Innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 31

Innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

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FOREWORD

By Theresia H. Schatz
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ACRP Report 31: Innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions examines the aviation capacity issues in the two coastal mega-regions located along the East and West coasts of the United States. The Report suggests integrated strategic actions to enhance decision making to address the constrained aviation system capacity and growing travel demand in the high-density, multijurisdictional, multimodal, coastal mega-regions. New and innovative processes are needed if the aviation capacity issues in these congested coastal mega-regions are going to be successfully addressed. These high-density areas invite an entirely new approach for planning and decision making that goes beyond the existing practice for transportation planning and programming that is usually accomplished within single travel modes and political jurisdictions or regions.

This research will be useful for airport operators, regional transportation planners, and transportation agencies, as well as public officials at the federal, state, and local levels and other stakeholders involved in dealing with aviation capacity issues in the coastal mega-regions.

Most areas of the United States have plans and capabilities to meet projected aviation demand. However, this is not the case in the two mega-regions located along the East and West Coasts. A recently released Federal Aviation Administration study, *Capacity Needs in the National Airspace System 2007–2025* (commonly referred to as FACT-2) indicates metropolitan areas and regions along the East and West Coasts are experiencing large amounts of growth in population and economic activity that demonstrate chronic congestion problems in the air and on the ground. Based on the FACT-2 information, conditions in these two coastal mega-regions are projected to get worse in the future. Traditional approaches are unlikely to address these problems that extend beyond current jurisdictional and legislative authorities of existing agencies.

Current airport planning is done at three levels: (1) airport specific (master planning); (2) regional area (normally the geographic area corresponding to a metropolitan planning organization's jurisdiction); and (3) statewide system. Those focused plans are not sufficient to address capacity limitations when considering "mega-regions" of airports along the East and West Coasts. For example, the effects that the traffic from major airports within each of these coastal mega-regions have on each other need to be better understood. Optimizing available resources for the expansion of transportation infrastructure to accommodate anticipated growth should be a key consideration.

This research effort was conducted by Resource Systems Group, Inc., as the prime contractor, with Matthew A. Coogan, an independent consultant in transportation, serving as Principal Investigator, and with the assistance of University of California at Berkeley and several private consultants.

CONTENTS

EXECUTIVE SUMMARY

Innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions

Background

A major study undertaken by the FAA, known as the FACT 2 Report (*1*), suggested that the nation's airports will be able to provide for adequate aviation capacity in the United States to the year 2025, except for two major areas on the East and West Coasts. As noted in the Project Statement:

> FACT 2 indicates metropolitan areas and regions along the east and west coasts are experiencing large amounts of growth in population and economic activity that demonstrate chronic congestion problems in the air and on the ground. Based on the FACT 2 information, conditions in these two coastal mega-regions are projected to get worse in the future. Traditional approaches are unlikely to address these problems that extend beyond current jurisdictional and legislative authorities of existing agencies. (*2*)

ACRP Report 31: Innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions was created to examine the nature of the problem of addressing aviation capacity issues in the two coastal mega-regions.

Objectives of the Research

This Executive Summary provides a capsule summary of the content of each of the six chapters of *ACRP Report 31.* Specific suggestions for action or further research are presented in the summary of Chapter 6, where they are included in more detail in the main body of the text. Each of the major conclusions was created in order to carry out the objective of this research:

> The objective of this research is to identify potential actions to address the constrained aviation system capacity and growing travel demand in the high-density, multijurisdictional, multimodal, coastal mega-regions along the east and west coasts.
>
> New and innovative processes/methodologies are needed if the aviation capacity issues in these congested coastal mega-regions are going to be successfully addressed. These high-density areas invite an entirely new approach for planning and decision making that goes beyond the existing practice for transportation planning and programming that is usually accomplished within single travel modes and political jurisdictions or regions. (*2*)

Questions Addressed

The Executive Summary presents a shortened presentation of the results ACRP Project 03-10, which deals with the following four questions:

1. Is there a long-term crisis in aviation capacity in the coastal mega-regions, and is the basic premise of an overarching problem valid? If present patterns were simply continued, what would be the cost of doing nothing?
2. Is there a need for better integrating the aviation planning process with the other modes, with a particular emphasis on the emerging role of high-speed rail (HSR)? Does the scale of possible impacts merit an alteration of the aviation planning process? Might major advances in alternative transportation modes obviate the need for dealing with aviation capacity issues?
3. What changes could be made in the aviation planning process to make it more relevant to the public policy questions now being asked, which might demand alternative geographic focus and alternative tools and methods?
4. Given that some solutions to the issue of aviation capacity will require new multimodal and multijurisdictional strategies, are reforms on new approaches needed within the industry to better manage the airports that already exist?

Four Conclusions of ACRP Report 31

The Executive Summary is structured around the presentation of the four main conclusions of the research. In the report, they are presented in the following order:

1. *Under the present relationship between the airports and the airlines, there is a serious lack of usable aviation capacity in*

the mega-regions. Chapter 1 builds the case that there is a growing problem in the mega-regions and that the economic and environmental cost of doing nothing is significant. Without a proper response to the revealed problems, the basic validity of the long-term capacity forecasts must be considered to be in doubt. The chapter concludes that a new approach is needed.

2. *To gain access to alternative forms of short-distance trip-making capacity, the aviation planning system could benefit from becoming more multimodal.* Chapter 2 reviews the extent to which aviation planning is inherently intertwined with the planning and analysis of capacity increases in other longer distance modes, specifically HSR and highway planning.
3. *To gain better utilization of existing underused capacity at smaller airports in the region, the aviation capacity planning system could benefit from becoming more multijurisdictional.* Chapter 3 analyzes briefly the market potential of some smaller scale regional airports to provide additional capacity to the systems in the mega-regions, provided that the operating carriers decided to take advantage of their presence. The chapter examines the importance of gathering and analyzing data on a multi-airport, super-regional basis and shows examples of how such new regional aviation planning tools could be used.
4. The research has concluded that the current system suffers from unclear responsibility; *no one has the authority and accountability for the management of congestion at mega-region airports.* Chapter 5 builds the case that capacity in the mega-regions will be significantly increased only when the managers are empowered to solve the problem. The chapter concludes that the management of existing resources could be improved and that this represents the most important single element in a larger strategy to deal with potential aviation capacity issues in the coastal mega-regions.

An Overarching Theme in the Research

The conclusions and suggestions of the research share (to a varying degree) a common theme. The report concludes that the aviation planning process could benefit from becoming more user-oriented, more transparent, and, thus, more accountable. If the unreliability of service at a given airport reaches a "trigger point," the operating rules could be changed to regain the lost level of reliability for the benefit of the user. If the service levels of HSR, as experienced by the user, provide a superior overall product for the customer, that customer should be encouraged to select the higher quality good. If the planning process can explain why a given customer would reject use of a "reliever" airport, that process could muster the market research tools of user preference/choice to form policies to facilitate a change in those service conditions. If major agencies can learn to organize their most basic planning data in a manner that can be shared with others, a user-based description of demand can be assembled, replacing a modally based format for the benefit of all.

Responsibilities for providing reliability in air services should be transparent and accountable. Thus, those responsible for aviation planning should take steps to clarify the issue of accountability and bring it closer in format and method to the established continuing, comprehensive, cooperative planning process, which, in theory, applies to all the ground transportation modes.

Summary of Chapter 1—Defining the Issues: Defining the Problem

Chapter 1 presents an overview and introduction to the four major themes developed in the project (see Exhibit S1 for highlights and key themes included in Chapter 1). Chapter 1 also introduces the two study areas in terms of their geography,

- There is a major problem in the provision of effective aviation capacity in the coastal mega-regions, and the economic impacts of doing nothing are significant.
- The number of air trips within the West Coast study area is vastly higher than the number of air trips within the East Coast study area, even though their geographic area is similar.
- The present amount of air travel delay is vastly higher in the East Coast study area than in the West Coast study area, even though the intra-area volumes are much lower.
- Using a range of economic assumptions, the "cost" of present air travel delay in the coastal mega-regions ranges from a low of about $3 billion per year to a high of over $9 billion per year (2007).
- Using the same range of assumptions, the cost of air travel delay in the future (2025) would range from about $9 billion to about $20 billion, if none of the present capacity constraints were addressed—that is, the cost of doing nothing.
- Much of the aviation industry's capacity forecasting assumes that, by one means or another, a process of up-gauging of aircraft will occur: the research team did not find any support for the assumption that systematic up-gauging of aircraft will occur without some form of public policy intervention.

Exhibit S1. Highlights and key themes included in Chapter 1.

demographics, and propensity for shorter air trips within and between their mega-regions.

The Geographic Scale of the Mega-regions

The East Coast study area generally includes the states from New England in the north to Virginia in the south. Thus, the term *East Coast study area* includes all of the geography contained in the states between Maine and Virginia. The term *Eastern Mega-region* refers to the areas covered by the Boston region airports to the north and to the areas of Richmond and Norfolk, VA, to the south. The western edge of the Eastern Mega-region incorporates Syracuse, NY, and Harrisburg, PA.

The West Coast study area includes all of California and Clark County, Nevada. The term *Northern California Mega-region* refers to the Bay Area region and the Sacramento region. The term *Southern California Mega-region* refers to the Los Angeles Basin area, the San Diego region, and Clark County (NV) together.

Distances. Each of the two maps (Figures S1 and S2) is presented at similar scale: in the East Coast study area, the northernmost mega-region airport, MHT (Manchester, NH), is about 487 miles from the farthest airport (Richmond, VA). In the West Coast study area, the distance from the Sacramento airport to the San Diego airport is 480 miles.

Population. In terms of population, the two study areas are not so similar. The East Coast study area has about 69 million inhabitants, whereas the West Coast study area has about 38 million. This difference is explored in Chapter 1 where the number of internal aviation trips within each study area is compared. The results are startling and point to real differences in the transportation behavior of the two coastal regions.

The Scale of Air Travel within the Two Study Areas

This section of the Executive Summary deals with the city-pair volumes of existing air travel, which are perhaps better described as "metro-region pair" passenger volumes between "families of airports." Classic origin–destination (OD) "desire lines" are presented for the East Coast study area and the West Coast study area, making possible a startling comparison of the aviation passenger volumes between the two coastal areas.

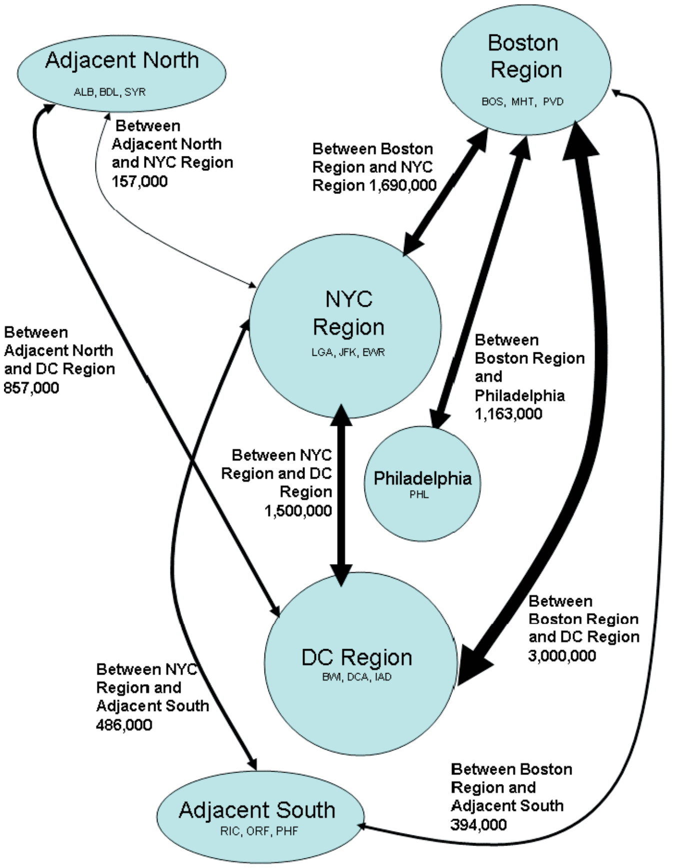
Metro-area to Metro-area Pair Air Passenger Flows within the Eastern Mega-region

Figure S3 summarizes air passenger travel within the East Coast study area between January and December 2007. It can be best understood as a desire line diagram showing the flows between airports of origin to the airports of destination of somewhat under *10 million air trips.* People making trips between Manchester, NH, and Richmond, VA, may undertake this trip by transferring at a point such as Newark (EWR), LaGuardia (LGA), or Philadelphia (PHL). From the vantage point of OD analysis, they are portrayed here as flows between the Boston region family of airports and the Richmond/Norfolk family of airports. These East Coast aviation flows are examined on an airport-by-airport basis in Chapter 4 of the report. (NB: The lack of a line between two areas in Figure S3 means that the number of air trips is insignificant.)

Metro-area to Metro-area Pair Air Passenger Flows within the West Coast Study Area

Air passenger travel within the West Coast study area between January and December 2007 is summarized in Figure S4. It can be best understood as a desire line diagram showing the flows between airports of origin to the airports of destination

Figures S1 and S2. The geographic extent of the East Coast study area and the West Coast study area (scale is constant) (3).



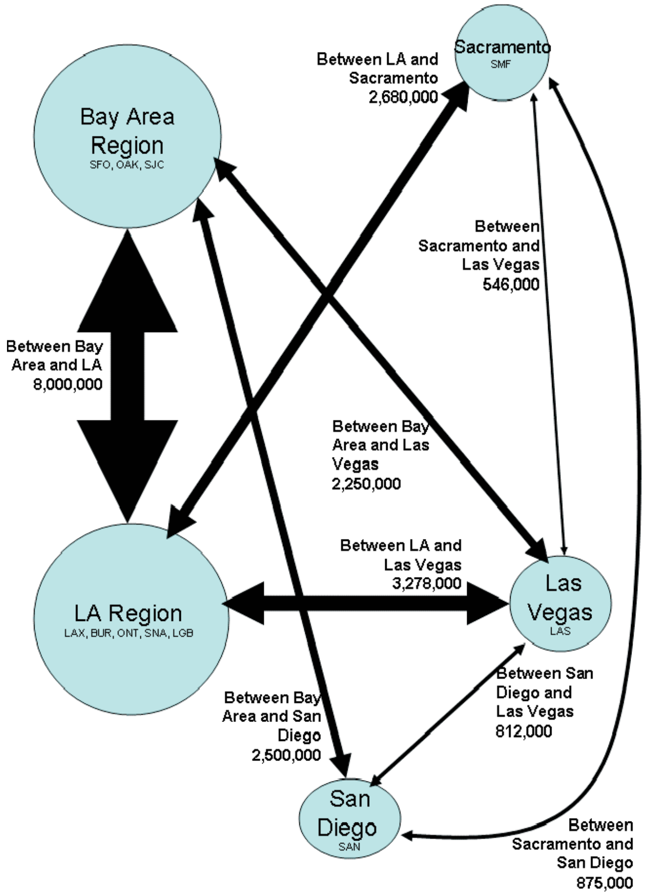
Note: The absence of a line between two areas means that the number of air trips is insignificant.

Figure S3. Air passenger flows between metro regions in 2007: East Coast (4).

of about *20 million air trips.* As in Figure S3, flows are expressed from their airport of origin to their airport of destination without reference to possible use of transfers or connections. These lines represent the flow of airport passengers between the large metropolitan areas and other large metropolitan areas. These West Coast aviation flows are examined on an airport-by-airport basis in Chapter 4 of the report.

Implications of Scale between the Two Study Areas

The first observation about our two study areas is that the West Coast generates about twice the volume of short-distance air passengers than does the East Coast. And within the West Coast study area, it is the air trips between the Bay Area family of airports to the north and the Los Angeles Basin family of airports to the south that dominate the travel. The Los Angeles Region, served by LAX, Burbank, John Wayne, Long Beach, and Ontario together, generates 8 million trips to or from the Bay Area region, which is served by the airports of San Francisco (SFO), Oakland (OAK), and San Jose (SJO).



Note: The absence of a line between two areas means that the number of air trips is insignificant.

Figure S4. Air passenger flows between metro regions in 2007: West Coast (4).

In terms of coast-versus-coast comparison, the volume of air travelers between the Los Angeles Region and the Bay Area Region is more than five times the air traveler volume between the New York region family of airports and the Washington/Baltimore family of airports. It is almost five times the volume between the Boston region family of airports and the New York region family of airports. It is also clear that air travelers on the West Coast have a short-distance trip generation rate that is more than three times that of those of the East Coast.

The Scale of the Problem of Airport Congestion in the Mega-regions

The research team has estimated that the phenomenon of aviation congestion associated with 11 of the largest airports in the two coastal study areas resulted in passenger-perceived delays calculated in the billions of dollars in 2007.

Importantly for the interpretations included in *ACRP Report 31,* those delays were not evenly divided between the two coastal study areas. Figure S5 shows the sharp differences in the delay patterns of the two coastal study areas. The “Total Delay Index” (Figure S5) has been calculated by the research

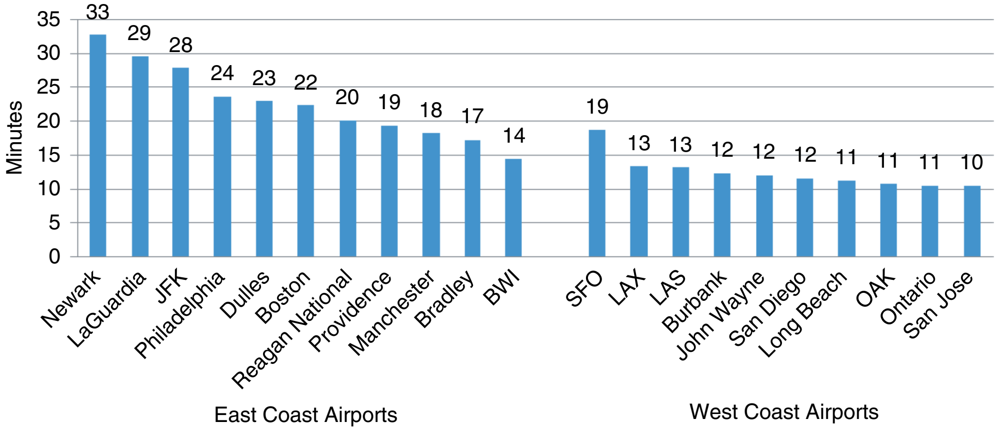


Figure S5. Total delay index for East Coast and West Coast airports, expressed as minutes per passenger trip (5).

team as the average frequency of delay times average duration of delay, plus the average frequency of cancellation times a value of 3 hours delay per cancellation. It is expressed as number of minutes of delay per total airport passenger. The index was calculated from Bureau of Transportation Statistics (BTS) Transtats data (*5*), for the 12 months of 2007.

The higher volumes are on the West, but the greater congestion is on the East, as shown in Figure S5. In short, there is no simple formula that suggests that higher amounts of short-distance air travel are linearly associated with higher levels of airport congestion. The causes of the delay need to be examined more carefully, as will be addressed in Chapter 5.

The Perceived Costs of Delay Times at the Mega-region Airports

The project undertook an estimation of the perceived costs of aviation delays. Based on a recent study by Resource Systems Group, Inc., (RSG), (*6*) special survey and modeling techniques were developed to measure the trade-offs (also called marginal rates of substitution) between the various components of service associated with air itineraries, resulting in a new measure of the value of time. From these calculations, values of time (VOT) to represent the perceived costs of aviation delays were calculated.

The RSG study found that the average VOT for domestic air travelers is approximately $70/hour for travelers on business trips and $31/hour for non-business trips. For the air travel market, which is split roughly between business (40%) and non-business (60%), the weighted average VOT is approximately $47/hour. That is, air passengers on average are willing to spend an additional $47 in higher fares to save an hour of travel time or, conversely, will be willing to accept an hour of additional travel time for a fare reduction of $47.

Between the years 2003 and 2007, the average on-time performance at the 12 largest coastal mega-region airports decreased on average by over 10 points. Applying the 2003 on-time performance benchmark, this means that the aggregate perceived cost across all boardings at the 12 airports of the performance decline in 2007 is approximately $3.9 billion/year (see Table S1).[1]

The Cost of Doing Nothing

In interviews with airport managers, managers of the forecasting process, and other leaders in the field, it became clear that in almost every case, in one manner or another, the optimistic assumptions about the amount of capacity that will be available in 2025 were based on the intuitive belief that, as demand grows over time, this will be matched by a voluntary program of up-gauging of the size of aircraft flown to the subject airport—currently a matter almost entirely under the control of the airlines, not the airport managers.

The research team devoted considerable attention to the economic and environmental implications of continuing with the present pattern of degradation in service quality in the mega-regions. The Report includes a new analytical procedure that examines the implications of having attained no solutions to the issues discussed in this project. The reader should be aware that these calculations are not based on the same set of assumptions as the FACT 2 study, which did explicitly deal with changes in capacity and operations that might come into play between now and 2025. Rather, the work of the research team predicts the future conditions

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[1] Chapter 2 reports on a wide range of definitions for these values: using methods adopted in a U.S. Senate Report, the total cost of delays for coastal airports is calculated at almost $15 million.

Table S1. 2007 Airport flight delay cost estimates (*4, 5*).

Airport	On-time 2003 (%)	On-time 2007 (%)	2003 Boardings	2007 Boardings	2007 Flight Costs (2003 On-time Benchmark) ($)
Baltimore, MD (BWI)	83	77	10,200,000	11,000,000	138,000,000
Boston, MA (BOS)	83	75	11,100,000	13,800,000	209,000,000
Las Vegas, NV (LAS)	85	76	17,800,000	23,100,000	379,000,000
Los Angeles, CA (LAX)	89	80	27,200,000	30,900,000	526,000,000
New York, NY (JFK)	83	69	15,900,000	23,600,000	633,000,000
New York, NY (LGA)	84	72	11,400,000	12,500,000	299,000,000
Newark, NJ (EWR)	83	68	14,800,000	18,200,000	519,000,000
Philadelphia, PA (PHL)	79	70	12,100,000	15,900,000	289,000,000
San Diego, CA (SAN)	88	83	7,700,000	9,400,000	98,000,000
San Francisco, CA (SFO)	89	76	14,400,000	17,600,000	438,000,000
Washington, DC (DCA)	88	77	6,900,000	9,100,000	183,000,000
Washington, DC (IAD)	82	74	8,200,000	11,900,000	182,000,000
			157,500,000	197,000,000	3,894,000,000

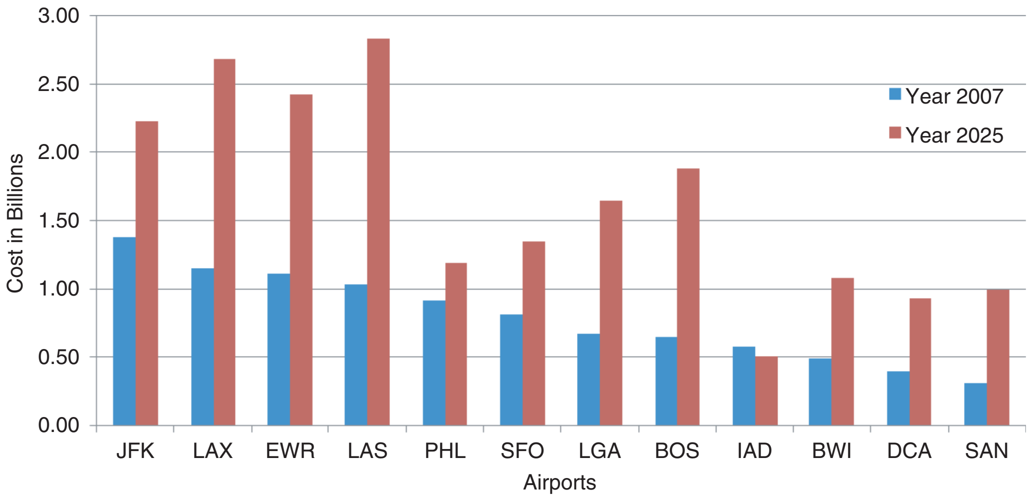

Figure S6. The cost of doing nothing: increase in passenger delay costs 2007–2025, assuming no resolution of key issues (based on Tables S1 and S2).

based strictly on the scenario that solutions are not found and implemented, as shown in Figure S6.

Between the years 2003 and 2025, the average on-time performance at the 12 largest coastal mega-regions airports is estimated to decrease on average by 25 points. Of course, this assumes status quo operating conditions (no capacity increases, etc.) and assumes air traffic growth as projected in the FACT 2 report. Applying the 2003 on-time performance benchmark, this means that the aggregate perceived cost of missed flight connections and other costs across all boardings at the 12 airports of the performance decline in 2025 is over \$12 billion/year (see Table S2).[2]

Chapter 1 concludes with a concern that the amount of 2025 aviation capacity assumed by leaders in the aviation community may be based, at least in part, on the working assumption that, as demand increases, a voluntary program of aircraft up-gauging can be expected to take place. Given the overall decrease in the average size of aircrafts over the past decade, it is clear that this assumption needs more analytic attention. This issue is addressed in Chapter 5, after the presentation of a review of both multimodal and multijurisdictional issues facing the industry.

Summary of Chapter 2—Aviation Capacity and the Need for a Multimodal Context

This research has concluded that, to gain the benefit of capacity provision by other high-quality inter-city transportation modes, the aviation capacity planning system could become

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[2] All 2025 costs cited here are in 2007 dollars. If a lower VOT used in FAA studies were applied to the 2003 benchmark assumption, a "low range" estimate of about \$9 billion would result. If assumptions made in a U.S. Senate report were used, a "high range" estimate would exceed \$20 billion.

Table S2. 2025 airport flight delay cost estimates (*1, 4, 5*).

Airport	On-time 2003 (%)	On-time 2025 (%)	2003 Boardings	2025 Boardings	2025 Flight Costs (2003 On-time Benchmark) ($)
Baltimore, MD (BWI)	83	61	10,200,000	14,900,000	613,000,000
Boston, MA (BOS)	83	53	11,100,000	21,100,000	1,212,000,000
Las Vegas, NV (LAS)	85	54	17,800,000	32,900,000	1,899,000,000
Los Angeles, CA (LAX)	89	63	27,200,000	38,800,000	1,898,000,000
New York, NY (JFK)	83	58	15,900,000	27,800,000	1,343,000,000
New York, NY (LGA)	84	54	11,400,000	18,800,000	1,082,000,000
Newark, NJ (EWR)	83	48	14,800,000	25,000,000	1,617,000,000
Philadelphia, PA (PHL)	79	62	12,100,000	16,700,000	533,000,000
San Diego, CA (SAN)	88	63	7,700,000	14,400,000	667,000,000
San Francisco, CA (SFO)	89	66	14,400,000	20,800,000	910,000,000
Washington, DC (DCA)	88	60	6,900,000	12,400,000	639,000,000
Washington, DC (IAD)	82	79	8,200,000	12,800,000	82,000,000
			157,500,000	256,300,000	12,496,000,000

more multimodal. Chapter 2 reviews the extent to which aviation planning is inherently intertwined with the planning and analysis of policy changes in other longer distance modes, specifically HSR and highway planning (see Exhibit S2 for highlights and key themes included in Chapter 2).

There are key conclusions from this portion of the research on two very different levels. First, the report reviews key results and conclusions concerning the potential scale of candidate HSR investment in the East and West Coast mega-regions. Then, the report reviews the rationale for integrating the aviation capacity planning process with that of HSR and more general surface transportation planning.

Intermodal Considerations

The federal government is now committed to an increase in federal participation in HSR projects of at least $8 billion (over and above previous investment commitments). The implications of this federal commitment for the need to undertake detailed multimodal analysis in such corridors as Boston–NYC, NYC–Washington, D.C., and SFO–LAX are immediate in nature and urgent in their ramifications for intermodal and multimodal policy making.

In the long-term planning period, the research concludes that the implications of possible HSR investment on aviation flows could be massive in scale, with a possible diversion of 10 million aviation passengers in California alone, more than 1 million to/from Las Vegas, and more than 3 million in the Northeast Mega-region. The scale of these numbers suggests that the aviation planning process should explicitly and overtly consider various HSR policy options as input variables for the forecasting process.

The potential impact on aviation volumes from the kind of HSR systems now under policy review is significant. A recent

- The aviation planning process could benefit from becoming more multimodal in nature.
- Plans for HSR investment now under consideration in both coastal mega-regions could result in a total diversion of up to 15 million air trips per year in the long term.
- The scale of diversion in the established literature is much higher in the West Coast study area than in the East Coast study area.
- Analysis undertaken in the EU shows that, when city-center to city-center rail times can be decreased to under 3.5 hours, rail can capture more market share than air.
- In some cases, such as Frankfurt–Cologne, HSR acts as a feeder for long-distance flights; in other cases, such as Frankfurt–Stuttgart, rail does not: the role of rail in a complementary mode should be studied further.
- High-speed rail can decrease the number of air travelers; without better management of the airports, this may not result in a decrease in flights.
- Although no breakthrough in highway capacity will change the need for air travel, the highway planning process could be better integrated with aviation capacity planning; better long-distance travel data will result when the two planning processes are combined.

Exhibit S2. Highlights and key themes included in Chapter 2.

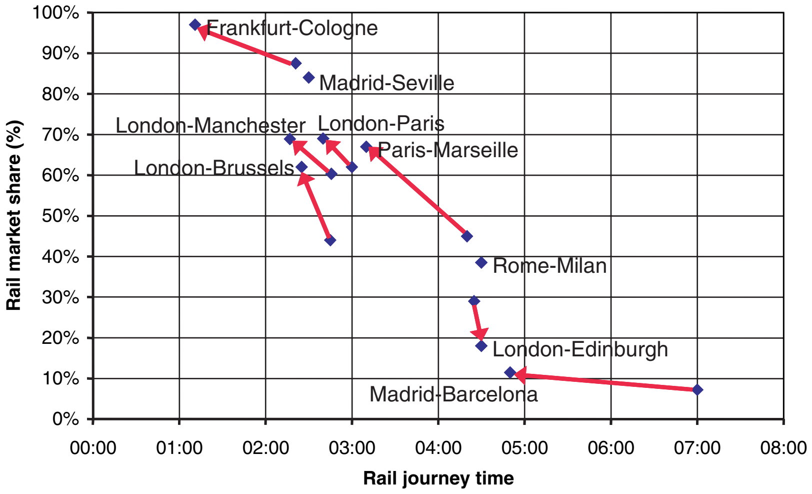

Figure S7. EU study of impact of change in rail travel time on air plus rail market share (7).

study from the EU undertaken by the British consulting firm Steer Davies Gleave (*7*) shows that rail services with city center to city center travel times of under 3½ hours can result in rail capturing a larger market share than air. Figure S7 shows that as rail journey time is improved (moving to the left on the x-axis) that market share of the rail plus air market increases (moving upward on the y access).[3]

This report has reviewed the available literature on potential diversions from air. Chapter 2 shows that the forecast diversions are greater on the West Coast than on the East Coast. This is in part because the intra-region air passenger volumes in the West are twice the scale of those in the East. It also reflects that a major diversion to rail has already occurred along the Northeast Corridor.

Scale of Diversions from Air to Rail in the West Coast Mega-regions

Much of the predicted air diversion in California would come from three major market corridors. Looking at the year 2030 forecasts undertaken for the California High Speed Rail Authority, and managed by MTC, (*8*) if there were about 25 million travelers between the Bay Area and Los Angeles, the reported decrease in market share (compared with the present share) would represent about 5 million air passengers diverted to rail. If there were about 14 million travelers between Los Angeles and Sacramento, air would capture 3.6 million, or 2 million passengers would be diverted to rail. If there were about 7.5 million travelers between the Bay Area and San Diego, air would capture about 3.4 million, or about 1.8 million passengers would be diverted to rail. At this point in the analysis, these diversion potentials are somewhat speculative and are presented here only to give a sense of scale to the possible diversion phenomenon.

Total system diversions. The California analysis is based on 65 million interregional HSR riders and 20 million intraregional HSR riders (*9*). Of the interregional trips, the California forecasting process calculates that 79% were diverted from auto, 16% were diverted from air, 3% diverted from other rail, and 2% never made the trip before. Thus, for the ambitious system as a whole, a high-end estimate is that more than 10 million riders are projected by the project proponents to divert from air in the analysis year of 2030.

Scale of Diversions from Air to Rail in the East Coast Mega-region

On the East Coast, a wide variety of sources were examined together for Chapter 2: a key U.S. DOT study forecast that moderate improvements to HSR between Boston and Washington, D.C., would divert an additional 11% of air passengers in that corridor; with the assumption of European-style HSR travel times, the diversion factor would be almost 20% of air volume (*10*).

Entirely on the basis of published forecasts (*10, 11, 12*), the research team assembled a very early and very preliminary estimate of upper limits of diversion from air that might be expected from an assertive program to transform the existing Northeast Corridor (NEC) into a European-style HSR system and to extend that concept to the many feeder corridors adjacent to the existing high-speed service area.

Chapters 2 and 4 present some of the first summary assessments of the impact of alternative HSR system assumptions on airport-to-airport flows and total East Coast study area flows.

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[3] Chapter 2 notes that since the publication of this graphic, better travel times and rail market shares have been established in Spain.

Table S3. Possible diversions from air to rail in the East Coast Mega-region (*10–12*).

Markets and Diversion Rates		Air Passengers; Base Case, No Diversion		Air Passengers Diverted to HSR: Low Diversion		Air Passengers Diverted to HSR: High Diversion	
Market	**Corridor Used for Diversion Rates***	**2007**	**2025**	**2007**	**2025**	**2007**	**2025**
Adjacent North–D.C.	Partial Empire/NEC	929,540	1,590,703	92,955	159,072	228,121	390,379
Adjacent North–PHL	Partial Empire/NEC	116,030	294,356	11,603	29,436	28,475	72,239
Adjacent North–Adjacent South	Partial Empire/NEC	113,200	194,767	11,320	19,477	27,781	47,798
Boston–D.C.	NEC	1,814,090	3,212,528	199,550	353,378	489,716	867,227
NYC–Albany/ Rochester	Full Empire/NEC	339,810	669,774	33,981	66,978	83,394	164,371
NYC–D.C.	NEC	1,503,440	3,049,680	165,378	335,465	405,856	823,266
NYC–BOS	NEC	1,680,870	3,253,951	184,896	357,935	453,753	878,409
NYC–Adjacent South	NEC/Partial SEC (Southeast Corridor)	484,520	969,040	49,468	98,935	121,398	242,797
PHL–BOS	NEC	579,390	1,119,553	63,733	123,151	156,407	302,225
NYC–Harrisburg	Partial Empire/NEC	880	1,935	88	193	216	475
		7,561,770	**14,356,286**	**814,979**	**1,546,045**	**1,997,125**	**3,791,210**

Definitions: Adjacent North= BDL, ALB, and SYR. Adjacent South= RIC, ORF, and PHF; from Figure 2.9

*Diversion rates by CRA International.

That early analysis suggested a total potential diversion of between 1.5 million (low estimate) and 3.8 million (high estimate) air travelers as a result of system-wide implementation of HSR throughout the East Coast Mega-region, as shown in Table S3. This number could be compared, in theory, with the 11 million air travelers forecast to be diverted in California and Nevada. Chapter 2 notes that much of the "diversion" to rail in key East Coast markets has already occurred, which helps to explain some of the difference in scale between East and West Coast levels of potential diversion from air.

At the same time, the project concluded (see Chapter 4) that the levels of diversion *on an airport-specific basis* do not support the concept that the provision of HSR in either corridor will make the problem of airport congestion disappear. The research team's very preliminary analysis of possible decreases in airport boardings ranged from a high of 6% at SAN, to under 1% at JFK and at EWR.

What Happened in Response to the Diversion of Air Passengers?

Parallel with the dramatic rise in Amtrak ridership over the past decade, air traffic between BOS and the NYC region (two directions) fell by more than 750,000 passengers, as shown in Table S4 (reported in one direction). Most of these moved to rail, which raised its ticket price; some rail riders (simultaneously) moved to low-fare bus carriers. But the impact on airport and airspace congestion is more complicated than implied by these basic observations. Although the number of passengers declined sharply, the number of planes did not. Looking just at BOS–LGA (home of the original two shuttle operators), the number of planes declined only by about 4%, responding to a corresponding passenger decline (for several reasons) of about 40%. In this period, the average aircraft size fell by about 30% for the BOS–LGA route.

There are two powerful "lessons" from the Boston–New York case study. First, the implementation of alternative policies toward HSR could have massive impacts on air passenger demand and should be explicitly modeled in the aviation forecasting process. Second, the expected "diversion" from air to rail cannot be seen as automatically causing any kind of linear, parallel impact on the number of planes in the subject corridor. This underscores the essential message of Chapter 5: the primary issue in aviation capacity in the two mega-regions concerns the need for airport managers to have more control

Table S4. Change in air passengers from BOS to NYC (*4*).

AIR PASSENGERS	1993	1999	2007
BOS to EWR	302,160	300,300	145,050
BOS to JFK	62,090	58,420	176,790
BOS to LGA	704,550	868,790	512,980
Total BOS to NYC	*1,068,800*	*1,227,510*	*834,820*

and more accountability for improving the throughput of their facilities. The research summarized in Chapter 2 suggests that only a *combination* of lowering actual air travel with a well-developed program to optimize the efficiency of the airports will bring about the policy objective of lowering congestion and producing the kind of 2025 aviation capacity the industry has been seeking.

Rail as a Complementary Mode to the Aviation System

Because of an extensive literature base on the subject of potential air passenger diversion from new HSR services from city center to city center, it has been possible to establish a sense of scale for the amount of possible diversions from air passenger traffic, and to briefly observe how the market has responded in one case study corridor (BOS–NYC). The same is not the case for analyzing the potential role of intercity rail in providing short-distance feeder service to airports providing long-distance air trip segments.

In theory, rail services could provide a complementary function in which short-distance intercity feeder services are provided to the airport, with precious slots freed for profitable use in longer distance services. In fact, however, the number of cases where the rail services have become feeder services to the exclusion of flights on that city-pair are few. To better understand the ability of intercity rail services to (a) feed longer distance flights and (b) decrease the actual number of short flights in the impacted airport, the project undertook a comparison of the highly integrated AIRail ticketing program offered by Lufthansa German Airlines between Frankfurt Airport and Cologne (90 miles to the north) and the same program offered between the airport Stuttgart (90 miles to the south).

As documented in Chapter 2, the joint ticketing project resulted in the abandonment of short flights in one case, Frankfurt Airport–Cologne (Figure S8) and no abandonment of short flights in the other, Frankfurt Airport–Stuttgart. This case study in air/rail complementarity shows that the concept is indeed viable (based on the Cologne leg), but that the airline will be driven by more concerns than just the quality of the services offered on the short leg of the trip; the decision not to abandon the short feeder flights to Stuttgart was based on a concern for market competitiveness for the profitable long-distance flight segments. The case study suggests that the public perception of rail for short-distance feeder service is still perceived as a good that is either inferior to the short-distance air segment or is simply not understood by the market.

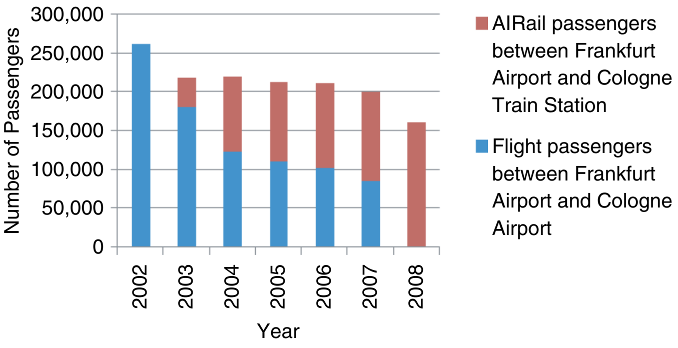

Figure S8. Rise in AIRail market share between Frankfurt airport and Cologne train stations (13).

The research team found the literature base to be distinctly weaker, and of generally lower quality, on the subject of rail services in a complementary mode to support longer distances air services at major airports than for city-center to city-center markets. In carrying out the work program for the preparation of this report, it has become clear that the technical base for analyzing rail services as part of an intermodal passenger trip is weaker than for other aspects of this project. In Chapter 6, the report suggests that the passenger rail and aviation communities should work together to better document the potential of intercity rail services to provide short-distance feeder access to long-distance flight segments.

The Adequacy of the Planning Process to Support Investment in Long-Distance Services

The research team concluded that the present level of coordination of alternative long-distance modes could benefit from a fundamental restructuring. The general state of data on which to base policies and judgments concerning the longer distance trip (i.e., beyond the metropolitan area or beyond the state borders) is lacking. That decisionmakers are being asked to allocate $8 billion to HSR, and even greater amounts to highways, with an absence of a common data source for interstate and interregional trips is of concern.

There is at present no publicly owned data set that describes county-to-county (or even state-to-state) automobile vehicle trip flows on a multistate basis. In this manner, the multimodal analysis capacity is far behind the MITRE FATE forecasts (*1*), which have created national county-to-county aviation trip flows. As a result, the mode share of airline trips as a portion of total trips *is not documented even for the largest, most dominant city-pairs.* This poses a challenge to even the best-intentioned analyses of longer distance travel.

Until very recently, airport forecasting has been focused on an airport-specific approach to demand. The shift to a county-of-origin to county-of-destination forecasting approach included in the FACT 2 study is laudable and should be widened considerably to accommodate recent policy and funding changes. It could benefit from becoming more multimodal in nature, to be merged with similar work from other modes. In many cases, modal agencies use elaborate descriptions of multistate travel, but these resources are not made available to the public for business reasons. The result is that the quality of public debate suffers from a lack of a continuous, comprehensive, and cooperative process.

To begin to develop the kinds of multimodal tools envisioned in this research, the research team has taken the first step in the development of county-to-county aviation trip tables reflecting the true origin and true destination of the tripmaker, as discussed in the Executive Summary under Chapter 3. Ultimately, the organization of aviation data in a format consistent with the requirements of the continuing, comprehensive, and cooperative planning process required for ground modes will support the development of a new, multimodal transportation planning process for the longer distance trip, including aviation.

Summary of Chapter 3—Multijurisdictional Issues in Aviation Capacity Planning

The research has concluded that changes could strengthen the aviation planning process in two dimensions. As discussed in the summary of Chapter 2, aviation decision making could benefit by being integrated with the decision-making process for the other long-distance modes—most notably, HSR and highways. Chapter 3 focuses on the opportunity for aviation planning to reach beyond the present boundaries of the airport at two scales, both of which can be described as multijurisdictional (See Exhibit S3 for highlights and key themes included in Chapter 3).

Gaps in the Current System Planning Process

First, national planning efforts may need to be augmented to a mega-regional scale to understand and model multimodal alternatives on a corridor-specific basis. Although it could be argued that gaining a full understanding of modal alternatives between the Bay Area and the Los Angeles Basin in the West Coast is fundamentally a national planning issue, extensive modeling of highway and rail alternatives (both data-intensive activities) will result in a geographic focus that takes the form of a mega-region, not a national model. To this end, the U.S. DOT commissioned a series of "Corridors of the Future" in which individual states are encouraged to form multistate, corridor-based joint planning efforts.

Second, what is often referred to as regional aviation planning needs to focus on a logical geographic area whenever there is a potential application of the "family of airports" concept brought to fruition by the New England Regional Aviation Systems Project (NERASP) (*15*).

The interviews with airport managers (Appendix A in the report) revealed that, with rare exceptions, the present system planning does not fill the gap between airport-based planning and national planning. Most airport executives reported that they are only slightly affected by regional planning.

Currently, no public agency is tasked with analyzing and presenting the needs and expectations of the longer distance travelers in the metropolitan areas. Topics that are not addressed include travel preferences in terms of markets and frequency of service as well as airport preferences in terms of accessibility and reliability. These topics are the logical starting point for a revitalized metropolitan (or a possible supra-metropolitan) system planning process that would monitor traveler expectations and document certain benchmark levels of measured performance.

A passenger-centric planning process could provide analytic support to airport planning and empower those officials who are interested in maximizing the satisfaction of travelers from the surrounding region. Such a multijurisdictional planning process could address such issues as benchmarking airport

- There is a gap in planning coverage between the scale of on-airport planning and national aviation planning: regional planning efforts have not yet met their potential.
- In New England, a highly innovative multi-airport planning process supported the eventual growth in the role of the smaller, more underused airports—to the benefit of all.
- Aviation planning could benefit from adopting the data organization scheme of the comprehensive transportation planning process, which is based on the flows by all modes from origins to destinations; this will support integration with planning for other modes.
- To support a multi-airport planning process, it is essential to create analysis tools that reflect the true origin and true destination of the passenger—not just airport to airport.
- The organization of aviation data in terms of true origin to true destination allows a more exact description of the potential contribution of underused airports.
- An evaluation process based on the measure of performance of the total trip experienced by the traveler would result in a planning process that is more transparent and accountable.

Exhibit S3. Highlights and key themes included in Chapter 3.

capacity, tracking projections for capacity enhancement, and raising issues of total system performance.

Gaining Capacity from Underused Airports

The research has concluded that to gain better use of existing underused capacity at smaller airports in the region, the aviation capacity planning system would need to become more multijurisdictional. Chapter 3 reviews how the creation of a unified, coordinated multi-airport planning process (NERASP) was associated with the creation of a more rational "family of airports" (Figure S9) for the Boston region. The chapter shows how a regional analysis (rather than an airport-based analysis) can support the study of the potential of lesser scale regional airports to provide additional capacity to the systems of the two mega-regions, provided that the operating carriers decided to take advantage of their presence. The chapter examines the importance of gathering and analyzing data on a multi-airport, super-regional basis and provides examples of how such new regional aviation planning tools can be used.

New England's regional airports have continued to evolve into a system in which increasingly overlapping service areas and improved ground access options are providing passengers with real options as they make air travel decisions. As Figure S10 shows, the goal of reducing passenger burden at BOS is being realized through this cooperative planning effort—since 1980, the share of New England air passengers at BOS has declined from about 75% to less than 60% in 2005. The conveners of the NERASP initiative believe the New England region has benefited by combining an understanding of the long-term needs of passengers with an appreciation for the financial risks in the air transportation industry and the interaction among airport markets. The FAA included the NERASP initiative as a strategy for increasing system capacity in its *2006–2010 Flight Plan* (*17*).

Figure S9. Airports included in the NERASP (15).

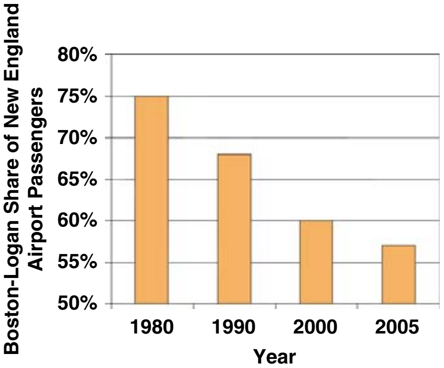

Figure S10. Restructuring of volumes in the Boston family of airports (16).

A key conclusion of this research is that enhanced metropolitan (or supra-metropolitan) airport system planning can be helpful in addressing airport congestion issues in regions that include major metropolitan areas. There are a variety of remedial measures available, from more efficient use of existing runways to expanded use of secondary airports and the shifting of some trips to surface transportation, particularly HSR. The evaluation of these options should take into account the need to generate passenger acceptance and political support.

When the tools of regional analysis, including the development and refinement of a planning process based on flows between true origins and true destinations, are applied to the question of underutilized capacity, market research data can be generated quickly and economically.

In the example shown in Table S5 and Figure S11, the present air travel patterns are revealed for all those living in a location closer to Allentown/Lehigh Valley International Airport in Pennsylvania than to any other airport. Of those in this "natural market area," 77% of air travelers do not use their "home town" airport. The policy question can then be examined concerning whether some of these local travelers could make their transfer movements outside of the congested mega-region, instead of at the heart of it. Organizing the planning data in this manner allows the examination of the possibility that underused airport capacity could make a greater contribution than is now the case.

The Importance of Applying Transport Planning Tools to Aviation Planning

The research team believes that employing a complete trip OD approach to airport planning would provide aviation

Table S5. Airport choice by trip destination and natural market area for Lehigh Valley international airport.

Destination Zone	EWR (%)	PHL (%)	Lehigh Valley Intl. (%)	JFK (%)	LGA (%)
Southeast U.S.	28	28	34	5	2
Upper Midwest	25	34	34	3	4
Transatlantic	52	13	1	33	0
Lower Midwest	35	36	21	5	3
California South	34	30	18	16	1
South-Central America	44	23	4	28	1
California North	33	29	19	18	1
Northwest Zone	35	30	23	9	1
New England	14	64	11	7	3
Transpacific	42	15	11	31	1
Alaska–Canada	35	23	30	7	5
NY, NJ, PA	14	52	9	23	2
Mid-Atlantic	26	22	17	18	14
Grand Total	**33**	**29**	**23**	**12**	**2**

planners with a view of the market-driven issues that airlines consider when planning service and routes. Importantly, this approach holds potential for enabling aviation managers to strike a better balance between meeting customer needs and operational desires. Finally, the organization of basic travel flow data in this manner will allow later integration with the dominant work describing highway and rail travel.

To enable such an approach to become the norm, rather than a periodic undertaking stemming from a particular one-time study, standards and protocols for data collection, management, and reporting could be developed. Unless "true" OD data on airport passengers are collected in a standardized way and on an appropriate geographic scale (as pioneered in NERASP), the usefulness of such data for improving mega-region scale airport

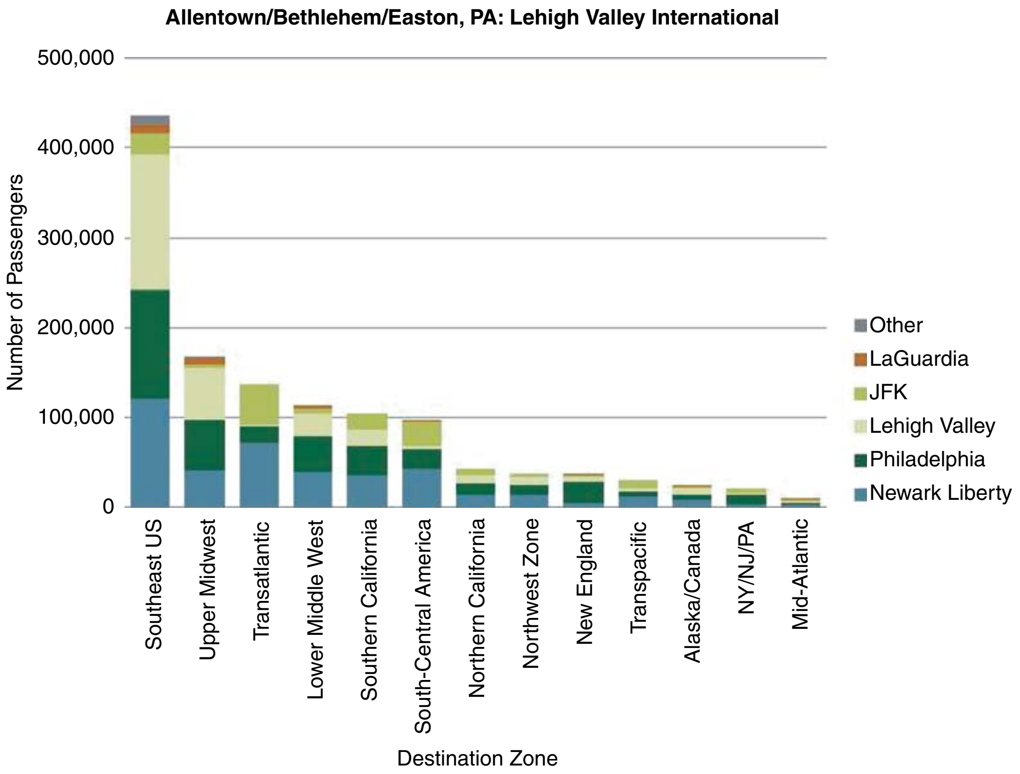

Figure S11. Airport choice by trip destination, Lehigh Valley natural market area.

For each major airport in the study areas, Chapter 4 includes the following:

- A summary of the role of shorter distance, intra-mega-region traffic at the subject airport.
- A review of the possible implications of planned rail projects for trip substitution.
- A review of the role for rail and proximate airports for multijurisdictional solutions.
- A review of the importance of shorter distance flights to support economically important longer distance flights, such as international services.
- Conditions in the year 2025, in which the calculated impacts of doing nothing are presented as a surrogate metric for the scale of the challenge at the subject airport.
- A quick, preliminary assessment of the potential roles of rail substitution, rail complementarity, and better regional cooperation, suggesting that none of these alone represents a "silver bullet" that will eliminate the problem of aviation capacity in the mega-regions.

Exhibit S4. Highlights and key themes included in Chapter 4.

planning will be minimal. However, by collecting data regularly and at the appropriate geographic level, airports within the mega-regions could jointly assess their capacity—individually and collectively—and plan for more efficient and customer-focused allocation of operations. Such multijurisdictional airport planning that seeks to share and take advantage of regional data can be a critical element of improving overall air system capacity in the coastal mega-regions and nationally.

Summary of Chapter 4—Airport-Specific Implications of the Major Themes

The previous chapters focused on the total impact of various strategies and management on the system as a whole, or as part of a larger aggregation. Chapter 4 reviews the implications of the major themes of the research on the largest airports in the two areas, with particular attention to the shorter distance trips and trip segments that occur within the borders of the study area (see Exhibit S4 for highlights and key themes included in Chapter 4).

In this research area, the short-distance air segments require the most analysis. Trips to and from areas outside the study area are simply not candidates for either rail for substitution or for providing complementary services, as discussed in Chapter 2. However, longer distance trips may be candidates for diversion to adjacent airports closer to the origin of the tripmaker, as discussed in Chapter 3. Thus, the longer distance trips are described for each major airport in terms of the geographic distribution of their destination trip ends. Table S6 shows an airport activity summary prepared for the San Francisco International Airport, allowing the analyst to examine

Table S6. An example of the airport activity summaries presented in Chapter 4 for SFO.

San Francisco, 2007 (SFO)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	**Total (%)**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**From West Coast Study Area**	**Outside West Coast Study Area**	**From Atlantic/ Pacific**	**From South-Central America**
California North	1.9	318,233	22,280	295,953	82,740	169,566	73,195	4,905
California South/LAS	14.6	2,405,822	1,614,370	791,452	127,720	618,016	271,751	7,868
To the North	11.2	1,852,852	1,250,521	602,331	278,036	145,823	155,797	29,199
To the East	42.2	6,963,448	6,067,140	896,308	251,760	271,390	504,283	2,220
Transatlantic	9.1	1,503,667	1,419,502	84,165	57,671	48,320	0	0
Transpacific	16.8	2,767,323	1,846,162	921,161	287,275	767,697	10	220
South-Central America	4.2	696,748	652,236	44,512	12,773	60,618	320	0
Totals	**100**	**16,508,093**	**12,872,211**	**3,635,882**	**1,097,975**	**2,081,430**	**1,005,356**	**44,412**

- This research has concluded that the current system suffers from unclear responsibility: no one has the authority and accountability for the management of congestion at mega-region airports.
- The management of existing resources could be improved: capacity in the mega-regions can be increased only when the all the major players are empowered to solve the problem.
- Opportunities to reduce mega-region airport congestion and improve the overall cost and quality of passenger service do exist; what would be beneficial are approaches and programs that encourage key decisionmakers to grasp such opportunities.
- When the system fails, a trigger mechanism could be set off; with the responsibilities of each party clearly specified, the goals of accountability and transparency could be met.
- There are roles for both the national and local levels in defining these roles and procedures.
- The responsibility of those in charge is to make air travel reliable for passengers; this is a form of accountability beyond making the airport available for all classes of aeronautical activities.
- A way to do this is to focus on the passenger experience. A congested airport does not necessarily make the airport reasonably available nor are delays arguably nondiscriminatory from the passenger perspective.

Exhibit S5. Highlights and key themes included in Chapter 5.

where travelers are going (the rows) and where they are coming from (the columns).

The Implications of the Airport-by-Airport Review

A quick, preliminary assessment of the potential roles of rail substitution, rail complementarity, and better local airport cooperation suggests that, while important, none of these represents a "silver bullet" that will eliminate the issue of lack of aviation capacity in the mega-regions, based on this airport-by-airport review. In the following chapter, the argument will be made that the aviation industry would benefit from significantly increasing the role of accountability and transparency in the management of the airport/aviation system. While the need to become more multimodal and more multijurisdictional is self-evident, the major opportunities to increase functional capacity in the coastal mega-regions lie within the aviation sector itself. Chapter 5 will suggest a new relationship between local and national institutions to deal with a real and present crisis in functional capacity.

Summary of Chapter 5—Airport Demand Management

The research team found that opportunities to reduce mega-region airport congestion and improve the overall cost and quality of passenger service do exist; what would be beneficial are policies and programs that encourage key decisionmakers to grasp them. The chapter concludes that the management of existing resources could be improved. Chapter 5 suggests that capacity in the mega-regions will be increased only when all the major players are empowered to solve the problem (see Exhibit S5 for highlights and key themes included in Chapter 5).

The Potential for Demand Management at Airports

From the research undertaken, it is clear that the scarce resource of capacity is not allocated efficiently. Chapter 5 investigates methods in which such capacity could be allocated in a way that balances passenger service from two perspectives: flight frequency and service reliability. The balance of stakeholder roles is explored in Chapter 5, with the goal of developing approaches that are agreeable to all stakeholders and fit the individual needs of a congested airport. The chapter examines alternatives to the current congestion and demand management structure in which the roles at the federal and local levels are unclear. It reviews a wide variety of candidate strategies and actions, under the context of local action with federal guidance. Chapter 5 further develops several strategies to increase airport throughput capacity, examining the barriers and constraints that impact their implementation. The report explores the idea that more attention should be paid to studies at individual congested airports that are using the methods to prioritize the value of individual flights, based on their contribution to delay and their customer service values.

In Chapter 5, the research team describes an example of how a framework might be developed for implementing demand management. The purpose of a demand management program as identified here is to limit delays that occur when the number of aircraft scheduled to arrive at an airport during a particular time exceeds the capacity of that airport. The most fundamental change suggested by the research is for all the major parties to recognize demand management as a legitimate alternative to capacity expansion as a means of ameliorating airport congestion problems.

The Purpose of Demand Management

The same quantity of air transport payload capacity can be provided with larger numbers of small aircraft flights or smaller numbers of large aircraft flights. It has long been recognized that the decisions of air carriers about what recipe to use have important ramifications for the quality of service and level of accessibility provided by the air transportation system on the one hand and for the amounts of flight traffic, levels of congestion and delay, and infrastructure requirements on the other. In most airports, small aircrafts use the same runways as large ones and occupy them for about the same length of time. Thus, when the airport is congested, the operational impact of a small flight is no less than that of a large one. Indeed, the slower approach speeds and longer in-trail separation requirements of small aircraft can result in longer effective service times. Thus, when airlines and other airport users provide capacity with more small flights rather than fewer large ones, the result can be higher levels of congestion and delay. Using the ability to predict the delay impacts of removing flights from the arrival stream, the research examined three up-gauging strategies in a detailed case study. In the first strategy, short-haul flights are eliminated. A second approach to up-gauging is to encourage, when appropriate, the substitution of less frequent large jet service for more frequent commuter service. Finally, the strategy of diverting small aircraft from the case study airport, SFO, to some other local airport is considered.

Implications

The chapter shows that changing the schedule, whether by eliminating short-haul flights, consolidating flights, or diverting very small aircraft, can reduce delays and often does so at a reasonable cost in terms of the extra line-haul time, schedule delay, and access time that such changes require. For any airport with high delays due to inadequate operational capacity, eliminating flights during busy periods will reduce delays considerably. The quantity of this benefit, as well as the cost of losing any particular flight, will vary from flight to flight, time period to time period, day to day, and airport to airport. There is, however, a wide body of research and experience suggesting that, in many circumstances, the benefit greatly exceeds the cost and that the cumulative gain from such changes would be impressive.

What should be done to realize these gains? Broadly speaking, in the current system there is no actor who has both the authority to make the desired schedule changes and the ability to realize the gains from doing so. Airlines and other aircraft operators whose decisions determine the flight demand at any particular airport can realize benefits for some flights they control by eliminating or rescheduling other flights, but this is generally a small fraction of the total benefit (*18*). Moreover, in a competitive, unregulated industry, the elimination of a flight by Airline A may be offset by initiation of a new service by Airline B. In this event, A has not only lost the operational benefit from its schedule change, but it also now faces stronger competition.

FAA-Proposed Changes in Rules/Regulations

Most recently, in a Notice of Proposed Rulemaking to amend its 1996 policy on rates and charges, the DOT proposed to explicitly allow airport proprietors to establish a two-part landing fee that recognizes both the number of operations and the weight of the aircraft, in order to provide incentives for airlines to modify aircraft gauge or frequency to reduce delays at a congested airport. In the words of the GAO, this should "provide greater flexibility to operators of congested airports to use landing fees to provide incentives to air carriers to use the airport at less congested times or to use alternate airports to meet regional air service needs" (*19*).

Airport operators have essentially no direct control of airline activity at their airports, including whether the airline serves the airport at all, the frequency or time of day of service, or the aircraft type or size used to provide service. They do have proprietors' rights to use rates and charges to influence airline service patterns, but those rights are still being refined.

In light of the potential to reduce delays with innovative management and the unclear role of aviation stakeholders in managing delays, a change in approach could better align flight scheduling decisions with the needs of society through demand management. The chapter argues that there are a number of reasons why the primary focus of demand management responsibility and action should be at the local level.

As currently practiced in the United States, air demand management is a reactive strategy that is performed after delays have reached unacceptable levels. In contrast to this, the demand management policies and programs could be implemented most effectively prior to the advent of severe congestion.

Guidance and Accountability

A broad outline for how this can be accomplished is the following: setting mutually agreeable airport-delay targets, providing a detailed list of actions an airport can take to meet the delay level, and implementing incentives and penalties for not meeting such an action.

Airports that exceed the delay trigger immediately could be requested to perform an immediate update to their master plan. This airport master plan update could have, at the minimum, two new sections. One could address the potential of the airport to expand capacity in the long term to manage demand. The other section could be the development of a demand management plan.

Airports where the trigger is not exceeded could be further subdivided into two categories. Some airports will find through their modeling that traffic will exceed the trigger before their next scheduled master plan update. There could then be guidance about how quickly such airports should update their master plans—potentially immediately. Airports where the trigger will be exceeded in over 5 years but before the next master plan could be requested to update their master plan in a 5-year period.

When airports accept public funds from the FAA, they agree under United States Code Title 49 (Section 5.4.3) to conditions of grant assurances. Agreeing to these assurances means that all aircraft that can safely land at that airport must be accommodated with no discrimination. The chapter introduces the idea that carriers have fleet mix recipes with important ramifications for the quality of service and the level of accessibility provided by airports and the entire air transportation system. It argues that when demand is high relative to capacity, demand management may be required to fulfill the commitment not to discriminate. The guidance provided to airports for accepting their designation as critical-delay airports could involve a new way to envision aviation system accountability.

Summary of Chapter 6—What Was Learned, and What Are the Next Steps?

Chapter 6 of the report presents a summary of major conclusions and lessons learned from the research and also presents a set of suggested directions (see Exhibit S6 for highlights and key themes included in Chapter 6), which are summarized and described in the following paragraphs.

Concerning a multimodal planning capability, the report suggests the following:

- An overarchingly intermodal approach to the analysis of long-distance trip-making and trip provision should be developed. Given the congestion at mega-region airports, a unit of capacity created on an HSR system need not be seen as a "competitor" to the aviation system, but as a complementary provider of services over a full multimodal system.
- Early examples of "Corridors of the Future," such as the I-95 Corridor Coalition, should be reviewed to find ways to help states who come together on a voluntary basis to improve their planning capabilities concerning longer distance trip-making.
- The integration of aviation trip flows with other modal trip flows be undertaken as a pilot project in the East and in California.
- Further research should be undertaken that would help provide a better understanding of the possible role of air and rail working together. The research team located an impressive amount of analytical work documenting the potential for rail to *substitute for* air travel. Concerning the potential role of rail to *complement* air travel (e.g., as a feeder mode to

The scale of the capacity problem:

- Analysis should continue on the questions of airport choice, schedule-based delay, and whether alternative forms of hubbing could relieve key mega-region airports.

Making the process more multimodal:

- The aviation system is not well equipped to undertake the kind of multimodal analysis associated with the present wider choice of options for long distance trip making; both the tools and the structure could be improved.
- The potential role of rail complementarity in the United States should be documented further.

Making the process more multijurisdictional:

- Regional solutions could gain optimized capacity from a "family of airports" concept.
- Regional organizations could be crafted based on unique local requirements and (at least partially) on a passenger-centric basis.
- Multimodal tools and procedures could be developed to support integration with the comprehensive planning process.

Dealing with airport management, the report explores a variety of approaches including the following:

- Giving individual airport operators the primary responsibility for developing demand management programs appropriate for their local circumstances, within broad national guidelines;
- Enhancing the ability of airports to manage demand through a variety of operational pricing-related options; and
- Outlining an example of a potential framework for demand management that would define a set of critical-delay airports, along with the establishment of delay standards, and an accepted method of predicting delay.

Exhibit S6. Highlights and key themes included in Chapter 6.

longer distance flights), the research did not reveal much solid analytical work.

Concerning alterations in the planning process, the report suggests the following:

- An expanded version of system planning could be made available throughout the congested mega-regions on the East and West coasts. This has been done in NERASP, which helped to identify unused capacity at secondary airports that could be used to relieve congestion at BOS. Similarly, the Metropolitan Transportation Commission Regional Airport System Plan (MTC RASP) is now underway in the Bay area, involving the cooperation of several major airports and looking into alternatives to meet the long-term travel demand, including the potential role of HSR passenger service.
- As multi-airport planning processes are established, the separate airports could be encouraged to undertake data collection efforts on as close to a simultaneous basis as possible, following the example set in both NERASP and MTC RASP. Standardization of data collection format and of period of acquisition allows for the creation of a meaningful, useful regional data resource that includes both long-distance segments and local ground access data.
- Even without new supra-regional studies, existing metropolitan planning organizations (MPOs) could become more involved in the collection, analysis, and support of data collection and management in the aviation sector, following the example of the Washington Metropolitan Council of Governments, among several other advanced examples of MPO participation in aviation planning.

Concerning the potential for demand management at airports, the report explores a variety of approaches including the following:

- Giving individual airport operators the primary responsibility for developing demand management programs that are appropriate for their local circumstances. These programs would follow broad guidelines that allow for a diversity of approaches.
- Enhancing the ability of airports to manage demand through a variety of operational and pricing-related initiatives.
- Outlining and giving examples of a potential framework for demand management that would define a set of critical-delay airports for which controlling delay is considered to be essential. Such airports could be provided with guidance on creating a demand management program, with demand management to be one of a wide range of strategies—including capacity expansion, development of alternative airports, and investments in alternative modes—to reduce delay.

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CHAPTER 1

Defining the Issues: Defining the Problem

- There is a major problem in the provision of effective aviation capacity in the coastal mega-regions and the economic impacts of doing nothing are significant.
- Using a range of economic assumptions, the "cost" of present air travel delay in the coastal mega-regions ranges from a low of about $3 billion per year to a high of over $9 billion per year (2007).
- Using the same range of assumptions, the "cost" of air travel delay in the future would range from about $9 billion to about $20 billion, if none of the present capacity constraints were addressed—that is, the cost of doing nothing (2025).
- Much of the aviation industry's capacity forecasting assumes that, by one means or another, a process of up-gauging of aircraft will occur: the research team found no support for the assumption that systematic up-gauging of aircraft will occur without some form of public policy intervention.
- The number of air trips within the West Coast study area is vastly higher than the number of air trips within the East Coast study area, even though their geographic area is similar.
- The present amount of air travel delay is vastly higher in the East Coast study area than in the West Coast study area, even though the intra-area volumes are much lower.

Exhibit 1.0. Highlights and key themes included in Chapter 1.

1.1 Introduction

This chapter presents an overview and introduction to the four major themes developed in the project. It introduces the two study areas in terms of their geography, demographics, and propensity to make shorter distance air trips within and between their mega-regions. It reveals a significant difference in the nature of the demand/capacity/delay characteristics between the East and West Coast study areas. The chapter describes what the researchers believe to be a present crisis in aviation systems capacity and provides a method of understanding the economic scale of that crisis. The chapter also documents the economic and environmental cost of doing nothing—letting the present system in the mega-regions continue to degenerate (see highlights of Chapter 1 in Exhibit 1.0).

