	6%	6%
15	4%	4%	4%	4%	4%	4%	5%	4%	5%	4%	4%	4%	4%	5%	4%
16	7%	7%	7%	7%	6%	8%	8%	7%	7%	7%	7%	7%	7%	7%	7%
17	6%	6%	6%	6%	6%	4%	4%	4%	5%	4%	5%	5%	5%	5%	5%
18	3%	3%	3%	4%	4%	7%	6%	6%	7%	7%	5%	4%	5%	5%	5%
19	5%	5%	4%	4%	4%	7%	7%	7%	5%	5%	6%	6%	6%	5%	5%
20	5%	5%	5%	5%	5%	6%	6%	7%	7%	6%	6%	5%	6%	6%	6%
21	3%	3%	3%	2%	2%	6%	6%	6%	6%	6%	5%	4%	5%	4%	4%
22	2%	2%	1%	1%	1%	5%	6%	6%	6%	6%	4%	4%	4%	4%	4%
23	1%	1%	1%	1%	1%	4%	5%	4%	4%	4%	3%	3%	3%	3%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: Future schedules were developed for the Scenario 1 (Median, 50th percentile) forecasts.
Sources: August 2008--Official Airline Guides, Inc., online database. Forecast--Jacobs Consultancy, June 2008.

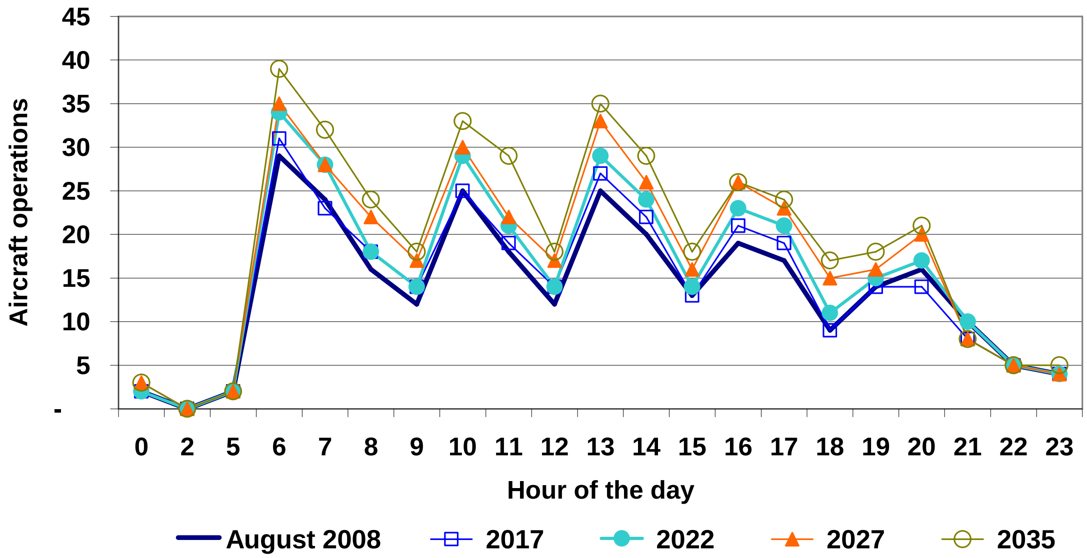
As shown on Figure 36, the overall hourly distribution of PDX total passenger airline aircraft operations is expected to remain generally the same over the forecast period. It was assumed that the most popular hours of passenger travel will not change materially over the forecast period. Figures 37 and 38 present the hourly distribution of passenger airline aircraft departures and arrivals, respectively.

Figure 36
HOURLY DISTRIBUTION OF PDX TOTAL PASSENGER AIRLINE AIRCRAFT OPERATIONS



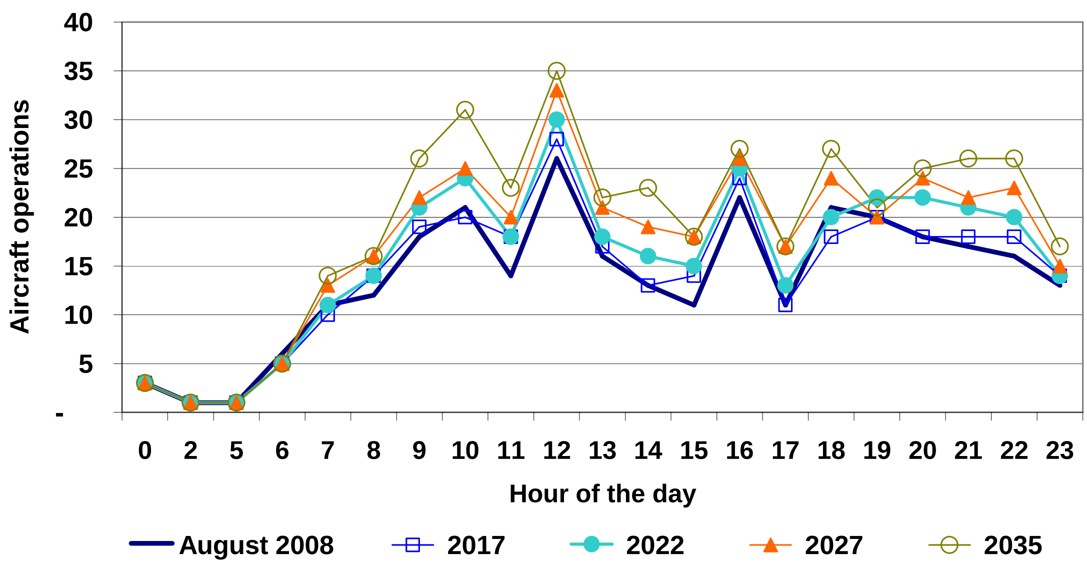
Sources: August 2008--Official Airline Guides, Inc., online database. Future schedules for 2017, 2022, 2027, and 2035--Jacobs Consultancy Inc., July 2008. Total operations include arrivals and departures.

Figure 37
HOURLY DISTRIBUTION OF
PDX PASSENGER AIRLINE AIRCRAFT DEPARTURES



Sources: August 2008--Official Airline Guides, Inc., online database. Future schedules for 2017, 2022, 2027, and 2035--Jacobs Consultancy Inc., July 2008.

Figure 38
HOURLY DISTRIBUTION OF
PDX PASSENGER AIRLINE AIRCRAFT ARRIVALS

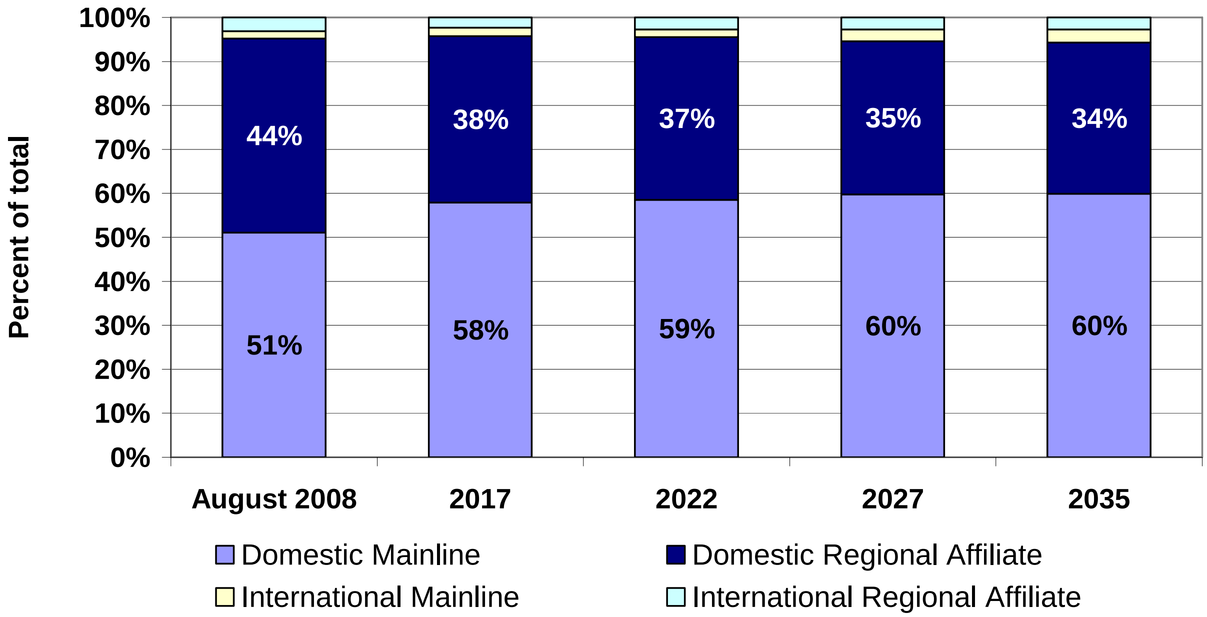


Sources: August 2008--Official Airline Guides, Inc., online database. Future schedules for 2017, 2022, 2027, and 2035--Jacobs Consultancy Inc., July 2008.

Passenger Airline Aircraft Fleet Mix

Table 32 presents the ADPM passenger airline fleet mix in August 2008 and for the future schedules for 2017, 2022, 2027, and 2035. The future schedules are summarized in terms of the shares of ADPM departures by market category (domestic and international, mainline and regional affiliate) and by aircraft type (narrowbody, B757, regional jet, turboprop, and widebody aircraft). Detailed information is presented in Table 32 for the age of aircraft by airline in 2007, the number of seats by aircraft type and airline, the number of ADPM departures, and the percentage of ADPM departures by market and aircraft category. Figure 39 presents a summary of the ADPM aircraft departures by market category. Figure 40 presents a summary of the ADPM aircraft departures by aircraft category. The smaller share of turboprop aircraft over the forecast period reflects the replacement of the Dash 8 aircraft (37 seats) with the Q400 (74 seats) as well as a decreasing number of smaller turboprop aircraft (30 seats).

Figure 39
ADPM PASSENGER AIRLINE DEPARTURES
Shares By Market Category



Sources: August 2008--Official Airline Guides, Inc., online database. Future schedules for 2017, 2022, 2027, and 2035--Jacobs Consultancy Inc., July 2008.

Table 32

HISTORICAL AND FORECAST AVERAGE DAY PEAK MONTH PASSENGER AIRLINE FLEET MIX
Master Plan Update
Portland International Airport
2006 - 2035

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

				ADPM departures					Percent of ADPM departures				
					Forecast					Forecast			
Aircraft type	Operators	Average aircraft age in 2007 (a)	Seats	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035
DOMESTIC MAINLINE													
Narrowbody													
A318	Frontier	3.0	118	1	1	1	1	1	0%	0%	0%	0%	0%
A319	Frontier	5.0	136	4	4	4	4	4	1%	1%	1%	1%	1%
	United	8.0	120	4	4	4	4	4	1%	1%	1%	1%	1%
	US Airways	7.2	124	2	2	2	2	2	1%	1%	1%	1%	0%
				10	10	10	10	10	3%	3%	3%	3%	2%
A320	JetBlue	3.6	150	1	2	2	3	3	0%	1%	1%	1%	1%
	Northwest	13.0	148	--	1	2	6	7	0%	0%	1%	2%	2%
	United	10.0	138	2	10	13	18	19	1%	3%	4%	5%	5%
	US Airways	9.7	150	6	11	11	13	14	2%	4%	3%	4%	3%
				9	24	28	40	43	3%	8%	8%	11%	11%
B-737-300/400/500	Alaska	12.4	144	10	5	5	1	1	3%	2%	1%	0%	0%
	United	16.0 - 19.0	110-120	8	--	--	--	--	3%	0%	0%	0%	0%
	US Airways	19.7	134	4	--	--	--	--	1%	0%	0%	0%	0%
	Southwest	16.8	137	23	12	12	1	1	8%	4%	4%	0%	0%
				45	17	17	2	2	15%	6%	5%	1%	0%
B-737-700	Alaska	7.0	124	22	22	22	22	22	8%	7%	7%	6%	5%
	Southwest	4.2	137	21	44	51	72	82	7%	14%	15%	20%	20%
				43	66	73	94	104	15%	22%	22%	26%	26%
B-737-800	American	--	150	--	9	10	11	12	0%	3%	3%	3%	3%
	Alaska	--	157	--	14	19	28	33	0%	5%	6%	8%	8%
	Continental	6.5	160	6	6	6	6	6	2%	2%	2%	2%	1%
	Delta	1.0 - 7.2	150-160	5	9	11	15	16	2%	3%	3%	4%	4%
				11	38	46	60	67	4%	13%	14%	16%	17%

Table 32 (page 2 of 4)

HISTORICAL AND FORECAST AVERAGE DAY PEAK MONTH PASSENGER AIRLINE FLEET MIX
Master Plan Update
Portland International Airport
2006 - 2035

				ADPM departures					Percent of ADPM departures				
					Forecast					Forecast			
Aircraft type	Operators	Average aircraft age in 2007 (a)	Seats	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035
DOMESTIC MAINLINE (continued)													
B-737-900	Continental	6.3	173	--	1	2	2	4	0%	0%	1%	1%	1%
MD-83	American	18.0	140	7	--	--	--	--	2%	0%	0%	0%	0%
MD-90	Delta	12.1	150	1	1	1	--	--	0%	0%	0%	0%	0%
Subtotal Narrowbody				**127**	**158**	**178**	**209**	**231**	**43%**	**52%**	**53%**	**57%**	**57%**
B-757													
B-757-100/200	Delta	16.3	183	5	2	2	--	--	2%	1%	1%	0%	0%
	Northwest	16.5	182	3	2	2	--	--	1%	1%	1%	0%	0%
	United	16.0	182	7	4	4	--	--	2%	1%	1%	0%	0%
				15	8	8	--	--	5%	3%	2%	0%	0%
B-757-300	Continental	5.3	216	1	1	1	1	1	0%	0%	0%	0%	0%
	Northwest	4.8	224	4	5	5	5	5	1%	2%	1%	1%	1%
				5	6	6	6	6	2%	2%	2%	2%	1%
Subtotal B-757				**20**	**14**	**14**	**6**	**6**	**7%**	**5%**	**4%**	**2%**	**1%**
Widebody													
A330-200	Northwest	2.7	243	--	--	--	1	1	0%	0%	0%	0%	0%
	Hawaiian	--	n.a.	--	2	2	3	3	0%	1%	1%	1%	1%
				--	2	2	4	4	0%	1%	1%	1%	1%
B-767-300	Hawaiian	21.0	264	2	2	2	1	1	1%	1%	1%	0%	0%
Subtotal Widebody				**2**	**4**	**4**	**5**	**5**	**1%**	**1%**	**1%**	**1%**	**1%**
TOTAL--DOMESTIC MAINLINE				**149**	**176**	**196**	**220**	**242**	**51%**	**58%**	**59%**	**60%**	**60%**

Table 32 (page 3 of 4)

HISTORICAL AND FORECAST AVERAGE DAY PEAK MONTH PASSENGER AIRLINE FLEET MIX
Master Plan Update
Portland International Airport
2006 - 2035

				ADPM departures					Percent of ADPM departures				
					Forecast					Forecast			
Aircraft type	Operators	Average aircraft age in 2007 (a)	Seats	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035
DOMESTIC REGIONAL AFFILIATE													
Regional jets													
Canadair Regional Jet	Delta Connection	6.2	50	3	--	--	--	--	1%	0%	0%	0%	0%
Embraer Regional Jet 135/140/145	ExpressJet	7.0	50	3	--	--	--	--	1%	0%	0%	0%	0%
Canadair Regional Jet 700	Horizon	5.5	70	40	35	35	22	15	14%	12%	10%	6%	4%
	Delta Connection	--	70	--	9	9	9	9	0%	3%	3%	2%	2%
	United Express	3.3	66	4	5	6	13	16	1%	2%	2%	4%	4%
				44	49	50	44	40	15%	16%	15%	12%	10%
Canadair Regional Jet 900	Horizon	n.a.	90	--	3	8	17	28	0%	1%	2%	5%	7%
	Delta Connection	n.a.	90	--	--	--	--	1	0%	0%	0%	0%	0%
				--	3	8	17	29	0%	1%	2%	5%	7%
Subtotal Regional jets				**50**	**52**	**58**	**61**	**69**	**17%**	**17%**	**17%**	**17%**	**17%**
Turboprop													
Embraer 120	United Express	10.7	30	23	18	18	11	9	8%	6%	5%	3%	2%
Dash 8	Horizon	10.2	37	33	--	--	--	--	11%	0%	0%	0%	0%
Q-400	Horizon	4.0	74	23	45	48	56	61	8%	15%	14%	15%	15%
Subtotal Turboprop				**79**	**63**	**66**	**67**	**70**	27%	21%	20%	18%	17%
TOTAL--DOMESTIC REGIONAL AFFILIATE				**129**	**115**	**124**	**128**	**139**	**44%**	**38%**	**37%**	**35%**	**34%**
INTERNATIONAL MAINLINE													
Narrowbody													
A319	Mexicana	n.a.	120	2	--	--	--	--	1%	0%	0%	0%	0%
B-737-800	New entrant	n.a.	n.a.	--	2	2	3	3	0%	1%	1%	1%	1%
Subtotal Narrowbody				**2**	**2**	**2**	**3**	**3**	**1%**	**1%**	**1%**	**1%**	**1%**

Table 32 (page 4 of 4)

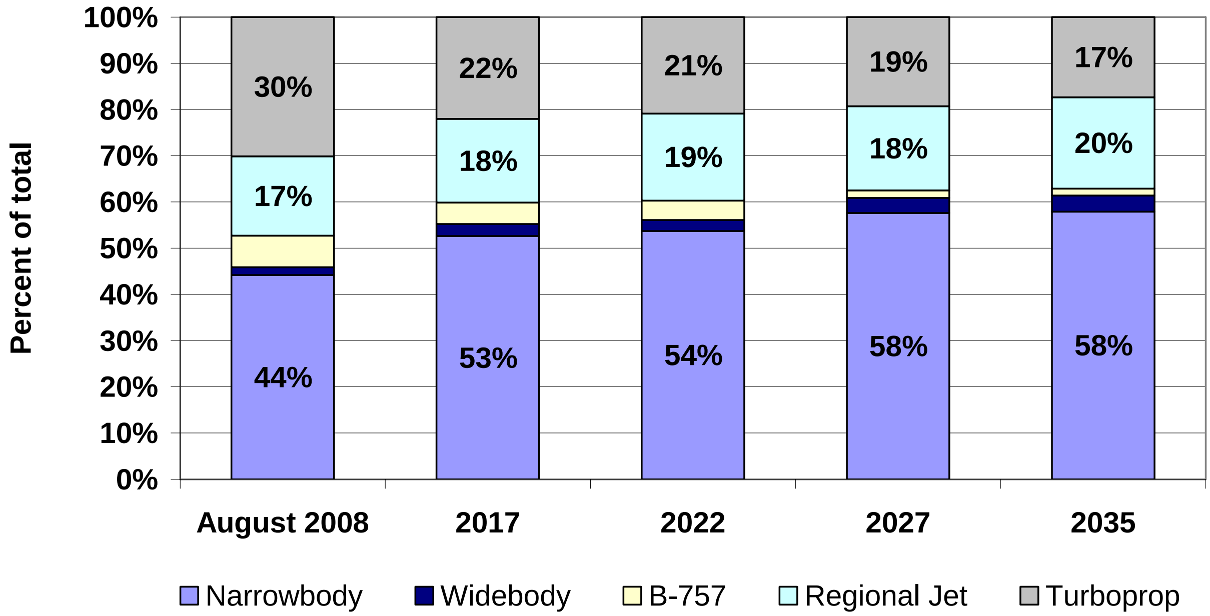
HISTORICAL AND FORECAST AVERAGE DAY PEAK MONTH PASSENGER AIRLINE FLEET MIX
Master Plan Update
Portland International Airport
2006 - 2035

				ADPM departures					Percent of ADPM departures				
					Forecast					Forecast			
Aircraft type	Operators	Average aircraft age in 2007 (a)	Seats	August 2008	2017	2022	2027	2035	August 2008	2017	2022	2027	2035
INTERNATIONAL MAINLINE (continued)													
Widebody													
A330-200	Northwest	2.7	243	2	2	2	3	4	1%	1%	1%	1%	1%
A340-300	Lufthansa	(b)	247	1	1	1	1	1	0%	0%	0%	0%	0%
B-777	New entrant	n.a.	n.a.	--	1	1	2	2	0%	0%	0%	1%	0%
B-787	New entrant	n.a.	n.a.	--	--	--	1	2	0%	0%	0%	0%	0%
Subtotal Widebody				**3**	**4**	**4**	**7**	**9**	**1%**	**1%**	**1%**	**2%**	**2%**
TOTAL--INTERNATIONAL MAINLINE				**5**	**6**	**6**	**10**	**12**	**2%**	**2%**	**2%**	**3%**	**3%**
INTERNATIONAL REGIONAL AFFILIATE													
Regional jets													
Canadair Regional Jet 700	Air Canada Jazz	--	70	--	2	2	2	--	0%	1%	1%	1%	0%
Canadair Regional Jet 900	Air Canada Jazz	n.a.	90	--	1	1	2	4	0%	0%	0%	1%	1%
	Horizon	n.a.	90	--	--	2	2	7	0%	0%	1%	1%	2%
				0	1	3	4	11	0%	0%	1%	1%	3%
Subtotal Regional jets				**--**	**3**	**5**	**6**	**11**	**0%**	**1%**	**1%**	**2%**	**3%**
Turboprop													
Dash 8-300	Air Canada Jazz	19.0	50	5	--		--	--	2%	0%	0%	0%	0%
Q-400	Horizon	4.0	74	4	4	4	4	--	1%	1%	1%	1%	0%
Subtotal Turboprop				**9**	**4**	**4**	**4**	**--**	3%	1%	1%	1%	0%
TOTAL--INTERNATIONAL REGIONAL AFFILIATE				**9**	**7**	**9**	**10**	**11**	**3%**	**2%**	**3%**	**3%**	**3%**
TOTAL AIRPORT				**292**	**304**	**335**	**368**	**404**	**100%**	**100%**	**100%**	**100%**	**100%**

n.a. = not available
Note: Future schedules were developed for the Scenario 1 (Median, 50th percentile) forecasts.
(a) Airline annual reports and SEC filings (Form 10-K).
(b) The first A340-300 was delivered in 1993, as reported in The Airline Monitor, May 2008.

Sources: August 2008--Official Airline Guides, Inc. Forecast--Jacobs Consultancy, July 2008.

Figure 40
ADPM PASSENGER AIRLINE FLEET
Shares of Departures By Aircraft Category



Sources: August 2008--Official Airline Guides, Inc., online database. Future schedules for 2017, 2022, 2027, and 2035--Jacobs Consultancy Inc., July 2008.

6. SENSITIVITY ANALYSES

Sensitivity tests of the forecasts were conducted to measure the effect of alternative assumptions on passenger demand, using the Scenario 1, 50th percentile forecasts in 2035. The alternative assumptions were based on the list of key issues and trends discussed earlier (see Table 1) and were grouped into five broad categories: (1) aviation industry, (2) regional and economic, (3) technology, (4) global, and (5) external events. A summary of the sensitivity tests and results is provided in Table 33.

6.1 Aviation Industry

Seven sensitivity tests were conducted of aviation industry related issues and trends as discussed in the following sections.

6.1.1 Leakage to Other Airports

Although PDX is the primary commercial service airport for the State of Oregon, it is anticipated that, by 2035, airline service and passenger traffic at the other airports in Oregon will have sufficiently expanded to support their regional populations and economies. As a result, these airports will be less reliant on PDX for airline service in the future. Using data from the PDX Terminal User Survey, it was estimated that the non-PDX catchment area represented approximately 8% of total PDX enplaned passengers in 2006. It was assumed that, by 2035, airline service at other airports in Oregon would have developed to support their regional population and economies and that approximately 8% of PDX enplaned passengers (or 1.1 million) would be leaked to other airports.

6.1.2 Leakage to Other Transportation Modes

The leakage of PDX passengers to other transportation modes such as rail and luxury shuttles is limited because diversion is likely to occur on a relatively small number of short haul routes served by PDX. Seattle, Eugene, and Spokane are the most likely markets to be affected and together are estimated to account for approximately 360,000 originating passengers at PDX in 2035. If 50% of the originating passengers to those markets in 2035 are leaked to other transportation modes, it is estimated that there would be a 1% reduction in passenger traffic (or a loss of 180,000 originating passengers).

6.1.3 Airline Mergers

As noted previously, PDX serves primarily origin-destination passengers. A large share of PDX passengers traveling to the eastern and southern United States make connections at other airline hub airports, given PDX's geographical location in the northwestern corner of the United States. An airline merger among the legacy or long

Table 33

SENSITIVITY TESTS OF ENPLANED PASSENGER FORECAST IN 2035

Master Plan Update

Portland International Airport

Category / Key Issue and Trend	Sensitvity test description	2035 Enplaned passengers (thousands)	Difference from 50th percentile forecast: Enplaned passengers (thousands)	Difference from 50th percentile forecast: Percent
Scenario 1 (Median, 50th percentile) forecast		*13,393*		
Aviation Industry				
Leakage to other airports	Loss of non-PDX catchment region passengers (8% decrease based on PDX Terminal User Survey)	12,322	-1,071	-8%
Leakage to other transportation modes	Originating passengers to Seattle, Eugene, and Spokane decrease by 50%	13,213	-180	-1%
Airline Mergers	Consolidation occurs among legacy carriers (excluding Southwest and Alaska); PDX passengers are rerouted through other connecting hubs.	13,393	0	0%
Security concerns	Impact of security concerns related to a terrorist event are included with the impact of that event (see below under External Events).	13,393	*(a)*	*(a)*
New market / airline service development by Port	Without the Port's marketing and airline service development efforts, enplaned passengers would be 4% lower than forecast.	12,857	-536	-4%
Airport fees	Airport rates and charges have represented 4% to 6% of airline revenue, notwithstanding increases in other costs, and are unlikely to change in the future.	13,393	0	0%
Congestion at other airports	PDX passengers are rerouted through other connecting hubs.	13,393	0	0%
Regional / economic				
Population age distribution	Assumes that people in the 65 years and over age category (500,000) would take one additional airline trip in 2035	13,893	500	4%
Propensity to travel by age group	Assumes that people in the 45-64 years age category (675,000) would take one additional airline trip in 2035	14,068	675	5%
Population in-migration	Net population in-migration is expected to decrease to 20,000 and account for 0.7% of the total population in the Portland-Vancouver Region in 2035	13,373	20	0%
Income distribution	Data for the number of households by income category in the Portland-Vancouver Region are not available	13,393	*(a)*	*(a)*
Wealth (accumulated income)	Assumes that people in the 65 years and over age category (500,000) would take one additional airline trip in 2035	13,893	500	4%
Technology				
Video Conferencing	5% Substitution of video conferencing for business travel	13,159	-234	-2%
Aircraft related	Aircraft related improvements increase fuel efficiency and decrease fuel consumption and costs by 20%	13,929	536	4%
Fuel (biofuels, solar)	Aviation fuel prices decrease by 20%, decreasing airline costs and the cost of travel for PDX passengers.	13,929	536	4%
Other new technologies	No estimates were made.	13,393	*(a)*	*(a)*

Table 32 (page 2 of 2)

SENSITIVITY TESTS OF ENPLANED PASSENGER FORECAST IN 2035

Master Plan Update

Portland International Airport

Category / Key Issue and Trend	Sensitvity test description	2035 Enplaned passengers (thousands)	Difference from 50th percentile forecast: Enplaned passengers (thousands)	Difference from 50th percentile forecast: Percent
Global				
Currency exchange rates	Devaluation of the U.S. dollar making travel less expensive for foreign visitors; PDX international service is limited	13,393	0	0%
Foreign-country air travel patterns	PDX international flights primarily serve the origin-destination passenger base and are supported by the regional economy.	13,393	0	0%
External event				
High oil prices	Oil prices increase by 20.8%	12,864	-529	-4%
National economic recession	4% decrease in PDX enplaned passengers based on performance during past economic recessions	12,857	-536	-4%
Terrorist event	8% decrease in PDX enplaned passengers comparable to decrease in 2001	12,322	-1,071	-8%
Biological event	Given the wide range of possible assumptions and outcomes, no result was calculated	13,393	*(a)*	*(a)*
Global economic crisis	4% decrease in PDX enplaned passengers, equla to performance during past national economic recessions	12,857	-536	-4%
Airline industry labor strikes / shortages	Airline strikes in recent years have been of limited duration / Presidential intervention possible	13,393	*(a)*	*(a)*
War	Assumes war is based outside the United States although there may be U.S. participation	13,393	0	0%

Note: Each sensitivity test was conducted independently; the results are not additive.

(a) Impacts are not quantifiable based on available information.

Source: Jacobs Consultancy, September 2008.

established airlines such as Northwest and Delta (excluding Southwest and Alaska Airlines) is unlikely to significantly affect the numbers of passengers enplaned at the Airport in 2035. A proposed merger may affect the itinerary of a PDX passenger in terms of the airline hub that is used for a connection but unlikely to affect the underlying origin-destination demand of PDX passengers.

6.1.4 Security Concerns

Concerns about the safety of airline travel and the effectiveness of security precautions influence passenger travel behavior and airline travel demand. Anxieties about the safety of flying and the inconveniences and delays associated with security screening procedures lead to both the avoidance of airline travel and the switching from air to surface modes of transportation for short trips. Safety concerns in the aftermath of the terrorist attacks in September 2001 were largely responsible for the steep decline in airline travel nationwide in 2002. In early 2003, safety concerns were again heightened by the beginning of hostilities in Iraq and the perceived threat of retaliatory terrorist attacks. Since September 2001, government agencies, airlines, and airport operators have upgraded security measures to guard against changing threats and maintain confidence in the safety of airline travel. These measures include strengthened aircraft cockpit doors, changed flight crew procedures, increased presence of armed sky marshals, federalization of airport security functions under the Transportation Security Administration and more intensive screening of passengers and baggage. In the summer of 2006, the discovery of a plot to attack transatlantic flights with liquid explosives led to further changes in security screening procedures. Historically, airline travel demand has recovered after temporary decreases stemming from terrorist attacks, hijackings, aircraft crashes, and international hostilities. Provided that intensified security precautions serve to maintain confidence in the safety of commercial aviation without imposing unacceptable inconveniences for airline travelers, it can be expected that future demand for airline travel at PDX will depend primarily on economic, not security, factors.

It is difficult to separate the impact of a terrorist event from the related impact of security concerns on passenger travel behavior and demand. There are no available data to support this analysis. Therefore, for the purposes of this sensitivity test, it is assumed that any impacts on PDX passenger traffic related to security concerns are included in the sensitivity test of a terrorist event, as described later in this section.

6.1.5 Airline Service Development

The marketing and airline service development efforts conducted by the Port of Portland contribute to continued growth in passenger and cargo traffic at PDX. These marketing efforts typically include the collection and presentation of data and information about the strengths of the Portland market to airlines that are considering new markets and expanding existing PDX service. It is important to note that these marketing efforts not only contribute to additional new PDX service but also help to maintain existing levels of service when airlines are considering other markets and uses of their aircraft. These marketing efforts keep an open line of communication between the airlines serving PDX and the Port. In recent years, the Port of Portland's marketing efforts directly resulted in the addition of nonstop service to Amsterdam and Tokyo as well the addition of nonstop long-haul service to Boston, New York, and Philadelphia. In August 2008, these international and long-haul markets accounted for approximately 4% of total seating capacity at PDX. For the purposes of this sensitivity test, it is assumed that the Port no longer conducts marketing and airline service development and, as a result, passenger traffic in 2035 is 4% lower. This represents the direct impacts of not developing these specific routes and does not include the indirect and induced impacts of the Port's marketing efforts, which are likely to be significantly greater and more difficult to evaluate.

6.1.6 Airport Fees

During the last 30 years, airport rates and charges have historically represented between 4% and 6% of airline fare revenues (except for a few years after September 11). In contrast, fuel costs, as a share of airline fare revenue, have varied significantly—from a low of approximately 11% in 1998 to nearly 35% in 2007. One of the reasons that the historical relationship between airport rates and charges and airline revenues exists is because airport operators and airlines review airport rates and charges on an annual basis together with the airport capital improvements that are planned. If a planned improvement will significantly increase airport fees and is not supported by passenger traffic growth, the project can be deferred. Given the relative stability of airport rates and charges as a share of airline revenues (and therefore, costs), it is unlikely that airport fees will change significantly from historical shares and impact airline service and passenger traffic levels.

6.1.7 Congestion at Other Airports

In 2007, there were three slot controlled airports (New York's JFK and LaGuardia and Washington National) and two airports (Chicago O'Hare and Newark) which operated under voluntary slot controls. PDX had service to 3 of the 5 slot controlled airports in August 2008 (JFK, EWR, and ORD), which together accounted for approximately 7% of the Airport's seating capacity. Significant congestion at airports such as these in 2035 could result in the loss of nonstop service from PDX to these airports and a rerouting of passengers through other connecting hub airports. Since PDX is primarily an origin-destination market, it is likely that such congestion will not significantly impact the numbers of passengers enplaned at the Airport in 2035, although it may result in reduced levels of customer service and convenience.

6.2 Regional and Economic Trends

Five sensitivity tests were conducted of regional and economic issues and trends as discussed in the following sections.

6.2.1 Population Age Distribution

During the next 30 years, the fastest growing age category is expected to be the share of the population 65 years and over. The Portland-Vancouver Region's population in the 65 years and over category is expected to increase an average of 3% per year between 2000 and 2030. This age category is also characterized by stronger than average growth in accumulated wealth and, given the retirement age range, significant amounts of available time for leisure travel. In 2007, approximately 12% of the Portland-Vancouver Region's population was 65 years and over. By 2030, the U.S. Census Bureau expects that 17% of the Portland Region population will be in this age category. In 2035, the number of people in the 65 years and over category in the Portland-Vancouver Region is expected to total approximately 500,000. If each person in this age category was to take one additional airline trip in 2035, it would result in an overall increase in PDX passenger traffic of approximately 4%.

6.2.2 Propensity to Travel by Age Group

According to the Port's Terminal User Survey, the 45 to 64 years age category accounted for approximately 43% of PDX passengers in 2007, compared with a 24% share of total population in the Portland-Vancouver Region. The higher share of PDX passengers in this age category reflects a greater number of business trips as well as higher disposable income levels that support leisure travel. In 2035, the number of people in this age category in the Portland-Vancouver Region is expected to total approximately 675,000. If each person in this age category was to take one additional airline trip in 2035, it would result in an overall increase in PDX passenger traffic of approximately 5%.

6.2.3 Population In-Migration

In 2007, the number of people who migrated to the Portland-Vancouver Region totaled approximately 26,000 (net in-migration) and accounted for 1.2% of the total population. By 2030, population net in-migration is expected to decrease to 20,000 and account for 0.7% of the total population in the Portland-Vancouver Region. The population forecasts prepared by Metro and used as a basis for the PDX MP forecasts incorporate estimates for in-migration. A reduction or loss in the share of the population that migrates to the Portland-Vancouver Region on an annual basis would not have a material impact on PDX passenger traffic in 2035.

6.2.4 *Income Distribution*

According to the Port's Terminal User Survey, approximately 8% of PDX passengers had household incomes of less than $20,000 in 2007. According to the U.S. Census Bureau, the official poverty threshold for a family of four is $21,000 in 2008, with approximately 12% to 16% of the U.S. population living below the poverty line at any given time. PDX passengers with household incomes of $20,000 to $99,000 accounted for 50% of the total survey sample in 2007. PDX passengers with household incomes of more than $100,000 accounted for 42% of the total survey sample in 2007. Historical and forecast data for the number of households by income category in the Portland-Vancouver Region are not available. Therefore, without income data by household, it is difficult to evaluate the impact of income distribution on the propensity to travel and potential traffic levels in 2035.

6.2.5 *Wealth*

According to the Federal Reserve Board, Survey of Consumer Finances, growth in accumulated wealth is strongest in the 55 years and over age categories, which are also experiencing the strongest growth in population. As noted earlier in Section 6.2.1, "Population Age Distribution", in 2035, the number of people in the 65 years and over category in the Portland-Vancouver Region is expected to total approximately 500,000. If each person in this age category was to take one additional airline trip in 2035, it would result in an overall increase in PDX passenger traffic of approximately 4%.

6.3 Technology

Four sensitivity tests were conducted of technology related issues and trends as discussed in the following sections.

6.3.1 *Video Conferencing*

Video conferencing has long been offered as a potential substitute to air travel. In the aftermath of the terrorist attacks in September 2001, video conferencing regained popularity and, as a result, the technology available to support video conferencing greatly improved (e.g., Web-based conferencing and pod casts). To test the sensitivity of the 2035 enplaned passenger forecasts to increased substitution of video conferencing, it was estimated that approximately 35% of PDX passengers travel for business based on 2007 data from the Port's Terminal User Survey. If 5% of PDX business travelers substitute video conferencing for air travel in 2035, there would be a reduction of approximately 234,000 enplaned passengers, or a 2% reduction overall.

6.3.2 *New Aircraft Technology*

Any new aircraft technology that is developed through 2035 will most likely be related to increasing the fuel efficiency of aircraft, or, at least, be developed in consideration of the tradeoffs with fuel efficiency. Advancements in aircraft technology related to increasing fuel efficiency, thereby reducing fuel consumption and the overall airline fuel costs, are likely to reduce the cost of travel. Based on the sensitivity test of high oil prices discussed below, it is estimated that a 20% decrease in aviation fuel costs as a result of increasing aircraft fuel efficiency and decreasing fuel consumption and costs, would result in a 4% increase in PDX passenger traffic.

6.3.3 Alternative Aviation Fuels

High world oil prices have facilitated the development of alternative aviation fuels. Boeing recently announced that commercially viable biofuel is likely to be available to partially power aircraft by 2013. According to Boeing representatives, the algae-based fuels being studied are showing better potential performance qualities than current jet fuel.* Although algae-based biofuels have successfully passed the specifications needed to meet industry aviation turbine fuel standards, it is yet unclear how costly these alternative fuels will be to produce. For the purpose of this sensitivity test, it was assumed that the alternative aviation fuels available in 2035 would be commercially viable, reducing airline costs and decreasing the cost of travel for PDX passengers. Based on the sensitivity test of high oil prices discussed below, it is estimated that a 20% decrease in the cost of aviation fuel as a result of alternative fuel development, would result in a 4% increase in PDX passenger traffic.

6.3.4 Other Technologies

Advancements in other technologies unrelated to the aviation industry could reduce the need for air travel in the future. Some of these advancements could reflect fundamental shifts in how companies conduct operations in the future and are difficult to predict. Other advancements such as the continued development of web-based conferencing are likely and would continue to reduce the need for air travel. No estimates were made of this trend other than to acknowledge the potential.

6.4 Global

Two sensitivity tests were conducted of global issues and trends as discussed in the following sections.

6.4.1 Currency Exchange Rates

The valuation of the U.S. dollar can have both positive and negative impacts on air travel demand. A strong U.S. dollar in relation to other currencies supports the growth of air travel from the United States to foreign destinations because a strong U.S. dollar provides more purchasing power and effectively reduces the cost of international travel

*ATW News, “Boeing: Biofuel research pace 'remarkable,' could partially power flights by 2013,” September 17, 2008.

for U.S. citizens. At the same time, a strong U.S. dollar makes U.S. exports more expensive relative to those of other countries and can dampen economic growth. In contrast, a weak or devalued U.S. dollar has the opposite effects: increased air travel from foreign destinations to the United States and less expensive U.S. exports. For the purposes of this sensitivity test, it was assumed that a weak or devalued U.S. dollar would have little impact on PDX passenger traffic given the relatively small share of international service.

6.4.2 Foreign Country Travel Patterns

Changes in foreign-country travel patterns are unlikely to significantly impact PDX passenger traffic given the relatively small amount of international activity, accounting for approximately 4% in 2007 and 7% in 2035. PDX international flights primarily serve the origin-destination passenger base and are supported by the regional economy. Changes in foreign-country travel patterns are more likely to impact international gateway airports.

6.5 External Events

Seven sensitivity tests were conducted of the potential effects of external events as discussed in the following sections.

6.5.1 High Oil Prices

According to the DOE's assessment of its price of oil forecasts, the absolute average difference between the DOE reference case forecasts and the actual price of oil has been 20.8% from 1994 through 2005. The absolute average difference includes both underestimates and overestimates of the price of oil. To test the sensitivity of the enplaned passenger forecasts to 20.8% higher oil prices, a Monte Carlo simulation of the passenger model was run using oil price parameters increased by 20.8% for the low, median, and high values. In 2035, a 20.8% increase in oil prices resulted in a 4% decrease in passenger activity, a reduction of approximately 529,000 enplaned passengers.

6.5.2 National Economic Recession

According to the National Bureau of Economic Research, the last national economic recession occurred from March 2001 through November 2001. It is difficult to separate the effects of the national economic recession in 2001 and the terrorist attacks in September 2001 on PDX passenger traffic. In addition, as noted earlier, there was a slowdown in regional economic activity during this period that also affected PDX passenger traffic. In 2001 and 2002, PDX passenger traffic decreased 7.9% and 3.5%, respectively. A review of earlier national economic recessions and changes in PDX passenger traffic suggests a range of impacts: (1) the 1980 recession relates to a 14.3% decrease in PDX passenger traffic in 1980, (2) the 1981 recession relates to a

4.1% decrease in PDX passenger traffic in 1981, and (3) the 1991 recession relates to a 0.1% decrease in PDX passenger traffic in 1991. For the purposes of this sensitivity test, it was assumed that a national economic recession would result in a 4% decrease in PDX passenger traffic in 2035.

6.5.3 Terrorist Event

As noted in the discussion above, the impact of the September 11 terrorist attacks on PDX passenger traffic is difficult to separate from the impacts of the national economic recession and slowdown in regional economic activity. For the purpose of this sensitivity test, it was assumed that a terrorist event would result in an 8% decrease in PDX passenger traffic, equal to the decrease in 2001.

6.5.4 Biological Event

The outbreak of severe acute respiratory system (SARS) in 2002 and 2003 is an example of a biological event. The SARS epidemic lasted for 19 months, from November 2002 when the first case was reported in the Guangdong province of China, which borders on Hong Kong, to May 2004 when the World Health Organization (WHO) declared that the outbreak in China was over. According to U.S. Department of Transportation statistics, U.S. and foreign-flag airline activity from the United States to countries in the Pacific region decreased approximately 9% in 2003, compared with a 1.4% increase in overall passenger traffic at PDX. According to data from the U.S. Department of Commerce, Office of Travel and Tourism Industries, visitors to the United States arriving from China and Japan decreased 30% and 13%, respectively, in 2003. The impact of a biological event on passenger traffic at an U.S. airport will depend on a number of factors, including where the biological event originates and whether there are sufficient medical resources available to control the outbreak. Given the wide range of possible assumptions and outcomes, no result was calculated for the purposes of a sensitivity test.

6.5.5 Global Economic Crisis

Global economic crises typically coincide with U.S. economic recessions. During the past 30 years, PDX passenger traffic has increased each year except in years corresponding to national economic recessions. There is no evidence to suggest that PDX passenger traffic would fare better or worse in a year of global economic crisis than during a year of national economic recession. Therefore, for the purposes of this sensitivity test, it is assumed that, similar to the test for national economic recessions described earlier, a global economic crisis would result in a 4% decrease in PDX passenger traffic in 2035.

6.5.6 Airline Industry Labor Strikes

The Railway Labor Act governs labor negotiations in the airline industry and under this act, airline labor contracts do not expire, but instead, become amendable. To help labor and management reach agreement before a strike occurs, the act also provides a process— including possible intervention by the President—that is designed to reduce the incidence of strikes. According to a 2003 U.S. Government Accounting Office (GAO) study*, the incidence of strikes in the airline industry has decreased over time. Of the 16 strikes that occurred since 1978, 12 occurred prior to 1990, and 4 occurred subsequently. These strikes ranged from as short as 24 minutes to more than 2 years. Compared to strikes, the pattern for non-strike work actions has been the opposite: their incidence has increased over time. In all, 10 court-recognized, non-strike work actions have occurred, each since 1998. Such actions included various forms of slowdowns such as sickouts, work-to-rule, and refusals to work overtime. The GAO study recognized that airline labor strikes have exerted adverse impacts on communities, but acknowledged that no published studies exist that systematically and comprehensively analyzed a strike's net impact at the community level. The impacts of a strike on a community would depend on a number of factors, such as availability of service from competing (non-striking) airlines and the length of the strike. Given the limited information available, no effort has been made to quantify the impact of an airline industry labor strike on PDX passenger traffic for the purposes of this sensitivity analysis.

6.5.7 War

During the past 30 years, there have been numerous wars and military conflicts throughout the world, including the Iran-Iraq War from 1980 to 1988, the Gulf War in 1991, and the ongoing Iraq War which started in 2003. All of the wars during this period occurred outside the United States and passenger traffic at PDX continued to increase. For the purposes of this sensitivity test, it was assumed that a war would be based outside the United States. While the United States may be a participant in such a war, it is unlikely that a war based outside the United States would impact PDX passenger traffic.

* U.S General Accounting Office, *Airline Labor Relations, Information on Trends and Impact of Labor Actions*, GAO-03-652, June 2003.

7. APPENDIX A: FORECAST PROCESS

White Paper

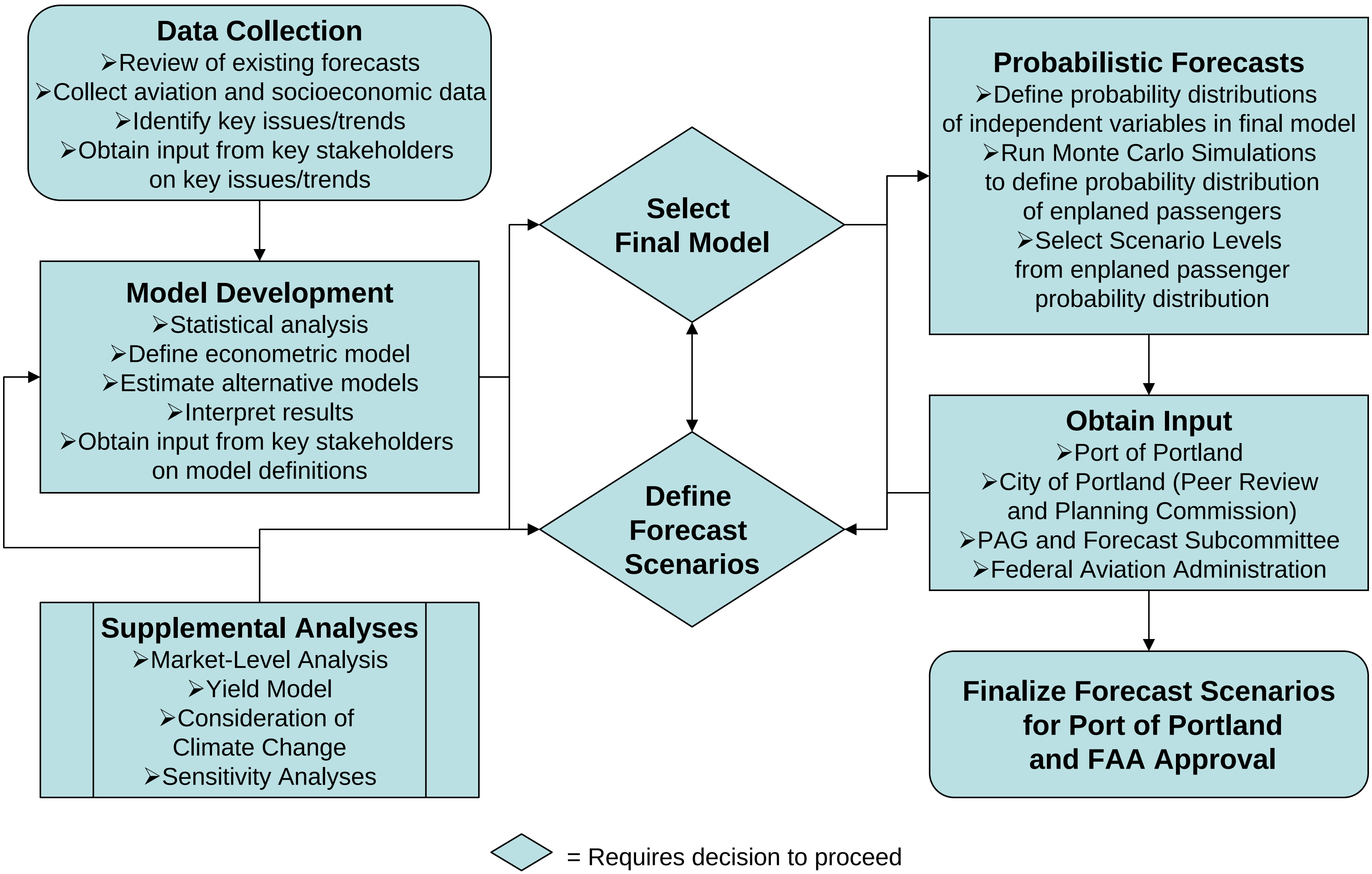
Forecast Approach and Methodology

PDX Airport Futures Project

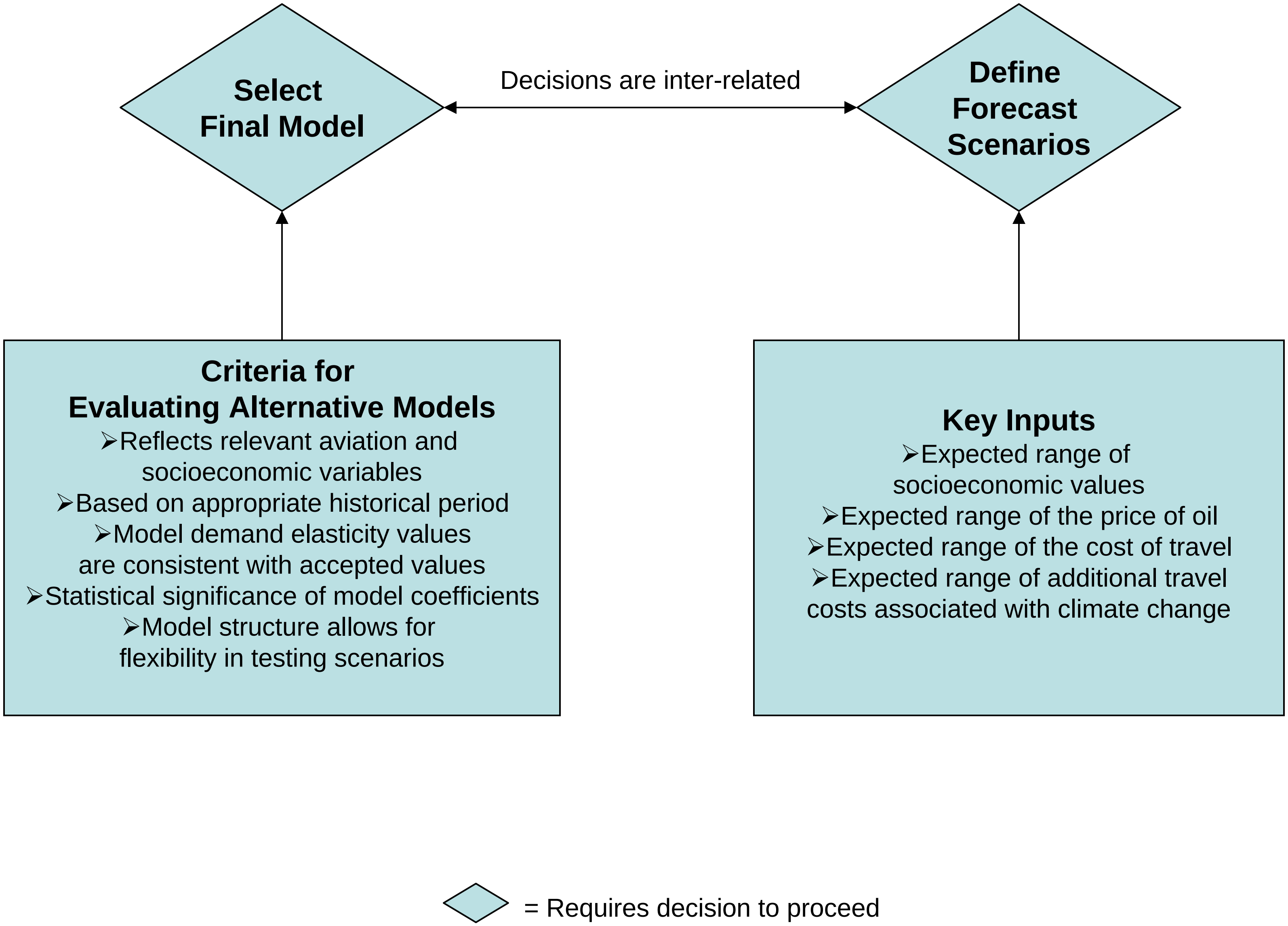
The attached diagrams outline the approach and methodology used in the preparation of forecasts for the PDX Airport Futures Project.

- **Forecast Process Diagram.** Illustrates the key elements and subtasks, decision points, and path to approval of the forecasts.
- **Forecast Decision Process Diagram.** Outlines the criteria and inputs needed to facilitate the selection of a final model and definition of forecast scenarios.
- **Sources of Forecast Uncertainty.** A summary of three sources of forecast uncertainty: model predictive error, coefficient estimation error, and independent variable forecast error.
- **Probabilistic Forecast Process Diagram.** Outlines the technical steps in preparing probabilistic forecasts.
- **Proposed PDX Passenger Model Diagram**
- **Aircraft Operations Forecasts Diagram**
- **Translating Passenger Forecasts into Operations Diagram**

FORECAST PROCESS DIAGRAM



FORECAST DECISION PROCESS DIAGRAM



SOURCES OF FORECAST UNCERTAINTY

There are no facts about the future.

- **Model predictive error**. Even a "perfect" regression model will have differences between predicted and observed values. A model that fits the historical data well may not fully reflect all the relevant factors that will influence demand in the future.

- **Coefficient estimation error**. The coefficients are estimates and will not exactly equal the true coefficients. These errors take two forms:
  - Errors in the historical coefficient values.
  - Uncertainty in how the coefficients may change in the future.

- **Independent variable forecast error**. The forecast requires forecasts of the independent variables such as yield, population, etc, which are themselves uncertain.

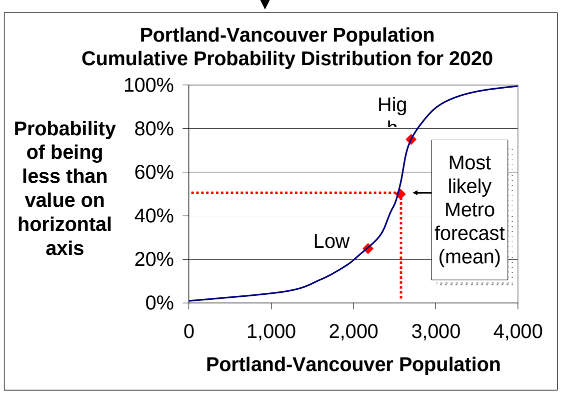
PROBABILISTIC FORECAST PROCESS DIAGRAM

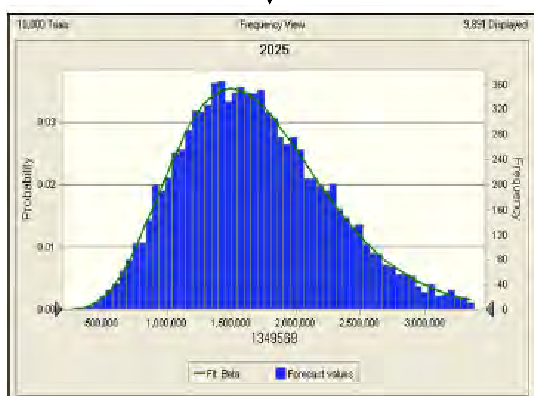
Final Model
Independent variables
Supplementary models

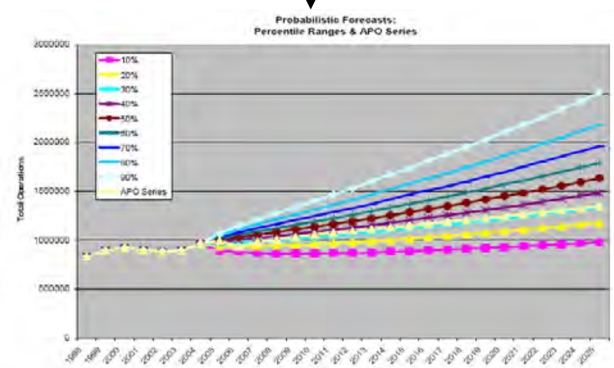
Probability Distributions of Independent Variables

Monte Carlo Simulation
- Randomly select values from each probability distribution
- Generates values of enplaned passengers using the final model equation
- Perform 10,000 trials to create probability distribution of enplaned passengers for 5, 10, and 20 year periods

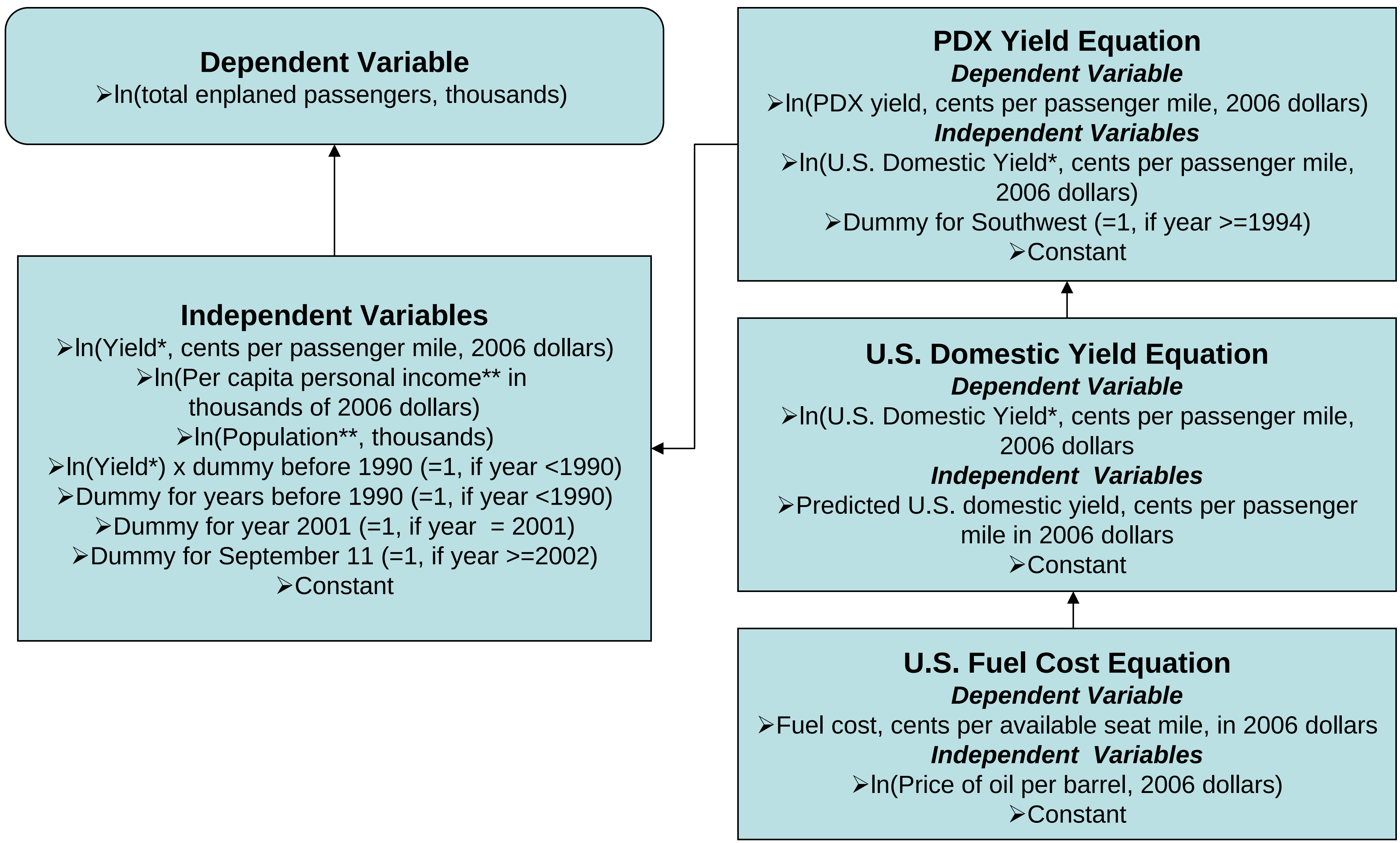
Probabilistic Forecasts







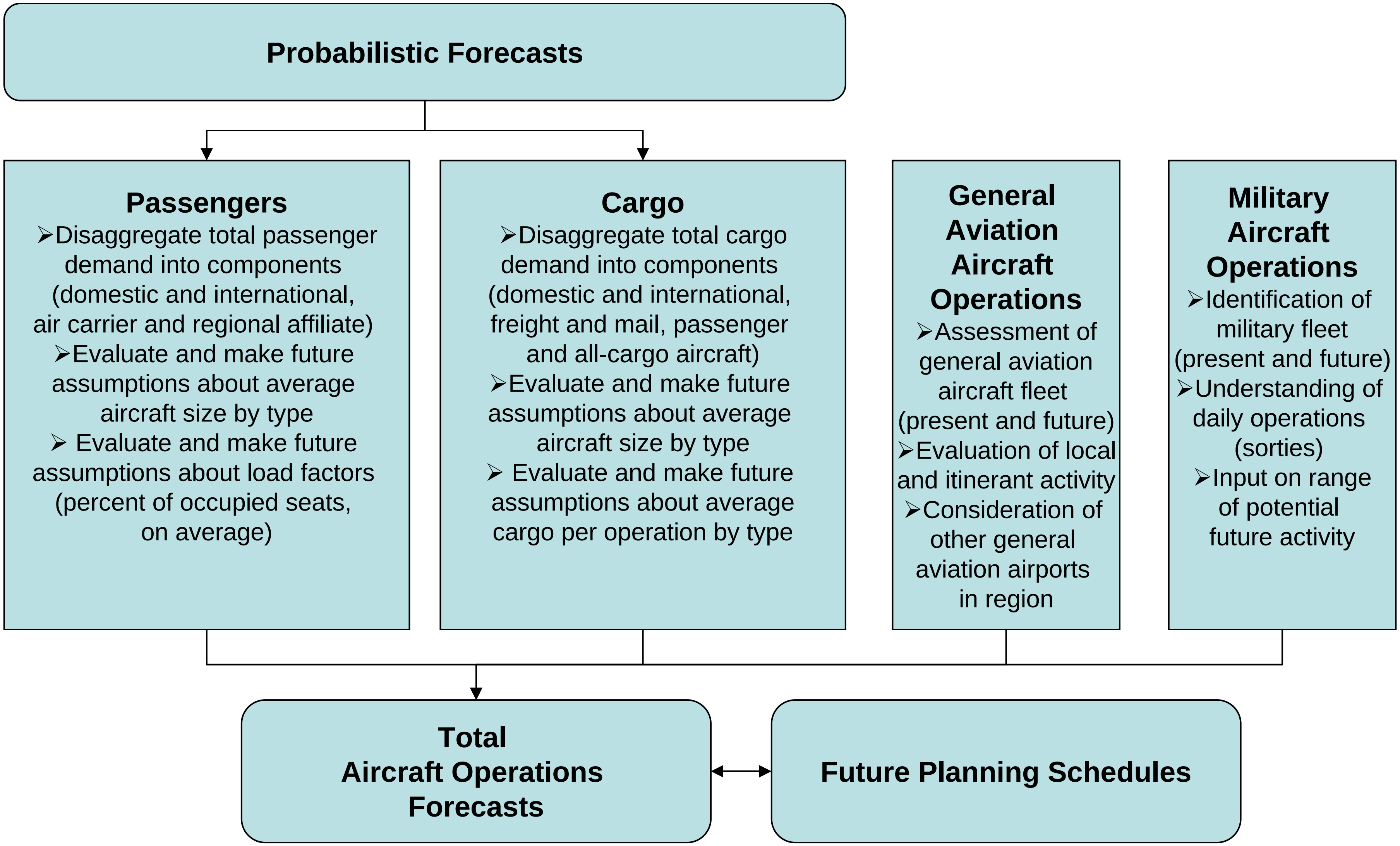
PROPOSED PDX PASSENGER MODEL



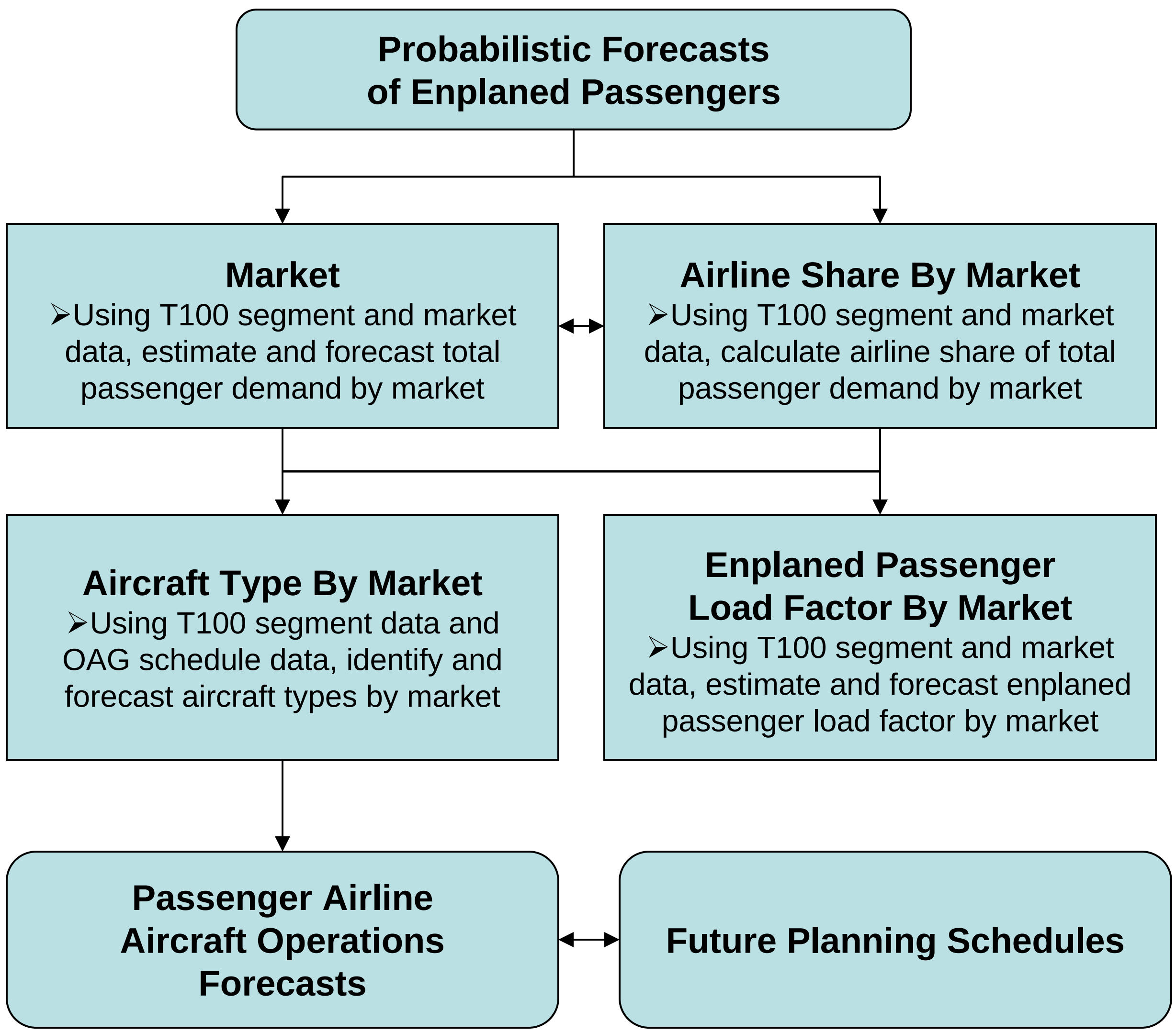
*Yield data include U.S. domestic yield from 1976 through 1989 and PDX yield from 1990 through 2006.

**Population and per capita income data are for the Portland-Vancouver region, including Clackamas, Multnomah, Washington, and Yamhill counties in Oregon and Clark County in Washington.

AIRCRAFT OPERATIONS FORECASTS DIAGRAM



TRANSLATING PASSENGER FORECASTS INTO OPERATIONS DIAGRAM



Example: PDX-LAS Market

	2035
Enplaned passengers (000s)	
Southwest (50%)	300
Alaska (30%)	180
Horizon (20%)	120
	600
Aircraft size (seats)	
Southwest	135
Alaska	130
Horizon	74
Enplaned passenger load factor	
Southwest	72%
Alaska	80%
Horizon	75%
Derived annual departures	
Southwest	3,100
Alaska	1,700
Horizon	2,200
	7,000
Average daily departures	
Southwest	8
Alaska	5
Horizon	6
	19

8. APPENDIX B: PASSENGER MODEL

UC Berkeley, Transportation Engineering

Memo

To: Linda Perry

From: Mark Hansen, Chieh-Yu Hsiao

Date: January 16, 2008

Re: PDX Forecast Models

This memo discusses estimation results for a set of panel models that analyze originating passenger traffic from PDX airport to various destinations. The models are estimated using 1990-2005 data and yield based derived from DB1A.

Socioeconomic data were obtained from BEA and are incorporated as the geometric product of the relevant variables. For example the population variable is:

$$pop_{pdx-dst,year} = \sqrt{pop_{pdx,year}} \cdot \sqrt{pop_{dst,year}} \quad (1)$$

By using the geometric mean, we ensure that a destination with zero population or zero income will have zero traffic, and that an x% growth in a given variable for both PDX and the destination will translate to an x% growth for the explanatory variable.

The models include fixed effects for each destination. The fixed effects capture persistent differences in proclivity to travel between markets. These could result from different service levels, different levels of competition from other modes, or particular affinities between the city-pairs in the market.

In addition to the panel models, a PDX-wide originating traffic model was estimated, for purposes of comparison. Estimation results appear in Table 1. The yield coefficient is less than 1, and only marginally significant. No more than one socioeconomic variable is found to be significant in any of the models. Depending on the model, this may be population, employment, or total income. These results are fairly consistent with the PDX enplanement models. For example, Model 6 of Table 1 was previously estimated with total enplanements. The yield coefficients are -0.644 and -0.858 for the originating traffic and enplanement models respectively, while the total income coefficients are 0.990 and 0.930 respectively. R^2's are in the 0.98-0.99 range.