Chapter 1 is organized in the following order:

- Section 1.1 summarizes the structure and main themes of the chapter.
- Section 1.2 presents a set of definitions concerning the geographic scale of the two study areas covered in this research and the size of the airports that serve them.
- Section 1.3 summarizes the airport congestion issue in the two mega-regions from a systems point of view and a customer point of view. The amount of congestion experienced is documented for a cross section of large and smaller airports in the two study areas, and the overall problem revealed on the East Coast is compared with that on the West Coast.
- Section 1.4 identifies the nature of the capacity problem that has been revealed over the past several years, culminating in the "perfect storm" of the summer of 2007, as described by the research team and the Federal Aviation Administration (FAA). It presents the results of an early outreach effort to define the nature of the present capacity problem in the mega-regions.
- Section 1.5 summarizes the perceived 2007 costs to airport travelers from congestion and airport delays, including a

procedure for assigning a "value of time" (VOT) to the delay experienced.

- Section 1.6 concludes Chapter 1 with an analysis of the economic and environmental impact of doing nothing about the issues raised in this research.

1.1.1 Overview

In the first half of this project, the research team examined the issue of aviation planning to deal with the capacity issues raised for the year 2025 for key airports in congested mega-regions, where warning flags have already been raised in the FACT 2 report (*1*). What the team found was of major concern.

In interviews[4] with airport managers, managers of the forecasting process, and other leaders in the field, it became clear that in almost every case,[5] in one manner or another, the optimistic assumptions about the amount of capacity to be available in 2025 were based on the intuitive belief that, as demand grows over time, this will be matched by a voluntary program of up-gauging of the size of aircraft flown to the subject airport—*a matter currently almost entirely under the control of the airlines, not the airport managers.*

For example, the team had a productive interview at one of the most important airports in the study area, generally covering issues of airport productivity. At the end of the interview, one of the hosts pointed out an entire wall of architectural designs for additional new passenger terminals at the airport, commenting, "Up-gauging? Everything on this wall is based on the assumption of up-gauging! Without that, we will not need any more terminal capacity. They can't get through the runways!"

The best and most analytic approach to the subject comes in the development by the MITRE group of an aircraft assignment submodel as part of their comprehensive multistep process of assigning aviation trips in the 2025 forecasts. Logically, it could be argued that even this state-of-the-art method is premised on the concept that airlines will, for one motivation or another, choose to place a given number of passengers on a smaller number of aircraft. The model assumes such actions on the part of the major players in its 2025 allocation of aircraft to segments within markets.

In short, when examining the possible breakdown of the aviation system in 2025, the research team essentially documented that the breakdown at key mega-region airports was already present in the base year of 2007. In case after case, airline managers were scheduling more small planes than could reasonably operate on time under any weather conditions of less than perfect visibility. The interviews with airport managers on the West Coast reported the same concern as those on the East Coast.

In the interpretation the research team presented in 2008, the team concluded that no one had the authority for getting effective capacity out of the runways and supporting facilities in major mega-region airports. The airport managers believe they have not been given an effective legal mandate to lower congestion. In some cases, efforts ended up in court. And a given airline scheduling manager—perhaps convinced of the social virtue of flying fewer, larger planes—is forced to act under the assumption that her/his competitors will simply take the released slots and use them to perpetuate the use of smaller aircraft. *In short, no single entity is accountable for a problem with economic impacts calculated in the billions of dollars per year,* as discussed in Section 1.5. Without a solution to this problem, the research team would have to conclude the 2025 capacity predictions included in the FACT 2 report to be optimistic, as documented in Section 1.6.

It is important to reiterate that the FACT 2 report (*1*) concluded that there would be considerable capacity problems in the coastal mega-regions, even assuming the success of the current national Next Generation Air Transportation (NextGen). This initiative centers on technologies and procedures that will boost airspace and airport capacity. A number of airports are also planning airfield improvements that will increase capacity. However, the boosts in capacity from such actions will not adequately meet all future demand at all airports in the National Airspace System (NAS). According to the FACT 2 report, many of the most congested airports in the coastal mega-regions will continue to need additional capacity to meet demand even with the capacity benefits of NextGen. Therefore, the innovations presented in this study, such as demand management, are vital, irrespective of the capacity gains promised by NextGen or airfield improvements. The reader is referred to Chapter 5, which focuses on capacity management rather than expansion. For a discussion about how NextGen issues might impact the individual airports, see Appendix B.

1.1.2 Four Conclusions of This Research

This report is structured around the presentation of the four main conclusions of the project. They are presented in the following order:

1. *Under the present relationship between the airports and the airlines, there is a serious lack of usable aviation capacity in the mega-regions.* Chapter 1 builds the case that there is a growing problem in the mega-regions, and that the eco-

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[4] The airport activity summary sheets are presented in Appendix C.

[5] An exception to this sentence might be the process described in Chapter 5, where innovative work undertaken by Massport in cooperation with the FAA is specifically dealing with the issue of need for up-gauging of aircraft.

nomic and environmental cost of doing nothing is significant. The chapter concludes that a new approach is needed.

2. *To gain access to alternative forms of short-distance trip-making capacity, the aviation capacity planning system could benefit from becoming more multimodal.* Chapter 2 reviews the extent to which aviation planning is inherently intertwined with the planning and analysis of capacity increases in other longer distance modes, specifically high-speed rail (HSR) and highway planning.
3. *To gain better utilization of existing underused capacity at smaller airports in the region, the aviation capacity planning system could benefit from becoming more multijurisdictional.* Chapter 3 analyzes the market potential of some smaller scale regional airports to provide additional capacity to the systems in the mega-regions, provided that the operating carriers decided to take advantage of their presence. The chapter examines the importance of gathering and analyzing data on a multi-airport, super-regional basis, and shows examples of how such new regional aviation planning tools could be used.
4. *No one has the authority and accountability for the management of congestion at mega-region airports.* Chapter 5 suggests that capacity in the mega-regions will be significantly increased only when the managers are empowered to solve the problem. The chapter concludes that the management of existing resources could be improved, and that this represents the single most important element in a larger strategy to deal with potential aviation capacity issues in the coastal mega-regions.

1.2 Understanding the Scale of the Mega-regions and Their Airports

1.2.1 Range of Scale of the Study Area Airports

Table 1.1 illustrates that the two coastal study areas contain some of the biggest airports in the United States, including Los Angeles (LAX) and New York (JFK). The two study areas also contain airports of concern and interest to multimodal planning that are currently very small and possibly underutilized, such as Allentown, PA. The reader should be aware that the passenger summaries used in the Airports Council International–North America (ACI-NA) surveys (*2*) are comprehensive and include more passengers than are included in the U.S. Department of Transportation's (DOT) Airline Origin and Destination Survey, from the Office of Airline Information of the Bureau of Transportation Statistics (DB1B) (*3*), which forms the backbone of most of the analysis contained in this report. The uses, and limitations, of various databases are discussed in Section 4.6 of this report. Table 1.1 also provides the three-letter codes, as set by the International Air Transport Association (IATA), for most airports referred to in this report. The base year for this analysis is 2007, which was a critical year for aviation in the mega-regions (as discussed in Section 1.4.3). The research team is aware that since that time, air passenger volumes have decreased by varying levels. This report, however, is based on a consistent use of one base-year assumption; most industry analysts believe that growth over the next 20-year planning period will indeed reappear at some point.

1.2.2 Geographic Scale of the Mega-regions

The East Coast study area generally includes the states from New England to Virginia. The West Coast study area includes all of California and Clark County, NV. In Chapter 4 of this report, flows are examined on a finer geographic scale, which emphasizes actual market areas. In general, when data are presented at a high level of aggregation, entire states are included; when data are presented on an airport-by-airport basis, only the catchment areas of those specific airports are included.

Thus, the term East Coast study area includes all of the geography contained in the states between Maine and Virginia. The term Eastern Mega-region refers to the areas covered by the Boston region airports to the north and to the areas of Richmond and Norfolk, VA, to the south. The western edge of the Eastern Mega-region incorporates Syracuse, NY, and Harrisburg, PA.

The term West Coast study area includes all of the state of California and Clark County (Las Vegas) NV. The term Northern California Mega-region refers to the Bay Area region and the Sacramento region. The term Southern California Mega-region refers to the Los Angeles Basin area, the San Diego region, and Clark County (NV) together.

Distances. The two maps (Figures 1.1 and 1.2) are presented at similar scale: in the East Coast study area, the northernmost mega-region airport, MHT (Manchester, NH), is about 487 miles from the farthest airport, RIC (Richmond, VA). In the West Coast study area, the distance from the Sacramento airport to the San Diego airport is 480 airline miles.

Population. In terms of population, the two study areas are not so similar. The East Coast study area has about 69 million inhabitants; the West Coast study area has about 38 million. This difference will become far more dramatic later in this chapter, where the numbers of internal aviation trips within each study area are compared. The results are startling and point to real differences in the transportation behavior of the two coastal regions.

Table 1.1. Airport codes and passenger activity summary from ACI-NA 2007 survey (*2*).

Rank in ACI-NA Survey	Airport Name and Code	Total Passengers 2007
3	LOS ANGELES (LAX)	61,896,075
6	NEW YORK (JFK)	47,716,941
7	LAS VEGAS (LAS)	46,961,011
11	NEWARK (EWR)	36,367,240
13	SAN FRANCISCO (SFO)	35,792,707
17	PHILADELPHIA (PHL)	32,211,439
20	BOSTON (BOS)	28,102,455
21	NEW YORK (LGA)	25,026,267
22	WASHINGTON DULLES (IAD)	24,525,487
25	BALTIMORE/WASHINGTON (BWI)	21,498,091
28	WASHINGTON REAGAN (DCA)	18,670,924
29	SAN DIEGO (SAN)	18,336,761
33	OAKLAND (OAK)	14,846,832
40	SACRAMENTO (SMF)	10,748,982
41	SAN JOSE (SJC)	10,658,389
43	SANTA ANA (SNA)	9,979,699
55	ONTARIO (ONT)	7,207,150
58	HARTFORD/SPRINGFIELD (BDL)	6,519,181
61	BURBANK (BUR)	5,921,336
68	MANCHESTER (MHT)	3,892,630
71	NORFOLK (ORF)	3,718,399
72	RICHMOND (RIC)	3,634,544
80	ALBANY (ALB)	2,874,277
82	LONG BEACH (LGB)	2,758,362
83	SYRACUSE (SYR)	2,360,878
121	ALLENTOWN (ABE)	847,526
180	PALMDALE (PMD)	12,022

Figures 1.1. and 1.2. The geographic extent of the East Coast study area and the West Coast study area (scale is constant) (3).

1.3 Scale of Air Travel within the Two Study Areas

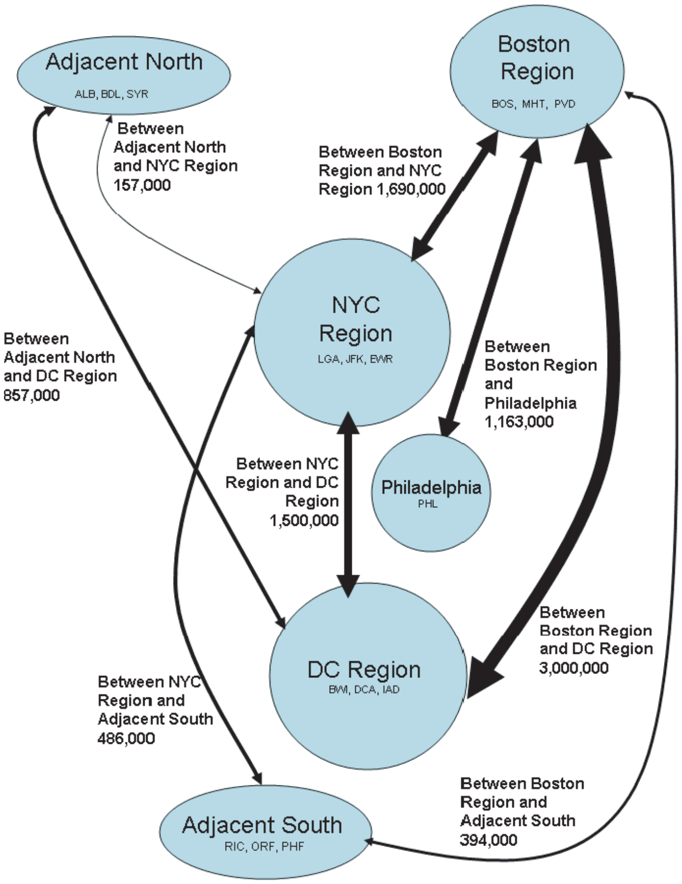
This section deals with the city-pair volumes of existing air travel, which are perhaps better described as "metro-region pair" passenger volumes between "families of airports." Classic origin–destination (OD) "desire lines" are presented for the East Coast study area and the West Coast study area, making possible a revealing comparison of the aviation passenger volumes between the two coastal areas.

1.3.1 Metro-area to Metro-area Pair Air Passenger Flows within the Eastern Mega-region

Figure 1.3 summarizes air passenger travel within the East Coast study area between January and December 2007. It can be best understood as a desire line diagram showing the flows between airports of origin to the airports of destination of somewhat under 10 million air trips. Trip makers between, say, Manchester, NH (MHT) and Richmond, VA (RIC) may undertake this trip by transferring at a point such as Newark (EWR), LaGuardia (LGA), or Philadelphia (PHL). From the vantage point of OD analysis, they are portrayed here as flows between the Boston region family of airports and the Richmond/Norfolk family of airports. These East Coast aviation flows are examined on an airport-by-airport basis in Chapter 4 of this report.

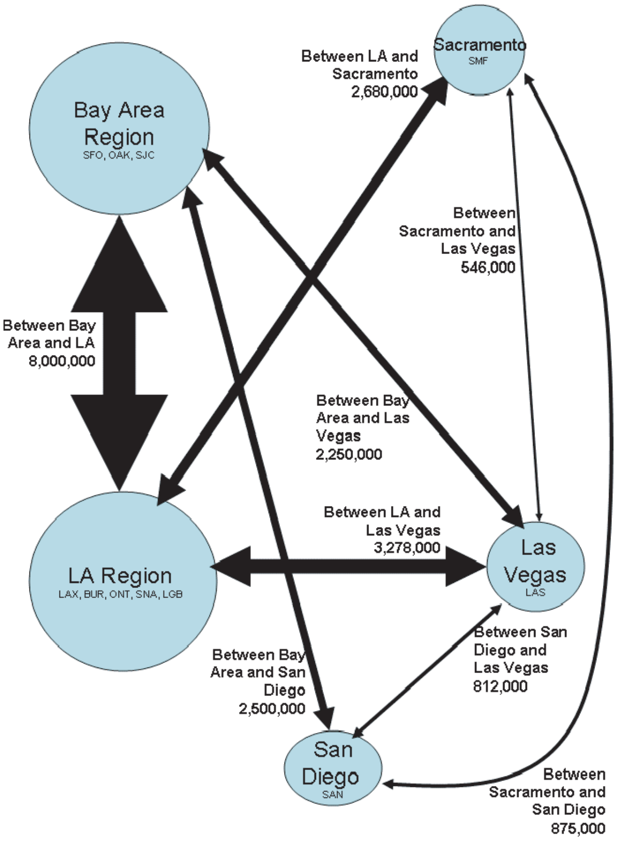
1.3.2 Metro-area to Metro-area Pair Air Passenger Flows within the West Coast Study Area

Figure 1.4 summarizes air passenger travel within the West Coast study area between January and December 2007. It can be best understood as a desire line diagram showing the flows between airports of origin to the airports of destination of about 20 million air trips. As in Figure 1.3, flows are expressed from their airport of origin to their airport of destination without reference to possible use of transfers or connections. These lines represent the flow of airport passengers between the large metropolitan areas and other large metropolitan areas. These West Coast aviation flows are examined on an airport-by-airport basis in Chapter 4 of this report.



Note: The absence of a line between two areas means that the number of air trips is insignificant.

Figure 1.3. Air passenger flows between metro regions in 2007: East Coast (4).



Note: The absence of a line between two areas means that the number of air trips is insignificant.

Figure 1.4. Air passenger flows between metro regions in 2007: West Coast (4).

1.3.3 Implications of Scale between the Two Study Areas

The first observation about the two study areas is that the West Coast generates about twice the volume of short distance air passengers than does the East Coast. And within the West Coast study area, it is the air trips between the Bay Area family of airports to the north and the Los Angeles Basin family of airports to the south that dominate the travel. The Los Angeles region, served by LAX, Burbank, John Wayne, Long Beach, and Ontario together, generates some 8 million trips to or from the Bay Area region, which is served by the airports of San Francisco (SFO), Oakland (OAK), and San Jose (SJO).

In terms of coast-versus-coast comparison, the volume of air travelers between the Los Angeles region and the Bay Area region is 5.3 times the air traveler volume between the New York region family of airports and the Washington/Baltimore family of airports. It is 4.7 times the volume between the Boston region family of airports and the New York region family of airports. It is also clear that air travelers on the West Coast have a short-distance trip generation rate that is more than three times that of air travelers on the East Coast. Chapter 2 will discuss in some detail the extent to which this difference in reliance on air travel can be traced back to a massively higher dependence on rail in the East Coast study area, particularly in and out of the New York region.

1.4 The Problem of Airport Congestion in the Mega-regions

The research team has estimated that the phenomenon of aviation congestion associated with 11 of the largest airports in the two coastal study areas resulted in passenger-perceived delays calculated in the billions of dollars in 2007, as documented in Section 1.5.

1.4.1 Comparing Congestion Delay between East and West Coast Mega-regions

Importantly for the interpretations needed in this research, those delays were not evenly divided between the two coasts. Figure 1.5 shows the sharp differences in the delay patterns of the two coast study areas. The “Total Delay Index” (Figure 1.5 and Table 1.2) has been calculated by the research team as the average frequency of delay multiplied by the average duration of delay, plus the average frequency of cancellation multiplied by a value of 3 hours delay per cancellation. It is expressed as number of minutes of delay per total airport passenger. The index was calculated from Bureau of Transportation Statistics (BTS) Transtats data (*5*), for the 12 months between January and December 2007.

The difference in the severity of the problem between coasts is somewhat surprising, given the widespread belief that delays are ubiquitously distributed around the country. But, it is clear that what SFO experienced in 2007 is quantitatively similar to the delay experienced at MHT and Providence, RI (PVD), which are regarded as East Coast airports with excess capacity and minimal delays. The economic impact of the aviation delays at the larger airports is presented in Section 1.5 for 2007 and Section 1.6 for 2025.

1.4.2 Where Is the Lack of Capacity?

From a nationwide perspective, there is no lack of airport capacity at which to provide hubbing operations. But interconnecting hub airport congestion is not the dominant factor in many of the project study areas where the most serious congestion occurs at the OD airports. In those cases where hubbing activity occurs, as at EWR or Washington Dulles (IAD), the hubbing carriers have options to shift connecting traffic to

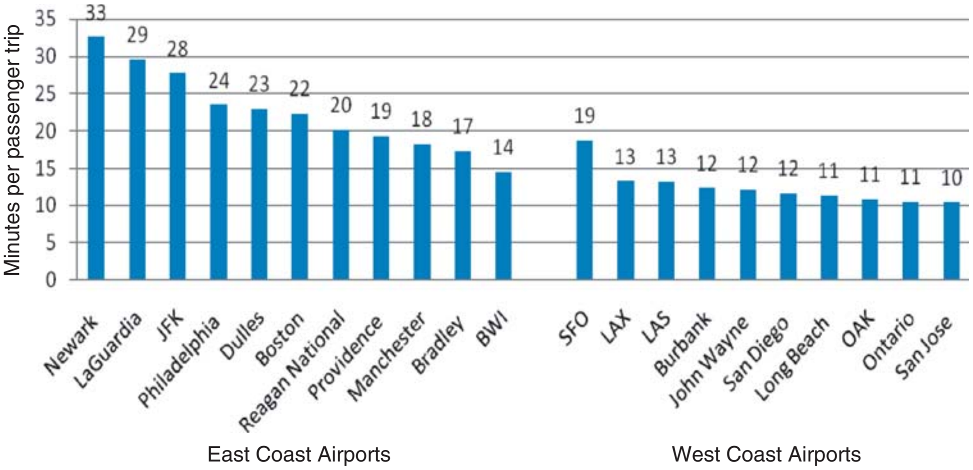


Figure 1.5. Total delay index for East Coast and West Coast airports, expressed as minutes per passenger trip (5).

Table 1.2. Total delay index (*5*).

Total Delay Index for East and West Coast Airports, 2007			
Airport	**Delay Index**	**Airport**	**Delay Index**
Newark	32.6	SFO	18.7
LaGuardia	29.5	LAX	13.3
JFK	27.7	LAS	13.2
Philadelphia	23.5	Burbank	12.3
Dulles	23.0	John Wayne	12.0
Boston	22.3	San Diego	11.7
Reagan National	20.1	Long Beach	11.3
Providence	19.3	OAK	10.9
Manchester	18.2	Ontario	10.5
Bradley	17.3	San Jose	10.4
BWI	14.5		

other hub airports in their systems. The ability to shift connecting traffic to other airports makes congestion at connecting hubs more of an individual airline problem than a broad public policy issue. In recent years, airlines have closed fully functional hubs at St. Louis and Pittsburgh, following the earlier abandonment of hubbing operations at places such as Kansas City and Raleigh-Durham. In the current round of airline mergers, connecting hubs such as Cincinnati and Memphis are now experiencing significant reductions in activity. The country has plenty of hub capacity available, in the event that carriers hubbing in the mega-regions choose to shift connecting traffic away from those areas in favor of accommodating additional OD traffic. The research question then turns to whether decreasing domestic feeder services at coastal airports would or would not damage their support of important longer distance services. Chapter 4 of this report presents an analysis of the role of longer distance flights needing to be fed by shorter distance flights, presented on an airport-by-airport basis.

Having made large investments in airport capacity, operators of airports in Kansas City, Raleigh-Durham, St. Louis, and, more recently, Pittsburgh had no effective control over airline decisions to abandon those airports as connecting hubs in their systems, thereby negating the substantial investments in capacity at those locations. In the summer of 2000, SFO suffered significant delays due in large measure to the decision by an airline to substantially increase the SFO–LAX market with high-frequency shuttle flights. In the summer of 2001, LGA airport was brought to a standstill by airlines' scheduling increases permitted by mandated relaxation of pre-existing slot controls under the high-density rule.

1.4.3 Capacity Issue Reaches a Crisis: The Summer of 2007

Many of the factors associated with excessive demands on aviation came together in the summer of 2007, in what might be seen as a "perfect storm" of capacity failure. The decision by one airline to build a major domestic hub at JFK was followed by a competitive response by other major airlines at JFK. Those combined airline decisions turned that airport from a major international gateway with congestion during limited hours of international activity to the most congested airport in the United States, requiring federal intervention in the form of flight limitations. In general, major study area airports have 30–50% of their runway capacity devoted to operations in small regional jet or turboprop aircraft in response to airlines' scheduling decisions over which the airport operators have no control.

The events of the summer of 2007 were summed up by the FAA, in the *Federal Register* of January 17, 2008, as follows:

> Market competition spurred by new-entrant, low-cost carriers and the competitive response by legacy airlines have generated much of the increase in air travel demand. Among the trends are new and expanded route networks to lesser-served markets connecting major hubs with regional jet service. The additional service in some cases provides no net increase in seats between origins and destinations but provides more operations in the system with greater numbers of smaller capacity aircraft.
>
> The experience of summer 2007 shows that congestion is a problem today. Airlines at New York JFK International Airport increased their scheduled operations by 41 percent between March 2006 and August 2007. As a result, the number of arrival delays exceeding one hour increased by 114 percent in the first ten months of fiscal year 2007, compared to the same period the previous year. During June and July 2007, on-time arrival performance at JFK was only 59 percent. Moreover, delays resulting from operations at New York metropolitan area airports alone can account for up to one-third of the delays throughout the entire national system. The congestion in the New York airspace has ripple effects across the national airspace system, causing flight delays, cancellations, and/or missed connections. These delays impose economic and social costs on airline passengers and shippers; airlines incur extra costs for fuel, flight crews, and schedulers. Delays are likewise beginning to increase at San Francisco (*6*).

1.4.4 Defining the Problem: Looking for Solutions

To examine the problem of capacity and demand management[6] and implications of reducing congestion at airports, members of the research team organized a session in January 2008 at the 87th Annual Meeting of the Transportation Research Board (TRB) to discuss capacity issues at the New York airport system and airport capacity issues nationwide. This session received input from an airport operator, an airline representative, a manager with a federal perspective, an aviation research academic, and aviation consultants. As the session unfolded, it was clear that different experts and stakeholders approach the subject of capacity and demand management in a different way. Such a finding illuminated the complexity of the multiple interpretations of the problem.

Discussions about capacity and congestion focused on issues regarding the number of operations per hour at congested airports. Multiple—not necessarily mutually exclusive—solutions were presented and debated such as operational caps, market-based mechanisms, technology enhancements, and multimodal solutions. Main themes involved (a) the balance between offering passenger service in terms of flight frequency and destinations in a congested region and reducing delays and unreliability that a congested airport or region can present and (b) who should be at the table to determine solutions to capacity and congestion problems.

1.4.4.1 The Balance Between Capacity Management and Passenger Service

The balancing of passenger access times or schedule delay penalties with actual delay savings becomes a central theme for resolution. On the one hand, the passenger values high-frequency services. At the same time, that passenger may be totally unaware that the lack of reliable services at the airport stems, in part, from the proliferation of high-frequency, low-capacity aircraft. Thus it becomes important to consider both capacity management and passenger service when developing solutions. This is noted in the debate over operational caps, on up-gauging, as well as in a discussion of multimodal solutions to reduce redundancy in flights. Consistent with the themes developed in this early outreach section, Chapter 5 elaborates on these themes, leading to suggestions in Chapter 6.

At the TRB session, it was noted that restricting the number of operations per hour, or managing airport access to reduce congestion, gives an initial insight into the complex way stakeholders view passenger service and capacity management. The airport managers and airlines spoke out against the idea of the federal government setting airport caps. Airport management spoke as being responsible for the entry point of passengers to their city; the airlines were concerned about the government engineering their business plans. In the panel discussion, the airport operators noted their desire to "accommodate demand of folks who want to come to and leave our region." It is for this reason then that the airport operators rejected the operational caps imposed, a sentiment the airline representative supported.

There is an interesting balance between providing frequency and providing reliability. Excessive frequency leads to low reliability, and vice versa. At the session, the aviation research academic noted this delicate balance:

> to solve the problem we have to start looking at the demand side of the equation and find ways to reduce demand or to moderate demand into the busiest airports. . . . If you try to control demand in aviation that means the airlines have fewer flights into the busiest airports. This does not mean that passenger service has to be diminished, or that passengers have to take fewer trips.

More directly challenging the employment of very high frequency at the expense of reliability, the aviation research academic followed up with a situation where "there are three airlines that provide hourly service between LaGuardia and Washington National airport." In response to comments like these, the airline representative stated that "somebody's demanding those services, whether it is because airlines offer superior service to (rail service) or it beats driving." Furthermore, not mentioned with this reasoning is that the airlines defend their market share by providing frequency; abandonment of service does not immediately lead to a reduction in flights, as a competing airline can enter into the schedule at any time. The impact of lowering overall volume on the number of flights scheduled is examined in Chapter 2, which presents a case study of the impact of a decline of air passengers between Boston and the New York airports.

This discussion among multiple stakeholders shows how there is not a clear path to choose in balancing flexibility and reliability. The following section addresses the need to involve multiple stakeholders in developing a solution.

1.4.4.2 Multiple Stakeholder Solutions

To sum up the challenges of providing and managing capacity and bringing all stakeholders to the table, the staff member from the FAA explained, "the administration does not have the luxury of one solution that will benefit one segment of society. We must balance all concerns." To find and agree on solutions to capacity, delay, and congestion issues, there are complex roles and responsibilities that must be deter-

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[6] As discussed in Chapter 5, the term "demand management" is used to describe strategies to limit delays that occur if too many aircraft are scheduled to arrive at an airport during a particular time. Under this use of the term, demand management is not meant to refer to any program designed to decrease the number of trips made.

mined. As he explained it, the administration was trying to take into account "a number of different perspectives but always with an eye to reducing disruption to the system." These perspectives span those of the panelists.

The roles these multiple voices should play were discussed. The airport operator said that in finding a solution, "we can't do it unilaterally. The airport operator should have a strong voice, and . . . complement the administration." This is because "the airport operator is in the best position to know what is right and wrong for their airport." The airline representative noted that a solution must "take into consideration the investment being made at the airports (by airlines). . . . Historic investments, historic operations, are something that we need to recognize." An aviation consultant echoed that statement, adding, "there are clear distributional issues between the airports and the airlines."

1.5 Costs to Travelers of Airport Congestion and Delays

Airport congestion causes air passengers to incur additional costs in several forms. Routine peak-period congestion increases the time between boarding and takeoff, and this additional time is built into airlines' schedules for congested airports. According to a recent DOT report (*7*), the average taxi-out time (i.e., time between leaving the gate and takeoff) increased by almost 3 min per flight between 1995 and 2007 (21% increase), whereas taxi-in times increased by approximately 1.5 min (25% increase) over the same period. Although some of these changes could be the result of several factors, airport congestion is certainly among the most prominent causes.

1.5.1 Delay Times at the Mega-region Airports

Six of the coastal mega-region airports are on the list of those with the 10 longest average 2007 taxi-out times—in order from longest: JFK, EWR, LGA, PHL, BOS, and IAD. JFK had over 37 min on average, IAD just under 20 min. These compare with the average across all airports of 13.8 min in 1995 and 16.7 min in 2007. The patterns are similar with taxi-in times, though the range is considerably smaller and only JFK, EWR, and LAX among the coastal mega-region airports are among the 10 longest. Although it is arguable as to the portion of these delays that is directly attributable to airport congestion, it is clear that they represent considerable costs to the airlines and, in turn, to the air passengers both directly (through extra time spent traveling) and indirectly (through higher fares charged for these flights to cover costs). See Figure 1.6.

Regular increases in taxi-out and taxi-in times due to congestion can be accommodated by adjusting scheduled flight times, but at a cost to passengers of additional travel time and to the airlines of additional crew, equipment, and fuel costs. However, the larger cost of airport congestion is more likely attributable to the additional random delays beyond scheduled times. These are caused by a confluence of departure schedules that create flight operations at or near maximum airport capacity and any event that reduces capacity. The "unexpected" delays result in additional costs to passengers

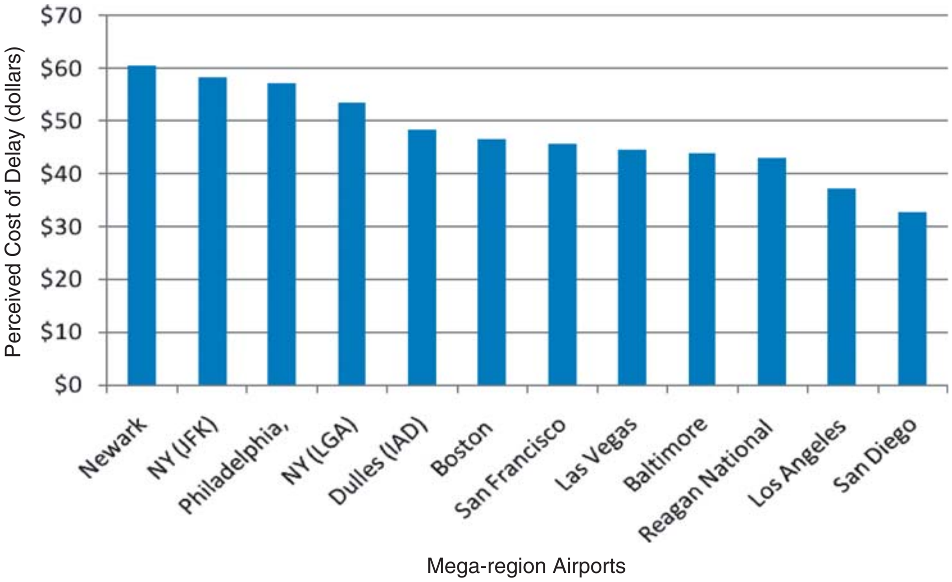

Figure 1.6. The perceived cost of delay per trip to or from major mega-region airports in 2007(5).

and to the airlines. All of these costs can be quantified to some degree and, in fact, represent considerable costs in total.

1.5.1.1 Understanding the Role of Airport Congestion

The U.S. DOT's BTS compiles both on-time performance data and information about the causes of delays that result in late arrivals. For calendar year 2007, those data indicate that, nationally, weather delays directly caused only slightly more than 5% of the late arrivals while "air carrier delays," "aircraft arriving late," and "national aviation system delays" accounted for virtually all of the remaining 95% of delayed arrivals. Although airport and air traffic congestion are not listed explicitly as the ultimate sources of those three major types of delay, over the 5 years between 2003 and 2007, boardings at the 12 largest airports in the coastal mega-regions increased by 25% in total, departures increased by 18%, and the percent of on-time commercial flights declined by over 10 points. This indicates a strong association between airport traffic and flight delays.

1.5.1.2 Conclusions of the U. S. Senate Report

According to a May 2008 report (*8*) from the U. S. Senate's Joint Economic Committee Majority Staff (JEC), flight delays in 2007 imposed a cost of over $40 billion per year on passengers, the airlines, and the U.S. economy and resulted in a release of an additional 7.1 million metric tons of carbon dioxide (CO_2). The report's authors describe the impact of the "staggering levels of delays" as "large and far-reaching" and express concerns that the delays will worsen without "reforms to the system." The study described in that report uses reasonable methods to derive its estimates but does not directly address three questions whose answers are important for this coastal mega-regions airport study:

1. What portion of this impact is incurred at the airports in the coastal mega-regions?
2. What are the full costs to coastal mega-region travelers of the delays?
3. How might these costs change in the future?

1.5.2 Costs of Delays at the Major Mega-region Airports

The answer to the first of these questions is relatively straightforward. The Senate JEC report (*8*) calculates the impacts of delays across the entire domestic air system, but also details delays at 60 of the largest airports, including all of the major mega-region airports. On the basis of these data, the pro rata share for the mega-regions of the $40.7 billion/year impact cited in the Senate JEC report is approximately $7.7 billion/year, of which $2.3 billion is due to passengers' lost time, $3.6 is due to airlines' increased cost, and the remaining $1.8 billion is due to economic spillover effects. One could argue that airlines' increased costs are largely passed along to passengers in the form of higher fares,[7] and so the net cost to passengers is likely closer to $6 billion/year (the sum of the passengers' travel time losses and increases in air fares resulting from increased airline costs).

1.5.2.1 Quantifying the Economic Value of Delays

The Senate JEC report (*8*) quantifies the increased travel times that passengers incur as a result of delays. However, it explicitly excludes the additional delays that result from missed connections and from the inconvenience imposed on travelers as a result of delays. The effects on passengers of unscheduled flight delays include elements such as loss of productive time, missed flight connections, missed ground connections, missed meetings, and the general inconvenience associated with the necessary schedule adjustments. All of these effects cannot be measured directly, but there are ways of estimating passengers' perceived costs. One recent study, conducted by Resource Systems Group, Inc., (RSG), employed special survey and modeling techniques to measure the trade-offs (also called marginal rates of substitution) between the various components of service associated with air itineraries (*9*). The survey used an approach known alternatively as "stated choices" in the transportation literature or "choice-based conjoint" in the market research literature. See, for example, Louviere et al. (*10*). In this approach, survey respondents are presented with a set of choice alternatives from which they are asked to select the one that they would most likely choose under the specified conditions.

For the study of air itineraries, the survey questionnaire asked respondents to describe their most recent domestic air trip, and then it created a set of realistic alternative flight itineraries with associated arrival and departure airports, carriers, schedules, flight times, aircraft types, fares, and percent on-time performance. Much as they would when faced with alternatives generated by travel agents or online flight search engines, respondents were asked to choose their most preferred itinerary from those shown. The data from this type of survey can be used to statistically estimate coefficients of a choice model and, from that model, rates of trade-off among

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[7] Carriers may not assign costs directly to the flight and airport combinations that are experiencing the delays, and thus peak-period passengers may not see higher fares associated with frequently delayed flights. Conversely, passengers on flights that operate at off-peak times from uncongested airports may pay higher fares as a result of the operational costs incurred on the other delayed peak-period flights from congested airports. However, the net effect is still that the costs are likely passed on to the passengers in the aggregate.

the attributes of the flight itineraries can be calculated. When these trade-offs are calculated relative to fares, they are called "willingness to pay" and can be interpreted as the amount of additional fare that a passenger is willing to pay to get different levels of that attribute.

1.5.2.2 Establishing the Value of Time

The most commonly calculated willingness to pay for transportation services is the Value of Time (VOT), which is simply the amount that an individual is willing to pay to save a unit of time. VOTs range considerably across individuals and individuals' circumstances. Generally, air travelers have higher VOTs than do travelers of other modes, in part because they have already opted to use a faster but more expensive mode.

The RSG study found that the average VOT for domestic air travelers is approximately $70/hour for travelers on business trips and $31/hour for non-business trips. For the air travel market, which is split roughly between 40% business and 60% non-business, the weighted average VOT is approximately $47/hour. That is, air passengers on average are willing to spend an additional $47 in higher fares to save an hour of travel time or, conversely, will be willing to accept an hour of additional travel time for a fare reduction of $47.

The FAA uses a value of time of $28.60/hour (in 2000 dollars) for regulatory and facilities cost-benefit analyses based on guidance provided in the following documents: "APO Bulletin APO-03-1—Treatment of Values of Travel Time in Economic Analysis," FAA Office of Aviation Policy and Plans, March, 2003, and "Revised Departmental Guidance—Valuation of Travel Time in Economic Analysis," Office of the Secretary of Transportation Memorandum, February 11, 2003. This translates to $35/hour in 2007 dollars—still lower than the value used in this analysis. The primary difference is that the FAA value is based on percentages of average wage rates, whereas the values used here are those applied by travelers in their choices among alternative air travel itineraries. Thus, the use of an alternative method for calculating the VOT might lower the "costs" stated in Table 1.3 and Table 1.4 by about one quarter. Applying this lower VOT with the use of the year 2003 benchmark results in a "low-range" estimate of roughly $2.9 billion for 2007.

The time delays, while significant, do not account for the additional perceived costs of missed meetings, missed ground connections, and general inconveniences associated with delayed arrivals. Those effects were measured separately in the RSG survey using the FAA's standard on-time metric as a surrogate. That study found that business travelers are willing to pay on average approximately $38 per flight segment for each 10-point improvement in on-time performance (over the range of 50–90%). The equivalent measure for non-business travelers is $6 for each 10-point improvement in on-time performance. The several-fold difference in willingness of business travelers to pay for flights with high on-time performance is not surprising given that they are (a) generally traveling on much tighter schedules and (b) the economic consequences of disruptions to those schedules are generally more direct than for non-business travelers. Using, as before, a 40% business and 60% non-business weighting, the average passenger-perceived value of 10 points of on-time performance for a given flight is approximately $19.

As noted previously, between the years 2003 and 2007, the average on-time performance at the 12 largest coastal mega-region airports decreased on average by over 10 points. Applying the 2003 on-time performance benchmark, this means that the aggregate perceived cost across all boardings at the 12 airports of the performance decline in 2007 is approximately $3.9 billion/year. The absolute cost of the delays (compared

Table 1.3. 2007 Airport flight delay cost estimates (*4, 5*).

Airport	On-time 2003 (%)	On-time 2007 (%)	2003 Boardings	2007 Boardings	2007 Flight Costs (2003 On-time Benchmark) ($)	2007 Flight Costs (100% On-time Benchmark) ($)
Baltimore, MD (BWI)	83	77	10,200,000	11,000,000	138,000,000	483,000,000
Boston, MA (BOS)	83	75	11,100,000	13,800,000	209,000,000	643,000,000
Las Vegas, NV (LAS)	85	76	17,800,000	23,100,000	379,000,000	1,030,000,000
Los Angeles, CA (LAX)	89	80	27,200,000	30,900,000	526,000,000	1,148,000,000
New York, NY (JFK)	83	69	15,900,000	23,600,000	633,000,000	1,377,000,000
New York, NY (LGA)	84	72	11,400,000	12,500,000	299,000,000	671,000,000
Newark, NJ (EWR)	83	68	14,800,000	18,200,000	519,000,000	1,104,000,000
Philadelphia, PA (PHL)	79	70	12,100,000	15,900,000	289,000,000	908,000,000
San Diego, CA (SAN)	88	83	7,700,000	9,400,000	98,000,000	307,000,000
San Francisco, CA (SFO)	89	76	14,400,000	17,600,000	438,000,000	805,000,000
Washington, DC (DCA)	88	77	6,900,000	9,100,000	183,000,000	392,000,000
Washington, DC (IAD)	82	74	8,200,000	11,900,000	182,000,000	577,000,000
			157,500,000	197,000,000	3,894,000,000	9,445,000,000

Table 1.4. 2025 Airport flight delay cost estimates (*1, 4, 5*).

Airport	On-time 2003 (%)	On-time 2025 (%)	2003 Boardings	2025 Boardings	2025 Flight Costs (2003 On-time Benchmark) ($)	2025 Flight Costs (100% On-time Benchmark) ($)
Baltimore, MD (BWI)	83	61	10,200,000	14,900,000	613,000,000	1,078,000,000
Boston, MA (BOS)	83	53	11,100,000	21,100,000	1,212,000,000	1,874,000,000
Las Vegas, NV (LAS)	85	54	17,800,000	32,900,000	1,899,000,000	2,828,000,000
Los Angeles, CA (LAX)	89	63	27,200,000	38,800,000	1,898,000,000	2,681,000,000
New York, NY (JFK)	83	58	15,900,000	27,800,000	1,343,000,000	2,220,000,000
New York, NY (LGA)	84	54	11,400,000	18,800,000	1,082,000,000	1,640,000,000
Newark, NJ (EWR)	83	48	14,800,000	25,000,000	1,617,000,000	2,418,000,000
Philadelphia, PA (PHL)	79	62	12,100,000	16,700,000	533,000,000	1,184,000,000
San Diego, CA (SAN)	88	63	7,700,000	14,400,000	667,000,000	989,000,000
San Francisco, CA (SFO)	89	66	14,400,000	20,800,000	910,000,000	1,344,000,000
Washington, D.C. (DCA)	88	60	6,900,000	12,400,000	639,000,000	923,000,000
Washington, D.C. (IAD)	82	79	8,200,000	12,800,000	82,000,000	504,000,000
			157,500,000	256,300,000	12,496,000,000	19,682,000,000

to 100% on-time) is over $9.4 billion/year. When this is added to the $6 billion on-time costs and airline costs[8] that are likely added to passenger fares as calculated in the Senate JEC report (*8*), the total comes to $15.4 billion/year in passengers' lost value due to delays at the 12 largest mega-region airports. This amounts, on average, to $78 per passenger-trip at these airports. Of this, passengers would be willing to pay a fare that is $48 higher, on average, to avoid the time delays and additional inconveniences associated with delayed flights. The remaining $30/passenger is the amount that the airlines need to add to fares in order to compensate for their higher costs due to delays. The aggregate costs are shown in Table 1.3.

1.6 The Costs of Doing Nothing

It was requested that this project devote additional attention to the economic and environmental implications of continuing on with the present pattern of degradation in service quality in the mega-regions. In conformance with this request, the research team has created a new analytical procedure that would examine the implications of having attained no solutions to the issues discussed in this project. The reader should be aware that these calculations are *not* based on the same set of assumptions as the FACT 2 study (*1*), which did explicitly deal with changes in capacity and operations that might (or might not) come into play between now and 2025. Rather, the work of the research team predicts the future conditions based strictly on the scenario that solutions are not found and implemented (see Figure 1.7).

To reiterate, the assumptions made in this section are simply that the number of flight operations will increase in proportion to the number of passengers (as projected in the FACT 2 study and assuming no significant changes in average aircraft sizes) and that delays will increase also in proportion (as estimated from statistical regressions of past delays vs. flight volumes). Since FACT 2 passenger volumes are used as a base for these calculations, the relevant FACT 2 growth assumptions are incorporated. In addition, it is assumed that there are not significant airport capacity enhancement projects at the major airports nor any significant capacity increase from NextGen initiatives nor any policy intervention to reduce delays—in other words, a "do nothing" assumption.

1.6.1 Future Costs of Delays at the Mega-region Airports

The FAA's FACT 2 report (*1*) projects air traffic volumes out to the year 2025. It does not, however, forecast the likely delays associated with those volumes and with status quo policies. There are, of course, many factors that could affect future delays, not the least of which are the rates of progress on NextGen implementation, changes in airport and airspace configurations, and some of the policies described later in this report. However, historical data can provide an indication of how on-time performance at each airport has affected flight volumes given current and past conditions and operating policies. Monthly on-time performance and traffic volume data were obtained from U.S. DOT/BTS data (*5*) for the period 2002–September 2008 (the most recent month for which these data were available at the time of the analysis). These data were used to develop a simple regression model with on-time performance as the airport-dependent variable

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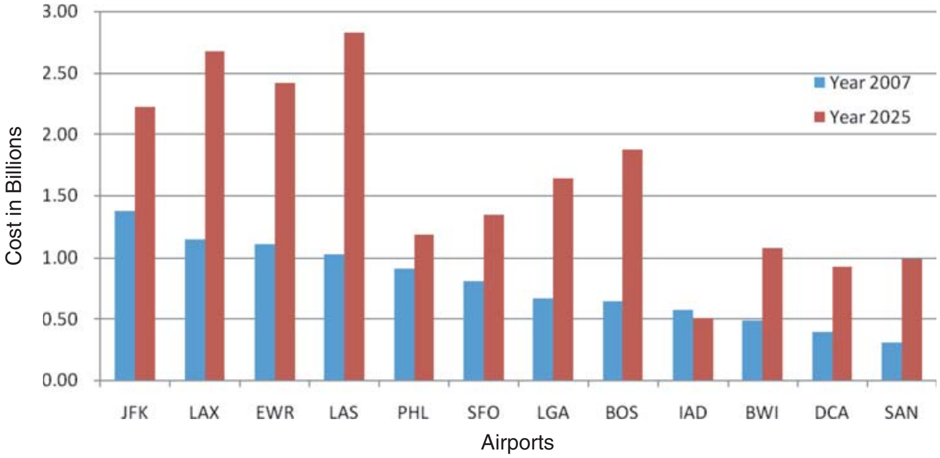
[8] It is unclear from the document cited what fuel burn assumptions were made for the time that the aircraft is on the ground and not at the gate. However, this is a small portion of the overall delay-related fuel burn.



Note: Based on Tables 1.3 and 1.4.

Figure 1.7. The cost of doing nothing: Increase in passenger delay costs 2007–2025, assuming no resolution of key issues.

and the number of scheduled flight departures as the primary independent variable.[9] This equation was used, along with the FACT 2 airport traffic forecasts, to estimate on-time performance in 2025 at those traffic volumes. The results are shown in Table 1.4.

Between the years 2003 and 2025, the average on-time performance at the 12 largest coastal mega-region airports is estimated to decrease on average by 25 points. This assumes status quo operating conditions (no capacity increases, etc.) and assumes air traffic growth as projected in the FACT 2 report.

Applying the 2003 on-time performance benchmark, this means that the aggregate perceived cost of missed flight connections and other costs across all boardings at the 12 airports of the performance decline in 2025 is over $12 billion/year.[10] The absolute cost of the delays (compared to 100% on-time)[11] is almost $20 billion/year. Assuming that the Senate JEC delay costs scale up proportionally, the airline and time delay costs would reach $14 billion/year. When these costs are added together, the total comes to $34 billion/year in passengers' lost value due to delays at the 12 largest mega-region airports. This amounts, on average, to over $130 per passenger trip at these airports in 2025, assuming that status quo operations prevail.

Assuming also that the Senate JEC estimates for delay-related fuel consumption scale directly with increases in delays, these delays would generate an additional 17 million metric tons of CO_2 per year.

It is important to note that this represents the implied costs of *doing nothing.* The FAA's Airport Cost Analysis Guidance suggests that aircraft operators might begin to modify schedules, adjust aircraft size, and take other actions to reduce delays. However, one of the theses of this ACRP research is that airlines in fact will not modify schedules and adjust aircraft sizes (up-gauge) of their own accord, absent policies that explicitly incentivize such actions. It is assumed that each airline, acting in its own individual interest, uses airport capacity in a way that consumes rather than protects airport capacity. The problem lies with the concept that the aircraft operator may have a greater tolerance for delay than the policy makers seeking to establish a proper balance of throughput and system delay. Chapter 5 explores this issue further, leading to the suggestions presented in Chapter 6.

1.6.1.1 Implication for the Themes of this Research

The magnitude of the effects of delayed flights both on passengers and on carriers should constitute a strong incentive to address at least one of the root causes: congestion caused by flight schedules that approach or exceed airport capacity. Most experienced travelers are well aware of the locations and patterns of flight delays from their own personal experience and may further inform themselves using information from the numerous online sites that offer both

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[9] The actual regression equation used percent of flights delayed as the dependent variable. It included constants to represent the unique conditions at each airport and the weather conditions in each month. It included departures as both a linear effect and the ratio of monthly departures to the maximum number of monthly departures from that airport as a quadratic effect.

[10] All 2025 costs cited here are in 2007 dollars. If the lower VOT used in FAA studies were applied to the 2003 benchmark assumption, a low-range estimate of about $9 billion would result.

[11] The research team agrees with the FAA that a 100% on-time standard for air service is not realistically attainable. The report provides estimates of passenger-perceived costs using 2003 delay levels as a "realistic" benchmark, but also shows the total cost of all delays for completeness and for comparison to the other costs as calculated in the JEC study (8).

historical and real-time flight performance data.[12] However, less-experienced air travelers, who constitute the majority in most air markets, do not necessarily apply similar knowledge when choosing among alternative travel itineraries. Few of the major consumer-oriented online booking sites provide on-time performance information for the flight itineraries that they create.[13] As a result, a flight during a peak period with very low on-time performance will, in advance, appear undifferentiated from other flights with higher on-time performance.

1.6.2 Environmental Effects of Doing Nothing

As noted in the Senate JEC report (*8*), airport delays currently result in an additional 7.1 million metric tons per year of CO_2 emissions in the United States, with 1.3 million tons from the major coastal mega-regions airports alone. On the basis of aviation data published by the FAA (*11*), these represent approximately 3.6% of the total greenhouse gas (GHG) emissions in the aviation sector. However, future increases in delays could substantially increase the total delay-related emissions and their fraction of total aviation emissions. As described previously, increases in delays as a result of growth in air traffic could result in delay-related emissions growing to 17 million metric tons per year across the United States. This translates to over 3.2 million per year in the major coastal mega-region airports—more than doubling that impact.

The 2025 projections of GHG emissions (which are in turn based on the air traffic forecasts in the FACT 2 report) assume that mega-region airports will continue to function in much the same way as they do now, that air travel patterns will remain similar to the current ones, and that the fleet mix does not change substantially. Of course, any or all of these assumptions could be affected by deliberate policy changes or by unanticipated events with resulting impacts on GHG emissions.

The coastal mega-region airports may well be able to reduce delays or at least prevent them from increasing to the extent that would be indicted by the simple extrapolation to the FACT 2 traffic levels. Any such improvements would obviously have a direct effect on the delay-related emissions. However, the changes could also affect the ways that the airports serve travelers, patterns of air travel, and fleet mixes in ways that could either amplify or diminish these effects. For example, regional initiatives to promote other modes as alternatives for the shorter distance markets could do the following:

- **Cause some diversion of air trips to other modes.** Estimates of changes in GHG emissions from diversion to other modes range from a factor of three or more reduction for diversions to rail or intercity bus (*12*) to a much more modest 15–20%, depending on assumptions about vehicle types, occupancies, and other factors that affect the relative fuel efficiencies (*11*).
- **Result in net changes in trip patterns.** Alternative modes such as rail and bus are most competitive for shorter distance trips for which air is generally the least efficient, for a given aircraft type. For a given type of aircraft, there is almost a factor of two difference in GHG emissions per passenger-mile between short-haul and the most energy-efficient medium-haul flights (*11*). This is largely a result of the take-off and landing stages, which represent relatively large energy expenditures that are approximately the same regardless of the flight length.
- **Affect aircraft mix.** The shorter trips that are the most likely to be diverted to alternative modes are also those that are most likely to be served by smaller regional jets and propjets. The effects of shifting shorter trips to alternative modes depend on the types of aircraft that are being reduced in the airports' mix. Figure 1.8 describes the relative fuel consumption levels for different aircraft types and trip (stage) lengths, derived from Smirti and Hansen (*13*). In this example, which compares a standard 137-seat narrow body jet, a 72-seat turboprop, and a 42-seat regional jet, the fuel consumption rates per seat-mile are lowest for the turboprop and highest by a factor of up to five for the regional jets. Reductions in smaller regional jet aircraft trips at an airport most likely will result in significant fuel—and thus GHG—reductions. On the other hand, reductions in relatively fuel-efficient turboprop trips would have more modest effects on GHG emissions.

Overall, there are clearly significant opportunities for reducing GHG emissions both as a direct result of reducing delays and indirectly as a result of shifts that could occur from changed air traffic patterns.

1.7 Conclusion

Chapter 1 concludes with a concern that the amount of 2025 aviation capacity assumed by leaders in the aviation community and reflected in the FACT 2 study (*1*) may be based, as least in part, on the working assumption that, as demand increases, a voluntary program of aircraft up-gauging can be expected to take place. Given the overall decrease in

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[12] For example, DOT's BTS maintains monthly online flight performance data and dedicated sites such as flightstats.com offer detailed ratings of flights by OD pair, carrier, and even flight number along with real-time tracking of flights.

[13] When this report was written, most of the available websites did not offer online performance data for each alternative itinerary presented in flight searches.

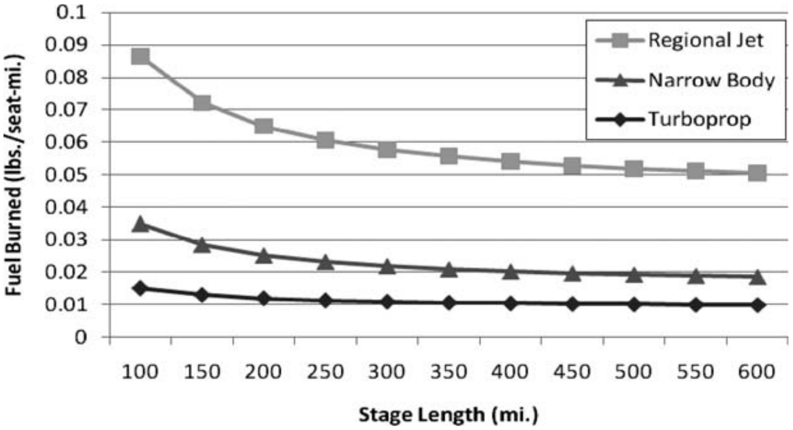

Figure 1.8. Fuel consumption rates for representative aircraft (14).

the average number of passengers per plane over the past decade, the research team believes that this assumption needs more analytic attention. The research team addresses this in Chapter 5 after presenting a review of both multimodal and multijurisdictional issues facing the industry.

The concern that more help may be needed in finding long-distance trip-making capacity merely increases the need of forging a better level of integration with HSR planning and better use of procedures developed for highway planning. Chapter 2 explores both.

A lack of immediate answers for how to get more capacity from the overcrowded airports should lend support for local and regionally based initiatives to find more usable capacity at underused airports in the two study areas. This need for greater multijurisdictional planning to solve the air capacity problem is discussed in Chapter 3.

CHAPTER 2

Aviation Capacity and the Need for a Multimodal Context

- The aviation planning process could benefit from becoming more overtly and directly multimodal in nature.
- Plans for high-speed rail investment now under consideration in both coastal mega-regions could result in a total diversion of up to 15 million air trips per year in the long term.
- The scale of diversion in the established literature is much higher in the West Coast study area than in the East Coast study area.
- Analysis undertaken in the EU shows that, when city-center to city-center rail times can be decreased to under 3.5 hours, rail can capture more market share than air.
- In some cases, such as Frankfurt–Cologne, rail acts as feeder for long-distance flights; in other cases, such as Frankfurt–Stuttgart, rail does not. The role of rail in a complementary mode should be studied further.
- High-speed rail can decrease the number of air travelers; without better management of the airports, this may not result in a decrease in flights
- Although no breakthrough in highway capacity will change the need for air travel, the highway planning process could be better integrated with aviation capacity planning; better long-distance travel data will result when the two planning processes are combined.

Exhibit 2.0. Highlights and key themes included in Chapter 2.

2.0 Introduction

One of the major conclusions of this research is that the aviation system planning process could benefit from facilitating a closer relationship with the planning process for the other modes providing longer distance services in the United States, with particular emphasis on the longer distance travel modes such as highway, rail, and intercity bus. Chapter 1 built the case that there is a problem in the mega-regions and that the cost of doing nothing is significant. That chapter concluded that a new approach is needed to respond to economic impacts of doing nothing.

Chapter 2 now reviews the extent to which aviation planning is inherently intertwined with the planning and analysis of capacity increases in other longer distance modes—specifically, HSR and highway planning (see Exhibit 2.0 for highlights and key themes included in the chapter). The first five sections of Chapter 2 review the extent to which HSR planning might and might not play a role in accommodating demand currently expected to occur in mega-region airports. The concluding sections of Chapter 2 review the extent to which underused highway capacity might play a role in the solution of problems revealed in this analysis, referencing supporting documentation in Appendix C. Chapter 2 concludes that HSR programs now under consideration could affect the very accuracy of the aviation forecasts. It also concludes that there is no viable scenario in which an increase in highway capacity would significantly alter the need for more capacity in the aviation system. Integration of the modally based planning process in the mega-regions is, however, essential to support improved multimodal decision-making. Specific suggestions to improve the multimodal planning process are presented in Chapter 6 of this report.

In the next five sections, Chapter 2 presents the logic of better integration with HSR. Section 2.1 reviews some basic concepts needed to differentiate the function of rail in *substituting* for air services from the function of rail in *complementing* air services. (Figure 2.1 illustrates the most basic relationship between rail travel times to air- vs. rail-market share for new services, based primarily on the substitution of trips from city to city.)

Section 2.2 reviews the possible role of vastly improved new rail services that would connect the Northern California Mega-region with the Southern California Mega-region; possible service to Las Vegas is covered in lesser detail. The section reviews the city-pairs (metro-pairs) identified in Chapter 1 and documents the present use of rail within California for those pairs. (Figure 2.3 summarizes the projected volumes for each of the city pairs and the projected mode share for each pair.) Diversions from air are summarized and compared with calculations of diversions made earlier by the Federal Railroad Administration (FRA) in 1997.

Section 2.3 reviews the present and possible future of HSR in the East Coast Mega-region. The section reviews the city-pairs (metro-pairs) identified in Chapter 1 and documents the role of present rail services for each of the larger pairs. (Figure 2.10 summarizes the most basic relationship between a change in rail travel time and the resultant change in rail mode share for the improved services.) Diversions from air are presented in a variety of technical formats. The possible projected increases in rail share are discussed, based on existing work on the subject undertaken by the FRA and by the Office of the Inspector General (U.S. DOT), noting their implications for aviation planning.

Section 2.4 addresses the issue of what actually happens at an airport when there is a diversion of air travelers to another mode. On the basis of a detailed case study of the decline in air traffic between Boston and New York City (NYC) airports, Section 2.4 shows that—without the kind of controls discussed in Chapter 5—a similar number of flights may be operated with smaller aircraft, resulting in only minor improvements in aviation congestion, if any.

Section 2.5 introduces the issue of rail in the complementary mode, where rail services are seen as integrated feeder services in a unified air-plus-rail ticket offering. The research team has concluded that the basis for analyzing these patterns lags far behind the analysis of rail in competition with air (substitution mode). Elements of a case study are introduced that analyze the decision by a major international airline to discontinue short-distance feeder flights between Frankfurt Airport and one nearby airport and continue short-distance feeder flights to a second airport at the same distance. Also documented is the similar U.S. situation, in which one U.S. airline presently offers a joint air-plus-rail ticket to a series of rail stations in the East Coast Mega-region.

2.1 Demand for HSR in Travel from City Center to City Center

The available data and experience suggest that there is a very strong potential role for HSR in the East and West Coast Mega-regions as a *substitution* for present aviation trips. The research team also believes that successful ground transportation services can play an increased role in providing complementary short-haul services in support of longer haul airline services, although the exact form of this is less clear. In the former category, HSR services are focused on city center to city center; in the latter category, HSR services are focused on points of connection with major airports, either directly or by some form of connector (e.g., people movers). The research team believes that there is a gap in the existing methodology to support the analysis of rail in the complementary mode, which should be explored further in continuing research in this subject area. To explore further the nature of the issue of “rail as feeder to plane,” this report includes a brief case study of the experience in Germany, where there are several air–rail combined service models in operation at one airport.

Successful high-speed ground services can provide a clear-cut alternative to air travel in the two study areas (i.e., East and West Coasts), largely providing services from one downtown center to another downtown center. The primary support for this concept can be found in the Northeast Corridor (NEC) and in Western Europe. A key concern, however, is the set of capacity constraints existing in the NEC Mega-region and the need for completely new infrastructure in California. In short, the potential demand is readily documentable, as presented on the following pages; the need for capacity increases will require considerable additional engineering and cost documentation. Available cost “estimates” are presented as they exist, but they do not match the detail of the demand information.

The extent to which improvements in rail can shift market behavior away from air services and to HSR services has been well documented over the last decade of HSR implementation in Western Europe. Figure 2.1 was prepared for the EU by the British consulting firm, Steer Davies Gleave, in *Air and Rail Competition and Complementarity, Final Report* (*1*) for EU’s Directorate General for Energy and Transportation.

The implications of the graph are startling in their simplicity. Under present airport conditions, when a European train can provide city-center to city-center service in less than 3.5 hours, that train can gain a market share of greater than 50% of the aggregate of air and rail combined. A quick visual inspection of Figure 2.1 indicates that the “successful” European city-pair routes are in the upper left-hand portion of the graph and the unsuccessful are in the lower right-hand quadrant. Of course, no conclusions can be drawn about the portion of a city-pair market that goes to the automobile, as these data are often not available.

This observation provides the reader with a “rule of thumb” for looking at proposals to divert air travelers to rail services. Interestingly, this rule-of-thumb process relies only on rail travel time and does not rely on either the distance between the city pairs or the travel time of the air journey.

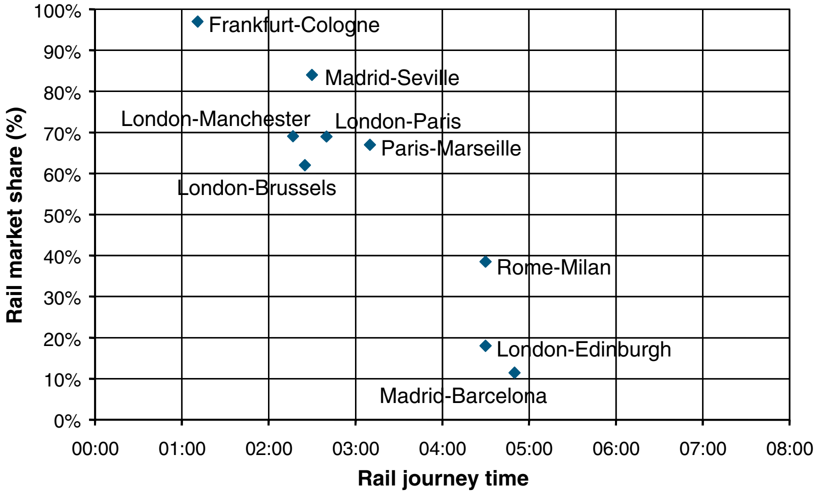

Figure 2.1. Relationship of rail journey time to air- vs. rail-market share (1).

The reader may wish to keep in mind this formula in observing the design characteristics of HSR in California, which does meet the travel-time criteria between Los Angeles and San Francisco but does not meet it between San Diego and Sacramento, to give an obvious example.

2.2 Rail Services in the Western Mega-regions that Could Influence Aviation Capacity Issues

The analysis of the role of rail services in the two California Mega-regions is fundamentally different from the analysis appropriate for the East Coast, as the services are radically different. On the one hand, the role of existing services tends to focus on a small number of successful state-sponsored short-distance services. On the other hand, the role of possible *future* HSR has been examined at a level of detail more intensive than is available in the East Coast study area or anywhere else.

Figure 2.2 is presented here (reproduced from Chapter 1 of this report) as a point of quick reference. It shows the annual volume of OD aviation trips for key "region pairs" for both of the West Coast Mega-regions. The reader will again note the sheer scale of aviation trip making between the San Francisco Bay Area and the Los Angeles Basin. Similarly, the scale of air trips between Los Angeles and Las Vegas should be noted. By way of comparison, the number of air passengers between these two families of airports is roughly the same as the air markets between New York/Boston and New York/Washington, D.C., *combined.*

Figure 2.3 shows the number of *daily* trips by all modes (including car) between key California metro areas, by trip purpose. Note that the Los Angeles–San Diego region pair is virtually twice the size of any other intra–mega-region movement. This begins to set the stage for an examination of the possible role of HSR in the area. By contrast, Figure 2.2 shows that the volume of air travelers beginning their trip in San Diego with a destination in Los Angeles (or vice versa) is minimal, and, thus, not included in the diagram.

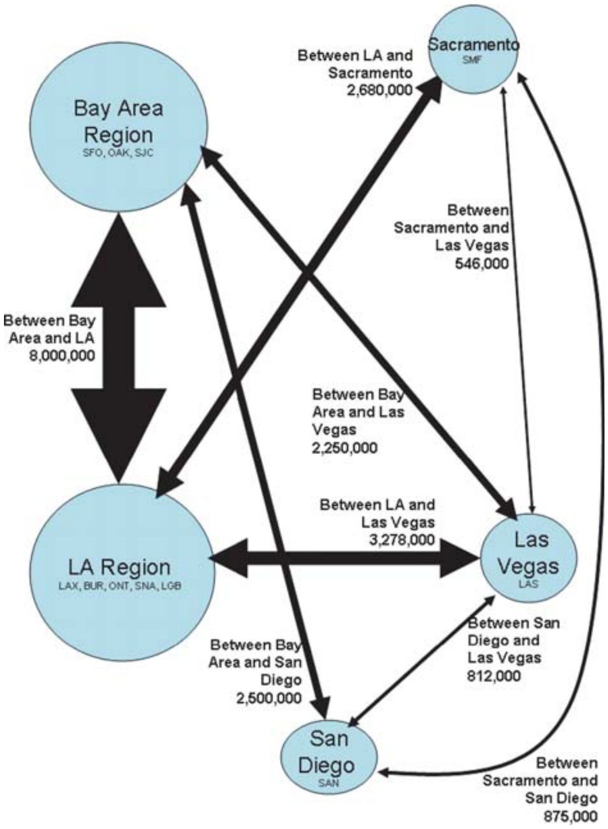

Figure 2.2. West Coast inter-metropolitan air travel, by metro-pair (2).

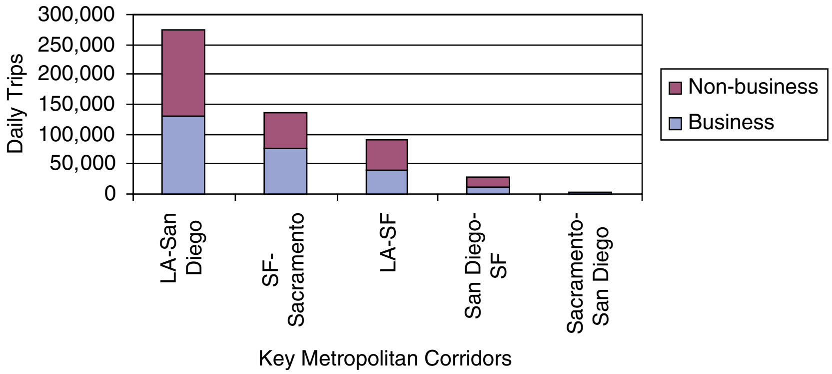

Figure 2.3. Scale of travel in key inter-metropolitan corridors—daily trips, all modes, all distances (3).