Table 2 provides the first set of panel model estimates. In this case the panel consists of 20 markets. Yield coefficient is somewhat higher and quite consistent—between -0.97 and -0.99—across the models. Socioeconomic variable coefficients also have higher magnitudes: in excess of 1 for total income and in excess of 2 for population. Many of the market dummy variables are highly significant. This is probably because the reference market is PDX-ATL, the longest and thinnest of the top 20. R^2 are 0.95-0.96 range.

Table 3 re-estimates model 4 from Table 2 for different numbers of markets, from the Top 20 (identical to model 4 from Table 2) to the Top 100. Estimates are fairly stable, but the general pattern is that the yield coefficient increases in magnitude and the income coefficient decreases in magnitude with larger numbers of markets.

Table 4 includes a cross-elasticity term that captures the phenomenon of air travelers substituting trips in low fare markets for trips in high fare ones. To do this, we calculate, for passengers in any given market, the average yield in all other markets. This coefficient is consistently positive. It is larger, and significant, in models that use population as a socioeconomic variable. When total personal income is used instead then the coefficient becomes smaller and less significant. The own-yield coefficient in these models is just slightly greater than 1. Table 5, which investigates how the number of markets affects the results for Model 3 of Table 4, shows that this cross-elasticity effect becomes insignificant when larger panels are used.

Discussion

The primary motivation for the panel analysis was to investigate if the relatively low fare elasticity found in the total enplanement models would also be found in a market-level model. This is an important issue from a forecasting standpoint because of the possibility that future yields will increase substantially because of fuel price hikes and other factors.

Our results show that, in fact, fare elasticity is higher in a market-level model. The size of the different depends on the model, and is generally higher in models that employ total income as a socioeconomic variable.

Part, but not all, of the explanation for this difference can be found in the cross-elasticity. To understand this, consider Model 4 in Table 1, 2, and 4. Imagine that there is a 1% across-the-board increase in yield for PDX markets. This would result in a:

- 0.64% decrease in traffic according to Table 1.
- 0.98% decrease in traffic according to Table 2.
- 0.81% decrease in traffic according to Table 4. (This reflects the sum of the own-market and other-market yield coefficients.)

This pattern varies from model to model. For example, if Model 1 is compared, then the cross-elasticity model (Table 4) yields a lower decrease (0.59%) then the aggregate model (Table 1--0.85%). Model 1, however, has implausible parameters for the socio-economic variables.

The major decision at this point is whether to proceed to the probabilistic forecast based on an aggregate model of a market-level model. This decision must take the following factors into account:

- The more plausible aggregate models seem to yield somewhat lower fare elasticities, which in turn will make future demand less sensitive to cost changes, and perhaps raise the objection that uncertainty related to how costs will change in the future is being downplayed.
- The use of disaggregate models to generate the forecast yields would require a substantial effort. In addition to requiring socioeconomic forecasts for each markets, covariation between markets must be considered. While I am sure that these challenges can be overcome, we do not, as of right now, know exactly how to do so.

PDX Airport Futures

Memo

To: Linda Perry, Geoff Gosling

From: Mark Hansen, Chieh-Yu Hsiao

Date: March 24, 2008

Re: PDX Risk Analysis

This memo documents the probabilistic analysis of future enplanement levels at PDX.

The analysis employs a regression model relating PDX enplanements to:

- Yield (US domestic yield prior to 1990 and PDX yield thereafter)
- Regional population
- Regional income per capita
- A dummy variable for 2001
- A dummy variable for post 2001

The regression model is:

$$\ln Q = 1.393 + 0.888 \cdot \ln POP + 1.042 \cdot \ln PCI - 1.147 \cdot \ln P_{MIX} - 1.828 \cdot D_{<1990} + 0.600 \cdot D_{<1990} \cdot \ln P_{MIX} - 0.293 \cdot D_{2001} - 0.387 \cdot D_{>2001} \; (Adj.R^2 = .991) \quad (1)$$

Where Q is PDX enplanements (000), POP is PDX regional population (000), PCI is PDX regional per capita income (000), P_{MIX} is average US domestic yield prior to 1990 and PDX yield thereafter, $D_{<1990}$ is a dummy variable for years before 1990, D_{2001} is a dummy variable for 2001, and $D_{>2001}$ is a dummy variable for years after 2001.

We used this model to develop a probabilistic enplanement forecast. Probabilistic elements of the forecast include:

- Regression model predictive error
- Future PDX yield
- Future regional population
- Future regional income per capita

Regression Model Predictive Error

The forecast error variance for a regression model with known residual variance σ^2 is given by:

$$Var(e^0) = \sigma^2(1 + \mathbf{x}^{0'}[\mathbf{X}'\mathbf{X}^{-1}]\mathbf{x}^0) \quad (2)$$

where $\mathbf{x}^0$ contains the values for the independent variables for which the forecast is being made and $\mathbf{X}$ contains the data for the independent variables used to estimate the model. This variance equation is used whenever a regression is employed in the forecast.

Future PDX Yield

Future PDX yield is predicted using a regression equation relating historical PDX yield to US domestic yield. The estimated equation is:

$$\ln P_{PDX} = -0.145 - 0.184 \cdot LCC + 1.048 \cdot \ln P_{USD} \quad (Adj\ R^2 = .97) \tag{3}$$

where P_{PDX} is PDX yield, LCC is a low-cost carrier dummy variable set to 1 for the years 1994 and after, and P_{USD} is US domestic yield. (All money variables are expressed in constant 2006 dollars.)

To use this regression equation requires a probabilistic forecast of US domestic yield. To produce this forecast, we estimate a regression model relating US domestic yield to "break-even" yield, which we calculate as:

$$P_{BE} = \frac{1}{L}\left(C_{NF} + \hat{C}_F\right) \tag{4}$$

Where P_{BE} is break-even yield, L is load factor, C_{NF} is non-fuel cost per available seat-mile (ASM), and $\hat{C}_F$ is predicted fuel cost per ASM. Predicted \fuel cost per ASM is based on the regression equation:

$$C_F = 0.393 + 0.0455 \cdot P_{oil} \quad (Adj.R^2 = .87) \tag{5}$$

where P_{oil} is oil price in \$/bbl.

US domestic yield is related to break-even yield by the regression equation:

$$P_{USD} = -3.475 + 1.097 \cdot P_{BE} \ (Adj.R^2 = .94) \tag{6}$$

Through the set of equations 2-5, we are able to translate distributions for future oil price, load factor, and non-fuel cost per ASM to a distribution for PDX yield. The future oil price is drawn from a triangular distribution with minimum, mode (most likely), and maximum values of P_{oil}^{min}, P_{oil}^{mode}, and P_{oil}^{max} respectively. These values are obtained using

$$P_{oil}^{min} = F_{DOE}^{min} + 0.5 \cdot 0.25 \cdot C_{MIT}^{min} \tag{7}$$

$$P_{oil}^{mode} = F_{DOE}^{mode} + 0.5 \cdot 0.5 \cdot C_{MIT}^{mode} \tag{8}$$

$$P_{oil}^{max} = F_{DOE}^{max} + 0.5 \cdot 0.75 \cdot C_{MIT}^{max} \tag{9}$$

where $F_{DOE}^{\cdot}$ are the low, base, and high values estimated from the Department of Energy oil price forecast and adjusted for recent changes to the base forecast that have not yet been translated into low and high values[a]; and $C_{MIT}^{\cdot}$ are the low, median, and high estimates of the carbon tax per ton of CO_2 emissions, obtained from an assessment of U.S. Cap-and-Trade Proposals prepared by the MIT Joint Program on the Science and Policy of Global Change[b] and adjusted to 2006 dollars The constant 0.5 is the emissions coefficient for the metric tons of

---

[a] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2008* (Revised Early Release), Revised March 2008, Reference case results only and Annual Energy Outlook 2007, high and low cases. High and low 2008 forecasts are not yet available and were calibrated to March 2008 reference case based on the 2007 forecasts.
[b] MIT Joint Program on the Science and Policy of Global Change, *Assessment of U.S. Cap-and-Trade Proposals*, Report No. 146, April 2007. The MIT Emissions Prediction and Policy Analysis model is applied to an assessment of cap-and-trade proposals being considered by the U.S. Congress in spring 2007.

CO_2 generated from burning a barrel of oil[c], while the other constant is the fraction of the tax assumed to be passed on purchasers (rather than absorbed by oil suppliers).

The distributions of future load factor and non-fuel cost per ASM are also assumed triangular. The parameters of these distributions were calculated from trend projections. Uncertainty in these projections was estimated through application for the forecast error variance formula (2).

With these distributions, the process of drawing a value for P_{PDX} proceeded as follows:

1. Draw values for P_{oil}, L, and C_{NF} from their respective triangular distributions.
2. Calculate $\hat{C}_F$ using equation (5).
3. Calculate P_{BE} using equation (4).
4. Draw a value from the distribution of P_{USD} using equation (6) and the forecast error variance formula (2).
5. Using the result of step 4, draw a value for P_{PDX} using equation (3) and the variance formula (2).

Future Regional Population

The distribution of regional population is obtained from a probabilistic forecast prepared by Portland Metro,. Based on simulation results, Metro concluded that future population has a normal distribution and provided the mean and variance of that distribution for each forecast year.

Future Per Capita Income

Future per capita income is drawn from a triangular distribution. The distribution is derived from Metro's 2006 income forecast, which is used to calculate forecast annual income growth rates. To assess the uncertainty in these growth rates, we analyzed the differences in forecast annual growth rates and realized growth for the 1994 and 2001 forecasts. We found that the forecast error has a mean of 0.0036 and a standard deviation of 0.0233. We then simulated future income growth by assuming that for a given year, the growth rate over the previous year has a normal distribution whose mean is 0.0036 less than the forecast growth and whose standard deviation is 0.0233. Based on 500 trials, we calculated the mean and variance of the per capital income for each forecast year. Finally, we set the parameters of the triangular distribution such that:

- The most likely value is the 2006 forecast.
- The mean value comes from the simulation.
- The standard deviation comes from the simulation.

Future Enplanement Simulation

Finally, we simulate the future enplanement distribution at PDX as follows:

1. Draw a value from the population distribution.
2. Draw a value from the per capita income distribution.
3. Draw a value for PDX yield.
4. Using the regression model (1) and the forecast error variance formula (2) determine the distribution of enplanements, conditional on the values obtained in steps 1-3.
5. Repeat steps 1-4 10,000 times to obtain the unconditional enplanement distribution.

---

[c] U.S. Department of Energy, Energy Information Administration, Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source Codes and Emissions Coefficients, online database, www.eia.doe.gov. Per a discussion with DOE representatives, the emissions coefficient used for a barrel of oil approximates that for residential fuel.

Caveats

Aside from the distributions for future population, per capita income, and oil price, the procedure described above makes two important assumptions.

First, it is assumed that statistical relationships derived from past data will continue to hold in the future. While this is certainly possible, it is difficult to quantify its effect on the probability distributions for future enplanements. In this respect, the possibilities for structural changes that invalidate the historical relationships are a source of uncertainty rather than risk.

Second, it is assumed that the independent variables are independent. For example, it is possible that sharp increases in oil prices will result in reduced economic growth, but our simulation does not incorporate this linkage. Our historical data offers some justification for this simplification. Over the last 30 years, the correlation between oil price increase and Portland per capita income increase is -0.12 and statistically insignificant.

Software Used to Run the Simulations

The simulations were run in Microsoft Excel.

1. PDX total originating passenger (base)

Dependent variable: ln(originating passenger, thousands)

	(1)	(2)	(3)	(4)
ln(yield, cents per pax-mile)	-0.849	-0.554*	-0.333	-0.644*
	(-1.61)	(-1.86)	(-0.79)	(-1.94)
ln(area population, thousands)	-2.489		1.887	
	(-1.15)		(1.82)	
ln(area employment, thousands)	3.368*	1.351***		
	(1.97)	(5.87)		
ln(per capita personal income, thousands in 2006 dollars)	-0.691		0.212	
	(-0.73)		(0.19)	
ln(personal income, millions in 2006 dollars)				0.990***
				(3.53)
dummy for year 2001 (=1, if year =2001)	-0.0911	-0.147***	-0.181***	-0.192***
	(-1.76)	(-3.24)	(-3.77)	(-4.02)
dummy for Sept. 11 (=1, if year >=2002)	-0.0611	-0.174**	-0.268**	-0.222**
	(-0.54)	(-2.25)	(-2.45)	(-2.65)
1/(# of years after 2001)	-0.0304	-0.0236	-0.00814	-0.0515*
	(-0.62)	(-1.57)	(-0.14)	(-1.82)
dummy for Southwest (=1, if year >=1994)	0.0236	0.124	0.174	0.156
	(0.09)	(1.28)	(1.53)	(1.40)
1/(# of years after 1993)	0.0421			
	(0.29)			
Constant	2.701	-4.214***	-9.534**	-6.210**

	(0.43)	(-3.34)	(-2.40)	(-2.24)
Observations	17	17	17	17
R^2	0.987	0.985	0.980	0.979
Adjusted R^2	0.971	0.976	0.965	0.967
F	.	.	.	.

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2. Market originating passenger

*Model (4) has similar specification as model (4) of PDX total originating passenger (base)
*Comparing to base, both coefficients of yield and income become larger in absolute values.

Dependent variable: ln(originating passenger, thousands)

	(1)	(2)	(3)	(4)
ln(yield, cents per pax-mile in 2006 dollars)	-0.972***	-0.971***	-0.988***	-0.975***
	(-17.46)	(-17.63)	(-17.58)	(-19.39)
ln(Market population, thousands)	2.056***	2.077***		
	(5.33)	(6.03)		
ln(Market per capita personal income, thousands in 2006 dollars)	0.105			
	(0.29)			
ln(Market personal income, millions in 2006 dollars)			1.356***	1.225***
			(5.83)	(9.87)
dummy for year 2001 (=1, if year =2001)	-0.246***	-0.244***	-0.247***	-0.240***
	(-7.37)	(-7.11)	(-6.82)	(-6.97)
dummy for Sept. 11 (=1, if year >=2002)	-0.416***	-0.417***	-0.351***	-0.340***
	(-6.91)	(-7.15)	(-6.64)	(-12.29)
1/(# of years after 2001)	0.0231	0.0230	0.00208	
	(0.32)	(0.32)	(0.03)	

dummy for LCC (=1, if year >=1994)	-0.0223	-0.0130	-0.0554	
	(-0.38)	(-0.22)	(-0.82)	
1/(# of years after 1993)	-0.0293	-0.0404	0.0423	
	(-0.46)	(-0.67)	(0.57)	
dummy for Market PDX-LA (=1, if Reference=LA)	1.073***	1.057***	1.561***	1.642***
	(4.02)	(4.49)	(9.96)	(17.75)
dummy for Market PDX-SF (=1, if Reference=SF)	2.150***	2.160***	2.152***	2.196***
	(23.95)	(22.33)	(21.43)	(31.62)
dummy for Market PDX-LAS (=1, if Reference=LAS)	2.294***	2.305***	1.882***	1.797***
	(9.83)	(10.85)	(11.91)	(17.60)
dummy for Market PDX-PHX (=1, if Reference=PHX)	1.494***	1.492***	1.444***	1.412***
	(24.61)	(23.62)	(24.95)	(42.12)
dummy for Market PDX-SMF (=1, if Reference=SMF)	1.993***	1.998***	1.775***	1.716***
	(13.80)	(14.63)	(16.82)	(28.18)
dummy for Market PDX-DEN (=1, if Reference=DEN)	1.630***	1.641***	1.379***	1.344***
	(14.11)	(17.63)	(24.78)	(43.50)
dummy for Market PDX-NY (=1, if Reference=NY)	-1.167***	-1.172***	-0.756***	-0.634***
	(-4.12)	(-4.28)	(-3.56)	(-5.71)
dummy for Market PDX-SAN (=1, if Reference=SAN)	1.347***	1.353***	1.181***	1.152***
	(14.52)	(16.10)	(20.52)	(29.97)
dummy for Market PDX-CH (=1, if Reference=CH)	-0.0190	-0.0224	0.194*	0.249***
	(-0.13)	(-0.16)	(1.87)	(4.02)
dummy for Market PDX-BOI (=1, if Reference=BOI)	3.563***	3.581***	2.838***	2.671***
	(8.46)	(9.28)	(10.35)	(20.41)

dummy for Market PDX-DC (=1, if Reference=DC)	-0.246***	-0.241**	-0.173**	-0.121***
	(-2.69)	(-2.50)	(-1.98)	(-2.74)
dummy for Market PDX-SLC (=1, if Reference=SLC)	2.162***	2.163***	1.896***	1.807***
	(11.27)	(11.53)	(12.73)	(24.49)
dummy for Market PDX-GEG (=1, if Reference=GEG)	3.685***	3.699***	3.001***	2.825***
	(8.76)	(9.39)	(10.36)	(20.84)
dummy for Market PDX-RNO (=1, if Reference=RNO)	3.408***	3.439***	2.475***	2.317***
	(6.86)	(7.91)	(8.64)	(14.81)
dummy for Market PDX-HNL (=1, if Reference=HNL)	1.423***	1.442***	0.837***	0.743***
	(4.50)	(5.18)	(4.45)	(6.22)
dummy for Market PDX-DW (=1, if Reference=DW)	0.215***	0.214***	0.276***	0.287***
	(3.93)	(4.03)	(6.18)	(7.44)
dummy for Market PDX-SEA (=1, if Reference=SEA)	2.999***	3.005***	2.906***	2.877***
	(22.60)	(22.92)	(21.05)	(22.43)
dummy for Market PDX-MSP (=1, if Reference=MSP)	0.589***	0.598***	0.421***	0.406***
	(8.23)	(11.14)	(13.57)	(17.77)
dummy for Market PDX-MCO (=1, if Reference=MCO)	0.0728	0.0713	-0.0747	-0.126
	(0.54)	(0.53)	(-0.64)	(-1.60)
Constant	-16.75***	-16.54***	-14.14***	-12.80***
	(-6.85)	(-6.22)	(-6.03)	(-10.54)
Observations	320	320	320	320
R^2	0.957	0.957	0.954	0.954
Adjusted R^2	0.953	0.953	0.950	0.951
F	736.4	757.6	814.2	928.7

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: Base Market: PDX-ATL(Rank 20)

3. What if we include more markets (20, 40, 60, 80, and 100)

*The coefficients of yield become a little larger when we add more markets.

* The coefficients of personal income are closer to 1 when we add more markets.

Dependent variable: ln(originating passenger, thousands)

	(1) Top20	(2) Top40	(3) Top60	(4) Top80	(5) Top100
ln(yield, cents per pax-mile in 2006 dollars)	-0.975***	-0.958***	-1.008***	-1.012***	-1.014***
	(-19.39)	(-21.89)	(-23.09)	(-26.01)	(-28.42)
ln(Market personal income, millions in 2006 dollars)	1.225***	1.297***	1.235***	1.181***	1.097***
	(9.87)	(14.54)	(14.92)	(17.20)	(17.60)
dummy for year 2001 (=1, if year =2001)	-0.240***	-0.224***	-0.211***	-0.215***	-0.228***
	(-6.97)	(-9.83)	(-9.05)	(-10.84)	(-12.49)
dummy for Sept. 11 (=1, if year >=2002)	-0.340***	-0.322***	-0.297***	-0.302***	-0.308***
	(-12.29)	(-16.74)	(-15.70)	(-17.66)	(-19.86)
Constant	-12.80***	-13.67***	-14.60***	-13.63***	-12.65***
	(-10.54)	(-17.53)	(-19.80)	(-24.96)	(-24.65)
Observations	320	592	880	1168	1440
R^2	0.954	0.981	0.981	0.985	0.986
Adjusted R^2	0.951	0.980	0.980	0.984	0.985
F	928.7	1820.9	2138.9	2595.5	2783.2

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:1. Market dummies were used, but they are not shown here; 2.Choose lowest rank market as base market

4. Cross-Elasticity: Add an "average yield of other markets" variable

*The coefficients of average yield of other markets are significant in model (1), (2), and (3).

*Model (5) has similar specification as base model, except adding an" average yield of other markets" variable.

Dependent variable: ln(originating passenger, thousands)

	(1)	(2)	(3)	(4)	(5)
ln(market yield, cents per pax-mile in 2006 dollars)	-1.004***	-1.005***	-1.011***	-1.006***	-1.008***
	(-18.28)	(-18.29)	(-18.29)	(-17.57)	(-17.72)
ln(yield of other markets, cents per pax-mile in 2006 dollars)	0.410**	0.406**	0.256**	0.200	0.131
	(2.49)	(2.56)	(2.47)	(1.30)	(1.45)
ln(Market population, thousands)	2.441***	2.422***	2.512***		
	(5.82)	(6.56)	(8.87)		
ln(Market per capita personal income, thousands in 2006 dollars)	-0.0773				
	(-0.20)				
ln(Market personal income, millions in 2006 dollars)				1.445***	1.376***
				(6.03)	(9.07)
dummy for year 2001 (=1, if year =2001)	-0.206***	-0.208***	-0.226***	-0.228***	-0.238***
	(-5.69)	(-5.73)	(-7.04)	(-5.70)	(-6.88)
dummy for Sept. 11 (=1, if year >=2002)	-0.359***	-0.359***	-0.380***	-0.313***	-0.329***
	(-5.79)	(-5.83)	(-12.95)	(-5.10)	(-11.40)
1/(# of years after 2001)	0.0307	0.0306		0.00281	
	(0.42)	(0.42)		(0.04)	
dummy for LCC (=1, if year >=1994)	0.118	0.110		0.00825	
	(1.49)	(1.50)		(0.09)	
1/(# of years after 1993)	-0.0525	-0.0443		0.0411	
	(-0.80)	(-0.74)		(0.55)	

dummy for Market PDX-LA (=1, if Reference=LA)	0.818***	0.832***	0.775***	1.506***	1.552***
	(2.85)	(3.33)	(4.01)	(9.39)	(14.88)
dummy for Market PDX-SF (=1, if Reference=SF)	2.101***	2.095***	2.075***	2.129***	2.156***
	(23.24)	(21.47)	(26.04)	(21.05)	(30.37)
dummy for Market PDX-LAS (=1, if Reference=LAS)	2.531***	2.520***	2.578***	1.938***	1.894***
	(10.16)	(11.29)	(15.02)	(12.18)	(16.31)
dummy for Market PDX-PHX (=1, if Reference=PHX)	1.553***	1.554***	1.572***	1.465***	1.450***
	(23.72)	(22.97)	(29.10)	(24.69)	(35.23)
dummy for Market PDX-SMF (=1, if Reference=SMF)	2.150***	2.145***	2.181***	1.820***	1.793***
	(13.49)	(14.47)	(18.55)	(16.69)	(22.94)
dummy for Market PDX-DEN (=1, if Reference=DEN)	1.762***	1.752***	1.779***	1.407***	1.393***
	(13.42)	(16.70)	(21.18)	(23.75)	(30.74)
dummy for Market PDX-NY (=1, if Reference=NY)	-1.461***	-1.455***	-1.527***	-0.841***	-0.777***
	(-4.71)	(-4.92)	(-6.69)	(-3.84)	(-5.57)
dummy for Market PDX-SAN (=1, if Reference=SAN)	1.437***	1.432***	1.453***	1.201***	1.188***
	(14.37)	(16.04)	(19.69)	(20.35)	(26.67)
dummy for Market PDX-CH (=1, if Reference=CH)	-0.155	-0.151	-0.185	0.158	0.188***
	(-1.01)	(-1.05)	(-1.64)	(1.49)	(2.68)
dummy for Market PDX-BOI (=1, if Reference=BOI)	4.025***	4.007***	4.114***	2.960***	2.878***
	(8.58)	(9.45)	(12.57)	(10.33)	(15.60)
dummy for Market PDX-DC (=1, if Reference=DC)	-0.346***	-0.348***	-0.373***	-0.212**	-0.186***
	(-3.39)	(-3.27)	(-4.41)	(-2.32)	(-3.07)
dummy for Market PDX-SLC (=1, if Reference=SLC)	2.373***	2.370***	2.422***	1.962***	1.918***
	(11.13)	(11.51)	(15.20)	(12.61)	(18.91)

dummy for Market PDX-GEG (=1, if Reference=GEG)	4.152***	4.137***	4.246***	3.132***	3.045***
	(8.86)	(9.56)	(12.74)	(10.37)	(15.72)
dummy for Market PDX-RNO (=1, if Reference=RNO)	3.900***	3.873***	3.986***	2.582***	2.500***
	(7.26)	(8.35)	(11.36)	(8.82)	(13.75)
dummy for Market PDX-HNL (=1, if Reference=HNL)	1.713***	1.697***	1.765***	0.895***	0.842***
	(5.11)	(5.85)	(7.82)	(4.70)	(6.57)
dummy for Market PDX-DW (=1, if Reference=DW)	0.189***	0.190***	0.182***	0.272***	0.280***
	(3.37)	(3.52)	(3.71)	(6.01)	(7.08)
dummy for Market PDX-SEA (=1, if Reference=SEA)	3.163***	3.157***	3.156***	2.972***	2.964***
	(20.20)	(21.06)	(21.27)	(19.57)	(19.64)
dummy for Market PDX-MSP (=1, if Reference=MSP)	0.663***	0.656***	0.670***	0.433***	0.427***
	(8.19)	(10.79)	(13.32)	(12.94)	(14.62)
dummy for Market PDX-MCO (=1, if Reference=MCO)	0.175	0.175	0.204*	-0.0457	-0.0776
	(1.26)	(1.26)	(1.85)	(-0.39)	(-0.95)
Constant	-18.67***	-18.80***	-19.68***	-14.82***	-14.20***
	(-7.33)	(-6.75)	(-9.33)	(-6.21)	(-9.71)
Observations	320	320	320	320	320
R^2	0.958	0.958	0.958	0.955	0.955
Adjusted R^2	0.954	0.954	0.954	0.951	0.951
F	687.2	718.6	783.1	791.2	895.6

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: Base Market: PDX-ATL(Rank 20)

5. What if we include more markets and consider cross-elasticity

5.1 Include more markets for cross-elasticity model (3)

*The coefficients of average yield of other markets are only significant in the top 20 market model.

Dependent variable: ln(originating passenger, thousands)

	(1) Top20	(2) Top40	(3) Top60	(4) Top80	(5) Top100
ln(market yield, cents per pax-mile in 2006 dollars)	-1.011***	-0.962***	-1.050***	-1.041***	-1.038***
	(-18.29)	(-20.76)	(-21.91)	(-25.33)	(-27.53)
ln(yield of other markets, cents per pax-mile in 2006 dollars)	0.256**	0.0987	0.0851	0.0216	0.0329
	(2.47)	(1.55)	(1.37)	(0.43)	(0.71)
ln(Market population, thousands)	2.512***	2.389***	2.109***	1.899***	1.820***
	(8.87)	(12.06)	(10.86)	(10.88)	(10.62)
dummy for year 2001 (=1, if year =2001)	-0.226***	-0.213***	-0.188***	-0.195***	-0.209***
	(-7.04)	(-9.76)	(-8.08)	(-9.81)	(-11.52)
dummy for Sept. 11 (=1, if year >=2002)	-0.380***	-0.371***	-0.325***	-0.328***	-0.332***
	(-12.95)	(-18.89)	(-16.13)	(-18.35)	(-20.53)
Constant	-19.68***	-18.11***	-18.15***	-15.42***	-14.78***
	(-9.33)	(-13.89)	(-13.50)	(-14.99)	(-14.17)
Observations	320	592	880	1168	1440
R^2	0.958	0.982	0.980	0.984	0.986
Adjusted R^2	0.954	0.981	0.979	0.983	0.985
F	783.1	1804.8	1946.1	2379.1	2574.0

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:1. Market dummies were used, but they are not shown here; 2.Choose lowest rank market as base market

5.2 Include more markets for cross-elasticity model (5)

*The coefficients of average yield of other markets are not significant all models.

Dependent variable: ln(originating passenger, thousands)

	(1) Top20	(2) Top40	(3) Top60	(4) Top80	(5) Top100
ln(market yield, cents per pax-mile in 2006 dollars)	-1.008***	-0.957***	-1.022***	-1.013***	-1.016***
	(-17.72)	(-20.15)	(-21.67)	(-24.93)	(-27.46)
ln(yield of other markets, cents per pax-mile in 2006 dollars)	0.131	-0.00410	0.0611	0.00469	0.0121
	(1.45)	(-0.07)	(1.11)	(0.10)	(0.29)
ln(Market personal income, millions in 2006 dollars)	1.376***	1.292***	1.315***	1.188***	1.115***
	(9.07)	(12.37)	(13.10)	(13.29)	(13.50)
dummy for year 2001 (=1, if year =2001)	-0.238***	-0.224***	-0.212***	-0.215***	-0.228***
	(-6.88)	(-9.82)	(-9.11)	(-10.84)	(-12.49)
dummy for Sept. 11 (=1, if year >=2002)	-0.329***	-0.322***	-0.294***	-0.302***	-0.308***
	(-11.40)	(-16.51)	(-15.38)	(-17.49)	(-19.64)
Constant	-14.20***	-13.63***	-15.32***	-13.68***	-12.79***
	(-9.71)	(-15.01)	(-17.03)	(-19.25)	(-19.00)
Observations	320	592	880	1168	1440
R^2	0.955	0.981	0.981	0.985	0.986
Adjusted R^2	0.951	0.980	0.980	0.984	0.985
F	895.6	1772.3	2136.1	2562.9	2755.0

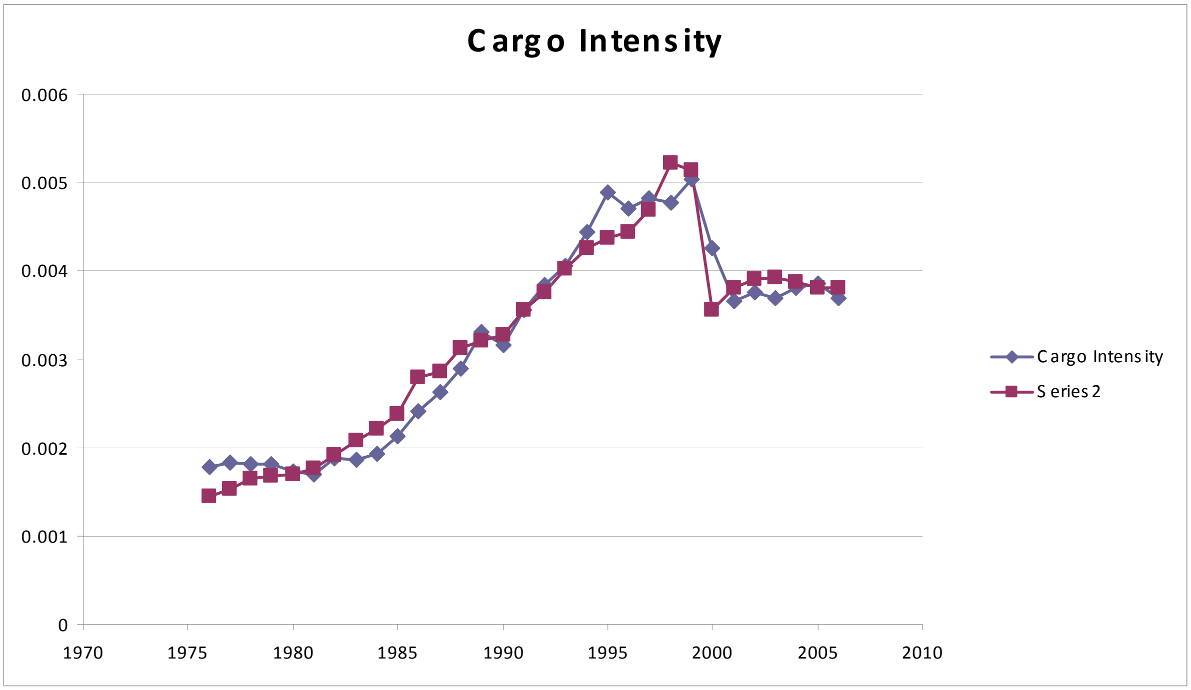
t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:1. Market dummies were used, but they are not shown here; 2.Choose lowest rank market as base market

9. APPENDIX C: CARGO MODEL

SUMMARY OF REVISED CARGO MODEL
Aviation Demand Forecasts
PDX Futures Project



1. LOGISTIC MODEL

a. (cargo/total income)=0.0147*exp(-329*dummy)(=1 if year >1999)*(price of oil^-.164)/(1+exp(1.53-0.079*(year-1976))

b. Adjusted R^2=0.94

2. CARGO INTENSITY

a. In the graph above, the variable plotted is the ratio of cargo to total personal income (for the Portland region). It is a measure of the cargo intensity of the Portland economy.

b. Note that the plot follows a classic s-curve--with accelerating growth followed by decelerating growth, reaching maturity in the mid 1990s. After 1999, it plunged abruptly to a different level, where it has remained since 2001.

3. PROBABILISTIC CARGO FORECASTS

a. We used the model in (1) along with the variance-covariance estimates of the parameter values and the distribution of oil prices to draw a cargo intensity. The intensity is approximated to have a normal distribution whose means and variance are based upon Taylor series approximations of the logistic model given in (1).

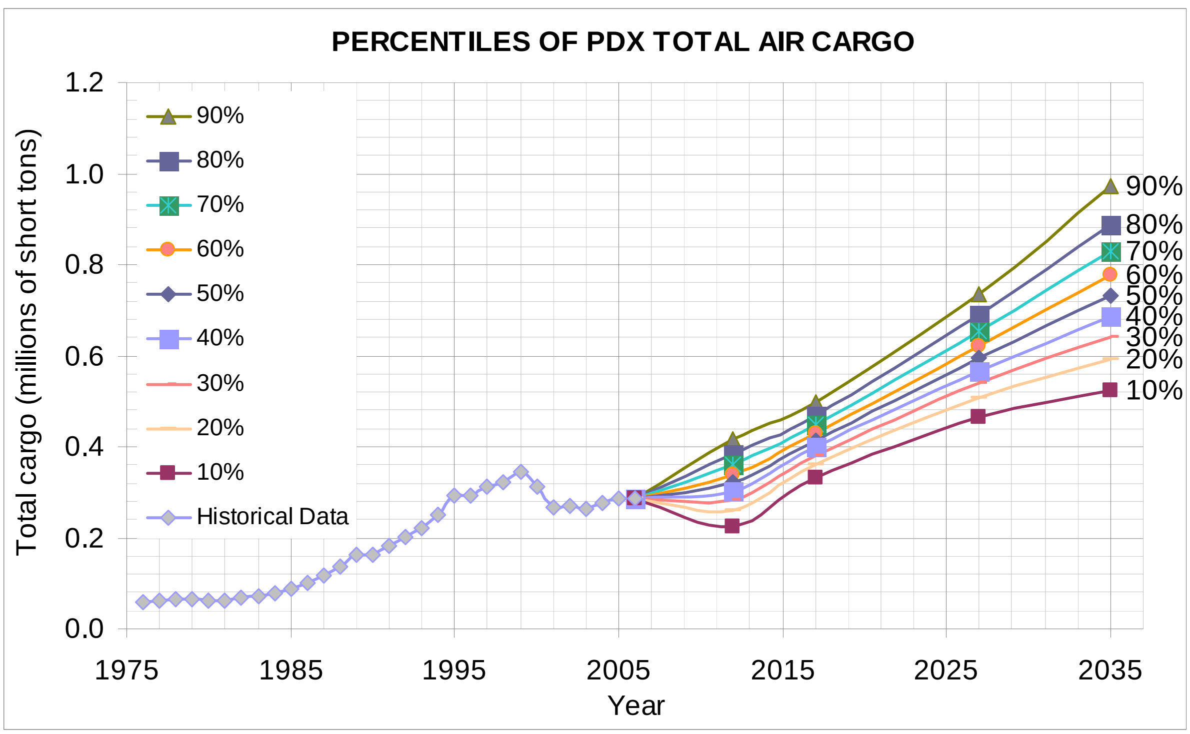
b. For a given year, the following steps were conducted:

i. Draw an oil price.

ii. Draw a cargo intensity based on the method described in a.

c. Draw a population and a per capita income and multiply to get total income.

d. Multiply results of steps *i* and *ii*.



4. SOFTWARE USED: MATLAB

10. APPENDIX D: CARBON EMISSIONS

White Paper

Review of Carbon Emissions Costs

PDX Airport Futures Project

This white paper summarizes (1) recent research on the European Union (EU) Emissions Trading Scheme** (ETS) and (2) the cost of carbon emissions from selected company web sites offering voluntary carbon offsets. The objective of this white paper is to provide a basis for (1) estimating the costs associated with a U.S. carbon trading program and (2) preparing forecasts for the PDX Airport Futures Project. The following is summarized:

- •EU-ETS Research on Carbon Emissions Trading
  - •Research Study Assumptions
  - •Option 1 in 2012: Based on Historical Emissions in 2007
  - •Option 2 in 2012: Based on Benchmarking
  - •Option 3 in 2012: Based on Historical Emissions from 2005-2007 (mean value)
- •The Cost of Voluntary Carbon Offsets from Selected Company Websites

Note: Four types of airlines were represented in the EU-ETS study: a low cost carrier (Ryan Air), a legacy network carrier (Lufthansa), a vacation airline (Condor), and a regional airline (Air Dolomiti).

**The EU-ETS was implemented to supplement national programs for climate change and to meet EU member reduction targets agreed under the Kyoto Protocol.

Study Assumptions

Review of Emissions Trading Costs Per Passenger Mile From Study of Selected European Airlines

Study assumption	Option 1	Option 2	Option 3
Price of an EU allowance (Euros) *(a)*	15	20	30
Equivalent cost in U.S. dollars	$22	$30	$44
Method/Base year of initial allocation of EU allowances	Historical / 2007	Benchmark of 12.64 kg CO_2 per 100 passenger kilometers	Historical / Mean of 2005-2007
Flights subject to Emissions Trading Scheme (ETS)	Intra-EU only	Intra-EU only	All flights departing from and arriving at EU airports
Autonomous efficiency increases per aircraft	1.47%	1.20%	1.00%
Price elasticity of demand			
Business travelers	-0.5	-0.7	-0.9
Leisure travelers	-1.1	-1.3	-1.5

(a) Aviation allowances permit emissions of 1 ton of CO_2 equivalent during a specified period and are valid only for meeting the requirements of airport operators to surrender allowances and are transferable in accordance of Directive 2003/87/EC.

Source: Scheelhaase, Janina D., Grimme, Wolfgang G., 2007. Emissions trading for international aviation--an estimation of the economic impact on selected European airlines. Journal of Air Transport Management 13, 253-263.

Option 1 in 2012: Based on Historical Emissions in 2007

Review of Emissions Trading Costs Per Passenger Mile From Study of Selected European Airlines

Methodology	Input	Representative airlines			
		Ryanair	Lufthansa	Condor	Air Dolomiti
		Low cost carrier	*Legacy network*	*Vacation*	*Regional*
	Estimated fuel consumption (thousand tons)	1,130	1,003	291	50
	Estimated CO_2 emissions (thousand tons)	**3,570**	**3,168**	**920**	**158**
	Allocation of EU allowances free of charge in thousand tons of CO_2	2,602	3,085	773	154
	Allowances to be acquired in thousand tons of CO_2	968	83	146	4
[A]	**Value of allowances (millions of Euros)**	**68.06**	**48.76**	**16.00**	**1.42**
	Acquired and allocated for free (millions of Euros)	53.54	47.52	13.80	1.36
	Cost of acquisition of allowances (millions of Euros)	14.52	1.24	2.20	0.06
[B]	Revenue passenger kilometer (RPK) (millions)	37,202	20,819	12,228	1,170
[C] =[B] X 0.62	Equivalent revenue passenger miles (millions)	23,065	12,908	7,581	813
[D] = [A] x 1.48	Equivalent value of allowances (millions of U.S. dollars)	$100.73	$72.16	$23.68	$2.10
[D] / [C]	**Estimated cost per passenger mile**	**$0.0044**	**$0.0056**	**$0.0031**	**$0.0026**
	Potential additional cost per ticket				
	Short-haul trip (500 miles)	$2.18	$2.80	$1.56	$1.29
	Medium-haul trip (1,000 miles)	$4.37	$5.59	$3.12	$2.58
	Long-haul trip (1,500 miles)	$6.55	$8.39	$4.69	$3.88
	International trip (5,000 miles)	$21.84	$27.95	$15.62	n.a.

Note: Option 1 in this study was based on historical emissions (2007 base year) and reflects favorable conditions for airlines, including generous allocation of allowances, low allowance prices, low price elasticities of demand, and emissions growth.

Source: Scheelhaase, Janina D., Grimme, Wolfgang G., 2007. Emissions trading for international aviation--an estimation of the economic impact on selected European airlines. Journal of Air Transport Management 13, 253-263.

Option 2 in 2012: Based on Benchmarking

Review of Emissions Trading Costs Per Passenger Mile From Study of Selected European Airlines

		Representative airlines			
		Ryanair	**Lufthansa**	**Condor**	**Air Dolomiti**
Methodology	**Input**	*Low cost carrier*	*Legacy network*	*Vacation*	*Regional*
	Estimated fuel consumption (thousand tons)	1,487	1,153	341	61
	Estimated CO_2 emissions (thousand tons)	**4,700**	**3,643**	**1,078**	**192**
	Allocation of EU allowances free of charge in thousand tons of CO_2	6,066	2,958	1,780	141
	Allowances to be acquired in thousand tons of CO_2	0	685	0	51
[A]	**Value of allowances (millions of Euros)**	**94.00**	**86.55**	**21.55**	**7.26**
	Acquired and allocated for free (millions of Euros)	94.00	72.85	21.55	5.74
	Cost of acquisition of allowances (millions of Euros)	0.00	13.70	0.00	1.52
[B]	Revenue passenger kilometer (RPK) (millions)	47,988	23,398	40,414	1,114
[C] =[B] X 0.62	Equivalent revenue passenger miles (millions)	29,753	14,507	25,057	691
[D] = [A] x 1.48	Equivalent value of allowances (millions of U.S. dollars)	$139.12	$128.09	$31.89	$10.74
[D] / [C]	**Estimated cost per passenger mile**	**$0.0047**	**$0.0088**	**$0.0013**	**$0.0156**
	Potential additional cost per ticket				
	Short-haul trip (500 miles)	$2.34	$4.41	$0.64	$7.78
	Medium-haul trip (1,000 miles)	$4.68	$8.83	$1.27	$15.56
	Long-haul trip (1,500 miles)	$7.01	$13.24	$1.91	$23.34
	International trip (5,000 miles)	$23.38	$44.15	$6.36	n.a.

Note: Option 2 in this study was based on an initial allocation based on a benchmark, a specific permissible emissions value, set at 12.64 kg CO_2 per 100 passenger kilometers corresponding to fuel consumption of 4 kg, about 5 l of jet fuel per passenger kilometer. This reflects emissions of state-of-the-art aircraft such as the A320 and B737 Next Generation at industry seating densities and passenger load factors.

Source: Scheelhaase, Janina D., Grimme, Wolfgang G., 2007. Emissions trading for international aviation--an estimation of the economic impact on selected European airlines. Journal of Air Transport Management 13, 253-263.

Option 3 in 2012: Based on Historical Emissions 2005 - 2007

Review of Emissions Trading Costs Per Passenger Mile From Study of Selected European Airlines

Methodology	Input	Representative airlines			
		Ryanair	**Lufthansa**	**Condor**	**Air Dolomiti**
		Low cost carrier	*Legacy network*	*Vacation*	*Regional*
	Estimated fuel consumption (thousand tons)	1,806	5,067	910	74
	Estimated CO_2 emissions (thousand tons)	**5,708**	**16,012**	**2,876**	**235**
	Allocation of EU allowances free of charge in thousand tons of CO_2	2,684	12,661	1,690	150
	Allowances to be acquired in thousand tons of CO_2	3,024	3,351	1,186	85
[A]	**Value of allowances (millions of Euros)**	**261.95**	**580.88**	**121.85**	**9.57**
	Acquired and allocated for free (millions of Euros)	171.24	480.35	86.28	7.03
	Cost of acquisition of allowances (millions of Euros)	90.71	100.53	35.57	2.54
[B]	Revenue passenger kilometer (RPK) (millions)	57,548	143,241	40,414	1,170
[C] =[B] X 0.62	Equivalent revenue passenger miles (millions)	35,680	88,809	25,057	725
[D] = [A] x 1.48	Equivalent value of allowances (millions of U.S. dollars)	$387.69	$859.70	$180.34	$14.16
[D] / [C]	**Estimated cost per passenger mile**	**$0.0109**	**$0.0097**	**$0.0072**	**$0.0195**
	Potential additional cost per ticket				
	Short-haul trip (500 miles)	$5.43	$4.84	$3.60	$9.76
	Medium-haul trip (1,000 miles)	$10.87	$9.68	$7.20	$19.53
	Long-haul trip (1,500 miles)	$16.30	$14.52	$10.80	$29.29
	International trip (5,000 miles)	$54.33	$48.40	$35.99	n.a.

Note: Option 3 in this study was based on historical emissions and embodied relatively unfavorable assumptions, such as a reluctance in the initial allocation, and higher allowances prices, price elasticities of demand, and emissions growth.

Source: Scheelhaase, Janina D., Grimme, Wolfgang G., 2007. Emissions trading for international aviation--an estimation of the economic impact on selected European airlines. Journal of Air Transport Management 13, 253-263.

Survey of Selected Voluntary Carbon Offset Company Websites

				atmosfair		Carbon Planet		Climate Friendly	
Rank	Top 20 PDX O&D markets (representative airport)	Tons CO_2e	Distance in miles	Cost per one-way trip (U.S. dollars)	Emissions cost per mile	Cost per one-way trip (U.S. dollars)	Emissions cost per mile	Cost per one-way trip (U.S. dollars)	Emissions cost per mile
1	Los Angeles (LAX)	0.4	837	$15	$0.0171	$21	$0.0248	$9	$0.0108
2	San Francisco (SFO)	0.4	552	$10	$0.0178	$21	$0.0377	$6	$0.0107
3	Las Vegas	0.4	763	$15	$0.0187	$21	$0.0272	$8	$0.0108
4	Phoenix	0.5	1,011	$18	$0.0171	$21	$0.0206	$10	$0.0099
5	Sacramento	0.3	484	$10	$0.0204	$21	$0.0430	$5	$0.0107
6	Denver	0.5	992	$18	$0.0175	$21	$0.0209	$11	$0.0108
7	New York (JFK)	1.2	2,443	$37	$0.0149	$42	$0.0170	$24	$0.0100
8	San Diego	0.5	936	$31	$0.0322	$21	$0.0222	$10	$0.0108
9	Chicago (ORD)	0.8	1,730	$28	$0.0159	$21	$0.0120	$17	$0.0100
10	Boise	0.4	375	$9	$0.0237	n.a.	n.a	$4	$0.0099
11	Washington, D.C. (IAD)	1.1	2,344	$36	$0.0151	$42	$0.0177	$23	$0.0098
12	Salt Lake City	0.3	632	$12	$0.0179	$21	$0.0329	$7	$0.0107
13	Spokane	0.2	279	$9	$0.0286	$21	$0.0745	$4	$0.0134
14	Reno	0.3	446	$9	$0.0187	$21	$0.0466	$5	$0.0107
15	Honolulu	1.2	2,598	$41	$0.0158	$42	$0.0160	$26	$0.0100
16	Detroit	0.9	1,947	$31	$0.0157	$21	$0.0107	$19	$0.0099
17	Seattle	0.1	130	$24	$0.0163	$21	$0.1596	$2	$0.0142
18	Minneapolis/St. Paul	0.7	1,420	$9	$0.0551	$21	$0.0146	$14	$0.0100
19	Orlando	1.2	2,530	$40	$0.0157	$42	$0.0164	$25	$0.0099
20	Atlanta	1.0	2,164	$34	$0.0155	$21	$0.0096	$22	$0.0100
Top 20 PDX markets average				$435	$0.0173	$478	$0.0203	$251	$0.0102

Sources: atmosfair, https://www.atmosfair.de, Carbon Planet, http://www.carbonplanet.com, Climate Friendly, https://climatefriendly.com.

Summary

- Emissions trading costs can vary depending on:
  - The initial allocation of allowances
  - The allowance price
  - The price elasticities of demand
  - Rates of emissions growth (as reflected in the growth in passenger activity and associated demand for fuel)
- Based on the recent research of the EU-ETS, the estimated cost per passenger mile of a carbon trading program could range from as little as 0.1 cents per passenger mile to as much as 2.0 cents per passenger mile (depending on the factors noted above).
- Based on a survey of selected company websites that offer carbon offsets for purchase by individuals, the estimated cost per passenger mile of a carbon trading program could range from 1 cent to 2 cents and is a function of the cost per ton of CO_2 offset and the pricing structure of each company.

11. APPENDIX E: OIL PRICE FORECASTS

CITY OF PORTLAND, OREGON
BUREAU OF Planning

PORT OF PORTLAND
Possibility. In every direction.

Review of Oil Price Forecasts

Supplementary Information
Response to PAG Comments

April 1, 2008

AIRPORT FUTURES
CHARTING A COURSE FOR PDX

INTRODUCTION AND PURPOSE

What is the purpose of this research?

- The purpose of this research is to respond to PAG requests from the meeting of February 19 for additional agencies or institutions that prepare oil price forecasts [other than the Department of Energy (DOE)].

- A second objective was to investigate the performance of DOE oil price forecasts compared with actual oil prices and to test for optimism bias*.

- This review included:
  - Long-term forecasts prepared by DOE, International Energy Agency (IEA), Federal Aviation Administration (FAA), and the World Bank
  - Short-term forecasts prepared by financial investors and commodity traders such as Morgan Stanley, Goldman Sachs, Duetsche Bank, Lehman Brothers, and Barclay's Bank

***Optimism bias** is the demonstrated systematic tendency for people to be over-optimistic about the outcome of planned actions.

KEY FINDINGS

How do DOE forecasts of oil prices compare with actual prices historically?

- The absolute average difference between DOE forecasts and actual oil prices is 20.8% for the period from 1994 through 2005.*

- Note: The absolute average difference ignores whether DOE overestimated or underestimated prices.

- In recent years, DOE forecasts have underestimated actual oil prices and the differences have been larger than 20.8%.

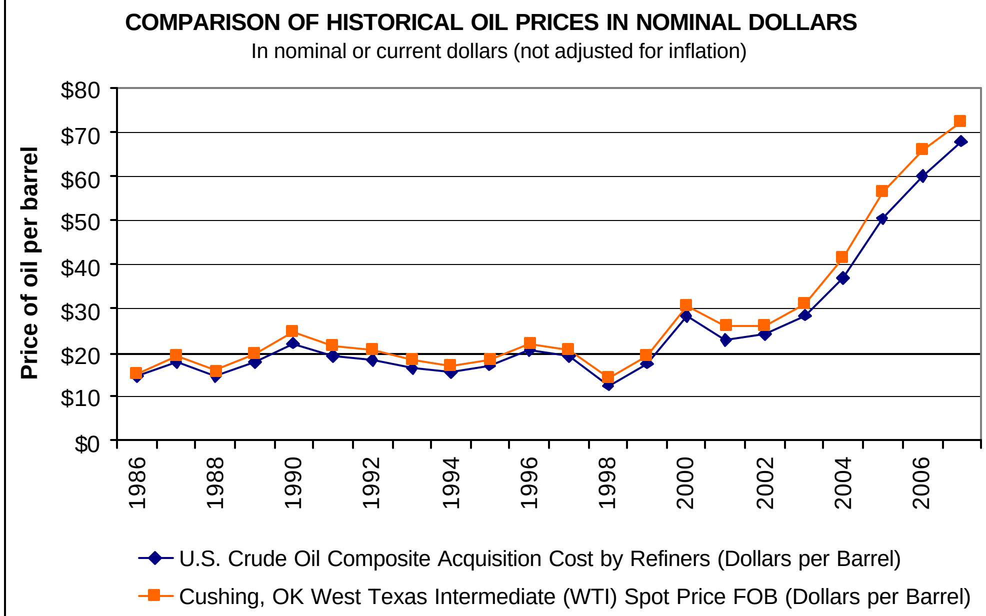
- For example, the price of oil was underestimated by 36.7% in 2005 (based on all the forecasts prepared through 2005).

*The National Energy Modeling System (NEMS) was completed in December 1993 and was first used for the DOE energy forecasts in 1994. Therefore, the period from 1994 through 2005 is evaluated because it includes only NEMS generated forecasts.

KEY FINDINGS

Are all oil prices the same?

- West Texas Intermediate (WTI) Crude is typically quoted in news articles and forecast by financial investors and commodity traders.
- The composite cost of oil to refiners is forecast by the DOE and was used in the PDX MP forecasts.
- WTI is about 10% higher, on average, than the refiners cost.



Source: U.S. Department of Energy, Energy Information Administration, online data.

TABLE OF CONTENTS

This review includes long-term forecasts prepared by DOE, IEA, FAA, and the World Bank and short-term forecasts by financial investors and commodity traders such as Morgan Stanley.

Table 1

REVIEW OF OIL PRICE FORECASTS IN NOMINAL DOLLARS

In current or nominal dollars per barrel (not adjusted for inflation)

	Acquisition Cost by Refiners					West Texas Intermediate Crude							
	Department of Energy (DOE) (a)						Morgan Stanley (e)						
Year	Reference (base case)	High	Low	2007 International Energy Administration (IEA) (b)	FAA 2008 National Aviation Forecasts (c)	2007 World Bank Commodity Forecasts (d)	Base	High	Low	Goldman Sachs (f)	Deutsche Bank (g)	Lehman Brothers (h)	Barclay's Bank (i)
2008	$76	$80	$74	$62	$86	$84	$80	$110	$65	$95	$80	$84	$98
2009	$73	$81	$67	$64	$79	$78	$83	$112	$67	$105	$75	$79	--
2010	$71	$86	$61	$65	$75	$73	$85	$115	$70	$110	--	--	--
2011	$70	$92	$56	$67	$74	$73	$87	$117	$72	--	--	--	--
2012	$69	$97	$52	$68	$74	$68	$90	$120	$75	--	--	--	--
2013	$67	$100	$49	$70	$74	$64	--	--	--	--	--	--	--
2014	$66	$102	$46	$72	$73	$60	--	--	--	--	--	--	--
2015	$64	$102	$44	$74	$73	$53	--	--	--	--	--	--	--
2016	$62	$102	$42	$75	$74	$53	--	--	--	--	--	--	--
2017	$64	$105	$42	$77	$75	$53	--	--	--	--	--	--	--
2018	$66	$110	$44	$79	$77	$54	--	--	--	--	--	--	--
2019	$68	$115	$45	$81	$79	$54	--	--	--	--	--	--	--
2020	$71	$121	$46	$83	$80	$54	--	--	--	--	--	--	--
2021	$73	$125	$48	$86	$82	--	--	--	--	--	--	--	--
2022	$76	$129	$49	$88	$84	--	--	--	--	--	--	--	--
2023	$79	$133	$50	$90	$86	--	--	--	--	--	--	--	--
2024	$82	$138	$51	$92	$87	--	--	--	--	--	--	--	--
2025	$86	$144	$53	$94	$87	--	--	--	--	--	--	--	--
2026	$89	$149	$55	$97	--	--	--	--	--	--	--	--	--
2027	$90	$151	$55	$99	--	--	--	--	--	--	--	--	--
2028	$94	$158	$57	$102	--	--	--	--	--	--	--	--	--
2029	$98	$165	$59	$104	--	--	--	--	--	--	--	--	--
2030	$101	$171	$61	$107	--	--	--	--	--	--	--	--	--

(a) U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2008* (Revised Early Release), Revised March 2008, Reference case results only and Annual Energy Outlook 2007, high and low cases. High and low 2008 forecasts are not yet available and were calibrated to March 2008 reference based on the 2007 forecasts.

(b) Organization for Economic Co-operation and Development (OECD), International Energy Administration, *World Energy Outlook 2007, Fact Sheet Oil*, 2007. Forecasts were provided for 2015 and 2030. Values for intermediate years were interpolated.

(c) U.S. Department of Transportation, Federal Aviation Administration, *FAA Aerospace Forecasts, Fiscal Years 2008-2025*, March 2008. Oil price forecasts are sourced to the Office of Management and Budget.

(d) The World Bank, Development Prospects Group, *Commodity Prices*, online website. Forecasts were prepared December 20, 2007.

(e) Bloomberg News, "Morgan Stanley Raises Long-Term Oil Forecast to $85 (Update 2)", December 3, 2007.

(f) Market Watch, "New 'Super-Spike' Might Mean $200 A Barrel Oil, Goldman's Projections Foretell Persistent Turbulence in Energy Prices", March 7, 2008.

(g) Bloomberg News, "Deutsche bank Raises Oil Price Forecast 6.3% to $85", January 12, 2008.

(h) Bloomberg News, "OPEC Should Increase Output to Rebuild Inventories, Lehman Says", January 10, 2008.

(i) Bloomberg News, "Barclays Raises 2008 Crude Oil Price Forecast by 12% (Update 1)", February 28, 2008.

Figure 1

REVIEW OF OIL PRICE FORECASTS IN NOMINAL DOLLARS

In nominal or current dollars (not adjusted for inflation)

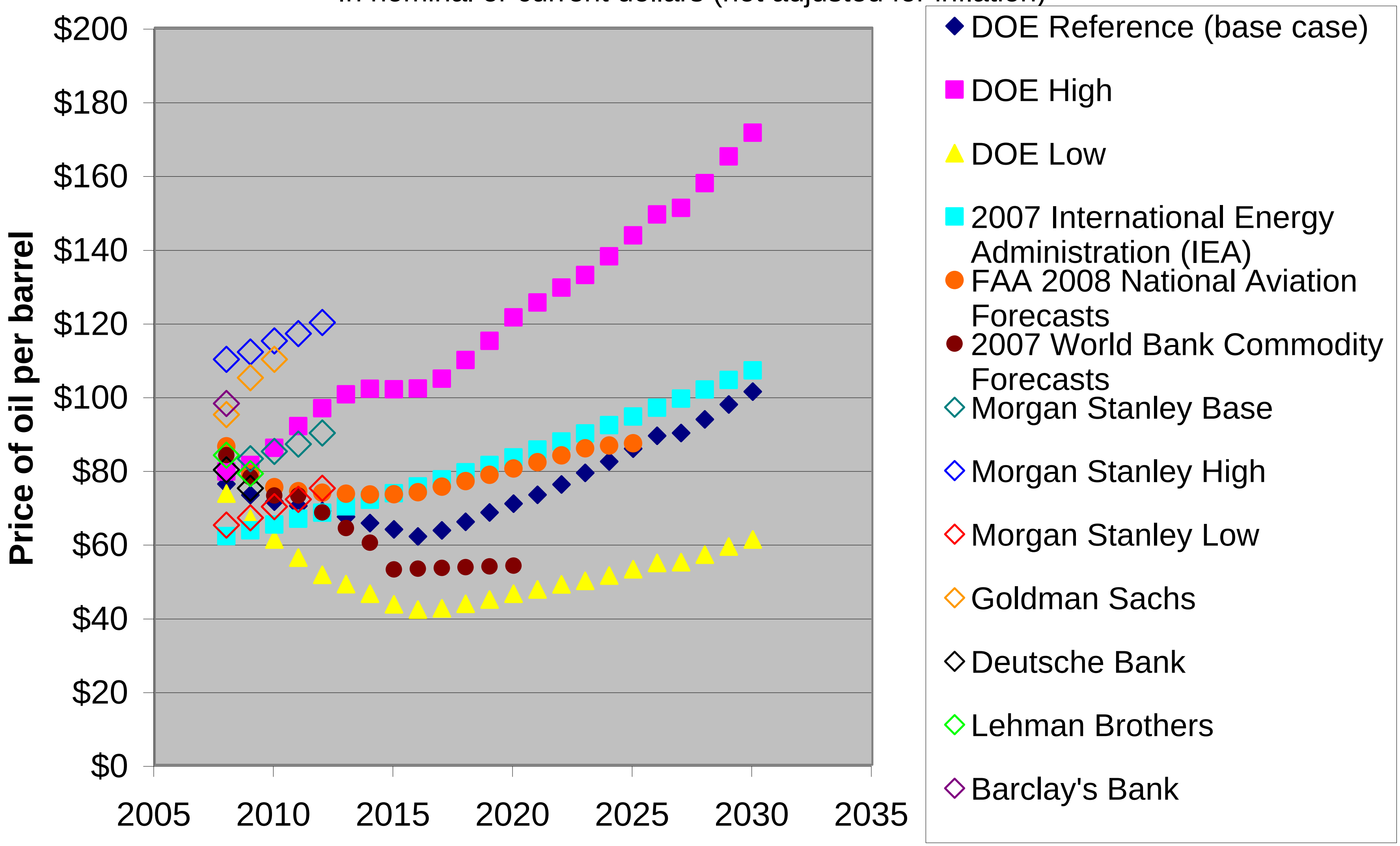


Table 2

REVIEW OF OIL PRICE FORECASTS IN CONSTANT DOLLARS

In 2006 dollars per barrel (adjusted for inflation)

	Acquisition Cost by Refiners					West Texas Intermediate Crude							
	Department of Energy (DOE) (a)			2007 International Energy Administration (IEA) (b)	FAA 2008 National Aviation Forecasts (c)	2007 World Bank Commodity Forecasts (d)	Morgan Stanley (e)			Goldman Sachs (f)	Deutsche Bank (g)	Lehman Brothers (h)	Barclay's Bank (i)
Year	Reference (base case)	High	Low				Base	High	Low				
2008	$73	$76	$70	$59	$83	$80	$76	$105	$62	$91	$76	$80	$94
2009	$68	$76	$62	$59	$74	$73	$78	$105	$63	$98	$70	$74	--
2010	$65	$78	$56	$59	$69	$67	$78	$105	$64	$100	--	--	--
2011	$63	$82	$50	$60	$66	$65	$78	$104	$64	--	--	--	--
2012	$60	$84	$45	$60	$64	$60	$79	$105	$65	--	--	--	--
2013	$57	$86	$42	$60	$63	$55	--	--	--	--	--	--	--
2014	$55	$85	$39	$60	$61	$50	--	--	--	--	--	--	--
2015	$52	$83	$35	$60	$60	$43	--	--	--	--	--	--	--
2016	$49	$81	$34	$60	$59	$42	--	--	--	--	--	--	--
2017	$49	$82	$33	$60	$59	$42	--	--	--	--	--	--	--
2018	$50	$84	$33	$60	$59	$41	--	--	--	--	--	--	--
2019	$51	$86	$33	$61	$59	$40	--	--	--	--	--	--	--
2020	$52	$88	$34	$61	$58	$39	--	--	--	--	--	--	--
2021	$52	$89	$34	$61	$58	--	--	--	--	--	--	--	--
2022	$53	$90	$34	$61	$58	--	--	--	--	--	--	--	--
2023	$54	$90	$34	$61	$58	--	--	--	--	--	--	--	--
2024	$55	$92	$34	$61	$57	--	--	--	--	--	--	--	--
2025	$56	$93	$34	$61	$57	--	--	--	--	--	--	--	--
2026	$57	$95	$35	$61	--	--	--	--	--	--	--	--	--
2027	$56	$94	$34	$62	--	--	--	--	--	--	--	--	--
2028	$57	$96	$35	$62	--	--	--	--	--	--	--	--	--
2029	$58	$98	$35	$62	--	--	--	--	--	--	--	--	--
2030	$59	$99	$35	$62	--	--	--	--	--	--	--	--	--

Note: Nominal oil prices from Table 1 were adjusted to 2006 dollars by Jacobs Consultancy, Inc. using an inflation rate of 2.3%.

(a) U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2008 (Revised Early Release)* , Revised March 2008, Reference case results only and Annual Energy Outlook 2007, high and low cases. High and low 2008 forecasts are not yet available and were calibrated to March 2008 reference based on the 2007 forecasts.

(b) Organization for Economic Co-operation and Development (OECD), International Energy Administration, *World Energy Outlook 2007, Fact Sheet Oil* , 2007. Forecasts were provided for 2015 and 2030. Intermediate years were interpolated.

(c) U.S. Department of Transportation, Federal Aviation Administration, *FAA Aerospace Forecasts, Fiscal Years 2008-2025* , March 2008. Oil price forecasts are sourced to the Office of Management and Budget.

(d) The World Bank, Development Prospects Group, *Commodity Prices* , online website. Forecasts were prepared December 20, 2007.

(e) Bloomberg News, "Morgan Stanley Raises Long-Term Oil Forecast to $85 (Update 2)", December 3, 2007.

(f) Market Watch, "New 'Super-Spike' Might Mean $200 A Barrel Oil, Goldman's Projections Foretell Persistent Turbulence in Energy Prices", March 7, 2008.

(g) Bloomberg News, "Deutsche bank Raises Oil Price Forecast 6.3% to $85", January 12, 2008.

(h) Bloomberg News, "OPEC Should Increase Output to Rebuild Inventories, Lehman Says", January 10, 2008.

(i) Bloomberg News, "Barclays Raises 2008 Crude Oil Price Forecast by 12% (Update 1)", February 28, 2008.

Figure 2

REVIEW OF OIL PRICE FORECASTS IN CONSTANT DOLLARS

In 2006 dollars (adjusted for inflation)

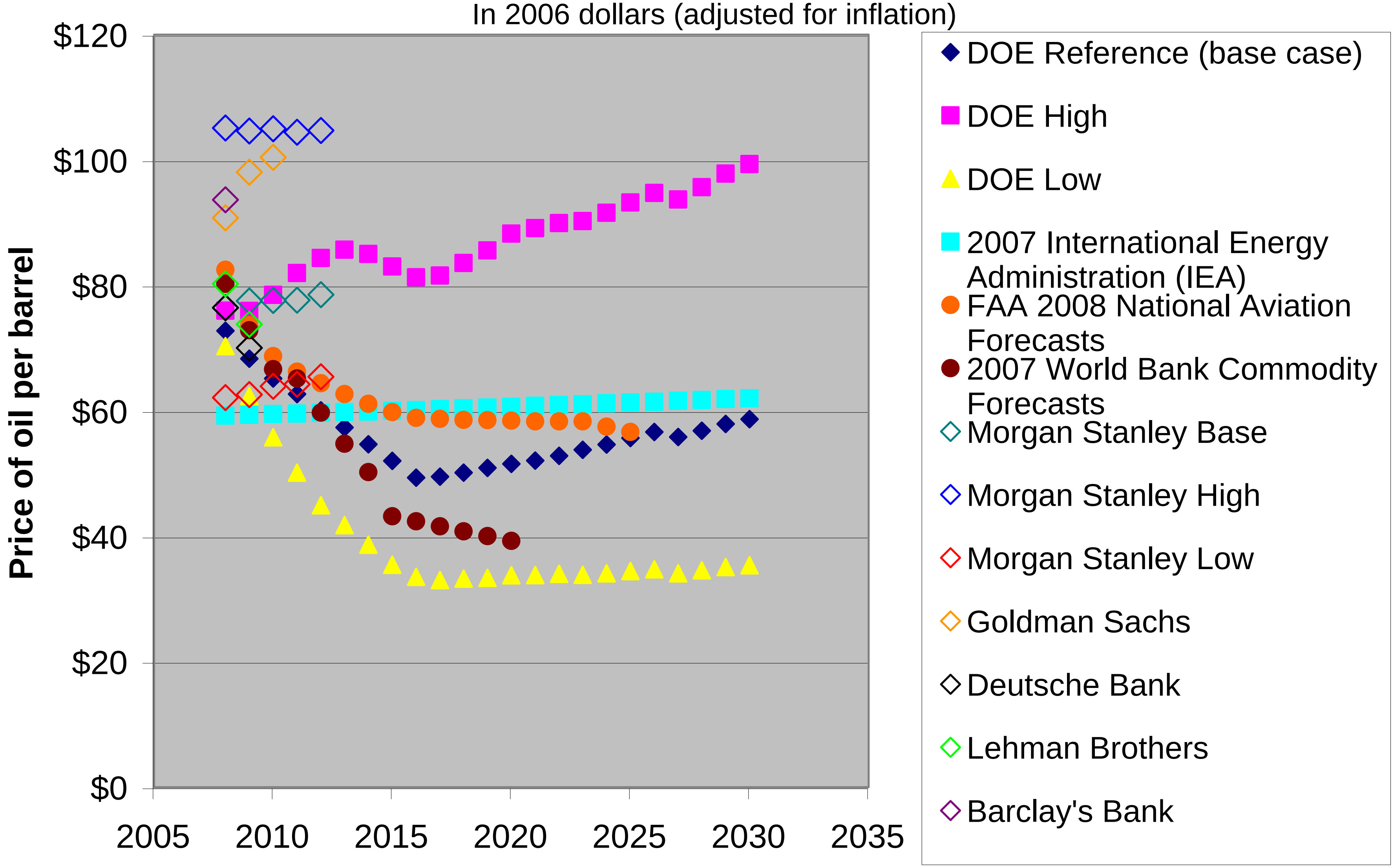


Table 3

COMPARISON OF HISTORICAL OIL PRICES

In current or nominal dollars (not adjusted for inflation)

	U.S. Crude Oil Composite Acquisition Cost by Refiners (Dollars per Barrel)	Cushing, OK WTI Spot Price FOB (Dollars per Barrel)	Percent difference--WTI vs. refiners acquisition cost
1986	$15	$15	3%
1987	$18	$19	7%
1988	$15	$16	9%
1989	$18	$20	9%
1990	$22	$25	10%
1991	$19	$22	13%
1992	$18	$21	12%
1993	$16	$18	12%
1994	$16	$17	10%
1995	$17	$18	7%
1996	$21	$22	7%
1997	$19	$21	8%
1998	$13	$14	15%
1999	$18	$19	10%
2000	$28	$30	8%
2001	$23	$26	13%
2002	$24	$26	9%
2003	$29	$31	9%
2004	$37	$42	12%
2005	$50	$57	13%
2006	$60	$66	10%
2007	$68	$72	6%

Source: U.S. Department of Energy, Energy Information Administration, online data.