The modeling process undertaken in support of the California High Speed Rail Authority (HSRA) summarized the scale of several markets of interest to the mega-regions study (*3*). As Figure 2.3 shows, the volume of daily trips by all modes between Los Angeles and San Diego dwarfs that of Los Angeles to San Francisco, for example. The figure gives a sense of scale to the market for HSR services, as it includes both trips that are over 100 miles and trips along the corridors that are less than 100 miles.

2.2.1 Existing Short-distance Rail in California

Section 2.2.1 examines the market between San Francisco and Sacramento, where Amtrak primarily competes with the private automobile and not the short-distance airplane. Reportedly, Amtrak's Capital Corridor carries over 1 million annual trips, of which 770,000 are between the Bay Area region and the Sacramento region, whereas almost 300,000 are within either region. The research team estimates that this corridor rail service captures about 3% of the market, with the rest overwhelmingly served by private vehicles. By contrast, total aviation trips between SFO/OAK and Sacramento airport add up to about 130,000 passengers per year, most of whom are transferring to other flights at the Bay Area airports. Looking only at interregional OD passengers, the research team's aviation volumes suggest that Amtrak has an air–rail mode share of well over 90% between Sacramento and SFO/OAK (see Table 2.1).

Between the Los Angeles Mega-region and the San Diego Mega-region, Amtrak's Surfliner carries 840,000 passengers per year and another 673,000 within the regions. By contrast, there are about 320,000 passengers flying between San Diego and the Los Angeles area, including Santa Barbara, which is the northernmost terminal of the Amtrak Surfliner service. Most of these air passengers are connecting to/from longer distance flights.

2.2.2 Proposed New HSR Services in California

In November 2008, the voters of California supported a major program of HSR services in California. The implications for the demands on airports (and all other modes of transportation) influenced by this possible investment could be immense in terms of intrastate trip-making.

In terms of the primary focus area of this research, the system has some potential points of interchange with California airports. The alignment goes immediately adjacent to SFO (Millbrae) but not at all near to OAK. It goes very close to Palmdale, but is not in the same geographic area as LAX. Ontario and San Diego airports could be served by the proposed alignments.

Table 2.1. The role of rail service in major intra-California corridors (*3*).

Mode Share	Auto (%)	Air (%)	Rail (%)	Total Daily Trips
LA to SAN	97.9	0.0	2.1	262,926
SF to Sacramento	98.7	0.0	1.3	139,580
LA to SF	51.1	48.9	0.0	54,898
SAN to SF	31.0	69.0	0.0	14,939
LA to Sacramento	60.2	39.8	0.0	12,414
SAN to Sacramento	5.8	94.2	0.0	3,033

Figure 2.4. Proposed California HSR network (3).

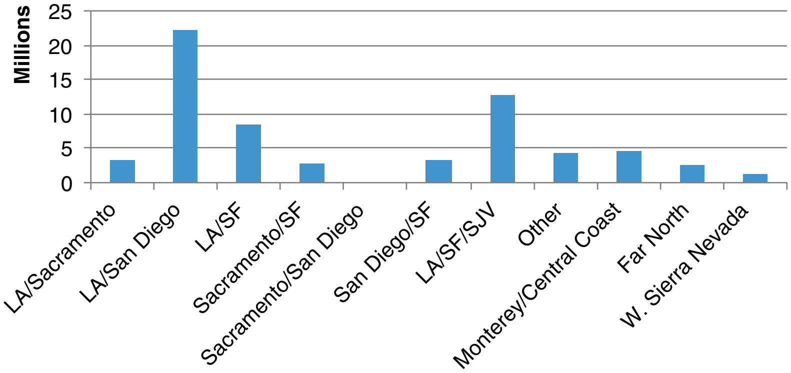

Figure 2.5. Number of interregional California high speed rail trips by corridor, 2030 (4).

Figure 2.4 shows the present configuration of the full project, as of the summer of 2008. The network configuration has two branches in the Bay Area region and two branches through the Los Angeles Basin region.

Figure 2.5 shows the latest ridership forecasts available to the research team. The reader should be aware that the forecasts have been formulated to allow for variation in input assumptions (e.g., the price of fuel as assumed at the outset of the analysis vs. the price of fuel reasonably forecast for the next 25-year period). The ridership forecasts should be seen as part of a possible range of predictions, based on a possible range of input assumptions. Thus, these ridership numbers should be seen as a good summary of the information now being reviewed by the California HSRA and may indeed change.[14] Figure 2.6 shows the mode-share forecasts for each of the major intra-California corridors discussed in this chapter.

2.2.2.1 Analysis of Future Ridership in the West Coast Mega-regions

As expected, the volume of rail passengers shown in Figure 2.5 between Los Angeles and San Diego at above 20 million riders, is more than double the volume of rail passengers

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[14] To maximize their legibility, the figures are presented in color for the Adobe PDF file version of the report.

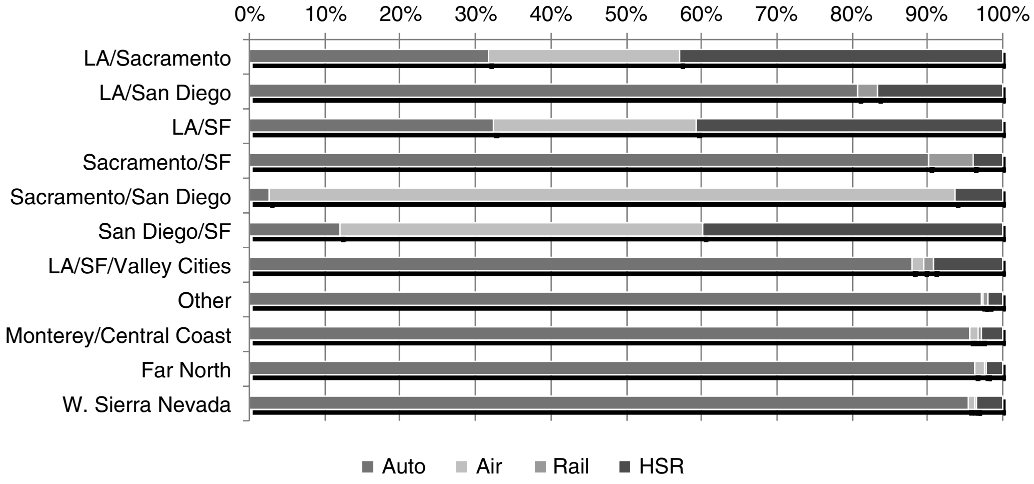

Figure 2.6. Mode share for interregional travel in California, 2030 (4).

between Los Angeles and the San Francisco Bay Area. As demonstrated in the previous section, the LA–SAN volumes are largely diverted from the automobile—not from the airplane—with a dominant role in this large market continuing to be played by the automobile.

Flows to and from the Valley comprise the second largest set of HSR users. Most definitions of a Northern California and a Southern California Mega-region do not include the area between Fresno and Bakersfield in either mega-region.

A volume of over 8 million rail riders per year is shown in Figure 2.5 for the critical LA–SF corridor, with an HSR mode share of about 40% (Figure 2.6), which is higher than either air or automobile. Strong market shares to HSR are reported between Los Angeles and Sacramento, and between San Diego and San Francisco.

2.2.2.2 Scale of Diversions from Air to Rail in the West Coast Mega-regions

On the basis of the calculations presented, three major sources of diversion from air to rail in California can be noted. At present, air captures approximately the following:

- 49% of the market between Los Angeles and the Bay Area, with the rest by auto. In 2030, that share might fall to about 29%.
- 40% of the market between Los Angeles and Sacramento, with the rest by auto. In 2030, that share might fall to about 26% of the total market.
- 69% of the market between San Diego and San Francisco, with the rest by auto. In the analysis year of 2030, the air share falls to about 45%.

Looking exclusively at year 2030 forecasts, if there were about 25 million travelers between the Bay Area and Los Angeles, the reported decrease in market share (compared with the present share) would represent about 5 million air passengers diverted to rail.[15] If there were about 14 million travelers between Los Angeles and Sacramento, air would capture 3.6 million or 2 million passengers would be diverted to rail. If there were about 7.5 million travelers between the Bay Area and San Diego, air would capture about 3.4 million, or about 1.8 million passengers would be diverted to rail. At this point in the analysis, these diversion potentials are somewhat speculative and are presented here only to give a sense of scale to the possible diversion phenomenon. But it does suggest that some 8.8 million air passengers are forecast to divert to rail in these three corridors of the larger system by the year 2030.

Total system diversions. The California analysis being using is based on about 65 million interregional HSR riders and 20 million intra-regional HSR riders (*4*). Of the interregional trips, the California forecasting process calculates that 79% were diverted from auto, 16% were diverted from air, 3% diverted from other rail, and 2% never made the trip before. Thus, for the ambitious system as a whole, this estimate projects that about 10 million riders would be diverted from air in the analysis year of 2030.

Figure 2.7 is reproduced from *High Speed Ground Transportation for America* (*5*), the FRA's landmark study of high-speed ground systems in 1997, discussed in the following sections. It shows the diversion from air and the diversion from auto trips. This 1997 study predicted a diversion of about 8 million passengers from air to rail in 2020 based on a smaller and somewhat slower California HSR system than

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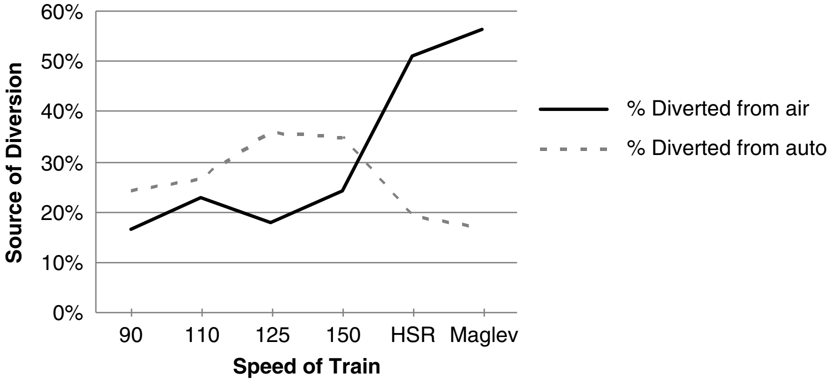
[15] A more complete analysis would build a revised 2030 air mode share for the no-build rail condition, but this was not done for this report; the purpose is only to establish a sense of scale for the possible diversions.



These forecasts resulted in a projected diversion of 8 million riders from air to HSR in 2020 (*5*).

Figure 2.7. FRA Study of the relationship between speed of train and source of diverted riders in California.

is proposed at present. It is based on a different forecasting process than used in the present study used in the preceding paragraphs (*4*).

2.2.2.3 A Consistent View of National Corridor Markets from the FRA

The previous sections of Chapter 2 have relied heavily on the most recent work for the California HSRA, undertaken in cooperation with the Metropolitan Transportation Commission (MTC) of the Bay Area. In Section 2.3 of this chapter, there is the case of the NEC of the East Coast Mega-region. In the East, no specific proposal has been agreed upon, and a major capital investment plan is now being drafted. For that section, the research team's analysis will first rely on the latest comprehensive, nationwide study of the issue by the FRA (*5*). This document was produced at the FRA with major input from the Volpe National Transportation Systems Center and traffic forecasting from the firm of CRA International. A more recent U.S. DOT study, also based on the work of CRA International, will be used to update the 1997 work in the NEC.

To provide the reader with as much comparable data as possible between the two mega-regions, this section of Chapter 2 presents a brief summary of the California rail corridor that appeared in the FRA study (*5*), which still remains the major benchmark for examining several corridors simultaneously.

In terms of service levels, the FRA's category "New HSR" seems appropriate for this comparison. The California HSRA is now referring to travel times from San Francisco as somewhat under 3 hours (*16*), and the FRA analysis refers to an HSR travel time of slightly above 3 hours, which is close enough for this kind of comparison. Looking at Figure 2.7 for example, "HSR" is the second category from the right.

The relationship between the speed of service, arrayed on the x-axis in terms of rail speeds and the previous mode of projected HSR passengers, arrayed on the y-axis in terms of percent of riders diverted from two modes, is explored in Figure 2.7. At speeds in the range of 110 to 125 mph, about 20% of the rail riders are projected to have been diverted from competing air services. At speeds of around 200 mph (labeled "HSR" in Figure 2.7), about 50% of the rail riders are projected to have been diverted from air, in the 1995 FRA study.

Looking at the California HSRA's diversion calculations, it appears the present HSR program is projected to divert about 10 million air trips in 2030. The present HSR program has more branches and services than assumed in the FRA study. In the earlier FRA study, the estimate for a smaller rail system was a diversion of 8 million air trips in 2020. For the purposes of this study, there is a reasonable level of comparability between the two estimates of diversion from air to HSR. The scale is massive: given the assumption of a continued growth rate for total volumes between 2020 and 2030, an estimate of over 10 million air diversions in 2030 is not inconsistent in general scale with the earlier work on diversion.

As noted in Figure 2.7, the California North–South system was expected to attract comparatively few air travelers at rail speeds of 150 mph or less. Projected diversions from air were summarized in a recent independent review of the forecasting for such a "lower" speed alternative in the West; see Las Vegas study, below. Based on the results of the FRA Commercial Feasibility Studies, and some additional corridors, a summary chart of air diversion by project was created and is reproduced here as Table 2.2.

2.2.3 HSR between Las Vegas and the Los Angeles Region

This section of Chapter 2 has so far focused on the California HSRA's program for the state, which was approved on the

Table 2.2. Summary of diversions from air (*6*).

Forecast High-Speed Rail Mode Shares from Some Recent Studies Corridor (with HSR top speed and study year)	FORECAST MODE SHARE		
FRA Commercial Feasibility Studies			
North–South California (150; 1998)	8.6% from air	4.3% from auto	
Los Angeles–San Diego (150; 1998)	19.8% from air	0.7% from auto	
Chicago Hub (150; 1998)	18.6% from air	4.3% from auto	
Chicago–Detroit (150; 1998)	17.6% from air	2.8% from auto	
Chicago–St. Louis (150; 1998)	22.2% from air	5.2% from auto	
Florida (150; 1998)	8.5% from air	2.3% from auto	
Pacific Northwest (150; 1998)	32.0% from air	3.5% from auto	
Texas Triangle (150; 1998)	17.9% from air	5.0% from auto	
Specific Corridor Studies			
California Statewide (250; 2007)	33% from air	6% auto	27% from rail
Cleve–Columbus–Cin (150; 2001)	2% from air	1.7% auto	16.2% bus
Boston–Montreal (110; 2005)	18% from air	0.2% auto	
Baltimore–Washington (300; 2003)	13% from air	0.1% auto	
Tampa–Orlando (150; 2003)		12% auto	
New York–Buffalo (150; 1995)	67% from air	6% auto	29% rail
New York–Boston (200; 1996)	50% from air	7% auto	15% rail

November 2008 ballot. In addition, other projects are being examined by several organizations. One such proposal, the "Desert Xpress," is a proposed privately funded rail project between Victorville, CA, to Las Vegas, NV. After an extended process of the peer review, estimates were made of ridership between the Los Angeles area and Las Vegas (see Table 2.3). The rail trip was expected to take 116 minutes, with 30-min headways, and a present fare of $55. (The rail ridership forecasts shown in Table 2.3 were originally done by RSG,[16] for inclusion in a complete analysis managed by URS, Inc. These forecasts were then subject to an independent peer review by the consulting firm Steer Davies Gleave. That review was subsequently reviewed by Cambridge Systematics, who proposed that the forecasts be lowered slightly. The data contained in Table 2.3 represent the work of the previous teams, with the decrease recommended by Cambridge Systematics.)

The original projections for the project estimated that rail would capture 22–24% of the total market, whereas the peer review process lowered the estimates by roughly one tenth. In short, the project is projected to capture about 20% of the total market, depending on final assumptions used. Importantly, the use of 150-mph "conventional" rail for the project does not result in diversions from air at the scale proposed in the California HSR project, with only about 0.7 million diversions from air in the analysis year of 2030. If speed assumptions are similar to those used in the California HSR project, the diversions from air would be significantly higher. The research team's analysis concludes that projects in California and Nevada together could divert in the range of 11 million air trips in the planning horizon.

2.2.4 Costs for the New Projects

In November 2008, California voters approved a $9.95 billion bond issue. At the time of the research team's latest interviews in California, the exact portion of the full program that will be built from those funds had not been determined. The California HSRA's website refers to the total project as $40 billion.

Table 2.3. Projected rail ridership LA to Las Vegas, 2030 (*6*).

Projected Ridership on the Desert Xpress Rail Project, by Source of Diversion, 2030	
Diverted from Air	733,051
Diverted from Auto	4,399,113
Diverted from Bus	293,983
Total Rail Ridership, 2030	5,426,147

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[16] RSG is the prime contractor for ACRP 3-10.

In the past, it has been difficult to make accurate cost estimates of projects that are still in the preliminary design phase.

Of equal importance in the treatment of the cost issue is that there is no comparable level of project planning completed on the East Coast. By way of example, in 1997 the FRA estimated the costs of a (smaller) HSR system for California at $19.5 billion; the costs of a 200-mph HSR in the NEC were estimated at $24.3 billion. As is discussed in the following section, the cost of incrementally improving the present NEC facility to attain the originally defined travel-time objectives has been estimated at about $14 billion.

2.3 Rail Services in the Eastern Mega-region that Could Influence Aviation Capacity Issues

2.3.1 Market Share Impacts of Improved Travel Time

Almost all of the analysis presented for the Western Mega-regions concerned the creation of entirely new services, built "from scratch" to gain very significant market share, and lowering overall intra-California air passenger volumes by a possible 10 million passengers per year in 2030.

The existing situation on the East Coast is fundamentally different, as highly successful HSR services already exist for the city pairs of Boston–New York, New York–Washington, D.C., Philadelphia–New York, and Philadelphia–Washington, D.C.

What happens to competing air market share when existing competing HSR services improve, as would have to be the case in the Northeast? Figure 2.8 was prepared by a British consulting firm, Steer Davies Gleave, for the European Commission, and it builds on the simpler chart shown in Figure 2.1.

Figure 2.8 shows the impact of a change of the independent variable "rail journey time" arrayed along the x-axis (horizontal) on the dependent variable "rail market share" arrayed along the y-axis (vertical). To use one of the earliest examples of HSR influencing an air market, when Paris–Marseille had a rail journey time of over 4 hours, its rail versus air mode share was under 50%. When the journey time was improved to under the rule-of-thumb value of 3.5 hours, the market share increased to 65%.

When rail journey times between London and Brussels improved by about 0.5 hours, its rail versus air mode share moved up by about 20 percentage points. In the lower right-hand quadrant, early improvement in rail times between Madrid and Barcelona still resulted in a nearly 5-hour rail journey time, the mode share improvement was slight. Since the publication of the graph, travel time between Madrid to Barcelona has been improved to about 3 hours, and the reported rail versus air mode share has risen to about 38% (*7*). Thus, the shift is similar in overall direction and slant to most of the other arrows on the graph.

The present rail-versus-air mode share shown in Figure 2.8 between Frankfurt and Cologne is so high that it deserves a separate treatment in this chapter (see Section 2.4). The almost nonexistent air mode share for this city pair is the result of the dominant airline at Frankfurt deciding to cease providing air service in the corridor and to provide rail service instead. Because this case is fundamentally different than others shown on the chart, and fundamentally different than what might happen in the Northeast, it will be treated separately in this chapter.

2.3.2 Existing City-pair Rail Services in the East Coast Mega-region

Rail has already played a major part in moderating the aviation flows in the East Coast Mega-region. Figure 2.9,

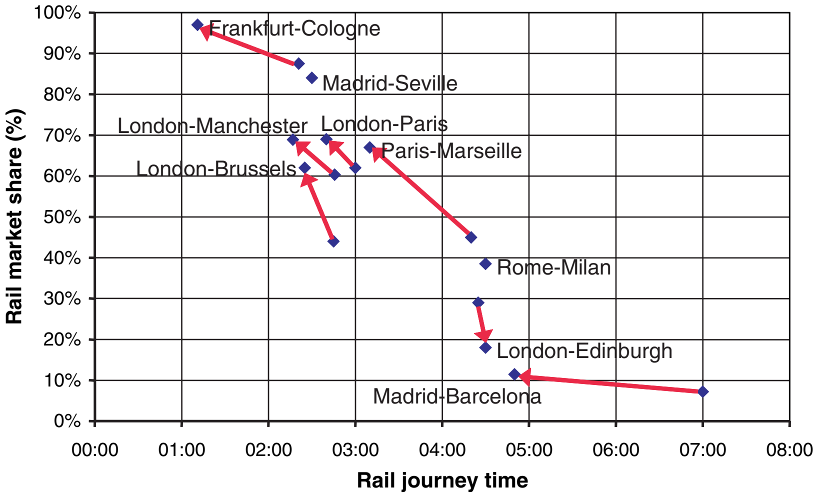
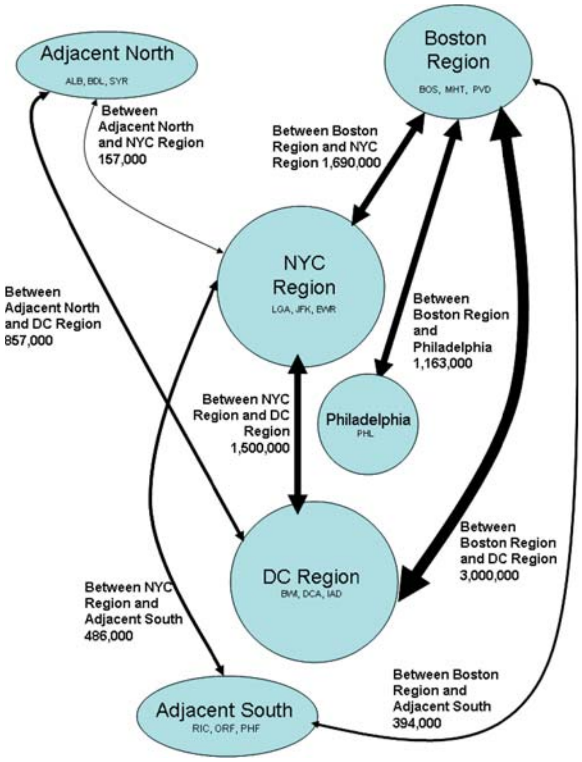


Figure 2.8. Changes in market share from changes in travel time (1).



Note: The absence of a line between two areas means that the number of air trips is insignificant.

Figure 2.9. East Coast inter-metropolitan air passenger flows (2).

reproduced from Chapter 1, shows no OD air passenger volumes of significance between Philadelphia and the metro regions to its immediate north or south. Air volumes between New York and Boston, and New York and Washington, D.C., show the strong influence of HSR market shares.

This section of Chapter 2 explores the existing rail volumes in these major city-pair corridors. The market shares have been calculated by Amtrak and are presented in Table 2.4 as received. Note that the metro-area pair data derived in Chapter 1 (and reproduced here in Figure 2.9) use a definition of "airport families" that is different from Amtrak's definition of immediately competing airports, and the two values should not be used interchangeably. (The Boston Airport System, as used in Chapter 1, includes BOS, MHT, and PVD together.)

Table 2.4. Existing city-pair rail market shares in the East Coast Mega-region (*8*).

City–Pair Corridor	Rail Share of Air + Rail Total (%)
Boston–New York	49
Boston–Philadelphia	17
Boston–Washington	7
Providence–New York	90
Albany–New York	97
New York–Philadelphia	95
New York–Washington	63
Philadelphia–Washington	89

The rail market shares for Providence, Albany, and Philadelphia (to and from NYC) show that rail has already established a market dominance in these areas and that most air traffic in these city-pair corridors is for the purpose of connecting flights, not OD travel. This will have significant implications for later analysis for the ability to divert short-distance flights out of New York and Philadelphia airports.

2.3.3 Future Improved City-Pair Rail Services in the East Coast Mega-region

As noted earlier, the future form of HSR in the Northeast has yet to be determined. Various policy options have, however, been studied on several occasions and forecasts have been done for a variety of possible futures. This report now presents an analysis of the potential for HSR services from Boston to Washington, D.C., from two separate perspectives. First, an analysis included in the FRA's comprehensive 1997 study (*5*) is summarized; second, a 2008 study is reported. The first study represents a 1997 vision of the task remaining after completion of the upgraded project as then envisioned. The second presents a more up-to-date and more relevant analysis of the need for upgrading first to the earlier 1997 expectation of performance (i.e., 3 hours of travel time between BOS and NYC) and then to a faster service (i.e., 2.5 hours).

First, the FRA's 1997 study is reviewed, as it allows a common method of comparing various corridor investments throughout the nation, based on a common methodology and set of assumptions. Figure 2.10 is reproduced to show calculations on travel time and diversions from air and auto. Note that the format differs somewhat from what was presented earlier in the chapter that concerned the FRA's analysis of HSR in Northern and Southern California. The first set of policy alternatives, which allow for incremental analysis of incremental improvement to the rail system, is missing from the page. This is because, at the time of the study, the decision had already been made to proceed with an aggressive 150-mph electrified alternative, now generally known as Acela. This presents complexities for this analysis, but certain observations can be made from the nationwide 1997 study.

The FRA study concluded that total passenger miles could increase over the Amtrak system in place in 1993. Compared with an observed 1.3 billion passenger miles in that base case, the analysis predicted that true HSR could attract more than 3.5 times that volume of passenger miles, in the forecast year of 2020. Figure 2.10 shows that HSR was predicted to divert more than 4.5 million air trips in the total corridor and less than 1 million auto trips.

The "New HSR" assumed in the 1997 FRA study had a Boston–New York running time of less than 2 hours, compared with the nearly 5 hours in its base case, and roughly 3.5 hours in 2008.

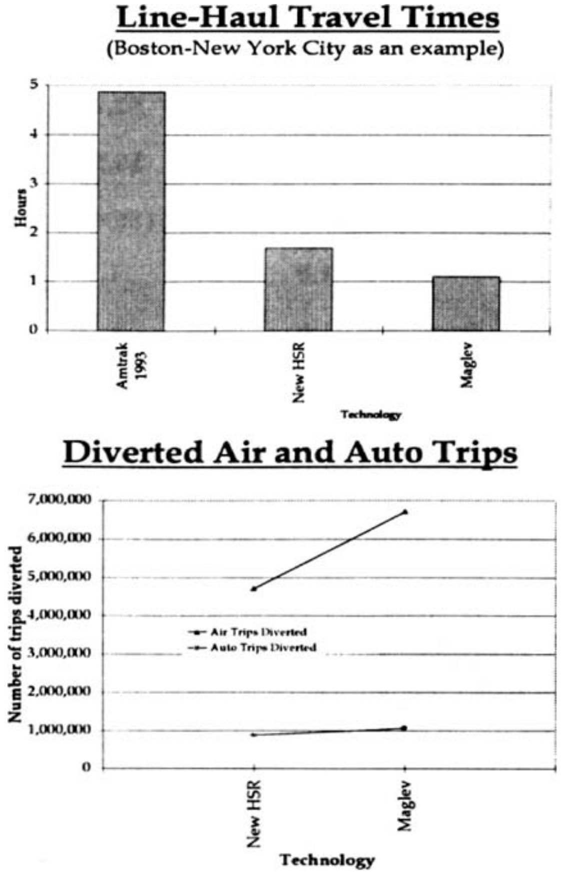


Figure 2.10. The FRA's 1997 analysis of HSR in the East Coast Mega-region (5).

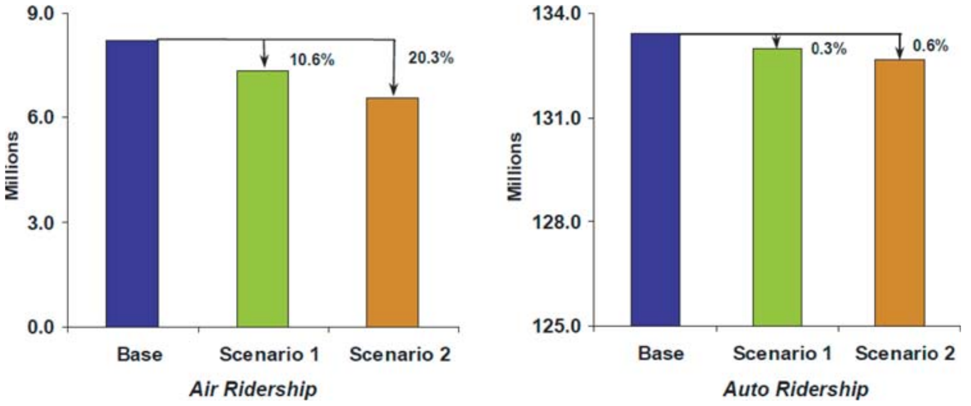
2.3.4 Diversions from High-Speed Rail Above and Beyond Present Conditions

In the summer of 2008, the Office of the Inspector General, within the Office of the Secretary of the DOT, released an updated report that fits the needs of this study in the analysis of possible improvements over and above the present status quo. The objectives of their review were to "(1) estimate the revenue and congestion relief benefits associated with different levels of HSR on the NEC and (2) determine whether HSR would pay for itself through increased revenues, congestion relief, or a combination of the two" (*9*).

2.3.5 Additional Corridor Development in the East Coast Mega-region?

First, CRA International estimated the benefits associated with achieving the travel times initially envisioned in the 1976 legislation: 3-hour service between Boston and New York and 2.5-hour service between New York and Washington. Then the consultants estimated the benefits of achieving travel times that are 0.5 hours shorter on both ends: 2.5 hours between Boston and New York and 2 hours between New York and Washington. The results of the analysis are reproduced here, including Figure 2.11, from the Inspector General's report (*9*):

- HSR on the NEC would cause a notable share of current air travelers to choose to travel by rail rather than by plane. Roughly 11 percent of air travelers would divert to HSR at scenario 1 travel times. This would provide congestion relief at NEC airports and in NEC airspace. However, less than 1 percent of automobile travelers along the NEC would divert to HSR in scenario 1. This result reflects the greater similarities between air and rail travel than rail and automobile travel, particularly with regards to convenience.
- Benefits from HSR would grow at an increasing rate with each further reduction in travel time. Scenario 2, with its travel time reduced by an additional ½ hour from scenario 1 on both the north and south ends of the NEC, would produce net present value benefits of $36.0 billion. This is more than double those in scenario 1. The research team's evaluation showed that each further ½-hour reduction in travel time would generate benefits at a greater rate as travel time decreased.



Source: OIG analysis.

Figure 2.11. Projected diversions from air and auto from completing the Northeast High Speed Rail Project, 2008 (8).

2.3.5.1 Empire Corridor and the East Coast Mega-region

In the FRA 1997 study (*5*), an Empire Corridor project was examined as an incremental extension of other presumed investments in the currently defined NEC. The travel time from NYC to Buffalo was calculated at 3.3 hours, with 50 trains per day assumed. The new Empire HSR corridor was expected to attract 32.6 million passengers in the year 2020. The project was forecast to divert nearly 24% of air travelers and about 3% of auto traffic in the city-pair corridor.

A brief review of the data suggests that Albany is clearly a candidate for an extension of the existing NEC network, and that strong performance to NYC (and its airports) could be attained as far west as Syracuse. The sheer distance between NYC and Buffalo casts doubt on the idea that rail could replace and or/complement air services at Buffalo. As a result of these observations, Figure 2.9 *does* include Syracuse in an Upper New York family of airports for inclusion in the East Coast Mega-region analysis. It does not include Buffalo in that category.

In the summer of 2008, a new study (*10*) of the potential for the Empire Corridor was released. The study pointed out that there are essentially two markets for HSR services in the Empire Corridor and the possibility of some synergistic connection between the two markets:

- The west corridor, comprising travel between all station pairs between Buffalo/Niagara Falls and Albany–Rensselaer;
- The south corridor, comprising travel between all station pairs between Albany and NYC (Penn Station); and
- Through, comprising all travel between all stations in the west corridor and the south corridor. (*10*).

Consistent with the assumptions made by the research team, little opportunity exists for additional diversion from the NYC-to-Albany air market, because the rail/air mode share is so high already. At the opposite end of the spectrum, the distance between NYC and Buffalo may make a realistic alternative to air somewhat difficult to accomplish.

By the year 2025, an aggressive HSR program is projected to attract more than 2.5 million in the Albany–NYC corridor, compared with about 750,000 between Albany and Buffalo. Those traveling between the "west" corridor and onto the "south" corridor were calculated at 412,000. (In the super-speed maglev-like scenario, this number shoots to 2.4 million passengers.) The authors note the following:

> Because of its speed advantage, air competes effectively with auto over the longer distances (greater than 200 to 250 mi) between the major through markets (for example, Rochester to NYC is 370 mi). Rail only competes effectively with air in these long distance travel markets when it provides a line haul travel time of two hours or less, and when it also offers a slightly lower fare (which it does in these phases) to compensate for its longer travel time (*10*).

2.3.5.2 Southeast Corridor and the East Coast Mega-region

The FRA 1997 report also examined the extension of improved rail from Washington, D.C., as far as Charlotte, NC. The travel time from D.C. to Charlotte via New HSR was calculated at 3 hours, with 52 trains per day. The full corridor (i.e., to Charlotte) was expected to attract 32.5 million passengers in 2020. The project would divert about 25% of the corridor air travelers and about 3% of auto traffic in the city-pair corridor.

Analysis of the catchment areas (and, to a lesser extent, the air-feeder patterns) at the three Mid-Atlantic (BWI, DCA, and IAD) airports resulted in the decision by the research team to include Richmond, Norfolk, and Newport News in the description of the East Coast Mega-region, as described in Figure 2.9 (and Figure 1.3 in Chapter 1).

2.3.5.3 Other Rail Investments in the East Coast Mega-region?

The FRA 1997 report provides little guidance on extensions of improved rail either to Hartford/Springfield, CT, or to Harrisburg, PA, and beyond. From the point of view of this study, inclusion of airports in Manchester, NH, and Albany already warrants that the geographic area north and west of Boston be included in the definition of the East Coast Mega-region.

The corridor from Philadelphia to Harrisburg and beyond needs to be considered a major candidate for improved rail to the NEC system; however, its airport traffic was so low that it was not specifically included in the analysis presented in Chapter 1, or specifically incorporated into Figure 2.9. The summary analysis that follows assumes, in a general way, significant improvements for higher speed rail services to both Hartford/Springfield and to Harrisburg.

2.3.6 What Additional Capacity Is Needed for Core Services?

The 1997 FRA studies (*5*) refer to the potential of a threefold—even a fourfold—increase in the volume of rail traffic on the existing lines of the NEC, for an analysis year of 2020.

The concept of a 300% increase in ridership over the existing infrastructure of the NEC is cause for concern. If the NEC infrastructure were devoted only to long-distance rail services, life would be simpler. But with NJ Transit, Long Island Railroad, and, to a lesser extent, Metro North, all sharing the tunnels in, out, and through NY Penn Station, the infrastructure capacity issue is considerable. With over 2,500 trains operating on the NEC each weekday, scheduling systems in which local and slower trains need to be overtaken by faster trains is a challenge. A track utilization diagram is presented as Figure 2.12, which was designed to be interpreted by those trained in railroad operations management. The message that the system is very busy, however, is clear—even to the railroad layman.

The throughput at major terminals has been identified by Amtrak as the major constraint on capacity. The research team interviewed managers at Amtrak, who emphasized the need to fundamentally replace NY Penn Station as the effective center of the NEC network. Capital costs in the nature of $2 billion were discussed, with the understanding that engineering work had not progressed at this point. It has been repeatedly noted that the so-called Moynihan Terminal project, immediately to the west of NY Penn Station, will improve the quality of pedestrian access and egress to/from the platforms, but not increase the throughput of the station.

At this point, a strategy to provide additional capacity for longer distance HSR has not been developed. More capacity is being proposed for access to Manhattan over the two major rivers. New York's MTA, through Metro North, will connect the Long Island Railroad into Grand Central Station, using an existing but presently unused tunnel under the East River. Turnback tracks for that project will extend southward for several blocks under Park Avenue.

NJ Transit is proceeding with the planning of the Access to the Regional Core/Trans-Hudson Express Tunnel project, which would provide an additional tunnel under the Hudson River to an alignment immediately north of the existing NY Penn Station. Turnback tracks for that project will extend several blocks east of that station toward Park Avenue.

The concept of linking the two projects has been raised in public dialogue. According to project managers, the timing of such a later project is interrelated with the rebuilding of new water/sewer tunnels in the area and must await resolution of those and other issues. At present, both projects are proceeding as independent, free-standing commuter rail projects. Reportedly, the clearances on the new East River tunnel are not consistent with HSR requirements.

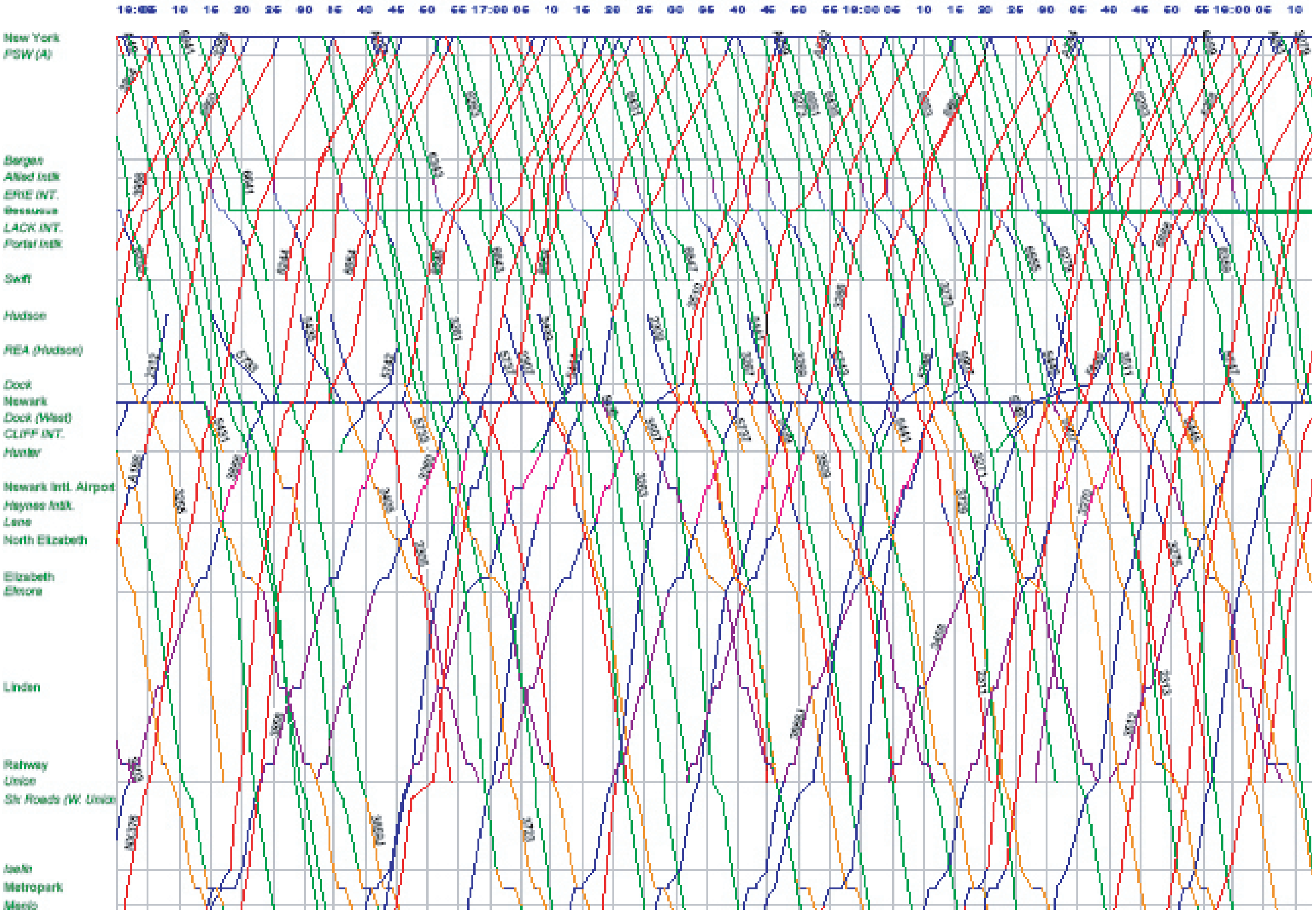


Figure 2.12. Track utilization diagram, New York Penn station to Metropark, Evening Peak (11).

2.3.7 Summary Scenarios for Possible Diversion in the East Coast Mega-region

To what extent might investment in higher quality HSR in the East Coast Mega-regions divert future aviation passengers away from overcrowded airports? The challenge to answering this question is based on the fact that there is not a single, agreed-upon "master plan" for investment between New England and Virginia. Section 2.2 in this chapter concluded that in the next 21 years, an upper limit for diversion from the California rail network would be on the scale of 10 million passengers per year, with more than a million air diversions in a Los Angeles-Las Vegas system of similar speed.

As noted in Chapter 1, the East Coast Mega-region of the United States is at present less dependent on short-distance airline trips than are the West Coast Mega-regions. On the basis of BTS statistics (*2*), a detailed aviation trip table was built for the base year 2007. Using airport-pair expansion factors developed in the FACT 2 project, airport-to-airport trip tables were constructed for the future year, 2025.

The airports were then aggregated into regions for the analysis of air travel within the study area, as shown in Figure 2.2 for the West Coast Mega-regions and in Figure 2.9 for the East Coast Mega-region. Thus, the analysis of possible rail diversion has been geographically organized to be consistent with the air passenger flow maps first presented in Chapter 1.

The research team has created three forecasts for the year 2025 to support the analysis of possible system-wide rail diversions in the East Coast Mega-region. For each "airport family" to every other "airport family" in Figure 2.9, year 2025 air passenger flows were calculated with (a) a no diversion to rail scenario, (b) a moderate diversion to rail scenario, and (c) an upper-level diversion to rail scenario. The reader should be aware that these three scenarios do not represent the result of any system-wide application of a single, consistent model. Rather, for each pair of airport groups, the existing literature supported by the previous FRA/DOT research to predict diversion to rail from air was reviewed for its relevance and possible applicability. In most cases, a previously published diversion factor for a moderate rail scenario and a diversion factor for higher quality rail scenario were located. In other subcorridors, diversion factors were assumed from corridors with similar characteristics (see note for Table 2.5).

Table 2.5 presents the results of the application of these three hypothetical diversion scenarios for the analysis year of 2025. (The implications of applying the diversion factors to the 2007 base case are also shown on the table.)

The high diversion scenario for the East Coast Mega-region shows a high-range estimate of about 3.8 million air trips to HSR in the year 2025. This upper level of the range represents about 25% of the total short-distance air trip-making predicted in the mega-region, at about 14.4 million air passenger

Table 2.5. Summary of possible high- and low-diversion scenarios in the East Coast mega-region.

Markets and Diversion Rates		Air Passengers; Base Case, No Diversion		Air Passengers Diverted to HSR: Low Diversion		Air Passengers Diverted to HSR: High Diversion	
Market	Corridor Used for Diversion Rates*	2007	2025	2007	2025	2007	2025
Adjacent North–D.C.	Partial Empire/NEC	929,540	1,590,703	92,955	159,072	228,121	390,379
Adjacent North–PHL	Partial Empire/NEC	116,030	294,356	11,603	29,436	28,475	72,239
Adjacent North–Adjacent South	Partial Empire/NEC	113,200	194,767	11,320	19,477	27,781	47,798
Boston–D.C.	NEC	1,814,090	3,212,528	199,550	353,378	489,716	867,227
NYC–Albany/Rochester	Full Empire/NEC	339,810	669,774	33,981	66,978	83,394	164,371
NYC–D.C.	NEC	1,503,440	3,049,680	165,378	335,465	405,856	823,266
NYC–BOS	NEC	1,680,870	3,253,951	184,896	357,935	453,753	878,409
NYC–Adjacent South	NEC/Partial SEC (Southeast Corridor)	484,520	969,040	49,468	98,935	121,398	242,797
PHL–BOS	NEC	579,390	1,119,553	63,733	123,151	156,407	302,225
NYC–Harrisburg	Partial Empire/NEC	880	1,935	88	193	216	475
		7,561,770	**14,356,286**	**814,979**	**1,546,045**	**1,997,125**	**3,791,210**

Definitions: Adjacent North= BDL, ALB, and SYR. Adjacent South= RIC, ORF, and PHF; from Figure 2.9

* Diversion rates were adapted from published data in Reference 5. They were modified further from data published by the DOT (*9*) and from data published in Reference 10. Each of these three documents was based on forecasting undertaken by CRA International.

trips per year. The lower level of the range shows a diversion of 1.5 million air trips to rail, or about 11% of the predicted air passenger volume in 2025.

By way of comparison, California's absolute value of diverted riders is somewhat more than twice the high estimate for the northeast for 2025 (as extrapolated.) In general, short-distance air trip generation rates in the West Coast study area are more than three times those of the East Coast study area. In short, there are more short-distance air riders to divert in the California market than there are in the Northeast market. One reason for this is that Amtrak has "already" captured far more of these short-distance trips in the East than in California. Amtrak ridership in the Northeast Megaregion study area is above 13 million riders in 2008, whereas its California ridership was about 5.5 million riders (*12*).

In conclusion, improvements to HSR now under discussion at various levels of detail and various levels of probability might have profound effects on airport-pair corridors associated with airports with severe capacity problems over the next several decades. A planning process is needed to better integrate aviation planning with the public policy options actively being examined in the United States, consistent both with the initial $8 billion outlay for HSR in the adopted stimulus bill and with the proposed intention to continue this program over the next years.

Section 2.3 of Chapter 2 has focused on the scale and range of diversions from air to rail that are possible in the two study areas. Section 2.4 now presents an analysis of the extent to which lowered air passenger volumes (resulting from rail diversion or from other factors) actually decreases the level of congestion at impacted airports and air traffic corridors. The conclusions of Section 2.4 may have an impact on the need for the kind of reforms suggested in Chapter 5, which support a more transparent and accountable system of management.

2.4 What Happens at the Airports When Air Passengers Are Diverted to Other Modes?

A central theme of this chapter is that modal alternatives, and HSR in particular, have a profound impact on aviation patterns and thus should be better integrated into a more multimodal aviation capacity analysis process. The previous sections document well-publicized changes in air–rail mode share in corridors like London–Paris and Madrid–Barcelona. This section of Chapter 2 documents how this process has already taken place in the United States, using the Boston–NYC corridor as a case study. Although improvements in rail mode share have also occurred in the NYC–Washington, D.C., corridor, the change in travel behavior is more dramatic in the BOS–NYC corridor, as its base case travel times were considerably worse.

Table 2.6. 1995 mode shares between Boston and NYC–Newark, with Auto (*13*).

BOSTON TO NYC–NEWARK 1995		
Mode	**Share of All Modes (%)**	**Share of Air+ Rail (%)**
Auto	48.3	
Air	37.3	84.0
Bus	6.7	
Rail	7.1	16.0
Other	0.5	
Total	100	100

2.4.1 Historical Mode Share (Including Autos), Boston to NYC Airports

According to the American Travel Survey (ATS) (*13*), which is the only source of multistate public data that includes highway travel, in 1995 the private automobile represented about half of the travel between the Boston standard metropolitan statistical area and the combination of NYC and Newark metro areas in the southern end of this corridor (Table 2.6). Because there has been no systematic updating of longer distance highway flows, and because the study of longer distance travel relies on unreliable data on the long-distance bus traffic, the rest of the analysis will be confined to the two component shares of the total air plus rail market in this corridor.[17] According to the ATS, rail captured about one passenger in six in this corridor. Rail travel times were about 5 hours between the two cities.[18]

At present (after accounting for the Acela service), travel times have been improved to about 3 hours and 25 min. This process of improvement commenced in December 2000.[19] As of 2008, rail can be conservatively estimated to capture more than 50% of the air-plus-rail market between Boston and the three NYC main airports.[20]

2.4.2 Changes in Air Passenger Traffic, Boston to NYC Airports

In 1993, more than 1 million passengers flew from Boston and terminated their air trips at NYC's three main airports,

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[17] The ATS data are important in that they are the only publicly available data that directly include auto flows. Direct comparison of data from this source to later rail and air mode shares may be problematical.

[18] If the 1995 reported Boston-NYC mode share had been included on the chart reproduced as Figure 2.8, the base-case market share would be located between the (then) Madrid-Barcelona value and that for London-Edinburgh.

[19] From 1999 to 2007, Amtrak ridership grew about 40% systemwide. City-pair mode-share-specific data were not available.

[20] Between 2007 and 2008, Amtrak ridership was up sharply, and segment volumes on flights between BOS and NYC airports were down by about 10%.

Table 2.7. Historical changes in Boston to New York air traffic (*2*).

PASSENGERS	1993	1999	2007
BOS to EWR	302,160	300,300	145,050
BOS to JFK	62,090	58,420	176,790
BOS to LGA	704,550	868,790	512,980
Total BOS to NYC	*1,068,800*	*1,227,510*	*834,820*
Total All BOS Origins	7,475,400	9,513,440	10,426,610

Notes: Acela service began in December 2000; JetBlue began JFK operations in February 2000 and began BOS to JFK service in 2004.

according to the BTS DB1B description of OD travel (Table 2.7) (*2*). Although overall domestic passenger originating volumes at BOS airport are now rising again from their 2002 nadir, air passenger volumes in the study corridor are down by over 20%. Examining the change between 1999 and 2007, study corridor volumes are down by about 30%. Thus, in the general period where the Acela rail services were competing with the air services, nearly one third of the OD air passengers between BOS and the three NYC airports ceased flying in the study corridor (Table 2.8).

The shift in the corridor travel market, as it impacts airport/aviation capacity, is expressed in two ways. First, the airlines lowered the number of flights in the corridor, but only slightly. More important, the airlines have used smaller aircrafts for the remaining flights. Comparing the 1999 flows with the 2007 flows, the number of flights in the corridor fell from more than 25,000 to under 24,000, or by about 6%. The number of passengers per flight fell from 67 to 59, or a drop of about 13% (Table 2.9).

The average size of the aircraft decreased by about 22%—from 124 seats per plane to 97 (Table 2.10). The pattern of shrinking aircraft size is consistent over the 15-year period, from 1993 to the present. The net result of multiple changes in operations is a lowering of the number of passengers per plane.

Table 2.8. Change in number of flights, Logan to NYC airports (*2*).

FLIGHTS	1993	1999	2007
BOS to EWR	9,511	5,379	4,394
BOS to JFK	3,729	8,266	8,089
BOS to LGA	11,741	11,959	11,478
Total BOS to NYC	24,981	25,604	23,961

Table 2.9. Change in average passengers per flight (*2*).

ROUTE	1993	1999	2007
BOS to EWR	59	93	66
BOS to JFK	47	30	58
BOS to LGA	67	81	58
Total BOS to NYC	**61**	**67**	**59**

Table 2.10. Change in average aircraft size (*2*).

ROUTE	1993	1999	2007
BOS to EWR	118	141	99
BOS to JFK	92	65	79
BOS to LGA	153	158	109
Total BOS to NYC	**131**	**124**	**97**

2.4.3 Conclusion: What Happened in Response to the Diversion of Air Passengers?

Parallel with the dramatic rise in Amtrak ridership over the past 8 years, air traffic between BOS and the NYC region fell by more than 750,000 passengers. Most of these moved to rail, which raised its ticket price; some rail riders (simultaneously) moved to low-fare bus carriers. But the impact on airport and airspace congestion is more complicated than implied by these basic observations. For, while the number of passengers declined sharply, the number of planes did not. Looking just at BOS–LGA (home of the original two shuttle operators), the number of planes declined only by about 4%, responding to a corresponding passenger decline (for several reasons) of about 40%. In this period, the average aircraft size fell by about 30% for the BOS–LGA route.

There are two powerful "lessons" from the Boston–NYC case study. First, the implications of alternative policies toward HSR can have massive impacts on air passenger demand and should be explicitly modeled in the aviation forecasting process. Second, the expected "diversion" away from air to rail cannot be seen as automatically having any kind of linear, parallel impact on the number of planes in the subject corridor. This underscores the essential message of Chapter 5: *the primary issue in aviation capacity in the two mega-regions is the need for airport managers to have more control and more accountability for improving the throughput of their facilities.*

2.5 Rail as a Complementary Mode to the Aviation System

Because of an extensive literature base on the subject of potential diversion from air travel stemming from new HSR services from city center to city center, it has been possible to establish a sense of scale for the amount of diversion from air passenger traffic that might be possible and to briefly observe how the market has responded in one case study corridor (BOS–NYC).

At the same time, the research team has found the literature base to be distinctly weaker, and of generally lower quality, on the subject of rail services in a complementary mode to support longer distances services at major airports. In carrying out the work for this report, it has become clear that the technical base for analyzing rail services as part of an intermodal passenger trip is weaker than for other aspects of this project. This section of Chapter 2 reviews what is known about the use of rail service as a feeder mode to airports both in the United States and internationally.

2.5.1 Experience with Rail as a Feeder Mode to Aviation in the United States

In the United States, the issue of improved interconnection of airports with national ground transportation systems has been raised repeatedly over the last decade. A major American transportation advocacy group, "Reconnecting America," has made the case that the national decline of the airline hub-spoke system has severely reduced service to smaller airports and that there is a void in terms of effective access to the remaining airports with growing air services (*14*). At present, there is only a modest amount of study underway to better understand this issue.

2.5.1.1 Northeast Corridor Master Planning Process

The question of how to define and develop the rail complementarity concept is still in its infancy. A 2005 report by the U.S. Government Accountability Office (GAO) describes EWR AirTrain (monorail) as the most advanced connection with the National Rail system (*15*). A conceptual diagram (Figure 2.13), created for discussion purposes in the NEC Master Planning process and furnished to the research team by Amtrak, raises the question of a different form of "rail as feeder" service. The reader is reminded that this diagram was developed to help define a concept and does not represent any kind of policy position on the part of Amtrak. The diagram illustrates the concept of creating new train lines directly on airport property and creating a service package specifically designed to support the rail as feeder concept.

The concept shown in Figure 2.13 is based largely on the experience in the Paris Charles de Gaulle and Frankfurt airports, where entirely new high-speed intercity rail lines have been built to be integrated with major air passenger terminals. (Other cities have diverted lower speed intercity services to airport terminals, such as Zurich and Geneva.) The diagram refers to "dedicated trains," a concept further explored in Section 2.5.2.

2.5.1.2 GAO Report on Air/Rail Complementarity

A recent congressionally mandated study by the GAO focused on the connections to nationwide systems for several reasons. In answer to the question of why the GAO undertook the study, the agency notes that:

> Increases in the number of passengers traveling to and from airports will place greater strains on our nation's airport access roads and airport capacity, which can have a number of negative economic and social effects. U.S. transportation policy has generally addressed these negative economic and social effects from the standpoint of individual transportation modes and local government involvement. However, European transportation policy is increasingly focusing on intermodal transportation as a possible means to address congestion without sacrificing economic growth. (*15*)

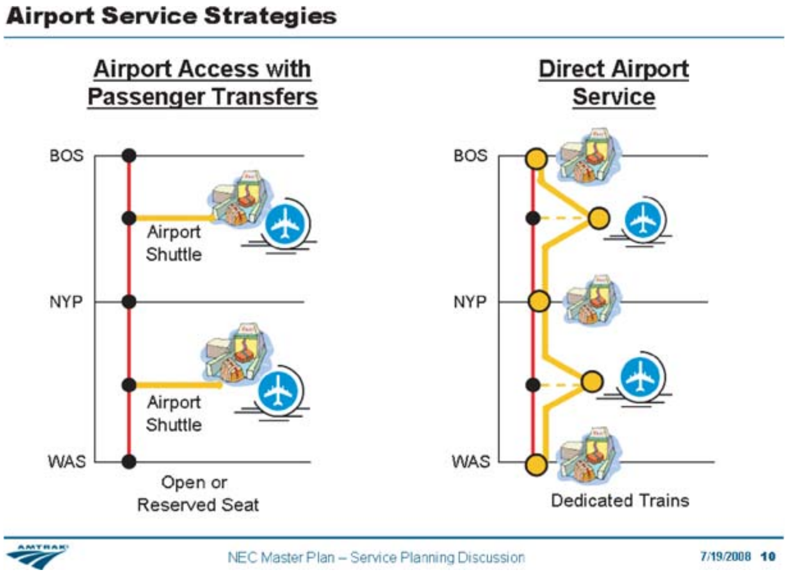

Figure 2.13. Conceptual diagram used in the development of the NEC master plan, May 2008 (11).

The study notes that, although there is only one American airport with a people mover to an Amtrak station, no American airport *reported* to the GAO an intention to build a new connection to an Amtrak facility. Figure 2.14 shows that EWR is the only current example of such a national connection in contrast to the 18 other less direct shuttle connections documented in the study.

The GAO report did not discuss the developing connection at PVD, in Warwick, RI, serving the Providence area. The "Warwick Intermodal Facility" is located on the NEC main line and is scheduled to open for train service in mid-2010. It will also house bus and rental car facilities and provide parking for rail users. After a prolonged design process, the airport managers settled on a 1,250-ft elevated skyway with moving sidewalks to connect the airport with the new rail station. This is described as the closest connection between any Amtrak station and adjoining airport and will not require a shuttle bus (unlike the other airports reviewed in the GAO report).

If PVD is to extend its geographic market area to the south, toward New Haven, CT, and northward to Boston, rail services provided by Amtrak and rail services provided by the Massachusetts Bay Transportation Authority (MBTA) will have to be designed to serve the needs of air passengers. Reportedly, Amtrak was at one point considering an airport stop on its regional service, but not on the high-speed Acela service. More recent statements from the airport note only that "the Intermodal Facility will serve MBTA commuter trains travelling between Warwick, Providence, and Boston" (*16*).

2.5.1.3 The American Experience with Rail as a Feeder Mode: Newark

As noted in the GAO study (*15*), there is only one example in the United States of an airport terminal area that is physically linked with the national rail system, either directly or by people mover. EWR rail station stands as the best American test case for the integration of long-distance ground service (Amtrak) with long-distance air service (the airlines.) An elaborate intermodal joint marketing and ticketing program was developed to utilize the physical facilities developed.

Throughout the implementation process, a four-party group developed the plans: NJ Transit, the Port Authority of New York and New Jersey (PANYNJ), Amtrak, and Continental Airlines. The result was the most concentrated attempt yet undertaken to integrate air and ground services. Continental entered into an agreement with Amtrak to code share certain rail services to Stamford, New Haven, Philadelphia, and Wilmington, DE. As such, Continental is able to sell a single, unified ticket (Figure 2.15) from Stamford to John Wayne Airport, for example.

A recently published ACRP study (*18*) on airport ground access concluded, "The goal of seamless integration between

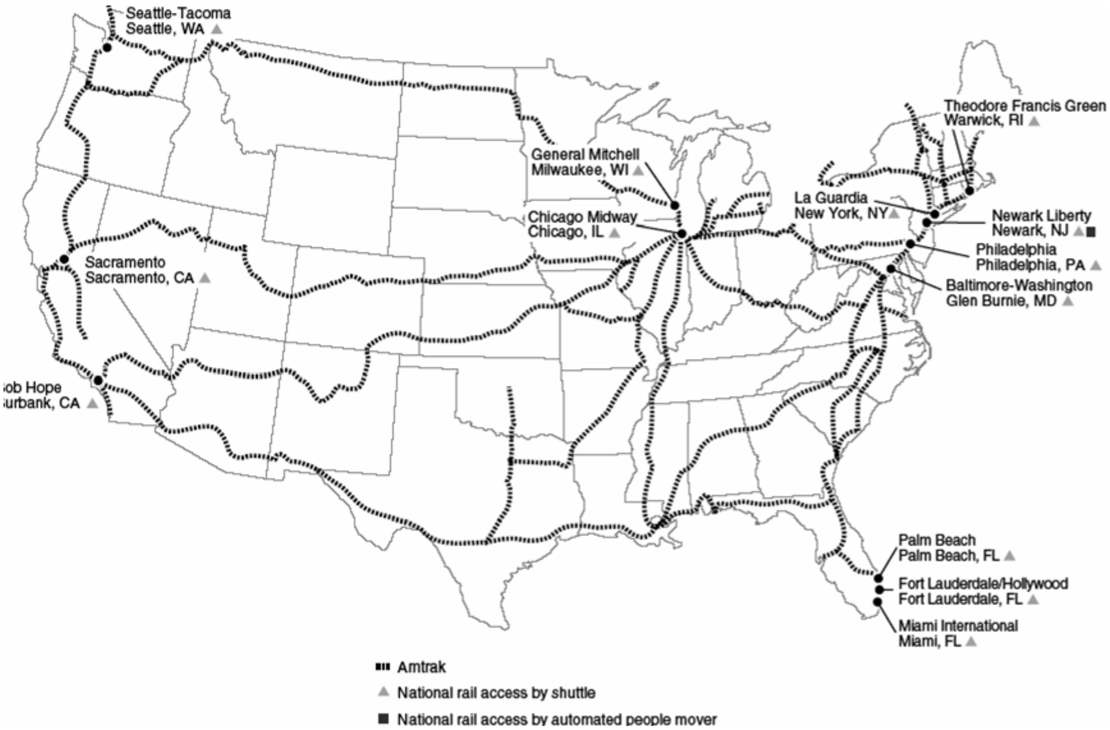

Figure 2.14. The GAO study on the complementary role of rail to aviation documented only one direct connection from Amtrak to airport terminals, at EWR (15).

Select Your Departing Flight for Wed., Apr. 25, 2007:

Price | Departing | Arriving | Travel Time | OnePass Miles

Flights with stops from $403.06

LOWEST FARE From **$403.06**	Depart: **8:24 a.m.** **Wed., Apr. 25, 2007** Stamford Rail Station, CT (ZTF)	Arrive: **9:57 a.m.** **Wed., Apr. 25, 2007** New York/Newark, NJ (EWR - Liberty)	Flight Time: 1 hr 33 mn	OnePass Miles/ Elite Qualification: **500 /50%**	Flight: **CO9434** Aircraft: **NOTE: This is Train Service** Fare Class: **Economy (S)** Meal: **None** View Seats
Select	**Change Planes.** Connect time in New York/Newark, NJ (EWR - Liberty) is 1 hour 53 minutes.				
	Depart: **11:50 a.m.** **Wed., Apr. 25, 2007** New York/Newark, NJ (EWR - Liberty)	Arrive: **2:47 p.m.** **Wed., Apr. 25, 2007** Orange County, CA (SNA)	Flight Time: 5 hr 57 mn Travel Time: **9 hr 23 mn**	OnePass Miles/ Elite Qualification: 2,433 /100% Total Miles: **2,933**	Flight: **CO387** Aircraft: **Boeing 737-700** Fare Class: **Economy (S)** Meal: **Lunch** View Seats

Continental flight 9434 operated by Amtrak.
Check in at the Amtrak Quik-Trak Self-Service Machine for Continental flight 9434 operated by Amtrak.

Figure 2.15. A Continental Airlines flight from Stamford, CT, rail station to California (16).

the national aviation system and the national rail system is as yet unrealized. As of 2005, about 370 daily Amtrak riders boarded or alighted at the station, while in 2006 about 350 daily riders used the station."

The experience of the EWR rail station and its rail as feeder service has been documented in some detail. In November 2004, the I-95 Corridor Coalition published the results of an intensive study of the intermodal coordination associated with the rail station project, which is available on the Coalition's website (*19*).

2.5.2 Rail as a Feeder Mode: The Frankfurt Case Study

The most highly developed program to implement the concept of rail as feeder was developed at Frankfurt Airport, with connecting rail service from a city 96 miles to the north and a city 91 miles to the south (as a comparison, Albany, NY, is about 136 miles from LGA.)

Importantly, the rail service to the north (Cologne) *did* lead to a decision on the part of the dominant airline to cease its short-distance feeder flights, whereas the rail service to the south (Stuttgart) did *not* lead to a decision to cancel its short-distance feeder flights. For the purposes of this report, this section of Chapter 2 will review the major aspects of the two rail services and present new information concerning the demand characteristics of the two services.[21]

2.5.2.1 Rail Services between Frankfurt Airport and Cologne and Stuttgart

The railway connections were developed with new infrastructure and offering new services to the customers traveling via Frankfurt Airport. Figure 2.16 shows the location of Frankfurt Airport (airport code = FRA), the Cologne downtown rail station (airport code = QKL), and the Stuttgart downtown rail station (airport code = ZWS). The project is a cooperative venture between the airline operator (Lufthansa), the rail operator (German Rail), and the airport operator (Fraport).

The new long-distance train station at FRA started its operation in May 1999. Two years later, Lufthansa, German Rail, and Fraport announced their cooperation and implemented the new AIRail service; initially it ran between FRA and ZWS. Thanks to the new high-speed track between Mannheim and Stuttgart, it takes 75 min of travel time for the 97-mile distance from downtown Stuttgart to FRA. The train operated on a 2-hour frequency, which results in five to six connections a day.

Initially, Lufthansa leased one complete railroad carriage of the ICE train set operated by German Rail. This carriage was assigned to AIRail customers and offered only first-class seats with respective services. Customers of Lufthansa or Star Alliance carriers were able to book a single ticket that includes a coupon for the train ride. Thus, passengers could book all the way to the final destinations at ZWS and QKL, respectively. The train ride fully substitutes a feeder flight and has a minimum connection time of 45 min in Frankfurt. But, during the first months, the load factor of the separate AIRail coach was just around 30%, while the expected figure had previously been about 50–60%.

The cooperation was initially limited to 2 years, but was prolonged by the inauguration of an additional service from

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[21] This section has been prepared for this report by members of the research team who are based in Germany, and it is based on their personal experiences with the project.

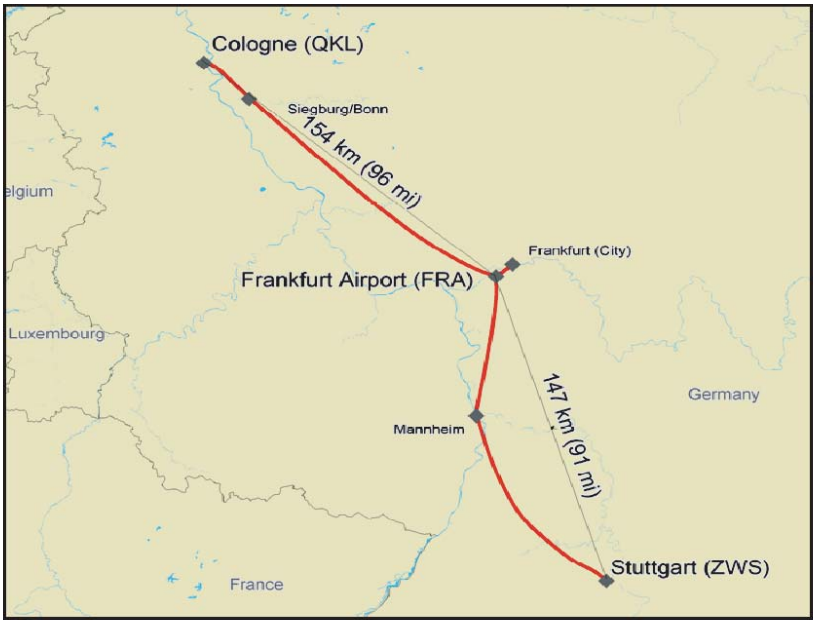

Figure 2.16. Location of the two services (20).

FRA to QKL. This service started in May 2003. A new HSR link halved the travel time by train to FRA to 51 min. This implied a very attractive offer for business travelers from the Cologne area. Long-haul customers were able to use the AIRail service without additional costs. Consequently, Lufthansa cancelled 4 of 12 parallel flights from FRA to CGN (Cologne Airport) when AIRail operations started in May 2003 and ceased all remaining flights on this route in October 2007.