Table 4

OIL PRICE FORECASTS IN NOMINAL DOLLARS: OPTIONS TO ADJUST THE MODEL PARAMETERS

In current or nominal dollars per barrel (not adjusted for inflation)

	Option 1: DOE			Option 2: IEA	Option 3: Morgan Stanley		
	Shifted up 20.8% to reflect average percent difference--forecast vs. actual*			Shifted up 27% to reflect average percent difference--forecast vs. actual	Morgan Stanley projections from 2008-2012; annual growth in DOE projections from 2013-2030		
	Department of Energy (DOE)				Morgan Stanley		
Year	Reference (base case)	High	Low	2007 International Energy Administration (IEA)	Base	High	Low
2008	$92	$96	$89	$79	$80	$110	$65
2009	$88	$98	$81	$81	$83	$112	$67
2010	$86	$104	$74	$83	$85	$115	$70
2011	$85	$111	$68	$85	$87	$117	$72
2012	$83	$117	$62	$87	$90	$120	$75
2013	$81	$121	$59	$89	$88	$125	$71
2014	$79	$123	$56	$91	$86	$127	$68
2015	$77	$123	$53	$94	$83	$126	$63
2016	$75	$123	$51	$96	$81	$127	$61
2017	$77	$127	$51	$98	$83	$130	$62
2018	$80	$133	$53	$101	$86	$136	$64
2019	$83	$139	$54	$103	$89	$143	$65
2020	$86	$147	$56	$106	$93	$151	$68
2021	$88	$151	$57	$109	$96	$156	$69
2022	$92	$156	$59	$111	$99	$161	$71
2023	$96	$161	$60	$114	$104	$165	$73
2024	$99	$167	$62	$117	$108	$171	$75
2025	$104	$173	$64	$120	$112	$178	$77
2026	$108	$180	$66	$123	$117	$185	$80
2027	$109	$182	$66	$126	$118	$187	$80
2028	$113	$191	$69	$129	$123	$196	$83
2029	$118	$199	$72	$133	$128	$205	$86
2030	$122	$207	$74	$136	$132	$213	$89
Average annual percent growth							
2006-2030	2.27%	4.54%	0.14%	2.51%			
2008-2030					2.31%	3.04%	1.43%

*Reflects National Energy Modeling System (NEMS) Annual Energy Outlooks (AEO) only. The National Energy Modeling System (NEMS) was completed in December 1993 and was first used for the DOE energy forecasts in 1994. Therefore, the period from 1994 through 2005 is evaluated because it includes only NEMS generated forecasts.

Table 5

OIL PRICE FORECASTS IN CONSTANT DOLLARS: OPTIONS TO ADJUST THE MODEL PARAMETERS

In 2006 dollars per barrel (adjusted for inflation)

	Option 1: DOE			Option 2: IEA	Option 3: Morgan Stanley		
	Shifted up 20.8% to reflect average percent difference--forecast vs. actual*			Shifted up 27% to reflect average percent difference--forecast vs. actual	Morgan Stanley projections from 2008-2012; annual growth in DOE projections from 2013-2030		
	Department of Energy (DOE) (a)				Morgan Stanley (e)		
Year	Reference (base case)	High	Low	2007 International Energy Administration (IEA) (b)	Base	High	Low
2008	$88	$92	$85	$75	$76	$105	$62
2009	$83	$92	$75	$75	$78	$105	$63
2010	$79	$95	$67	$76	$78	$105	$64
2011	$76	$99	$61	$76	$78	$104	$64
2012	$73	$102	$54	$76	$79	$105	$65
2013	$69	$104	$50	$76	$75	$106	$61
2014	$66	$103	$47	$76	$71	$105	$56
2015	$63	$100	$43	$76	$68	$103	$52
2016	$60	$98	$41	$76	$65	$101	$49
2017	$60	$99	$40	$77	$65	$101	$48
2018	$61	$101	$40	$77	$66	$104	$48
2019	$62	$103	$40	$77	$67	$106	$49
2020	$62	$107	$41	$77	$67	$110	$49
2021	$63	$108	$41	$77	$68	$111	$49
2022	$64	$109	$41	$77	$69	$112	$50
2023	$65	$109	$41	$78	$70	$112	$49
2024	$66	$111	$41	$78	$71	$114	$50
2025	$67	$113	$42	$78	$73	$116	$50
2026	$68	$114	$42	$78	$74	$118	$51
2027	$67	$113	$41	$78	$73	$116	$50
2028	$69	$116	$42	$78	$74	$119	$50
2029	$70	$118	$42	$79	$76	$121	$51
2030	$71	$120	$43	$79	$77	$123	$52
Average annual percent growth							
2006-2030	-0.03%	2.19%	-2.11%	0.20%			
2008-2030					0.01%	0.73%	-0.85%

Note: Nominal oil prices from Table 1 were adjusted to 2006 dollars by Jacobs Consultancy, Inc. using an inflation rate of 2.3%.

*Reflects National Energy Modeling System (NEMS) Annual Energy Outlooks (AEO) only. The National Energy Modeling System (NEMS) was completed in December 1993 and was first used for the DOE energy forecasts in 1994. Therefore, the period from 1994 through 2005 is evaluated because it includes only NEMS generated forecasts.

DOE DEFINITION OF TERMS

- **West Texas Intermediate (WTI - Cushing):** A crude stream produced in Texas and southern Oklahoma which serves as a reference or "marker" for pricing a number of other crude streams and which is traded in the **domestic spot market** at Cushing, Oklahoma.

- **Spot price:** The price for a one-time open market transaction for immediate delivery of a specific quantity of product at a specific location where the commodity is purchased "on the spot" at current market rates.

- **Refiner acquisition cost of crude oil:** The cost of crude oil, including transportation and other fees paid by the refiner. The composite cost is the weighted average of domestic and imported crude oil costs. *Note:* The refiner acquisition cost does not include the cost of crude oil purchased for the Strategic Petroleum Reserve (SPR).

Report #: DOE/EIA-0640(2006)

Release Date: March 2007

Next release date: February 2008

Annual Energy Outlook Retrospective Review

Table 4. World Oil Prices, Actual vs. Forecasts

(current dollars per barrel)

Annual Energy Outlook report	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AEO 1982	29.66	34.82	41.43	48.04	53.75	59.06															
AEO 1983	28.99	29.39	32.67	39.32	46.07	53.22					101.59										
AEO 1984	29.07	29.39	30.97	33.96	37.23	40.82					73.87										
AEO 1985	27.00	25.86	24.83	26.05	29.69	33.75	36.96	40.54	42.89	46.92	49.65										
AEO 1986		14.57	15.87	17.30	18.86	20.64	22.25	25.37	29.75	34.85	39.91	44.86	49.71	54.30	58.99	64.42					
AEO 1987			18.11	17.30	18.91	19.93	20.90	21.77	23.99	27.50	32.03					57.72					
AEO 1989*				14.70	14.93	16.33	17.75	19.15	21.68	25.21	28.91	33.29	37.81	42.47	46.36	49.98					
AEO 1990					17.70	17.49					26.58					46.17					69.08
AEO 1991						22.00	24.77	25.59	26.45	27.34	28.37	29.44	30.54	32.03	34.28	36.89	39.84	43.34	47.08	50.99	55.23
AEO 1992							19.03	20.06	20.65	22.27	24.20	26.31	28.66	31.17	33.96	36.96	39.90	42.96	46.05	49.18	52.53
AEO 1993								18.86	20.25	21.24	22.45	23.68	25.02	26.71	28.64	31.02	33.48	36.27	38.90	41.21	43.63
AEO 1994									17.06	17.21	18.24	19.43	20.64	22.12	23.76	25.52	27.51	29.67	31.86	34.00	36.05
AEO 1995										15.24	17.27	18.23	19.26	20.39	21.59	22.97	24.33	25.79	27.27	28.82	30.38
AEO 1996											17.16	17.74	18.59	19.72	20.97	22.34	23.81	25.26	26.72	28.22	29.87
AEO 1997												19.99	19.42	19.55	20.07	20.59	21.68	22.71	23.75	24.78	25.87
AEO 1998													18.54	18.79	19.87	20.95	21.79	22.53	23.46	24.34	25.27
AEO 1999														12.50	13.64	14.67	16.35	17.87	19.64	21.14	22.59
AEO 2000															17.35	21.80	20.99	21.52	22.05	22.62	23.23
AEO 2001																28.21	24.86	22.82	22.36	23.04	23.65
AEO 2002																	22.99	21.99	24.00	24.86	25.66
AEO 2003																		23.65	26.92	25.70	25.40
AEO 2004																			27.65	24.54	24.45
AEO 2005																				35.74	35.40
AEO 2006																					50.97
Actual	26.99	14.00	18.13	14.56	18.08	21.76	18.70	18.20	16.14	15.51	17.14	20.64	18.53	12.04	17.26	27.70	22.00	23.71	27.71	35.90	48.85
Average Absolute Difference (All AEOs)	1.7	12.8	9.9	13.5	12.4	12.5	5.2	6.3	9.2	11.0	19.8	6.8	8.3	15.2	11.6	11.7	5.7	5.7	6.2	9.8	18.4

NOTE: The average absolute percent difference is the simple mean of the absolute values of the percentage difference between the reference case projection and the actual value.

Report #: DOE/EIA-0640(2006)
Release Date: March 2007
Next release date: February 2008

Annual Energy Outlook Retrospective Review

Table 4. World Oil Prices, Actual vs. Forecasts

(percent difference)

Annual Energy Outlook report	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AEO 1982	9.9	148.7	128.5	229.9	197.3	171.4															
AEO 1983	7.4	110.0	80.2	170.0	154.8	144.6					492.7										
AEO 1984	7.7	110.0	70.8	133.2	105.9	87.6					331.0										
AEO 1985	0.0	84.7	36.9	78.9	64.2	55.1	97.7	122.7	165.8	202.5	189.6										
AEO 1986		4.1	-12.5	18.8	4.3	-5.2	19.0	39.4	84.3	124.7	132.9	117.3	168.3	351.0	241.7	132.5					
AEO 1987			-0.1	18.8	4.6	-8.4	11.8	19.6	48.7	77.3	86.9					108.4					
AEO 1989*				1.0	-17.4	-24.9	-5.1	5.2	34.3	62.5	68.7	61.3	104.1	252.7	168.6	80.4					
AEO 1990					-2.1	-19.6					55.1					66.7					41.4
AEO 1991						1.1	32.4	40.6	63.9	76.3	65.5	42.6	64.8	166.0	98.6	33.2	81.1	82.8	69.9	42.0	13.1
AEO 1992							1.8	10.2	28.0	43.6	41.2	27.5	54.7	158.9	96.7	33.4	81.4	81.2	66.2	37.0	7.5
AEO 1993								3.6	25.5	36.9	31.0	14.7	35.0	121.8	65.9	12.0	52.2	53.0	40.4	14.8	-10.7
AEO 1994									5.7	10.9	6.4	-5.9	11.4	83.7	37.7	-7.9	25.0	25.1	15.0	-5.3	-26.2
AEO 1995										-1.8	0.8	-11.7	4.0	69.4	25.1	-17.1	10.6	8.8	-1.6	-19.7	-37.8
AEO 1996											0.1	-14.0	0.3	63.8	21.5	-19.3	8.2	6.5	-3.6	-21.4	-38.8
AEO 1997												-3.1	4.8	62.4	16.3	-25.7	-1.5	-4.2	-14.3	-31.0	-47.0
AEO 1998													0.0	56.1	15.1	-24.4	-1.0	-5.0	-15.3	-32.2	-48.3
AEO 1999														3.8	-21.0	-47.0	-25.7	-24.6	-29.1	-41.1	-53.8
AEO 2000															0.5	-21.3	-4.6	-9.2	-20.4	-37.0	-52.5
AEO 2001																1.8	13.0	-3.7	-19.3	-35.8	-51.6
AEO 2002																	4.5	-7.3	-13.4	-30.8	-47.5
AEO 2003																		-0.3	-2.9	-28.4	-48.0
AEO 2004																			-0.2	-31.7	-49.9
AEO 2005																				-0.4	-27.5
AEO 2006																					4.3
Average Absolute Percent Difference (All AEOs)	6.3	91.5	54.8	93.0	68.8	57.5	28.0	34.5	57.0	70.7	115.5	33.1	44.7	126.3	67.4	42.1	25.7	24.0	22.3	27.2	37.6

----

* There is no report titled *Annual Energy Outlook 1988* due to a change in the naming convention of the *AEO* s.

Sources: Forecasts: *Annual Energy Outlook* , Mid-Price or Reference Case Projections, Various Editions.

Historical Data: Energy Information Administration, Annual Energy Review 2005, DOE/EIA-0384(2005) (Washington, DC, July 2006) , Table 5.21.

NOTE: The average absolute percent difference is the simple mean of the absolute values of the percentage difference between the reference case projection and the actual value.

Report #: DOE/EIA-0640(2006)
Release Date: March 2007
Next release date: February 2008

Annual Energy Outlook Retrospective Review

Table 4. World Oil Prices, Actual vs. Forecasts

(absolute forecasting errors, current dollars per barrel)

Annual Energy Outlook report	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average Absolute Error (All Years)
AEO 1982	2.67	20.82	23.30	33.48	35.67	37.30																25.54
AEO 1983	2.00	15.39	14.54	24.76	27.99	31.46					84.45											28.65
AEO 1984	2.08	15.39	12.84	19.40	19.15	19.06					56.73											20.66
AEO 1985	0.01	11.86	6.70	11.49	11.61	11.99	18.26	22.34	26.75	31.41	32.51											16.81
AEO 1986		0.57	2.26	2.74	0.78	1.12	3.55	7.17	13.61	19.34	22.77	24.22	31.18	42.26	41.73	36.72						16.67
AEO 1987			0.02	2.74	0.83	1.83	2.20	3.57	7.85	11.99	14.89					30.02						7.59
AEO 1989*				0.14	3.15	5.43	0.95	0.95	5.54	9.70	11.77	12.65	19.28	30.43	29.10	22.28						11.64
AEO 1990					0.38	4.27					9.44					18.47					20.23	10.56
AEO 1991						0.24	6.07	7.39	10.31	11.83	11.23	8.80	12.01	19.99	17.02	9.19	17.84	19.63	19.37	15.09	6.38	12.02
AEO 1992							0.33	1.86	4.51	6.76	7.06	5.67	10.13	19.13	16.70	9.26	17.90	19.25	18.34	13.28	3.68	10.26
AEO 1993								0.66	4.11	5.73	5.31	3.04	6.49	14.67	11.38	3.32	11.48	12.56	11.19	5.31	5.22	7.18
AEO 1994									0.92	1.70	1.10	1.21	2.11	10.08	6.50	2.18	5.51	5.96	4.15	1.90	12.80	4.32
AEO 1995										0.27	0.13	2.41	0.73	8.35	4.33	4.73	2.33	2.08	0.44	7.08	18.47	4.28
AEO 1996											0.02	2.90	0.06	7.68	3.71	5.36	1.81	1.55	0.99	7.68	18.98	4.61
AEO 1997												0.65	0.89	7.51	2.81	7.11	0.32	1.00	3.96	11.12	22.98	5.84
AEO 1998													0.01	6.75	2.61	6.75	0.21	1.18	4.25	11.56	23.58	6.32
AEO 1999														0.46	3.62	13.03	5.65	5.84	8.07	14.76	26.26	9.71
AEO 2000															0.09	5.90	1.01	2.19	5.66	13.28	25.62	7.68
AEO 2001																0.51	2.86	0.89	5.35	12.86	25.20	7.94
AEO 2002																	0.99	1.72	3.71	11.04	23.19	8.13
AEO 2003																		0.06	0.79	10.20	23.45	8.63
AEO 2004																			0.06	11.36	24.40	11.94
AEO 2005																				0.16	13.45	6.81
AEO 2006																					2.12	2.12
39%																						
Average Absolute Error (All AEOs)																						10.71

NOTE: The average absolute percent difference is the simple mean of the absolute values of the percentage difference between the reference case projection and the actual value.

Report #: DOE/EIA-0640(2006)
Release Date: March 2007
Next release date: February 2008

Annual Energy Outlook Retrospective Review

Table 4. World Oil Prices, Actual vs. Forecasts

(absolute percent error)

Annual Energy Outlook report	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average Absolute Percent Error (All Years)
AEO 1982	9.9	148.7	128.5	229.9	197.3	171.4																147.6
AEO 1983	7.4	110.0	80.2	170.0	154.8	144.6					492.7											165.7
AEO 1984	7.7	110.0	70.8	133.2	105.9	87.6					331.0											120.9
AEO 1985	0.0	84.7	36.9	78.9	64.2	55.1	97.7	122.7	165.8	202.5	189.6											99.8
AEO 1986		4.1	12.5	18.8	4.3	5.2	19.0	39.4	84.3	124.7	132.9	117.3	168.3	351.0	241.7	132.5						97.1
AEO 1987			0.1	18.8	4.6	8.4	11.8	19.6	48.7	77.3	86.9					108.4						38.4
AEO 1989*				1.0	17.4	24.9	5.1	5.2	34.3	62.5	68.7	61.3	104.1	252.7	168.6	80.4						68.2
AEO 1990					2.1	19.6					55.1					66.7					41.4	37.0
AEO 1991						1.1	32.4	40.6	63.9	76.3	65.5	42.6	64.8	166.0	98.6	33.2	81.1	82.8	69.9	42.0	13.1	60.9
AEO 1992							1.8	10.2	28.0	43.6	41.2	27.5	54.7	158.9	96.7	33.4	81.4	81.2	66.2	37.0	7.5	51.3
AEO 1993								3.6	25.5	36.9	31.0	14.7	35.0	121.8	65.9	12.0	52.2	53.0	40.4	14.8	10.7	37.0
AEO 1994									5.7	10.9	6.4	5.9	11.4	83.7	37.7	7.9	25.0	25.1	15.0	5.3	26.2	20.5
AEO 1995										1.8	0.8	11.7	4.0	69.4	25.1	17.1	10.6	8.8	1.6	19.7	37.8	17.3
AEO 1996											0.1	14.0	0.3	63.8	21.5	19.3	8.2	6.5	3.6	21.4	38.8	18.0
AEO 1997												3.1	4.8	62.4	16.3	25.7	1.5	4.2	14.3	31.0	47.0	21.0
AEO 1998													0.0	56.1	15.1	24.4	1.0	5.0	15.3	32.2	48.3	21.9
AEO 1999														3.8	21.0	47.0	25.7	24.6	29.1	41.1	53.8	30.8
AEO 2000															0.5	21.3	4.6	9.2	20.4	37.0	52.5	20.8
AEO 2001																1.8	13.0	3.7	19.3	35.8	51.6	20.9
AEO 2002																	4.5	7.3	13.4	30.8	47.5	20.7
AEO 2003																		0.3	2.9	28.4	48.0	19.9
AEO 2004																			0.2	31.7	49.9	27.3
AEO 2005																				0.4	27.5	14.0
AEO 2006																					4.3	4.3
Average Absolute Percent Error (All Years, All AEOs)																68.4	65.5	62.4	59.3	56.4	54.1	52.9
NEMS AEOs Only																						**20.8**
Pre-NEMS AEOs																						77.0

----

* There is no report titled *Annual Energy Outlook 1988* due to a change in the naming convention of the *AEO* s.

NEMS = National Energy Modeling System

AEO = Annual Energy Outlook (annual energy reports)

NOTE: The average absolute percent difference is the simple mean of the absolute values of the percentage difference between the reference case projection and the actual value.

12. APPENDIX F: PEER REVIEW

Aviation Forecast Peer Review Report

June 11, 2008

Prepared for

City of Portland

Aviation System Consulting, LLC
805 Colusa Avenue
Berkeley, CA 94707-1838

Table of Contents

EXECUTIVE SUMMARY

This executive summary documents the findings and conclusions of a review of the aviation forecast methodology and resulting traffic forecasts developed for the Portland International Airport (PDX) *Airport Futures* project by the Port of Portland's aviation consultant team. The Forecast Peer Review was undertaken for the City of Portland by Dr. Geoffrey Gosling, Principal of Aviation System Consulting, LLC, with the objective of providing the City of Portland, the Port of Portland, and the PDX Airport Futures Planning Advisory Group (PAG) and its Forecast Subcommittee with an independent assessment of the forecast methodology, forecast scenarios, and associated assumptions, including the treatment of uncertainty in the forecast process.

At the start of the forecast development process it was recognized that it would be more productive to have the Peer Review Consultant interact closely with the Port's Consultant (Jacobs Consultancy) during the preparation of the forecasts rather than commenting after the fact. This would allow any concerns to be raised at an early stage in the process while there was time to address them and provide an opportunity for the Peer Review Consultant to make suggestions as the work is proceeding. As a result, the Peer Review Consultant has been closely involved in the forecast development throughout the process, has been included in the distribution of draft products and working materials, including technical memoranda on the model estimation and drafts of presentations to the Forecast Subcommittee and PAG, and provided the opportunity to comment prior to their presentation. More substantively, a number of concerns raised by the Peer Review Consultant during the forecast model development have been addressed in the final models. Overall, this has been a very productive relationship.

A central feature of the process adopted for the current forecast is the decision to develop a probabilistic approach to generating the forecasts, also termed a risk analysis. This represents a significant technical improvement over the typical approach adopted in most airport master plan forecasts, including the previous master plan forecast for PDX. The principal advantages of this approach is that it provides a much better representation of the uncertainties inherent in forecasting future traffic at an airport and provides a basis for assessing the robustness of alternative facility plans considered in the master plan to different future traffic levels. In particular, it allows a more quantified approach to understanding the risks involved if traffic grows faster or slower than expected and provides the ability to address questions such as "how soon might we need the capability to handle 30 million annual passengers at PDX?" or "what is the likelihood that we will need to build another terminal concourse by 2015?"

However, an important consequence of adopting this approach is that the analysis is significantly more complex than is usual for an airport master planning study. This was further complicated by the recognition of the need to give detailed attention to assumptions regarding the future price of oil and the impact of policies to address climate change, aspects that have generally been ignored in past forecasts. As in other areas of transportation planning, the Portland region is well ahead of the state of the art elsewhere and is setting new standards of practice for aviation forecasting, something that the PDX Aviation Futures project and the Port's aviation consultant team can be justifiably proud of.

Although adopting a probabilistic approach incorporating the effect of future oil prices and climate change policies improved the usefulness of the forecast, the steps required proved technically challenging, time-consuming and costly. As a result there were a number of issues that arose during the forecast development process that it was decided there was neither the time nor the resources to pursue any further at the present time. Recognizing these limitations, the PAG voted to accept the forecasts at its meeting on April 15, 2008 with the condition that that the forecasts should be revisited before the end of the master plan update process to determine whether the assumptions underlying the forecasts still appear to be reasonable.

The Forecast Peer Review identified a number of aspects of the forecast methodology and assumptions that could have a significant impact on the forecasts and that appear deserving of further analysis in order to better understand how these could impact future traffic levels at PDX. The following aspects are likely to have the greatest influence on the forecast traffic:

- The enplaned passenger demand model assumes that the historical relationship between total passenger traffic at the airport and regional population, per capita disposable income, and average cost per passenger-mile of airfares from PDX (termed airline yield) will continue unchanged in the future and that the recent reduction in traffic from the levels predicted by the historical relationship will also continue unchanged.

- The air cargo model assumes that the past growth in air cargo is largely explained by an increasing weight of air cargo per thousand dollars of regional income and that this ratio will continue to increase in the future to a level about 40 percent above the 2006 level, while the effect of the recent reduction in air cargo traffic from the levels predicted by the historical relationship will continue unchanged.

- The forecast assumptions use current U.S. Department of Energy (DOE) projections of the future price of oil. In recent years the DOE has significantly under-predicted the increase in the real price of oil. In addition, the assumed future price of carbon offsets for aircraft emissions are reduced below the price levels identified in a recent study by the Massachusetts Institute of Technology by assuming that only a proportion will be passed on the airlines. The assumptions also do not include a factor to increase carbon offset costs to account for the radiative forcing effects of aircraft emissions. As a result, the assumed future range of airline fuel and carbon offset costs may be too low.

Since without further analysis it is unclear how these factors might interact to affect the forecast traffic, it is recommended that the Port and City continue to pursue these issues in parallel with the remaining steps in the master plan process, so that they are better understood when the time comes to revisit the forecasts at the end of the master plan process or closer to the time when important facility development decisions need to be made.

AVIATION FORECAST PEER REVIEW REPORT

Introduction

This report presents the findings and conclusions of a review of the aviation forecast methodology and resulting traffic forecasts prepared by the Port of Portland's aviation consultant team for the Portland International Airport (PDX) *Airport Futures* project, based on analysis undertaken as part of the Forecast Peer Review. The Forecast Peer Review was undertaken for the City of Portland by Dr. Geoffrey Gosling, Principal of Aviation System Consulting, LLC, with the objective of providing the City of Portland, the Port of Portland, and the PDX Airport Futures Planning Advisory Group (PAG) and its Forecast Subcommittee with an independent assessment of the forecast methodology, forecast scenarios, and associated assumptions, including the treatment of uncertainty in the forecast process.

At the start of the forecast development process it was recognized that it would be much more productive to have the Peer Review Consultant interact closely with the Port's Consultant (Jacobs Consultancy) during the preparation of the forecasts rather than commenting after the fact. This would allow any concerns to be raised at an early stage in the process while there is time to address them and provide an opportunity for the Peer Review Consultant to make suggestions as the work is proceeding. As a result, the Peer Review Consultant has been closely involved in the forecast development throughout the process, has been included in the distribution of draft products and working materials, including technical memoranda on the model estimation and drafts of presentations to the Forecast Subcommittee and PAG, and provided the opportunity to comment prior to their presentation. Many of the comments provided to Jacobs Consultancy, particularly suggestions on presentations to the Forecast Subcommittee and PAG, have been incorporated into the final presentations. Overall, this has been a very productive relationship.

Peer Review Findings

A central feature of the process adopted for the current forecast is the decision to develop a probabilistic approach to generating the forecasts, also termed a risk analysis. This represents a significant technical improvement over the typical approach adopted in most airport master plan forecasts, including the previous master plan forecast for PDX. The principal advantages of this approach is that it provides a much better representation of the uncertainties inherent in forecasting future traffic at an airport and provides a basis for assessing the robustness of alternative facility plans considered in the master plan to different future traffic levels. In particular, it allows a more quantified approach to understanding the risks involved if traffic grows faster or slower than expected.

However, an important consequence of the decision to adopt this approach is that the analysis is significantly more complex than is usual for an airport master planning study and involves many difficult technical issues. This was further complicated by the recognition of the need to give detailed attention to assumptions regarding the future price of oil and the impact of policies to address climate change, aspects that have generally been ignored in past forecasts. As in other areas of transportation planning, the Portland region is well ahead of the state of the art elsewhere and is setting new standards of practice for aviation forecasting. This is something that the PDX Aviation Futures project and the Port's aviation consultant team can be justifiably proud of. However, the price to be paid for this capability is that the process is technically challenging, complex, time-consuming and costly. Many of the analytical steps have had to be developed specifically for this study and assumptions made on the basis of limited information.

This report addresses three broad aspects of the forecasting process and is intended to help the City of Portland and PAG understand some of the implications of the technical approach adopted for the forecast, the assumptions used in the analysis, and the range of forecast values generated by the probabilistic modeling. This summary provides an overview of the principal issues identified in the review. More detail is provided in the following sections.

Forecast Models and Probabilistic Forecasting Approach

The forecast models for both enplaned passengers and total air cargo are aggregate models that explain the total traffic at the airport in terms of regional values of the causal variables. This is a fairly standard approach in airport master planning forecasts, but as with any modeling process, the ability of such models to predict future traffic is critically dependent on the choice of variables and structure of the model. A model can fit the historical data quite well and yet produce very inaccurate forecasts, as illustrated by the models developed for the last PDX master plan update. In deciding whether a particular model is likely to produce reasonable forecasts, it is important to consider the variables included in the model, the structure of the model, and estimated values of the model coefficients. Each of these aspects has implications for the ability of the model to generate reasonable forecasts.

In considering whether the current models used in the forecast process are likely to produce reasonable forecasts, the peer review has identified the following issues:

- The use of an aggregate model for forecasting implies that past trends in the composition of the traffic across different markets will continue in the future.
- The use of a constant dummy variable in the enplaned passenger model to account for the drop in passenger traffic since 2001 implies that the proportional reduction in traffic since 2001 will continue in the future. If this effect does not continue, or significantly reduces, the model would under-predict the traffic by as much as 30%.
- The elasticity of demand with respect to both population and income in the air passenger model are lower than would be expected from a general understanding of the determinants of air travel. If the demand elasticity is in fact higher in the future than the model suggests, this would cause the model to tend to under-predict future traffic growth. However, any such effect is likely to be relatively small compared to the overall traffic growth.

The first two issues are intrinsic aspects of the passenger model that should be considered in deciding how to interpret the current forecasts. It would of course be possible to generate different forecasts with some assumed reduction in the post-2001 effect. In order to understand the implications of the third issue for the passenger forecasts, it would be desirable to conduct further analysis on the sensitivity of the forecasts to changes in the implied demand elasticity.

The latest air cargo model is based on an underlying logistic growth relationship in the total weight of air cargo per thousand dollars of regional personal income (expressed in constant dollars) that the model development team has termed the cargo intensity. This relationship is adjusted by a term that reflects changes in the price of oil. In addition the model includes a dummy variable that reduces the predicted cargo tonnage by 28% for the years after 1999. The demand elasticity with respect to oil price is about –0.16, which appears reasonable from a consideration of the proportion of integrated air cargo carrier operating costs accounted for by fuel.

The forecasts of future air cargo traffic are significantly affected by the continued increase in the logistic growth relationship, which implies that the air cargo intensity will reach about 37% above 2006 levels by 2035. In deciding how to interpret the current forecasts, consideration should be given to whether this appears reasonable, as well as whether the reduction in cargo intensity since 1999 is likely to continue in the future and by the same percentage.

The probabilistic forecasts use a Monte Carlo simulation approach that is highly dependent on the assumed distributions of the explanatory variables in the passenger and cargo models. The effect of these variables has been assumed to be independent, although in reality there is likely to be some correlation. Assuming the variables are independent will tend to reduce the spread of the forecasts. It would also be desirable to perform some additional analysis to quantify the likely impact of this effect.

In order to translate the forecasts of passengers and cargo into forecasts of aircraft operations, a process was developed to allocate the forecast traffic to individual markets (or market segments in the case of air cargo) and then estimate the number of aircraft operations needed to serve each market. This process considered the airlines currently serving each market, the aircraft fleet that they currently operate and any anticipated future changes in their fleet, and trends in average load factors. The process implicitly assumed that the basic structure of the airline industry remains unchanged from 2007 and in fact is independent of changes in the determinants of future demand, particularly the price of oil. While accounting for these effects at the market level may be beyond the resources of the current project, the limitations that this imposes on the resulting forecasts of aircraft operations should be understood.

Forecast Assumptions

Forecast values of future air traffic are only as good as the assumptions on which they are based. The review identified a number of key assumptions that should be borne in mind in considering the forecasts and that appear deserving of further analysis to clarify their impact on the forecasts:

- The use of current U.S. Department of Energy (DOE) projections of the future price of oil. In recent years the DOE has significantly under-predicted the increase in the real price of oil.
- The assumed price of carbon offsets for aircraft emissions are based on carbon offset price levels identified in a recent study by the Massachusetts Institute of Technology, but are reduced below those levels by assuming that only a proportion will be passed on the airlines. These assumptions also do not appear to include a factor to account for the full radiative forcing effect of aircraft emisisons.
- The assumed distributions used in the Monte Carlo simulation reduce the average per capita income levels below that forecast by Portland Metro and

limit the range considered for the price of oil to the low and high scenario of the DOE oil price forecasts.

Use of Probabilistic Forecasts

The value of the probabilistic forecasts, apart from being more transparent about how uncertain the forecasts are, lies in the ability to address questions such as "how soon might we need the capability to handle 30 million annual passengers at PDX?" or "what is the likelihood that we will need to build another terminal concourse by 2015?" One useful way to use the graphs that show the varying percentiles of forecast traffic level for any given year is to take a horizontal line at any given traffic level and express the percentiles in terms of the corresponding future year at which the given traffic level will be reached.

Conclusion

The various issues identified in this review suggest that a number of the steps in the forecast process could benefit from further study and development, and that further examination of some of the assumptions appears warranted. At a minimum, this additional information will increase the confidence in the forecasts, even if it is decided that there is no reason to change the current forecasts. On the other hand it may suggest aspects where it would be appropriate to make some revisions to the forecasts. In either case, the sooner that this is known, the better.

While this additional work need not delay starting the remaining steps in the master planning process on the basis of the current forecasts, it would be in the Port's and City's interests to continue to refine the forecasting process in parallel with this other work, so that there is a better understanding of the sensitivity of the current forecasts to the issues identified in the review as the other steps in the master plan evolve. It would also be desirable to continue to develop the forecasting methodology so that future updates of the forecasts can benefit from better models and analytical tools. This will be particularly helpful when the forecasts are revisited closer to the time when important facility development decisions need to be made.

Particular issues that appear deserving of further work include:

- Improving the passenger and cargo forecast models to better account for recent changes in the airline industry and reduce the importance of dummy variables in predicting recent traffic trends.
- Development of a market-based forecast model so that future changes at a market level can be explicitly forecast rather than assumed.
- Development of a more detailed representation of airline costs.
- Obtaining more detailed regional cargo data.
- Further study of likely impacts of climate change policies or public attitudes on the demand for air travel.
- Further study of the most appropriate probability distributions for the Monte Carlo simulation and consideration of correlation between future values of explanatory variable.
- Development of analytical software to simplify the process of performing the forecast analysis with different assumptions.

The remainder of this report provides a more detailed explanation of the different issues discussed above. The next section discusses the forecast models that have been developed for enplaned air passengers and total air cargo. The following two sections review the methodology used to develop the probabilistic forecasts and derive the forecasts of aircraft operations. The subsequent section discusses the input assumptions used to generate the forecasts. The last two sections discuss the use of probabilistic forecasts in airport master planning and suggest areas where further work could improve the usefulness and robustness of the forecasting process.

These sections are followed by two appendices. The first appendix presents a supplementary analysis of the enplaned passenger demand model that was undertaken following the PAG Meeting on April 15, 2008 at which the PAG voted to accept the forecasts. The second appendix presents a short biographical summary of the Peer Review Consultant.

Forecast Models

The forecast models for both enplaned passengers and total air cargo are aggregate models that explain the total traffic at the airport in terms of regional values of the causal variables. They are also both multiplicative models (linear in logarithms), which has the consequence that the model coefficient for each variable can be interpreted as the direct elasticity of demand with respect to that variable.

Of course, in reality the total traffic is composed of the traffic in many different markets (e.g. different flight destinations) each with different prices and service levels. A given percent change in price is likely to affect traffic in each market differently. Similarly, a given change in the average price across all the markets could be the result of very different changes in each market. An aggregate model thus attempts to measure the combined effect of all these changes in terms of the change in the average values of the causal variables. In the case of variables defined at a regional or national level, such as population or the price of oil, a given change applies to all the markets equally, although that change may affect each market differently. For example, an increase in the price of oil may affect some markets more than others.

It follows from this that the use of an aggregate model for forecasting implies that past trends in the composition of the traffic across different markets will continue in the future. This needs to be borne in mind in interpreting the forecasts produced using such models.

Passenger Model

The passenger model explains total enplaned passengers at PDX in terms of three continuous variables (regional population, regional average per capita personal income, and average airline yield) and three dummy variables. The airline yield variable (defined as the average airfare revenue per passenger-mile) uses the average PDX yield for years from 1990 and the average U.S. domestic yield for years before 1990. One of the dummy variables is used to adjust for the use of a different yield variable prior to 1990. The other two dummy variables attempt to account for the drop in traffic from 2001. One dummy variable is used for 2001 and the second is used for 2002 on.

Figure 1 shows the fit of the model to the historical data. It can be seen that the model fits the actual data fairly well until 2000, although it under-predicts the traffic in 1996 and then predicts a higher growth rate from 1996 to 2000 than actually occurred, resulting in an over-prediction in 2000. Without the effect of the two dummy variables for the years from 2001, the model would have significantly over-predicted the traffic. The dummy variable for 2001 forces the model to predict the actual traffic in that year. The model then slightly over-predicts the traffic in the next three years, but under-predicts the recovery since 2004. This is to be expected since the effect of the dummy variable from 2002 provides the same percentage reduction for each year. To the extent that the drop in traffic following 9/11 and the SARS scare were most pronounced in 2002 and 2003, a constant adjustment would tend to under-predict the reduction in those years and over-predict the reduction as the recovery proceeds. This has two important implications for the use of the model for forecasting future traffic. The first is that applying a constant proportional adjustment for the years after 2002 is likely to under-predict any continuing recovery of traffic levels from the reductions in 2001 and 2002. The second is that without the adjustments from the dummy variable for years after 2001, the model would greatly over-predict the traffic levels. It is hard to believe that five years after 9/11 the lingering effects have reduced the traffic by almost a third. What is much more likely is that a model based on the relationships between traffic and the causal variables during the era of rapid traffic growth from 1990 to 2000 is not providing a good representation of these relationships in the current environment. The implications of this are discussed further below.

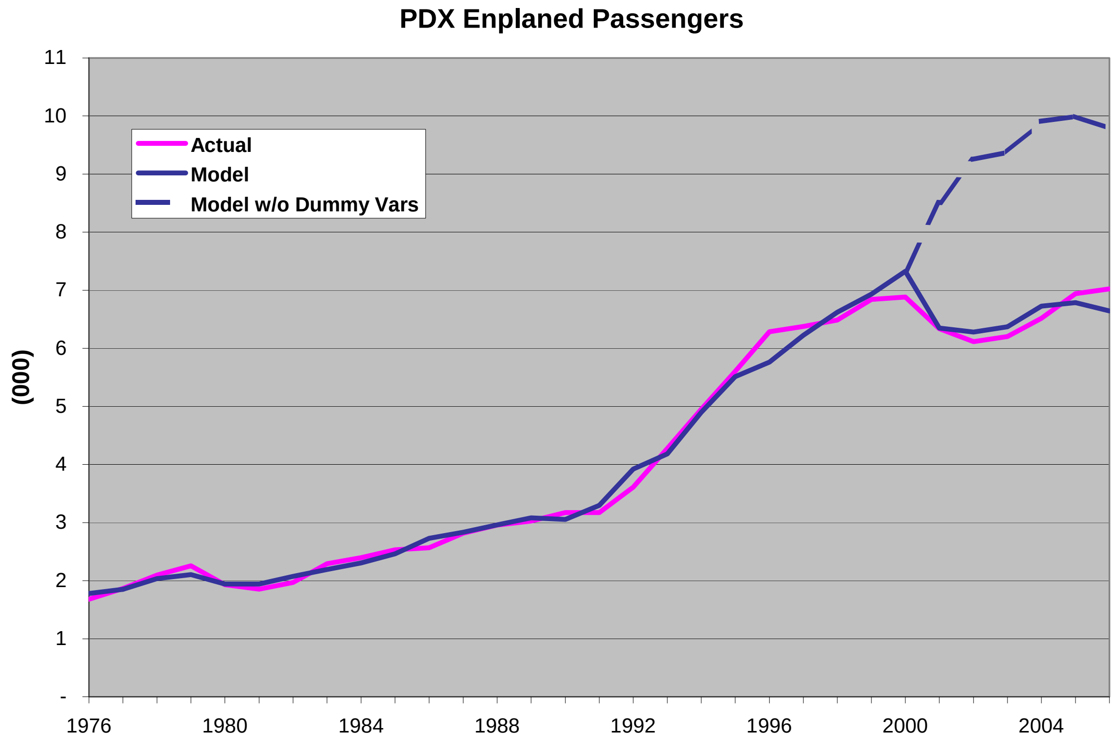


Figure 1 Enplaned Passenger Model

In considering the fit of the passenger model to the historical data, it should be borne in mind that the total enplaned passengers at PDX consist of four different market segments:

1. Originating passengers from the Portland metropolitan area
2. Originating passengers from outside the Portland metropolitan area who travel to PDX by ground transportation
3. Visitors to the Portland region (using ground transportation to access PDX from within and outside the metropolitan area)
4. Passengers connecting between flights at PDX.

Use of Portland metro area population and income and PDX average yield in the model implicitly assumes that the traffic in market segments (2) through (4) maintains a consistent relationship to the traffic in segment (1). Market segment (2) is likely to be fairly small but the proportion of connecting passengers at PDX was around 15 percent in 2005. Both segments can be expected to decline as a percent of PDX traffic as air service improves at other airports in Oregon. Changes in these shares over time are likely to bias the model coefficients, although the magnitude and effect of any such bias is unclear without further analysis.

The passenger demand elasticity with respect to population is about 0.9, which implies that a 10 percent increase in regional population will lead to about a 9 percent increase in air traffic, other things being equal. *A priori* one would expect the demand elasticity for population to be around 1.0 or perhaps slightly higher. If the composition of the population is unchanged, then 10 percent more people would make 10 percent more trips. However, increasing population could imply changes in the composition of the population as well. People moving to the Portland area may be more likely to have family elsewhere and hence the need to make more air trips or to be working in those sectors of the economy that generate more business travel. This would tend to give a population elasticity higher than 1.0, but probably no higher than 1.05.

The per capita income elasticity is a little over 1.0 (1.04). This implies that air travel propensity will increase marginally faster than income. In fact, air passenger surveys show that air travel propensity increases very strongly with income. Households making $200,000 per year make significantly more air trips than those making $30,000 per year. Thus *a priori* one would expect air travel demand elasticity with respect to income to be higher than 1.04, although by how much would depend on any changes in the income distribution as well as the average.

If both population and income elasticity turn out to be higher in the future than predicted by the model, then the model will tend to under-predict the future growth in air travel for any given assumptions about the cost of air travel.

The elasticity with respect to PDX yield is –1.15 or slightly elastic (an increase in average air fares of 10 percent would reduce traffic by 11.5 percent). This is broadly consistent with airfare elasticity found in other studies, particularly for longer haul domestic trips.

A critical issue in the application of the model is the use of the dummy variable for years after 2001. This term reduces traffic by 32 percent below the level predicted by the model without including the variable. While it may be true that there are lingering effects of 9/11 that have continued to reduce the demand for air travel in recent years, the relevant question for the use of the model to forecast future traffic is how long these effects will last and whether the model provides a reasonable representation of the future causal relationships without the use of the dummy variable.

The recent trends in traffic suggest that keeping the dummy variable in the model for future years will tend to under-predict the level of air traffic for any given set of input assumptions. However, excluding the dummy variable completely is likely to greatly over-predict traffic levels, particularly in the near term, and anyway changing one term in a model will impact the values of the other coefficients.

- ❖ **Further work appears to be warranted to better understand the impact of the use of the dummy variables in the model on the forecasts, as well as the sensitivity of the forecasts to changes in demand elasticity with respect to population and income.**

Cargo Model

The air cargo model was revised immediately prior to the PAG Meeting of April 15, 2008, to respond to peer review comments on the previous model and thus has not been subject to the same level of review as the passenger model.

The revised cargo model is based on an underlying logistic growth relationship in the total weight of air cargo per thousand dollars of regional personal income (expressed in constant dollars) that the model development team has termed the cargo intensity. This relationship is adjusted by a term that reflects changes in the price of oil. In addition the model includes a dummy variable that reduces the predicted cargo tonnage by 28% for the years after 1999. The demand elasticity with respect to oil price is about –0.16, which appears reasonable from a consideration of the proportion of integrated air cargo carrier operating costs accounted for by fuel.

Figure 2 shows the fit of the model to the historical data.

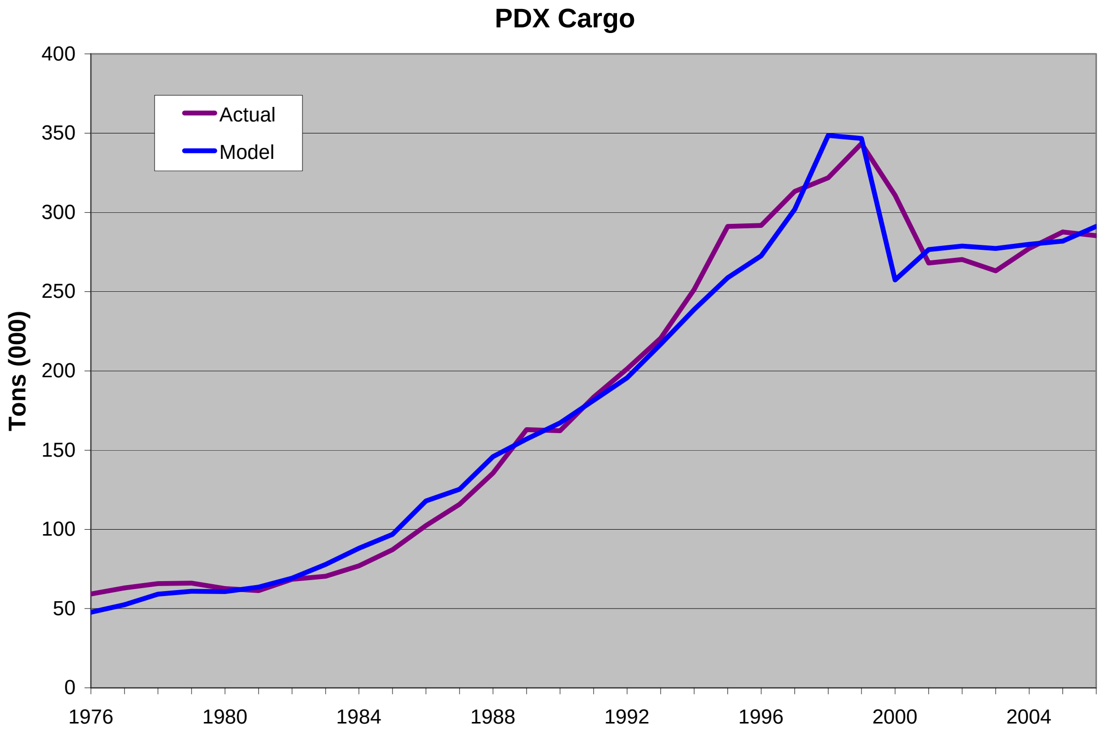


Figure 2 Total Air Cargo Model

It can be seen that the model fits the data fairly well until about 1993, but then does a relatively poorer job of explaining the year-to-year changes thereafter. The model captures the drop in traffic after 1999, but does so through a dummy variable. In fact the use of a single dummy variable for the period after 1999 overstates the drop from 1999 to 2000 and then predicts an increase from 2000 to 2001, instead of the decrease that actually occurred. Rather than predict air cargo tonnage directly, the model predicts air cargo intensity and then this is multiplied by the total regional personal income to predict the actual air cargo traffic. Not surprisingly, the corresponding fit of the cargo intensity model to the actual cargo intensity data looks very similar to the total air cargo results, as shown in Figure 3.

Figure 4 shows the underlying logistic growth relationship for the period of the model estimation and its projection to 2035. Since this relationship is defined solely in terms of the number of years since 1975, its future growth is unaffected by any causal variables, although for any given year, this relationship will be adjusted by the change in oil price.

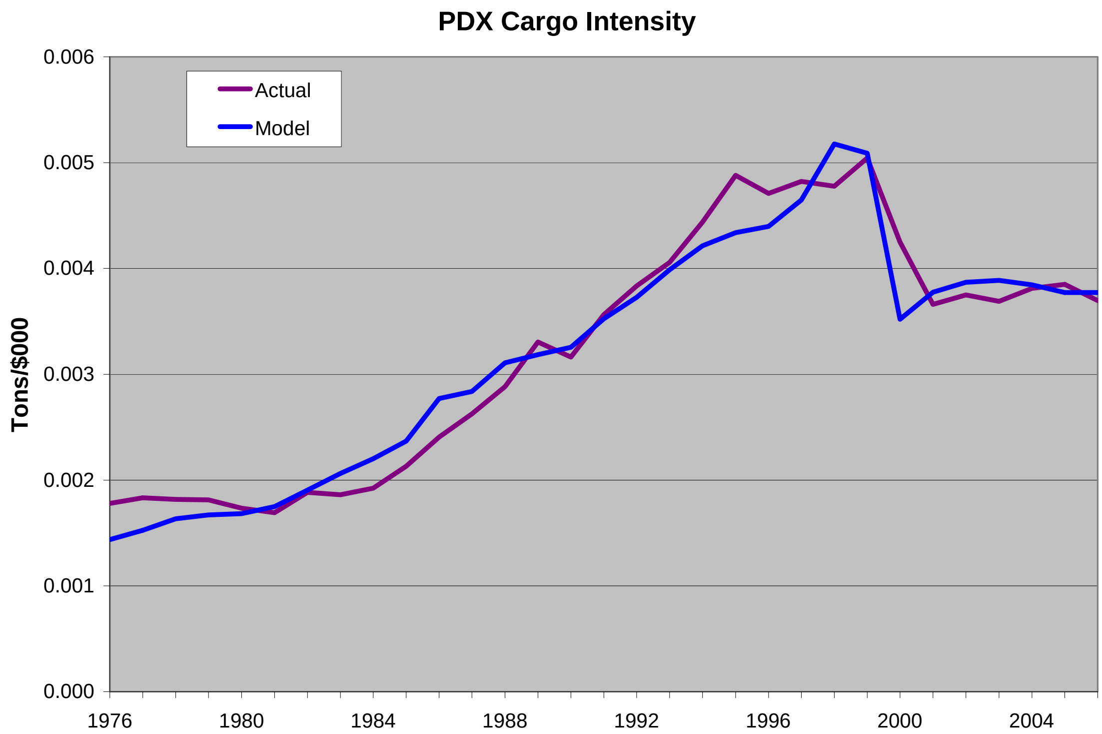


Figure 3 Air Cargo Intensity Model

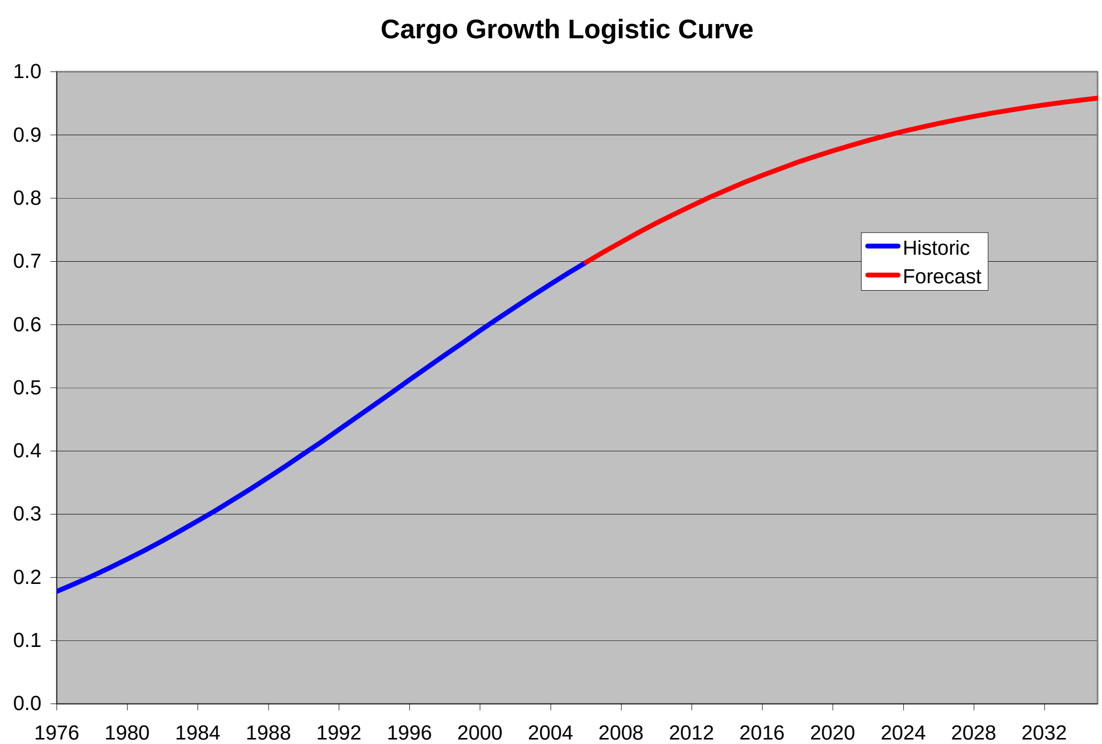


Figure 4 Logistic Growth Relationship

The forecasts of future air cargo traffic are significantly affected by the continued increase in the logistic growth relationship, which implies that the air cargo intensity will reach about 37% above 2006 levels by 2035.

- **Further work appears to be warranted to better understand the factors that caused the strong growth in cargo intensity until the late 1990s and the subsequent decline. This would allow a better informed assessment of the extent to which these relationships are likely to continue in the future.**

Development of Probabilistic Forecasts

A key feature of the forecasting approach adopted for the PDX Airport Futures project is the use of a probabilistic forecasting approach, also termed a risk analysis. This recognizes and attempts to address the inherent uncertainty in any attempt to predict the future. This uncertainty arises from at least three factors:

1. The models used in the forecasting do not completely explain the historical data on which they have been estimated, and as a consequence there is uncertainty in the values of their coefficients and residual errors in their predictions
2. Forecasts of future values of the explanatory variables are inherently uncertain, as illustrated by the difficulty of predicting future oil prices
3. Unanticipated events may occur that change the demand for air transportation (such as another terrorist attack) or structural changes may occur in the airline industry or the economy at large that change the relationships between the causal variables and air travel or air cargo traffic from those observed during the period on which the models have been estimated.

The way in which these factors are accounted for in the probabilistic forecasts is to define a probability distribution for each of the input variables in the models, and then calculate a large number of different values for each forecast traffic level, sampling randomly from these input variable distributions. The resulting values can then be used to define a probability distribution for the forecast traffic level. This process is termed a Monte Carlo simulation. In addition to varying the values of each input variable, the Monte Carlo simulation also varied the parameter values of the model and applied an error term to the model prediction, reflecting the uncertainty in the estimated model parameters and the residual errors in the model predictions of the historical data.

Obviously, this process is highly dependent on the assumptions made about the distributions of the future values of the input variables. These distributions cannot be directly observed from past data, but rather are measures of the confidence with which we can predict the future values of the input variable. The assumptions made in developing the distributions for use in the Monte Carlo simulation are discussed further below in the section on forecast assumptions.

An important consideration is performing a Monte Carlo simulation is whether the distribution of each input variable is assumed to be independent or whether the future values of some of these variables are likely to be correlated. For example, a higher oil price may be more likely to be associated with a low growth rate in per capita income than a high growth rate. In the current analysis it was assumed that each variable is independent. With the current models this will tend to produce a smaller spread of values than if the variables were assumed to have some correlation.

Of the explanatory variables included in the forecast models, the one that has the highest level of uncertainty about future values is the average value of airline yield (in the case of the passenger model) or the price of oil in the case of the cargo model. Since the price of oil has a direct effect on the passenger yields needed for the airlines to remain economically viable, the analysis developed a sub-model to predict the effect of changing oil price on airline yield. This considered not only the effect of future oil prices on airline fuel costs, but also likely changes in non-fuel costs and airline load factors, since these also affect the yields needed for the airlines to cover their operating costs.

One factor that will affect future airline fuel costs that was not explicitly included in the analysis is the continuing trend in improved aircraft fuel efficiency. The analysis implicitly assumed that this is subsumed in the past relationship between oil prices and airline fuel costs. However, any such relationship is likely to be very weak, given past trends in aircraft fuel efficiency and oil prices.

- ❖ **Further work appears to be warranted to clarify how a more explicit accounting for trends in aircraft fuel efficiency might change future projections of airline yield.**

Derivation of Forecasts of Aircraft Operations

The forecast models predict total enplaned passengers and total air cargo tonnage. In order to translate these forecasts into forecasts of aircraft operations, a process was developed to allocate the forecast traffic to individual markets and then estimate the number of aircraft operations needed to serve each market. This process considered the airlines currently serving each market, the aircraft fleet that they currently operate and any anticipated future changes in their fleet, and trends in average load factors.

This process was based on a number of key assumptions that should be borne in mind in interpreting the aircraft operations forecasts:

- The volume of international passenger travel was forecast externally from the forecast model by making assumptions about future growth rates in international travel under a median, low and high growth scenario. The future level of domestic travel was then obtained by simply subtracting the international travel from the total travel predicted by the forecast model.
- The share of passenger travel in each market served by non-stop flights from PDX was assumed to remain the same as in 2007.
- The share of the passenger traffic in each market carried by each airline was assumed to be the same as in 2007.
- The future percent change in load factors in each forecast year was assumed to be the same for every airline and market, although the growth in load factor compared to 2007 was assumed to increase slowly over time.

These assumptions implicitly assume that the basic structure of the airline industry remains unchanged from 2007 and in fact is independent of changes in the determinants of the future demand for air travel, particularly the price of oil. While it is true that airlines cannot change their fleets significantly in the short run, they can certainly do so over the time frame of the forecast. It can be expected that continuing high oil prices will force airlines to use larger, more fuel-efficient equipment and may lead to shifts in airline market share in favor of those airlines with more fuel-efficient aircraft. Pressures to increase average aircraft size may also result from airport capacity concerns under scenarios of high traffic growth, as illustrated by the current discussion about the introduction of congestion pricing at capacity-constrained airports.

While accounting for these effects at the market level may be beyond the resources of the current project, the limitations that this imposes on the resulting forecasts of aircraft operations should be understood.

Forecast Assumptions

Forecast values of future air traffic are only as good as the assumptions on which they are based. In the case of the current forecasting process, there are two separate issues that should be considered: the assumed expected value for each input variable for a given forecast year and the assumed distribution of likely values around the expected value. In fact, the expected (or average) value is implied by the distribution. However, it is easier to think about the assumptions by separating the two issues.

Expected Values of Explanatory Variables

There are really only three explanatory variables that drive the PDX air traffic forecasts: population, per capita income, and the price of oil. Although the passenger model is based on the average PDX yield, the projected values of this variable were derived from the projected price of oil.

The expected future values of population and per capita income were obtained from regional forecasts prepared by Portland Metro. These forecasts appear to be widely accepted and there is obviously a good argument to be made that planning for PDX should be based on consistent assumptions with the regional planning for the rest of the transportation system. On the other hand, the Port may wish to understand the implications for its own financial and facilities planning of different assumptions about future growth in population and income. While these assumptions are varied in the probabilistic forecasts, it is not currently possible to separate out the effects of varying one particular assumption. This would require a sensitivity analysis with different input assumptions.

The expected future values for oil price were based on the most recent U.S. Department of Energy projections, although an extensive comparative analysis was undertaken of oil price forecasts by other organizations. In recent years, the U.S. Department of Energy has significantly under-predicted the increase in the real price of oil. Whether this tendency to under-predict the future price of oil will apply to the most recent forecast only time will tell. However, this places a particular importance on the assumed distribution of likely future values, as discussed further below. A sensitivity test of oil price assumptions indicated that a 21% increase in the price of oil resulted in about a 4% decrease in passenger traffic, which seems reasonable given the proportion of airline costs accounted for by fuel and the elasticity of demand with respect to yield. This suggests that a doubling of oil price over the DOE forecasts could reduce traffic by perhaps 20%. However, the more serious concern from the perspective of the forecasts is that if the lower-bound scenario is too low ($44 per barrel in 2035 in 2006 dollars), this will tend to overstate future growth in traffic.

Other assumptions that influence the forecast include future values of average load factor and aircraft size. These were generally based on the most recent national aerospace forecast prepared by the Federal Aviation Administration (FAA). These values are not likely to deviate significantly at a national level from the FAA projections, since there are physical limits on how many seats can be sold or how quickly the airlines can increase the average size of their fleets. Although the corresponding values at PDX may differ somewhat from national averages, due to differences in traffic composition, airline shares and aircraft fleets, the growth trend is likely to be similar, since the airlines and flights serving PDX are part of the larger system. In any event, differences in these factors are likely to have much less impact on the forecasts than changes in the price of oil.

Impact of Climate Change Policies

One issue that has been of particular interest to the Planning Advisory Group Forecast Subcommittee is the effect of future climate change policies on the cost of air travel or the propensity to make air trips. These effects have been incorporated in the forecasts through adjustments to the assumed price of oil. These adjustments have been expressed as a carbon tax that would be payable by oil companies (and presumably passed on to their customers) or directly by oil users. Future costs of carbon emissions could also be the result of a cap-and-trade program or other regulatory environment that requires airlines to purchase carbon offsets. While the need to purchase carbon offsets will not affect the price of oil directly, to the extent that the required offsets will be based on fuel consumption, the effect will be the same as if the price of oil increased.

In addition to assuming a price per barrel for a carbon tax, the analysis also assumed that only a proportion of this tax would be passed on the airlines. This obviously would not apply to a carbon offset program, unless the government were to provide exemptions to airlines on some basis. It is also unclear why oil companies would choose to pay some proportion of a carbon tax out of their profits (or indeed could even afford to). It is possible that the introduction of a carbon tax would reduce the demand for oil, resulting in oil producers lowering their prices to offset the lost revenue through greater production. However, this involves a complex market dynamic that is beyond the scope of the current forecast analysis to perform. It is also unclear to what effect these factors have already been accounted for in the DOE scenarios. Of course, as far as the traffic forecast is concerned, there is no difference between a higher carbon tax, only some of which is passed on to the airlines, and a lower tax that results in the same cost per barrel. On balance, it would be clearer to assume that the entire carbon tax is passed on the airlines and simply vary the assumed tax.

The assumed price of carbon emissions ranged from $35 to $109 per metric ton in 2035 in 2006 dollars, based on a recent study by the Massachusetts Institute of Technology. However, there are those who feel that much higher levels will be required to achieve the targets proposed in recent state and federal legislation, particularly by 2035 when many of the cheaper alternative strategies to reduce carbon emissions will have been exhausted. In addition, the assumed carbon prices do not appear to account for the radiative forcing effect of aircraft emissions, which has been estimated by the Intergovernmental Panel on Climate Change[1] to require the direct aircraft emissions (expressed as carbon equivalent) to be increased by a factor of about 2.7 or more to fully offset the impact on climate change.[2] In addition, there is no adjustment in the models to reflect possible effects of growing public concern about climate change on the propensity to make air trips. **Thus it appears that the assumptions used in the forecast analysis may significantly understate the likely future costs of climate change policies or public attitudes.**

- ❖ **Further work appears to be warranted to clarify the sensitivity of the forecasts to more stringent assumptions about potential responses to climate change.**

Assumed Distributions

The assumed distribution for future values of the regional population was obtained directly from the population forecast approach used by Metro. However, in the case of the per capita income Metro had not developed a predicted distribution and it was necessary to develop an assumed distribution from the per capita income forecast scenarios prepared by Metro. This distribution was based on analysis of past performance of the Metro income forecasts by the Jacobs Consultancy team. Since this found that Metro had tended to over-predict the growth in real income in the past, this was incorporated in the assumed distribution. A consequence of this approach is that the PDX traffic forecasts are based on a somewhat lower average per capita income assumption than the baseline forecast by Metro.

The assumed distribution of future values of the price of oil was based on the high and low scenarios forecast by the U.S. Department of Energy (DOE). No adjustments were made to account for the past performance of the DOE in forecasting oil prices. Therefore if the DOE high growth scenario has substantially under-estimated the potential for continued future growth in oil prices, this possibility will not be considered in the PDX traffic forecasts. Thus while the assumed distribution for the price of oil covers a wide range (from $44 per barrel to $128 per barrel in 2035 in 2006 dollars), this range may understate the possibility of even higher prices.[3]

An important assumption in developing distributions of likely future values of explanatory variables is the shape of the distribution. Apart from the distribution for population, which was obtained from Metro, the other distributions were assumed to be triangular. In most cases, the upper and lower limits of the distribution were derived from high and low scenarios of the relevant variable. This constrains the values to lie between the high and low scenario. It is likely that in developing high and low growth scenarios, other organizations are not assuming that these are the highest and lowest values that could possibly occur, but rather represent a range within which future values have a reasonable likelihood of occurring (although what this likelihood is may not be explicitly defined). **This will tend to under-predict the range of forecast values, although it is unclear by how much.**

[1] Intergovernmental Panel on Climate Change, *Aviation and the Global Atmosphere*, Special Report, 1999. Available at http://www.ipcc.ch/ipccreports/sres/aviation/index.htm.

[2] More recent estimates by Robert Sausen and others ("Aviation radiative forcing in 2000: An update on IPCC (1999)," *Meteorologische Zeitschrift*, Vol. 14, No. 4, pp. 555-561, August 2005) have suggested that the factor of 2.7 may be too high, but it is generally accepted that there is a high degree of uncertainty in these estimates and there is ongoing research under way to improve the understanding of the issues involved.

[3] It should be noted that at the time of writing this report (June 2008), oil prices had exceeded $130 per barrel in current dollars.

- **Further work appears to be warranted to clarify the sensitivity of the forecasts to changes in the assumed distributions for the explanatory variables.**

Use of Probabilistic Forecasts in Master Planning

The development of probabilistic forecasts that express the likelihood of future traffic levels exceeding any given value raises the question of how such forecasts can be used in the remaining steps of the master planning process. There are two important points that should be noted in discussing the probabilistic forecasts:

1. The forecasts express the likelihood of obtaining a future traffic level that lies between any two values, or conversely the likelihood of the future traffic being greater than (or less than) a given value. It is misleading to talk about the "most likely" value for the future traffic level in any given year. The median value (50 percentile) represents the value that the future traffic is equally likely to be greater than or less than. While the likelihood of the future traffic lying in a given range around this value (say plus or minus 1 million annual passengers) may well be higher than the corresponding likelihood of the traffic lying within the same range around any other value, this likelihood is still very small unless the range in question is fairly wide.

2. Although the graphs of forecast traffic levels show curves for different percentile forecasts, this does not imply that the future traffic growth will follow any one of these curves. These merely join points with the same percentile likelihood in successive years. It is entirely possible for the future traffic to evolve such that it corresponds to one particular percentile value in one year and as quite different percentile value some years later. Obviously in the real world there are constraints on how rapidly traffic can grow, so a change from the 10-percentile value to the 90-percentile value in just a few years is highly unlikely.

The real value of the probabilistic forecast, apart from being more transparent about how uncertain the forecasts are, lies in the ability to address questions such as "how soon might we need the capability to handle 30 million annual passengers at PDX?" or "what is the likelihood that we will need to build another terminal concourse by 2015?" While some alternative facility development options may be fairly easy to advance or defer if traffic grows more quickly or more slowly than assumed, others may be much harder to implement sooner than expected due to the need for other actions to be completed that take time (e.g. land acquisition or relocating other facilities).

One useful way to interpret the graphs that show the varying percentiles of forecast traffic level for any given year is to take a horizontal line at any given traffic level and express the percentiles in terms of the corresponding likely future year at which the given traffic level will be reached.

Considerations for Further Work

The various issues identified in this review suggest that a number of the steps in the forecast process could benefit from further study and development, and that further examination of some of the assumptions appears warranted.

While this additional work need not delay starting the remaining steps in the master planning process on the basis of the current forecasts, it would be in the Port's and City's interests to continue to pursue these issues in parallel with this other work, so that there is a better understanding of the sensitivity of the current forecasts to the issues identified in the review as the other steps in the master plan evolve. It would also be desirable to continue to develop the forecasting methodology so that future updates of the forecasts can benefit from better models and analytical tools. This will be particularly helpful when the forecasts are revisited closer to the time when important facility development decisions need to be made. However, deferring further work to that time will not only leave these issues unresolved for several years, but runs the risk of not leaving enough time to complete the necessary analysis before a decision is needed. Where additional data is required, as in the case of air cargo, it is important to begin collecting this as soon as possible.

The more significant aspects that could benefit from further work include:

- Improving the passenger and cargo forecast models to better account for recent changes in the airline industry and reduce the importance of dummy variables in predicting recent traffic trends. These improvements should include the development of a market-based analytical approach so that future changes at a market level can be explicitly forecast and do not need to be assumed.
- Incorporation of a more detailed representation of airline costs that can better account for the effects of fuel prices, aircraft fuel efficiency, and changes in other non-fuel costs.
- Obtaining more detailed regional cargo data to identify changes in the relative role of trucks and air, and trends in air cargo use by different sectors of the economy.
- Further study of the likely impact of climate change policies on oil prices or airline costs, as well as possible effects of growing public concern about climate change on the propensity to make air trips.
- Further study of the most appropriate probability distributions for the forecast values of explanatory variables in the Monte Carlo simulation and consideration of likely correlation between future values of explanatory variable.
- Development of analytical software to simplify the process of re-running the models and forecast analysis with different assumptions. The current analysis process is very labor intensive and relies heavily on the use of spreadsheet programs, which are not readily usable by others.

While this work would require a significant commitment of resources, this would still be fairly minor compared to the future capital investment in airport facilities, and indeed compared to the engineering and design work for those facilities. It would also greatly enhance the Port's ability to track the changes in airport traffic compared to the forecasts and understand whether the level or pattern of demand is changing in unforeseen ways that should precipitate a review of the implications for its established master plan.

APPENDIX A

Supplementary Analysis

Enplaned Passenger Demand Model

One of the features of the enplaned passenger demand model noted earlier in this report and discussed at the Planning Advisory Group (PAG) meeting on April 15, 2008 is the use of a constant dummy variable to reflect the reduction in air travel since 2001. This dummy variable has the effect of reducing the forecast level of enplaned passengers by a constant proportion relative to the traffic level predicted by the model on the basis of the relationship between enplaned passengers and the other explanatory variables prior to 2001. The supplementary analysis presented in this appendix was performed subsequent to the April 15 PAG meeting, at which the PAG voted to accept the forecasts, with the objective of shedding some additional light on the issue and its potential implications for the forecasts generated using the model.

Post-2001 Reduction in Air Travel

The key issue raised in the Peer Review Status Report of April 15, 2008 and discussed at the PAG meeting is whether the reduction in air travel since 2001 relative to the traffic level predicted by the enplaned passenger model is likely to remain constant in the future or whether traffic levels may return to the levels predicted by the model without the post-2001 effect. Operationally, this involves assumptions about the use of the post-2001 dummy variable in the forecasts. There is some evidence in the recent data that the post-2001 reduction may be becoming less over time.

Figure A-1 shows the actual enplaned passenger traffic and that predicted by the model using a constant dummy variable, expressed as a proportion of the traffic predicted by the model without the use of the post-2001 dummy variable. The constant percentage reduction implied by the estimated coefficient of the dummy variable is shown by the dark blue line. It can be seen that the actual traffic (the pink line) was about 66% of the predicted traffic without considering the effect of the dummy variable from 2001 to2004, and then increased slowly thereafter to 2006, reaching about 72% in 2006. Obviously, this is a fairly modest change, and there is no guarantee that it will continue in the future or by how much. However, if the trend from 2004 to 2006 were to continue at the same rate, the effect of the post-2001 reduction implied by the dummy variable would disappear by 2015.

In the PAG meeting, representatives of Jacobs Consultancy stated that they had tried estimating a model with a reducing post-2001 factor, but this had not fit the data as well as a constant factor. From the model documentation that was provided as part of the peer review, it appears that they estimated a model using a dummy variable defined as the inverse of the number of years since 2001 (1 / (y-2001) where y is the year in question). This function declines in value very rapidly for the first few years and then progressively more slowly for subsequent years, as indicated by the dark green line in Figure A-1. It is clear from Figure A-1 why a constant dummy variable would fit the data better than a dummy variable defined as an inverse function of the years since 2001, particularly since there was effectively the same reduction in the actual traffic for the first three years.