2.5.2.2 Demand for Rail as a Feeder Service to Frankfort Airport

Frankfurt–Cologne. The AIRail operations in the market between Frankfurt Airport and Cologne market started in 2003. The market itself, like many others, was decreasing due to the advent of low-cost carriers. CGN started positioning itself as one of the major low-cost airports in Germany. This new supply lowered a considerable amount of Lufthansa's market from CGN via the FRA international hub. The market decreased from 320,000 passengers in the late 1990s by more than one third.[22]

Figure 2.17 shows that, from an initial market share in 2003 of roughly a quarter, the share of the AIRail (shown in higher portion of the bar) service rose to 50% during the next 3 years. This development also led to the reduction in parallel flight capacities. In autumn 2007, all remaining flights between FRA and CGN ceased. Consequently, the AIRail market share reached 100% in 2008. The relatively high market share of the AIRail service was mainly based on the hourly train departures. This frequency gives travelers the opportunity to arrive within a sufficient time before their flight departure in FRA or have enough time to claim their baggage and reach a train in an appropriate amount of time.

Frankfurt–Stuttgart. The market between Frankfurt Airport and Stuttgart was also significantly affected by the emergence of the low-cost carriers. The passenger figures decreased from 440,000 in 2002 to below 250,000 in 2008. Figure 2.18 shows that roughly one out of six passengers used the AIRail service in this market. The 2-hour train frequency between the Stuttgart rail station and FRA and the continued operation of the parallel Lufthansa flights combine to explain the generally smaller AIRail market share compared with the connection to the Cologne train station.

Lufthansa's decision not to reduce parallel flights significantly was due to concerns that a significant number of passengers would circumvent the train to the FRA hub otherwise and would fly into alternative hubs like AMS, CDG, or LHR. Given that the FRA–ZWS market is approximately twice as large as FRA–CGN's, a cessation of flights in Stuttgart would require a quadrupling of train seat capacity jointly with a doubling of train frequency to compensate for all flights.

In 2008, Lufthansa abandoned the option of checking bags into, and out of, the two downtown railroad station terminals. The service was only lightly used, as passengers preferred to keep control of their baggage to the greatest extent possible.

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[22] Owing to data confidentiality, only isolated figures could be gathered from a variety of sources. On the basis of the official statistics on passenger movements collected and published by the German Federal Bureau of Statistics, the research team estimated and calculated a nearly comprehensive demand picture on these markets.

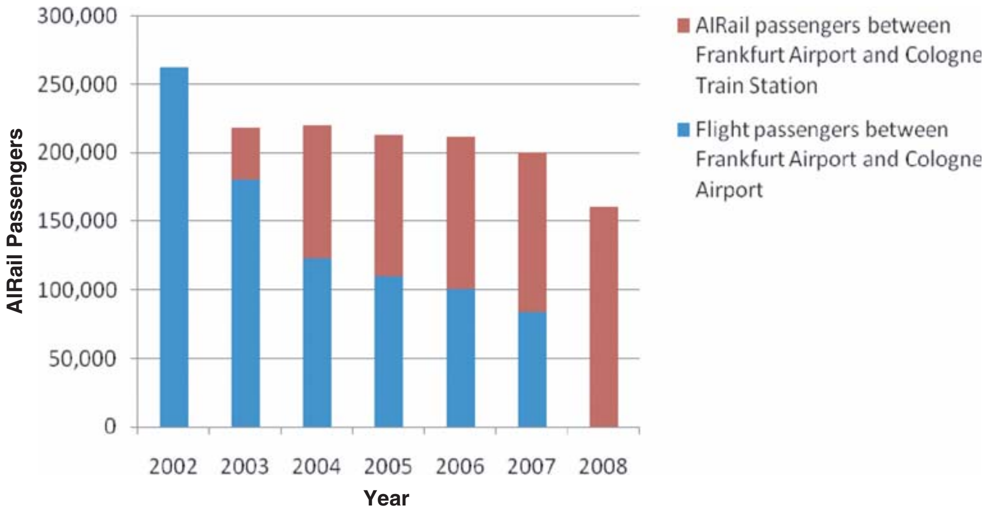

Figure 2.17. Rise in AIRail market share between Frankfurt Airport and Cologne train stations (20).

Although ticket sales were high for the rail connections to the airport, the presentation of the entire air-plus-rail journey as one ticket proved less popular than expected. In some cases, first-time users of the joint ticket would note that separately purchased tickets and last-minute choice of trains were more efficient than booking all segments at once.

2.5.2.3 Feeder Flight Substitution and Increased Slot Availability

The Cologne case in particular shows that sufficient rail services can be a full substitute for very short-haul flights. As feeder flights are usually not profitable and have to be cross-subsidized by long-haul revenues, a substitution with less costly ground-based transport means could be economically reasonable. In the ZWS–FRA market, Lufthansa decided to cease only some of the flights to avoid a spill of demand to other airlines (via hubs other than FRA).

Airlines often operate with small aircrafts when feeding from their spokes into a hub. In these cases, the ratio of passengers per slot at the hub is suboptimal. The operation of larger airplanes might require that frequency be reduced and fixed costs increase. Thus, feeder flights will become less attractive to time-sensitive passengers (business travelers) and will also become more expensive. Freeing slots by substitution by adequate frequent rail services could be a good solution to increase the overall network performance of airlines or airports, respectively.

The substitution of feeder flights by rail services could be reasonable also in a non-hub context, as observed in the

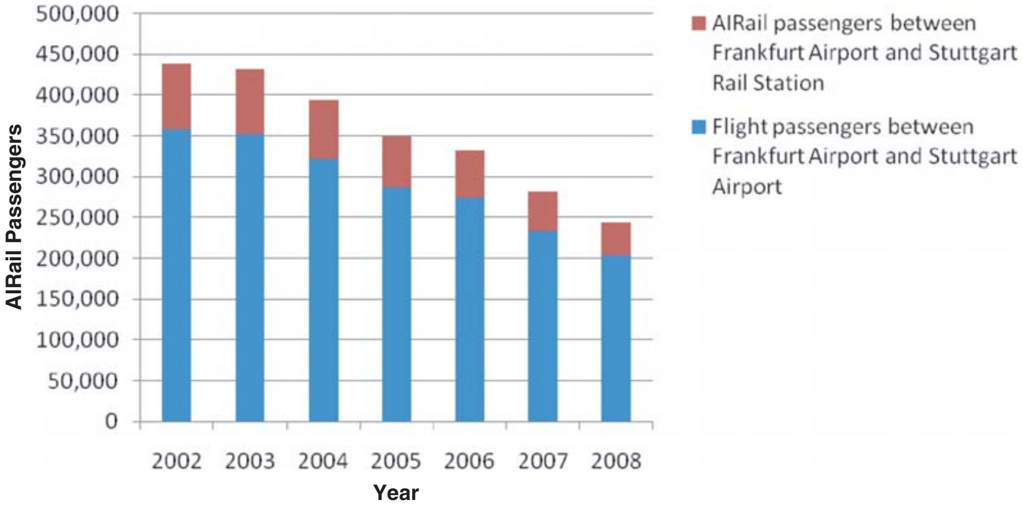

Figure 2.18. Drop in AIRail market between Frankfurt Airport and Stuttgart rail station (20).

Hamburg–Berlin market. There, Lufthansa Regional ceased all flights in 2002. The train ride takes only 2 hours from city center to city center, and the long-haul load factor was below 30% during the last months of their operation.

2.5.2.4 Rail Service Replacing Air Flights: Lessons Learned

Reviewing the last 7 years of intermodal development in Germany, some general conclusions can be drawn. Regarding AIRail, the initial level of service was diluted over time and more flexible service components were introduced. The ambitious baggage service that imitated the aviation processes was readjusted to better match the railway operations where baggage transport was abandoned several years ago.

Experts do not negate the strong influence of politics on the decision to develop the German AIRail services, and one can question whether the operators would have inaugurated this product of their own accord. Considering the early prospects about the effects of passenger intermodality, it can be observed that integrated services between railway companies and airlines have been rare since then.

From a neutral perspective, the current AIRail service can best be seen as an add-on to an existing HSR service. It benefits from the existence of a good infrastructure at Frankfurt Airport and its dominance as the main German hub airport. For incoming travelers, the product itself is influenced by how the service is portrayed in the international airline booking systems (GDS). For them, the visibility in the GDS is crucial. Additional rail travel times compete directly with existing flights that directly serve the hub. Thus the integration of infrastructure and the realized overall travel times (including transfers) determine and influence the choice of ground-based modes in an integrated trip chain. In most cases, the user is provided with a total trip time to the destination airport for the air-feeder option, and total trip time to the downtown station on the rail-feeder option. The former will usually look faster than the latter, even though the user must continue onward from the destination airport.

All in all, this case study supports the observation that customers are not interested in complex products. They want to have smooth and reliable transfers between two segments of their journey without paying attention to the “modes” involved. Thus, there could be a future for combined journeys and easy-to-use access/egress train connections to airports. Airlines should be interested in substituting their unprofitable feeder flights by other less costly means of transport, but they have to assure their customers that rail connections are as reliable and convenient as connecting flights.

Some capacity shortages—on both air and land—could generally be overcome by suitable ground transportation investments. Therefore, it is essential to activate the individual modes’ strengths and to combine them optimally. In doing so, both perspectives are essential: the customer’s and the operator’s perspective. But the case study presented here suggests that the complete abandonment of air service in response to the introduction of very high-quality rail service is very rare (e.g., the decision not to delete flights from Stuttgart) even in the context of strong government support for the idea. This further challenges the concept that the provision of HSR service in the United States will, on its own, reduce airport congestion unless this is undertaken in a more complete program that implements the concepts discussed in Chapter 5.

2.6 Additional Capacity from Highways in the Mega-regions to Accommodate Excess Aviation Demand

Overview and Structure. From the original scope, this project has been concerned with the potential impacts on aviation capacity from possible changes in competing or complementary modes. The work has included, therefore, a review of the extent to which there might be some additional capacity in the roadway networks in the two mega-regions that could in some way influence alternative futures for the accommodation of aviation demand. This section of Chapter 2 summarizes the results of the review of demand and capacity of highways as undertaken as an input to the analysis of the capacity needs of the U.S. aviation/airport system based on the more thorough coverage included in Appendix B.

Appendix B includes a review of what is known about the bottlenecks and sources of congestion in the East Coast Mega-region; it reviews highway demands and capacities at the region’s key locations. Areas where demand significantly outweighs capacity are documented for the East Coast. By way of example, demands and supplies on a key link across the Hudson River in the NYC area are reviewed to show the difficulty of predicting what major improvements to the total network can be expected.

Appendix B also includes a review of known congested segments of the California highway system—in particular, those that serve as gateways for north–south traffic between the two West Coast Mega-regions. In California, a future highway network was developed as part of the HSR forecasting process, and the impact of that future highway network on interregional travel was calculated. The California analysis shows that, even with the creation of an aggressive future highway network, fundamental long-distance intercity travel times do not improve.

2.6.1 Future Highway Capacity to Respond to Aviation Demand: Conclusion

The implication of the case studies included in Appendix C is that, even with the assumption of new highway capacity, there does not seem to be any breakthrough that would invalidate the basic assumption that the roadway system is highly used and that any future unmet needs at congested airports will not be mitigated by newly available reliable traffic flows on the roadway system.

The exception to this conclusion, though unexplored in this study of aviation capacity, is the possibility that the roadways on both coastal regions might become more carefully managed, with the specific inclusion of managed lanes capable of supporting reliable bus service for short-distance services such as Boston–NYC, or NYC–Washington, D.C. In this case, buses might play a significantly larger role in complementing the nation's air system than they do now.

2.6.1.1 The Under-examined Role of Intercity Busses

The quality of data used to help the research team understand the role of the intercity bus is significantly limited. The BTS monitors a massive program to document air travel, and good information is available to policymakers and to the public alike. Amtrak has shared key data with this project, which reveals its exceptional market strength in certain OD pair corridors. By contrast, ridership and other market research data concerning intercity buses is often considered proprietary by the private bus companies, who do not receive any government subsidy for their services.

Nevertheless, one can make some observations regarding scale. In a recent analysis,[23] reasonable assumptions about bus occupancy rates were applied to published data of bus supply between NYC and Boston and NYC and Washington, D.C. The estimates developed were dramatic: intercity bus ridership between Boston and NYC was estimated at around 1.6 million trips per year; intercity bus ridership between Washington, D.C., and NYC was estimated at about 1.0 million trips per year. Because the load factor (50%) was assumed and not empirically derived, these estimates remain only estimates and should not be used for comparisons with other modal data.

Nevertheless, the scale of ridership is interesting for this analysis. This chapter reports that in 2007, air attracted about 1.6 million riders between Boston and NYC, whereas rail attracted roughly the same.[24] Thus, the initial approximation of 1.6 million bus riders would rank it as equal in importance to both air and rail in this metro-area pair.[25]

Interviews with key analysts suggest that a "trickle down" market impact has occurred. As reliability of the aviation system increasingly worsened, travelers moved to Amtrak's higher quality services. Amtrak has raised fares in the Boston–Washington, D.C., corridor, which in turn encouraged the development of entirely new bus services. The bus analysis project determined that of the bus seats provided between Boston and NYC, only 27% were provided by the traditional carrier (combination Greyhound/Peter Pan). The rest of the capacity is provided by a wide variety of start-up services.

The possible role of better-managed highway systems that would better support intercity bus services that which might then take the place of low-volume, short-distance airline routes should be examined in further research efforts. Intercity buses are being placed into service where local air services have been curtailed; the research team knows of no authoritative source of data that documents this existing pattern.[26]

2.6.1.2 Aviation Planning and Highway Planning

Although it is not clear that the highway infrastructure will produce any relevant level of new capacity to deal with unmet demand for short-distance aviation trips, it is clear that the highway planning process is a central location for comprehensive transportation resources.

Over the past 40 years, the Federal Highway Administration (FHWA) has taken the lead in many advances in implementing a continuous, comprehensive (multimodal) transportation planning process, including the development of statewide planning using techniques originally developed for metropolitan planning. Clearly, better integration of aviation planning with long-distance surface transportation planning could be undertaken. The question of how aviation planning could be better integrated into more comprehensive planning activities and into the established metropolitan and statewide programs in particular is first addressed in Chapter 3. Implications for change are noted in Chapter 6.

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[23] Personal communications from Robin Phillips, American Bus Association, summarizing estimates performed by Julius Vizner, PANYNJ, September 2008. These must be seen as preliminary and not reflecting positions of either organization.

[24] The research team also observed that between 2007 and 2008, rail increased while air decreased.

[25] In 1995, the ATS reported that in travel between Boston and NYC, bus shares were about equal to rail shares.

[26] Reportedly, the FAA has been asked to examine the role of buses as replacement for low-volume air segments; personal communication with Robin Phillips, American Bus Association.

CHAPTER 3

Multijurisdictional Issues in Aviation Capacity Planning

- There is a gap in planning coverage between the scale of on-airport planning and national aviation planning: regional planning efforts have not yet met their potential.
- In New England, a highly innovative multi-airport planning process supported the eventual growth in the role of the smaller, more underused airports—to the benefit of all.
- Aviation planning could benefit from adopting the data organization scheme of the comprehensive transportation planning process, which is based on the flows by all modes from origins to destinations; this will support integration with planning for other modes.
- To support a multi-airport planning process, it is essential to create analysis tools that reflect the true origin and true destination of the passenger—not just airport to airport.
- The organization of aviation data in terms of true origin to true destination allows a more exact description of the potential contribution of under-utilized airports.
- An evaluation process based on the measure of performance of the total trip experienced by the traveler would result in a planning process that is more transparent and accountable.

Exhibit 3.0. Highlights and key themes included in Chapter 3.

3.1 Purpose

In Chapter 3, the research team suggests options for enhancing the capacity of the airport systems in the East and West Coast Mega-regions to more effectively serve customer needs through multijurisdictional planning processes, including data sharing and cooperative and collaborative decision-making on airport planning and operations.

3.2 Background

Beginning in the early 1970s, the availability of technical guidance and new federal aid resulted in greatly increased levels of airport planning activity. At that time, the FAA developed the procedures and principles for comprehensive airport planning in a series of advisory circulars that addressed master planning, regional planning, and statewide system planning. An airport's receipt of certain federal aid grants depended largely on its willingness to conduct planning studies that conformed to the advisory circulars. By the early 1980s, almost every state had adopted a state aviation plan, and a variety of metropolitan areas were involved in system planning studies. The FAA encouraged large commercial service airports to develop master plan reports to explain the basis for development shown on airport layout plans.

During this same period, the rapid growth in air travel warranted significant improvements to all commercial service airports. The federal government would provide a large part of the funds for those improvements, and it wanted them to be compatible with other aspects of regional development. Government actions encouraged state DOTs to develop state aviation system plans, but those plans left off at the boundaries of major metropolitan areas. The operators of the largest commercial service airports retained authority over detailed planning and development decisions, subject only to review by regional metropolitan planning organizations (MPOs)[27] of applications for federal aid for specific development projects. However, formal MPO approval was not necessary (*1*). Regional planning focused initially on the details of reliever airports and general aviation airports that were located and equipped to attract small personal use and corporate aircraft away from the congested commercial service airports.

3.2.1 Gaps in the Current System Planning Process

The interviews[28] with airport managers undertaken in this project revealed that, with rare exceptions, the present system planning process does not fill the gap between airport-based planning and national planning. Most airport executives reported that they are not significantly affected by regional planning. This reflects the limited role of system planning since the FAA first prepared guidance[29] and began to provide aid in the early 1970s. The FAA guidance focused the scope of work on simple forecasting procedures and did not include market research and complex statistical forecasting techniques if they added to project cost.[30] In short, a robust, consumer-oriented data collection program was not historically part of the regional aviation systems planning effort.

Currently, no public agency is tasked with analyzing and presenting the needs and expectations of the longer distance travelers in the metropolitan areas. Topics that are not addressed include travel preferences in terms of markets and frequency of service as well as airport preferences in terms of accessibility and reliability. The lack of attention to these topics leaves the traveler as the missing person when development decisions are made. These topics are the logical starting point for a revitalized metropolitan (or a possible supra-metropolitan) system planning process that would monitor traveler expectations and document certain benchmark levels of measured performance. Passenger expectations are now expressed only through mathematical projections of demand and engineering analyses of how to accommodate them, typically through development at a single airport. At present, the examination of alternatives beyond the airport perimeter is required for large projects that are subject to impact analysis, but these usually address travelers only in the broadest terms, such as projected volume of passengers sorted by ZIP codes.

A passenger-centric planning process could provide analytic support to airport planning and empower those officials who are interested in maximizing the satisfaction of travelers from the surrounding region. It would also equip them with tools to measure and compare airport performance. Logically, some of the efforts to better track the experience of the passenger would be located at the airport level; others, with regional implications, could be tracked on a multi-airport basis. Given that many airports already have aggressive programs to monitor customer satisfaction, this report will focus on those measures with regional or multi-airport ramifications.

Such a multijurisdictional planning process could address such issues as benchmarking airport capacity, tracking projections for capacity enhancement, and raising issues of performance in the air traffic control arena. A recent example of such a joint, multijurisdictional effort is the program of the PANYNJ to take the lead in explaining the need for FAA's NextGen program to the civic and political leaders of the NYC region.

3.3 Examples of Existing Multijurisdictional Airport Planning Processes

To illustrate the potential for a multijurisdictional airport planning approach, the research team examined several such existing processes in detail. One of these is a joint federal/multistate effort, and others are at least partially managed by an MPO.

3.3.1 New England Regional Airport System Plan

The 2006 New England Regional Airport System Plan (NERASP) is the most recent product of more than a decade of work by the New England Airport Coalition, a collaboration which includes 11 of the region's major airports (see Figure 3.1), the six New England state aviation agencies, the Massachusetts Port Authority, the New England Council, and the FAA (*2*). In 1994, a coalition of the six New England state aviation agencies, all of the scheduled jet passenger service airports, and the New England Council was formed, and it initiated the first "New England Regional Air Service Study." In 1996, the regional coalition held a "Fly New England" workshop with airline representatives to present the findings of this study and to outline collaborative marketing programs. In 1998, the coalition conducted Phase 2 of the regional air service study, which provided updated data on air service opportunities in the region. About 4 years later, Phase 1 of the FAA-led NERASP was initiated. Phase 2 was conducted between 2004 and 2006.

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[27] An MPO is a transportation policy-making organization made up of representatives from local government and transportation authorities. In the early 1970s, the U.S. Congress passed legislation that required the formation of an MPO for any urbanized area (UZA) with a population greater than 50,000. Congress created MPOs to ensure that existing and future expenditures for transportation projects and programs are based on a continuing, cooperative, and comprehensive ("3-C") planning process. Federal funding for transportation projects and programs are channeled through this planning process. As of 2009, there are 385 MPOs in the United States.

[28] See Appendix A for the summary of the airport interviews.

[29] Planning the Metropolitan Airport System, FAA AC150/5070-5, May 1970.

[30] FAA Order 5100.5c, paragraph 405.c

Figure 3.1. Airports included in the NERASP (2).

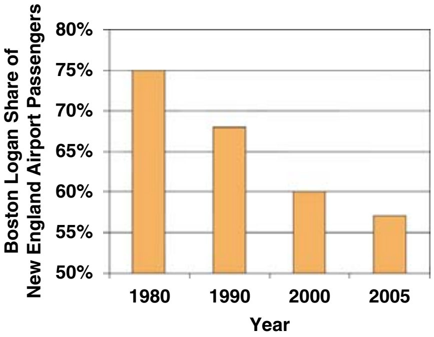


Figure 3.2. Restructuring of volumes in the Boston family of airports (3).

The coalition intended for both phases of the NERASP study to examine travel patterns in the region and make the best predictions possible about how future travel demand can be accommodated using all the facilities available in New England. One of the key features of the study is its multimodal approach—it examined air travel combined with rail and other ground access modes to produce a comprehensive picture for the region.

The NERASP project describes the foundations of a regional strategy for the air carrier airport system to support the needs of air passengers through 2020. Its underlying theme is to develop an airport system based on the location of passengers and with adequate facilities to allow airlines to evolve the range of services that provide the best mix of efficiency, convenience, and reliability. The NERASP effort also found that New England's airport system does have the ability to meet passenger demand through 2020. However, this will require continued efforts to enhance the performance of each airport in the system. This is essential to achieve the level of efficiency and resiliency the system must have for a region so dependent on the services of a constantly evolving airline industry.

Phase II of NERASP found that New England has an unusually high reliance on air transportation. The region generates 2.5 air passenger trips per year per capita, almost 80% higher than the national rate of 1.4. Most of the region's passengers will continue to fly through BOS. Therefore, the system will rely on BOS to continue to improve its efficiency in handling aircraft operations and passengers. This study also identifies several airports that could improve the performance of the regional system if they can overcome the challenges they face in developing the services required by their communities. For example, PVD lacks sufficient runway length to efficiently serve its communities' needs for West Coast and international markets. Worcester and New Haven have the potential to serve a total of 3.8 million passengers, drawing almost 1 million of these passengers away from congested airports in New England and New York. The forecast models also reveal an emerging market for a jet service from Cape Cod to major domestic markets.

New England's regional airports have continued to evolve into a system in which increasingly overlapping service areas and improved ground access options are providing passengers with real options as they make air travel decisions. As Figure 3.2 shows, the goal of reducing passenger burden at BOS is being realized through this cooperative planning effort—since 1980, the share of New England air passengers at BOS has declined from about 75% to less than 60% in 2005. The conveners of the NERASP initiative believe the New England region has benefited by combining an understanding of the long-term needs of passengers with an appreciation for the financial risks in the air transportation industry and the interaction among the airport markets. The FAA included the NERASP initiative as a strategy for increasing system capacity in its *2006–2010 Flight Plan* (4).

Importantly, NERASP is somewhat unique in its multistate orientation. Leadership can also come from existing, regional institutions. The following sections provide two examples of existing situations in which MPOs have assumed a significant or leading role in planning for airport systems at the metropolitan or regional level.

3.3.2 Regional Airport System Plan—San Francisco Bay Area, California

The San Francisco Bay Area is home to some 23 airports (Figure 3.3) that serve commercial and general aviation users.

Figure 3.3. San Francisco Bay Area airports (5).

This regional airport system forms an integral part of the Bay Area's transportation network by providing links to communities throughout the United States and abroad.

Since 1972, the MTC and the Association of Bay Area Governments (ABAG), the principal regional planning bodies for the San Francisco Bay region, have periodically updated the Regional Airport System Plan (RASP) to provide analysis and policy-level guidance on aviation requirements for commercial and general aviation airports in the region. These agencies, plus the San Francisco Bay Conservation and Development Commission (BCDC), created the Regional Airport Planning Committee (RAPC) to advise the three agencies on regional aviation matters. Figure 3.4 shows the relationship of the RAPC and the three key agencies in relationship to development of the RASP (5).

Figure 3.4. RASP development organizational structure.

The RAPC's responsibilities include the following:

- Serving as a public forum for regional aviation issues, including aircraft flight noise;
- Preparing updates to the RASP for consideration by the ABAG, the BCDC, and the MTC;
- Reviewing and commenting on airport master plans, layout plans, and environmental documents and local land-use plans affecting the regional aviation system;
- Coordinating with county Airport Land Use Commissions;
- Facilitating discussions between airports, cities, and counties and Airport Land Use Commissions on land-use issues around airports that affect the regional aviation system;
- Conducting studies related to the RASP; and
- Making recommendations to the ABAG, the BCDC, and the MTC on regional aviation matters.

The Bay Area airports and the FAA consider the RASP when preparing airport master plans and environmental documents for proposed airport improvements. The MTC uses the RASP to guide decisions about surface transportation investments that provide access to airports. In addition, the BCDC's *Bay Plan* airport policies refer to the RASP for guidance when evaluating proposals for airport improvements that would require Bay fill. Further, the Bay Area Air Quality Management District will consider the aviation emission estimates in preparing federal and state air quality plans for meeting adopted air quality standards.

3.3.3 Continuous Airport System Planning—Metropolitan Washington, D.C., Region

The National Capital Region Transportation Planning Board (TPB), the MPO for the Washington, D.C., metropolitan region, has conducted a Continuous Airport System Planning (CASP) program since the FAA approved its first grant application in 1978. TPB develops, implements, and monitors the CASP program with the assistance of the Aviation Technical Subcommittee of the TPB Technical Committee. The subcommittee is responsible for coordinating airport system planning with the regional transportation planning process, through presentation of airport system planning matters to the TPB Technical Committee and the TPB. The Maryland Department of Transportation and the Metropolitan Washington Airports Authority (MWAA) represent the region's three major commercial airports (Figure 3.5)—Washington National (DCA), Washington Dulles International (IAD), and Baltimore-Washington International (BWI)—on the TPB.

Figure 3.5. Washington–Baltimore air system planning region (6).

The CASP program's goal is to provide a process that supports the planning, development, and operation of airport facilities and the transportation facilities that serve the airports in a systematic framework for the Washington-Baltimore region. In October 1998, the TPB unanimously adopted the Vision for the future of transportation in the region. The Vision is a policy document with eight key goals and associated objectives and strategies to guide transportation into the 21st century.

Goal 8 of the TPB's Vision reads: "The Washington metropolitan region will support options for international and interregional travel and commerce. Goal 8 has the following three objectives:

1. The Washington region will be among the most accessible in the nation for international and interregional passenger and goods movements.
2. Continued growth in passenger and goods movement between the Washington region and other nearby regions in the mid-Atlantic area.
3. Connectivity to and between Washington Dulles International, Ronald Reagan Washington National, and Baltimore-Washington Thurgood Marshall International Airports" (*6*).

The first strategy for implementing Goal 8 is to maintain convenient access to all of the region's major airports for both people and goods.

The CASP process consists of a continuous cycle that begins with a regional air passenger survey. This survey is followed by forecasts of future air passenger travel and the ground travel of these air passengers to and from the region's three commercial airports. These forecasts in turn lead to the development of a revised ground access plan for the region.

The aviation group within the TPB Technical Committee is responsible for the coordination of airport system planning with the regional transportation planning process. The subcommittee provides technical review for projects and reports stemming from the CASP program. Presentations regarding such projects are made to the subcommittee, and comments and suggestions are solicited. Then, presentations are made to the TPB Technical Committee and the TPB. All CASP program products follow this technical review process, prior to submission to the funding agencies, which include the FAA, the MWAA, and the Maryland Aviation Administration (MAA).

The aviation subcommittee includes representatives from the MAA, the MWAA, the D.C. Government, the Virginia Department of Aviation, and the FAA, as well as representatives of local jurisdictions within the Council of Governments' membership. In addition, other regional agencies with aviation interests, airport sponsors, and aviation interest groups and associations are encouraged to participate.

3.4 Mega-region Framework Approach to Airport Planning

Chapters 1 and 2 of this report have documented that capacity problems at airports in the coastal mega-regions are driven significantly by a mismatch of travel demand with travel options, in both air and ground modes. Addressing these issues effectively requires the ability to understand the nature and scale of demand for air service in each mega-region. The following subsections present examples of how data could be analyzed to more effectively explain air traveler behavior in the context of *complete trips*. By taking a complete-trip perspective, airport planners and managers would be able to manage airport capacity at a more regional level and potentially strike a balance between service frequency and capacity (using the mega-region as the geographic unit of analysis).

3.4.1 Applying County-to-County Trip Tables in the West Coast Mega-region

To facilitate regional analysis of travel within the California Corridor, the research team developed regional trip tables that encompass complete trips. This task involved collecting air traveler surveys from five airports in two regions. In the first region (the San Francisco Bay Area), the team collected data from the MTC derived from air traveler surveys at SJC, OAK, and SFO. For the second region

(Southern California), the team collected surveys from Los Angeles World Airports for LAX and Ontario International Airport (ONT). Subsequently, the managers at the Southern California Association of Governments (SCAG) contributed calculations of origins and modes for airports in the entire region.

Each air traveler survey included a passenger's true origin, such as a ZIP code or a county code for the county where the trip to the origin airport started. These surveys were used to understand the distribution of true origins and true destinations for air travel on the California Corridor. Using statistical methods, the research team used the air traveler survey data sets as well as BTS data to develop datasets reflecting the following travel progression: true origin (by county) to origin airport to destination airport to true destination (by county). Figure 3.6 displays the airport pairs for which the research team developed these county-to-county trip tables.

The end result is 12 county-to-county trip tables, one for each airport OD pair shown. A county-to-county trip table can reveal the details of traveler origins and destinations for passengers passing through two airports in question. For example, by reviewing such a trip table, one could tell the number and percentage of total passengers traveling between ONT and SFO who originated in a particular county. It could also show a breakdown of destination counties for such passengers. As transportation is a "derived demand," such trip tables expose the underlying *county-to-county* demand that an *airport-to-airport* trip table obscures.

As discussed in this study, major (or hub) airports such as those shown in Figure 3.6 are at or are near operating capacity. Innovative ways to move a growing number of passengers through airports while reducing delay are therefore welcome. Chapter 5 will examine the potential of reducing delay at a hub airport by eliminating short-haul flights and diverting very small aircraft. The county-to-county trip tables allow for a regional analysis to understand whether traveler patterns could facilitate shifting traffic to non-hub airports to reduce hub delay and pressure. Passengers may divert away from a major hub on just one link, one end substitution, or on both links, two end substitutions.

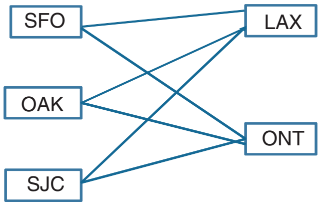


Figure 3.6. West Coast Mega-region airport pairs.

3.4.2 The Need to Go Beyond Airport-to-Airport Data Sources

The previous section illustrates the potential for using trip tables based on the complete trip concept to help airport managers better understand passenger travel patterns and needs. Notably, if such trip tables were available for all airports within each mega-region, there would be great potential for focusing airport planning on passenger demand rather than flight demand.

Use of mega-region–level data can pinpoint whether passengers would willingly divert from hub airports to smaller non-hub airports based on their true origins and destinations. Such diversions could alleviate pressure on the hub airports. For example, the county-to-county trip table from travel between the ONT and SJC airports shows that demand exists between Monterey and Orange County. Smaller aircraft could serve these two regions directly, reducing pressure on ONT and SJC and also serving passengers with less surface access.

True origin to true destination trip tables could also provide important insights into the potential of intermodal substitution. For example, the trip tables show demand between Fresno and San Bernardino Counties. The California HSR line is slated for service between Fresno and ONT; the number of passengers traveling between the SJC and ONT airports could greatly decrease with the introduction of rail. Furthermore, these passengers would have their access time and costs significantly reduced. Without HSR, the region could be also be served with air traffic if there were a need to reduce pressure on SJC.

Another application of these county-to-county trip tables is the consolidation of flights across hub airports. The 12 county-to-county trip tables can help determine the potential volume of passengers to divert from one hub airport to another. For example, there may be two flights within a few minutes of one another traveling to LAX but departing from SFO and OAK. With a county-to-county trip table, one may be able to discover that the majority of passengers flying from OAK are within a reasonable ground travel distance of SFO. With this information, it might be possible to up-gauge the flight from SFO to LAX, thus accommodating passengers originally traveling from OAK. A flight might be added between a nearby airport to the remaining true passenger origins, such as Hayward, to LAX. While the number of operations is preserved at the destination (LAX), an operation was eliminated at OAK, allowing OAK the capacity to serve another non-redundant operation.

3.4.3 The Importance of Applying Transport Planning Tools to Aviation Planning

The research team believes that employing a complete trip OD approach to airport planning would provide aviation planners with a view of the market-driven issues that airlines consider when planning service and routes. Importantly, this approach holds potential for enabling aviation managers to strike a better balance between meeting customer needs and operational desires. Finally, the organization of basic travel flow data in this manner will allow later integration with the dominant work describing highway and rail travel.

To enable such an approach to become the norm, rather than a periodic undertaking stemming from convenience associated with a particular one-time study, standards and protocols for data collection, management, and reporting could be developed. Unless "true" OD data on airport passengers are collected in a standardized way and on an appropriate geographic scale (as pioneered in NERASP), the usefulness of such data for improving mega-region scale airport planning will be minimal. However, by collecting data regularly and at the appropriate geographic level, airports within the mega-regions could jointly assess their capacity—individually and collectively—and plan for more efficient and customer-focused allocation of operations. Such multi-jurisdictional airport planning that seeks to share and take advantage of regional data is a critical element of improving overall air system capacity in the coastal mega-regions and nationally.

3.5 Underused Airports in the East Coast Mega-region: Examples

As a pilot project, the research team first created a county-to-county trip table to support the analysis of flows affecting key airports in California. On a more ambitious scale, the team has developed a multi-state county-to-county trip table of aviation trip-making in the East Coast Mega-region using data from the NERASP study and other sources. The following sections include a series of charts and trip tables developed through application of the county-to-county database that depict the air passenger OD patterns for seven airports in the East Coast Mega-region. These analyses could provide support to larger, more comprehensive studies to determining if smaller, under-capacity airports could take flights to common destinations away from large over-capacity hubs, potentially facilitating improvements in on-time performance, ground access congestion, and passenger choice.

3.5.1 Applying County-to-County Trip Tables in the East Coast Mega-region: Delaware River Valley

To lay the foundations for a contribution to the full-scale study of the potential of underused airports to be undertaken by the Delaware Valley Regional Planning Commission, the research team has applied the results of new methods of data organization and data presentation developed for this study, based on the county-to-county database assembled. This section summarizes what was learned about three airports in close proximity to the highly congested PHL.

In this exercise, the research team developed "natural geographic market areas" that illustrate the theoretical market potential of presently underused smaller airports in the greater Philadelphia region. By way of example, Figure 3.7 shows the counties in which Allentown, Trenton, and Philadelphia represent the closest airports measured only by highway travel times. Such definitions will allow the analysis of air travelers in the region in terms of both their demographics and their airline trips. Each of the three airports is examined in terms of their air-trip destination, and the airport they use at present in the charts and tables is presented in the following section.

3.5.1.1 Lehigh Valley International Airport

As Figure 3.8 shows, only 23% of those passengers for whom Lehigh Valley International (Allentown/Bethlehem/Easton, PA) Airport is the closest airport select the local option. Most use EWR, PHL, LGA, or JFK. More than 400,000 passengers per year fly to the Southeast (i.e., the Florida area). Of these travelers, about two thirds select a different airport. There are more than twice as many passengers flying to this region than to the next most popular region, the Upper Midwest.

In short, more than 75% of the population for whom Lehigh Valley International is the "closest" airport do not use it, choosing instead to travel to adjacent, congested airports.

3.5.1.2 Atlantic City International Airport

Figure 3.9 shows that almost half of the flights for travelers in the Atlantic City area originate at Atlantic City International. When flying to the U.S. Southeast, almost 75% of the flights originate from this airport. By contrast, travelers primarily use PHL when flying to other destinations in the United States. Those flying internationally travel either to EWR or JFK rather than use Atlantic City International or PHL. Thus, the addition of flights to new southeastern destinations would be unlikely to help the current conditions at Atlantic City International, as almost all passengers use this airport when traveling to the Southeast, which garners a disproportionate amount of destinations.

In contrast with the pattern seen at other local airports in the study area, a surprisingly high number of air travelers in

Figure 3.7. "Natural geographic market" areas for Allentown, Trenton, and Philadelphia airports.

the natural market area do choose to fly out of this relatively small airport.

3.5.2 Application of the Tools to Other Underused Airports: NYC Area

These tools to create quick summary descriptions of the travel patterns of those who might logically benefit from using a smaller, closer airport can now be applied to virtually any airport in the project study areas. Because much of this information was included (and was pioneered by) the NERASP project, airports in New England have not been included in this chapter, with the exception of New Haven, CT, which is now shown in the context of NYC airports. The researchers have merged NERASP data with similar, but different, data collected in the NYC region to develop these unique market description summaries of smaller airports relevant to the New York capacity debate.

3.5.2.1 Long Island-Macarthur Airport

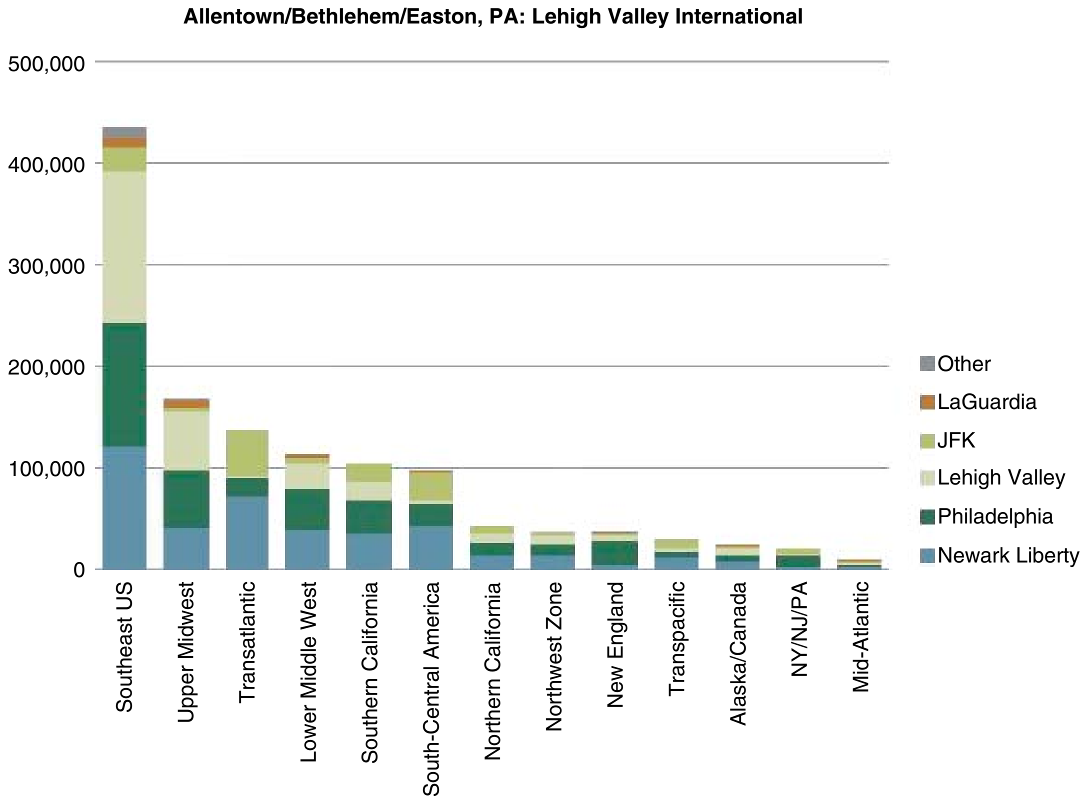
Long Island-Macarthur Airport (Islip, NY) provides another example of the potential benefits of approaching airport planning and operations from a regional perspective. Figure 3.10 shows that the airport captures a healthy share of trips to the Southeast—some 63%. Of the 254,000 air trips taken in 2007 to the U.S. Upper Midwest by passengers whose closest airport is Islip, about 47% flew from LGA. Similarly, of 32,000 air trips to New England, about 73% also flew from LGA.

In short, about 55% of the natural geographic market "leaks" out of the area to the larger airports that offer more direct services to more locations. That Long Island-Macarthur Airport captures the remaining 45%, however, reflects the strong attraction of the services of Southwest Airlines.

3.5.2.2 Stewart Airport

Figure 3.11 shows, quite dramatically, that although 57% of travelers in the Newburgh/Poughkeepsie area flying to the Southeast begin their trips from Stewart Airport, the airport otherwise captures barely one third of its natural geographic market. JFK is the primary airport used when flying to an international destination or to California; LGA is used when flying to Mid-Atlantic and New England destinations and to Alaska or Canada.

In short, about two thirds of those for whom Stewart would be the closest local airport are attracted to the greater range of air services in the adjacent, larger airports.



Destination Zone	EWR (%)	PHL (%)	Lehigh Valley Intl. (%)	JFK (%)	LGA (%)
Southeast U.S.	28	28	34	5	2
Upper Midwest	25	34	34	3	4
Transatlantic	52	13	1	33	0
Lower Midwest	35	36	21	5	3
Southern California	34	30	18	16	1
South-Central America	44	23	4	28	1
Northern California	33	29	19	18	1
Northwest Zone	35	30	23	9	1
New England	14	64	11	7	3
Transpacific	42	15	11	31	1
Alaska–Canada	35	23	30	7	5
NY, NJ, PA	14	52	9	23	2
Mid-Atlantic	26	22	17	18	14
Grand Total	**33**	**29**	**23**	**12**	**2**

Figure 3.8. Present airport of departure for Lehigh Valley International natural market area, by trip destination.

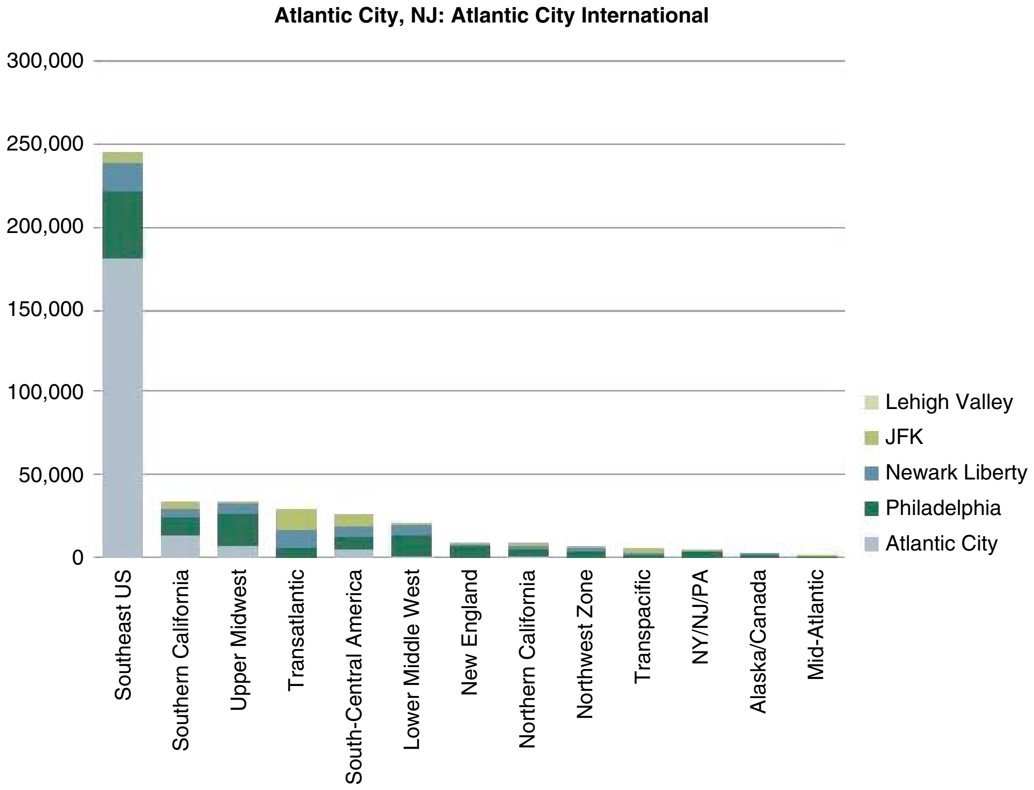
3.5.2.3 Westchester County Airport

As Figure 3.12 shows, of the few trips in the White Plains area that originate from the Westchester County Airport, most are for flights going to the Southeast and Midwest. Passengers traveling to California and overseas prefer JFK. In general, airport destinations which require some transfer/hubbing could be served by connections from White Plains, while destinations with direct service from competing local airports will be harder to attract market share.

In short, of those travelers for whom Westchester County would be the closest local airport, about 85% of them choose to go to adjacent, larger airports.

3.5.2.4 Tweed-New Haven Regional Airport

Tweed-New Haven Regional Airport, in New Haven, CT, exemplifies an underused airport situated in the core of a geographic area that generates millions of air passenger trips.



Destination Zone	Atlantic City Intl. (%)	PHL (%)	EWR (%)	JFK (%)
Southeast U.S.	74	16	7	2
Southern California	40	31	15	14
Upper Midwest	23	55	18	4
Transatlantic	1	21	36	42
South-Central America	20	27	24	28
Lower Midwest	3	62	27	7
New England	0	83	8	7
Northern California	8	45	23	23
Northwest Zone	3	55	28	14
Transpacific	2	25	31	42
NY, NJ, PA	0	68	8	24
Alaska–Canada	0	52	35	12
Mid-Atlantic	0	45	24	30
Grand Total	**48**	**28**	**14**	**10**

Figure 3.9. Present airport of departure for Atlantic City International natural market area, by trip destination.

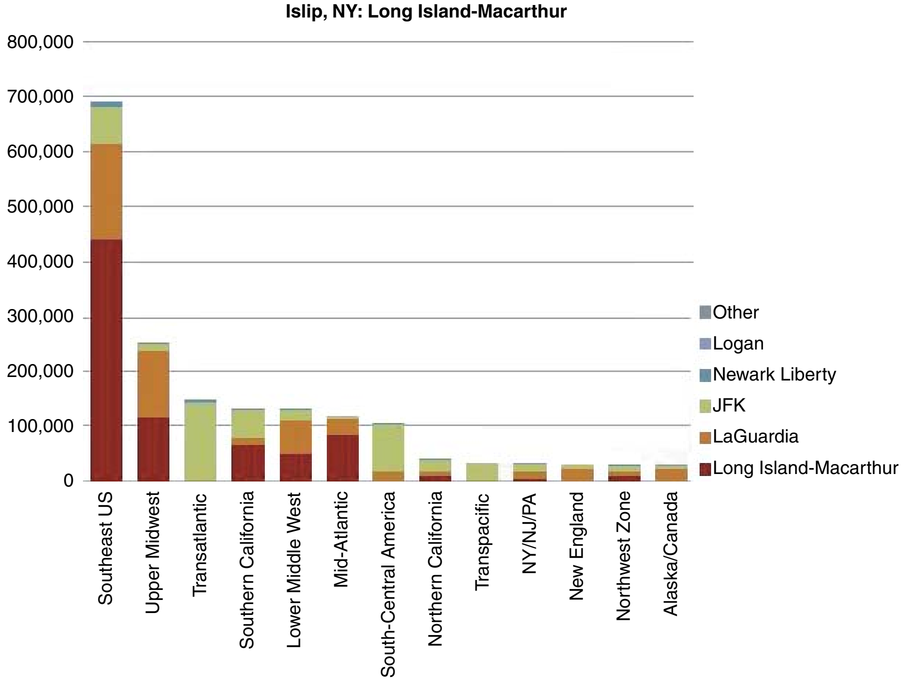
Figure 3.13 shows that, of the 5.8 million flights taken in 2007 by passengers whose closest airport is Tweed-New Haven Regional, only about 30,000 of these were from that airport. Nearly 1.4 million of these passenger trips were to the Southeast. The vast majority of fliers traveled 60–90 min to reach their outbound airport, mainly JFK, LGA and Bradley (Hartford, CT).

In short, of those travelers for whom Tweed-New Haven Regional Airport is the closest local airport, 99% choose to go elsewhere—primarily to JFK.

3.6 Reviewing the Potential Roles of the MPOs and the Need for Larger Geographic Coverage

3.6.1 Background

A powerful regional transportation planning process is a mandatory aspect of federal aid for surface transportation in major metropolitan areas. However, the mandate does not extend to aviation, with the result that airport involvement in regional planning varies from city to city.



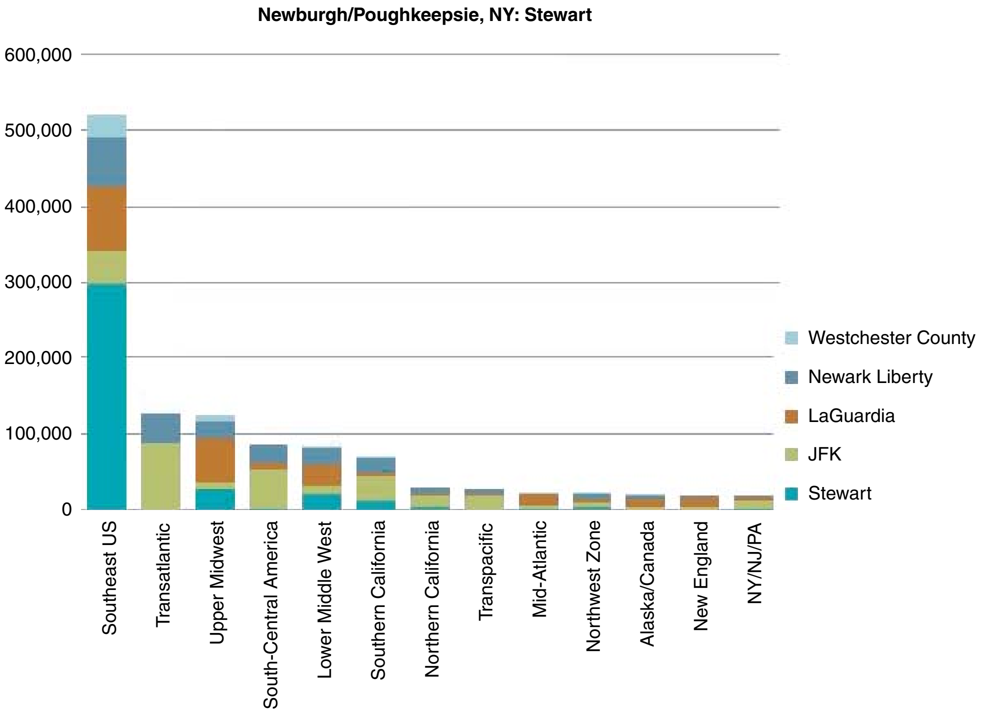
Destination Zone	Long Island-Macarthur (%)	LGA (%)	JFK (%)	EWR (%)
Upper Midwest	45	47	6	1
Southern California	50	9	39	2
Mid-Atlantic	70	25	5	0
Northern California	26	13	57	3
NY, NJ, PA	19	31	47	1
Northwest Zone	34	25	37	3
Grand Total	**44**	**27**	**27**	**2**

Figure 3.10. Present airport of departure for Long Island-Macarthur Airport natural market area, by trip destination.

Only a handful of the nation's MPOs (notably Washington, D.C., Philadelphia, St. Louis, and Southern California) have been able to maintain a staff specialist dedicated to aviation issues, and only one (Washington, D.C.) receives a steady and reliable stream of federal aid to support aviation activities. In the Washington metro area, ongoing activities include forecasting and passenger surveys. The development of effective reliever airports to serve general aviation has been an important activity in Philadelphia and St. Louis.

In Southern California, numerous studies have been undertaken, including airspace utilization and potential sites for new airports. The ongoing program of SCAG (the MPO for Southern California) in regional aviation system planning includes multi-airport demand allocation modeling and airport capacity analysis using an advanced discrete choice model (RADAM) that replicates air passenger choice behavior based on airport passenger surveys collected since 1992. SCAG is now planning a new program to work with the airports of Southern California to address multijurisdictional issues.

The amount of cooperation and coordination between the planning staff of major airports and MPOs depends largely on the activities the MPO has underway. The broadest and best defined relationship is in the Washington, D.C., area, where three major airports (IAD, DCA, and BWI) draw on the Washington metro area MPO for passenger survey data, forecasts, and support in airport ground access analysis. The airport managers are pleased with the arrangement and rely on the data as a sound basis for planning. The more typical



Destination Zone	Stewart (%)	JFK (%)	LGA (%)	EWR (%)	Westchester County (%)	Long Island-Macarthur (%)	Bradley (%)
Transatlantic	0	68	1	31	0	0	0
South-Central America	3	61	9	27	0	0	0
Southern California	17	45	8	27	1	1	0
Transpacific	3	65	7	25	0	0	0
			59				
Northwest Zone	18	30	16	32	3	0	1
			55				
New England	1	25	59	15	0	0	0
Grand Total	**32**	**25**	**20**	**19**	**4**	**0**	**0**

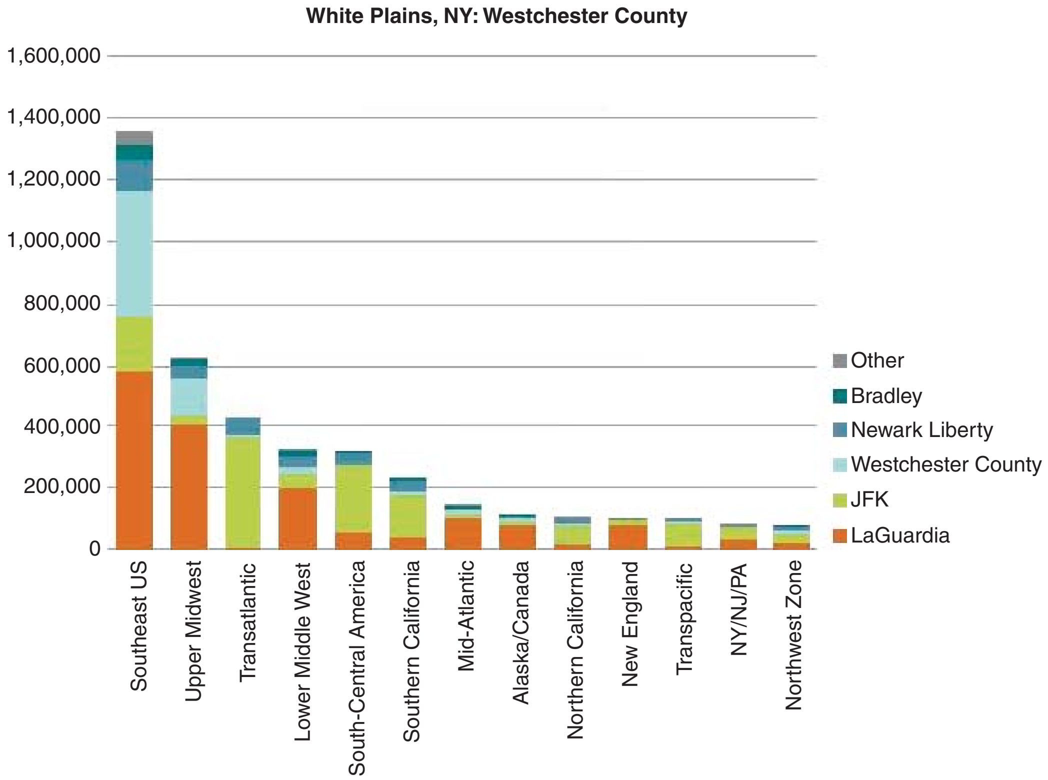
Figure 3.11. Present airport of departure for Stewart Airport natural market area, by trip destination.

arrangement, however, is an annual meeting of the airport and MPO staff, with briefings on current activities and surface transportation plans.

3.6.2 Improvements

There are important opportunities to improve aviation system capacity and airport operations by embracing more collaborative and cooperative regional approaches to airport planning. Particularly in the coastal mega-regions, proactively seeking ways to use commercial airport capacity more efficiently will be important to maintaining the viability of air travel while accommodating forecasted growth in demand for air travel. To do so will require airport managers and governing bodies to think beyond their traditional fence lines and embrace the concept of capacity-sharing with other airports in their market areas.

It may not, however, be necessary to engineer an entirely new way of regional planning to make this possible. Rather, facilitating such collaboration is a traditional and well-established role for MPOs. MPOs can offer airport managers truly regional perspectives on planning, data, and analyses on travel behav-



Destination Zone	LGA (%)	JFK (%)	Westchester County (%)	EWR (%)	Bradley (%)	Stewart (%)	BOS (%)
Southeast U.S.	43	13	30	8	3	2	0
Upper Midwest	64	6	19	6	4	0	0
Transatlantic	2	83	0	15	0	0	0
Lower Midwest	62	14	7	11	5	1	0
South-Central America	17	68	1	12	2	0	0
Southern California	17	57	6	13	5	1	0
Mid-Atlantic	68	10	9	2	8	0	1
Alaska–Canada	70	12	9	7	2	0	0
Northern California	18	58	7	12	4	0	1
New England	76	19	0	4	0	0	0
Transpacific	12	73	2	11	2	0	0
NY, NJ, PA	41	47	3	3	3	0	2
Northwest Zone	31	35	12	15	6	1	0
Grand Total	**41**	**30**	**15**	**9**	**3**	**1**	**0**

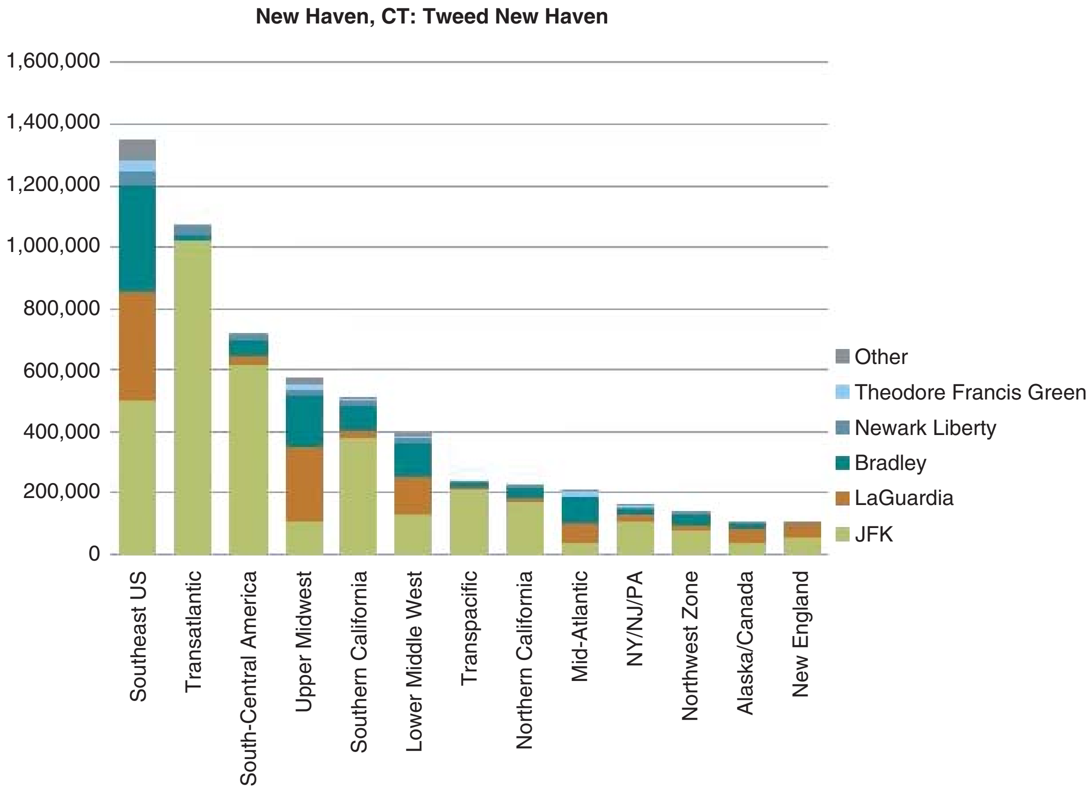
Figure 3.12. Present airport of departure for Westchester County Airport natural market area, by trip destination.

ior and demand in a geographically broad area and a neutral "table" at which airport managers and other key stakeholders can sit to work through coordination options and opportunities. Further, MPOs are in a logical position to lead or facilitate development of county-to-county trip tables for travel within and to mega-regions, which could assist in aviation planning in a way that serves passenger demand while acknowledging flight demand.

In April 2008, a staff member of the FAA gave the following views on a possible framework for the MPO's role in airport planning:

- Consult with the FAA, state aviation agency, and local airports to determine role, identify critical issues, and discuss needed study types;
- Manage regional aviation studies;
- Complement state aviation studies;
- Advocate for aviation enhancement and preservation; and
- Serve as a contact for regional surface access, air quality, and land-use planning issues (*7*).

Consistent with this framework, the research team believes that airport planning could be regionalized by reaching out



Destination Zone	JFK (%)	LGA (%)	Bradley (%)	EWR (%)	PVD (%)	Westchester County (%)	BOS (%)	Tweed-New Haven (%)
Southeast US	37	26	26	4	2	4	1	1
Transatlantic	95	0	1	3	0	0	0	0
South-Central America	85	5	7	2	0	0	0	0
Upper Midwest	19	42	30	3	2	2	1	1
Southern California	74	5	16	3	1	0	0	0
Lower Midwest	33	30	29	4	2	1	1	1
Transpacific	88	3	5	2	0	0	0	0
Northern California	76	5	14	3	1	0	1	0
Mid-Atlantic	20	28	41	1	6	1	1	2
NY, NJ, PA	68	13	12	1	4	0	2	1
Northwest Zone	56	11	25	4	2	1	1	0
Alaska–Canada	35	45	14	3	0	1	1	0
New England	53	44	0	2	0	0	0	0
Grand Total	**59**	**17**	**17**	**3**	**1**	**1**	**1**	**1**

Figure 3.13. Present airport of departure for Tweed-New Haven Regional Airport natural market area, by trip destination.

to MPOs and engaging them in aviation system planning efforts. Joint discussions could be convened among airport managers and MPO officials, to outline the structure and content of regional planning efforts, tailored to the specific needs of each major metropolitan area. Although “official” MPO planning areas are not necessarily precisely coincident with the geographic market areas of airports, it is not uncommon for co-terminus MPOs to formally or informally share data and modeling tools and expertise. This has been particularly true in mega-regions with multiple MPOs where formal jurisdictional boundaries do not reflect actual travel patterns (e.g., Washington, D.C.–Baltimore, the Tampa Bay Region, and the San Joaquin Valley).

3.7 Summary Observations

The existing multijurisdictional projects discussed in this chapter provide examples of ways in which transportation issues that transcend airport boundaries have been addressed through regional planning approaches. Most important is that, in each case, the airport managers/operators recognized the need to cooperate and collaborate, to varying degrees, for their common good. In addition, the cross section of applications of advanced planning methods for California, the Philadelphia region, and the NYC region show that data collected and analyzed on a multijurisdictional basis can be directly applied to decision making on a local or case-by-case basis.

In the case of NERASP, a variety of parties representing diverse interests across six states recognized the value of thinking as a region in order to help air travelers fly to and from New England in an efficient and timely manner. The NERASP initiative has facilitated greater air service access for more people throughout the region and decreased BOS's share of the region's air traffic even as the number of flights overall has climbed.

In the two major regions of California and the Washington/Baltimore region, well-established MPOs have assumed major roles in facilitating a regional perspective on airport planning. In the Washington/Baltimore region, the MWCOG has collected, analyzed, and reported data on passengers, ground access, and other areas for all three major hubs (IAD, DCA, and BWI). This information has been used not only for airport facility planning, but also for multimodal ground access planning that facilitates more flexibility in what airports flights may serve and in passenger choice. In the Los Angeles Basin, SCAG has developed new modeling tools for airport access. In San Francisco, the MTC leads development of the RASP and convenes stakeholders in the often-contentious airport system planning process. Importantly, the MTC's regional perspective has helped create a willingness among airport managers to think "beyond their fence lines" about how to continue serving the region's increasing demand for passenger air service in ways other than further overburdening major hubs.

Content. The creation of new regional analyses would allow the collection and analysis of information not previously examined in the planning process, with a few exceptions such as NERASP and on-going work in California. As noted in Section 3.2.1, the research team believes that one of the missing elements in the process of regional analysis is a well-articulated and well-documented statement of passenger preference. This is not a simple matter, as it would encompass a variety of factors typically grouped as airport level-of-service issues (average delay, number of delays in excess of 15 min, number of cancellations) as well as airline service considerations (competition, fare structure, non-stop destinations and type of equipment). However, a thorough analysis of these factors could produce the information and the regional consensus needed to support local recommendations on how to develop strategies to deal with congestion and delay at airports. Another topic that needs regional attention is the transition to more efficient airport ground access, to offer greater convenience and lower carbon emissions.[31]

As noted, for a multi-airport (regional) systems planning process to work, there has to be a transition from over-reliance on airport-to-airport analysis of flows. While critically important, they must be supplemented by data to support a more fine-grained analysis. To support the policy analysis of alternative roles for various airports in a super-region, it is necessary to organize the basic data on a true-origin to true-destination basis. Pioneering work undertaken by MITRE in the FATE data uses a county-to-county basis for their forecasting activities. Such a focus for the data structure allows for a better integration with presently available data from non-aviation sources and potentially would support later integration with highway and rail forecasting activities. This chapter has demonstrated the application of county-based true origin data to the simple task of examining natural geographic market areas—but this is only a rudimentary example of the need to organize aviation data in this manner.

Timing. Today, planning and development decisions for major commercial service airports are usually not influenced in any significant way by regional planning. The researchers believe, while this is the prevailing situation, it is far from desirable. A major finding of this research is that the regional planning process is not being used to its potential. The weak regional system planning process is an artifact of an earlier era, and today it can impede efforts to optimize the airport system.

The concept of improving the regional planning approach is timely; changes would have little immediate financial impact and therefore should not confront overwhelming institutional obstacles. The critical parties for changing regional airport system practices exist on the federal, metropolitan, and airport-specific levels. The research team believes that there is willingness to implement major changes at all three levels. The major obstacle is inertia, and on the basis of the interviews, it appears that there is more than enough energy and enthusiasm to overcome such inertia. To start the process of revitalizing and empowering the regional system planning process, the research team suggests that airport operators and MPOs could be contacted to outline the structure and content of regional planning efforts, tailored to the specific needs of each major metropolitan area.

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[31] The reader is referred to *ACRP Report 4* for a complete discussion of these issues.

CHAPTER 4

Airport-Specific Implications of the Major Themes

The focus of the previous chapters was on the total impact of various strategies and management processes; this chapter reviews these concepts on an airport-by-airport basis. The content of Chapter 4 includes the following:

- A summary of the role of shorter distance, intra-mega-region traffic at the subject airport.
- A review of the possible implications of planned rail projects for trip substitution.
- A review of the role for rail and proximate airports for multijurisdictional solutions.
- A review of the importance of shorter distance flights to support economically important longer distance flights, such as international services.
- Conditions in the year 2025, in which the calculated impacts of doing nothing are presented as a surrogate metric for the scale of the challenge at the subject airport.
- A quick, preliminary assessment of the potential roles of rail substitution, rail complementarity, and better regional cooperation, which suggests that, while important, none of these alone represents a "silver bullet" that will eliminate the problem of aviation capacity in the mega-regions.

Exhibit 4.0. Highlights and key themes included in Chapter 4.