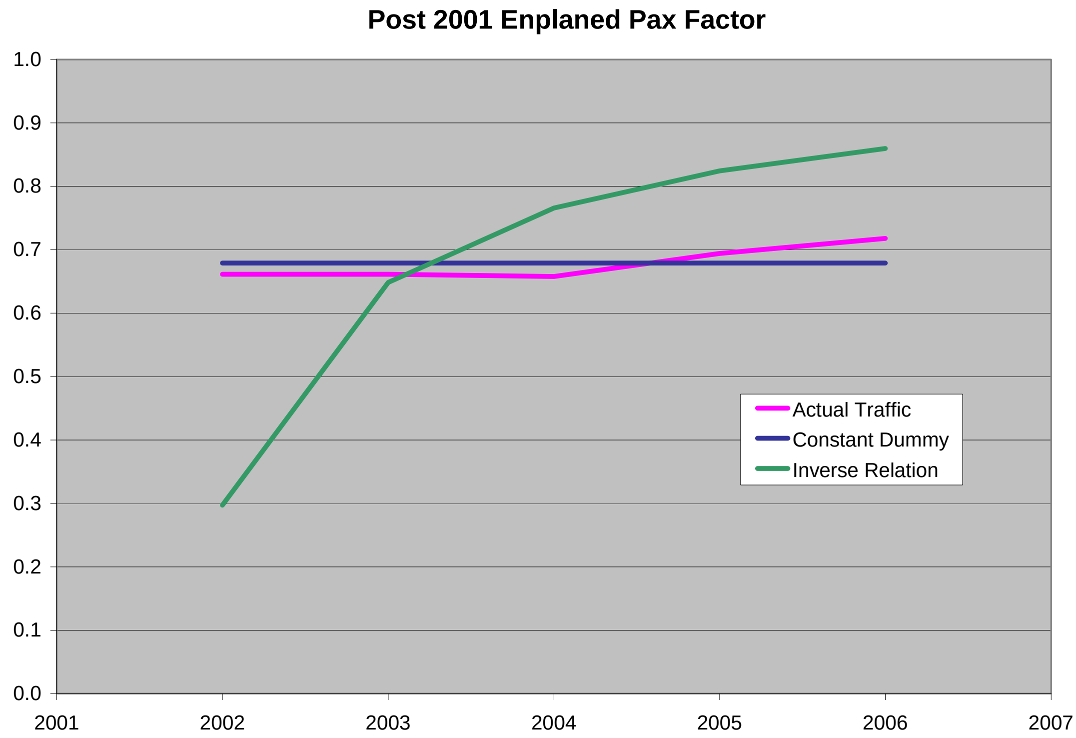


Figure A-1 Change in Post-2001 Enplaned Passenger Reduction Factor

It is clear from the relationships shown in Figure A-1 that a continuing reduction in the post-2001 effect is at least as valid a hypothesis for forecasting future traffic as that it remains constant. The efforts to develop a model with a reducing post-2001 effect used a function with such a rapidly declining effect that bore no relationship to the actual data, that the fact that this produced a poorer fit to the data is hardly surprising. However, equally, this is no reason to reject the approach of a declining function. There are obviously a number of other functions that would not only fit the data quite well, but better than a constant function. All of these functions would give significantly greater forecasts of future traffic.

Stability of the Enplaned Passenger Model Over Time

At the PAG meeting the question was raised whether the decline in passenger traffic after 2001 was really a reduction or whether the higher traffic levels after 1990 were unduly inflated by the dot-com bubble (or possibly some other effects). In order to test this hypothesis, the enplaned passenger model was re-estimated for the pre-1990 and post-1990 periods. The results are shown in Table A-1.

Table A-1 Stability of Enplaned Passenger Model Coefficients Over Time

Parameter	Full Model	1976-1989	1990-2000	1990-2006
Intercept	1.393	0.302	6.573	-3.495
Population	0.888	0.771	0.211	1.830
Per-capita income	1.042	1.089	1.223	0.236
US domestic yield	-0.548	-0.566		
PDX yield	-1.147		-1.436	-0.866
Dummy pre-1990	-1.828			
Dummy 2001	-0.293			-0.289
Dummy 2002 on	-0.387			-0.427

Key:
- (pink) t-statistic < 0.5
- (orange) t-statistic 0.5 to 1.5
- (yellow) t-statistic 1.5 to 2.0

Naturally the fit of the models for the separate periods is poorer than for the full period, since there are fewer years of data from which to estimate the coefficient values. However, the changes in the coefficient values for the different periods are noteworthy and have important implications for the use of the model for forecasting.

The changes in the model coefficients from the full model to the model for the period 1976 to 1989 are not particularly large (apart from the intercept, which will necessarily be very different to account for the exclusion of several of the variables in the model for 1976 to 1989). This suggests that the values of the coefficients for population and real per-capita disposable income are largely determined by the relationships prior to 1990.

The model for the period from 1990 to 2000 has a higher elasticity for airline yield than the full model, a higher elasticity of per-capita income (PCI), and a much lower elasticity of population. (In a log-linear model of the form adopted, the coefficients can be interpreted as the demand elasticity with respect to that variable.) However the coefficient for PCI has a fairly low statistical significance and the coefficient for population is not statistically significant at all.

Adding the years from 2001 to 2006 and introducing dummy variables for 2001 and 2002 on, as in the full model, changes the coefficients again, quite dramatically. The PDX yield elasticity drops to about –0.9, the population elasticity increases to about 1.8 and is reasonably statistically significant, while the PCI elasticity drops to about 0.2 and becomes statistically insignificant. As might be expected, the two dummy variable coefficients are highly statistically significant.

It is noteworthy that the PDX yield coefficient is statistically significant (although of very different values from the full model) in both the 1990 to 2000 model and the 1990 to 2006 models.

The changes in the coefficients of population and PCI between the period 1990 to 2000 and the period 1990 to 2006 (which includes the period from 1990 to 2000), combined with their general lack of statistical significance during this period suggests that their values in the full model are largely driven by the relationships prior to 1990, as noted above, and that the model does a much poorer job of reflecting their effect on traffic since 1990. The changes in the coefficient values when the six years from 2001 to 2006 are added to the prior 11-year period suggests that the dummy variables for 2001 on are capturing effects that should have been explained by changes in population and PCI (as well as potentially other variables not included in the model).

Conclusion

It is clear from the above analysis that the coefficients of the enplaned passenger model are largely determined by relationships between passenger traffic and the causal variables that pre-date 1990 and that the model does a fairly poor job of explaining the relationships since then. In particular, there is reason to think that the PDX yield elasticity since 1990 could be higher than estimated for the full model. This would be reasonable in the light of the fact that the increasing role of low-fare airlines since 1990 would have stimulated a lot of discretionary travel, which is likely to be very price-elastic.

There is also reason to think that the way the dummy variables for the period from 2001 are defined has not only underestimated the traffic recovery since 2004 but may have significantly distorted the coefficients for population and PCI for recent years. While it may be reasonable that the relationship between population and air travel has remained relatively stable over the full 31-year period since 1976, and thus basing the model on the relationship prior to 1990 may not significantly distort the forecasts, it is less obvious that the relationship between PCI and air travel would be stable over such a long period. The increasing role of low-fare airlines has opened up air travel opportunities to a broader segment of the population that may have a very different income elasticity from the typical air travelers before 1990. There may also have been shifts in the income structure of the population over the full 31-year period that would also impact the overall income elasticity.

It therefore appears likely that the enplaned passenger model used for the forecasts is not providing a very convincing explanation of the relationships between population, income and airline yield in recent years. While the model appears to fit the traffic data reasonably well since 1990, this is largely a consequence of the use of two dummy variables that effectively force the model to fit the data fairly well since 2000. The price that is paid for this fit is that the coefficients for the continuous variables are unable to properly reflect the recent relationship between those variables and the passenger traffic.

However, it is the coefficients of the continuous variables (and their implied elasticity of demand) that are driving the forecasts of future passenger traffic, and in particular the probabilistic analysis that is used to examine the likely future range of traffic under different assumptions for such factors as the price of oil and strategies to address climate change. What matters for the forecasts is not whether the model does a good job of explaining what happened from 1976 to1990, but whether it does a good job of explaining what is happening now, and more importantly what is likely to happen in the future.

APPENDIX B

Peer Reviewer Resume

Geoffrey D. Gosling, Ph.D.

Principal
Aviation System Consulting, LLC
Berkeley, California

Geoffrey Gosling is an independent consultant providing system planning, analysis and research expertise on a range of air transportation topics. He has a Ph.D. in transportation engineering from the University of California at Berkeley and has served as a consultant and expert witness in the areas of airport planning, aviation system planning, and airline economics to a variety of clients, including the Federal Aviation Administration, the Southern California Association of Governments, San Francisco International Airport, the State of California, the Government of Canada, and the Inter American Development Bank. From 1987 to March 2002 he was a member of the research staff of the Institute of Transportation Studies at the University of California, Berkeley and helped establish the National Center of Excellence for Aviation Operations Research, (NEXTOR) serving as its first program manager. He is a past chair of the Transportation Research Board Committee on Aviation System Planning and until early 2006 served as co-chair of the Working Group on Analytical Methods and Tools of the Global Aviation Information Network (GAIN), a government/industry partnership to promote and facilitate the sharing of aviation safety information. He has published a wide range of technical reports, journal papers, and other articles in various areas of transportation, and is a co-author of the book *Strategic Airport Planning*.

12. APPENDIX F: PEER REVIEW

Aviation Forecast Peer Review Report

June 11, 2008

Prepared for

City of Portland

Aviation System Consulting, LLC
805 Colusa Avenue
Berkeley, CA 94707-1838

Table of Contents

EXECUTIVE SUMMARY

This executive summary documents the findings and conclusions of a review of the aviation forecast methodology and resulting traffic forecasts developed for the Portland International Airport (PDX) *Airport Futures* project by the Port of Portland's aviation consultant team. The Forecast Peer Review was undertaken for the City of Portland by Dr. Geoffrey Gosling, Principal of Aviation System Consulting, LLC, with the objective of providing the City of Portland, the Port of Portland, and the PDX Airport Futures Planning Advisory Group (PAG) and its Forecast Subcommittee with an independent assessment of the forecast methodology, forecast scenarios, and associated assumptions, including the treatment of uncertainty in the forecast process.

At the start of the forecast development process it was recognized that it would be more productive to have the Peer Review Consultant interact closely with the Port's Consultant (Jacobs Consultancy) during the preparation of the forecasts rather than commenting after the fact. This would allow any concerns to be raised at an early stage in the process while there was time to address them and provide an opportunity for the Peer Review Consultant to make suggestions as the work is proceeding. As a result, the Peer Review Consultant has been closely involved in the forecast development throughout the process, has been included in the distribution of draft products and working materials, including technical memoranda on the model estimation and drafts of presentations to the Forecast Subcommittee and PAG, and provided the opportunity to comment prior to their presentation. More substantively, a number of concerns raised by the Peer Review Consultant during the forecast model development have been addressed in the final models. Overall, this has been a very productive relationship.

A central feature of the process adopted for the current forecast is the decision to develop a probabilistic approach to generating the forecasts, also termed a risk analysis. This represents a significant technical improvement over the typical approach adopted in most airport master plan forecasts, including the previous master plan forecast for PDX. The principal advantages of this approach is that it provides a much better representation of the uncertainties inherent in forecasting future traffic at an airport and provides a basis for assessing the robustness of alternative facility plans considered in the master plan to different future traffic levels. In particular, it allows a more quantified approach to understanding the risks involved if traffic grows faster or slower than expected and provides the ability to address questions such as "how soon might we need the capability to handle 30 million annual passengers at PDX?" or "what is the likelihood that we will need to build another terminal concourse by 2015?"

However, an important consequence of adopting this approach is that the analysis is significantly more complex than is usual for an airport master planning study. This was further complicated by the recognition of the need to give detailed attention to assumptions regarding the future price of oil and the impact of policies to address climate change, aspects that have generally been ignored in past forecasts. As in other areas of transportation planning, the Portland region is well ahead of the state of the art elsewhere and is setting new standards of practice for aviation forecasting, something that the PDX Aviation Futures project and the Port's aviation consultant team can be justifiably proud of.

Although adopting a probabilistic approach incorporating the effect of future oil prices and climate change policies improved the usefulness of the forecast, the steps required proved technically challenging, time-consuming and costly. As a result there were a number of issues that arose during the forecast development process that it was decided there was neither the time nor the resources to pursue any further at the present time. Recognizing these limitations, the PAG voted to accept the forecasts at its meeting on April 15, 2008 with the condition that that the forecasts should be revisited before the end of the master plan update process to determine whether the assumptions underlying the forecasts still appear to be reasonable.

The Forecast Peer Review identified a number of aspects of the forecast methodology and assumptions that could have a significant impact on the forecasts and that appear deserving of further analysis in order to better understand how these could impact future traffic levels at PDX. The following aspects are likely to have the greatest influence on the forecast traffic:

- ❖ The enplaned passenger demand model assumes that the historical relationship between total passenger traffic at the airport and regional population, per capita disposable income, and average cost per passenger-mile of airfares from PDX (termed airline yield) will continue unchanged in the future and that the recent reduction in traffic from the levels predicted by the historical relationship will also continue unchanged.
- ❖ The air cargo model assumes that the past growth in air cargo is largely explained by an increasing weight of air cargo per thousand dollars of regional income and that this ratio will continue to increase in the future to a level about 40 percent above the 2006 level, while the effect of the recent reduction in air cargo traffic from the levels predicted by the historical relationship will continue unchanged.
- ❖ The forecast assumptions use current U.S. Department of Energy (DOE) projections of the future price of oil. In recent years the DOE has significantly under-predicted the increase in the real price of oil. In addition, the assumed future price of carbon offsets for aircraft emissions are reduced below the price levels identified in a recent study by the Massachusetts Institute of Technology by assuming that only a proportion will be passed on the airlines. The assumptions also do not include a factor to increase carbon offset costs to account for the radiative forcing effects of aircraft emissions. As a result, the assumed future range of airline fuel and carbon offset costs may be too low.

Since without further analysis it is unclear how these factors might interact to affect the forecast traffic, it is recommended that the Port and City continue to pursue these issues in parallel with the remaining steps in the master plan process, so that they are better understood when the time comes to revisit the forecasts at the end of the master plan process or closer to the time when important facility development decisions need to be made.

AVIATION FORECAST PEER REVIEW REPORT

Introduction

This report presents the findings and conclusions of a review of the aviation forecast methodology and resulting traffic forecasts prepared by the Port of Portland's aviation consultant team for the Portland International Airport (PDX) *Airport Futures* project, based on analysis undertaken as part of the Forecast Peer Review. The Forecast Peer Review was undertaken for the City of Portland by Dr. Geoffrey Gosling, Principal of Aviation System Consulting, LLC, with the objective of providing the City of Portland, the Port of Portland, and the PDX Airport Futures Planning Advisory Group (PAG) and its Forecast Subcommittee with an independent assessment of the forecast methodology, forecast scenarios, and associated assumptions, including the treatment of uncertainty in the forecast process.

At the start of the forecast development process it was recognized that it would be much more productive to have the Peer Review Consultant interact closely with the Port's Consultant (Jacobs Consultancy) during the preparation of the forecasts rather than commenting after the fact. This would allow any concerns to be raised at an early stage in the process while there is time to address them and provide an opportunity for the Peer Review Consultant to make suggestions as the work is proceeding. As a result, the Peer Review Consultant has been closely involved in the forecast development throughout the process, has been included in the distribution of draft products and working materials, including technical memoranda on the model estimation and drafts of presentations to the Forecast Subcommittee and PAG, and provided the opportunity to comment prior to their presentation. Many of the comments provided to Jacobs Consultancy, particularly suggestions on presentations to the Forecast Subcommittee and PAG, have been incorporated into the final presentations. Overall, this has been a very productive relationship.

Peer Review Findings

A central feature of the process adopted for the current forecast is the decision to develop a probabilistic approach to generating the forecasts, also termed a risk analysis. This represents a significant technical improvement over the typical approach adopted in most airport master plan forecasts, including the previous master plan forecast for PDX. The principal advantages of this approach is that it provides a much better representation of the uncertainties inherent in forecasting future traffic at an airport and provides a basis for assessing the robustness of alternative facility plans considered in the master plan to different future traffic levels. In particular, it allows a more quantified approach to understanding the risks involved if traffic grows faster or slower than expected.

However, an important consequence of the decision to adopt this approach is that the analysis is significantly more complex than is usual for an airport master planning study and involves many difficult technical issues. This was further complicated by the recognition of the need to give detailed attention to assumptions regarding the future price of oil and the impact of policies to address climate change, aspects that have generally been ignored in past forecasts. As in other areas of transportation planning, the Portland region is well ahead of the state of the art elsewhere and is setting new standards of practice for aviation forecasting. This is something that the PDX Aviation Futures project and the Port's aviation consultant team can be justifiably proud of. However, the price to be paid for this capability is that the process is technically challenging, complex, time-consuming and costly. Many of the analytical steps have had to be developed specifically for this study and assumptions made on the basis of limited information.

This report addresses three broad aspects of the forecasting process and is intended to help the City of Portland and PAG understand some of the implications of the technical approach adopted for the forecast, the assumptions used in the analysis, and the range of forecast values generated by the probabilistic modeling. This summary provides an overview of the principal issues identified in the review. More detail is provided in the following sections.

Forecast Models and Probabilistic Forecasting Approach

The forecast models for both enplaned passengers and total air cargo are aggregate models that explain the total traffic at the airport in terms of regional values of the causal variables. This is a fairly standard approach in airport master planning forecasts, but as with any modeling process, the ability of such models to predict future traffic is critically dependent on the choice of variables and structure of the model. A model can fit the historical data quite well and yet produce very inaccurate forecasts, as illustrated by the models developed for the last PDX master plan update. In deciding whether a particular model is likely to produce reasonable forecasts, it is important to consider the variables included in the model, the structure of the model, and estimated values of the model coefficients. Each of these aspects has implications for the ability of the model to generate reasonable forecasts.

In considering whether the current models used in the forecast process are likely to produce reasonable forecasts, the peer review has identified the following issues:

- The use of an aggregate model for forecasting implies that past trends in the composition of the traffic across different markets will continue in the future.
- The use of a constant dummy variable in the enplaned passenger model to account for the drop in passenger traffic since 2001 implies that the proportional reduction in traffic since 2001 will continue in the future. If this effect does not continue, or significantly reduces, the model would under-predict the traffic by as much as 30%.
- The elasticity of demand with respect to both population and income in the air passenger model are lower than would be expected from a general understanding of the determinants of air travel. If the demand elasticity is in fact higher in the future than the model suggests, this would cause the model to tend to under-predict future traffic growth. However, any such effect is likely to be relatively small compared to the overall traffic growth.

The first two issues are intrinsic aspects of the passenger model that should be considered in deciding how to interpret the current forecasts. It would of course be possible to generate different forecasts with some assumed reduction in the post-2001 effect. In order to understand the implications of the third issue for the passenger forecasts, it would be desirable to conduct further analysis on the sensitivity of the forecasts to changes in the implied demand elasticity.

The latest air cargo model is based on an underlying logistic growth relationship in the total weight of air cargo per thousand dollars of regional personal income (expressed in constant dollars) that the model development team has termed the cargo intensity. This relationship is adjusted by a term that reflects changes in the price of oil. In addition the model includes a dummy variable that reduces the predicted cargo tonnage by 28% for the years after 1999. The demand elasticity with respect to oil price is about –0.16, which appears reasonable from a consideration of the proportion of integrated air cargo carrier operating costs accounted for by fuel.

The forecasts of future air cargo traffic are significantly affected by the continued increase in the logistic growth relationship, which implies that the air cargo intensity will reach about 37% above 2006 levels by 2035. In deciding how to interpret the current forecasts, consideration should be given to whether this appears reasonable, as well as whether the reduction in cargo intensity since 1999 is likely to continue in the future and by the same percentage.

The probabilistic forecasts use a Monte Carlo simulation approach that is highly dependent on the assumed distributions of the explanatory variables in the passenger and cargo models. The effect of these variables has been assumed to be independent, although in reality there is likely to be some correlation. Assuming the variables are independent will tend to reduce the spread of the forecasts. It would also be desirable to perform some additional analysis to quantify the likely impact of this effect.

In order to translate the forecasts of passengers and cargo into forecasts of aircraft operations, a process was developed to allocate the forecast traffic to individual markets (or market segments in the case of air cargo) and then estimate the number of aircraft operations needed to serve each market. This process considered the airlines currently serving each market, the aircraft fleet that they currently operate and any anticipated future changes in their fleet, and trends in average load factors. The process implicitly assumed that the basic structure of the airline industry remains unchanged from 2007 and in fact is independent of changes in the determinants of future demand, particularly the price of oil. While accounting for these effects at the market level may be beyond the resources of the current project, the limitations that this imposes on the resulting forecasts of aircraft operations should be understood.

Forecast Assumptions

Forecast values of future air traffic are only as good as the assumptions on which they are based. The review identified a number of key assumptions that should be borne in mind in considering the forecasts and that appear deserving of further analysis to clarify their impact on the forecasts:

- The use of current U.S. Department of Energy (DOE) projections of the future price of oil. In recent years the DOE has significantly under-predicted the increase in the real price of oil.
- The assumed price of carbon offsets for aircraft emissions are based on carbon offset price levels identified in a recent study by the Massachusetts Institute of Technology, but are reduced below those levels by assuming that only a proportion will be passed on the airlines. These assumptions also do not appear to include a factor to account for the full radiative forcing effect of aircraft emisisons.
- The assumed distributions used in the Monte Carlo simulation reduce the average per capita income levels below that forecast by Portland Metro and

limit the range considered for the price of oil to the low and high scenario of the DOE oil price forecasts.

Use of Probabilistic Forecasts

The value of the probabilistic forecasts, apart from being more transparent about how uncertain the forecasts are, lies in the ability to address questions such as “how soon might we need the capability to handle 30 million annual passengers at PDX?” or “what is the likelihood that we will need to build another terminal concourse by 2015?” One useful way to use the graphs that show the varying percentiles of forecast traffic level for any given year is to take a horizontal line at any given traffic level and express the percentiles in terms of the corresponding future year at which the given traffic level will be reached.

Conclusion

The various issues identified in this review suggest that a number of the steps in the forecast process could benefit from further study and development, and that further examination of some of the assumptions appears warranted. At a minimum, this additional information will increase the confidence in the forecasts, even if it is decided that there is no reason to change the current forecasts. On the other hand it may suggest aspects where it would be appropriate to make some revisions to the forecasts. In either case, the sooner that this is known, the better.

While this additional work need not delay starting the remaining steps in the master planning process on the basis of the current forecasts, it would be in the Port’s and City’s interests to continue to refine the forecasting process in parallel with this other work, so that there is a better understanding of the sensitivity of the current forecasts to the issues identified in the review as the other steps in the master plan evolve. It would also be desirable to continue to develop the forecasting methodology so that future updates of the forecasts can benefit from better models and analytical tools. This will be particularly helpful when the forecasts are revisited closer to the time when important facility development decisions need to be made.

Particular issues that appear deserving of further work include:

- Improving the passenger and cargo forecast models to better account for recent changes in the airline industry and reduce the importance of dummy variables in predicting recent traffic trends.
- Development of a market-based forecast model so that future changes at a market level can be explicitly forecast rather than assumed.
- Development of a more detailed representation of airline costs.
- Obtaining more detailed regional cargo data.
- Further study of likely impacts of climate change policies or public attitudes on the demand for air travel.
- Further study of the most appropriate probability distributions for the Monte Carlo simulation and consideration of correlation between future values of explanatory variable.
- Development of analytical software to simplify the process of performing the forecast analysis with different assumptions.

The remainder of this report provides a more detailed explanation of the different issues discussed above. The next section discusses the forecast models that have been developed for enplaned air passengers and total air cargo. The following two sections review the methodology used to develop the probabilistic forecasts and derive the forecasts of aircraft operations. The subsequent section discusses the input assumptions used to generate the forecasts. The last two sections discuss the use of probabilistic forecasts in airport master planning and suggest areas where further work could improve the usefulness and robustness of the forecasting process.

These sections are followed by two appendices. The first appendix presents a supplementary analysis of the enplaned passenger demand model that was undertaken following the PAG Meeting on April 15, 2008 at which the PAG voted to accept the forecasts. The second appendix presents a short biographical summary of the Peer Review Consultant.

Forecast Models

The forecast models for both enplaned passengers and total air cargo are aggregate models that explain the total traffic at the airport in terms of regional values of the causal variables. They are also both multiplicative models (linear in logarithms), which has the consequence that the model coefficient for each variable can be interpreted as the direct elasticity of demand with respect to that variable.

Of course, in reality the total traffic is composed of the traffic in many different markets (e.g. different flight destinations) each with different prices and service levels. A given percent change in price is likely to affect traffic in each market differently. Similarly, a given change in the average price across all the markets could be the result of very different changes in each market. An aggregate model thus attempts to measure the combined effect of all these changes in terms of the change in the average values of the causal variables. In the case of variables defined at a regional or national level, such as population or the price of oil, a given change applies to all the markets equally, although that change may affect each market differently. For example, an increase in the price of oil may affect some markets more than others.

It follows from this that the use of an aggregate model for forecasting implies that past trends in the composition of the traffic across different markets will continue in the future. This needs to be borne in mind in interpreting the forecasts produced using such models.

Passenger Model

The passenger model explains total enplaned passengers at PDX in terms of three continuous variables (regional population, regional average per capita personal income, and average airline yield) and three dummy variables. The airline yield variable (defined as the average airfare revenue per passenger-mile) uses the average PDX yield for years from 1990 and the average U.S. domestic yield for years before 1990. One of the dummy variables is used to adjust for the use of a different yield variable prior to 1990. The other two dummy variables attempt to account for the drop in traffic from 2001. One dummy variable is used for 2001 and the second is used for 2002 on.

Figure 1 shows the fit of the model to the historical data. It can be seen that the model fits the actual data fairly well until 2000, although it under-predicts the traffic in 1996 and then predicts a higher growth rate from 1996 to 2000 than actually occurred, resulting in an over-prediction in 2000. Without the effect of the two dummy variables for the years from 2001, the model would have significantly over-predicted the traffic. The dummy variable for 2001 forces the model to predict the actual traffic in that year. The model then slightly over-predicts the traffic in the next three years, but under-predicts the recovery since 2004. This is to be expected since the effect of the dummy variable from 2002 provides the same percentage reduction for each year. To the extent that the drop in traffic following 9/11 and the SARS scare were most pronounced in 2002 and 2003, a constant adjustment would tend to under-predict the reduction in those years and over-predict the reduction as the recovery proceeds. This has two important implications for the use of the model for forecasting future traffic. The first is that applying a constant proportional adjustment for the years after 2002 is likely to under-predict any continuing recovery of traffic levels from the reductions in 2001 and 2002. The second is that without the adjustments from the dummy variable for years after 2001, the model would greatly over-predict the traffic levels. It is hard to believe that five years after 9/11 the lingering effects have reduced the traffic by almost a third. What is much more likely is that a model based on the relationships between traffic and the causal variables during the era of rapid traffic growth from 1990 to 2000 is not providing a good representation of these relationships in the current environment. The implications of this are discussed further below.

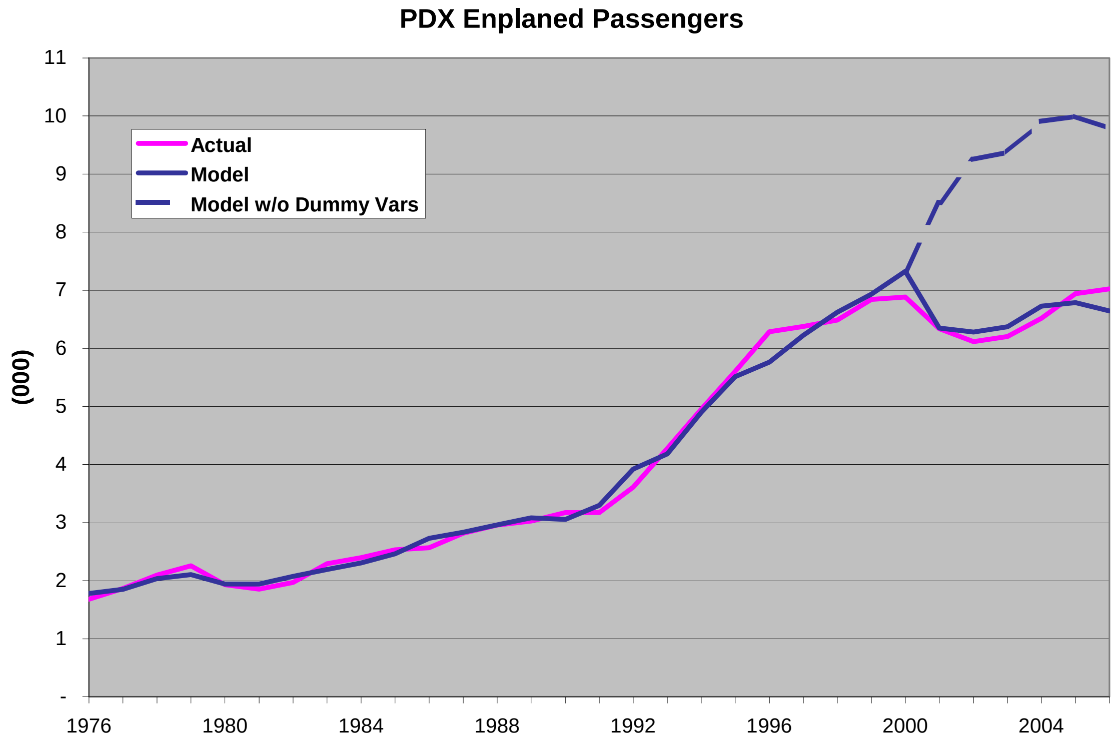


Figure 1 Enplaned Passenger Model

In considering the fit of the passenger model to the historical data, it should be borne in mind that the total enplaned passengers at PDX consist of four different market segments:

1. Originating passengers from the Portland metropolitan area
2. Originating passengers from outside the Portland metropolitan area who travel to PDX by ground transportation
3. Visitors to the Portland region (using ground transportation to access PDX from within and outside the metropolitan area)
4. Passengers connecting between flights at PDX.

Use of Portland metro area population and income and PDX average yield in the model implicitly assumes that the traffic in market segments (2) through (4) maintains a consistent relationship to the traffic in segment (1). Market segment (2) is likely to be fairly small but the proportion of connecting passengers at PDX was around 15 percent in 2005. Both segments can be expected to decline as a percent of PDX traffic as air service improves at other airports in Oregon. Changes in these shares over time are likely to bias the model coefficients, although the magnitude and effect of any such bias is unclear without further analysis.

The passenger demand elasticity with respect to population is about 0.9, which implies that a 10 percent increase in regional population will lead to about a 9 percent increase in air traffic, other things being equal. *A priori* one would expect the demand elasticity for population to be around 1.0 or perhaps slightly higher. If the composition of the population is unchanged, then 10 percent more people would make 10 percent more trips. However, increasing population could imply changes in the composition of the population as well. People moving to the Portland area may be more likely to have family elsewhere and hence the need to make more air trips or to be working in those sectors of the economy that generate more business travel. This would tend to give a population elasticity higher than 1.0, but probably no higher than 1.05.

The per capita income elasticity is a little over 1.0 (1.04). This implies that air travel propensity will increase marginally faster than income. In fact, air passenger surveys show that air travel propensity increases very strongly with income. Households making $200,000 per year make significantly more air trips than those making $30,000 per year. Thus *a priori* one would expect air travel demand elasticity with respect to income to be higher than 1.04, although by how much would depend on any changes in the income distribution as well as the average.

If both population and income elasticity turn out to be higher in the future than predicted by the model, then the model will tend to under-predict the future growth in air travel for any given assumptions about the cost of air travel.

The elasticity with respect to PDX yield is –1.15 or slightly elastic (an increase in average air fares of 10 percent would reduce traffic by 11.5 percent). This is broadly consistent with airfare elasticity found in other studies, particularly for longer haul domestic trips.

A critical issue in the application of the model is the use of the dummy variable for years after 2001. This term reduces traffic by 32 percent below the level predicted by the model without including the variable. While it may be true that there are lingering effects of 9/11 that have continued to reduce the demand for air travel in recent years, the relevant question for the use of the model to forecast future traffic is how long these effects will last and whether the model provides a reasonable representation of the future causal relationships without the use of the dummy variable.

The recent trends in traffic suggest that keeping the dummy variable in the model for future years will tend to under-predict the level of air traffic for any given set of input assumptions. However, excluding the dummy variable completely is likely to greatly over-predict traffic levels, particularly in the near term, and anyway changing one term in a model will impact the values of the other coefficients.

- **Further work appears to be warranted to better understand the impact of the use of the dummy variables in the model on the forecasts, as well as the sensitivity of the forecasts to changes in demand elasticity with respect to population and income.**

Cargo Model

The air cargo model was revised immediately prior to the PAG Meeting of April 15, 2008, to respond to peer review comments on the previous model and thus has not been subject to the same level of review as the passenger model.

The revised cargo model is based on an underlying logistic growth relationship in the total weight of air cargo per thousand dollars of regional personal income (expressed in constant dollars) that the model development team has termed the cargo intensity. This relationship is adjusted by a term that reflects changes in the price of oil. In addition the model includes a dummy variable that reduces the predicted cargo tonnage by 28% for the years after 1999. The demand elasticity with respect to oil price is about –0.16, which appears reasonable from a consideration of the proportion of integrated air cargo carrier operating costs accounted for by fuel.

Figure 2 shows the fit of the model to the historical data.

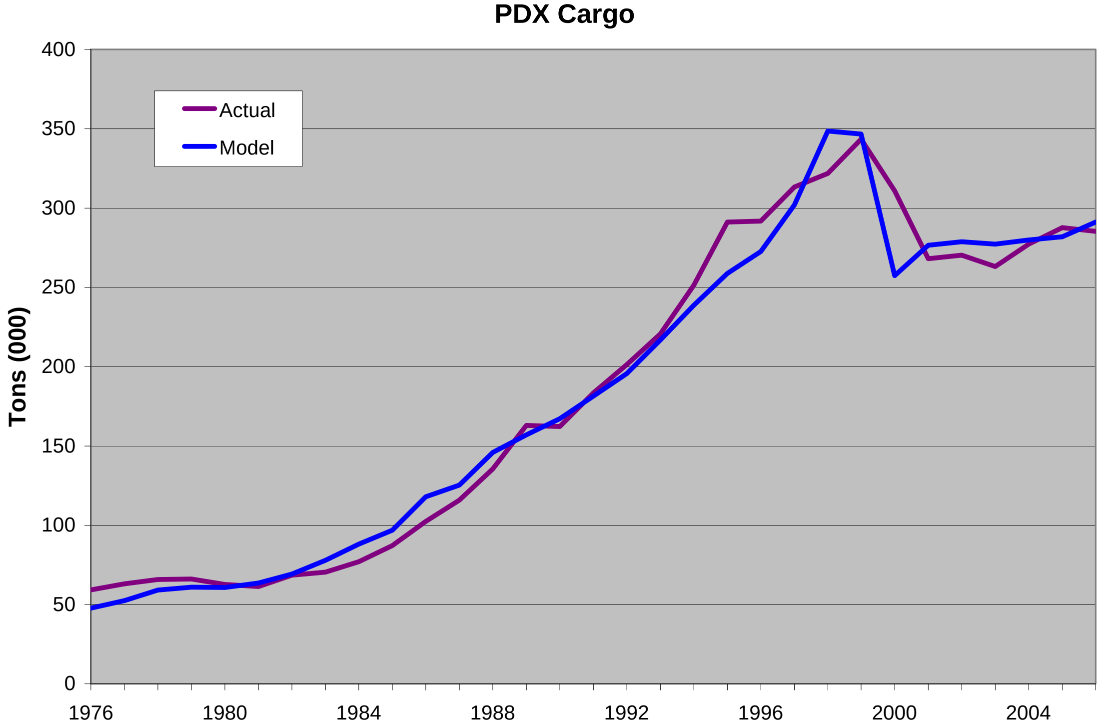


Figure 2 Total Air Cargo Model

It can be seen that the model fits the data fairly well until about 1993, but then does a relatively poorer job of explaining the year-to-year changes thereafter. The model captures the drop in traffic after 1999, but does so through a dummy variable. In fact the use of a single dummy variable for the period after 1999 overstates the drop from 1999 to 2000 and then predicts an increase from 2000 to 2001, instead of the decrease that actually occurred. Rather than predict air cargo tonnage directly, the model predicts air cargo intensity and then this is multiplied by the total regional personal income to predict the actual air cargo traffic. Not surprisingly, the corresponding fit of the cargo intensity model to the actual cargo intensity data looks very similar to the total air cargo results, as shown in Figure 3.

Figure 4 shows the underlying logistic growth relationship for the period of the model estimation and its projection to 2035. Since this relationship is defined solely in terms of the number of years since 1975, its future growth is unaffected by any causal variables, although for any given year, this relationship will be adjusted by the change in oil price.

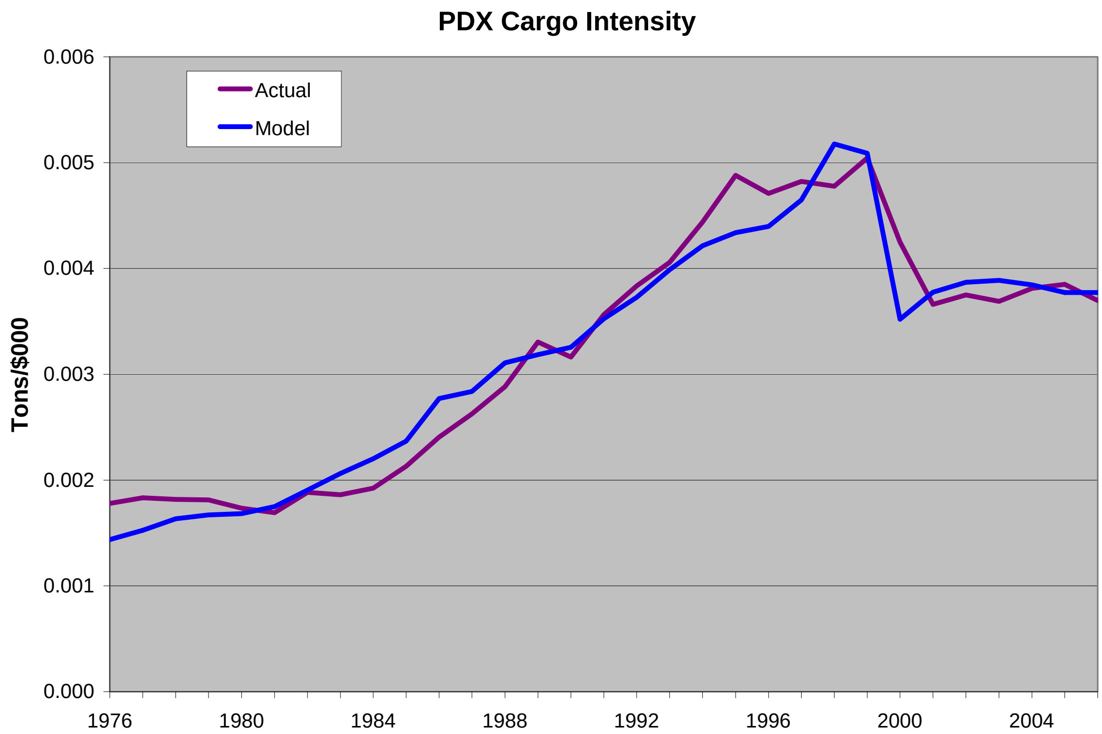


Figure 3 Air Cargo Intensity Model

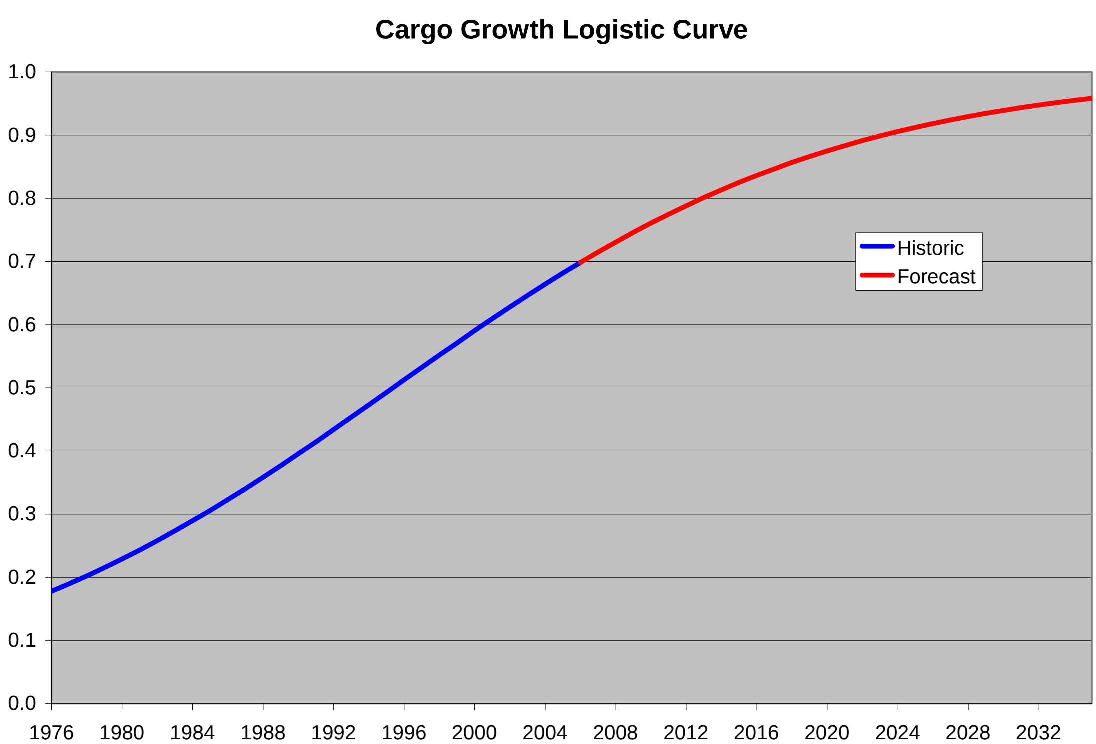


Figure 4 Logistic Growth Relationship

The forecasts of future air cargo traffic are significantly affected by the continued increase in the logistic growth relationship, which implies that the air cargo intensity will reach about 37% above 2006 levels by 2035.

- **Further work appears to be warranted to better understand the factors that caused the strong growth in cargo intensity until the late 1990s and the subsequent decline. This would allow a better informed assessment of the extent to which these relationships are likely to continue in the future.**

Development of Probabilistic Forecasts

A key feature of the forecasting approach adopted for the PDX Airport Futures project is the use of a probabilistic forecasting approach, also termed a risk analysis. This recognizes and attempts to address the inherent uncertainty in any attempt to predict the future. This uncertainty arises from at least three factors:

1. The models used in the forecasting do not completely explain the historical data on which they have been estimated, and as a consequence there is uncertainty in the values of their coefficients and residual errors in their predictions
2. Forecasts of future values of the explanatory variables are inherently uncertain, as illustrated by the difficulty of predicting future oil prices
3. Unanticipated events may occur that change the demand for air transportation (such as another terrorist attack) or structural changes may occur in the airline industry or the economy at large that change the relationships between the causal variables and air travel or air cargo traffic from those observed during the period on which the models have been estimated.

The way in which these factors are accounted for in the probabilistic forecasts is to define a probability distribution for each of the input variables in the models, and then calculate a large number of different values for each forecast traffic level, sampling randomly from these input variable distributions. The resulting values can then be used to define a probability distribution for the forecast traffic level. This process is termed a Monte Carlo simulation. In addition to varying the values of each input variable, the Monte Carlo simulation also varied the parameter values of the model and applied an error term to the model prediction, reflecting the uncertainty in the estimated model parameters and the residual errors in the model predictions of the historical data.

Obviously, this process is highly dependent on the assumptions made about the distributions of the future values of the input variables. These distributions cannot be directly observed from past data, but rather are measures of the confidence with which we can predict the future values of the input variable. The assumptions made in developing the distributions for use in the Monte Carlo simulation are discussed further below in the section on forecast assumptions.

An important consideration is performing a Monte Carlo simulation is whether the distribution of each input variable is assumed to be independent or whether the future values of some of these variables are likely to be correlated. For example, a higher oil price may be more likely to be associated with a low growth rate in per capita income than a high growth rate. In the current analysis it was assumed that each variable is independent. With the current models this will tend to produce a smaller spread of values than if the variables were assumed to have some correlation.

Of the explanatory variables included in the forecast models, the one that has the highest level of uncertainty about future values is the average value of airline yield (in the case of the passenger model) or the price of oil in the case of the cargo model. Since the price of oil has a direct effect on the passenger yields needed for the airlines to remain economically viable, the analysis developed a sub-model to predict the effect of changing oil price on airline yield. This considered not only the effect of future oil prices on airline fuel costs, but also likely changes in non-fuel costs and airline load factors, since these also affect the yields needed for the airlines to cover their operating costs.

One factor that will affect future airline fuel costs that was not explicitly included in the analysis is the continuing trend in improved aircraft fuel efficiency. The analysis implicitly assumed that this is subsumed in the past relationship between oil prices and airline fuel costs. However, any such relationship is likely to be very weak, given past trends in aircraft fuel efficiency and oil prices.

- ❖ **Further work appears to be warranted to clarify how a more explicit accounting for trends in aircraft fuel efficiency might change future projections of airline yield.**

Derivation of Forecasts of Aircraft Operations

The forecast models predict total enplaned passengers and total air cargo tonnage. In order to translate these forecasts into forecasts of aircraft operations, a process was developed to allocate the forecast traffic to individual markets and then estimate the number of aircraft operations needed to serve each market. This process considered the airlines currently serving each market, the aircraft fleet that they currently operate and any anticipated future changes in their fleet, and trends in average load factors.

This process was based on a number of key assumptions that should be borne in mind in interpreting the aircraft operations forecasts:

- The volume of international passenger travel was forecast externally from the forecast model by making assumptions about future growth rates in international travel under a median, low and high growth scenario. The future level of domestic travel was then obtained by simply subtracting the international travel from the total travel predicted by the forecast model.
- The share of passenger travel in each market served by non-stop flights from PDX was assumed to remain the same as in 2007.
- The share of the passenger traffic in each market carried by each airline was assumed to be the same as in 2007.
- The future percent change in load factors in each forecast year was assumed to be the same for every airline and market, although the growth in load factor compared to 2007 was assumed to increase slowly over time.

These assumptions implicitly assume that the basic structure of the airline industry remains unchanged from 2007 and in fact is independent of changes in the determinants of the future demand for air travel, particularly the price of oil. While it is true that airlines cannot change their fleets significantly in the short run, they can certainly do so over the time frame of the forecast. It can be expected that continuing high oil prices will force airlines to use larger, more fuel-efficient equipment and may lead to shifts in airline market share in favor of those airlines with more fuel-efficient aircraft. Pressures to increase average aircraft size may also result from airport capacity concerns under scenarios of high traffic growth, as illustrated by the current discussion about the introduction of congestion pricing at capacity-constrained airports.

While accounting for these effects at the market level may be beyond the resources of the current project, the limitations that this imposes on the resulting forecasts of aircraft operations should be understood.

Forecast Assumptions

Forecast values of future air traffic are only as good as the assumptions on which they are based. In the case of the current forecasting process, there are two separate issues that should be considered: the assumed expected value for each input variable for a given forecast year and the assumed distribution of likely values around the expected value. In fact, the expected (or average) value is implied by the distribution. However, it is easier to think about the assumptions by separating the two issues.

Expected Values of Explanatory Variables

There are really only three explanatory variables that drive the PDX air traffic forecasts: population, per capita income, and the price of oil. Although the passenger model is based on the average PDX yield, the projected values of this variable were derived from the projected price of oil.

The expected future values of population and per capita income were obtained from regional forecasts prepared by Portland Metro. These forecasts appear to be widely accepted and there is obviously a good argument to be made that planning for PDX should be based on consistent assumptions with the regional planning for the rest of the transportation system. On the other hand, the Port may wish to understand the implications for its own financial and facilities planning of different assumptions about future growth in population and income. While these assumptions are varied in the probabilistic forecasts, it is not currently possible to separate out the effects of varying one particular assumption. This would require a sensitivity analysis with different input assumptions.

The expected future values for oil price were based on the most recent U.S. Department of Energy projections, although an extensive comparative analysis was undertaken of oil price forecasts by other organizations. In recent years, the U.S. Department of Energy has significantly under-predicted the increase in the real price of oil. Whether this tendency to under-predict the future price of oil will apply to the most recent forecast only time will tell. However, this places a particular importance on the assumed distribution of likely future values, as discussed further below. A sensitivity test of oil price assumptions indicated that a 21% increase in the price of oil resulted in about a 4% decrease in passenger traffic, which seems reasonable given the proportion of airline costs accounted for by fuel and the elasticity of demand with respect to yield. This suggests that a doubling of oil price over the DOE forecasts could reduce traffic by perhaps 20%. However, the more serious concern from the perspective of the forecasts is that if the lower-bound scenario is too low ($44 per barrel in 2035 in 2006 dollars), this will tend to overstate future growth in traffic.

Other assumptions that influence the forecast include future values of average load factor and aircraft size. These were generally based on the most recent national aerospace forecast prepared by the Federal Aviation Administration (FAA). These values are not likely to deviate significantly at a national level from the FAA projections, since there are physical limits on how many seats can be sold or how quickly the airlines can increase the average size of their fleets. Although the corresponding values at PDX may differ somewhat from national averages, due to differences in traffic composition, airline shares and aircraft fleets, the growth trend is likely to be similar, since the airlines and flights serving PDX are part of the larger system. In any event, differences in these factors are likely to have much less impact on the forecasts than changes in the price of oil.

Impact of Climate Change Policies

One issue that has been of particular interest to the Planning Advisory Group Forecast Subcommittee is the effect of future climate change policies on the cost of air travel or the propensity to make air trips. These effects have been incorporated in the forecasts through adjustments to the assumed price of oil. These adjustments have been expressed as a carbon tax that would be payable by oil companies (and presumably passed on to their customers) or directly by oil users. Future costs of carbon emissions could also be the result of a cap-and-trade program or other regulatory environment that requires airlines to purchase carbon offsets. While the need to purchase carbon offsets will not affect the price of oil directly, to the extent that the required offsets will be based on fuel consumption, the effect will be the same as if the price of oil increased.

In addition to assuming a price per barrel for a carbon tax, the analysis also assumed that only a proportion of this tax would be passed on the airlines. This obviously would not apply to a carbon offset program, unless the government were to provide exemptions to airlines on some basis. It is also unclear why oil companies would choose to pay some proportion of a carbon tax out of their profits (or indeed could even afford to). It is possible that the introduction of a carbon tax would reduce the demand for oil, resulting in oil producers lowering their prices to offset the lost revenue through greater production. However, this involves a complex market dynamic that is beyond the scope of the current forecast analysis to perform. It is also unclear to what effect these factors have already been accounted for in the DOE scenarios. Of course, as far as the traffic forecast is concerned, there is no difference between a higher carbon tax, only some of which is passed on to the airlines, and a lower tax that results in the same cost per barrel. On balance, it would be clearer to assume that the entire carbon tax is passed on the airlines and simply vary the assumed tax.

The assumed price of carbon emissions ranged from $35 to $109 per metric ton in 2035 in 2006 dollars, based on a recent study by the Massachusetts Institute of Technology. However, there are those who feel that much higher levels will be required to achieve the targets proposed in recent state and federal legislation, particularly by 2035 when many of the cheaper alternative strategies to reduce carbon emissions will have been exhausted. In addition, the assumed carbon prices do not appear to account for the radiative forcing effect of aircraft emissions, which has been estimated by the Intergovernmental Panel on Climate Change[1] to require the direct aircraft emissions (expressed as carbon equivalent) to be increased by a factor of about 2.7 or more to fully offset the impact on climate change.[2] In addition, there is no adjustment in the models to reflect possible effects of growing public concern about climate change on the propensity to make air trips. **Thus it appears that the assumptions used in the forecast analysis may significantly understate the likely future costs of climate change policies or public attitudes.**

- ❖ **Further work appears to be warranted to clarify the sensitivity of the forecasts to more stringent assumptions about potential responses to climate change.**

Assumed Distributions

The assumed distribution for future values of the regional population was obtained directly from the population forecast approach used by Metro. However, in the case of the per capita income Metro had not developed a predicted distribution and it was necessary to develop an assumed distribution from the per capita income forecast scenarios prepared by Metro. This distribution was based on analysis of past performance of the Metro income forecasts by the Jacobs Consultancy team. Since this found that Metro had tended to over-predict the growth in real income in the past, this was incorporated in the assumed distribution. A consequence of this approach is that the PDX traffic forecasts are based on a somewhat lower average per capita income assumption than the baseline forecast by Metro.

The assumed distribution of future values of the price of oil was based on the high and low scenarios forecast by the U.S. Department of Energy (DOE). No adjustments were made to account for the past performance of the DOE in forecasting oil prices. Therefore if the DOE high growth scenario has substantially under-estimated the potential for continued future growth in oil prices, this possibility will not be considered in the PDX traffic forecasts. Thus while the assumed distribution for the price of oil covers a wide range (from $44 per barrel to $128 per barrel in 2035 in 2006 dollars), this range may understate the possibility of even higher prices.[3]

An important assumption in developing distributions of likely future values of explanatory variables is the shape of the distribution. Apart from the distribution for population, which was obtained from Metro, the other distributions were assumed to be triangular. In most cases, the upper and lower limits of the distribution were derived from high and low scenarios of the relevant variable. This constrains the values to lie between the high and low scenario. It is likely that in developing high and low growth scenarios, other organizations are not assuming that these are the highest and lowest values that could possibly occur, but rather represent a range within which future values have a reasonable likelihood of occurring (although what this likelihood is may not be explicitly defined). **This will tend to under-predict the range of forecast values, although it is unclear by how much.**

[1] Intergovernmental Panel on Climate Change, *Aviation and the Global Atmosphere*, Special Report, 1999. Available at http://www.ipcc.ch/ipccreports/sres/aviation/index.htm.

[2] More recent estimates by Robert Sausen and others ("Aviation radiative forcing in 2000: An update on IPCC (1999)," *Meteorologische Zeitschrift*, Vol. 14, No. 4, pp. 555-561, August 2005) have suggested that the factor of 2.7 may be too high, but it is generally accepted that there is a high degree of uncertainty in these estimates and there is ongoing research under way to improve the understanding of the issues involved.

[3] It should be noted that at the time of writing this report (June 2008), oil prices had exceeded $130 per barrel in current dollars.

- **Further work appears to be warranted to clarify the sensitivity of the forecasts to changes in the assumed distributions for the explanatory variables.**

Use of Probabilistic Forecasts in Master Planning

The development of probabilistic forecasts that express the likelihood of future traffic levels exceeding any given value raises the question of how such forecasts can be used in the remaining steps of the master planning process. There are two important points that should be noted in discussing the probabilistic forecasts:

1. The forecasts express the likelihood of obtaining a future traffic level that lies between any two values, or conversely the likelihood of the future traffic being greater than (or less than) a given value. It is misleading to talk about the "most likely" value for the future traffic level in any given year. The median value (50 percentile) represents the value that the future traffic is equally likely to be greater than or less than. While the likelihood of the future traffic lying in a given range around this value (say plus or minus 1 million annual passengers) may well be higher than the corresponding likelihood of the traffic lying within the same range around any other value, this likelihood is still very small unless the range in question is fairly wide.

2. Although the graphs of forecast traffic levels show curves for different percentile forecasts, this does not imply that the future traffic growth will follow any one of these curves. These merely join points with the same percentile likelihood in successive years. It is entirely possible for the future traffic to evolve such that it corresponds to one particular percentile value in one year and as quite different percentile value some years later. Obviously in the real world there are constraints on how rapidly traffic can grow, so a change from the 10-percentile value to the 90-percentile value in just a few years is highly unlikely.

The real value of the probabilistic forecast, apart from being more transparent about how uncertain the forecasts are, lies in the ability to address questions such as "how soon might we need the capability to handle 30 million annual passengers at PDX?" or "what is the likelihood that we will need to build another terminal concourse by 2015?" While some alternative facility development options may be fairly easy to advance or defer if traffic grows more quickly or more slowly than assumed, others may be much harder to implement sooner than expected due to the need for other actions to be completed that take time (e.g. land acquisition or relocating other facilities).

One useful way to interpret the graphs that show the varying percentiles of forecast traffic level for any given year is to take a horizontal line at any given traffic level and express the percentiles in terms of the corresponding likely future year at which the given traffic level will be reached.

Considerations for Further Work

The various issues identified in this review suggest that a number of the steps in the forecast process could benefit from further study and development, and that further examination of some of the assumptions appears warranted.

While this additional work need not delay starting the remaining steps in the master planning process on the basis of the current forecasts, it would be in the Port's and City's interests to continue to pursue these issues in parallel with this other work, so that there is a better understanding of the sensitivity of the current forecasts to the issues identified in the review as the other steps in the master plan evolve. It would also be desirable to continue to develop the forecasting methodology so that future updates of the forecasts can benefit from better models and analytical tools. This will be particularly helpful when the forecasts are revisited closer to the time when important facility development decisions need to be made. However, deferring further work to that time will not only leave these issues unresolved for several years, but runs the risk of not leaving enough time to complete the necessary analysis before a decision is needed. Where additional data is required, as in the case of air cargo, it is important to begin collecting this as soon as possible.

The more significant aspects that could benefit from further work include:

- Improving the passenger and cargo forecast models to better account for recent changes in the airline industry and reduce the importance of dummy variables in predicting recent traffic trends. These improvements should include the development of a market-based analytical approach so that future changes at a market level can be explicitly forecast and do not need to be assumed.
- Incorporation of a more detailed representation of airline costs that can better account for the effects of fuel prices, aircraft fuel efficiency, and changes in other non-fuel costs.
- Obtaining more detailed regional cargo data to identify changes in the relative role of trucks and air, and trends in air cargo use by different sectors of the economy.
- Further study of the likely impact of climate change policies on oil prices or airline costs, as well as possible effects of growing public concern about climate change on the propensity to make air trips.
- Further study of the most appropriate probability distributions for the forecast values of explanatory variables in the Monte Carlo simulation and consideration of likely correlation between future values of explanatory variable.
- Development of analytical software to simplify the process of re-running the models and forecast analysis with different assumptions. The current analysis process is very labor intensive and relies heavily on the use of spreadsheet programs, which are not readily usable by others.

While this work would require a significant commitment of resources, this would still be fairly minor compared to the future capital investment in airport facilities, and indeed compared to the engineering and design work for those facilities. It would also greatly enhance the Port's ability to track the changes in airport traffic compared to the forecasts and understand whether the level or pattern of demand is changing in unforeseen ways that should precipitate a review of the implications for its established master plan.

APPENDIX A

Supplementary Analysis

Enplaned Passenger Demand Model

One of the features of the enplaned passenger demand model noted earlier in this report and discussed at the Planning Advisory Group (PAG) meeting on April 15, 2008 is the use of a constant dummy variable to reflect the reduction in air travel since 2001. This dummy variable has the effect of reducing the forecast level of enplaned passengers by a constant proportion relative to the traffic level predicted by the model on the basis of the relationship between enplaned passengers and the other explanatory variables prior to 2001. The supplementary analysis presented in this appendix was performed subsequent to the April 15 PAG meeting, at which the PAG voted to accept the forecasts, with the objective of shedding some additional light on the issue and its potential implications for the forecasts generated using the model.

Post-2001 Reduction in Air Travel

The key issue raised in the Peer Review Status Report of April 15, 2008 and discussed at the PAG meeting is whether the reduction in air travel since 2001 relative to the traffic level predicted by the enplaned passenger model is likely to remain constant in the future or whether traffic levels may return to the levels predicted by the model without the post-2001 effect. Operationally, this involves assumptions about the use of the post-2001 dummy variable in the forecasts. There is some evidence in the recent data that the post-2001 reduction may be becoming less over time.

Figure A-1 shows the actual enplaned passenger traffic and that predicted by the model using a constant dummy variable, expressed as a proportion of the traffic predicted by the model without the use of the post-2001 dummy variable. The constant percentage reduction implied by the estimated coefficient of the dummy variable is shown by the dark blue line. It can be seen that the actual traffic (the pink line) was about 66% of the predicted traffic without considering the effect of the dummy variable from 2001 to2004, and then increased slowly thereafter to 2006, reaching about 72% in 2006. Obviously, this is a fairly modest change, and there is no guarantee that it will continue in the future or by how much. However, if the trend from 2004 to 2006 were to continue at the same rate, the effect of the post-2001 reduction implied by the dummy variable would disappear by 2015.

In the PAG meeting, representatives of Jacobs Consultancy stated that they had tried estimating a model with a reducing post-2001 factor, but this had not fit the data as well as a constant factor. From the model documentation that was provided as part of the peer review, it appears that they estimated a model using a dummy variable defined as the inverse of the number of years since 2001 (1 / (y-2001) where y is the year in question). This function declines in value very rapidly for the first few years and then progressively more slowly for subsequent years, as indicated by the dark green line in Figure A-1. It is clear from Figure A-1 why a constant dummy variable would fit the data better than a dummy variable defined as an inverse function of the years since 2001, particularly since there was effectively the same reduction in the actual traffic for the first three years.

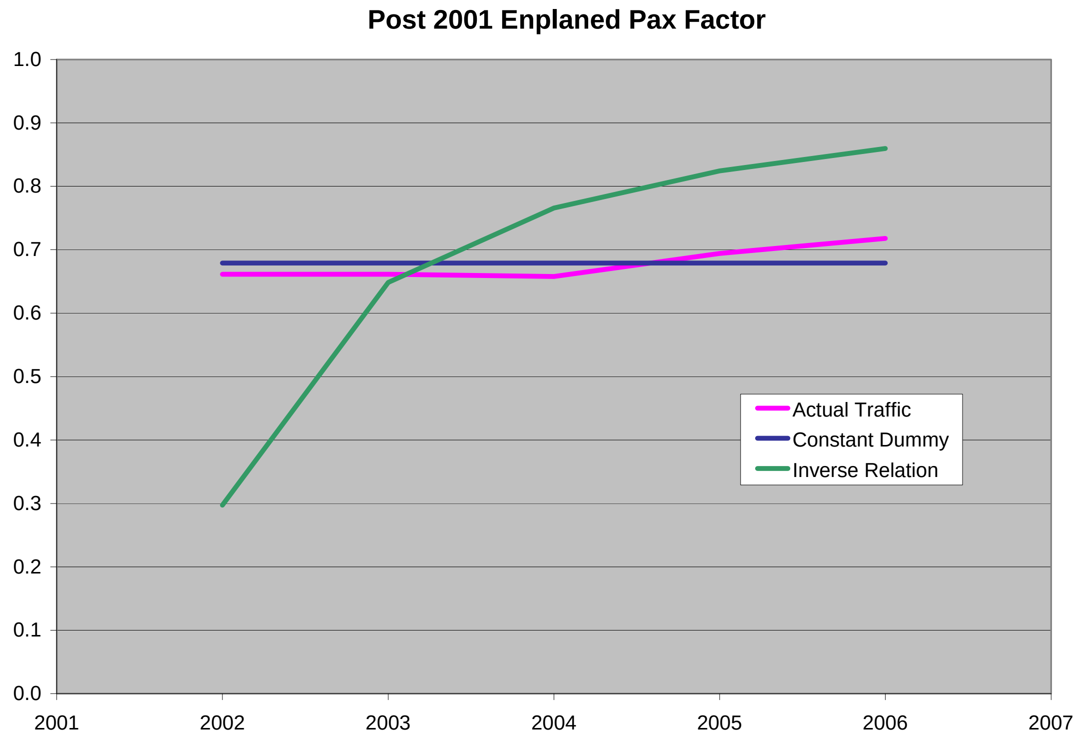


Figure A-1 Change in Post-2001 Enplaned Passenger Reduction Factor

It is clear from the relationships shown in Figure A-1 that a continuing reduction in the post-2001 effect is at least as valid a hypothesis for forecasting future traffic as that it remains constant. The efforts to develop a model with a reducing post-2001 effect used a function with such a rapidly declining effect that bore no relationship to the actual data, that the fact that this produced a poorer fit to the data is hardly surprising. However, equally, this is no reason to reject the approach of a declining function. There are obviously a number of other functions that would not only fit the data quite well, but better than a constant function. All of these functions would give significantly greater forecasts of future traffic.

Stability of the Enplaned Passenger Model Over Time

At the PAG meeting the question was raised whether the decline in passenger traffic after 2001 was really a reduction or whether the higher traffic levels after 1990 were unduly inflated by the dot-com bubble (or possibly some other effects). In order to test this hypothesis, the enplaned passenger model was re-estimated for the pre-1990 and post-1990 periods. The results are shown in Table A-1.

Table A-1 Stability of Enplaned Passenger Model Coefficients Over Time

Parameter	Full Model	1976-1989	1990-2000	1990-2006
Intercept	1.393	0.302	6.573	-3.495
Population	0.888	0.771	0.211	1.830
Per-capita income	1.042	1.089	1.223	0.236
US domestic yield	-0.548	-0.566		
PDX yield	-1.147		-1.436	-0.866
Dummy pre-1990	-1.828			
Dummy 2001	-0.293			-0.289
Dummy 2002 on	-0.387			-0.427

Key:
- (pink) t-statistic < 0.5
- (orange) t-statistic 0.5 to 1.5
- (yellow) t-statistic 1.5 to 2.0

Naturally the fit of the models for the separate periods is poorer than for the full period, since there are fewer years of data from which to estimate the coefficient values. However, the changes in the coefficient values for the different periods are noteworthy and have important implications for the use of the model for forecasting.

The changes in the model coefficients from the full model to the model for the period 1976 to 1989 are not particularly large (apart from the intercept, which will necessarily be very different to account for the exclusion of several of the variables in the model for 1976 to 1989). This suggests that the values of the coefficients for population and real per-capita disposable income are largely determined by the relationships prior to 1990.

The model for the period from 1990 to 2000 has a higher elasticity for airline yield than the full model, a higher elasticity of per-capita income (PCI), and a much lower elasticity of population. (In a log-linear model of the form adopted, the coefficients can be interpreted as the demand elasticity with respect to that variable.) However the coefficient for PCI has a fairly low statistical significance and the coefficient for population is not statistically significant at all.

Adding the years from 2001 to 2006 and introducing dummy variables for 2001 and 2002 on, as in the full model, changes the coefficients again, quite dramatically. The PDX yield elasticity drops to about –0.9, the population elasticity increases to about 1.8 and is reasonably statistically significant, while the PCI elasticity drops to about 0.2 and becomes statistically insignificant. As might be expected, the two dummy variable coefficients are highly statistically significant.

It is noteworthy that the PDX yield coefficient is statistically significant (although of very different values from the full model) in both the 1990 to 2000 model and the 1990 to 2006 models.

The changes in the coefficients of population and PCI between the period 1990 to 2000 and the period 1990 to 2006 (which includes the period from 1990 to 2000), combined with their general lack of statistical significance during this period suggests that their values in the full model are largely driven by the relationships prior to 1990, as noted above, and that the model does a much poorer job of reflecting their effect on traffic since 1990. The changes in the coefficient values when the six years from 2001 to 2006 are added to the prior 11-year period suggests that the dummy variables for 2001 on are capturing effects that should have been explained by changes in population and PCI (as well as potentially other variables not included in the model).

Conclusion

It is clear from the above analysis that the coefficients of the enplaned passenger model are largely determined by relationships between passenger traffic and the causal variables that pre-date 1990 and that the model does a fairly poor job of explaining the relationships since then. In particular, there is reason to think that the PDX yield elasticity since 1990 could be higher than estimated for the full model. This would be reasonable in the light of the fact that the increasing role of low-fare airlines since 1990 would have stimulated a lot of discretionary travel, which is likely to be very price-elastic.

There is also reason to think that the way the dummy variables for the period from 2001 are defined has not only underestimated the traffic recovery since 2004 but may have significantly distorted the coefficients for population and PCI for recent years. While it may be reasonable that the relationship between population and air travel has remained relatively stable over the full 31-year period since 1976, and thus basing the model on the relationship prior to 1990 may not significantly distort the forecasts, it is less obvious that the relationship between PCI and air travel would be stable over such a long period. The increasing role of low-fare airlines has opened up air travel opportunities to a broader segment of the population that may have a very different income elasticity from the typical air travelers before 1990. There may also have been shifts in the income structure of the population over the full 31-year period that would also impact the overall income elasticity.

It therefore appears likely that the enplaned passenger model used for the forecasts is not providing a very convincing explanation of the relationships between population, income and airline yield in recent years. While the model appears to fit the traffic data reasonably well since 1990, this is largely a consequence of the use of two dummy variables that effectively force the model to fit the data fairly well since 2000. The price that is paid for this fit is that the coefficients for the continuous variables are unable to properly reflect the recent relationship between those variables and the passenger traffic.

However, it is the coefficients of the continuous variables (and their implied elasticity of demand) that are driving the forecasts of future passenger traffic, and in particular the probabilistic analysis that is used to examine the likely future range of traffic under different assumptions for such factors as the price of oil and strategies to address climate change. What matters for the forecasts is not whether the model does a good job of explaining what happened from 1976 to1990, but whether it does a good job of explaining what is happening now, and more importantly what is likely to happen in the future.

APPENDIX B

Peer Reviewer Resume

Geoffrey D. Gosling, Ph.D.

Principal
Aviation System Consulting, LLC
Berkeley, California

Geoffrey Gosling is an independent consultant providing system planning, analysis and research expertise on a range of air transportation topics. He has a Ph.D. in transportation engineering from the University of California at Berkeley and has served as a consultant and expert witness in the areas of airport planning, aviation system planning, and airline economics to a variety of clients, including the Federal Aviation Administration, the Southern California Association of Governments, San Francisco International Airport, the State of California, the Government of Canada, and the Inter American Development Bank. From 1987 to March 2002 he was a member of the research staff of the Institute of Transportation Studies at the University of California, Berkeley and helped establish the National Center of Excellence for Aviation Operations Research, (NEXTOR) serving as its first program manager. He is a past chair of the Transportation Research Board Committee on Aviation System Planning and until early 2006 served as co-chair of the Working Group on Analytical Methods and Tools of the Global Aviation Information Network (GAIN), a government/industry partnership to promote and facilitate the sharing of aviation safety information. He has published a wide range of technical reports, journal papers, and other articles in various areas of transportation, and is a co-author of the book *Strategic Airport Planning*.