4.1 Major Themes of the Report for Airport-Specific Application

Chapter 4 now presents an airport-by-airport review of how major airports in the two study areas might, and might not, be influenced by each of the major themes of the study that have been presented up until this point in the analysis (see Exhibit 4.0). Each major airport will be reviewed in terms of the themes developed in the previous three chapters. In terms of their implications for specific airports, the major themes of the project can be summarized as follows:

1. The problem of lack of effective aviation capacity in the East Coast and West Coast Mega-regions is real and present and has significant economic and environmental consequence. The cost *of not addressing the problem* could rise in 2025 to as high as $20 billion in the aggregate and would be associated with GHG impacts of 17 million metric tons of CO_2 per year. The surrogate measure of the future cost of doing nothing provides a quick metric that scales the urgency, presented in this section on an airport-by-airport basis.
2. Aviation planning could benefit from becoming more multimodal. At the moment, there is no universally accepted method to examine the possible impact of parallel federal and local policies toward existing and planned HSR improvement. Although HSR projects in the aggregate could divert as many as 14 million air trips per year in the next 25 years, the early implications for individual airports should be examined now.
3. Aviation planning could benefit from becoming more multijurisdictional. In some cases, chronically underused runway and supporting facilities can take the pressure off of larger, more strategically important regional airports. In some cases, innovative ground services could provide complementary roles to major airports; in other cases, adjacent airports could provide more services to national hub transfer points. Data could be provided that would help explain the extent to which shorter distance flights are key to making longer distance flights successful.

In short, this chapter provides airport-specific information that would be involved in the application of a revised planning process that was more multimodal and multijurisdictional in nature. After this analysis of the potential role of strategies external to the aviation industry, the following chapter (Chapter 5) examines alternative strategies to better manage the airport and air systems facilities themselves.

Issues for Airport-by-Airport Review

For each of the largest airports in the two study areas, this section of the report reviews the local airport data to provide the following:

1. A summary of the role of shorter distance, intra-mega-region traffic at the subject airport.
2. A review of the possible implications of planned rail projects for trip substitution.
3. A review of the role for rail and proximate airports for multijurisdictional solutions.
4. A review of the importance of shorter distance flights to support economically important longer distance flights, such as international services.
5. Conditions in the year 2025, in which the calculated impacts of doing nothing are presented as a surrogate metric for the scale of the challenge at the subject airport.

4.2 Strategic Implications for the Major Airports in the West Coast Study Area

Section 4.2 reviews the implications of the major themes of this research project on the four largest airports in the West Coast study area, with particular attention to the shorter distance trips and trip segments that occur within the borders of the study area.

In this project, the shorter distance air segments require the most analysis. Trips to and from areas outside the study area are simply not candidates for either rail substitution or for providing complementary services, as discussed in Chapter 2. However, longer distance trips may be candidates for diversion to adjacent airports closer to the origin of the trip-maker, as discussed in Chapter 3. Thus, the longer distance trips are described for each major airport in terms of the geographic distribution of their destination trip ends.

4.2.1 San Francisco International Airport (SFO)

SFO ranks 13th in the ACI-NA list of American airports in 2007. On the basis only of the DOT's OD survey, it is estimated that about 22% of enplanements at SFO are made by those from connecting flights (see Table 4.1). The limitations of various data sources are discussed in Section 4.6.

4.2.1.1 The Role of Intra-Mega-region Traffic at SFO

Of all those passengers enplaning at SFO (both originating and connecting), 17% are going to destinations within the West Coast study area: 15% are going to destinations in the Southern California/Las Vegas McCarran Airport (LAS) Mega-region, with only 2% going to the Northern California Mega-region. Of all those enplaning at SFO, 11% are making trips entirely within the West Coast study area.

4.2.1.2 Rail as a Substitution for Air Travel: Impacts on SFO

Of these trips, the 1.6 million SFO trips with actual destinations in the southern portion of the study area are the

Table 4.1. Origin–destination passenger volumes at SFO (*1*).

San Francisco, 2007 (SFO)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	Total (%)	Total Boardings	Originating Boardings	Boardings from Transfer Flights	From West Coast Study Area	Outside West Coast Study Area	From Atlantic/ Pacific	From South-Central America
Northern California	1.9	318,233	22,280	295,953	82,740	169,566	73,195	4,905
Southern California/ LAS	14.6	2,405,822	1,614,370	791,452	127,720	618,016	271,751	7,868
To the North	11.2	1,852,852	1,250,521	602,331	278,036	145,823	155,797	29,199
To the East	42.2	6,963,448	6,067,140	896,308	251,760	271,390	504,283	2,220
Transatlantic	9.1	1,503,667	1,419,502	84,165	57,671	48,320	0	0
Transpacific	16.8	2,767,323	1,846,162	921,161	287,275	767,697	10	220
South-Central America	4.2	696,748	652,236	44,512	12,773	60,618	320	0
Totals	**100**	**16,508,093**	**12,872,211**	**3,635,882**	**1,097,975**	**2,081,430**	**1,005,356**	**44,412**

most logical candidates for diversion HSR services. Chapter 3 reported that air volumes between the Bay Area and the Los Angeles Basin could be expected to drop by about 40% with the inauguration of the full California HSR project. From the same calculations, the air volumes between the Bay Area and San Diego would fall by about 35%.

Assuming that HSR lowered the number of air trips to the southern region *as a whole* by about 35%, this would be a decrease of 600,000 air passengers from SFO. This would represent a decrease in total SFO boardings of between 3–4% of total SFO air passengers. No direct rail services between the Bay Area and Las Vegas are contemplated at present.

4.2.1.3 Rail as a Complementary Mode and the Role of Adjacent Airports

SFO will be linked to the California HSR system, possibly using the existing (currently unused) Bay Area Rapid Transit alignment between the International Terminal and Millbrae Station along the existing CalTrain right of way. This alignment could have major implications for the use of HSR as a feeder mode for longer distance flights, particularly extending the airport's market-shed area far to the south, to San Diego, Gilroy, and beyond. Airport rail ground access to Merced, Modesto, and Stockton would also be somewhat improved.

All of this supports the need to examine alternative futures for each of the airports in the region, to build on the strengths of each. That study could also examine the possibility of more flights from smaller airports directly to transfer hubs (e.g., Salt Lake, Denver, and Phoenix) that would avoid movements in the West Coast study area airports.

The existing scope of services for the MTC RASP reflects very positively many of the innovations commenced in the FAA's NERASP program in New England (*2*). An early RASP meeting included a major presentation from managers at Boston's Logan Airport, reflecting the progress encouraged by the NERASP program. The MTC project could be closely monitored for its implication for future multijurisdictional aviation studies, including a proposed project for Southern California.

4.2.1.4 Feeding Longer Distance Flights

Of the 2.8 million boardings for transpacific flights, two thirds of those come from local originations, with another 900,000 transferring from feeder flights. Clearly, the success of SFO as a jump-off point for transpacific flights is the combination of a strong home (origination) market and the ability to continue filling seats with flights from distant areas. Overwhelmingly, those feeder trips are coming from outside California, with nearly 770,000 connecting trips. Of all the SFO passengers connecting to the Pacific, only about 60,000 per year (6% of passengers transferring to the Pacific) are being supplied on the short flights from the immediate Northern California area.

The airport does not play much role in shorter distance (OD) travel in the Northern California. Local air travelers with destinations in this part of the state make up about 0.1% of the total enplanements at SFO.

Its role as a transferring "gateway" to the West Coast study area is modest, with only about 7% of SFO airport users connecting to other airports in the West Coast study area. The SFO airport passenger activity summary (Appendix A) presents the 10 closest airports, the most distant of them being Santa Barbara (257 miles).

4.2.1.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE (*3*) program predicts that demand for *domestic originations* at SFO will increase by about 76% over what the research team reported for the year 2007. The FAA's Terminal Area Forecasts, which look at domestic originations, transfer activity, and international activity, have predicted an 84% growth between 2007 and 2025 for SFO.

The implications of doing nothing at SFO. Given the definitions established in Chapter 1, the 2025 cost of not dealing with the issues addressed in this project at SFO would be about $0.8 billion compared with a base-case benchmark condition of the delay experienced at SFO in the year 2003.

4.2.2 Los Angeles International Airport (LAX)

LAX is the largest airport in our two study areas, commanding both domestic and international markets and ranking as the third largest airport in the United States according to the ACI-NA 2007 rankings. From the DOT's OD survey, about 19% of enplanements are estimated to be made by those from connecting flights (see Table 4.2).

4.2.2.1 The Role of Intra-Mega-region Traffic at LAX

Of all those enplaning at LAX (originating and connecting), 15% are going to destinations within the West Coast study area, 6% are going to destinations in the Southern California/LAS Mega-region, and 9% are going to the Northern California Mega-region. Of all those enplaning at LAX, 10% are making trips entirely within the West Coast study area.

Table 4.2. Origin–destination passenger volumes at LAX (*1*).

Los Angeles, 2007 (LAX)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	Total (%)	Total Boardings	Originating Boardings	Boardings from Transfer Flights	From West Coast Study Area	Outside West Coast Study Area	From Atlan-tic/Pacific	From South-Central America
Northern California	9.2	2,627,051	1,917,500	709,551	117,190	345,914	140,034	106,413
Southern California/LAS	6.1	1,762,497	720,760	1,041,737	225,160	523,295	253,302	39,980
To the North	9.2	2,630,745	2,248,781	381,964	123,939	88,277	77,337	92,411
To the East	42.8	12,291,794	10,499,730	1,792,064	817,950	92,297	860,166	21,651
Transatlantic	7.1	2,034,528	1,923,241	111,287	91,411	19,876	0	0
Transpacific	16.9	4,863,465	3,642,293	1,221,172	301,925	918,087	20	1,140
South-Central America	8.7	2,495,635	2,233,500	262,135	146,393	114,022	1,720	0
Totals	**100**	**28,705,715**	**23,185,805**	**5,519,910**	**1,823,968**	**2,101,768**	**1,332,579**	**261,595**

4.2.2.2 Rail as a Substitution for Air Travel: Impacts on LAX

In terms of potential intermodal impacts, the 10% of LAX-originating boarders with actual destinations in the study area are the most important. Table 4.2 shows that 1.9 million passengers are destined to the Northern California Mega-region; if HSR could divert 35% of these travelers from air, boardings at LAX would decrease by 670,000.

The total number of passengers flying from LAX to the destination of Las Vegas Airport is 629,000. Assuming a range of air diversions from 20% to 35%, the decrease in LAX boardings would range between 126,000 and 220,000.[32] If HSR were assumed in both corridors, the higher level of diversion would result in a decrease of 3–4% of LAX total boardings.

4.2.2.3 Rail as a Complementary Mode and the Role of Adjacent Airports

It has now been established that the California HSR system will not directly serve LAX, and thus the role of HSR as feeder to longer distance flights at LAX will be insignificant. However, HSR's role as a feeder to both ONT and Palmdale should be explored in the next phase of Regional Aviation Systems Planning in California. It may be possible to use HSR meaningfully to increase the relative role of Palmdale and ONT as part of a "family of airports" concept. SCAG has done extensive modeling of HSR access to both Ontario and Palmdale airports in its 2001, 2004, and 2008 Regional Transportation plans. The modeling work showed both modal shifts and passenger and cargo demand increases at those airports resulting from HSR access. The impacts of HSR access to other airports in the SCAG region were also modeled for these plans, including San Bernardino International, March Inland Port, and Southern California Logistics airports.

This underscores the need, as discussed in Chapter 3, to continue the emphasis on multijurisdictional planning efforts in the aviation sector in Southern California. Such study efforts would also examine the possibility of more flights from smaller Southern California airports directly to transfer hubs (e.g., Salt Lake, Denver, and Phoenix) that would avoid transfer movements in the West Coast study area airports. The timing of the proposed regional program could benefit both from the innovations of the FAA's NERASP program and from the other multijurisdictional work undertaken by the major MPOs in California.

4.2.2.4 Feeding Longer Distance Flights

Of a total of about 29 million boardings in the OD database, 23 million are from the Los Angeles area, with less than 6 million transferring from a feeder flight. Of about 4.9 million passengers boarding from transpacific flights (including Hawaii), about 1.2 million are brought to LAX on feeder flights, and about one quarter of these are from the West Coast study area, which includes all of California and the Las Vegas area.

Additionally, LAX is a major beginning point for transatlantic travel, in spite of its western location. In fact, more people (at more than 2.0 million) board a plane at LAX for a transatlantic trip than do from IAD, PHL, or BOS. The transatlantic flyers are overwhelmingly from the Los Angeles area, as only 5% of those boarding for a transatlantic destination are transferring from a connecting flight.

Its role as a transferring gateway to the West Coast study area is modest, with only about 6% of LAX users connecting to other airports in the West Coast study area. The 10 closest air-

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[32] This range represents a higher level of diversion than that reported in Chapter 2, which was for a specific, non-electrified rail technology.

ports are described with their segment passenger volumes and their distance from LAX in the LAX airport passenger activity summary included in Appendix A.

4.2.2.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for *domestic originations* at LAX will increase by about 80% over what the research team has reported for the year 2007. The FAA's more comprehensive Terminal Area Forecasts have predicted a 98% growth between 2007 and 2025 for LAX.

The implications of doing nothing at LAX. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at LAX would be about $1.8 billion compared with a base-case benchmark condition of the delay experienced at LAX in the year 2003.

4.2.3 Las Vegas McCarran Airport (LAS)

LAS has the highest volume of domestic origination passengers in the nation—about 16.9 million in the Las Vegas area. In total volume, it ranks seventh among airports in the United States in the ACI-NA 2007 survey. On the basis of the DOT's OD sample, about 16% of the enplanements are from connecting flights (see Table 4.3).

4.2.3.1 The Role of Intra-Mega-region Traffic at LAS

Of all those passengers enplaning at McCarran Airport, 26% are going to destinations within the West Coast study area; 16% are going to destinations in the Cal South/LAX Mega-region and 10% are going to the Cal North Mega-region. Of all those enplaning at LAS, 20% are making trips entirely within the West Coast study area, which is the second highest level of intraregional orientation in the full ACRP sample of major airports.

4.2.3.2 Rail as a Substitution for Air Travel: Impacts on LAS

Looking first at the 20% of LAS boarders who are originating in Las Vegas and ending their trip in California, Figure 2.2 shows that 1.6 million people are currently flying from LAS to the Los Angeles Basin. If air volumes decreased by 35%, that would be a drop of 560,000 air passengers. This would represent about a 3% decrease in the number of air passengers at LAS.

At present, no direct rail services are planned from Las Vegas to San Diego or to Northern California, unless the two programs are merged, which is under discussion.

4.2.3.3 Rail as a Complementary Mode and the Role of Adjacent Airports

As interviews with managers at LAS revealed, there is no major logical feeder area for LAS flights beyond Clark County. On the basis of the growth in demand revealed in this analysis, the major question concerns new airport capacity to serve what is basically a Clark County market.

4.2.3.4 Feeding Longer Distance Flights

At LAS, few people actually start, or end, an international flight of any kind—about 2% of the total boardings. Still, the airport handles more than 3 million transfers, generally from the lower 48 states. The majority of these are from California, transferring to a flight to the more eastern parts of the country. Of those eastbound, more transfer from the West Coast study area than from the rest of the country combined.

Its role as a transferring gateway to the West Coast study area is modest, with only about 7% of LAS airport users

Table 4.3. Origin–destination passenger volumes at LAS (*1*).

Las Vegas, 2007 (LAS)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	**Total (%)**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**From West Coast Study Area**	**Outside West Coast Study Area**	**From Atlantic/ Pacific**	**From South-Central America**
Northern California	9.8	1,958,160	1,494,860	463,300	93,190	364,270	4,170	1,670
Southern California	15.8	3,178,330	2,192,520	985,810	164,530	813,290	5,760	2,230
To the North	9.8	1,959,300	1,685,100	274,200	71,180	200,700	1,470	850
To the East	62.6	12,572,580	11,203,850	1,368,730	1,097,420	218,180	52,960	170
Transpacific	1.9	378,100	313,450	64,650	9,930	54,650	0	70
South-Central America	0.2	30,640	25,700	4,940	3,900	960	80	0
Totals	**100**	**20,077,110**	**16,915,480**	**3,161,630**	**1,440,150**	**1,652,050**	**64,440**	**4,990**

transferring to other airports in the West Coast study area. The 10 closest airports are described with their segment passenger volumes and their distance from LAS in the LAS airport passenger activity summary (Appendix A). Looking at the shortest flights feeding LAS, nearly a quarter of the passengers are traveling less than 260 mi, with major concentration of destinations into Phoenix, LAX, SAN, Burbank, and John Wayne.

4.2.3.5 *Conditions in the Year 2025*

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at LAS will increase by about 85% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 104% growth between 2007 and 2025 for LAS.

The implications of doing nothing at LAS. Given the definitions established in Chapter 1, the 2025 cost of not dealing with the issues addressed in this project at LAS would be about $1.8 billion compared with a benchmark condition of the delay experienced at LAX in the year 2003.

4.2.4 San Diego International Lindbergh Field (SAN)

San Diego is a major airport in the United States, ranking 29th in the ACI-NA 2007 listings. It is characterized by an extraordinary reliance on originating traffic, with only 5% of enplaning passengers having arrived by connecting flight (see Table 4.4).

4.2.4.1 *The Role of Intra-Mega-region Traffic at SAN*

Of all those enplaning at SAN, 26% are going to destinations within the West Coast study area; 6% are going to destinations in the Southern California/LAS Mega-region, and 20% are going to the Northern California Mega-region. Of all those enplaning at SAN, 24% are making trips entirely within the West Coast study area, which is the highest level of intra-regional travel of any major airport in the ACRP study.

4.2.4.2 *Rail as a Substitution for Air Travel: Impacts on SAN*

In the analysis presented in Chapter 2, the HSR program could lower the number of passengers flying between San Diego and the Northern California Mega-region by about 35%. Assuming that diversion, the total number of air passengers boarding at San Diego would decrease by about 6%.

4.2.4.3 *Rail as a Complementary Mode and the Role of Adjacent Airports*

The California HSR system can directly serve SAN, where studies are now underway to make the airport more oriented to a possible intermodal center located on the rail right of way. In theory, the logical catchment area of SAN could geographically grow to increase market participation from communities near the proposed rail stations at Escondido, Murrieta, and University of California-Riverside. Alternatively, the opposite phenomenon might also be true: these market areas might be more attracted to ONT, assuming that its services and prices were improved. With a greater variety of destinations and flight options available at SAN compared with ONT, an HSR connection might have the initial affect of drawing more passengers to use SAN rather than shifting passengers to ONT until possible airport congestion or cost causes SAN to be a less attractive alternative. With increased use, ONT might develop route patterns similar to SAN; at best, the rail system would provide a mechanism that would allow more optimized airport choice by the customer.

Table 4.4. Origin–destination passenger volumes at SAN (*1*).

San Diego, 2007								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	Total (%)	Total Boardings	Originating Boardings	Boardings from Transfer Flights	From West Coast Study Area	Outside West Coast Study Area	From Atlantic/ Pacific	From South-Central America
Northern California	19.7	1,831,720	1,731,620	100,100	11,480	84,513	2,310	1,797
Southern California/LAS	6.0	552,448	447,460	104,988	19,430	80,543	3,293	1,722
To the North	11.2	1,038,112	1,014,541	23,571	5,316	11,669	922	5,664
To the East	54.6	5,063,861	4,891,420	172,441	144,680	12,259	14,531	971
Transatlantic	2.7	248,829	245,848	2,981	2,095	886	0	0
Transpacific	3.8	352,355	334,250	18,105	3,508	14,567	10	20
South-Central America	2.1	190,137	179,963	10,174	3,519	6,635	20	0
Totals	**100**	**9,277,462**	**8,845,102**	**432,360**	**190,028**	**211,072**	**21,086**	**10,174**

As noted, the proposed California HSR system will not serve as a feeder to LAX, so the problem of where to transfer SAN-originating passengers seeking access to more difficult destinations remains to be resolved, including the increased role of ONT. This underscores the need for a comprehensive Regional Aviation System Plan in Southern California to maximize the potential contribution of all major regional airports in the study area. Because of the recent decision to have the airport remain in its present, highly constricted location, the importance of increased roles for airports to the north (and possibly more use of airport capacity to the south) should be a high priority for the long-term intermodal strategy in San Diego. (In the event that San Diego managers find an alternative location, the role of rail would need to be re-examined.)

4.2.4.4 Feeding Longer Distance Flights

Historically, SAN has not been a major international airport. It was once served by an international airline, which had to fly partially empty planes in order to deal with the limited runways at the airport; this service has since been abandoned.

SAN's role as a transferring gateway to the West Coast study area is minimal, with only about 2% of airport users transferring to other airports in the West Coast study area. SAN is not characterized by having direct service to nearby smaller airports. Indeed, the closest airport with direct service is LAX, where many SAN passengers go to transfer to the more abundant set of services to varied destinations.

4.2.4.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for *domestic originations* at SAN will increase by about 72% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 73% growth between 2007 and 2025 at SAN.

The implications of doing nothing at SAN. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at SAN would be about $0.6 billion compared with a benchmark condition of the delay experienced at SAN in the year 2003.

4.3 Understanding the Role of Smaller Airports in the West Coast Study Area

Most of the transfer activity and the international activity in the West Coast study area occur at the airports whose passenger flows are documented in some detail in the previous sections. The other airports tend to be dominated by domestic flows, with less reliance on transfers, and a greater percentage of boardings from the local area (originations).

To better understand the passenger activity in more of the West Coast airports, Appendix C includes the comprehensive passenger activity summary tables for the following 11 airports (generally ordered from north to south):

- Sacramento Airport,
- OAK,
- SJO,
- Burbank Airport,
- Long Beach Airport,
- ONT,
- John Wayne Santa Anna Airport, and
- The four airports discussed in this section.

The airport passenger activity summary tables developed in this project are described in the introduction to Appendix C. With these summary tables, the reader can learn the following:

- The absolute volumes of origination and transferring air passengers at the subject airport, from the Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics (DB1B);
- The destinations of all originating and transferring air passengers at the subject airport, organized by 13 super zones of origin and 13 super zones of destination (also from the DB1B);
- The volumes of total air passengers carried to the 10 closest airports to the subject airport, from the DOT T100 database, which includes very small commuter carriers not included in the DB1B data; and
- A single example of the number of such air travelers who are traveling to that destination with the subject airport as the origin (again from the DB1B).

4.4 Strategic Implications for the Major Airports in the East Coast Study Area

4.4.1 Boston Logan Airport (BOS)

BOS is ranked as the 20th airport in the United States in terms of passenger activity in the ACI-NA 2007 survey. BOS is primarily an airport for originating/ending traffic. Of the trips captured in the DOT's OD survey, about 5% of the enplanements are by passengers who arrived at the airport by connecting airplanes (see Table 4.5).

4.4.1.1 Role of Intra-Mega-region Traffic at BOS

Of all those passengers enplaning at BOS, 21% are going to destinations within the East Coast study area: 1% are going to destinations in New England; 12% are going to New

Table 4.5. Origin–destination passenger volumes at BOS (*1*).

Boston, 2007 (BOS)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	**Total (%)**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**East Coast Study Area**	**Outside of East Coast Study Area**	**From Atlantic/ Pacific**	**From South-Central America**
New England	0.8	102,529	3,270	99,259	28,160	65,490	3126	2,483
NY, NJ, PA	11.6	1,573,230	1,459,650	113,580	24,940	62,628	18,301	7,711
Mid-Atlantic	8.2	1,106,834	1,060,670	46,164	11680	17943	14,109	2,432
To the South	22.7	3,085,099	2,981,240	103,859	51,970	24,685	25,332	1,872
To the West	35.3	4,788,332	4,629,810	158,522	68,350	26,312	55891	7,969
To the North	2.5	341,529	309,261	32,268	10,161	22,097	0	10
Transatlantic	11.1	1,502,673	1,393,366	109,307	32,167	77,140	0	0
Transpacific	2.3	305,501	298,039	7,462	3,369	4,083	0	10
South-Central America	5.6	764,752	742,275	22,477	12,626	9,851	0	0
Totals	**100**	**13,570,479**	**12,877,581**	**692,898**	**243,423**	**310,229**	**116,759**	**22,487**

York, New Jersey, or Pennsylvania; and 8% are going to the Washington, D.C./Baltimore region. Of all those enplaning at BOS, 19% are making trips entirely within the East Coast study area, the highest level of any East Coast study area airport.

4.4.1.2 Rail as a Substitution for Air Travel: Impacts on BOS

According to the analysis by the DOT's Office of the Inspector General, increased investment in the rail system between Boston and NYC could divert an additional 10% of air passengers in a lower speed scenario, and 20% in a higher speed scenario. In the research team's database, departing air traffic from BOS with actual destinations in NYC, Philadelphia, and the Washington, D.C., region constitutes about 2.0 million annual passengers (2007). Applying this range of diversions would lower this volume between 0.2 million and 0.4 million passengers. This suggests that improved rail as far south as Washington, D.C., could lower the volume of total passengers boarding at BOS by 1–3%.

4.4.1.3 Rail as a Complementary Mode and the Role of Adjacent Airports

Table 4.5 shows that passengers boarding at BOS are not coming from adjacent airports, with less than 1% of its traffic associated with other New England airports. Thus, even assuming a hypothesized rail (not planned) between Boston and Maine, for example, would not decrease local feeder flights. An air market does exist between BOS and Cape Cod and the Islands, but the geography is not conducive to a rail connection. An HSR connection west to Worcester and Springfield would improve ground access for those Western Massachusetts passengers willing to change to some connecting mode at South Station to get to BOS.

Rather, continued regional airport systems planning should build upon the analysis commenced in the NERASP study to widen the unique and successful system of intercity bus services directly serving BOS. The need in New England is not to alter the present pattern of regional sharing of demand, but to continue building on the success of NERASP.

4.4.1.4 Feeding Longer Distance Flights

BOS serves as the point of origin for 1.5 million trips across the Atlantic, most of which fly directly from the airport, but there is considerable "leakage" to other gateway airports. Looking at BOS as the "logical" gateway for transatlantic travel from New England, note that on an annual basis about 64,000 air passengers from New England choose JFK; 55,000 choose EWR; about 42,000 choose PHL; and 32,000 choose IAD.

Of the 1.5 million passengers boarding a plane at BOS for a transatlantic trip, only about 7% got to the airport by a connecting flight. Its role as a transferring gateway to the East Coast study area is minimal, with only about 2% of airport users transferring to airports in the East Coast study area. The role of nearby airports in providing feeder service to BOS is somewhat low. Of the 10 closest airports with direct service, three—Martha's Vineyard, Provincetown, and Nantucket—can only be accessed by (or over) water, so they cannot be considered as prime candidates for relief by new rail service.

In short, BOS does not rely on a network of New England local services to feed its longer distance services; such traffic from Maine, New Hampshire, and Vermont travels directly from those states to points of hubbing (e.g., Chicago, Detroit, Atlanta, etc.).

4.4.1.5 *Conditions in the Year 2025*

Demand in the year 2025. The MITRE FATE program predicts that demand for *domestic originations* at BOS will increase by about 75% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 45% growth between 2007 and 2025.

The implications of doing nothing at BOS. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at BOS would be $1.8 billion when compared against a base-case benchmark condition of 100% flights on schedule, or about $1.2 billion compared with a benchmark condition of the delay experienced at BOS in the year 2003.

4.4.2 John F. Kennedy International Airport (JFK)

JFK ranks sixth among airports in the United States in the ACI-NA ranking for 2007. Of the passengers in the DOT's OD database, some 17% of boardings at JFK are by people who accessed the airport by a connecting flight (see Table 4.6). JFK carries about 7.4 million passengers across the Atlantic and the Pacific, making it the largest intercontinental airport in the study, just ahead of LAX, which has about 6.9 million such passengers.

4.4.2.1 *The Role of Intra-Mega-region Traffic at JFK*

Of all those enplaning at JFK, 10% are going to destinations within the East Coast study area: 4% are going to destinations in New England; 4% are going to New York, New Jersey, or Pennsylvania; and 2% are going to the Washington, D.C./ Baltimore region. Of all those enplaning at JFK, only 6% are making trips entirely within the East Coast study area.

4.4.2.2 *Rail as a Substitution for Air Travel: Impacts on JFK*

The 6% of JFK traffic that is internal to the mega-region can be examined for potential diversions. JFK currently sends about 316,000 OD passengers to the other major airports on Amtrak's Northeast Corridor. Assuming an additional range of diversions between 10% and 20%, boardings at JFK would decrease by 30,000–60,000 passengers.

JFK currently sends about 480,000 OD passengers to Albany, Syracuse, and Buffalo along a potential Empire Corridor HSR line. Applying the same diversion factors (with the understanding that Buffalo would get a diversion in the lower range), boardings at JFK might decrease by 48,000–96,000 passengers.

Assuming HSR were implemented on both the NEC and on the Empire Corridor, the decrease in JFK total boardings would represent less than 1% under the higher diversion scenarios.

4.4.2.3 *Rail as a Complementary Mode and the Role of Adjacent Airports*

Looking at segment ridership (which includes both feeder and OD traffic), JFK gets a small amount (28,000) of air passengers connecting from Albany just 145 miles away; with a larger contribution (190,000) from Syracuse (208 miles) from JFK. Hartford (106 miles), Providence (143 miles), and Manchester (199 miles) each contribute more than 20,000 air passengers.

Table 4.6. Origin–destination passenger volumes at JFK (*1*).

JFK, 2007 (JFK)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	**Total (%)**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**East Coast StudyArea**	**Outside of East Coast StudyArea**	**From Atlantic/ Pacific**	**From South-Central America**
New England	3.6	785,829	297,990	487,839	38,940	300,140	91,478	57,281
NY, NJ, PA	4.3	934,491	583,290	351,201	29,980	239,594	56,013	25,614
Mid-Atlantic	2.0	428,277	221,960	206,317	31,830	54,554	100,182	19,751
To the South	14.7	3,208,073	2,603,270	604,803	254,390	55,559	275,574	19,280
To the West	25.1	5,470,486	4,540,380	930,106	316,940	67,046	473,038	73,082
To the North	1.0	221,079	196,956	24,123	5,438	18,495	0	190
Transatlantic	28.5	6,212,549	5,293,191	919,358	204,210	715,148	0	0
Transpacific	5.4	1,183,751	1,106,744	77,007	43,463	33,464	0	80
South-Central America	15.5	3,388,359	3,193,241	195,118	102,646	92,452	20	0
Totals	**100**	**21,832,894**	**18,037,022**	**3,795,872**	**1,027,837**	**1,576,452**	**996,305**	**195,278**

Under present configurations, neither service on the Empire Corridor nor service on the NEC is routed to the major airport transfer facility at Jamaica Station on Long Island. As long as this configuration exists, the role of rail to substitute for or augment feeder services will be minimal.

In terms of track geometry, trains that currently terminate at NY Penn Station could be through-routed (without reversing directions at Penn Station) from the Empire Corridor in the North and from Philadelphia in the South to provide direct service to Jamaica Station. Questions of rail system capacity under the East River would need to be resolved as part of the larger question of through-routings between the systems now underway in New York.

4.4.2.4 Feeding Longer Distance Flights

Looking just at the enplanement with destinations across the Atlantic, about 15% of those passengers accessed the airport by a connecting flight. This is much lower than with a mirror situation in LAX, where about 25% of those boarding places for the Pacific have come by connecting flight. As might be expected, those that do use JFK for a transfer to a transatlantic flight come from longer, not shorter distances. More people transfer to a transatlantic flight at JFK from the Southeast than from the entire Mega-region from Maine to Virginia.

Passengers leaving JFK for Pacific destinations (including Hawaii) are overwhelmingly local in origin; only 6% came by a connecting flight. As an airport designed for longer distance trips, JFK's role as a transferring gateway to the East Coast study area is modest, with only about 5% of airport users connecting to other airports in the East Coast study area. More detail is presented in the JFK airport passenger activity summary (Appendix A).

4.4.2.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at JFK will increase by about 71% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 76% growth between 2007 and 2025.

The implications of doing nothing at JFK. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at JFK would be about $1.2 billion compared with a benchmark condition of the delay experienced at JFK in the year 2003.

4.4.3 LaGuardia Airport (LGA)

LGA airport ranks 21st in activity level among airports in the United States, as ranked in the 2007 ACI-NA report. Although LGA is designed as a shorter distance OD airport, passengers do use it for transferring. About 8% of those boarding a flight at LGA arrived there by a connecting flight (see Table 4.7).

4.4.3.1 The Role of Intra-Mega-region Traffic at LGA

Of all those enplaning at LGA, 16% are going to destinations within the East Coast study area: 6% are going to destinations in New England; 3% are going to New York, New Jersey, or Pennsylvania; and 6% are going to the Washington, D.C./Baltimore region. Of all those enplaning at LGA, 13% are making trips entirely within the East Coast study area.

Table 4.7. Origin–destination passenger volumes at LGA (*1*).

LaGuardia, 2007 (LGA)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	Total (%)	Total Boardings	Originating Boardings	Boardings from Transfer Flights	East Coast Study Area	Outside of East Coast Study Area	From Atlantic/ Pacific	From South-Central America
New England	6.4	804,995	556,390	248,605	59,650	169,416	11,136	8,403
NY, NJ, PA	3.1	386,013	241,930	144,083	43,890	93,903	3,316	2,974
Mid-Atlantic	6.3	794,248	707,890	86,358	51,750	24,325	7,433	2,850
To the South	34.2	4,299,430	4,094,210	205,220	130,310	40,585	28,267	6,058
To the West	40.2	5,054,435	4,818,840	235,595	136,710	48,721	35,336	14,828
To the North	4.6	581,598	558,928	22,670	5,434	17,236	0	0
Atlantic/Pacific	1.8	222,999	137,511	85,488	21,885	63,603	0	0
South-Central America	3.3	417,342	382,209	35,133	14,227	20,906	0	0
Totals	**100**	**12,561,060**	**11,497,908**	**1,063,152**	**463,856**	**191,051**	**85,488**	**35,113**

4.4.3.2 Rail as a Substitution for Air Travel: Impacts on LGA

The 13% of LGA passengers with OD trips entirely within the East Coast Mega-region represent the market segment of most interest in the study of rail diversion. Currently, LGA sends 1.0 million OD passengers to the major airports along Amtrak's NEC system. Applying the low- and high-diversion factors would predict a diversion of 100,000–200,000 LGA-departing passengers to Amtrak's NEC.

At present, LGA sends about 79,000 air passengers with OD trips to Rochester, Syracuse, and Buffalo, along a possible Empire Corridor HSR system. Applying the range of diversion factors would predict a decrease in air volumes of 8,000–16,000 LGA-boarding passengers. If HSR improvements were implemented in *both* the NEC and the Empire Corridor, the total number of boarding passengers at LGA might decrease between 1% and 2%.

4.4.3.3 Rail as a Complementary Mode and the Role of Adjacent Airports

Like JFK, LGA is not characterized by having a large network of close-in feeder airports with direct services. Using segment data that combine OD traffic with feeder traffic, the LGA airport passenger activity summary (Appendix A) describes the 10 closest airports with direct service. These include Albany (136 miles) with 10,000 annual passenger trips; Providence (143 miles) with 17,000 trips; Ithaca (178 miles) with 18,000 trips; and Syracuse (197 miles) with 51,000 trips. Again, Nantucket and Martha's Vineyard together have 18,000 trips, but their over-water trip makes them less relevant to the concepts of rail diversion.

Unlike JFK, LGA currently has no connection to the regional rail system. Thus, there is no immediately obvious strategy to bring rail travelers to this airport to continue the longer distance segment of their trip.

LGA is, however, intricately intertwined with the present and potential role of adjacent airports. The major rise of traffic at Long Island-Macarthur Airport (ISP) in Long Island has moderated demand at both LGA and JFK. (By way of example, ISP sends 263,000 passengers to BWI, of which 116,000 are OD in nature.) Similarly, the PANYNJ is undertaking a major effort at present to expand the role of its newly acquired Stewart Airport. Because of the PANYNJ's dominance in the major airports for the region, multijurisdictional planning there is now underway on a major scale.

4.4.3.4 Feeding Longer Distance Flights

LGA plays no direct role in long-distance international fights, with about 2% of its users working their way through other gateways to finish their intercontinental trip. Its role as a transferring gateway to the East Coast study area is modest, with only about 4% of airport users transferring to other airports in the East Coast study area. Of those boarding a plane at LGA to a destination in the East Coast study area, 24% were connecting from another flight.

4.4.3.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at LGA will increase by about 71% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 37% growth between 2007 and 2025 at LGA

The implications of doing nothing at LGA. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at LGA would be about $1.1 billion compared with a benchmark condition of the delay experienced at LGA in the year 2003.

4.4.4 Newark Liberty International Airport (EWR)

EWR ranked as the 11th most active airport in the United States in the ACI-NA survey. Unlike LGA—and to a greater extent JFK—EWR operates as a hub for connecting flight activity. Of the passengers included in the DOT's OD sample, 21% of enplanements at EWR gained access to the airport by a connecting flight (see Table 4.8).

Of the passengers on-board flights from EWR to the East Coast study area, two thirds are connecting passengers, rather than passengers with origin or destination in the Newark area.

4.4.4.1 Role of Intra-Mega-region Traffic at EWR

Of all those enplaning at EWR, 7% are going to destinations within the East Coast study area: 3% are going to destinations in New England; 2% are going to New York, New Jersey, or Pennsylvania; and 2% are going to the Washington, D.C./Baltimore region. Of all those enplaning at EWR, only **2%** are making trips entirely within the East Coast study area.

4.4.4.2 Rail as a Substitution for Air Travel: Impacts on EWR

EWR's role in providing services within the East Coast Mega-region is small, with only 2% of its users making trips with both origins and destinations in the corridor. Thus, the potential for adjacent improvements to Amtrak to lower demand at EWR is limited. Currently, about 210,000 EWR

Table 4.8. Origin–destination passenger volumes at EWR (*1*).

Newark, 2007 (EWR)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	**Total (%)**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**East Coast Study Area**	**Outside of East Coast Study Area**	**From Atlantic/ Pacific**	**From South-Central America**
New England	3.0	498,987	167,220	331,767	10,670	203,477	79,146	38,474
NY, NJ, PA	2.1	352,863	95,760	257,103	8,750	171,024	58,195	19,134
Mid-Atlantic	1.6	259,276	88,330	170,946	10,260	56,401	84,589	19,696
To the South	26.4	4,371,081	3,811,240	559,841	139,730	88,189	318,698	13,224
To the West	33.2	5,499,294	4,575,950	923,344	281,190	91,538	484,358	66,258
To the North	2.2	358,408	281,069	77,339	11,042	66,177	0	120
Transatlantic	19.3	3,190,883	2,267,337	923,546	174,854	748,692	0	0
Transpacific	3.1	516,935	415,365	101,570	47,076	54,364	0	130
South-Central America	9.1	1,501,701	1,344,455	157,246	77,304	79,662	280	0
Totals	**100**	**16,549,428**	**13,046,726**	**3,502,702**	**760,876**	**1,559,524**	**1,025,266**	**157,036**

OD passengers go to major airports in the NEC, and three quarters of those go to BOS. Applying the range of diversion factors, the decrease in air passengers could range from 21,000 to 42,000. This would decrease total passenger boardings at EWR by less than one half of 1%.

4.4.4.3 Rail as a Complementary Mode and the Role of Adjacent Airports

The EWR Rail Station provides a high-quality transfer capability between the airport internal circulation system (AirTrain) and the main line of Amtrak's NEC service. In theory, such a connection could be used to provide reliable feeder services to longer distance flight segments. As discussed in Section 2.5.1.3, efforts to market rails as a feeder mode to EWR have had limited success.

Realistically, through-routing of some Empire Corridor services might be required to make HSR truly serve as a feeder mode. (See Section 2.5.2 for a discussion of the difficulties in making this work.) Higher speed and more reliable service along the NEC could strengthen feeder service patterns to Philadelphia, Wilmington, and Baltimore. Significant rail investment in the Keystone Corridor between Harrisburg and New York could also improve the market for feeder services to EWR.

The multijurisdictional relationship between EWR and Stewart Airport is being addressed.

4.4.4.4 Feeding Longer Distance Flights

The carriers at EWR have developed an aggressive program to build up transatlantic services over the past decades. Currently, 19% of the originating passengers at EWR have destinations across the Atlantic. Of those enplanements, 30% of passengers are connecting from feeder flights, making that market one of local origination by more than two-thirds.

EWR's role as a transferring gateway to the East Coast study area is modest, with only about 5% of airport users connecting on to other airports in the East Coast study area. Of the passengers on board flights from EWR to the East Coast study area, two thirds are connecting passengers, rather than passengers with origin or destination in the Newark area.

EWR does not have significant OD volumes to many close-in airports—the closest is Bradley Field in Hartford, some 115 miles from EWR (with 47,000 segment passengers). The EWR passenger activity summary included in Appendix A shows volumes for proximate airports including Albany at 143 miles, Providence at 159 miles, Syracuse at 194 miles, and Rochester at 246 miles.

4.4.4.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at EWR will increase by about 93% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 66% growth between 2007 and 2025.

The implications of doing nothing at EWR. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at EWR would be about $1.6 billion compared with a benchmark condition of the delay experienced at EWR in the year 2003. This level of delay potential is by far the largest of any airport in the East Coast Mega-region.

4.4.5 Philadelphia International Airport (PHL)

PHL ranked as the 17th busiest airport for passenger activity in the ACI-NA 2007 survey. Of those boarding planes at PHL, 36% are connecting from other flights, making it the most aggressive connecting airport in the two ACRP 3-10 study areas (see Table 4.9).

4.4.5.1 Role of Intra-Mega-region Traffic at PHL

Of all those enplaning at PHL, 22% are going to destinations within the East Coast study area: 10% are going to destinations in New England; 9% are going to New York, New Jersey, or Pennsylvania; and 3% are going to the Washington, D.C./Baltimore region. Of all those enplaning at PHL, 10% are making trips entirely within the East Coast study area, reflecting its role as a gateway from more distant origins.

4.4.5.2 Rail as a Substitution for Air Travel: Impacts on PHL

Looking first at the 10% of PHL making trips entirely within the mega-region, 480,000 trips are made from origins in Philadelphia to destinations at major East Coast airports. Virtually all of these trips are from airports along the northern portion of the corridor, including Boston, Providence, and Bradley. A low-range estimate of decrease in air passengers at PHL due to this diversion would be 48,000; a high range would be 96,000. These would represent a decrease of between three tenths of 1% and six tenths of 1% of total boarding passengers at PHL.

4.4.5.3 Rail as a Complementary Mode and the Role of Adjacent Airports

Some of the direct flights that feed this network come from airports relatively near Philadelphia. The PHL airport passenger activity summary (in Appendix A) shows that, of the 10 closest airports with direct service, Allentown (55 miles away) sends 40,000 passengers; Harrisburg (83 miles away) sends 60,000; Wilkes Barre–Scranton (104 miles away) sends 60,000; Salisbury, MD, (106 miles away) sends 39,000; and Westchester County (116 miles away) sends 25,000. Of these present feeders, significantly improved rail service might compete effectively for feeder passengers from Harrisburg and Westchester County. More importantly, improved rail would strengthen existing market patterns from the NEC stations in New Jersey and Wilmington.

Given presently existing track geometry, rail service from the north, which today terminates at Philadelphia's 30th Street Station, could continue on to PHL, assuming capacity issues could be resolved on the "high-speed" line. Reportedly, considerations are also being given for a new airport-related stop directly on the NEC main line.

The possible roles of adjacent airports to operate in a complementary mode to the operations of PHL were explored in Chapter 3. The kind of work program briefly initiated in the analysis of Chapter 3 should be continued and expanded by the ongoing program of the Delaware Valley Regional Planning Commission.

4.4.5.4 Feeding Longer Distance Flights

PHL relies heavily on a system of feeder connections to position itself in the markets deemed most important. Over 1 million passengers board with transatlantic destinations;

Table 4.9. Origin–destination passenger volumes at PHL (*1*).

Philadelphia, 2007 (PHL)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	**Total (%)**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**East Coast Study Area**	**Outside of East Coast Study Area**	**From Atlantic/ Pacific**	**From South-Central America**
New England	9.7	1,505,299	660,820	844,479	142,300	596,696	44,286	61,197
NY, NJ, PA	9.2	1,427,940	314,290	1,113,650	188,460	772,477	85,093	67,620
Mid-Atlantic	3.1	488,810	64,630	424,180	144,560	195,350	54,764	29,506
To the South	28.5	4,432,596	3,318,690	1,113,906	745,840	195,460	159,970	12,636
To the West	34.8	5,418,630	4,194,550	1,224,080	765,660	196,069	215,130	47,221
To the North	1.7	264,031	158,589	105,442	33,543	71,809	0	90
Transatlantic	6.8	1,054,772	507,231	547,541	175,936	371,605	0	0
Transpacific	0.9	140,824	129,062	11,762	8,207	3,495	0	60
South-Central America	5.3	819,621	601,271	218,350	158,323	59,907	120	0
Totals	**100**	**15,552,523**	**9,949,133**	**5,603,390**	**2,362,829**	**2,462,868**	**559,363**	**218,330**

of those, the majority (52%) have flown to PHL to make that connection. Making this network system work, two thirds of the transferring travelers come from beyond the East Coast study area. Market share is attained from as far as the West Coast (defined as California and the Northwest states), where 132,000 trips originated in 2007.

The role of PHL as a transferring gateway to the East Coast study area is significant, with about 15% of airport users connecting to other airports in the East Coast study area.

4.4.5.5 *Conditions in the Year 2025*

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at PHL will increase by about 68% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 79% growth between 2007 and 2025.

The implications of doing nothing at PHL. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at PHL would be $1.1 billion when compared against a base-case benchmark condition of 100% flights on schedule, or about $0.5 billion compared with a benchmark condition of the delay experienced at PHL in the year 2003.

4.4.6 Baltimore Washington International Thurgood Marshall Airport (BWI)

BWI ranked 25th among airports in the United States in passenger activity in the 2007 ACI-NA survey. About 13% of enplanements at BWI are by connecting passengers, according to the DOT's OD sample, placing it in the midrange of study area airports (see Table 4.10).

4.4.6.1 *Role of Intra-Mega-region Traffic at BWI*

Of all those enplaning at BWI, 22% are going to destinations within the East Coast study area: 13% are going to destinations in New England; 8% are going to New York, New Jersey, or Pennsylvania; and 1% are going to the Washington, D.C./Baltimore region. Of all those enplaning at BWI, 16% are making trips entirely within the East Coast study area, which is high for this sample of major airports.

4.4.6.2 *Rail as a Substitution for Air Travel: Impacts on BWI*

Currently, about 870,000 air travelers fly from origins at BWI to destinations at airports to the north along the Amtrak NEC, serving NYC, Connecticut, Rhode Island, Massachusetts, and Virginia. If HSR on the NEC could divert these travelers, a decrease of 87,000–174,000 could be expected.

Currently, another 160,000 OD travelers fly from BWI to Albany and Rochester on the Empire Corridor. Application of the diversion range suggests between 16,000 and 32,000 potential diversions to rail, assuming the Empire Service was through-routed to Washington, D.C. If improvements were made to *both* the full NEC and the Empire Corridor (extended), the decrease in passenger boardings at BWI due to substitution of trips could be 1–2%.

4.4.6.3 *Rail as a Complementary Mode and the Role of Adjacent Airports*

BWI has a moderate-quality connection with Amtrak's NEC, with a 10-min bus trip between the rail station and the airport. At present, rail services at BWI are providing feeder services, predominantly from Washington, D.C. Between 1%

Table 4.10. Origin–destination passenger volumes at BWI (*1*).

Baltimore/Washington, 2007 (BWI)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	Total (%)	Total Boardings	Originating Boardings	Boardings from Transfer Flights	East Coast Study Area	Outside of East Coast Study Area	From Atlantic/ Pacific	From South-Central America
New England	12.7	1,267,249	980,020	287,229	25,000	261,708	248	273
NY, NJ, PA	7.7	765,056	490,800	274,256	31,150	241,517	637	952
Mid-Atlantic	1.2	121,814	48,420	73,394	25,290	47,670	135	299
To South	28.3	2,815,842	2,503,910	311,932	245,410	63,805	2,507	210
To West	43.2	4,301,984	3,939,840	362,144	286,420	70,006	4,291	1,427
To North	0.7	69,914	68,578	1,336	295	1,041	0	0
Transatlantic	1.8	182,322	176,403	5,919	467	5,452	0	0
Transpacific	1.1	107,569	105,670	1,899	553	1,346	0	0
South-Central America	3.2	318,053	314,882	3,171	1,524	1,647	0	0
Totals	**100**	**9,949,803**	**8,628,523**	**1,321,280**	**616,109**	**694,192**	**7,818**	**3,161**

and 2% of non-connecting air passengers use the rail system to access the airport.

Significant improvements in rail travel times could increase the geographic scale of the market watershed area to the north and to the south.

The analysis of the operations (particularly groundside) of BWI have benefitted from a long-standing program at the Metropolitan Washington Council of Governments to survey all three metro-D.C. airports in one coordinated effort. As discussed in Chapter 3, these efforts could be expanded into a more complete merging of ground and air destination data, as was pioneered in the NERASP program.

4.4.6.4 Feeding Longer Distance Flights

BWI does offer limited transatlantic service, for which 97% of the passengers are of local origination. For a variety of reasons, the airport is not particularly dependent on a system of feeder flights to make its operations successful.

BWI's role as a transferring gateway to the East Coast study area is average, with about 6% of airport users transferring to other airports in the East Coast study area. Its primary air carrier, Southwest Airlines, does transfer many passengers at this airport, though not following in the path of a traditional dominant hubbing airport. Of the passengers at BWI going to the East Coast study area, most are not transferring: 71% of them are originating in the BWI area.

4.4.6.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at BWI will increase by about 80% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have also predicted an 80% growth between 2007 and 2025.

The implications of doing nothing at BWI. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at BWI would be about $0.6 billion compared with a benchmark condition of the delay experienced at BWI in the year 2003.

4.4.7 Dulles International Airport (IAD)

IAD operates as both a center of hubbing and server of local origins in the southernmost area of the East Coast study area and ranks 22nd in passenger activity in airports in the United States in the year 2007 ACI-NA survey (see Table 4.11). Of those trips documented in the DOT's OD survey, 33% of IAD's enplaning passengers came to the airport on a connecting flight. Thus, the role of transferring passengers in the activity of the airport is slightly less than at PHL and considerably higher than at either EWR or JFK.

4.4.7.1 The Role of Intra-Mega-region Traffic at IAD

Of all those enplaning at IAD, 16% are going to destinations within the East Coast study area: 7% are going to destinations in New England; 7% are going to New York, New Jersey, or Pennsylvania; and 2% are going to the Washington, D.C./Baltimore region. Of all those enplaning at IAD, only 6% are making trips entirely within the East Coast study area.

Table 4.11. Origin–destination passenger volumes at IAD (*1*).

Dulles, 2007 (IAD)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	Total (%)	Total Boardings	Originating Boardings	Boardings from Transfer Flights	East Coast Study Area	Outside of East Coast Study Area	From Atlantic/ Pacific	From South-Central America
New England	6.6	732,916	336,310	396,606	27,090	293,408	53,051	23,057
NY, NJ, PA	7.1	792,541	202,680	589,861	43,440	425,690	86,516	34,215
Mid-Atlantic	2.3	254,026	7,570	246,456	37,690	164,513	38,397	5,856
To the South	19.0	2,114,290	1,305,570	808,720	311,920	260,405	220,027	16,368
To the West	37.1	4,122,526	2,951,190	1,171,336	562,870	234,266	302,199	72,001
To the North	1.9	215,233	136,991	78,242	17,341	60,861	0	40
Transatlantic	16.9	1,879,036	1,278,306	600,730	122,374	478,356	0	0
Transpacific	3.8	424,932	325,362	99,570	55,590	43,870	0	110
South-Central America	5.2	580,579	428,942	151,637	63,128	88,389	120	0
Totals	**100**	**11,116,079**	**6,972,921**	**4,143,158**	**1,241,443**	**2,049,758**	**700,310**	**151,647**

4.4.7.2 Rail as a Substitution for Air Travel: Impacts on IAD

With only 6% of IAD's passengers taking trips wholly within the East Coast Mega-region, the potential for many diversions of trips onto Amtrak is somewhat low.

IAD currently sends a total of 435,000 OD air passengers to the airports serving Amtrak's NEC (including BDL). The majority of these passengers are going to BOS, 412 miles away—a distance that is difficult for even the fastest HSR services. With the understanding that modal diversion between Boston and Northern Virginia will be lower than others in this section, the same factors used in the preceding sections can be applied, gaining a range of diversions for between 43,000 and 87,000 passengers.

IAD sends an additional 18,000 OD passengers to Albany and Rochester. Assuming that the Empire high-speed services were through-routed on NEC high-speed services, 2,000–4,000 passengers could be diverted.

Dulles also serves a total of 33,000 OD passengers to Norfolk, Richmond, Greensboro, and Raleigh-Durham with direct flights. If a southern corridor HSR service were developed, rail might substitute for 3,000–6,000 air passengers.

Assuming that *all* of these services influence travel to the Northern Virginia area, a decrease in IAD total boarding of less than 1% could be expected.

4.4.7.3 Rail as a Complementary Mode and the Role of Adjacent Airports

IAD is not located near proposed HSR services in the region. For this reason, a major role for rail in providing feeder services to longer segment air services is highly unlikely. As noted, IAD could benefit from the more complete integration of aviation and ground destination data pioneered in the NERASP program in New England.

4.4.7.4 Feeding Longer Distance Flights

About 1.9 million enplanements are to destinations across the Atlantic, which is higher than at BOS or PHL but lower than at LAX, EWR, or JFK. Two thirds of those Atlantic-bound passengers are from local origination, with one third from the feeder network.

IAD's role as a transferring gateway to the East Coast study area is significant, with about 11% of airport users transferring to other airports in the East Coast study area. The IAD passenger activity summary in Appendix A shows there are several close-in airports providing feeder services to IAD. Charlottesville, VA, is 77 miles to the south; Harrisburg, PA, is 94 miles to the north; and State College, PA, is 128 miles to the northwest.

4.4.7.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at IAD will increase by about 95% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted an unusual 129% growth between 2007 and 2025 at IAD.

The implications of doing nothing at IAD. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at IAD are about $80 million compared with a benchmark condition of the delay experienced at IAD in the year 2003.

4.4.8 Washington Reagan National Airport (DCA)

DCA primarily serves a market of local origination, but some passengers transfer there anyway. According to the DOT's OD sample, 18% of DCA enplanements are by travelers who arrived at the airport by a connecting flight. Since 2001, the airport operations have been characterized by various levels of security control procedures that make it a difficult airport in which to make connections (see Table 4.12).

4.4.8.1 Role of Intra-Mega-region Traffic at DCA

Of all those enplaning at DCA, 23% are going to destinations within the East Coast study area: 10% are going to destinations in New England; 12% are going to New York, New Jersey, or Pennsylvania; and 1% are going to the Washington, D.C./Baltimore region. Of all those enplaning at DCA, 16% are making trips entirely within the East Coast study area, which is high for this sample of major airports.

4.4.8.2 Rail as a Substitution for Air Travel: Impacts on DCA

As can be seen from the data, DCA is more oriented to the travel of the East Coast Mega-region than its longer distance partner, IAD. DCA currently sends more than 1.1 million OD air passengers to the airports of Amtrak's NEC. With the largest single portion going to NYC airports, this market is prime for diversion to improved HSR services. A range of diversions would see between 110,000 and 220,000 additional air passengers diverted in this major market for HSR.

To Empire Corridor destinations such as Albany, Syracuse, and Rochester, DCA currently sends nearly 70,000 OD passengers. Assuming the through-routing of Empire Corridor trains to the NEC destinations, 7,000–14,000 diversions are possible.

Table 4.12. Origin–destination passenger volumes at DCA (*1*).

Washington Reagan National, 2007 (DCA)								
Where Are the Enplaning Passengers Going?				From Where Are the Connecting Passengers Coming?				
Destination Zone	**Total (%)**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**East Coast StudyArea**	**Outside of East Coast StudyArea**	**From Atlantic/ Pacific**	**From South-Central America**
New England	10.1	928,827	597,040	331,787	21,780	301,060	1,962	6,985
NY, NJ, PA	12.5	1,147,001	752,900	394,101	34,780	347,579	3,004	8,738
Mid-Atlantic	1.0	89,456	12,360	77,096	24,460	51,421	410	805
To the South	28.8	2,651,418	2,114,310	537,108	453,220	74,918	5,878	3,092
To the West	39.1	3,601,540	3,305,320	296,220	203,250	78,052	9,475	5,443
To the North	1.8	163,605	153,365	10,240	2,200	8,030	0	10
Atlantic/Pacific	2.3	214,126	193,387	20,739	5,376	15,353	0	10
South-Central America	4.4	408,051	382,988	25,063	16,528	8,535	0	0
Totals	**100**	**9,204,024**	**7,511,670**	**1,692,354**	**761,594**	**884,948**	**20,729**	**25,083**

If HSR were to be extended to the south, DCA might lose some present passengers to Norfolk, Raleigh-Durham, Greensboro, and Charlotte—currently at 136,000. Such a southern corridor might divert between 14,000 and 28,000 travelers from DCA.

Assuming *all* three HSR corridors are created, the number of diverted travelers would be 1–3% of DCA's total boardings.

4.4.8.3 Rail as a Complementary Mode and the Role of Adjacent Airports

Because DCA is near a longer distance rail line (similar in nature to EWR), rail services could possibly grow over time to serve as a feeder service to flights from DCA. For travelers approaching from a potential southern rail corridor, DCA would have ground access travel time advantages over BWI, for example. About 130,000 feeder passengers to DCA are provided by the four southern corridor airports.

On the other hand, rail access as a feeder to airports probably makes most sense when the subject airport is offering highly specialized services, such as international or direct longer distance domestic services. DCA is constrained in the amount of such services it can provide and, as shown in this section, it tends to focus on the moderate distance trip. Thus, the market for complicated feeder access services might be smaller than otherwise.

4.4.8.4 Feeding Longer Distance Flights

DCA's role as a transferring gateway to the East Coast study area is moderate, with about 9% of airport users transferring to other airports in the East Coast study area.

Consistent with its function as an OD airport, DCA is not fed by much of a local network of nearby airports. The DCA summary activity sheet in Appendix A shows direct flights to Norfolk, VA (118 miles away) and Westchester County (233 miles). All other connections are to major airports.

4.4.8.5 Conditions in the Year 2025

Demand in the year 2025. The MITRE FATE program predicts that demand for domestic originations at DCA will increase by about 77% over what the research team has reported for the year 2007. The FAA's Terminal Area Forecasts have predicted a 23% growth between 2007 and 2025.

The implications of doing nothing at DCA. Given the definitions established in Chapter 1, the cost of not dealing with the issues addressed in this project at DCA would be about $0.6 billion compared with a benchmark condition of the delay experienced at DCA in the year 2003.

4.5 Understanding the Role of Smaller Airports in the East Coast Study Area

Most of the transfer activity and international activity in the East Coast study area take place at the eight airports whose passenger flows are documented in some detail in the previous sections.

To better understand the passenger activity in more of the East Coast airports, Appendix C includes the complete ACRP project airport passenger activity summary tables for the following airports (generally ordered from north to south):

- Manchester, NH;
- Albany, NY;
- Syracuse, NY;

- Providence, RI;
- Hartford/Springfield, CT;
- Richmond, VA;
- Norfolk, VA; and
- The eight East Coast airports described in this section.

The ACRP project airport passenger activity summary tables are described in the introduction to Appendix A. For each of the 15 airports covered within the East Coast study area, the summary tables reveal the following:

- The absolute volumes of origination and transferring air passengers at the subject airport, from the Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics (DB1B).
- The destinations of all originating and transferring air passengers at the subject airport, organized by 13 superzones of origin and 13 superzones of destination (also from the DB1B).
- The volumes of total air passengers carried to the 10 closest airports to the subject airport, from the DOT T100 database, which includes very small commuter carriers not included in the DB1B data.
- A single example of the number of such air travelers who are traveling to that destination with the subject airport as the origin (again from the DB1B).

4.6 Description of the ACRP Project Database

The research team has created the ACRP project database to quickly summarize vast amounts of data and information about making aviation trips in the United States and international destinations. The database incorporates both the DB1B database of the Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics and the BTS T-100 segment volumes. In the format presented in Appendix A, the database allows the access of both data sources at once. The DB1B source is comprehensive in its coverage of airport-to-airport OD patterns, but does not always cover all flights by very small commercial aircraft. By contrast, the T-100 source does not provide OD information, but provides solid data concerning the total number of passengers on a given flight, regardless of the size of the plane. Additional information is presented in Section C.3 of Appendix C of this report.

The ACRP project database has made certain simplifying assumptions to deal with limitations in the source data, particularly concerning flights that originate outside of the United States. For that reason, OD volumes in the database may be slightly higher than reported in other applications built from DB1B data.

The ACRP project database is so large that it is, in essence, not feasible to create simplified spreadsheets (e.g., in Excel format) from which the analyst can select the information appropriate to the region or issue being examined. Rather, the “raw” data are kept in a large server (computer) housed at the research team’s main office in White River Junction, VT.

The data concerning airline passenger flows are organized by each airport located in the two study regions, as presented in Appendix C.

4.7 Implications of the Airport-by-Airport Review for a Comprehensive Strategy to Deal with Aviation Capacity in the Coastal Mega-regions

A quick, preliminary assessment of the potential roles of rail substitution, rail complementarity, and better local airport cooperation suggests that, while important, none of these represents a “silver bullet” that will eliminate the issue of lack of aviation capacity in the mega-regions, based on this airport-by-airport review. In the following chapter, the argument will be made that the aviation industry needs to significantly increase the role of accountability and transparency in the management of the airport/aviation system. Although the need to become more multimodal and more multijurisdictional is self-evident, the major opportunities to increase functional capacity in the coastal mega-regions lie within the aviation sector itself. Chapter 5 will suggest a new relationship between local and national institutions to deal with a real and present crisis in functional capacity.

CHAPTER 5

Airport Demand Management

- The research has concluded that the current system suffers from unclear responsibility: no one has the authority and accountability for the management of congestion at mega-region airports.
- The management of existing resources could be improved: this chapter builds the case that capacity in the mega-regions can be increased only when the all the major players are empowered to solve the problem.
- Opportunities to reduce mega-region airport congestion and improve the overall cost and quality of passenger service exist; what would be beneficial are policies and programs that encourage key decisionmakers to grasp such opportunities.
- When the system fails, a trigger mechanism could be set off; with the responsibilities of each party clearly specified, the goals of accountability and transparency could be met.
- There are roles for both the national and local levels in defining these roles and procedures.
- The responsibility of those in charge is to make air travel reliable for passengers; this is a form of accountability beyond making the airport available for all classes of aeronautical activities.
- A way to do this is to focus on the passenger experience. A congested airport does not necessarily make the airport reasonably available nor are delays arguably nondiscriminatory from the passenger perspective.

Exhibit 5.0. Highlights and key themes included in Chapter 5.

5.1 Introduction

From the research undertaken to date on this project, it is clear that the scarce resource of capacity is not allocated efficiently. Chapter 5 investigates methods in which such capacity could be allocated in a way that balances passenger service from two perspectives: flight frequency and service reliability. The balance of stakeholder roles is explored in this chapter, with the goal of developing approaches that are agreeable to all stakeholders and fit the individual needs of a congested airport. The chapter examines alternatives to the current congestion and demand management structure in which the roles at the federal and local levels are unclear. It reviews a wide variety of candidate strategies and actions. Chapter 5 further develops several strategies to increase airport throughput capacity, examining the barriers and constraints that impact their implementation. The research explores the idea that more attention should be paid to studies at individual congested airports to prioritize the value of individual flights, based on their contribution to delay and their customer service values (see Exhibit 5.0 for highlights and key themes in Chapter 5).

As used in this report, the term “demand management program” is one that limits delays that occur if too many aircraft are scheduled to arrive at an airport during a particular time. Under this use of the term, demand management is not meant to refer to any program specifically designed to decrease the number of air trips made.[33]

5.2 The Promise of Demand Management: A Case Study

The same quantity of air transport payload capacity can be provided with larger numbers of small aircraft flights or smaller numbers of large aircraft flights. It has long been

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[33] See Chapter 2 for a discussion of strategies that are designed to decrease the number of passengers flying.

recognized that the decisions of air carriers about what recipe to use have important ramifications for the quality of service and level of accessibility provided by the air transportation system on the one hand and for the amounts of flight traffic, levels of congestion and delay, and infrastructure requirements on the other. To explore these trade-offs, the research team analyzed June 2008 schedules for several days at one coastal mega-region airport, SFO. The aim was to document and analyze the wide diversity of aircraft sizes contained in the SFO fleet mix in order to identify situations where a different choice of aircraft size could substantially reduce delay with a minimal loss or (taking the reduced delay into account) even an improvement in the level of service provided.

5.2.1 SFO Fleet Mix

The research team examined SFO arrivals on four days in June 2008: the 5th, 13th, 18th, and 25th. These days were chosen because they feature varying levels of congestion and delay, as measured by on-time performance. Flight information was downloaded from the FAA Aviation System Performance Metrics (ASPM) database. In theory, the database includes all flights, including air carrier, general aviation, and cargo, that were actually flown. The database does not include cancelled flights. Altogether, there were 2,165 arriving flights on these days, of which 10 were cargo flights. In the fleet-mix analysis, the team focused on the 2,155 passenger flights.

The ASPM passenger flight data was supplemented with two other variables: the estimated seats available for passengers based on the aircraft type and the great circle distance of the flight route. The seat information is based on U.S. averages obtained from the DOT's T100 database, when available, and company websites in other cases. Hereafter, the term "aircraft size" is used to mean the number of seats.

The average size of an SFO arrival flight over the four selected days was 135 seats, whereas the standard deviation is 80 seats, reflecting the diverse size of the fleet serving SFO. To examine the size distribution in more detail, a cumulative distribution function was constructed (Figure 5.1), which indicates, for any given size, the proportion of flights with aircraft at or below that size. On the small end of the distribution, about 3% of the flights are 13 seats or below. These include a smattering of corporate jets. Next there are a sizable number of regional jets, of sizes ranging from 30 to 80 seats. Altogether, aircraft 80 seats and smaller account for 26% of the fleet mix.

The biggest portion of the fleet—about 60%—is in the 100–180 seat range. These include the large jet mainstays of the domestic airline fleet, such as the Boeing 737, MD 80 series, and A320 series. Widebodies of 200 seats or more—including Boeing 767s, 777s, and 747s along with Airbus 340s—account for the remaining 14% of the SFO fleet mix.

The diverse fleet mix at SFO means that the vast majority of total seats are provided by a relatively small proportion of flights, as shown in Figure 5.2. This figure was constructed by sorting the 2,155 flights from largest to smallest, and then computing the fraction of total seats provided by the cumulative sum of the seats with the largest aircraft. To aid with interpretation, the aircraft size for each of these flights is also plotted

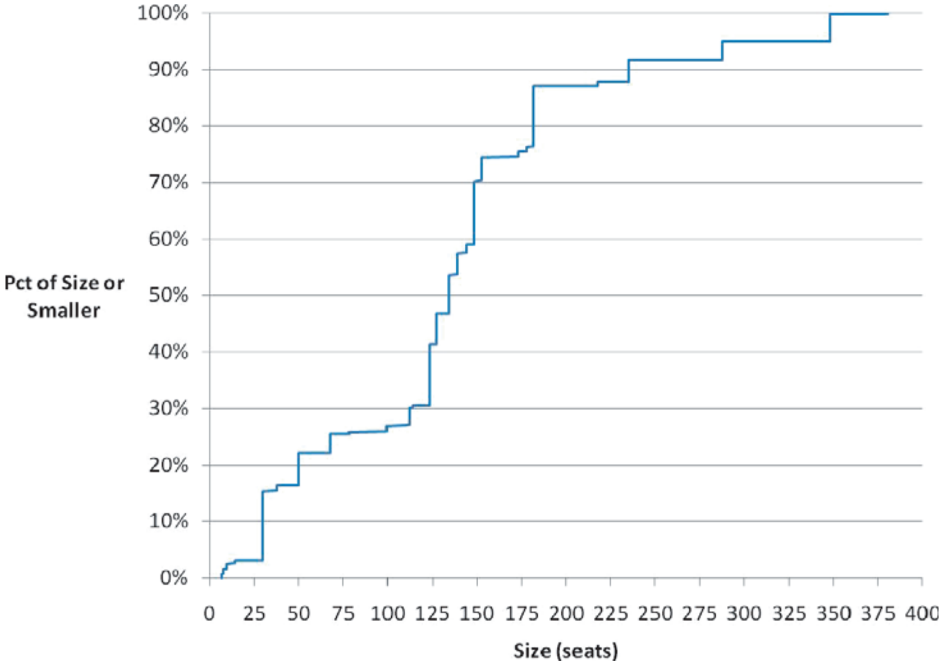

Figure 5.1. Aircraft size distribution, SFO (June 2008).

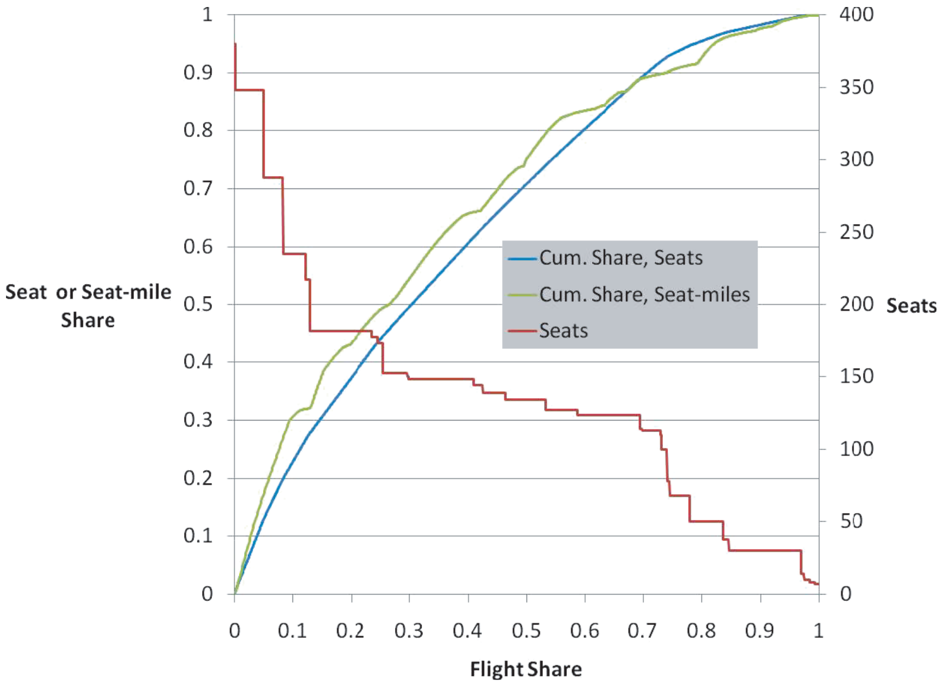

Figure 5.2. SFO fleet mix profile (June 2008).

using the secondary vertical axis. Figure 5.2 reveals that 87% of the seat capacity is provided by the 66% of the flights using Airbus 319 (124 seats) or larger aircraft. Conversely, 10% of the SFO flights using the smallest aircraft account for less than 2% of the total seats.

One could argue that the "value" of a flight depends on not only its size but also its distance. Longer distance flights generally have higher fares and serve trips of longer duration. Moreover, the time savings from making the trip by air instead of by surface mode is roughly proportional to distance. Figure 5.2 therefore contains a second share curve that is based on seat-miles instead of seats. This curve is generally higher than the seat-share curve. For example, the 40% of the flights flown with the largest aircraft generate 60% of the seats but 66% of the seat-miles. This difference reflects the positive correlation between aircraft size and flight distance. The only exception is for the smallest aircraft in the fleet, bizjets of 15 seats or fewer, on which many of the flights are quite long, which accounts for the sharp up-tick in the seat-mile share curve at the far right of the figure.

The relationship between size and distance is shown more directly in Figure 5.3, which plots aircraft size against flight length on a log-log scale. The data in this figure are differentiated according to whether the flight was a scheduled flight appearing in the Official Airline Guide. The correlation for the scheduled flights is evident, with the trend-line indicating that aircraft size increases proportionally with the square root of flight distance. No such relationship is evident for the non-scheduled data. The small corporate jet flights have lengths ranging from around 100 to several thousand miles, while the handful of non-scheduled large jet flights—often diversions or ferries—are on average somewhat shorter.

Aside from distance, aircraft size is related to segment traffic density—the quantity of passenger traffic per unit time. If the density is low, smaller aircraft are needed to attain an acceptable level of flight frequency. As traffic increases, airlines can use larger aircraft, exploiting economies of scale while still maintaining a convenient number of daily flights.

Figure 5.4 depicts this phenomenon. Based on the June 18, 2008, SFO arrival schedule, Figure 5.4 summarizes the service provided by individual passenger carriers on individual flight segments in terms of the number of flights (plotted on the horizontal axis) and the average seats per flight (plotted on the vertical axis). Different symbols are used to differentiate the segments according to length. Seats per day for a segment, which is directly related to traffic density, is the product of the two coordinates. A series of isoquants indicate combinations of aircraft size and flight frequency that yield the same quantity of seats per day. Segments on which small (<100 seats, in this discussion) aircraft are used have low densities, almost always less than 300 seats/day. Within this set of segments, the key determinant of aircraft size is distance, with smaller Embraers assigned to segments 300 miles or less, larger Canadairs serving the 601- to 1,200-miles segments, and a mixture of the two types employed on the 301- to 600-miles segments.

Although all the segments served by small aircraft are low density, not all low-density segments are served by small aircraft. The variability is particularly notable for segments of

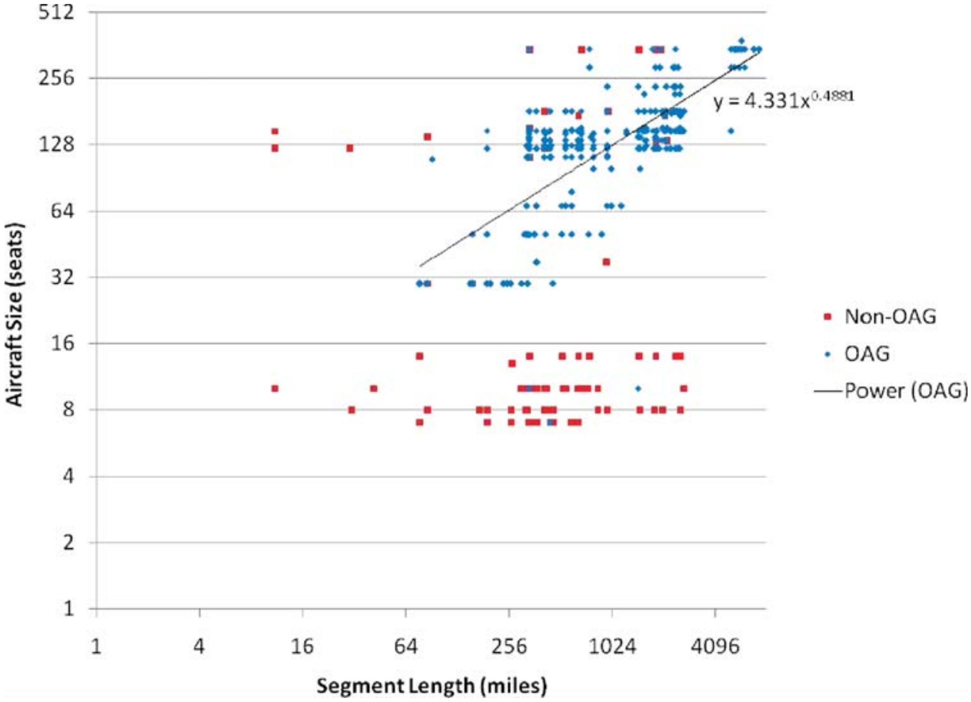

Figure 5.3. Aircraft size versus segment length, SFO arrivals (June 2008).

300–600 miles. For example, one airline provides 280 seats per day from Portland (a 551-miles segment) with two MD80s, whereas another airline uses five Canadair flights to provide 270 seats from Boise (522 miles). Similarly, an airline flies eight Embraers a day from Medford, a distance of 329 miles, whereas another provides almost as many seats (239 vs. 260) with two 737 flights from Burbank, which is 326 miles away.

5.2.2 Economies of Aircraft Size

The fleet-mix behaviors observed in the previous discussion are shaped by two main economic factors: economies of scale in the cost of operating aircraft and the service advantages of higher flight frequency. Cost economies are illustrated in Figure 5.5, which plots aircraft direct operating cost per seat

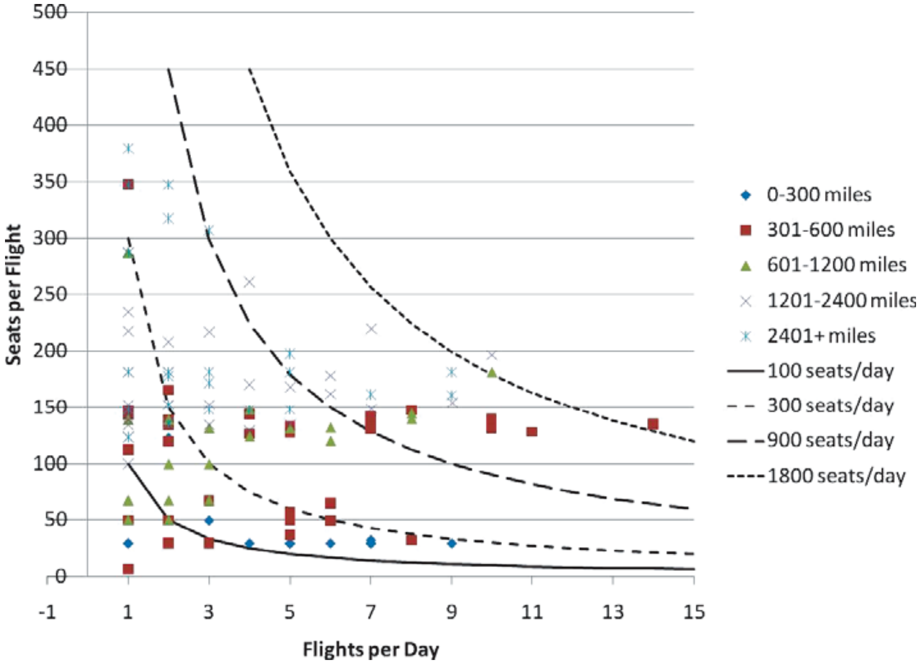

Figure 5.4. Daily seat capacity production, SFO (June 18, 2008).

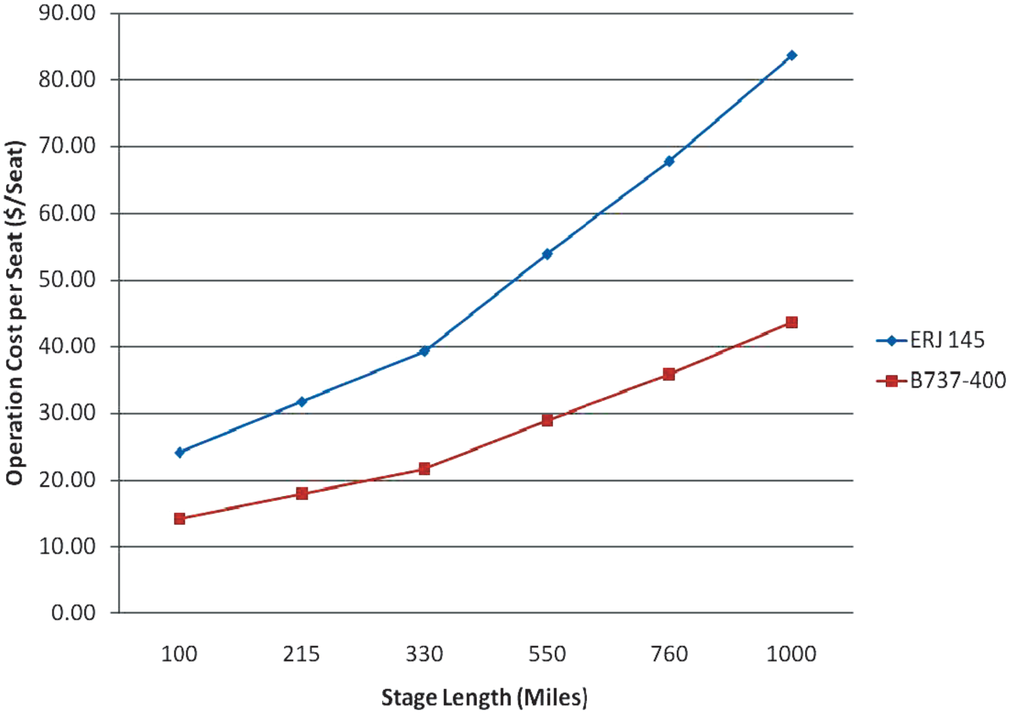

Figure 5.5. Operating cost per seat, fuel: $4.30/gal.

against segment distance for two aircraft types, the 144-seat Boeing 737-400 and the 50-seat Embraer 145. Unit costs for the regional jet are consistently higher, but the ratio increases with stage length, from 1.7 at 100 miles to 1.9 at 1,000 miles. More important, however, the absolute difference in cost per seat increases rapidly with distance. Therefore, the cost of increasing schedule convenience by offering more flights is the lowest on short-haul flights. On the other hand, the benefits of high frequency are probably greater for these flights, as they often are used for short-duration business trips and also must compete with the automobile. Finally, short-haul segments have traditionally been served by commuter airlines, which in the past were subject to less stringent safety regulation if they operated aircraft of 60 seats or fewer. Pilot contracts with large jet carriers have also limited the sizes of aircraft that can be operated by their lower-paid counterparts working for commuter affiliates.

5.2.3 Operational Impacts of Up-gauging

At SFO, as in most airports, small aircraft use the same runways as large ones and occupy them for about the same length of time. Thus, when the airport is congested, the operational impact of a small flight is no less than that of a large one. Indeed, the slower approach speeds and longer in-trail separation requirements of small aircraft can result in longer effective service times. Thus, when airlines and other airport users provide capacity with more small flights rather than fewer large ones, the result can be higher levels of congestion and delay. This does not mean that such a choice is a bad one, but it does imply that the service benefits of operating small aircraft must be weighed against the congestion costs.

These trade-offs were analyzed using the four June 2008 days described, based on a deterministic queuing analysis. The approach can be visualized using a queuing diagram, as shown in Figure 5.6, which is based on June 5th operations. The horizontal axis is the time of day; the vertical axis is the cumulative count. There are two count curves, one for the schedule and one for actual arrivals. The schedule curve gives the number of flights that are scheduled to arrive at or before a given time. It is constructed by sorting the flights in order of scheduled arrival time. The horizontal coordinate of the point corresponding to the nth flight is the time when it is scheduled to arrive, and the vertical coordinate is n. The actual curve is constructed in a similar way, except in this case the flights are sorted in order of actual arrival time.

Looking at Figure 5.6, one can observe that the two curves virtually overlap during the early part of the day. This means that at the time when n flights were scheduled to have arrived, very close to n flights had arrived, implying very little delay. Later on, the curves separate. For example, the 500th arrival was scheduled to occur around 21:20, but it was not until more than an hour later that the 500th flight actually did pull in. This implies that arriving flights at SFO were delayed during the latter part of the day. The total amount of this delay can be obtained by subtracting the sum of the scheduled arrival times from the sum of the actual arrival times. On June 5, it was 12,790 min, or an average of 24 min per flight.

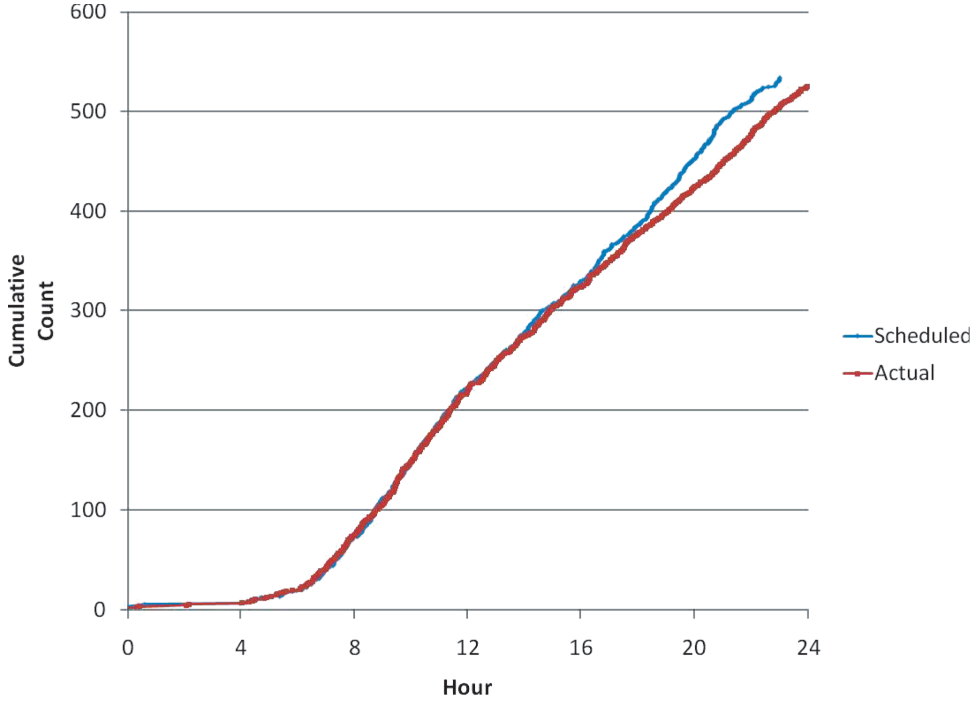

Figure 5.6. Queuing diagram, SFO arrivals (June 5, 2008).

Figures 5.7–5.9 show the queuing diagrams for the remaining three days. Figure 5.7, for June 13, shows slight delays over much of the day, but no high-delay periods such as seen in the later part of June 5. June 18 is free of significant delays, except for a very small amount at the end of the day. Finally, June 25 is a very bad day, with substantial delays beginning at 8 AM in the morning. Average arrival delays on these three days are, respectively, 15, 8, and 45 min per flight. The research team wanted to estimate how arrival delays on these days would be different if certain flights were removed from the arrival traffic

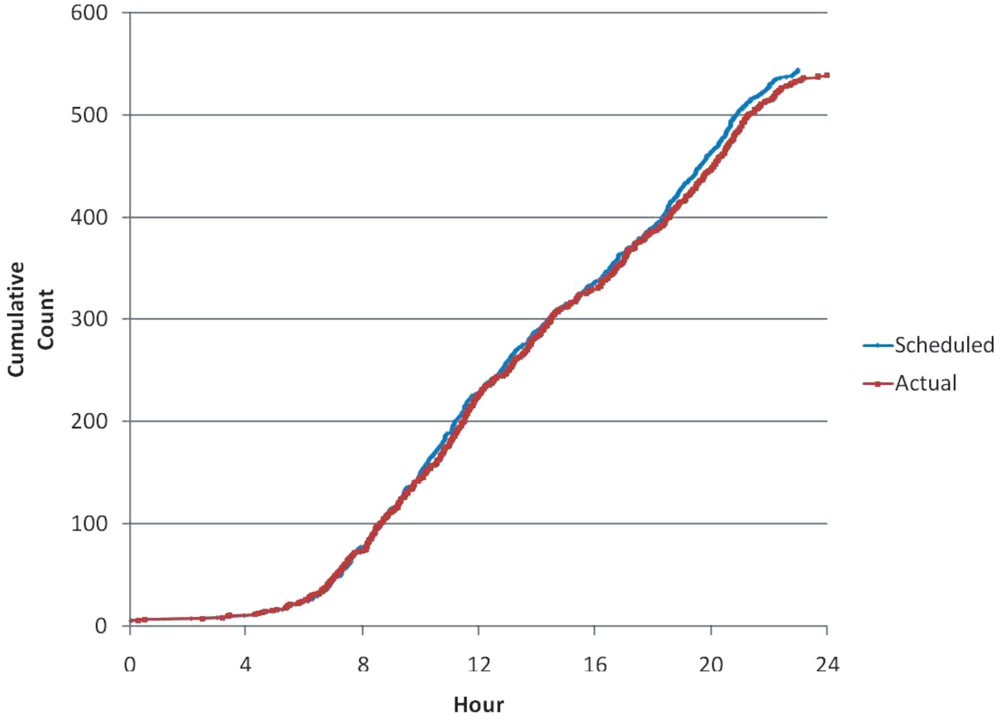

Figure 5.7. Queuing diagram, SFO arrivals (June 13, 2008).

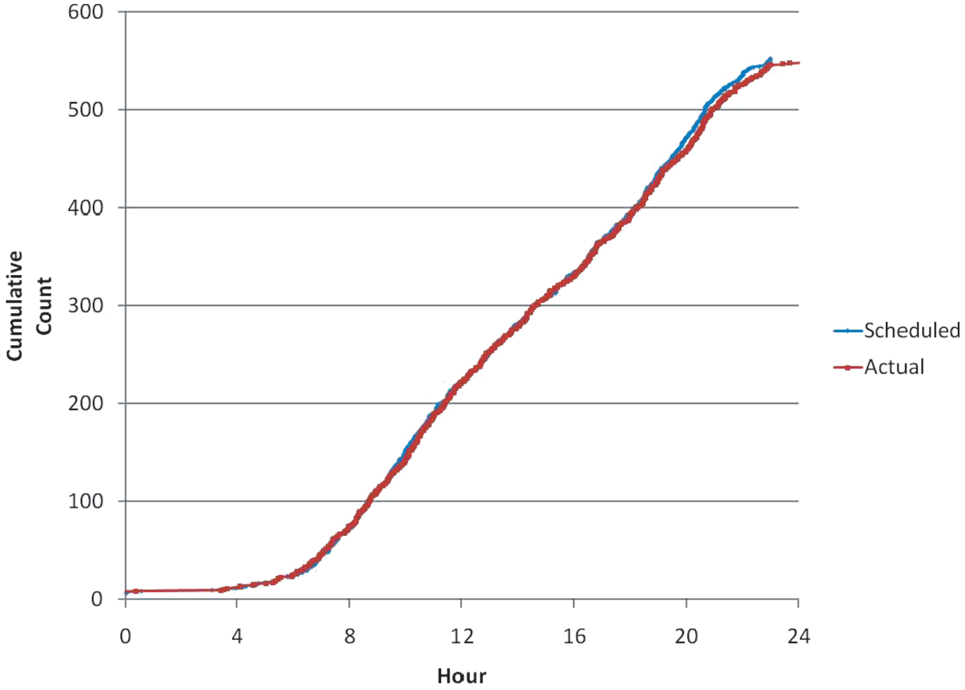

Figure 5.8. Queuing diagram, SFO arrivals (June 18, 2008).

and developed an algorithm for doing so. The details of the process are not important, but the basic principles are very straightforward:

- If the actual arrival time of the removed flight was during a period with no delay, removing it will make no difference.
- Removing a flight can never make the arrival time of another flight later.
- If a delayed flight is removed, the delay incurred by that flight is (of course) eliminated.
- If the actual arrival time of a flight is during a high-delay period, removing the flight enables subsequent flights to

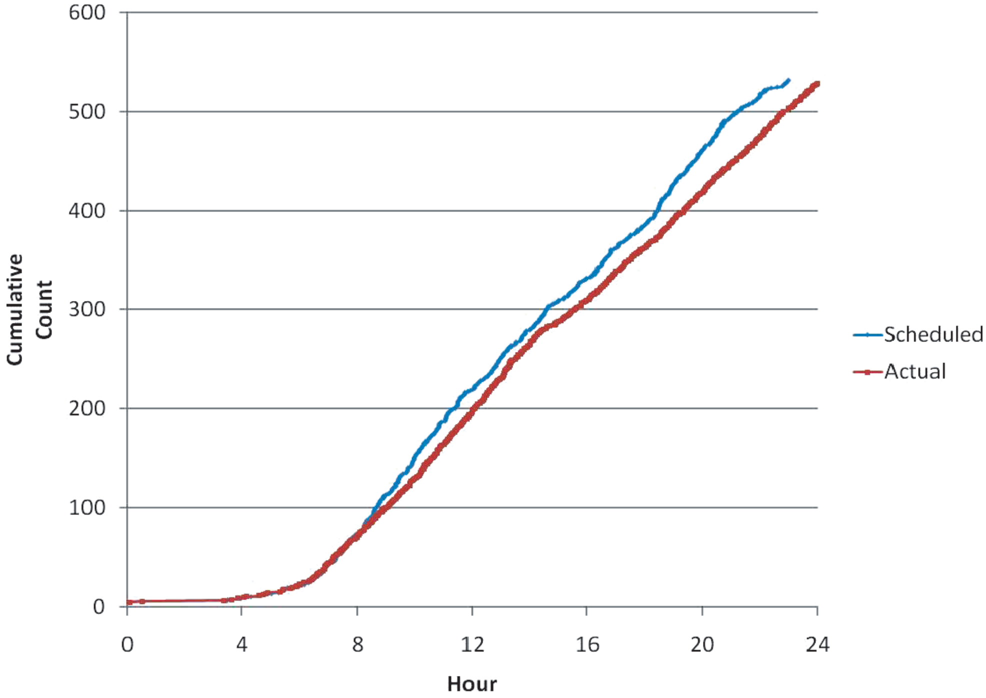

Figure 5.9. Queuing diagram, SFO arrivals (June 25, 2008).

move up and incur less delay, until there is a gap in the traffic stream large enough to make a trailing flight's arrival time independent of the time of the flight in front of it.

Among these principles, the last is the most ambiguous, as one must determine whether another flight could move up if a preceding flight were eliminated or landed earlier. If the time between the two successive arrivals is, say, 60 min, there is clearly no interaction between them, but if it is 1 min, there almost certainly is. The question is where to draw the line. The 90th percentile of the observed inter-arrival times was used (i.e., time between successive arrivals), conditional on airport capacity, in the data. This turned out to be 4 min for high-capacity conditions and 4.4 min for other conditions. With these assumptions, about one third of the total delay—or 8 min per flight—incurred by SFO arrivals can be attributed to arrival capacity constraints. The remainder is due to problems at other airports and airline internal malfunctions such as maintenance problems.

Using the ability to predict the delay impacts of removing flights from the arrival stream, the research team considered three up-gauging strategies.

5.2.4 Up-gauging Through Elimination of Short-haul Flights

In the first strategy, short-haul flights are eliminated. As observed, short-haul flights generally use smaller aircraft, so this strategy implicitly involves up-gauging. In addition, short-haul flights are most easily substituted by surface transport. Thus, eliminating short-haul flights could be an efficient way to reduce congestion and delay at SFO.

In assessing the operational impacts of eliminating short-haul flights or any other strategy, it is useful to quantify delay in seat-minutes rather than aircraft-minutes. The costs of delay to airlines increase with aircraft size, as do (on average) the number of passengers affected by a delay. Thus, the operational impacts will be calculated in units of seat-minutes. Seat-minute delay can be calculated from a queuing diagram in which one counts seats on the vertical axis instead of counting flights.

To predict the seat-delay impact of eliminating short-haul flights, a set of hypothetical "cut-off" distances (80, 150, 200, and 300 miles) was chosen. For a given distance, the research team predicted how seat-delay would change if all of the flights within that distance were removed from the arrival stream. Also, to put these results in perspective, the additional line-haul time was calculated if these aircraft seats were transformed into car seats—that is, the passenger on these flights drove to SFO instead of flying. This was done by comparing the scheduled flight time with the driving time estimated from Yahoo maps. This additional line-haul time is also expressed in seat-minutes, based on the sizes of the aircraft used for the eliminated flights. Although the units are the same, the unit values may be different, depending on the relative seat-minute cost of vehicle operation, aircraft operation, and aircraft delay, as well as the fact that driving times are more predictable than flight delays.

Results averaged over all four days are shown in Figure 5.10. Eliminating flights shorter than 150 miles saves more in delay

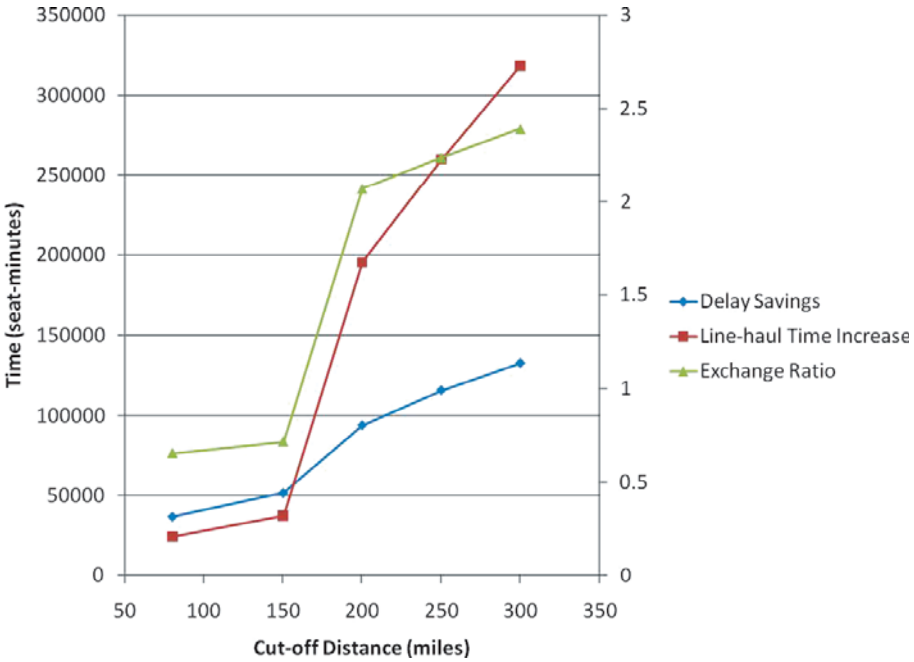

Figure 5.10. Time impacts of eliminating short-haul flights, by cut-off distance, 4-day average.

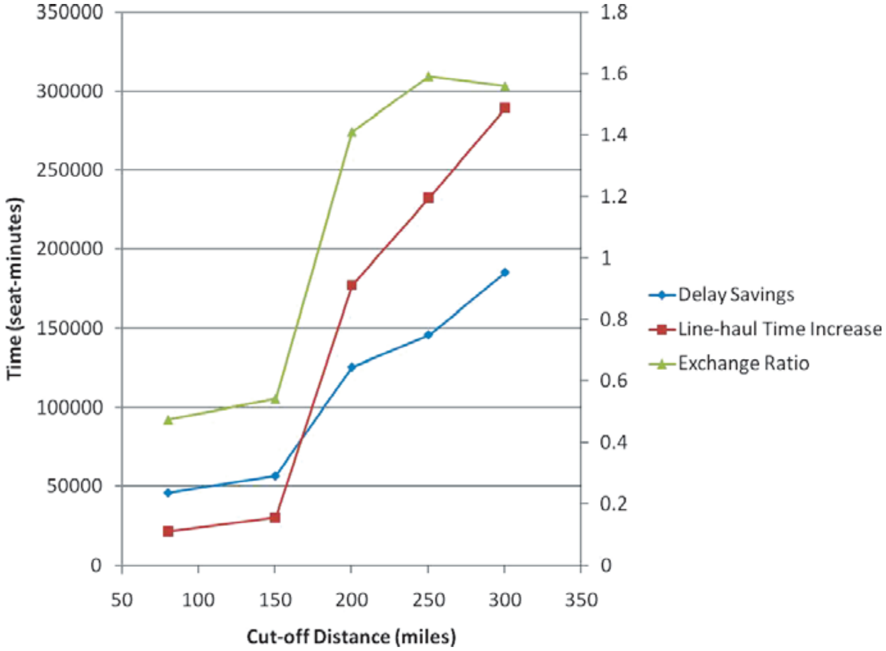

Figure 5.11. Time impacts of eliminating short-haul flights, by cut-off distance (June 25, 2008).

than it costs in additional line-haul time. As the cut-off distance increases, more flights are eliminated and the delay savings increases, but the extra line-haul time increases much faster. The cross-over point, assuming equal valuation of the two forms of time, is somewhere between 150 and 200 miles, and probably closer to the former. If, as may well be the case, the unit cost of flight-delay seat-minutes is considerably greater than that of extra flight time, eliminating flights of 200 miles, or even 300 miles, or less may be cost-beneficial.

The greatest operational benefit from eliminating short-haul flights occurs on highly congested days, such as June 25 in the sample. Figure 5.11 therefore shows results for that day only. Although it displays the same pattern as in Figure 5.10, the delay savings curve is shifted up, so that, for short distances, delay savings are double the line-haul time increase. Moreover, if the unit cost of flight delay were more than 1.6 times that of extra driving time, eliminating all flights less than 300 miles on such a highly congested day would be justified. The day-to-day differences found in comparing Figures 5.10 and 5.11 point to the promise of having a flexible strategy for serving short-haul trips, using flights on good days and surface modes on congested days. This strategy is referred to as real-time intermodalism.

5.2.5 Up-gauging Through Flight Consolidation

A second approach to up-gauging is to encourage, when appropriate, the substitution of less frequent large jet service for more frequent commuter service. As discussed, there are situations in which segments of comparable length and total seat capacity vary differently—for example, Boise to SFO with five small jet flights a day on one airline versus Portland to SFO with two large jet flights on another. In the flight consolidation approach, the migration of services from the former model to the latter one is encouraged.

Like the short-haul flight elimination strategy, this one involves trade-offs. The cost of flight consolidation is less frequent service and diminished schedule convenience. To make flight consolidation as painless as possible, it is desirable to identify situations in which the elimination of a flight through consolidation has the least impact on convenience. To quantify the effect of consolidation, it is imagined that if a given flight is eliminated, the passengers on that flight would be forced to take the next earlier flight on the same airline from the same origin airport. This is somewhat arbitrary, as passengers could respond in other ways, such as taking the next later flight, switching airlines, or going to a different airport. However, the assumption has the virtue of simplicity, and for most passengers, the assumed response is probably the least disruptive one. It respects customer brand (and airport) loyalty, and, because it assumes early arrival, does not disrupt passengers' planned activities in the Bay Area.[34]

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[34] On the other hand, schedules at the origin may be disrupted because passengers must depart earlier. For this reason, some passengers would opt to take the next later flight, but modeling this mixed response is not complex and probably not worthwhile.

With this assumption, one can evaluate the loss of convenience from eliminating a particular flight by finding the difference between its scheduled arrival time and the scheduled arrival time of the previous flight from the same origin operated by the same airline and multiplying this difference by size of the aircraft serving that flight. A metric is obtained with units of seat-minutes, which is traded against the seat-minutes of delay that would be saved if the flight did not take place. This metric is termed "schedule delay impact" (SDI).

SDI was evaluated for each SFO arrival in the four June 2008 days in the sample. Figure 5.12 shows the cumulative distribution of the SDI obtained, using a log scale. It is apparent from the figure that flights fall into three categories. First, there is a set of "one-off" passenger and cargo flights for which this metric is meaningless. These were all assigned an arbitrary, large SDI value and correspond to the vertical part of the distribution on the right of the figure. Next, there is a set of flights that are the first flights of the day for a given airline and origin. Given assumptions, elimination of these flights would force passengers to travel on the previous day. For all intents and purposes, these flights are "off the table" as far as consolidation is concerned. Flights in this category appear in the s-shaped portion of the curve to the left of the vertical portion.

The remaining flights—about 65% of the total—are the ones that can be considered for elimination through flight consolidation. Among these, the most promising are those with the lowest SDI values—say, 10,000 seat-min or less. (To put this figure in perspective, a flight using a 56-seat aircraft would have an SDI of 10,000 if the previous flight was scheduled to arrive 180 min—or 3 hours—earlier.) The portion of the distribution corresponding to these flights is shown in Figure 5.13. It shows that a small but non-zero fraction of flights have an SDI of zero. These are cases in which airlines intentionally schedule two arrivals from the same origin at exactly the same time. The data contain five such cases, all involving major carriers operating large equipment from distant hubs. Carriers do this presumably to provide sufficient capacity while maintaining the ability to cancel flights without disrupting passengers when traffic or capacity is low. Aside from these cases, the lowest SDI values are on the order of 1,000-seat minutes, the equivalent of a 33-seat flight whose predecessor is 30 min earlier.

The research team used the SDI metric to identify the best flights to eliminate in pursuing the flight consolidation strategy. Analogous to the short-haul elimination strategy, a minimum SDI value was set and eliminated all flights below that value. The impact on queuing delay at SFO was then assessed. The procedure is somewhat complicated by the fact that when one removes a flight, the SDI values of other flights may change, as the removed flight is no longer available to receive passengers from some other flight. The team therefore updated the SDIs after each flight consolidation. The results for June 25, the worst day in the sample, appear in Figure 5.14.

Queuing-delay savings of a magnitude greater than schedule-delay savings are obtained for SDI cut-offs up to 4,000 seat-min. Queuing delay is clearly more expensive than schedule delay, as it ties up aircraft and forces passengers to wait in planes and airport terminals, whereas schedule delay can be

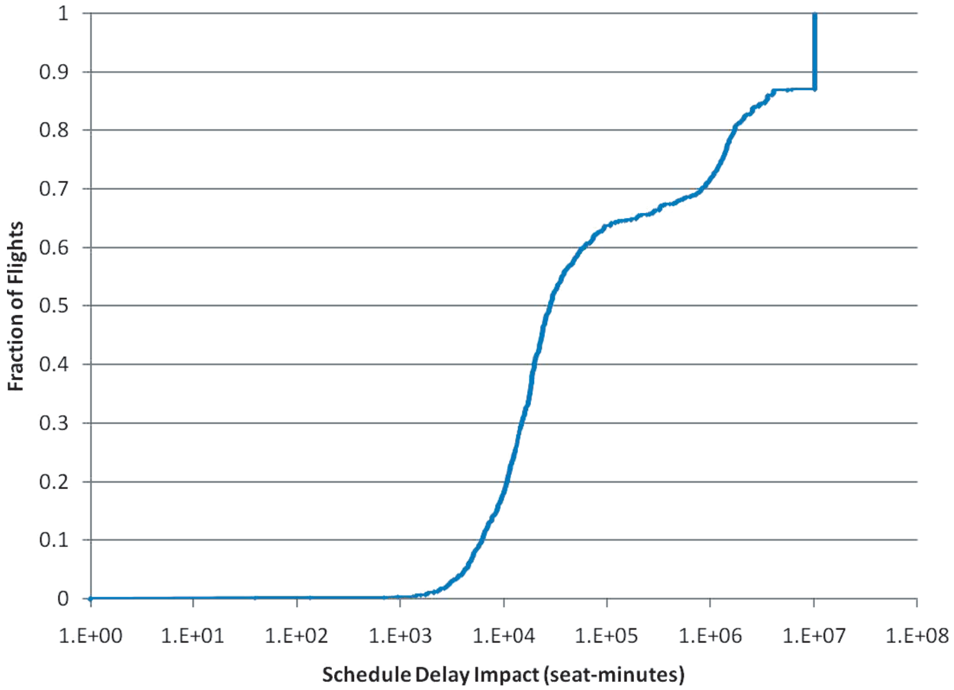

Figure 5.12. Cumulative distribution of SDI, SFO arrivals (June 2008).

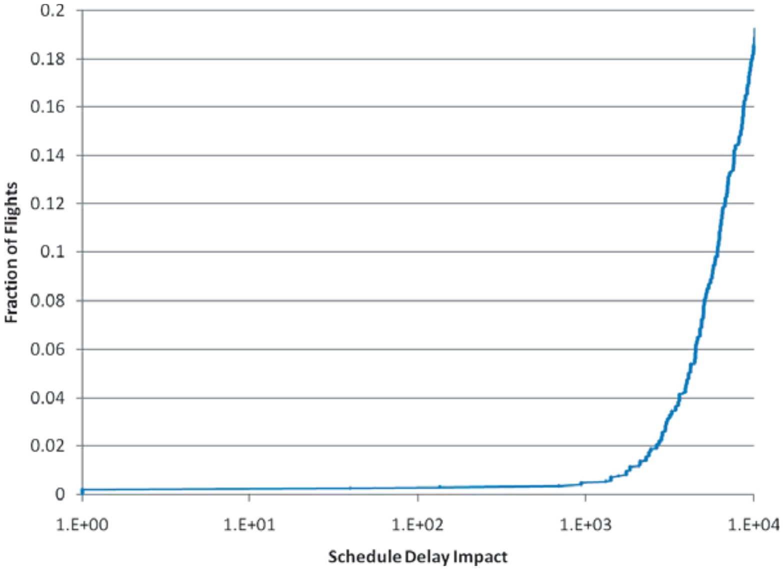

Figure 5.13. Cumulative distribution of SDI, SFO arrivals (June 2008).

anticipated and incorporated into passengers' activity schedules. For these reasons, it is not unreasonable to assume a unit cost ratio of 2:1 or more. Figure 5.14 suggests that a considerable number of flights could be eliminated through consolidation before the optimal trade-off point is reached.

5.2.6 Up-gauging by Diverting Very Small Aircraft

Finally, the strategy of diverting small aircraft from SFO to some other local airport was considered. The research team set 15 seats as the threshold for small aircraft, which would eliminate all bizjets but no commuter flights. To assess the mobility impacts of this strategy, one must assume a time penalty for diverting a flight (or a seat) from SFO to some other alternative. That penalty reflects the additional travel time from being forced to fly into a less accessible airport. Depending on one's point of view, it may also be increased to capture the greater value of time of bizjet travelers as compared to the rest of us.

Figure 5.15 summarizes the impacts of this strategy. On June 25, diverting aircraft of 15 seats or fewer saves over

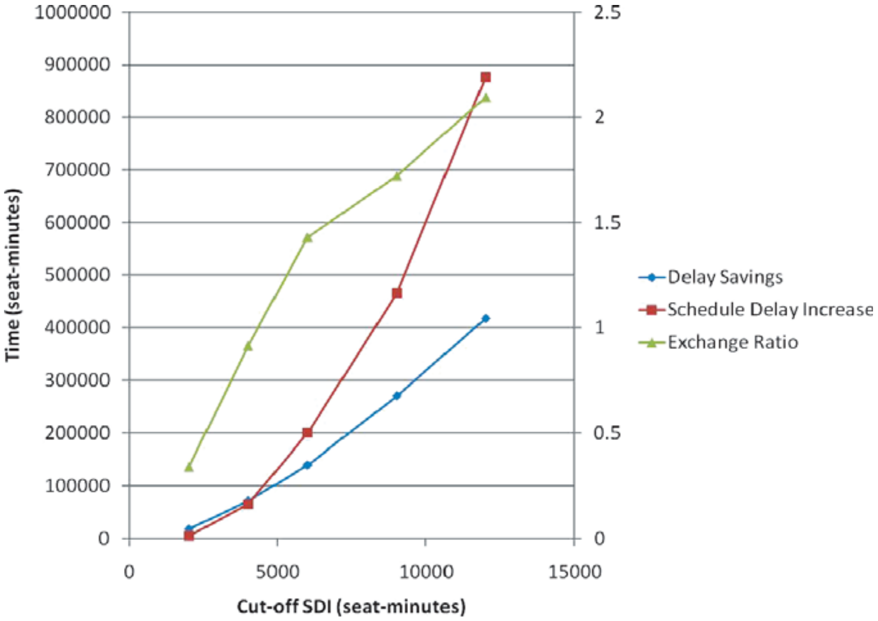

Figure 5.14. Time impacts of eliminating short-average; June 25, 2008).

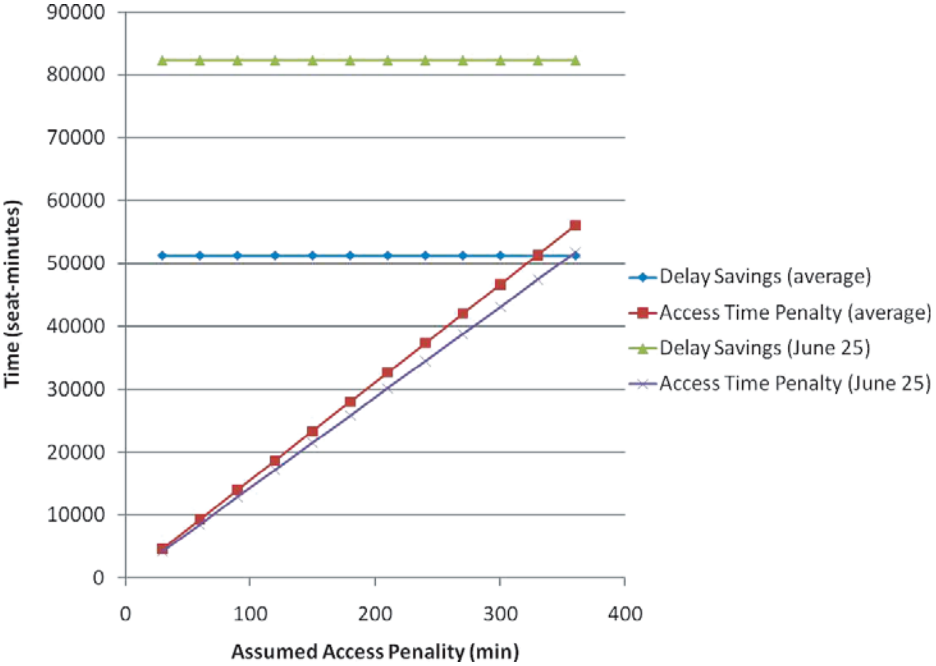

Figure 5.15. Time impacts of eliminating short-haul flights, by assumed access penalty, 4-day average.

50,000 seat-min of delay on average and over 80,000 seat-min. The savings exceed the access time penalty unless diversion penalty exceeds 5 hours. As the actual extra time involved cannot be more than a hour or so, one would need to value biz jet passengers' unit time cost at more than 5 times that of queuing delay to justify their presence at SFO.

5.3 Implications

It has been shown that changing the schedule at SFO, whether by eliminating short-haul flights, consolidating flights, or diverting very small aircraft, can reduce delays and often does so at a reasonable cost in terms of the extra line-haul time, schedule delay, and access time that such changes require. There is strong evidence that the conclusion generalizes. For any airport with high delays due to inadequate operational capacity, eliminating flights during busy periods will reduce delays considerably. The quantity of this benefit, as well as the cost of losing any particular flight, will vary from flight to flight, time period to time period, day to day, and airport to airport. There is, however, a wide body of research and experience suggesting that, in many circumstances, the benefit greatly exceeds the cost, and that the cumulative gain from such changes would be impressive.

What could be done to realize these gains? If the answer to this question were easy, it would have already been done. Broadly speaking, in the current system there is no actor who has both the authority to make the desired schedule changes and the ability to realize the gains from doing so. Airlines and other aircraft operators whose decisions determine the flight demand at any particular airport can realize benefit for some flights they control by eliminating or rescheduling other flights, but this is generally a small fraction of the total benefit (*1*). Moreover, in a competitive, unregulated, industry, the elimination of a flight by Airline A may be offset by initiation of a new service by Airline B. In this event, A has not only lost the operational benefit from its schedule change, but it also now faces stronger competition.

The misalignment between authority and benefit realization is greatest in airports that have both substantial congestion and an unconcentrated distribution of flight traffic. In the United States, such airports are found primarily in the coastal mega-regions. By virtue of their high densities and land constraints, these are places with high levels of flight traffic relative to airport capacity. On the other hand, the peripheral location of coastal airports discourages their use as hubs, which tend to be more concentrated. Thus, in addition to the other conditions—such as strong competition from other modes—that make coastal mega-region airports unique, such airports face unique challenges in encouraging their users to schedule flights that appropriately reflect the costs of congestion.

5.4 The Role of Airport Managers in Increasing Capacity

Airport operators in the United States are only one element of a complex set of factors that affect the creation and resolution of airport capacity issues. A major, yet highly constrained and limited, role is played by the airport managers.

5.4.1 Financing Enhancements

The most obvious, and best understood, role of airport operators is in providing the physical infrastructure that supports increased airport traffic. The United States is almost unique in providing a system of federal grants and municipal debt financing that, when combined with local public ownership of airports, provides both the capital and management resources needed for stable investments in infrastructure at the large airports that handle most passenger traffic. These annual investments typically range from $7 to $10 billion.

The primary financing tools used to support airport capital development are debt from the tax-exempt municipal bond market, Passenger Facility Charges (PFC), the federal Airport Improvement Program (AIP), and retained earnings. Together, these funding sources provide large airports with the financial capability for infrastructure development. Medium-sized airports, while having less financial capability, still retain access to these resources, with funding levels that generally increase with increases in passenger traffic.

However, as is well known, adverse public reaction to aircraft noise and pollutant emissions at and near major airports continues to seriously impede development of new airport infrastructure. This resistance is unlikely to decrease at the study area airports, and major development in the form of new airports or new runways at existing major airports is unlikely, despite the ability to adequately fund such projects. Still, at the core, the public management teams who operate airports in the United States are deeply committed to expanding airport capacity through infrastructure development and the deployment of new technologies and procedures, wherever possible.

5.4.2 Market Factors

A second major factor affecting airport capacity is the interaction of airports, airlines, and market forces. The decisions airlines make about which markets to serve, which aircraft types to serve them with, and the frequency of service all have a large impact on airport capacity. Yet, because of federal laws and regulations, airports are extremely limited in affecting those airline decisions.

As discussed in Chapter 1 (Section 1.4.2), airport managers are often disconnected from decisions made by the airlines concerning where to concentrate hubbing activities and where to eliminate them. As noted in that section, fluctuations in airline policies have significantly affected management of delay (congestion) at SFO, LGA, and JFK. The need to clarify the airport manager's role in the determination of the number of flights, and to forge a cooperative relationship with the airlines in the provision of those flights, has emerged as major themes of this research.

5.4.3 Restrictions Based in Law

Despite the tremendous impact of airline scheduling decisions on airport capacity, airport operators are very limited by federal law, regulation, and policy in their ability to control scheduling practices or aircraft size. Although a full legal discussion of these restrictions is beyond the scope of this study, understanding the issues affecting airport operators requires some discussion of the pertinent restrictions (*2*).[35]

In some cases, restrictive interpretation of legally enforceable policies may act as a capacity constraint, or at least impede potential solutions. The most noteworthy is the assurance of AIP grant recipients to the secretary of Transportation. This assurance is threefold: that their airports will be available for public use on reasonable conditions and without unjust discrimination, that air carriers making similar use of an airport will be subject to substantially comparable charges, and that the airport operator will not withhold unreasonably tenant/signatory status from an air carrier that assumes obligations substantially similar to those already imposed on air carriers of that classification or status. This assurance, required by Title 49 USC 47107, and the restrictions contained in Title 49 USC 40116 on state and local taxes, fees, and other charges on air travelers and air transportation, have proven to be significant issues with local efforts to allocate traffic among airports.

In general, airports are prohibited from direct regulation of airline routes, rates, and charges. This prohibition has been determined to include direct regulation of equipment type, frequency of operation, time of day of operation, and aircraft environmental emissions. Airport proprietors' rights have long included the right to establish discriminatory fees and charges for aeronautical use of the airfield. These rights have been recognized as including the right to set minimum landing fees designed to affect various weight classes of aircraft differently, with the intent of providing incentives to reduce airfield delay during periods of congestion.

In addition, the DOT 1996 Rates and Charges Policy (*3*) provides that an airport owner may impose a "properly structured peak pricing system that allocates limited resources using price" and may "establish fees that enhance the efficient utilization of the airport." Similarly, the DOT's regulations on airport noise and access restrictions (14 CFR Part 161) provide that a peak-period pricing program with an objective "to align the number of aircraft operations with airport capacity" is not an "access restriction" (*4*). In a series of decisions in the Massport Program for Airfield Capacity Efficiency (PACE) proceeding, where the airport operator sought to use landing fees to regulate airfield congestion, the DOT concluded that, "landing fee structures that vary from the traditional weight-based approach are permissible so long as the approach

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[35] A thorough legal discussion of these issues can be found in the DOT NPRM on its policy on airport rates and charges.

adopted reasonably allocates costs to the appropriate users on a rational and economically justified basis" (*5*).

5.4.4 FAA-Proposed Changes in Rules/Regulations

Most recently, in the Notice of Proposed Rulemaking to amend its 1996 policy on rates and charges, the DOT proposed to explicitly allow airport proprietors to establish a two-part landing fee that recognizes both the number of operations and the weight of the aircraft, in order to provide incentives for airlines to modify aircraft gauge or frequency to reduce delays at congested airport. According to the U.S. Government Accountability Office (GAO), the 2008 Amendment to the Airport Rates and Charges policy allows the following:

> Announced in July 2008, the policy clarifies the ability of airport operators to establish a two-part landing fee structure consisting of both an operation charge and a weight-based charge, giving airports the flexibility to vary charges based on the time of day and the volume of traffic. It also permits the operator of a congested airport to charge users a portion of the cost of airfield projects under construction and expands the authority of an operator of a congested airport to include in the airfield fees of congested airports a portion of the airfield fees of other underutilized airports owned and operated by the same proprietor (*6*).

The combination of these three new rules would give airport managers more control over the efficient use of their runway and landside facilities, "These amendments are intended to provide greater flexibility to operators of congested airports to use landing fees to provide incentives to air carriers to use the airport at less congested times or to use alternate airports to meet regional air service needs" (*6*).

Airport operators have essentially no direct control of airline activity at their airports, including whether the airline serves the airport at all, the frequency or time of day of service, or the aircraft type or size used to provide service. They do have proprietors' rights to use rates and charges to influence airline service patterns, but those rights are still being refined. Building on the experience reviewed here, the following section will develop some potential demand management principles.

5.5 Guiding Principles for Demand Management

5.5.1 Legitimation

In light of the potential to reduce delay with innovative freight management and the unclear role of aviation stakeholders in managing delay, a demand management approach could be tried, to better align flight scheduling decisions with the needs of society. The most fundamental, and therefore the most difficult, would be for all relevant parties to recognize demand management as a legitimate alternative to capacity expansion as a means of ameliorating airport congestion problems. Some parties within the aviation community continue to believe that congestion and delay are required to spur development of the aviation system both nationally and locally. Demand management is perceived by such individuals as a palliative that inhibits the often difficult cure of capacity expansion. In such a view, only when the pain becomes unbearable—as in the New York airports or Chicago O'Hare—should demand management be undertaken. And even in these cases, the goal should be simply to reduce congestion to tolerable levels. Any further refinements, such as market-based slot allocation, again raise the specter of demand management becoming a way of life, rather than a temporary expedient or last resort.

There are certainly cases where capacity expansion is more desirable than demand management. But the time is long past when capacity expansion should be viewed as the inherently superior solution. At many airports, given current technology and regulations, it may no longer be feasible to expand runway capacity. At others, the costs of expansion may simply be higher than those of demand management. And at yet others, agreement on an ultimate capacity may be the price for securing approval for expanding the airport to reach that capacity. In all of these instances, demand management could be a legitimate tool for preventing or alleviating excess airport delay.

Beyond legitimizing demand management, the approach could be guided by two other principles. First, primary responsibility for demand management should be at the local level. Second, demand management should be anticipatory rather than reactive.

5.5.2 Localization

There are a number of reasons why the primary locus of demand management responsibility and action would ideally be at the local level. First, recent federal efforts to innovate policy in this area have been met by strong resistance. The FAA's attempt in the fall of 2008 to institute slot auctions at a modest scale at the New York airports was temporarily blocked by a federal court after an appeal by the PANYNJ.

Demand management at the local level would be immune to legal or political challenges. It is likely that slot auctions would be opposed by airlines regardless of the body implementing the auctions. Political hurdles would also exist. In 2007, the FAA proposed a pilot program to give select airport authorities flexibility to impose market-based measures at the local level with guidance; this proposal did not gain traction and was not included in recent reauthorization bills that were introduced. Another challenge to demand management policy localization, airport monopoly power, is touched on in Section 5.7.2.2. There would likely be significant challenges to innovation in airport demand management whether it occurs nationally or locally, subject to federal oversight. Nonetheless, the research team argues that the latter course would be the more promising one.

Second, it would be very difficult to craft a federal demand management program that would be effective across the wide variety of circumstances that exist at different airports. Important differences in this context include the following:

- **Airline/airport relations.** Although in some cases airlines and airports maintain a straightforward landlord–tenant relationship, in other cases the relationship more closely resembles co-ownership. In the latter case, certain airlines have invested in both the airport itself and in developing the markets that the airport serves. In the context of demand management, this affects the manner in which available capacity could be allocated: through a market mechanism based on willingness to pay, or through a process that gives more consideration of established airport-airline relationships.
- **Financing mechanism.** Airports are financed in one of two ways. In the residual approach, airlines agree to make up any shortfall in revenues in return for having a strong role, often including a veto, in airport capital expenditure decisions as well as the agreement that any airport's non-airline revenue will go toward reducing the costs borne by airlines. In the compensatory approach, the airport assumes the risk, and in return can earn substantial surpluses that can finance future airport development, decisions about which it largely controls. Residual airports face unique constraints in employing market approaches to demand management because (a) any revenue from such charges is ultimately recaptured by the airlines in the form of reduced fees and (b) they typically have long-term usage agreements with airlines to which any demand management program must conform.
- **Variability in capacity.** Some airports have fairly similar capacities under most weather conditions, whereas in others, capacity is highly variable. In the latter cases, a decision must be made about what capacity scenario to assume in formulating the demand management strategy. If the capacity is set too low, the airport will be underused much of the time; if set too high, there may be severe delays much of the time. There may also be cases where it is appropriate to assume different capacities for different times of day or seasons of the year. Such trade-offs are best understood at the local level.
- **Expandability.** The appropriate mix of demand management and demand accommodation depends on the cost and political difficulty of expanding an airport. Some factors that determine expandability, such as the cost and availability of land and the sensitivity of surrounding land uses, can be assessed objectively, whereas others cannot. This is one reason why airport planning and expansion decisions have traditionally been made at the local level. Given the close coupling between such decisions and those related to demand management, it is appropriate for the same entity to make both.
- **Valuation of competing goals.** Demand management involves complex trade-offs between competing goals, including delay reduction, schedule convenience, competitiveness, equity, and service stability. Different regions will place different values on these goals. Localizing demand management policy increases the opportunity to design programs that reflect these differences.
- **Competitiveness.** Demand management policies can reduce competition between airlines serving a given airport as well as create entry barriers for airlines seeking to initiate service. Although such outcomes are rarely desirable, the severity of their consequences varies according to how competitive the airport is to begin with, the availability of alternative airports nearby, and, in some cases, the availability of competitive modes. It follows that the weight given to preserving competition in formulating demand management programs should vary from airport to airport.

A third rationale for demand management being determined at the local level is that, for the most part, delay is a local problem. It is the local population and economy that experience the brunt of delay impacts. Although high delays at one airport can propagate throughout the system, most of the delay experienced in the United States is not propagated. Moreover, the airlines that operate at a high-delay airport recognize the system-wide impacts of the delays and will certainly express these—both explicitly and behaviorally—to local policymakers. There is also anecdotal evidence from places such as San Francisco, New York, and Boston that if demand management were made a local responsibility, it would be embraced by many of the localities where it may be needed.

To ensure that a solution developed to solve a local delay problem does not have the effect of making the situation worse downstream at other airport(s), the delay modeling used to develop the delay triggers at an airport would account for the impact on other airports.

Fourth, local responsibility would result in a variety of approaches being tried. Much can be learned from this process. Just as states are the laboratories of democracy, airports could become laboratories for demand management. Our limited experience with airport demand management in this country, as well as the limited success of attempts at it to date, suggests that there is much to learn.

Finally, as the research team elaborates below, making demand management primarily a local responsibility does not mean that the federal government would have no recourse when that responsibility is performed improperly or not at all. Airports' increased latitude in developing demand management programs could be accompanied by clear guidance and principles of accountability.

5.5.3 Anticipation

As currently practiced in the United States, air demand management is a reactive strategy that is performed after delays have reached unacceptable levels. For example, there is legislation authorizing meetings with airlines to discuss schedule reductions at severely congested airports. The authority appears to be restricted to cases where the airport is already severely congested. In contrast to this, the demand management programs can be implemented most effectively prior to the advent of severe congestion.

Such pro-activity could take two forms. The demand management programs could be formulated while the airport is relatively uncongested and prior to the time when severe congestion is clearly foreseeable. This would allow a deliberative approach. Moreover, it would require stakeholders, lacking reliable information about when and where congestion will occur, to participate in the process without clear knowledge about how it will affect their own interests.

Second, the program itself could be proactive, with actions that are triggered when unacceptable levels of congestion are foreseeable, rather than when they actually occur. It is possible to foresee congestion because airline schedules are available several months ahead of time. Capacity, the other key determinant on congestion, can also be confidently characterized within this time frame, at least in a probabilistic sense. This demand and capacity information would be used to determine what, if any, demand management actions are needed. Airlines could then make adjustments to their schedules accordingly, thereby alleviating or preventing the congestion that would otherwise have occurred. This is the basic logic of the Massport demand management plan put in place several years ago at BOS.

Such an anticipatory approach offers great advantages for both airlines and passengers. Airlines are given relatively long lead times to adjust their schedules. This expands the range of possible responses. Carriers can adjust flight schedules, shift operations to other airports, up-gauge, and increase fares in congested periods. Passenger dislocation is kept to a minimum, as most bookings are made just a few weeks in advance, well after the schedule adjustments would have taken place.

Such an approach would certainly arouse concern for those who believe that severe congestion is the only reliable means to secure consensus to expand airport capacity. In this research, severe capacity shortages manifest primarily in the form of demand management actions and air carrier responses to them, rather than long delays. But these actions and responses will themselves be clearly visible to policymakers, stakeholders, and the public at large. Local politics could be relied upon to balance the costs of demand management against those of increasing airport capacity.

5.6 Guidance and Accountability

This research has revealed the benefit and need for multiple parties to be at the table when considering airport demand management. At a recent panel discussion, participating airport operators expressed their support for multistakeholder involvement stating that the airport operator should be a strong player in capacity and demand management. To work together effectively, all parties would need to be clear on expectations and roles. Clear guidance could help airports manage congestion through the entire process. Guidance can be thought of as the boundaries or constraints of operation. Within these boundaries, the airport would have latitude in how it decides to manage congestion. The following two examples will shed light on how guidance for overall management of capacity and delay might occur.

5.6.1 Existing Examples of Guidance

Although local airport managers enjoy a unique perspective on their airports, they also are heavily involved with the air carriers at the airport. Federally mandated rules, such as the development and adherence to airport competition plans and providing service to small communities, provide the airport with a clear set of rules for airport management. This can prove to be useful, as explained in the following examples.

Airport competition plans are developed by an airport following guidelines set out by the FAA. The plans are to show how an airport is open to opportunities for carrier relations (*7*). Although it is an extra task for an airport to develop such a plan, airports welcome these plans because they provide operating guidelines for the airport that are agreed upon with the FAA. Having federal policy that supports new entries allows airports to uphold competition. The competition plan allows the airport to have guidelines against which airline service decisions can be made; the federal government helps preserve competition.

Defining small communities for designated air service and allocating seat capacity to these small communities are traditionally federal roles. Definition of these small communities is often politically charged. Instead of the airport getting involved in both politics and controversial carrier relations, the federal government can define small communities and necessary capacities to service these communities. The airport avoids discussing with communities why they were denied access and avoids any difficult carrier relations.

5.6.2 Example: Developing a Framework for Demand Management

In consideration of Section 5.2 which displayed how delay can be reduced with innovative aircraft management, the following discussion centers on an example of how a framework for the airports to manage congestion might be developed. A broad outline for how this could be accomplished is the following: setting mutually agreeable airport-delay targets, developing a detailed list of actions an airport can take to meet the delay level, and identifying incentives and penalties for not meeting such an action.

The first step would be to define "critical-delay airports." This definition could be tied with an existing program, such as the Operational Evolution Partnership (OEP) airports, which are the commercial U.S. airports with the most activity. According to the FAA (*8*), more than 70% of passengers move through these airports, and delays at the OEP 35 airports have a ripple effect on other locations. Therefore, containing delays at these airports could be considered to be of national significance.

Critical-delay airports could be given this designation to ensure that local decisions regarding a congested airport do not hinder the entire NAS. The goal would be for these airports to hold delays to a certain level. This level is called a "trigger" because any delay experienced beyond this level could set off a series of actions. The trigger would be determined by using a combination of experience and economic modeling techniques. This delay trigger would be developed to ensure other airports in the NAS are not unduly affected by local decisions, particularly ones that result in high levels of delay. It is also expected that airlines using an airport would be well aware of the ripple effects to their own operations caused by delays there and would make these known to the local airport operator.

Critical-delay airports could be further divided based on their current levels of delay. Once the delay trigger is decided, each critical-delay airport could model the delay experienced on a fair-weather day with their existing schedules and an estimation of unscheduled traffic. Airports could be divided into those that exceed the trigger under existing conditions and those that will exceed it in the future.

5.6.2.1 Airports with Trigger Exceeded

Airports that immediately exceed the delay trigger would update their master plan at once. This airport master plan update could have, at minimum, two new sections. One could address the potential of the airport to expand capacity in the long term to manage demand. The other section could be the development of a demand management plan.

The capacity expansion plan could take the perspective of regional growth accommodation instead of airport-specific growth. The airport could study how it can provide its passengers service without being limited to runway development. The airport capacity expansion plan could incorporate many strategies, including multimodal solutions, regional airports, airports under the main airports purview, and HSR. An example is the Massport 1993 Strategic Assessment Report, which evaluated regional solutions for intercity travel demand.

The demand management plan could outline the steps an airport would take to enforce the delay trigger. This could include the strategies to be employed to satisfy the trigger and also the details behind these strategies. For example, if an airport planned to use peak-period pricing to reduce delay in its demand management plan, the airport would discuss the extra peak-period charge, the duration of the peak in which to charge, and other details. Other detailed strategies an airport could consider are discussed in Section 5.7.

5.6.2.2 Airports with Trigger Not Exceeded

Airports where the trigger is not exceeded could be further subdivided into two categories. Some airports would find through their modeling that traffic will exceed the trigger before their next scheduled master plan update. Such airports could update their master plan—potentially immediately. Airports where the trigger would be exceeded in over 5 years but before the next master plan could update their master plan in a 5-year period.

5.6.3 Airport Accountability

Airports could have wide latitude to manage their own congestion and delay and could accept consequences for failing to meet the delay standard. To encourage airports to accept their designation of critical delay airports, incentives could be provided.

5.6.3.1 Accountability Incentives

There are ways to encourage airports to embrace the critical-delay airport designation. As noted, airport managers tend to favor solutions beyond demand management; one way to encourage airport managers to see greater benefits of demand management could be to allow more flexibility in using revenue from their demand management plan. If some aspects of revenue neutrality (discussed in Section 5.7) were relaxed and the operator was allowed to have wide latitude to use the funds to make improvements, an airport operator might more readily embrace the critical-delay airport designation. There is general consensus among experts that operators of congested airports have to make money to run the airport as efficiently as possible. Any revenue raised could be considered funds for airport improvements.

Certain airport demand patterns make revenue neutrality a challenge. For example, an airport with persistent all-day demand is unable to offer a discount in the off-peak, as the off-peak does not exist. Another example is an airport that experiences extreme peaks and an entrenched hub carrier. An airport with extreme peaking could offer negative landing fees; however, if the airport is a hub airport, the hub carrier would almost exclusively benefit from such an organization. Some airports could be able to remain revenue neutral with a demand management plan because they have a significantly long off-peak period in which they can offer discount landing fees. These airports could be given the option of remaining revenue neutral. These airports could use their revenue to offer off-peak discounts; they could also choose to operate like airports unable to remain revenue neutral.

Revenues could be placed in an airport's reserve fund and available for a wide range of purposes—from the capital program to the maintenance reserves. Although airports would have latitude in spending these funds, additional guidance would be necessary about how funds could be spent.

5.6.3.2 Passenger Accountability

When airports accept public funds from the FAA, they agree under United States Code Title 49 (Section 5.4.3) to conditions of grant assurances. Agreeing to these assurances means that all aircraft that can safely land at that airport must be accommodated with no discrimination. Section 5.2 introduced the idea that carriers have fleet mix recipes with important ramifications for the quality of service and the level of accessibility provided by airports and the entire air transportation system. The guidance provided to airports for accepting their designation as critical-delay airports could involve a new way to envision aviation system accountability.

Section 5.2 showed that a balance exists between providing customer service in the terms of flight frequency and reliability. It is possible that making an airport available to all aeronautical users increases frequency and degrades customer service to a point where an airport is not "reasonably available" to passengers. Similarly, nondiscrimination could lead to over scheduling and, as shown in Section 5.2, to the over scheduling of small aircraft. This excessive frequency tips the balance so that reliability is significantly decreased.

One of the many motivations behind demand management is to make air travel reliable for passengers. A way to consider airport accountability beyond making the airport available for all classes of aeronautical activities is to focus on the passenger experience. A congested airport does not necessarily make the airport reasonably available nor are delays arguably nondiscriminatory from the passenger perspective.

When there is a delay, passengers experience a loss from as small as lost time to a missed connection. According to research performed by the research team, passenger delay at the 12 largest coastal mega-region airports in 2007 cost passengers \$15.4 billion per year (as defined in Table 1.2, Section 1.2). Said another way, each passenger would be willing to pay an average of \$48 per passenger trip to avoid delays. Coupled with the findings that many delays are related to airport congestion, a conclusion is that the 12 largest coastal mega-region airports are not available on reasonable terms because passengers have a large willingness to pay to avoid delays. For this reason, it is possible that although congested airports are following the classical definition of making an airport available on "reasonable terms," passengers are not being served on reasonable terms. The delays incurred are also not equally distributed. Airport passengers on high-frequency, low-capacity aircraft are experiencing less delay than passengers on low-frequency, high-capacity aircraft because passengers on frequent, low-capacity aircraft experience less schedule delay (the difference between desired departure time and actual departure time) than passengers on larger, less frequent aircraft. Again, although an airport may not be discriminating against classes of aeronautical users, the delay distribution is not entirely equitable.

This key guidance that an airport receives is crucial in motivating an airport to manage congestion and delays in a way that is agreeable to all parties. The following section discusses an example of an airport receiving guidance from the FAA to develop a comprehensive demand management and capacity enhancing plan. The research team is not considering this a "best practice" case study, but rather one instance of guidance in action.

5.6.4 Example: Guidance in Action

The following example is based on Massport and the FAA's relationship in managing BOS—a unique airport and historically one of the nation's most delayed airports. It is an OD airport as opposed to a transfer, hub airport. It is the biggest airport in the upper Northeast and therefore attracts a diversity of fleet mixes. Being in the Northeast, BOS deals with extreme weather patterns. Finally, BOS is constrained in expansion due to its location and is operationally challenged due to community pressure.

In the mid-1980s, Massport worked to implement PACE. This program was implemented in response to a strong growth in regional operations; growth in this sector was threatening the capacity of the airport. The program changed the landing fee formula from weight-based to a hybrid-fixed and variable structure. However, owing to small aircraft being charged more and larger aircraft charged less under this fee structure, the DOT found that this scheme discriminated against an aeronautical user group and therefore was in violation of the grant assurances.

While PACE was closed, persistent delays continued at BOS, motivating further studies and investigations. Massport proactively sought out solutions that ranged from HSR to the increased use of regional airports. The purpose was to accommodate demand for intercity travel involving the Northeast region in the long run. However, the result of these studies pointed to BOS as the focus airport for the region. To this end, the airport proactively performed an environmental impact statement (EIS) in 1995. The goal of the EIS was a delay reduction program at BOS. The EIS included a feasibility study, which looked at different delay reduction items and came up with the following list of potential strategies:

- Demand management and peak-period pricing,
- A new runway and new taxiway improvements, and
- Using technologies to reduce spacing minimums on certain runways.

It is important to note from this list that demand management was one part of a larger list of delay reduction strategies. The analysis performed for the EIS showed that all these strategies were necessary for delay management. Furthermore, while a new runway was suggested, Massport was committed to staying within their spatial footprint and therefore knew a demand management portion of their plans was necessary to complement their capacity expansion. Because the strategies were complementary and Massport would remain in their existing footprint, the FAA Record of Decision and the state permit felt that all strategies should be implemented (*5*). Massport agreed to develop a demand management plan to complement their new runway development. This transparent, three-pronged delay reduction strategy also earned Massport stakeholders buy-in, as stakeholders were able to see the trade-offs among the strategies. Massport was obligated to develop a demand management program along with the plan for runway development, so as to both manage future demand and manage it in such a way that all stakeholders are prepared.

The demand management program at Massport is outlined as follows. Every 6 months, the airport collects the schedules given by the carriers. The airport then develops a monitoring report. This report involves the airport entering the collected schedules and non-scheduled traffic into a simulation model to estimate whether the airport is oversubscribed on a fair-weather day. Massport has a delay trigger of a 15-min average total delay per operation over a period of 3 consecutive hours. If the simulation report finds that this trigger is exceeded, the airport will tell the airlines that the congestion management program will go into place in the next schedule iteration. This action puts the airlines on notice that a peak fee will be implemented if the schedule does not change. The airport will recalculate the delay if the airlines update their schedules. Figure 5.16 displays the process for implementing the peak period pricing at BOS.

The FAA provided clear guidance to Massport to develop a capacity enhancement and demand management proposal in response to the airport's findings that both a runway for increased capacity and a demand management program would be necessary to balance future capacity and demand. There are many federal constraints with which Massport had to operate to develop their demand management plan. The plan references two decisions that, taken together, form the basis of the guidance for Massport's demand management plan. The 2008 Record of Decision allows airports to implement peak pricing under certain conditions; the PACE decision separates the role of the airport and the role of the FAA. In addition to these rulings, the FAA provided Massport with "guidance in the form of a policy statement relating to the development of a reasonable fee structure and in two pending policy initiatives addressing airport proprietor demand management programs" (*5*). It is this guidance from the FAA that enabled Massport to

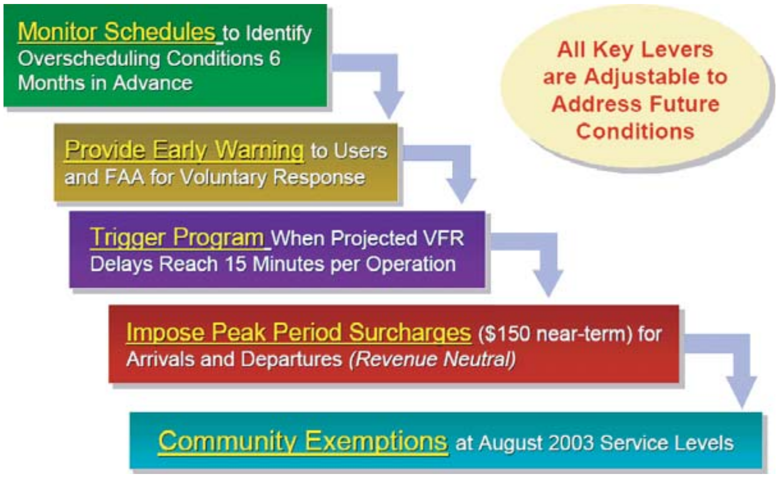

Figure 5.16. Time impacts of eliminating short-haul flights, by assumed access penalty, 4-day average (9).

develop their demand management plan with confidence after their previous attempt, PACE, was struck down.

5.7 Flexibility

In Section 5.6, the research team described an example of how a framework might be developed for implementing demand management. In such a scenario, it would be important that airports have flexibility in how they could perform demand management. This section discusses that flexibility by examining the actions that an airport could take to meet their delay goal. Airports could have many options to manage congestion in a way that fits the unique needs of each airport. Some of these involve loosening current restrictions on how airports can charge for airport usage, while others entail active cooperation of interested parties.

Three potential categories of actions an airport could take to manage their delays are introduced: capacity allocation, setting operational limits, and traffic flow management. Institutional changes that could help an airport employ these strategies are also discussed.

5.7.1 Capacity Allocation

5.7.1.1 Pricing

The idea that peak-period pricing could be used to help manage the demand/capacity balance for transportation services was first proposed formally in 1959 by William Vickrey, a Columbia University economist. That concept was advanced in 1989 in a text produced by a team at the Brookings Institution and has since been widely promoted in the economics and transportation literature as well as in public policy forums (*10*). Testimony to the U.S. Congress JEC provided in 2003 by the GAO concludes that, “Congestion pricing—although only one of several approaches that can be used to reduce congestion on our nation’s roads, airways, and waterways—shows promise in reducing congestion and better ensuring that our existing transportation systems are used efficiently” (*11*). The first roadway area pricing project was implemented in Singapore in 1975, and there have since been numerous projects in which peak pricing has been used for U.S. roadways. The FHWA’s Value Pricing Pilot Program has funded numerous studies and implementations of congestion pricing approaches for roadway projects.

The use of congestion pricing for managing airport capacity in the United States has been more limited. The PANYNJ implemented the first runway congestion pricing scheme in 1968, charging higher landing fees for peak-hour use by small aircraft at EWR, JFK, and LGA. As a result, general aviation activity during peak periods decreased by 30%. The peak-hour fees were discontinued after airline deregulation. In 1988, the Massachusetts Port Authority implemented higher landing fees for small aircraft at BOS as part of the PACE. With PACE, Massport experienced a significant drop in small regional aircraft. Although PACE was successful in promoting up-gauging, it was also found to be in violation of Title 49, U.S. Code, because the airport was not available to all aeronautical users on “reasonable terms without unjust discrimination.” Those fees were also discontinued after a court order cited the lack of reasonable airport alternatives in that region. Although the PACE program was ultimately found to be in violation of U.S. Code, it provides a good example of two crucial components of charging policies: nondiscrimination and revenue neutrality.

Changing the way aircraft operations are charged allows for demand management. Air carriers would have an incentive to use scarce runway capacity more efficiently, through up-gauging or rescheduling flights to less congested periods. Furthermore, signals (in the form of prices) that capacity expansion is needed would be sent.

A fee for use of the airfield could be levied in several ways. The most common approach is a peak-period surcharge that applies to all flights regardless of size. The permissibility of this option is explicitly mentioned in the Airport Noise and Capacity Act as well as the most recent FAA guidance on airport rates and charges. It is also the centerpiece of the Massport plan for BOS. Such a charge encourages aircraft operators to reduce flights in peak periods. Moreover, because the charge is size-independent, flights carrying smaller numbers of passengers are likely to be the most strongly affected. Depending on the circumstance, flights would be shifted to off-peak periods, combined through up-gauging, or eliminated altogether.

Although such a surcharge seems to be the most logical price-based solution, it might not always be feasible. For example, airports that have long-term agreements on airfield charges might be unable to obtain approval to amend the agreement. Other pricing changes could be considered in such cases. One example is a peak-period PFC surcharge on passengers. PFCs are automatically added to the price of a passenger ticket, based on the airports included in the itinerary. There is no obvious reason why the same system could not be employed to vary the PFC based on the flight arrival and departure times. As compared with a peak-period flight surcharge, a disadvantage of the PFC approach is that it does not reward up-gauging. This problem could be addressed by differentiating the PFC by the size of the aircraft on which the passenger is flying.

Parking and ground transportation charges could also be adjusted to encourage air travelers to fly in off-peak times. At OD airports, periods of high landside congestion are associated with periods of high airside congestion. Peak surcharges on landside access and egress can address both the landside problem and the airside problem. An additional advantage of this approach is that it could be done under current federal policy, which affords airport operators wide latitude to set landside charges. A disadvantage is that it would not be possible to differentiate landside charges by aircraft size. Additionally, it could be more difficult to make travelers aware of the price differentials when they make their travel decisions.

5.7.1.2 Capping

The alternatives to peak surcharges involve setting operational caps, as has been done in various fashions by the FAA—in cooperation with incumbent airlines—at severely capacity-constrained airports since the late 1960s. Airports could have discretion to manage demand through such slot controls. They may choose to do so for two main reasons. First, such controls are the most direct and reliable way to reach a desired level of demand and therefore operational performance. Responses to pricing solutions are difficult to predict, and the process of finding the right peak surcharge—however it is applied—would involve trial-and-error and, as demand conditions are ever-changing, continual adjustment. The slot-based solution "cuts to the quick," in this respect. Second, slot control is the most obvious—if not the only—practicable method of controlling demand for airports that do not wish to employ market-based solutions.

The primary disadvantages of slot limits are twofold. First, it is difficult for an airport to determine the appropriate number of slots. The decision depends not only on capacity, but also on the optimum level of congestion. A price-based solution will allow users to express, through their willingness to pay surcharges during peak times, what level of congestion is ideal. This is not possible with caps. Second, a means for allocating the slots must be found. There is considerable experience in this area, but the methods employed to date all give a considerable advantage to incumbent airlines, resulting in entry barriers.

The FAA has recently studied, and attempted to implement, auctions as a means of allocating slots at the New York airports. The idea proved unpopular with airlines and the PANYNJ, and it appears unlikely that it will go further as a federal initiative. Airports, however, could be given considerable latitude to experiment with slot auctions. A key problem with the previous initiative is that the use of a runway slot entails the use of a host of other facilities (e.g., gates, baggage facilities, ticket counters, and ground access) that are the province of the airport. Designing auctions that take this into account, so that transfers of all of these resources from one airline to another can be successfully coordinated, is a challenging task in any case, but one that the local airport is best equipped to handle.

A less adventurous alternative than auctions is an IATA-like slot procedure for negotiating slot allocation, combined with a secondary market. The IATA process is used at capacity-constrained airports in Europe. There is a considerable base of experience with this process, and most airlines are comfortable with it. Many argue that this comfort derives from the fact that the process favors incumbent airlines. If, therefore, an airline decides to adopt an IATA-like slot allocation procedure, it could be encouraged, or perhaps required, to take steps to create an active secondary market in which airlines can buy and sell slots. The market, if working properly, reduces barriers to entry without forcing incumbent airlines to give up their slots.

Secondary markets have existed for high-density airports in the United States for more than 20 years. They have not operated effectively for several reasons. On the one hand, slot holders have been reluctant to sell slots to would-be competitors. On the other, buyers have been reluctant to pay for slots because it has been less expensive to secure access to the airport through other means, such as making certain types of operations exempt from the slot limits. Under the concept presented here, airports could play an active role in lubricating the secondary market, by always having control of an inventory of slots, which it could lease or sell to airlines. The airport could acquire these slots through purchase and could include the acquisition cost in its cost base.

It is much easier to employ slot controls to limit growth in flight schedules than to reduce schedules already in place. This again points to the importance of performing demand management pro-actively, rather than waiting for high delays to occur before intervening.

5.7.2 Flexibility in Capacity Allocation

Airports undertaking demand management could be able to experiment with any or all of the capacity allocation policies. Implementing such an approach, however, would require changes and clarifications in policy. Three policies are of particular note: nondiscrimination among aeronautical users, the definition of cost centers for purposes of setting airport aeronautical fees, and airport profitability.

5.7.2.1 Nondiscrimination Across Aeronautical Users

In the PACE proceedings, among others, it was argued that a flat fee "discriminates" against small aircraft. A clear policy would have to be articulated that under no circumstances can a flat (undifferentiated by aircraft size) fee for use of aeronautical facilities be considered discriminatory. Although the accountability discussion centered on the passenger perspective related to nondiscrimination, the flexibility section would focus on aeronautical users.

Aside from the pragmatic consideration of allowing airports to include flat fees as part of their demand management programs, there are several ways that this change might be justified. First, from an economics perspective, it is not flat fees that discriminate, but the current weight-based fees. Second, it should be recognized that congestion is a cost, and one that is higher for certain classes of users (e.g., large aircraft operators and scheduled carriers) than others. A congested airport is therefore a discriminatory airport, and policies that mitigate this congestion have the effect of reducing discrimination. Third, when there is severe delay at an airport, the airport is no longer available to users "on reasonable terms." Thus the principle that an airport should set fees so that "it is available to all users on reasonable terms" could be construed to mean that a capacity-constrained airport could set fees to manage demand and not to be attractive to all potential users.

5.7.2.2 Cost Recovery and Revenue Neutrality

Federal law and policy require that airports use revenue generated from their operations for airport-related purposes. The use for other purposes is considered revenue diversion and is prohibited, with certain "grandfather" exceptions for airports with long-standing policies that included certain forms of diversion. Federal policy also requires that charges to aeronautical users reflect the historical costs of the airfield and airport roadways and be derived from some systematic accounting method. The latter policy is elaborated in the FAA Policy Regarding Airport Rates and Charges, first published in 1996. The Policy was revised to permit airports to include in the aeronautical cost base airfield projects that have yet to be completed but for which costs have been incurred and costs for projects at other airports that may be expected to divert traffic from the original one. The revised policy also explicitly authorizes the use of peak surcharges in order to manage demand.

Under these policies, airports that employ pricing or auctions to manage demand must ensure that their programs are revenue neutral, or at least do not generate revenue in excess of the allowable costs. For example, a peak surcharge would be accompanied by a reduction in the weight-based landing fee, so that the total revenue generated remains the same. It could, however, become impossible to maintain revenue neutrality while setting surcharges at the level required to induce behavior modification. This is particularly true for airports where demand exceeds capacity for many hours of the day, such as LGA.

To address this problem, current constraints on airport rates and charges could be relaxed. This could be done in two different ways. The first would be to abandon the principle that aeronautical revenues cannot exceed allowed costs. The policy against diverting revenue from the airport would be maintained, but airports would be permitted to use aeronautical revenue to cross-subsidize other cost centers, such as terminal facilities, ground access, and security. This would be a dramatic reversal from current practice, where subsidies often go in the opposite direction, but it might be appropriate at a capacity-constrained airport. As already noted, most other airport charges, such as parking and facility leasing, cannot instantiate the principle of charging per flight rather than per unit of payload. To raise per-flight charges large enough to effectively manage demand, it might be necessary to increase revenue generated from the class of charges where this is most easily made—those for airfield use.

A second alternative would be to expand the class of allowable costs that airfield charges can be used to recover. The recent changes to the Policy on Rates and Charges point the way here. By allowing airfield costs at other airports to be included in the costs base, the Policy establishes the principle that allowable costs include not only those for supplying necessary facilities at a given airport but also those for curtailing demand at the airport. The present policy allows such curtailment costs only when they are spent on airfield facilities at substitute airports, but the fundamental principle has much wider application. For example, as discussed in Section 5.2, there are instances when it might be cost-effective to shift short-haul traffic to other modes. Encouraging such modal diversion serves the same end as encouraging intra-modal diversion to other airports. The costs of doing so—for example, by subsidizing luxury motor coach services from close-in airports—might be recoverable from aeronautical charges. The idea could be stretched further to include costs for maintaining a functioning secondary market for airports opting for operational caps and IATA-like slot allocation. In this case, the cost might be justified because the secondary market allows competition at the airport to be maintained without having to continually expand the airport to serve all comers.

These potential options do not challenge the prohibition on revenue diversion, which would be maintained. Theoretically, any constraints on how airport revenue is spent can prevent those funds from being put to their highest and best use. And it is perhaps the case that applying airport revenue surpluses to improve urban schools or support other social programs would often serve society better than keeping them within the airport. The negative consequences of this practice, however, could be severe because of airports' monopoly power. In effect, airports could extract a profit by electing not to expand capacity even when it is cost-effective to do so. If an airport is really unable to find reasonable ways to spend revenue generated through congestion surcharges, it could be required to surrender that revenue into a fund that could be used for aviation projects in other locales.

5.7.3 Setting Operational Limits

Most demand management schemes require that operational caps be established. In some instances, the cap pertains to the number of operations in an hour or some other time unit. In others, the cap pertains to delay. Depending on the scheme, the cap may be a hard limit or a trigger for some demand management action. In the case of the New York airports, for example, there is a hard cap on the number of operations that can be scheduled in an hour. In the Massport plan for BOS, peak-pricing surcharges are triggered when the delay, under Visual Meteorological Conditions capacity, is predicted to exceed a certain threshold (an average 15 min per flight over a 2-hour period).

Airports might be given flexibility in establishing these caps. There are many legitimate reasons why the caps could vary from airport to airport, even when they have identical capacities. These caps involve complex trade-offs between airport use and delay, and the "sweet spot" in this trade space can vary from place to place. A tourist destination, for example, might place a higher premium on handling large volumes of passengers, and therefore flights, and be willing to accept high levels of delay in order to do so. An airport serving short-duration business travel might prefer a more reliable service, even if this entails reduced volume. There is no justification to require a single standard that would apply to both of these cases.

Of course, there are also situations where airports could abuse their discretion. On the one hand, they could use congestion as a reason to set caps that are really motivated by noise considerations, thereby undermining the compromise established in the Airport Noise and Capacity Act. On the other hand, they might set the caps too high, or not set them at all, because of the revenue that can be realized from the resulting traffic. It would therefore be necessary to determine how little or much traffic and/or delay could be tolerated. Airports with delays below a certain level might not use demand management to reduce flight volumes. Airports with delays exceeding a certain level, and who fail to act to address the situation, could be subject to slot controls such as exist today at the New York airports. The range between the high and low values could be a "zone of indifference" in which airport demand management is an option. As previously suggested, this zone of indifference policy could be applied prospectively to address the case of an anticipated surge of demand at an airport that is currently relatively uncongested.

There are some who believe that caps could be set too low. In certain European airports, pressure from controllers results in caps well below runway capacity being set. One possible solution would be for airports with slot controls to increase caps slightly on an experimental basis. If the resulting delays were within pre-established limits, the increased caps would become the baseline values; otherwise, the caps would return to their previous levels.

5.7.4 Traffic Flow Management

A ground-delay program (GDP) is "implemented to control air traffic volume to airports where the projected traffic demand is expected to exceed the airport's acceptance rate for a lengthy period of time" (*12*). Such a program is typically put into place when weather reduces the airport acceptance rate. However, the idea behind a GDP could be leveraged and used for chronically congested airports. It could be possible for a congested airport to request institution of a continuous GDP. With fair-weather capacity as the baseline capacity for the GDP, the GDP would impose ground delays when the demand for operations at the airport exceeded the fair-weather capacity.

Imposition of the continuous GDP allows airlines to use tools such as Flight Schedule Monitor to obtain updated information on how their flights would be delayed. In some cases, this knowledge alone might lead to delay-reducing schedule adjustments. Moreover, it would provide enough lead time to adjust their published schedules so that the scheduled departure time and arrival times would match the controlled times imposed by the GDP. In effect, the continuous GDP turns the process of smoothing schedules from a tactical, day-of-operation process to a strategic one. In principle, this could essentially eliminate delays from over-scheduling relative to fair-weather capacity, while also reducing delays under reduced capacity.

CHAPTER 6

What Was Learned, and What Are the Next Steps

The scale of the capacity problem
- Analysis should continue on the questions of airport choice, schedule-based delay, and whether alternative forms of hubbing could relieve key mega-region airports.

Making the process more multimodal
- The aviation system is not well equipped to undertake the kind of multimodal analysis associated with the present wider choice of options for long distance trip making; both the tools and the structure could be improved.
- The potential role of rail complementarity in the United States should be documented further.

Making the process more multijurisdictional
- Regional solutions could gain optimized capacity from a "family of airports" concept.
- Regional organizations could be crafted based on unique local requirements and (at least partially) on a passenger-centric basis.
- Multimodal tools and procedures could be developed to support integration with the comprehensive planning process.

Dealing with airport management, the report explores a variety of approaches, including the following:
- Giving individual airport operators the primary responsibility for developing demand management programs appropriate for their local circumstances within broad national guidelines;
- Enhancing the ability of airports to manage demand through a variety of operational and pricing-related options; and
- Outlining an example of a potential framework for demand management that would define a set of critical-delay airports, along with the establishment of delay standards and an accepted method of predicting delay.

Exhibit 6.0. What was learned and what are the next steps.

6.0 Introduction

Chapter 6 is presented in four major sections. The sections are designed to build upon the four major themes established in the project. Each section presents some major conclusions concerning that theme, and some specific suggestions for action or further research. Each of the major suggestions and conclusions are presented here in order to carry out the objective of this research.

> The objective of this research is to identify potential actions to address the constrained aviation system capacity and growing travel demand in the high-density, multijurisdictional, multimodal, coastal mega-regions along the East and West Coasts.
>
> New and innovative processes/methodologies are needed if the aviation capacity issues in these congested coastal mega-regions are going to be successfully addressed. These high-density areas invite an entirely new approach for planning and decision making that goes beyond the existing practice for transportation planning and programming that is usually accomplished within single travel modes and political jurisdictions or regions.

The conclusions and suggestions that follow tend to share (to a greater and lesser extent) a common theme (see Exhibit 6.0).

The research project concludes that the aviation planning process could become more user-based and thus more accountable. If indeed, the service reliability at a given airport reaches a "trigger point," the operating rules could be changed to regain the lost level of reliability. If indeed the service levels of HSR, as experienced by the user, provide a superior overall product for the customer, that customer could be encouraged to select the higher quality good. If indeed, a planning process can understand why a given customer would fail to select services at an airport serving in a "reliever" function, that planning process could employ the market research tools of expectation and user preference to form policies to bring about a change in those service conditions. If major agencies can learn to organize their most basic planning data in a manner that can be shared with others, a user-based description of demand could be assembled, replacing a modally-based format for the benefit of all.

Although suggestions range from the macro-scale to the micro-scale, they share the common theme of increasing accountability for actions. While this theme may appear to be new, it is in fact borrowed from a revolution in the management practices of the American intermodal freight industry, whose basic strategy was summarized in the phrase, "We seek to place strategic vision as high as possible in the organization and accountability as low as possible" (*1*).

6.1 Concerning Theme No. 1: The Scale of the Problem

6.1.1 What was Learned

This research has concluded that, under the *present* relationship between the airports and the airlines, there is a serious lack of usable aviation capacity in key airports in the mega-regions. The team also concluded that, unless a solution is found for the improved management of existing scarce runway capacity, assumptions made throughout the industry about available 2025 capacity in the mega-regions may be invalid. Chapter 1 built the case that there is a growing problem at key airports in the mega-regions and that the economic and environmental cost of doing nothing is significant. Under that *assumption of doing nothing,* the project estimated the cost of congestion at the largest airports in the study area in 2025 would range between $9 and $20 billion, depending upon the definitions of costs included.[36]

The research has documented the scale of intra-region air travel in the two study areas. The East and West Coast study areas have about the same geographic scale, and their longest air trips within each study area are about the same length. But the study found that the trip-making patterns were very different. The research team concluded that a properly defined family of airports approach showed that the air passenger volumes between the Bay Area and the Los Angeles basin are roughly 5 times the scale of either the NYC–Boston or NYC–Washington, D.C. corridors. The two OD desire-line diagrams (Figures 1.3 and 1.4, respectively) document about 10 million intra-area air trips in the East Coast, versus about 20 million in the West. Given that the East Coast study area has a population that is about 80% larger that of the West Coast study area, the West Coast has an overall short-distance air trip generation rate that is more than 3 times that of the East Coast. So the volumes are on the West, but the congestion is on the East. In short, there is no simple formula that suggests that higher amounts of short-distance air travel are linearly associated with higher levels of airport congestion. The causes of the delay needed to be examined more carefully, as was done in Chapter 5.

6.1.2 Suggestions Concerning Theme No. 1

The research analyzed the cost of present issues in airport capacity management in coastal mega-regions. The research team believes that further work in the field of issue definition, such as was undertaken in Chapter 1 for the mega-regions only, needs to be undertaken for the larger question of the potential lack of capacity for major hubbing operations. It must be noted that the FACT 2 calculations of the potential lack of capacity in 2025 made the simplifying assumption that the selection of transfer airports in 2025 would mirror (exactly) the pattern established in the base data. It is suggested that the highly usable MITRE FATE OD data be examined in a process that would allow the location of key hubbing activity *to be a variable for examination,* rather than a given. Logically, this should be done before the conclusion that a given hub location is, inherently, in need of further capacity.

6.2 Concerning Theme No. 2: Making the Process Multimodal

The research team concluded that to gain the benefit of capacity provision by other high-quality inter-city transportation modes, the aviation capacity planning system could benefit from becoming more multimodal. Chapter 2 reviewed the extent to which aviation planning is inherently intertwined with the planning and analysis of capacity increases in other longer distance modes, specifically HSR and highway planning.

There are key conclusions from this portion of the research on two very different levels. First, Section 6.2.1 reviews key results and conclusions concerning the potential scale of candidate HSR investment in the East and West Coast Mega-regions. Then, Section 6.2.2 reviews the need to integrate the aviation capacity planning process with that of other transportation modes for more general transportation planning purposes.

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[36] See Chapter 1 for the range of definitions reported, from both Table 1.4 and accompanying text.

6.2.1 What was Learned

The federal government is now committed to an increase in federal participation in HSR projects of at least $8 billion (over and above previous investment commitments). The implications of this federal commitment for the need to undertake detailed multimodal analysis in such corridors as Boston–NYC, NYC–Washington, D.C., and SFO–LAX are immediate in nature, with ramifications for intermodal and multimodal policy making.

6.2.1.1 What was Learned: Intermodal Considerations

Given the variety of data sources reviewed in Chapter 2, it is difficult to firmly quantify the extent to which HSR services could divert passengers away from congested airports. However, this research helps to give a sense of scale to the discussion. When examined on an aggregate basis, Chapter 2 reported that the forecasting process developed by the MTC for the California HSR authority predicted that about 10 million interregional passengers could be diverted to rail away from air. About 16% of forecasted interregional HSR trips were expected to have been diverted from airports.

On the East Coast, a wide variety of sources must be examined together: a key U.S. DOT study forecast that moderate improvements to HSR between Boston and Washington, D.C., would divert an additional 11% of air passengers in that corridor; with the assumption of European-style HSR travel times, the diversion factor would be about 20% of air volumes.

Chapters 2 and 4 presented what the research team believes to be the first summary of the impact of alternative HSR system assumptions on airport-to-airport flows and total East Coast study area flows.[37] That early analysis suggested a total potential diversion of between 1.5 million (low estimate) to 3.8 million (high estimate) air travelers as a result of systemwide implementation of HSR throughout the East Coast Mega-region. This number could be compared, in theory, with the 11 million air travelers forecast to be diverted in California and Nevada. Chapter 2 noted that much of the "diversion" to rail in key East Coast markets has already occurred, as documented in Section 3.4, which helps to explain some of the difference in scale between East and West Coast levels of potential diversion from air.

However, the research concluded in Chapter 4 that the levels of diversion *on an airport-specific basis* do not support the concept that the provision of HSR in either corridor will make the problem of airport congestion disappear. The research team's preliminary analysis of possible decreases in airport boardings ranged from a high of 6% at SAN, to under 1% at JFK and at EWR.

Finally, the research shows that the beneficial impacts of HSR on airport congestion might not be fully realized unless they were undertaken as part of a comprehensive multimodal strategy to optimize the use of capacity in a given corridor. Section 2.4 carefully documents the historical experience in the Boston–NYC airports market, where a very significant lowering of air passenger volume did not lead to a corresponding decrease in actual flights. The research summarized in Chapter 2 suggests that a *combination* of lowering of actual air travel *and* a well-developed program to optimize the efficiency of the airports as discussed in Chapter 5 will bring about the objective of lowering congestion and producing the kind of 2025 aviation capacity the industry has been assuming.

6.2.1.2 Suggestions: Intermodal Coordination

While it is generally beyond the scope of this ACRP project, the research team notes that there are major financial hurdles to be overcome before any of the HSR projects referenced in this document can become a reality (*3*).[38] Chapter 2 reported that, although the California bond issue was for less than $10 billion, the estimated costs of the full project are closer to $40 billion. The estimated costs for the attainment of the half-hour improvement in NEC travel times are estimated at $13 billion. This research has concluded that the systems resulting from these total investments would have serious implications for the next years of aviation capacity planning.

Overall, the implications for diverting shorter distance air travelers to rail are potentially very positive, but it is the research team's conclusion that procedures to coordinate investments would be beneficial.

6.2.2. Suggestions Concerning Theme No. 2

6.2.2.1 What was Learned: The Planning Process

The research team concluded that an enhanced level of incorporation of alternative long-distance modes in the planning process could be beneficial. The general state of data on which to base policies and judgments concerning the longer distance trip (i.e., beyond the metropolitan area, or beyond the state borders) is in need of improvement. There has been no major update of long-distance travel patterns since 1995. In an age when decisionmakers are being asked to allocate $8 billion to HSR, and even greater amounts to highways, the absence of a common data source for interstate and interregional trips is of concern.

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[37] The East Coast analysis examined improvement on both the Northeast Corridor itself, and the feeder system to it.

[38] This theme is developed in some detail in the recent GAO report (*3*).

There is at present no publicly owned data set that describes county-to-county (or even state-to-state) automobile vehicle trip flows on a multistate basis. In this manner, multimodal analysis capacity is far behind the MITRE FATE forecasts (*5*), which have created national county-to-county aviation trip flows. As a result, the mode share of airline trips as a portion of total trips *is not documented even for the largest, most dominant city-pairs.* This poses a challenge even to the best-intentioned analyses of longer distance travel.

Until very recently, airport forecasting has been focused on an airport-specific approach to demand. The current shift to a county-of-origin to county-of-destination forecasting approach is laudable, but could be widened considerably to accommodate recent policy and funding changes. It could become more multimodal in nature, to be merged with similar work from other modes. In many cases, modal agencies, such as Amtrak, use elaborate descriptions of multi-state travel, but these resources are considered "proprietary"[39] and are not shared with government agencies, which would benefit from such sharing. The result is that the quality of debate suffers from a lack of good supporting information.

6.2.2.2 Suggestions: Updating the Long-Distance Planning Process

This research has begun the task of creating a set of actual-origin to actual-destination trip tables.[40] What results from this process is a description of travel by aviation that can be melded and integrated with descriptions of travel by automobile and descriptions of travel by rail and bus. When these resources are assembled together, a trip table could be created that looks very similar *in concept* to the output of the 1995 ATS.

This research has assisted in the creation of a workable combination of the existing airport-of-origin to airport-of-destination DB1B data (*2*) with other sources, such as NERASP, the FAA New York Region Study, and, when needed, the surveyed results of local airport-based ground access surveys. From those assembled data together, the research team has made a first approximation of the actual origins of airline passengers (e.g., the county in which they started their trip, not the airport in which they started their flight) to the actual destinations (e.g., the county in which they end the trip, not the airport at which they land.)[41]

With the commencement and early application of these tools, the research team suggests:

- That an intermodal approach to the analysis of long-distance trip-making and trip provision be developed. Given the congestion at mega-regions' airports, a unit of capacity created on an HSR system need not be seen as a "competitor" to the aviation system, but as a complementary provider of services over a full multimodal system.
- That early examples of "Corridors of the Future," such as the I-95 Corridor Coalition, be reviewed to find ways to help states who come together on a voluntary basis to improve their data concerning longer distance trip-making. This research has made great strides in beginning the development of true-origin to true-destination aviation trip-making. The research team suggests that the initial county-by-county aviation trip tables for the East Coast Mega-region be integrated with other modal efforts to build a region-wide county-by-county auto vehicle trip table. In short, the team believes that the existing Coalition institution would represent a perfect "test bed" in which the cost-effectiveness of creating truly multimodal data needed in the analysis of a wide variety of longer distance investments and policies could be tested.
- That the issue of integrating aviation trip flows with other modal trip flows be undertaken by the relevant entities in the East and in California. The research team notes that the existing statewide trip tables developed by the MTC for the HSRA could be expanded to serve as a truly statewide resource. This could encourage and support the transformation of the MTC HSR trip table and model from its present coverage of the areas impacted by HSR to a state-of-the-art statewide data resource.
- That activities be pursued that would make the analysis of the intricate relationship between air travel patterns and rail travel patterns more immediately available to a wide variety of players involved. These players would include those that are inherently involved. The research team does not believe that high-quality analytical procedures do not exist; the research team believes that they are not available to support the public debate.
- The research team believes that the lack of data resources and tools concerning the major role of the intercity bus industry in trip-making of under 300 miles could be improved. Interviews conducted for the research revealed a uniform belief that the needs and potential of this industry simply could not be integrated into the public debate. Whatever research tools are developed could make special effort to create analyses that would help to better harness the potential of the privately owned intercity bus industry.

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[39] According to interviews, consulting firms tend to regard their methods as privately owned, and not to be shared with their competitors.

[40] These county-to-county aviation trip tables were used in the analysis of the market areas for underutilized airports presented in Chapter 3.

[41] The integration of airport ground access origin with flight destination was pioneered in the east coast by NERASP. The geographic scale of that project, however, did not allow many trips to be covered in terms of both their origin and their destination. Geographic coverage goes from the Boston family of airports in the north to the Washington family of airports in the south and covers most air travel with the East Coast Mega-region.

- The research team located an impressive amount of analytical work documenting the potential for rail to *substitute for* air travel, particularly from the EU. Concerning the potential role of rail to *complement* air travel (e.g., as a feeder mode to longer distance flights), the research team found a profound dearth of analytical work. The research team suggests that research at a high level would help better understand the possible role of the two modes working together.

6.3 Concerning Theme No. 3: Making the Process Multijurisdictional

6.3.1 What was Learned

This research has concluded that to gain better use of existing underutilized capacity at smaller airports in the region, the aviation capacity planning system could benefit from becoming more multijurisdictional. Chapter 3 reviewed how the creation of a unified, coordinated multi-airport planning process (NERASP) was associated with the creation of a more rational "family of airports" for the Boston region. The chapter showed how a regional analysis (rather than an airport-based analysis) can support the study of the potential of lesser scale regional airports to provide additional capacity to the systems of the two mega-regions, provided that the operating carriers decided to take advantage of their presence. The chapter examined the importance of gathering and analyzing data on a multi-airport, super-regional basis and provided examples of how such new regional aviation planning tools could be used.

The research concluded that certain issues are best addressed at a multi-airport level, which may or may not correspond with the geographic coverage of MPOs. For example, the geographic scope of the MPO in the Bay Area effectively reflects the service area of three major, important airports; an MPO covering the northern New Jersey portion of the NYC metro area would not be the logical location to better define the competitive roles of EWR and Stewart Airport. Thus, this research does not conclude that existing MPOs *automatically* represent the best locus for multijurisdictional aviation planning. But the pioneering work of NERASP demonstrates that some form of institution can be created that shifts the focus of transportation planning away from sole reliance on the individual airport, to a focus on the needs of a set of customers who really do have a choice of airports to patronize.

A key conclusion of this research is that enhanced metropolitan (or supra-metropolitan) airport system planning could be helpful in addressing airport congestion issues in regions that include major metropolitan areas. There are a variety of remedial measures available, from more efficient use of existing runways to expanded use of secondary airports and the shifting of some trips to surface transportation, particularly HSR. The evaluation of these options should take account of the need to generate passenger acceptance and public support.

The research team concludes that system planning is particularly useful when it provides insight into traveler needs and preferences. This information is useful for a host of management purposes in addition to development decisions. Indicators of the level of service that passengers experience at major airports are particularly useful. Eventually, the team expects that information about passenger level of service will be a major factor in the decision-making process, because it can illustrate the difference between passenger expectations and their experiences. Passengers are most interested in avoiding long and unpredicted air traffic delays that can lead to flight cancellations, missed connections, and disrupted travel plans. Performance measures can be used to track both average and severe delays and help in the development of multi-airport regional strategies.

6.3.2 Suggestions Concerning Theme No. 3

- An expanded version of system planning could be made available throughout the congested mega-regions on the East and West coasts. Chapter 3 noted that the FAA has been willing to expand the scope of system planning in a number of specific cases to address the distribution of travel demand among airports and to other modes. This has been done in NERASP, which helped to identify unused capacity at secondary airports that could be used to relieve congestion at BOS. Similarly, the MTC RASP is now underway in the Bay area, involving the cooperation of several major airports and looking into alternatives to meet the long-term travel demand, including the potential role of HSR passenger service.
- The general indicators of airport congestion are similar from one city to another, but the underlying details and options for improvement vary greatly. As a result, it is not suggested that much effort be spent on standardized guidance for regional airport system planning. Instead, it is suggested that studies be tailored to specific regional requirements, giving wide discretion to local leadership and initiative.
- To support these efforts, applied research should be continued on the question of "airport choice" by the traveler with multiple airports to choose from. The NERASP data, for example, provide much of the basic information required to truly improve the research team's understanding of just when an air traveler would divert to a smaller airport, and when she/he would not. This existing path of research should be supported, as it is critical to making these multi-airport planning processes truly meaningful. The research team believes the raw data are already in place to support improvements in these methods.

Support for expanded regional system planning could be provided in a number of ways:

- Reports such as FACT 2 (*5*) are very useful in presenting a national overview and summarizing the current outlook for airport congestion. They stimulate local action and signal a willingness to provide financial aid for solutions.
- The availability of specialists with expertise in airport capacity analysis could be very helpful. For example, capacity specialists are able to help local officials and planners design studies to address regional concerns and to coordinate those studies to ensure a high level of cooperation and technical acceptability. The capacity specialists could provide technical assistance for regional planning studies.

Those charged with managing new multijurisdictional efforts should use state-of-the-art practices in collection and analysis of data to be used by both aviation and non-aviation sectors:

- As multi-airport planning processes are established, the separate airports could be encouraged to undertake data collection efforts on as close to a simultaneous basis as possible, following the example set in both NERASP and MTC RASP. Standardization of data collection format and of period of acquisition allows for the creation of a meaningful, useful regional data resource.
- As regional processes are established, it is important that data about the ground origin (or destination) of the aviation trip be collected together with the data concerning the final destination of the trip. At its most basic, this would allow for county-to-county analysis to be undertaken in the data analysis phase. To make it most useful, the data collection method should allow for quick conversion to latitude and longitude descriptions needed for present-day applications of GIS technology.
- Even without new supra-regional studies, existing MPOs could become more involved in the collection, analysis, and support of data collection and management in the aviation sector, following the example of the Washington Metropolitan Council of Governments, among several other advanced examples of MPO participation in aviation planning.

6.4 Concerning Theme No. 4: The Potential for Demand Management

6.4.1 What was Learned

The research has concluded that the current system suffers from unclear responsibility, that no one has authority and accountability for the management of congestion at mega-region airports. The research team found that opportunities to reduce mega-region airport congestion and improve the overall cost and quality of passenger service do exist; what is needed is for key decisionmakers to grasp them. The chapter concluded that the management of existing resources could be improved. Chapter 5 suggested that capacity in the mega-regions will be increased only when the all the major players are empowered to solve the problem.

6.4.2 Suggestions Concerning Theme No. 4

In the following paragraphs, the research team identifies an example in which appropriate entities come together to develop a framework for demand management. The purpose of demand management as identified here is to limit delays that occur when the number of aircraft scheduled to arrive at an airport during a particular time exceeds the capacity of that airport. The most fundamental change required is that demand management be recognized as a legitimate alternative to capacity expansion as a means of ameliorating airport congestion problems. To carry out this vision, an example of a potential framework for demand management is outlined, with the following elements:

- Individual airport operators would have the primary responsibility for developing demand management programs that are appropriate for their local circumstances. These programs could potentially include a diversity of approaches and would require the removal of current constraints on the ability of airports to undertake demand management. In addition, the development and dissemination of knowledge concerning demand management methods could be encouraged.
- A set of critical-delay airports for which controlling delay is considered to be important would be defined. It is the research team's view that this set of airports would be smaller than the 35 airports currently identified in the OEP. Such airports could be provided with information on creating a demand management program. Demand management would be viewed as one of a wide range of strategies—including capacity expansion, development of alternative airports, and investments in alternative modes—to reduce delay. It is suggested that demand management be incorporated along with capacity expansion programs into the airport planning activities.
- Delay metrics for airports would be established, along with an accepted method of predicting delay from published airline schedules several months in advance. The metrics would define minimum levels of delay required for an airport to implement demand management and maximum levels of delay beyond which delay management is needed. Using the metrics and delay prediction method, airports

could be identified as eligible for demand management, and airports for which demand management is required.

Concerning guidance on airport demand management programs, a set of potential approaches could be identified. The airports would have the flexibility to choose a single or combination of methods to reduce delays. Two possible demand management actions are given as examples:

- Airports could levy a fee for use of the airfield. The most common proposal is a peak-period surcharge that applies to all flights regardless of size.
- Airports could assume the ability to manage demand through slot controls and setting operational caps at the airport. Airports could have substantial flexibility in establishing these caps, which should be established in a scientific manner and linked to delay thresholds.

Flexibility in using revenue from their demand management program could help incentivize the airport managers. The operator could have wide latitude in using the demand management funds to make airport improvements as well as certain off-airport expenditures that would contribute to alleviating delay.

The research team describes a number of options that could be considered to support such flexibility. These include redefinition of nondiscrimination across aeronautical users, cost recovery and revenue neutrality and setting operational limits.

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APPENDIX A

Airport Interviews and Technology Issues

Appendix A to the Report comprises three sections. Section A.1 presents a summary of what was learned in a series of detailed interviews with key technical managers at major airports in the two study areas, incorporating their views of constraints and the seriousness of the capacity problem over the next 20 years. Section A.2 includes a brief review of what might and might not be expected from the application of improved airspace management technology. Section A.3 reviews the concept that additional scheduled time for transfer movement would have a beneficial impact on spreading the peak movements at congested airports.

A.1 Issues of Capacity Limitation as Perceived at the Airport Level

A.1.1 Airport Interviews

The research team began by contacting the management of the busiest airports in the coastal metropolitan corridors. The planning staffs at those airports were interviewed to confirm the validity of the FACT 2 report and to obtain advice about current problems with congestion, the outlook for the future, and measures that might improve that outlook. Planners for 11 major airports were interviewed, through face-to-face meetings for 6 airports (JFK, LGA, EWR, IAD, DCA, and SFO) and telephone conversations for five (BWI, PHL, BOS, OAK, and LAX). The interviews ranged from 0.5 to 2 hours long. The interviews followed a standard format, but were flexible enough to allow airports to emphasize issues of local significance.

The airport representatives were asked about their experiences with regional transportation planning and their attitudes regarding the potential for expanded multimodal, multijurisdictional planning focused on short-haul passenger travel. Particular emphasis was placed on the airport's willingness to cooperate with regional and intercity rail operators.

This section of Appendix A summarizes the results of interviews conducted at each of 11 airports by the research team, first in terms of local views toward capacity and second in terms of other key issues brought up in the interviews. Table A.1 lists the location and dates of the interviews and the airport official(s) interviewed for each airport.

A.1.1.1 Boston Logan International Airport (BOS)

Primary Concerns. The research team identified limited land area and environmental issues as major constraints to expansion at BOS owing to the complexity and time requirements for environmental review of runway expansion. Congestion in New York airspace limits BOS operations to the south and east, and flights bound for New York are frequently delayed on the ground at BOS. These problems linger, even though passenger traffic between New York and BOS has been cut in half over the past 10 years by the introduction of competing air service at PVD and MHT and, more important, by very effective competition from Amtrak. (Hubbing is not a major issue, as airlines at BOS concentrate increasingly on direct flights and international growth.) The aviation planning manager interviewed for this study reported that BOS has not had to implement its demand management program because the trigger of a 15-min average delay during good weather conditions has not been reached, nor is it anticipated in the near term.

Other Research Findings. BOS is involved in regional transportation planning, as a permanent member of the MPO with a big interest in airport accessibility. The New England System Plan, initiated by the FAA in cooperation with the states and major transportation facility operators, has been very successful in promoting an effective regional system of airports. The regional plan has helped build confidence among investors and developers and provides a favorable context for local development decisions. According to interviews carried out by the research team, the governance of BOS by Massport has helped the transportation planning process because the airport is not unduly impeded by political interference and can proceed with planning in a businesslike manner. The regional planning process is now looking at issues such as

Table A.1. Airport interview list.

Airport	Date of Interview	Airport Official and Title
BOS	30 April 2008	Flavio Leo: Aviation Planning, Dept. of Aviation, Massachusetts Port Authority
JFK, LGA, and EWR	24 June 2008	William Radinson: Assistant Director of Capital Programs for Aviation Tom Bock: Assistant Director for Operational Enhancement Patty Clark: Senior Advisor to the Director of Aviation Ronnie Taste: Certified transportation planner Linda Bentz: Assistant Director of the Policy and Planning Department Richard Milhaven: Manager of the Aviation Department's Federal Aid Programs Gregory B.Wong: Policy analyst with the Policy and Planning Department Jeff Zupan: Senior research fellow with the Regional Planning Association; directing the Future of the NY Region Airports Study Richard Barrone: Researcher with the Regional Planning Association; working on the Future of the NY Region Airports Study Matt Lee: With Landrum & Brown, lead consultant on the Nine Airport Regional Air Service Demand Study
PHL	5 May 2008	Calvin M. Davenger, Jr.: Deputy Director of Aviation Planning & Environmental Stewardship Division of Aviation
BWI	6 May 2008	Wayne Schuster: Director, MAA—Office of Planning and Environmental Services
DCA and IAD	23 April 2008	William Lebergern: Manager, Planning Department, Office of Engineering
SFO	11 & 13 June 2008	Ivar Satero: Airport Deputy Director Danielle Rinsler: Director of Planning
OAK	10 June 2008	Kristi McKenney: Manager of Aviation Planning and Development
LAX	10 June 2008	Susan Collette: Supervisory Transportation Planner, LA World Airports

airspace use and bus/rail service. Interest in mass transit and rail is fairly high at BOS, partly because of the emerging concern about the carbon footprint of transportation systems.

A.1.1.2 Kennedy, LaGuardia, and Newark Airports (JFK, LGA, and EWR)

Primary Concerns. The New York region is unique in several ways, and on the basis of the research team's interviews, no single measure exists that will satisfy the region's requirements; consequently, a broad range of measures will be needed to meet emerging demands. The research team's findings of constraints at the three airports reflect this complexity:

- JFK, LGA, and EWR are all constrained by space limitations and environmental considerations;
- Airspace management issues constrain all three airports, owing to their proximity to one another and neighboring airports;
- Airline management issues affect the New York airports; and
- Legally enforceable policies, particularly restrictions on traffic management and rules limiting the use of airport revenues, limit the strategies that the PANYNJ can use to satisfy the demand for air travel.

Other Research Findings. As revealed in the interviews, no MPO or Councils of Government play a key role. The Regional Planning Association draws funds and support from public and private sources for ad hoc studies, but its influence is based on the usefulness of its products rather than from a statutory role. Regional planning is primarily done by the PANYNJ, often in cooperation with other agencies such as the NY DOT or the Delaware Valley Regional Planning Commission. The air transportation market is heavily concentrated, limiting the potential role of outlying supplementary airports.

The research team recorded evidence of frustration in two key areas. First, the local officials interviewed expressed concern that federal regulation of how airport funds can be used adds complexity and impedes efforts to maximize the role of rail. Rail already plays a large role in the region, with Amtrak diverting a large number of short-haul passengers from the airports—especially Boston, New York, and Washington, D.C. The team found no evidence that this increase in rail travel has led to reduced flight schedules accordingly.

During the interview, the PANYNJ staff presented their interpretation of the problems in the New York region. Although this view does not represent a complete summary of these complex issues, the interviews revealed their position that, despite extensive research and huge investments, there has been no increase in the throughput capacity of the runways at JFK, LGA, and EWR. Participants have seen the throughput reduced by 2–8 operations per hour at each airport over the past 10 years and the same schedule that was once handled in 14 hours now stretches to 16, costing airlines and travelers billions of dollars and exposing airport neighbors to late-night aircraft noise. Moreover, the gradual improvement of air traffic control (ATC) equipment has not increased runway throughput. Instead, the improved equipment is being used to enforce, ever more precisely, air traffic spacing rules that were developed decades ago when it was much less accurate and reliable. Those participating in the interviews believe that this may be the most important single issue for the New York region. The local participants stated their view that, until the new rules are developed that reflect the improved accuracy of the ATC system, the region will be subjected to billions of dollars in unnecessary travel delay and environmental degradation.

The research team found that landside improvements (e.g., terminal construction and ground access enhancements) are possible, and some airfield configuration changes may be studied in the future if improvements in ATC procedures provide a basis for them. NextGen should result in some relief to the airspace management issues identified, but NextGen must be translated into higher runway throughput if the region is to benefit substantially.

A.1.1.3 Philadelphia International Airport (PHL)

Primary Concerns. The research team determined that the expansion of PHL is very constrained by limited land area and environmental issues—for example, when adverse weather conditions severely reduce capacity. The current airport master plan is designed to work within those constraints to expand capacity, including the opening of a new runway.

Other Research Findings. According to interviews with the airport's deputy director of aviation, airlines are concerned that the New York and Washington air traffic affects the adequacy of airspace for operations at PHL. It is hoped that relief will come as new technology comes on line in the ATC system. The plans for airfield improvements and trends toward efficient airline schedules are expected to keep congestion within acceptable limits. The present requirement that congestion pricing be revenue neutral also limits the airport's interest in the subject. The airport participates in regional transportation planning, and the airport is connected to Amtrak by the Southeastern Pennsylvania Transportation Authority.

A.1.1.4 Baltimore Washington Thurgood Marshall International Airport (BWI)

Primary Concerns. The research team found that expansion of BWI will be constrained eventually by limited land area and environmental issues, but not before 2020. Local airspace management is generally adequate and free of serious constraints; however, airspace is a constant concern of airlines and could become a problem as activity increases at IAD and PHL.

Other Research Findings. Owing to frugal fiscal policies, airlines are slow to make improvements in tenant space. According to the interviews, a particular concern at BWI is in the baggage handling areas below the terminal that have been affected by baggage screening procedures. The space should be expanded and the flow streamlined, but the airlines do not want to make a major investment now. BWI is not currently affected by policies related to the use and allocation of capacity. BWI is accessible from a nearby rail station served by the Maryland Area Regional Commuter (MARC) and Amtrak. The airport is able to handle its projected growth without additional planning guidance and assistance. Although traffic is likely to grow at 1.5–2% annually, BWI probably will not become congested before 2020 or 2025.

A.1.1.5 Washington, D.C., Airports (DCA and IAD)

Primary Concerns. The research team found that DCA is very constrained by limited area and environmental issues. IAD, on the other hand, has adequate space and a more favorable environmental situation, but the environmental review and approval process for improvements is still very lengthy. Airspace management is a continuing issue for IAD: one concern is military airspace set aside for Quantico to the south of the airport. Airspace at DCA is less of a concern because traffic levels are more constant.

Other Research Findings. The team also found that airline policies on aircraft size and hubbing affect the airports but are viewed by airport staff as customer requirements that need to be accommodated. DCA is heavily affected by slot limits and limits on long-distance flights; IAD has a sharp peak in international departures because of curfews at major European airports. Regional planning has not addressed reliever airport issues. An effective regional planning effort aimed at reducing airport congestion was the airspace planning for the Potomac TRACON, which was conducted by the FAA. The team noted that although DCA is relatively close to Amtrak, and improved connectivity could be achieved with a large investment, the airlines would insist that Amtrak make an appropriate payment to the airport budget if it were to use airport facilities.

A.1.1.6 San Francisco International Airport (SFO)

Primary Concerns. The research team found that SFO is heavily impacted by limited space and environmental constraints. Space is limited and any major runway improvement would involve filling in a portion of the Bay. Although the long-term impact on the Bay might not be significant, community concern about airport development is a very large political issue.

Other Research Findings. SFO officials interviewed for this study reported that airspace is adequate for current operations, but SFO and other West Coast airports are disproportionately affected by flow control measures such as ground holds. The use of regional jets aggravates runway congestion at SFO, but the airport is less dependent on airline approval of policies and investments than most other airports because it has few airline-funded facilities. The emphasis on common-use facilities will continue in the future. SFO would like to have more authority to manage demand on the runways, particularly during bad weather conditions. The airport is participating in a Bay Area regional planning study and also supported the recent referendum on HSR. The research team's findings reflect a sense that local solutions to airport congestion can be crafted, but the federal government must be supportive. SFO's issues are thought to be significantly different from those of New York or Boston, so solutions must be tailored at the local level.

A.1.1.7 Oakland International Airport (OAK)

Primary Concerns. As OAK is a single-runway airport, it is not surprising that the research team found OAK to be highly constrained by limited area and environmental issues. Those interviewed took the position that a new runway is warranted by traffic levels, but would probably have to be built in the bay on fill at an extraordinarily high cost. A location on solid ground is possible but would result in public opposition because of noise impact.

Other Research Findings. Airspace management is not a major issue for OAK in its current configuration, but SFO does appear to take priority in some weather conditions. The airport does not have much regional-jet traffic. However, it does have a sharp peak in traffic during the morning departure push, which is common at West Coast airports. The research team reported that airline financial problems have curtailed capital spending at OAK and other airports and will be a major constraint to any large capital programs in the future. The authority to manage air traffic demand would be helpful at OAK, if only by providing greater flexibility to management. OAK is now involved, together with San Jose (SJO) and SFO, in a regional planning study with the technical work done by the Oakland MPO. The study will address the aviation capacity needs of the Bay Area and may recommend improvements.

A.1.1.8 Los Angeles International Airport (LAX)

Primary Concerns. In interviews with the supervisory transportation planner for LAX, it was reported that the airport is impacted by limited space and environmental constraints. The airport is heavily constrained on the landside, with aging terminals, congested access roads, and noise-sensitive communities and needs to be modernized. Space is limited, but there is room for midfield terminal expansion and runway redevelopment to provide more space for new large aircraft. Community concern about airport development is a very large political issue.

Other Research Findings. In contrast to most other airports where the research team conducted interviews, airspace at LAX is adequate for current operations. Capacity at the airport is limited by a cap of 89 million air passengers annually, which is a locally imposed ceiling on the future use of the airport. Diverse patterns of use by airlines, however, are a challenge. Interview results suggest that a significant portion of LAX runway capacity is used for short-haul flights, some of which may be handled by a future HSR system. Frequent flights by commuter aircraft and regional jets account for much of the air traffic at LAX. (Los Angeles maintains good alternative airports for general aviation, so general aviation does not use LAX.)

A.1.2 Lessons and Issues Raised in the Local Interviews

By design, much of the content of the interviews concerned local conditions and local interpretations, as summarized in sections A.1.1.1 to A.1.1.8 above. In addition, the research team explored many common themes that emerged from the interviews, as summarized here by subject area.

A.1.2.1 Local Perception of the Accuracy of the FACT-2 Report

The FACT 2 report, released by the FAA in 2007, was prepared by the FAA in cooperation with the MITRE Corp. and coordinated with airport managers when the final report was in draft form. However, the interviews showed that only a few representatives of airport management were fully aware of the report. The general sense of airport planners is that the FACT 2 report was accurate in its summary of the outlook for airport congestion (i.e., worsening problems at the busiest airports in the East and West Coast corridors through the foreseeable future). However, several current efforts that were not reflected in the FACT 2 analysis could reduce the severity of congestion.

A major new runway has been proposed for PHL to allow the airport to operate two runways at full potential during most weather conditions, greatly increasing the airport's capacity during instrument weather conditions. An analysis of the environmental impact of the proposed runway is underway and is expected to be completed in 2010. On the basis of the criteria used by FACT 2 for inclusion in the assumed capacity increases, the PHL runway was not included. Thus, congestion at a future PHL airport might be somewhat lower than that reported in FACT 2.

An airspace redesign effort is underway in the New York area, and it has the potential to improve the efficiency of the three major airports. The airspace redesign was not addressed by FACT 2, nor were the potential benefits factored into the report's conclusions. In addition, there is an ongoing effort at the national level to develop slot allocation procedures for use at the New York airports. Officials of the PANYNJ believe that well-designed procedures could play a key role in controlling congestion and delay, but they disagree with the approach that has been proposed over the past few years. They prefer schedule coordination procedures similar to those already in use in other countries, developed by the IATA, as better suited to the New York airports.

A regional airport system planning effort is underway in the Bay Area to address issues related to the distribution of traffic among the three major airports (SFO, OAK, and SJO); the potential to add traffic to other existing airports, construct a new airport, or add a new runway to an existing airport; and the prospects for some form of demand management to bring airline schedules into conformity with airfield capacity. The planning effort is in the early stages and, although participants are optimistic, major results are probably 5–10 years away.

A.1.2.2 Reduction of Airline Schedules

More significant to the near-term outlook is the combined effect of a struggling economy and substantial increases in fuel costs, which pose a threat to the financial viability of U.S. airlines. The airline reaction is still emerging, but major themes include de-emphasis of small aircraft—particularly regional jets—elimination of marginally profitable routes, retirement of inefficient aircraft, and downsizing of personnel rosters. These measures are likely to relieve runway congestion by reducing the number of flights and increasing the average number of passengers per aircraft operation, in effect up-gauging the airline fleets using congested airports.

Another likely effect of high fuel costs and a sluggish economy will be slower growth in demand, probably lagging well behind current FAA forecasts for at least the next 5 years. Slow growth could extend the time frame for some airport improvement programs.

The long-term outlook is muddied by the great difficulty that airlines are having with fuel costs, which approximately doubled in the 12 months before the interviews and then swung downward in the period after the interviews. The uncertain situation is not favorable to short flights by small aircraft, because these consume the most fuel per passenger mile flown. There is some possibility that, in the long term, high fuel costs may cause a sea change in the business model for commercial aviation, reversing the emphasis on stimulating growth by lowering cost that has dominated the industry since deregulation.

A.1.2.3 Airport Perspective on Congestion

The issue of air traffic congestion and delay is sometimes summarized at the national level as the simple prospect of impending gridlock in the sky. However, airport operators see a much more complicated situation, in which factors such as technology, government policy, economic growth, traveler preferences, market forces, finance, and local politics interact to influence the ability of an airport to perform at an acceptable level. Within this framework, congestion is viewed not as a looming disaster but rather an ongoing challenge that requires a multifaceted strategy that is technically feasible, affordable, politically acceptable, and flexible. Many of the planners who were interviewed addressed demand as a market force that is not entirely predictable. This is somewhat different from an alternative viewpoint, which envisions a steady growth in scheduled traffic, without regard to delay, until gridlock occurs. The airport planners emphasized the uncertainty that is inherent in forecasts of demand. All have had experience with some degree of congestion and high delay, particularly during extended periods of adverse weather. However, none of them spoke in terms of gridlock, and none foresaw a future in which all options to enhance capacity would be exhausted.

A.1.2.4 Financial Capability of Airports

Historically, the busiest airports have been able to draw on a variety of funding sources for capital improvements, including grants, passenger facility charges, and bonds. The busiest airports have been able to maintain excellent credit ratings even during periods of economic hard times for the airlines. However, the current financial crisis within the airline industry is clearly having an effect on airports. There is increased emphasis on revenue generation by airports and ongoing efforts to reduce costs.

Many airports indicated that airlines have become frugal and are reluctant to make improvements within leased areas, and some report that airlines may be neglecting expensive maintenance—for example, on baggage conveyor systems. The extent of these frugal policies varies, depending on the type of agreement an airport has with its tenants. Airports with primarily common-use gate and ticket counter areas, such as SFO, are less affected than airports where individual airlines have exclusive use of terminals. Another effect of frugal airline budgets is to delay ongoing capital improvement programs. For example, the pace of midfield terminal development at IAD would be slowed if the major tenant is forced to curtail spending. The regional planning effort in the Bay Area is in part a recognition that a new runway at SFO or OAK is likely to be too expensive in the future for a single airport to finance.

A.1.2.5 Interaction with Rail

Airport access is primarily by automobile, which provides a large part of airport revenues through parking lot and car rental fees. However, major airports tend to support linkages to regional rail systems wherever possible, despite high development costs. DCA has incorporated Metro rail into the terminal complex. BWI, PHL, EWR, BOS, JFK, SFO, and OAK have convenient links, typically by dedicated bus or people mover. Metro rail service to IAD is currently being designed. The most notable obstacle to effective rail links has been high cost, which can be subsidized by the airport only under certain conditions because of federal restrictions on the use of airport revenues for non-aviation purposes. Convenient connections are also provided to Amtrak at BWI, PHL, and EWR.

The PANYNJ has met and exchanged data with Amtrak regarding Boston and Washington service and discussed the need for more rail capacity in those markets. The enormous shift of travelers from aviation to Amtrak was the result of faster and more comfortable train sets and the additional time required by aviation security procedures enacted since 9/11/2001. The PANYNJ believes that the shift is long term and is unlikely to be reversed by faster security procedures. It is interesting to note that, while Amtrak's share of the Boston–NYC market has risen to over 50%—with a corresponding reduction in passengers at Boston and New York airports—the number of scheduled flights in those markets has not been significantly reduced. It appears that flight frequency in dense, short-haul markets is not always closely linked to passenger volume, as discussed in Chapter 2 of the Report.

On the West Coast, the director of SFO is a prominent supporter of a proposal to develop an HSR system to link major cities in California. The eventual benefit would be to give short-haul travelers the option of using rail, freeing airport space for long-haul passengers. The current thinking would locate the rail stations in densely populated areas, and airports would be linked to them by regional rail.

A.1.2.6 Involvement in Regional Planning through MPOs

A powerful regional transportation planning process is a mandatory aspect of federal aid for surface transportation in major metropolitan areas. However, the mandate does not extend to aviation, with the result that airport involvement in regional planning varies from city to city.

Only a handful of the nation's MPOs (notably Washington, D.C., Philadelphia, St. Louis, and Southern California) have been able to maintain a staff specialist dedicated to aviation issues, and only one (Washington, D.C.) receives a steady and reliable stream of federal aid to support aviation activities. In the Washington metro area, ongoing activities include forecasting and passenger surveys. The development of effective reliever airports to serve general aviation has been an important activity in Philadelphia and St. Louis. In Southern California, numerous studies have been undertaken, including airspace utilization and potential sites for new airports.

The amount of cooperation and coordination between the planning staff of major airports and MPOs depends largely on the activities the MPO has underway. The broadest and best defined relationship is in the Washington, D.C., area, where three major airports (IAD, DCA, and BWI) draw on the MPO for passenger survey data, forecasts, and support in airport ground access analysis. The airports are pleased with the arrangement and rely on the data as a sound basis for planning. The more typical arrangement, however, is an annual meeting of the airport and MPO staff, with briefings on current activities and surface transportation plans.

A.1.2.7 Ad Hoc Regional Planning

Many major airports have been or are now involved in regional planning efforts on an ad hoc basis, addressing issues that extend beyond their immediate service areas. A notable example is the New England Regional Airport System Plan, sponsored by the FAA and a coalition of 6 states and 11 airports. The study included a detailed analysis of the passenger forecasts, origins and destinations, and passenger preferences when deciding which airport to use. The resulting plan recognizes that BOS alone cannot meet the regional demand for air transportation, but the demand can be met by the 11-airport system, at least through 2020, provided appropriate improvements are made.

The regional approach was bolstered by the introduction of additional service by one national carrier to MHT, PVD, and Bradley. The regional concept has been very successful in New England. During the period 1996–1999, about 75% of increased passenger movements in the region occurred at regional airports rather than at BOS. Observers note that the regional concept was carefully tailored to the New England environment, where air travel is 80% higher than the national average and a number of large regional airports are surrounded by viable air transportation markets.

The PANYNJ undertook an inventory and forecast for the eight-airport system around the New York region, including Westchester County Airport, Islip, and Trenton. The findings indicate that demand for air transportation is heavily concentrated in the central core of the area, particularly within the limits of New York City, and this will limit the potential utility of outlying airports. However, the PANYNJ did take a leasehold interest in Stewart Airport and intends to improve it to draw air travelers from the surrounding area.

The regional study now underway in the Bay Area, involving the airport operators at SFO, OAK, and SJO, is another example of a regional strategy. This study reflects the unwillingness and perhaps the inability of the individual airports to undertake major improvements such as new runways without a regional consensus that the development is warranted and preferable to any alternatives.

A.1.2.8 Conclusions from the Airport Interviews

Major airports in the East and West Coast corridors are concerned about issues related to accommodating future demand for travel with an acceptable level of service.

The most difficult aspect is providing adequate runway capacity to meet forecast increases in aircraft operations. Improved ATC technology, presented by the FAA as the NextGen ATC system, is expected to increase the rate at which aircraft can land on runways. This improvement was included in the analysis for the FACT-2 Report and, while significant, it is not adequate to keep pace with rising demand. The biggest gains are likely to be enjoyed during instrument weather at airports, such as PHL, EWR, and SFO, which are currently unable to use their closely spaced parallel runways efficiently.

NextGen should permit aircraft to continue to use visual spacing rules even during instrument weather conditions. However, some airport managers interviewed are skeptical about the ability to translate technical advances into higher landing rates in a timely manner. New York area airport managers expressed the position that improvements to date have been used to monitor controller conformance to existing rules with greater precision, resulting in a decline in the number of aircraft that can be landed in a given amount of time. In this view, the eventual benefit of NextGen may be to greatly reduce the delays that are now encountered when adverse weather reduces runway capacity, but only permit the addition of a few flights during the visual flight rule weather that occurs more than 90% of the time.

Additional runways are under construction at IAD, where provision was made for them in the initial airport master plan. Runways will be very difficult to build at other airports where space is limited. LAX will pursue a runway relocation to expedite operations by very large aircraft for the purpose of reducing runway incursions, an important safety consideration. SFO has stopped the analysis of the environmental impact of a new runway, looking to a regional study for advice about future requirements and options. PHL has an environmental analysis underway for a new runway, but the results will not be known for several years. The outlook for new runways in general is particularly gloomy owing to high construction cost estimates and the weak financial condition of the airline industry.

Ground access and terminal buildings are also concerns, but these face fewer local political problems than new runways. The major obstacle they will face in the near term is apt to be financial.

Multimodal activities are often undertaken by major airports. Linkages to regional rail and connections to Amtrak, typically via a dedicated people mover, are common. On the West Coast, SFO is a major supporter of HSR proposed for service between major cities in California.

Major airports are not heavily involved with metropolitan planning agencies, which are a mandatory part of the federal funding process for federal aid to surface transportation. The coordination between airports and regional planning organizations depends greatly on whether the planning agency maintains a specialist in aviation and on the studies that are currently underway.

Some large airports are involved in ad hoc regional planning, including those in Boston, New York, and San Francisco. These studies are typically undertaken by the airport in cooperation with the FAA. The studies are multijurisdictional and extend beyond the airport service area. The purpose of the studies and the composition of sponsoring agencies vary from city to city.

A.2 Considerations about Airspace Limitations

A.2.1 Defining the Issues of Airspace Constraint

There are two different types of airspace constraints affecting airports in the study areas, each with somewhat different possible solutions: (a) deficiencies in individual airport capacity and (b) regional airspace interactions that prevent realization of individual airport capacity.

A.2.1.1 At the Airport Level

The most common and commonly recognized form of airspace constraint is the lack of capacity at the individual airport level, particularly at OD airports in the study regions.[1] Individual airports' lack of capacity most often manifests itself with high levels of delay during instrument meteorological conditions, when ATC procedures reduce the airport acceptance rate to below the scheduled levels. However, in some cases, such as what occurred in SFO in the summer of 2000 or at LGA in the summer of 2001, airport capacity can be exceeded even in good weather by unconstrained airline scheduling practices. Looking to a future that might require substantial increases in the number of aircraft operations needed to satisfy passenger demand, as is assumed by the NextGen program, this lack of individual airport capacity could pose a serious constraint at an increasing number of airports in the study areas.

The solutions to individual airport capacity limitations range from the construction of new runways, to improved air traffic procedures, to increased use of regional airports, to NextGen[2] technology improvements, to rational congestion management techniques that limit excessive scheduled activity. The difficulty of constructing new runways at the critical airports in the study areas is well known and is unlikely to prevent the addition of significant capacity at the critical study area airports. However, one advanced NextGen operational improvement being considered might permit instrument approaches to runways more closely spaced than today's technologies allow and could open the possibility of "infill" runways constructed between existing runways at some of the study area airports.

Improved air traffic procedures also hold significant potential. As an example, the New York Airspace Aviation Rulemaking Committee recommended initiation of mixed arrival/departure operations on EWR's two runways, which had been traditionally operated for only arrival or departure operations. This initiative is being pursued and represents a class of potential improvement to other idiosyncratic ATC procedures that limit capacity at study area airports. Increased use of regional airports has been well demonstrated in New England (BOS, MHT, PVD), and holds promise in other study areas, provided that regional air traffic capacity can support the increased traffic at secondary airports and environmental considerations do not preclude development of regional airports.

Other NextGen technologies also offer a broad promise of improving capacity, but the program is dealing with the inability to translate the theoretical promise of technologies like Automatic Dependent Surveillance–Broadcast (ADS–B) to benefits that airlines can realistically use. A telling example of this challenge is the ADS–B/OUT system that is currently being procured. That initial system provides surveillance performance similar to existing radar systems, requires that aircraft be equipped with the Wide Area Augmentation System (WAAS) that few airlines are planning to install,[3] cannot support approaches to runways spaced more closely than today's 4,300-ft limitation, and, in its present form, will not improve the capacity of constrained airports. Finally, the use of congestion management tools to maximize capacity and stimulate up-gauging at congested airports is being actively pursued, but it is highly controversial and may not be politically viable. Sections 5.3 and 5.4 of this Report address the issues of up-gauging and congestion management.

The existence of multiple airports in the mega-regions included in this study complicates the efficient use of terminal airspace. Airspace separation standards currently in use in these regions' terminal airspace were developed at a time when navigation and surveillance accuracies were primitive compared with current capabilities. In many instances, these regions must also deal with the existence of military airspace in close proximity to terminal airspace. The mega-region airports are also affected by the heavy traffic occurring in the en route environment that often limits the amount of traffic that en route sectors can accommodate from these airports. The application of Required Navigational Performance (RNP) technologies has potential to relieve these constraints.

A.2.1.2 Constraint from Conflicting Interactions

The second type of constraint in the study area is caused by conflicting interactions between airspace used to support multiple airports or military users in a given region. Within a given terminal area serving a metropolitan area, the airspace required under today's rules to ensure safe operations is large and overlaps between the surfaces needed to protect operations at one airport sometimes preclude the use of certain runways at other regional airports. This problem is currently most severe in the New York area, but exists to a lesser extent in other metropolitan areas.

At other locations, the requirements of the military have similar impacts on regional air traffic. The corridors leading into and out of Southern California and the offshore airspace in the Northeast are currently affected by the static nature of military airspace, which precludes its use by civil aviation, even when it is not actively being used by military exercises. In their most extreme manifestation, both of these types of regional airspace conflicts severely impede the delivery of

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[1] Interconnecting hub airport congestion is discussed in Section 1.3 of the Report.

[2] It should be noted that the full NextGen program includes the domain of air traffic, aircraft, and airports. The analysis contained in this section, however, deals primarily with those aspects impacting capacity and congestion.

[3] Major air carriers are reacting to FAA plans that envision WAAS as primarily of use by general aviation aircraft operating into small airports with no ground-based precision landing systems. The plan provided for development of a higher precision Local Area Augmentation System (LAAS) to be used by major airlines at larger commercial service airports. LAAS development is currently on hold.

aircraft to some critical airports, effectively resulting in an inability to use the existing regional runway capacity. Similar constraints exist in transitional en route airspace near the congested terminal areas, when departures from regional airports cannot be inserted into the overhead traffic flows because of nearby sector saturation.

Traditional solutions to this regional airspace congestion involve redesigning the airspace to provide additional routes and fixes. However, this is a painfully slow process, and environmental controversies stemming from new routings have the potential to limit their applicability.[4] As with individual airport capacity problems, NextGen technologies can greatly reduce the volume of airspace needed to protect approaches to airports and can permit simultaneous operations to different airports in high-density terminal airspace. However, as with the impact of NextGen on individual airports, it is unclear whether the actual delivery of those capabilities will be achieved or that air carriers will make the necessary investments in aircraft systems to support the NextGen technologies.

Airspace and ATC constraints affect the study area airports to varying degrees. Most of the major airports in the mega-regions either currently suffer from some degree of individual airport capacity constraint or are likely to under the NextGen traffic assumptions. Several of the major metroplexes also suffer regional airspace congestion that threatens to limit the ability of the en route ATC system to feed or accept traffic from study area airports. Traditional capacity enhancements such as adding runways or traditional navaids at major airports; airspace redesign; and adoption of simple overlay Area Navigation (RNAV), RNP, or WAAS procedures are unlikely to provide significant relief at the congested airports. Further development of regional airports in the mega-regions, while holding promise, is threatened by regional airspace conflicts. Innovative procedures supported by advanced NextGen technologies hold the promise of providing substantial capacity increases—both at the individual airport and at the regional level—but some leaders in the aviation community believe that the timing of their delivery is somewhat uncertain at present. In short, for purposes of this study, it is not clear at this point whether the airspace and air traffic capacity in the mega-regions will be capable of accommodating the anticipated demand.

A.2.1.3 Candidate Technologies for Application

A number of ATC programs and new technologies show promise to help ease congestion at some mega-region airports, including RNAV, RNP, ADS–B, and airspace redesign.

Around 80% of commercial aircraft are now equipped with RNAV and RNP avionics capability. RNAV increases the number of departure routes, allowing controllers to disperse aircraft more efficiently. The benefits of the use of RNAV departures to reduce terminal area inefficiency are being seen in some major airports (e.g., Dallas/Fort Worth and Atlanta Hartsfield), and such use of airplane capability is slowly increasing. As airplanes get close to the runway, airport throughput in today's system is often constrained by visibility and cloud ceiling conditions. The availability of runway configurations and separation standards on final approach is dependent on weather conditions—that is, visual meteorological conditions (VMC), marginal VMC, or instrument meteorological conditions (IMC). The result is that when weather conditions deteriorate, runway configurations are limited and in-trail separations between airplanes are increased, reducing throughput substantially in some cases. This problem is compounded when controllers are operating arrivals with mixed-weight categories, since IMC-based separations may be substantially larger than those during VMC to avoid wake vortex encounters between heavier leading and lighter trailing airplanes. Many of the problems associated with dependent operations on closely spaced parallel, crossing, and converging runways could be reduced by the development and use of alternate procedures that enable operations in lower ceiling and visibility conditions.

RNP builds on RNAV, allowing pilots to use more precise navigation upon arrival and departure. RNP is essentially RNAV with the addition of an onboard monitoring and alerting function. New procedures enabled by these capabilities should be implemented in the near future, with emphasis on arrivals and departures between airports near each other, including EWR, JFK, and LGA. RNP permits controllers to sequence aircraft further out from the airports, where there is more space to do so. This makes the flow of air traffic more efficient, even in bad weather.

ADS–B is a backbone of NextGen. It is a satellite-based technology that broadcasts aircraft identification, position, and speed with once-per-second updates (as compared with the current 5- to 12-second refresh from today's radar). Although a time savings of 4–11 seconds may seem brief, this savings actually allows for far greater accuracy in determining aircraft position. PHL, which has been selected as an initial key site for the installation of ADS–B, is scheduled to have coverage both in terminal airspace and on the airport surface by February 2010.

ADS–B technology allows time-critical information to be sent from air traffic managers to aircraft digitally rather than through voice-only analog means. ADS–B is to be implemented nationwide by the end of 2010. It holds the promise of providing more precise aircraft position information than radar and allows aircraft safely to fly closer together, increasing

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[4] The recent NYC area airspace redesign has prompted vigorous opposition by congressional delegations in New Jersey and Connecticut. It is unclear what effect this opposition will have on the ultimate adoption of the redesigned procedures.

capacity. However, as mentioned earlier, the actual in-service accomplishment of these higher precision capabilities remains uncertain.

The New York Airspace Redesign Project, currently underway, is intended to address congestion and delay in the New York/New Jersey/Philadelphia area. The project's goal is to enhance the efficiency and reliability of the airspace structure and the ATC system for pilots, airlines, and the traveling public, while laying a foundation for NextGen. Implementation of this project will be able to use procedures like RNAV and RNP. For example, only a few miles separate the streams of arrivals at EWR and LGA. Southbound LGA departures are "climbed over" EWR arrivals and the approach path to LGA can depend in part on runway use at JFK; this represents only a fraction of the activity. This interdependency means that PHL departures are frequently delayed because of volume in New York. With Philadelphia and New York airspace so interdependent, technologies deployed in one airport in the region will have a beneficial "cascade" effect on the others. Thus, deployment of technology and other solutions at JFK should reduce congestion and result in fewer delays at PHL.

One feature of the redesign effort is the "terminalization" of the airspace. The project expands the terminal airspace over a larger geographical area than is currently designated and expands it vertically up to 23,000 ft. above mean sea level in some areas. Upon project implementation, some airspace sectors that are currently worked in the en route or center environment will be worked using terminal rules and equipment. Expanding the terminal airspace permits air traffic control to use terminal separation rules as well as the more flexible terminal holding rules over a larger area. This improved flexibility should make traffic flow more efficient, even in poor weather conditions.

A.2.1.4 Capacity Impact Assessment

Some work is taking place to assess the expected benefits of the new concepts and technologies that NextGen comprises. The Boeing Commercial Airplane Company has assessed one of the NextGen technologies, and the DOT's Joint Planning and Development Office (JPDO) is currently developing an assessment that is still preliminary.

In 2006, Boeing assessed the implementation of RNP by performing a model-based benefits assessment for airports and airspace in the U.S. National Airspace System (NAS). The primary outputs of the model, Boeing's National Flow Model, are annualized delay across the NAS and sector-loading metrics. Delays tied to airport capacity constraints in all visibility conditions as well as airspace constraints due to air traffic sector workload were assessed.

The results indicate that, at an average system-wide level, RNP implementation would be adequate to enable traffic growth at least through 2010 and would reduce predicted system-wide delays by about 50% by 2020. Boeing staff believes that most improvements will be in the form of efficiency benefits to reduce fuel cost and emissions with some capacity benefits. The goal is to increase operational predictability, thus increasing efficiency. This should benefit chronically overloaded sectors such as those in the Cleveland center and sectors along the path between the LA area and the Northeast.

Boeing provided a caveat on its sector capacity analysis by noting that the quantification of sector capacity is controversial because there is yet no reliable and commonly accepted metric for this parameter. To get some sort of estimate of growth in sector capacity, Boeing held discussions with FAA staff about the extent to which sector capacity has increased due to adoption of another procedural improvement, Reduced Vertical Separation Minima (RVSM), a few years ago. Implementation of RVSM increased overall sector capacity on the order of 15% as a system-wide average according to FAA staff. Boeing used this estimate as a basis for its model-based estimate of the growth in sector capacity resulting from implementation of RNP. As a result of basing its modeling on an estimate, Boeing considers its model results to be a very preliminary assessment based on the only available sector capacity metric for the NAS. Further work would have to be done on human performance modeling to develop more confidence in these results.

The computer simulation modeling experts detailed to the JPDO office have been able to model today's national airspace system performance. They are still working up NextGen benefits and report having more work to do. It is proving difficult to translate surface operational improvements into the system model because many objectives do not lend themselves to being modeled. For example, some objectives are of the form, "Improve the efficiency of X," or, "Reduce inefficiency in Y." The problem is there is no information on what the baseline state is relative to efficiency/inefficiency, so there is nothing to track against to calculate the benefit. Thus, about half of the NextGen operational improvements have not yet been modeled because of lack of specificity.

It is difficult to cite the overall benefits of NextGen because many are airport specific. However, preliminary work conducted thus far indicates that full implementation of NextGen has the potential to eliminate the gap between VMC and IMC operations at many airports. However, since airlines typically schedule to near the VMC capacity of airports, reducing this gap has the potential to reduce delays, but not to materially increase capacity in VMC weather.

Table A.2. Study airports and their airspace constraints.

Boston Logan—Proximity to other airports and to heavy-traffic sectors
Kennedy—Proximity to other airports
La Guardia—Proximity to other airports
Newark—Proximity to other airports
Philadelphia—Proximity to other airports and to heavy-traffic sectors
Baltimore—Proximity to other airports
Washington National—Proximity to other airports
Washington Dulles—Proximity to other airports and to military-controlled airspace
San Francisco—Proximity to other airports
Oakland—Proximity to other airports
Los Angeles—Proximity to other airports and to heavy-traffic sectors
San Diego—Proximity to heavy-traffic sectors

A.2.2 Airspace Constraints at Study Airports

The primary airspace constraints affecting airport capacity are proximity to other airports, controlled/reserved military airspace, and heavy-traffic sectors. These are summarized in Table A.2.

A.3 Constraints Due to Airline Practices: Hubbing Congestion

Sections A.3 and A.4 review the basic logic of getting the airlines to cooperate in programs to gain more productivity out of a given amount of runway capacity, focusing on the concept of achieving more throughput through the use of larger aircraft and decreased use of smaller aircraft. For any given number of slots, or opportunities for take-off and landing, the size of the aircraft will determine the throughput of the airport (assuming the ground-side terminals are prepared for the increase in passenger volumes).

This section of Appendix A examines two cases in which airline operational strategy influences the capacity of the airport, usually above and beyond the control of the airport management, or even the FAA and examines the airport congestion implications of the assumption that all flights need to arrive and depart in a minimized time envelope. Rather, work undertaken recently by members of the research team, in cooperation with a major European airline and the Massachusetts Institute of Technology (MIT), suggests that the air traveler places value on the reliability of the plane-to-plane connection as much as the time-minimization of that transfer.

A.3.1 Effects of Air Carrier Hubbing on Airport Peaking

Although air carriers in practice operate using different competitive strategies for constructing optimal flight schedules, the use of hub airports suggests that carriers will try to match arrival and departure schedules so as to minimize passengers' connect times. As hub airports in the coastal mega-regions also serve passengers with local origins and destinations, flight schedules at these airports typically exhibit AM and PM peaking patterns that correspond to the peak demands of both local and connecting passengers. When carriers try to match arriving and departing flights in these peaks in a way that minimizes connect times, the peaks can be exacerbated.

A recent research project undertaken at MIT was designed to determine whether passengers in fact seek to minimize connect times in itineraries that involve connects at hub airports.[5] The hypothesis developed by the research team was that air passengers have a more complicated preference structure that includes several other factors and that, in particular, involves a non-monotonic relationship between connect times and "utility," or desirability, of an itinerary. Airport/airline minimum connect times are set in a way that in theory provides both (a) a reasonable time margin to allow passengers to deplane, move between gates, and board a connecting flight and (b) time for baggage for connecting passengers to move similarly between the arriving and departing flight. Further, these minimum connect times presumably allow for some level of delay in the arriving flight.

However, the minimum connect times do not explicitly represent the dimensions of passenger preferences beyond scheduled itinerary time minimization. The MIT research hypothesized that at least some passengers might actually prefer longer scheduled connect times to accommodate (a) risk averseness to missed connections and (b) activities such as eating and checking email. This potential attractiveness of addi-

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[5] Theis, G., et al. "Risk Averseness Regarding Short Connections in Airline Itinerary Choice," *Transportation Research Record 1951,* Transportation Research Board, National Research Council, Washington, D.C., 2006.

tional buffer time for transfer movement could offset the negative consequences of longer average itinerary times.

Figure A.1 illustrates three components of an air passenger's utility that could be affected by scheduled connect times. The "value of time" represents the cost that passengers associate with each minute of additional itinerary time. This can be offset in part by the perceived (and actual) increase in likelihood for a successful transfer with longer connect times. The final element, here labeled "Rush," may associate positive benefits to some additional amount of time available for eating, checking email, and so on during the transfer. When these elements are added together, the result is a shape that potentially has increasing utility (benefit) for some additional amount of time above the minimum connect time, flattens off, and then turns down as the value of additional time in the airport ends and the value of travel time component dominates. This shape implies that connecting times greater than the published minimum connect times are preferred by air travelers.

Within the coastal mega-regions, the minimum connect times for domestic-to-domestic transfers range from 30 min. (e.g., BOS) to 60 min. (e.g., JFK, EWR). Carriers will create itineraries that respect these minimum connect times, but these times do not always avoid missed connections, nor do they represent the amount of time that passengers will have to accommodate personal activities within the airport. During the peak periods and at the busiest hub airports, much of that connect time could be consumed by flight delays. As a result, knowledgeable air travelers whose itineraries require connections may well prefer itineraries with connections that are longer than the specified airport/carrier minimum connect times.

Many factors are confounded in data on actual travel patterns that are available through sources such as the DOT's DB1B 10% ticket sample and booking records from global distribution systems in the form of MIDT (Market Information Data Transfer) files. As a result, the MIT team chose to use a primary survey research approach to address the issue of whether and by how much connect times could be increased to best suit air passengers. A survey instrument was developed to address the research issue. That instrument included detailed questions about U.S. air passengers' most recent domestic air trips and a set of stated preference (also known as choice-based conjoint) questions that explored the effects of different connect times on passengers' likely behavior for a given trip. The survey was administered to more than 800 air passengers, and the results were used to develop discrete choice models of passengers' itinerary choices.

A.3.2 Findings: Delays Associated with Hubbing Connect Times

The findings of this research were that, on average, itineraries having additional connect times of up to 15 min. above the minimums were associated with increasing utilities (attractiveness) on the basis of the rush factor alone. Increasing connect times to reduce the likelihood of missed connections could further increase the passenger-perceived optimal connect time, especially during peak periods at busy hub airports. While this finding is not especially surprising in retrospect, the possibility of this type of result had not been previously theorized nor had any similar empirical work been previously reported.

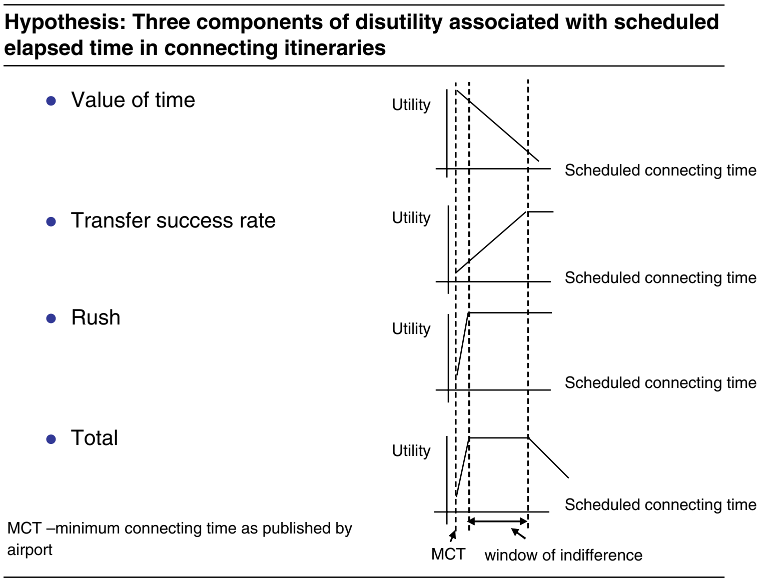

Figure A.1. Diagram showing how components of air passenger's utility potentially affected by scheduled connect times (from Adler, Clark, and Ben-Akiva; 2006).

Were air carriers to accept the notion that longer connect times might indeed be preferred by passengers, and given the operational costs associated with trying to maintain short connection times, it is possible that carriers could use this additional information to de-peak their schedules to some extent and thus relieve some of the peak congestion. However, given the natural tendency of travelers to prefer certain arrival and departure times and the fact that a major portion of traffic at the major airports in the coastal mega-region has local origins or destinations, this adjustment by itself would be unlikely to eliminate peak congestion at these airports.

The magnitude of the effects of delayed flights, both on passengers and on carriers, should constitute a strong incentive to address at least one of the root causes: congestion caused by flight schedules that approach or exceed airport capacity. Most experienced travelers are well aware of the locations and patterns of flight delays from their own personal experience and may further inform themselves using information from the numerous on-line sites that offer both historical and real-time flight performance data.[6] However, the less-experienced air travelers, who constitute the majority in most air markets, do not necessarily apply similar knowledge when choosing among alternative travel itineraries. Virtually none of the major consumer-oriented online booking sites provide on-time performance information for the flight itineraries that they create. As a result, a flight during a peak period with very low on-time performance will, in advance, appear undifferentiated from other flights with higher on-time performance.

Although carriers' yield management policies might result in higher fares for peak-period flights as a result of higher demands during those periods, the full "price signal" that includes both the fare and the indirect costs to the travel consumer of flight delays is not passed through to the less well-informed air travelers. As a result, many of the less-experienced air travelers end up with itineraries that are not, for them, optimal in that the hidden cost of flight delays have not been considered. In addition, given that approximately 60% of travelers are on non-business itineraries for which delays have much lower perceived costs, it is not surprising that airlines are able to continue to sell seats even on flights with exceptionally low on-time performance.

It is in each carrier's best interest to provide peak-period flights as long as there is demand for those flights at a reasonable price. The competition among airlines for slots in those periods with finite airside and landside capacity creates a "tragedy of the commons"[7] in which the individual airlines, each acting in its own interest, degrade a shared resource (in this case, the airports' peak period). In some ways, this problem is analogous to that faced by most transportation services. Transportation demands vary significantly over time, with strong diurnal, weekly, and seasonal patterns. Infrastructure capacity is generally fixed and, for a variety of reasons, service levels degrade rapidly as demand approaches capacity. In many cases, it is either too expensive or simply infeasible to provide sufficient infrastructure capacity for the peak demands. Although the actions of each individual in these cases may be optimal for that individual, the outcome can be one in which everyone is worse off than if some system were put in place to better allocate the capacity.

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[6] For example, DOT's BTS maintains monthly online flight performance data, and dedicated sites such as flightstats.com offer detailed ratings of flights by OD pair, carrier, and even flight number along with real-time tracking of flights.

[7] This term was popularized in the article by Hardin, G. "The Tragedy of the Commons." *Science*, Vol. 162, No. 3859, December 13, 1968, pp. 1243–1248.

APPENDIX B

Highway Congestion and the Aviation System

From the original project statement and request for proposal, the research effort has been concerned with the potential impacts on aviation capacity from possible changes in competing or complementary modes. The research team's work has included, therefore, a review of the extent to which there might be some additional capacity in the roadway networks in the two mega-regions that could in some way influence alternative futures for the accommodation of aviation demand. This Appendix to the main document summarizes the results of the research team's review of demand and capacity of highways as undertaken as an input to the analysis of the capacity needs of the U.S. aviation/airport system.

Section B.1 reviews what is known about the bottlenecks and sources of congestion in the East Coast Mega-region; it reviews highway demands and capacities at the region's key locations. Areas where demand significantly outweighs capacity are documented for the East Coast. By way of example, demands and supplies on a key link across the Hudson River in the NYC area are reviewed to show the difficulty of predicting what major improvements to the total network can be expected.

Section B.2 includes a review of known congested segments of the California highway system—in particular, those that serve as gateways for north–south traffic between the two West Coast Mega-regions. In California, a future highway network was developed as part of the HSR forecasting process, and the impact of that future highway network on interregional travel was calculated. The California analysis shows that, even with the creation of an aggressive future highway network, the fundamental long-distance intercity travel times do not improve.

Section B. 3 concludes with the finding that the only way in which future highways could provide continuous capacity not available today would be with the creation of continuous intercity-managed lanes to support new kinds of intercity bus services.

B.1 Highway Demand and Capacity in the East Coast Mega-region

The coastal mega-regions are served by highway systems that include major interstate highways, state highways, toll roads, and toll bridges. As with most transportation facilities, the performance of these systems is heavily affected by diurnal, daily, weekly, and seasonal fluctuations in demand. Because of this, characterizations of system capacity are generally referenced against some time period. The traditional traffic engineering approach is to design a facility so that it operates without significant congestion during the so-called "design hour" that, in many regions, is defined as the 30th highest hourly traffic flow over the course of a year. However, in the coastal mega-regions, most of the major highway facilities operate with traffic flows that are well above levels that would maintain that standard.

The I-95 Corridor Coalition has made a major commitment to providing improved understanding of the long-distance trip, including the trips by vehicles on the roadway system. The Coalition is an alliance of transportation agencies, toll authorities, and related organizations encompassing the multistate East Coast Mega-region. The Coalition provides a forum for key decision- and policymakers to address transportation management and operations issues of common interest, including current and future performance of the highway system. As one of its projects, the Coalition has been developing a new tool to identify major transportation system bottlenecks and potential multimodal approaches to address those bottlenecks. The tool, labeled ICAT (Integrated Corridor Analysis Tool), includes a coded highway network for the I-95 region with traffic flow and capacity data.

ICAT was used by the Coalition to identify major facilities that are subject to significant congestion and that, in effect, serve as bottlenecks in the corridor. A capacity index was calculated as the annual average daily traffic volume divided by the hourly traffic capacity of the facility. This can be interpreted as the number of hours of full capacity flow that are represented by the average daily traffic volumes. The maximum possible value for this index would be 24, but that would imply that traffic flows equal capacity for all 24 hours of an average day. As traffic flows in practice vary significantly across the day and, in particular, are very much lower at night, index values above 10.0 are generally associated with significant congestion levels on "average" days and for more than the typical few hours of peak congestion.

B.1.1 East Coast Highways with High Volume-to-Capacity Relationships

Table B.1 lists 20 of the East Coast Mega-region highways with the highest index values as calculated by ICAT. The full ICAT-generated lists includes close to 100 East Coast Mega-region highway sections with index values above 10.0, so the table should be viewed as indicative of the sections that are the most congested. I-95, which is the major highway serving the corridor, is heavily represented both in the truncated list above and in the longer ICAT list. This indicates that the corridor is currently operating at its effective capacity for much of the day and for much of its length.

A more direct measurement of the current highway operating conditions is provided by the detailed INRIX "Smart Dust Network" data (*B-2*). Since 2006, INRIX has acquired "GPS-enabled probe vehicle reports from commercial fleet vehicles – including taxis, airport shuttles, service delivery vans, long haul trucks – and cellular probe data." The I-95 Corridor Coalition has a contract to INRIX to provide the Coalition access to both real-time and historical performance data for the highways and arterials in the region. This dataset will provide detailed information about the performance of the highway network over time, and INRIX has used the data to calculate its own congestion index. That index is calculated as the number of hours during which traffic moves at a speed lower than 50% of the free-flow speed per week divided by the average speed during those hours.

It is not surprising that the coastal mega-regions highways are prominently featured in INRIX's list of the worst 100 bottlenecks in the United States, based on their index. Of the top 100, over 70% are in the coastal mega-regions, including all of the top 5. Table B.2 lists the East Coast Mega-region highways that appear on the INRIX Top 100 list, along with their performance statistics.

As shown in Table B.2, the top-ranked (worst) from this list, the Cross-Bronx westbound, is congested, on average, for 94 hours per week at an average speed of less than 10 mph. Assuming that the congested hours are spread across weekdays and weekends evenly, this amounts to over 13 hours of congested conditions per day.

Table B.1. ICAT Top 20 East Coast bottlenecks (*B-1*).

Location	Route	Daily Traffic	No. of Lanes	Capacity Index
Queens, NY	I-678	178,434	4	20.4
Delaware, PA	I-95	173,664	4	19.9
Norfolk, VA	I-264	198,317	5	18.1
Brooklyn, NY	I-278	156,632	4	17.9
Prince Georges, MD	I-95	191,610	5	17.5
Baltimore, MD	I-695	227,133	6	17.3
Fairfax, VA	I-95	146,114	4	16.7
Philadelphia, PA	I-76	139,692	4	15.9
Hartford, CT	I-84	137,500	4	15.8
Long Island, NY	I-495	206,379	6	15.7
New Castle, DE	I-95	130,459	4	15.1
Baltimore, MD	I-83	192,790	6	15.0
Staten Island, NY	I-278	194,734	6	14.8
Bronx, NY	I-95	130,012	4	14.8
Montgomery, MD	I-270	126,781	4	14.5
Bergen, NJ	I-95	312,592	10	14.3
New Haven, CT	I-91	90,800	3	14.0
Philadelphia, PA	I-95	178,945	6	13.7
Delaware, PA	I-476	117,378	4	13.4
Fairfax, VA	I-66	174,275	6	13.3

Table B.2. INRIX Top 100 U.S. bottlenecks—East Coast highways (*B-2*).

Rank	Road	County	Hours Congested	Avg. When Congested
1	Cross Bronx Expy WB	Bronx	94	9.8
2	Cross Bronx Expy WB	Bronx	92	9.5
4	Cross Bronx Expy WB	Bronx	81	11.1
5	Cross Bronx Expy WB	Bronx	95	11.3
5	Harlem River Dr SB	New York	65	8.4
7	I-95 NB	Bergen	65	7.2
8	Van Wyck Expy NB	Queens	81	12.3
15	Harlem River Dr. SB	New York	70	11.1
17	Van Wyck Expy NB	Queens	75	14.7
19	Lincoln Tunnel EB	Hudson	61	6.9
22	Hwy 495 EB	Hudson	42	7.2
23	Staten Island Expy EB	Richmond	64	12.4
24	I-95 NB	Bergen	55	10.4
25	George WA Bridge	Bergen	62	8.0
31	Major Deegan Expy NB	Bronx	52	10.4
34	Hwy 495 EB	Hudson	48	9.2
42	Van Wyck Expy NB	Queens	77	13.7
43	Cross Bronx Expy WB	Bronx	68	14.5
45	Staten Island Expy EB	Richmond	57	13.7
47	Alexander Hamilton Bridge EB	Bronx	63	12.7
51	I-91 SB	New Haven	68	15.4
59	Harlem River Dr SB	New York	45	11.1
61	Van Wyck Expy NB	Queens	58	13.3
67	Van Wyck Expy NB	Queens	58	13.1
70	Brooklyn Queens Expy SB	Kings	58	12.1
74	George WA Bridge	New York	68	14.4
75	Brooklyn Queens Expy SB	Kings	51	11.7
78	Major Deegan Expy NB	Bronx	50	12.5
79	FDR Dr SB	New York	67	13.1
80	Long Island Expy EB	Queens	42	11.8
84	Henry Shirley Memorial Hwy NB	Arlington	43	10.5
90	Cross Bronx Expy WB	Bronx	55	14.8
91	Van Wyck Expy NB	Queens	75	15.8
97	Cross Bronx Expy WB	Bronx	65	15.7

B.1.2 An Example of Road Capacity Constraints, Current and Future: A Hudson River Crossing

Tables B.1 and B.2 provide vivid proof that someone driving from Boston to Virginia will hit a bottleneck at some time, almost certainly including a peak-period delay. The Coalition's comprehensive program to deal with the I-95 corridor as a single network, including (at some point) the forecast for a 20-year timeframe, is not yet complete. Rather, this one example of an East Coast Mega-region bottleneck is presented here, this time providing some forecast of its possible future demand and its possible future capacity. (The project is currently under environmental analysis, and data about several alternative futures are readily available to the public.)

Present capacity, present demand. The Tappan Zee Bridge (TZB) is a major Hudson River crossing north of New York City and is a well-known bottleneck in the roadway network. It has been chosen as an example for this section as it provides a good representation of a major highway facility on U.S. roadways in the coastal mega-regions. It has also been chosen because, unlike most other U.S. highway facilities, it will likely receive a major upgrade of anywhere from $5 billion to $15 billion within the next decade. The bridge is old and needs significant repair or replacement, like many other major U.S. highway facilities. It opened in 1955 and carried an average of 18,000 vehicles daily in its first year. Now the bridge carries a huge number of vehicles relative to its original design, which was considered a maximum of 100,000 vehicles per day. This extra capacity is carried with little change to its original design: about 140,000 vehicles cross the 3.1-mi TZB every day, with daily volumes as high as 170,000. By 2030, traffic in this corridor is expected to increase significantly, with about 200,000 cars per day crossing the bridge. There is significant congestion on the bridge currently, even with a variety of transportation demand management measures in place, such as variable toll pricing, tolling in only one direction, a movable barrier system, and the like.

Owing to both congestion issues and structural problems, the bridge is slated for either complete overhaul or replacement. However, all replacement options offer little to no additional auto capacity to absorb the forecast growth in auto traffic. For example, most alternatives being considered add only one additional travel lane over what currently exists now (eight lanes instead of seven, and two of those are high-occupancy toll/bus rapid transit lanes).

Future capacity, future demand. The extra capacity estimates for the TZB constitute an increase of 14% in auto capacity, assuming the high-occupancy toll lanes are fully used (significant transit improvements are also planned for all alternatives), whereas auto traffic is expected to increase from an average of 140,000 vehicles daily to 200,000. That is an increase in auto volumes of 43%. When one subtracts the increased volume percentage from the increased capacity percentage, it is clear that the bridge will have 29% less capacity than it will need—and this is after a major replacement initiative. This undercapacity will create significant congestion and delay (although some corridor improvements will help mitigate this, but only slightly). In other words, the bridge, which today is already a highly congested facility, will be more congested in 2030 than it is today—even with additional capacity and significant infrastructure investment.

This example analysis leads the research team to conclude that, even with very expensive roadway investment and improvement, roadway capacity issues will not be solved by extensive capacity increases. There is not enough money to build the infrastructure; even when there is, as in the case of the TZB, roadway capacity additions are dwarfed by future auto demand. In the TZB example, mobility is being improved based on the new TZB alternatives that create additional transit options—not highway capacity. This is no coincidence, as planners for this improvement realize that high-volume transit modes are the only way to increase mobility in this corridor cost effectively and realistically.

Highway capacity, on the TZB and for most other locations, remains fairly stagnant and seems very unlikely to be increased in any significant basis over existing infrastructure. Therefore, the analyst must conclude that the answer to the issue of aviation capacity constraints as described in this report will not be provided in any significant way through additional roadway capacity.

B.2 Highway Demand and Capacity in the West Coast Mega-region

There are even more facilities on the West Coast on the INRIX list (*B-2*), as shown in Table B.3. These data are illustrated graphically in Figure B.1.

Overall, these data demonstrate that the highway systems in both the East and West Coast Mega-regions are currently operating at or near their effective capacities and, in the case of numerous bottlenecks, at severely degraded levels of service.

B.2.1 Future Increases in Capacity: The California Statewide Model Highway Network

As the East Coast Mega-region comprises several states—each of which has its own process for identifying and prioritizing highway improvement projects—there is currently no single, consistent plan for the highway system nor any projection of future traffic volumes and service levels. The I-95 Corridor Coalition plans to develop ICAT in a way that could be useful to that purpose, but that work will likely not be completed in time to be useful to this ACRP project. However, most of the major bottlenecks shown in the ICAT table are in sections of facilities whose expansion would be extremely difficult and expensive. Therefore, it likely is safe to assume that whatever highway improvements are implemented before 2025 would, at best, keep up with any increases in highway traffic and more likely will not keep up with any growth, resulting in further declines in travel speeds.

Without question, the roadways that make up the network carrying vehicles between the Northern California Mega-region and the Southern California Mega-region will experience great increases in demand over the next 25 years. One such gateway, made up of I-5 and State Road 14, is estimated to register a 170% growth in demand between 2000 and 2030; I-5 and I-15 between LA and San Diego are forecast to grow by 140%. The key cordon points in the study together show an average 119% growth projected.

Although it is difficult to forecast highway operating conditions as far as 25 years out, it appears from the available data that bottlenecks that currently exist in the coastal mega-regions highway networks are unlikely to be relieved over that time horizon. To test the relationship between future additional highway growth and improved highway travel speeds, the California modelers built a 2030 highway model.

Table B.3. INRIX top 100 U.S. bottlenecks—West Coast highways (*B-2*).

Rank	Road	County	Hours Congested	Avg. Speed when Congested
3	1 580 WB	Marin	69	7.6
10	Hollywood Fwy SB	Los Angeles	83	13.8
11	San Diego Fwy NB	Los Angeles	81	15.5
13	Hollywood Fwy NB	Los Angeles	79	12.9
14	Hollywood Fwy SB	Los Angeles	75	15.0
18	Harbor Fwy NB	Los Angeles	75	15.5
20	Hollywood Fwy SB	Los Angeles	67	14.5
21	Hollywood Fwy SB	Los Angeles	74	15.7
25	Harbor Fwy NB	Los Angeles	71	15.7
27	Moreno Valley Fwy WB	Riverside	72	14.7
28	Hollywood Fwy SB	Los Angeles	55	13.1
29	I-238 NB	Alameda	84	18.9
32	Hollywood Fwy NB	Los Angeles	68	12.2
35	Hollywood Fwy NB	Los Angeles	77	14.5
37	Harbor Fwy NB	Los Angeles	63	14.6
38	Hollywood Fwy SB	Los Angeles	79	17.9
40	Pomona Fwy EB	Riverside	32	7.9
45	San Diego Fwy NB	Los Angeles	61	17.2
50	Santa Monica Fwy EB	Los Angeles	59	15.7
53	Riverside Fwy EB	Orange	33	9.4
54	San Diego Fwy NB	Los Angeles	55	15.4
55	Santa Ana Fwy NB	Los Angeles	73	19.3
55	I-80 WB	Alameda	41	11.0
58	Riverside Fwy EB	Orange	32	9.3
60	Harbor Fwy SB	Los Angeles	62	15.4
64	Pomona Fwy EB	Riverside	29	8.3
65	Pomona Fwy EB	Riverside	41	9.1
69	Santa Monica Fwy EB	Los Angeles	60	15.9
71	Harbor Fwy SB	Los Angeles	54	15.0
72	Pasadena Fwy NB	Los Angeles	48	14.1
81	Harbor Fwy SB	Los Angeles	53	15.5
83	San Diego Fwy SB	Los Angeles	48	15.2
85	Harbor Fwy SB	Los Angeles	43	13.5
85	James Lick Fwy NB	San Francisco	40	10.2
88	Harbor Fwy SB	Los Angeles	43	13.3
92	Hollywood Fwy SB	Los Angeles	54	15.7
95	San Gabriel River Fwy SB	Los Angeles	55	18.0
98	James Lick Fwy NB	San Francisco	48	13.1
100	Santa Ana Fwy NB	Los Angeles	61	19.1

B.2.2 Stability in Predicted Change in Intercity Travel Times—West Coast

As part of the California HSR study, a multimodal travel forecasting model was developed, whose future highway network is shown in Figure B.2. In addition to representing current intercity travel conditions, the model includes forecasts to the year 2030 that consider growth in population and employment, corresponding growth in traffic, and planned major highway improvements. As shown in Table B.4, the net effects of all of those changes, however, were estimated to result in very little change in highway travel times—only small increases in most cases and no notable improvements.

B.3 Future Highway Capacity to Respond to Aviation Demand: Conclusion

Table B.4 shows clearly that, even with the assumption of new highway capacity, there does not seem to be any breakthrough that would invalidate the basic assumption

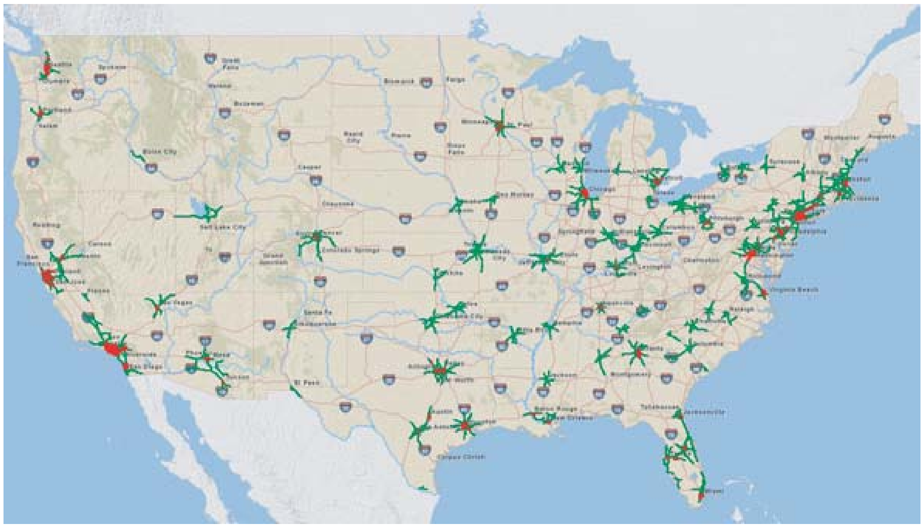


Figure B.1. U.S. Highway bottlenecks (B-2)*.*

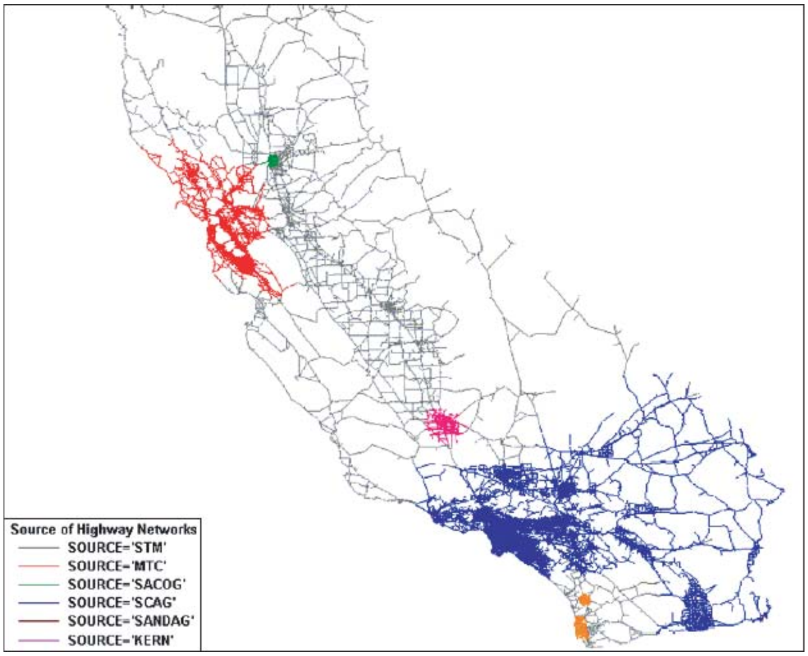


Figure B.2. The California 2030 highway network used in travel time calculations (B-3)*.*

Table B.4. Predicted changes in intercity travel times on the West Coast (2000–2030) (*B-3*).

City-to-City Pair	Auto		Air		High-Speed Rail	Conventional Rail
	2000	2030	2000	2030	2030	2000/2030
Los Angeles downtown to San Francisco downtown	*6:28*	*6:32*	3:30	3:38	3:23	No service
Fresno downtown to Los Angeles downtown	*3:32*	*3:38*	3:17	3:24	2:14	No service
Los Angeles downtown to San Diego downtown	*2:37*	*2:39*	2:51	3:01	2:13	3:26
Burbank (airport) to San Jose downtown	*5:31*	*5:40*	2:46	2:43	3:07	No service
Sacramento downtown to San Jose downtown	*2:29*	*2:24*	2:41	2:41	2:15	4:06

that the roadway system is highly used and that any future unmet needs at congested airports will not be mitigated by newly available reliable traffic flows on the roadway system.

The exception to this conclusion, though unexplored in this study of aviation capacity, is the chance that the roadways on both coastal regions might become more carefully managed, with the specific inclusion of managed lanes capable of supporting reliable bus service for short-distance services such as Boston–Washington, D.C., or Philadelphia–Washington, D.C. In this case, buses might play a significantly larger role in complementing the nation's air system than they do now.

References

B-1. ICAT output tabulations provided February 2008

B-2. INRIX—http://scorecard.inrix.com/scorecard/Top100WorstDetails.aspx retrieved 6/30/2008

B-3. Cambridge Systematics, *Bay Area/California High Speed Rail Ridership and Revenue Forecasting Study*. Prepared for the Metropolitan Transportation Commission and California High Speed Rail Authority, July 2007.

APPENDIX C

ACRP 3-10 Airport Activity Summary Sheets and Tables

Appendix C presents the ACRP 3-10 database, including the definitions of the geographic superzones of origin and of destination. Appendix C then presents a brief introduction about how to read the ACRP 3-10 airport passenger activity summary tables included at the end of this Appendix.

C.1 Description of the ACRP 3-10 Database

The research team has created the ACRP 3-10 database to quickly summarize vast amounts of data and information about making aviation trips in the United States and to and from international destinations. The ACRP 3-10 database is so large that it is, in essence, not feasible to create simplified spreadsheets (e.g., in Excel format) from which the analyst can select the information appropriate to the region or issue being examined. Rather, the raw data are kept in a large server (computer) housed at RSG's main office in White River Junction, VT.

The data concerning airline passengers flows are organized by each airport located in the two study regions.

C.2 Geographic Definitions

Figure C.1 shows the geographic categories for domestic locations. The lower 48 states are divided up in nine superzones.

In the West Coast study area, the Northern California Mega-region is contained entirely within the Northern California superzone. The Southern California/LA Mega-region is contained entirely within the Southern California/LA superzone; both are shown in the enlarged section on the lower left of the national map. (Note: the airports considered to be within the two California Mega-regions are identified in Figure 1.4 in the body of the Report.)

The East Coast study area consists of the New England states superzone, plus the NY/NJ/PA superzone, and the Mid-Atlantic states superzone. (Note: the airports considered to be within the Eastern Mega-region are shown in Figure 1.3 in the body of the Report.)

The rest of the lower 48 states are divided into the Southeast, Upper Midwest, Lower Middle West, and Northwest superzones.

Destinations accessed by flying across the Atlantic, including Europe, Africa, the Mid-East, and the Indian subcontinent, are described as the *transatlantic* superzone. Destinations accessed by flying across the Pacific, including Hawaii, Japan, Australia, New Zealand, and the rest of Asia, are described as being in the *transpacific* superzone.

Destinations to the north, including Alaska and all of Canada, are described as being in the *Alaska/Canada* superzone. Destinations to the south, including Mexico, the Caribbean, and Central and South America, are described as being in the *Central/South America* superzone.

Thus, the database has 13 superzones, which serve to describe the origin or destination of every trip documented.

C.3 Format of the ACRP 3-10 Database

The content of the ACRP 3-10 database is presented to the analyst on an airport-by-airport basis. The ACRP 3-10 database then presents data in two basic formats for analysis by the user. The database creates a summary of air passenger flow from origin to destination, which is based on calculations made by the research team, derived from the Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007, with international flight information integrated by Aviation Data Products, Inc. The same page also offers the analyst a summary of flight *segment* data for every destination airport served directly at the subject airport. Finally, the ACRP 3-10 database summary page offers the user the option of

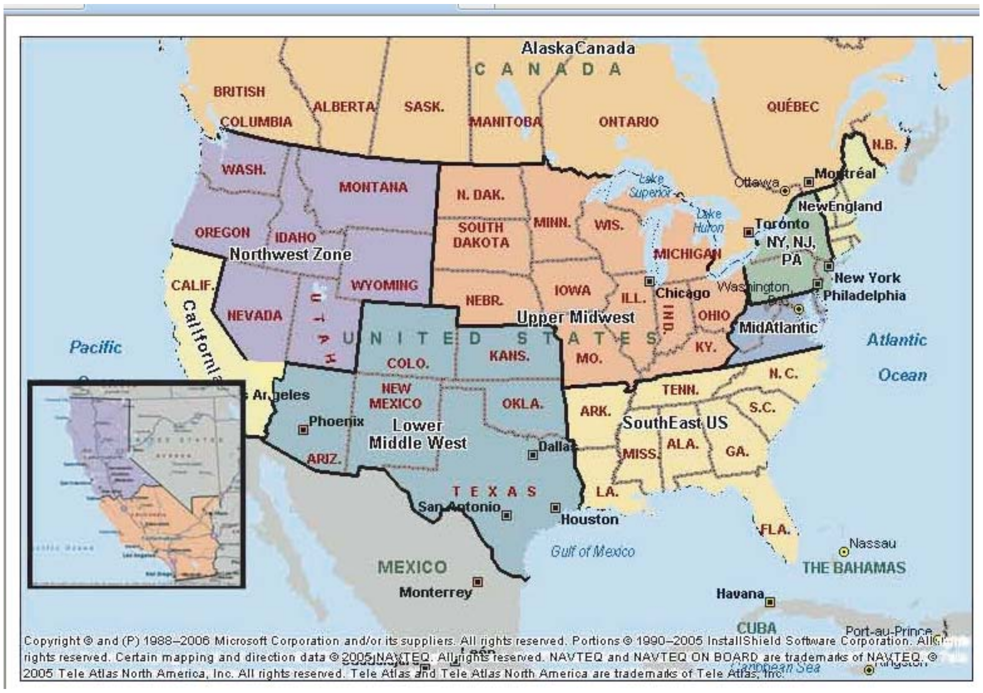


Figure C.1. North American superzones in the ACRP 3-10 database.

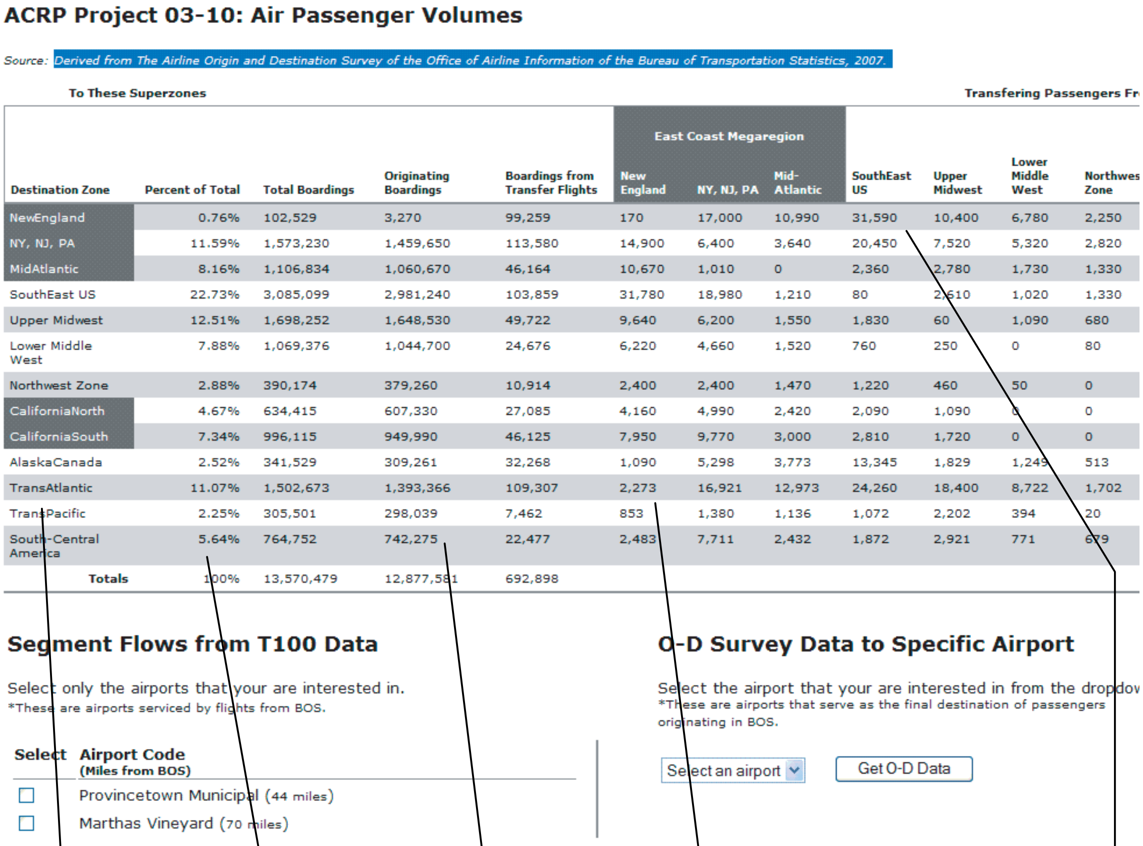
querying for the number of OD passenger volumes for every airport in the system.

Full discussions about the strengths and weakness of the available data are available elsewhere in the literature. In general, the basis of the work of the ACRP research team is the 10% sample of tickets in the system, as assembled by the Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics. The reader should be aware that this data source does not have access to certain small air companies (i.e., those with airplanes smaller than 60 passengers) who do not volunteer to give their OD information to the DOT effort. Therefore, the aggregate number of passenger enplanements in the ACRP 3-10 database summary page (leftmost numerical column) will almost always be smaller than the aggregate number of passenger enplanements created when the user requests to access all the destinations listed on the T-100 database, which is organized by flight segment, not by OD pairings.

With any use of the OD trip tables, the user will find the volumes somewhat lower than those reported through the segment-based T-100 system. The members of the research team explored the concept of estimating the number of passengers not captured in the OD data and consciously rejected the concept of manually "fudging" those numbers back in. For general discussion of total airport volumes, the research team recommends the use of data published by the ACI–NA, and included in Section 1.1 of Chapter 1. For a general discussion of total volumes leaving each airport for any purpose, the T-100 data system should be used. For any discussions about the real destinations of passengers, for later integration with examination of integration with rail planning or roadway planning, it is critical to rely on the 10% sample data.

The ACRP 3-10 airport passenger activity summary table is shown (partially) in Figure C.2. Using BOS as an example, the OD passenger volumes boarding at BOS are broken out between originating passengers and connecting passengers organized in terms of the superzone of their original origin. The callout boxes included in the figure show examples of some of the information that can be derived from the summary sheet.

In addition to the OD-based data presented on the top half of the sheet, the two functions of the lower half of the sheet are shown in Figure C.3. On the left side of the sheet, the airports with direct service to BOS are ordered by distance (shortest first). From this list, the analyst can select the airports of interest, and the program creates a summary of volumes of passengers of each segment. In the example reproduced here, airports included Nantucket, Bangor, Bar Harbor, Martha's Vineyard, and Provincetown. Most of these destinations are characterized by the need to be served by smaller connecting aircraft. On the right-hand side of the summary sheet, the user has requested more information about Nantucket airport, where the volume of OD traffic between Boston and Nantucket is reported (not shown.)



ACRP Project 03-10: Air Passenger Volumes

Source: *Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.*

To These Superzones					Transfering Passengers Fr						
					East Coast Megaregion						
Destination Zone	Percent of Total	Total Boardings	Originating Boardings	Boardings from Transfer Flights	New England	NY, NJ, PA	Mid-Atlantic	SouthEast US	Upper Midwest	Lower Middle West	Northwes Zone
NewEngland	0.76%	102,529	3,270	99,259	170	17,000	10,990	31,590	10,400	6,780	2,250
NY, NJ, PA	11.59%	1,573,230	1,459,650	113,580	14,900	6,400	3,640	20,450	7,520	5,320	2,820
MidAtlantic	8.16%	1,106,834	1,060,670	46,164	10,670	1,010	0	2,360	2,780	1,730	1,330
SouthEast US	22.73%	3,085,099	2,981,240	103,859	31,780	18,980	1,210	80	2,610	1,020	1,330
Upper Midwest	12.51%	1,698,252	1,648,530	49,722	9,640	6,200	1,550	1,830	60	1,090	680
Lower Middle West	7.88%	1,069,376	1,044,700	24,676	6,220	4,660	1,520	760	250	0	80
Northwest Zone	2.88%	390,174	379,260	10,914	2,400	2,400	1,470	1,220	460	50	0
CaliforniaNorth	4.67%	634,415	607,330	27,085	4,160	4,990	2,420	2,090	1,090	0	0
CaliforniaSouth	7.34%	996,115	949,990	46,125	7,950	9,770	3,000	2,810	1,720	0	0
AlaskaCanada	2.52%	341,529	309,261	32,268	1,090	5,298	3,773	13,345	1,829	1,249	513
TransAtlantic	11.07%	1,502,673	1,393,366	109,307	2,273	16,921	12,973	24,260	18,400	8,722	1,702
TransPacific	2.25%	305,501	298,039	7,462	853	1,380	1,136	1,072	2,202	394	20
South-Central America	5.64%	764,752	742,275	22,477	2,483	7,711	2,432	1,872	2,921	771	679
Totals	100%	13,570,479	12,877,581	692,898							

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from BOS.

Select	Airport Code (Miles from BOS)
☐	Provincetown Municipal (44 miles)
☐	Marthas Vineyard (70 miles)

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdow
*These are airports that serve as the final destination of passengers originating in BOS.

International enplanements are broken out by geographic categories

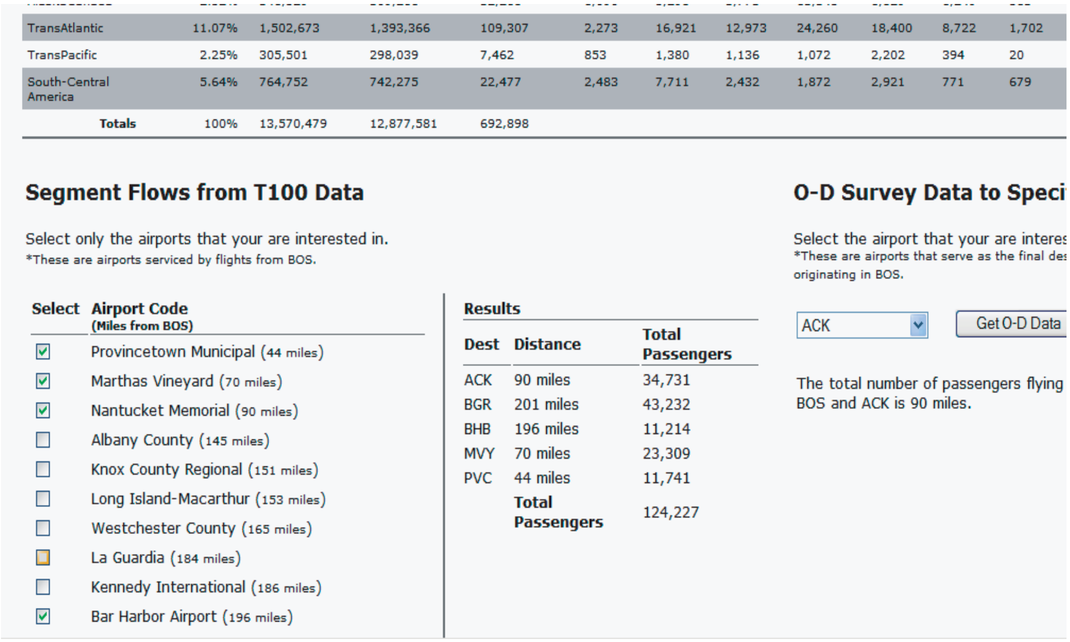
This column allows the reader a quick summary of the destinations of the enplaning passengers

The role of originating passengers vs. transferring passengers can be observed by destination group

Of more than one million Transatlantic enplanements, only about 2,000 came from local New England feeder flights

All most all enplanements to New England are from connecting flights – the largest market is from the south

Figure C.2. Understanding the ACRP 3-10 summary table—origin to destination data.



TransAtlantic	11.07%	1,502,673	1,393,366	109,307	2,273	16,921	12,973	24,260	18,400	8,722	1,702
TransPacific	2.25%	305,501	298,039	7,462	853	1,380	1,136	1,072	2,202	394	20
South-Central America	5.64%	764,752	742,275	22,477	2,483	7,711	2,432	1,872	2,921	771	679
Totals	100%	13,570,479	12,877,581	692,898							

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from BOS.

Select	Airport Code (Miles from BOS)
☑	Provincetown Municipal (44 miles)
☑	Marthas Vineyard (70 miles)
☑	Nantucket Memorial (90 miles)
☐	Albany County (145 miles)
☐	Knox County Regional (151 miles)
☐	Long Island-Macarthur (153 miles)
☐	Westchester County (165 miles)
☐	La Guardia (184 miles)
☐	Kennedy International (186 miles)
☑	Bar Harbor Airport (196 miles)

Results

Dest	Distance	Total Passengers
ACK	90 miles	34,731
BGR	201 miles	43,232
BHB	196 miles	11,214
MVY	70 miles	23,309
PVC	44 miles	11,741
	Total Passengers	124,227

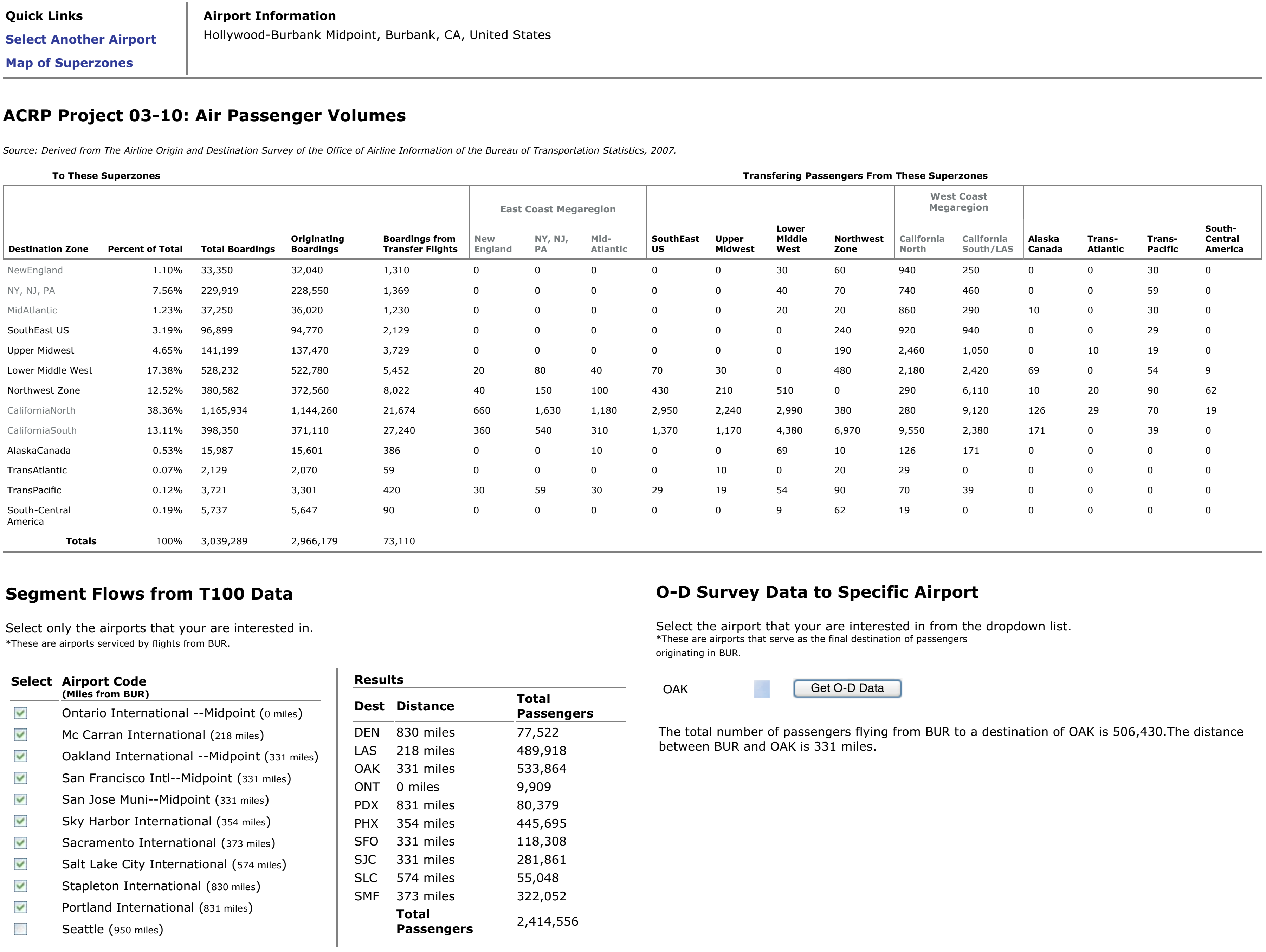
O-D Survey Data to Speci

Select the airport that your are interes
*These are airports that serve as the final des
originating in BOS.

The total number of passengers flying
BOS and ACK is 90 miles.

Figure C.3. Understanding the ACRP 3-10 summary tables—segment-based passenger volumes.

The following pages present 25 airport passenger activity summary sheets, with 14 developed for airports of interest to the study of airports in the East Coast study area and 11 airports of interest in the West Coast study area.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Hollywood-Burbank Midpoint, Burbank, CA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones | **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	1.10%	33,350	32,040	1,310	0	0	0	0	0	30	60	940	250	0	0	30	0
NY, NJ, PA	7.56%	229,919	228,550	1,369	0	0	0	0	0	40	70	740	460	0	0	59	0
MidAtlantic	1.23%	37,250	36,020	1,230	0	0	0	0	0	20	20	860	290	10	0	30	0
SouthEast US	3.19%	96,899	94,770	2,129	0	0	0	0	0	0	240	920	940	0	0	29	0
Upper Midwest	4.65%	141,199	137,470	3,729	0	0	0	0	0	0	190	2,460	1,050	0	10	19	0
Lower Middle West	17.38%	528,232	522,780	5,452	20	80	40	70	30	0	480	2,180	2,420	69	0	54	9
Northwest Zone	12.52%	380,582	372,560	8,022	40	150	100	430	210	510	0	290	6,110	10	20	90	62
CaliforniaNorth	38.36%	1,165,934	1,144,260	21,674	660	1,630	1,180	2,950	2,240	2,990	380	280	9,120	126	29	70	19
CaliforniaSouth	13.11%	398,350	371,110	27,240	360	540	310	1,370	1,170	4,380	6,970	9,550	2,380	171	0	39	0
AlaskaCanada	0.53%	15,987	15,601	386	0	0	10	0	0	69	10	126	171	0	0	0	0
TransAtlantic	0.07%	2,129	2,070	59	0	0	0	0	10	0	20	29	0	0	0	0	0
TransPacific	0.12%	3,721	3,301	420	30	59	30	29	19	54	90	70	39	0	0	0	0
South-Central America	0.19%	5,737	5,647	90	0	0	0	0	0	9	62	19	0	0	0	0	0
Totals	100%	3,039,289	2,966,179	73,110													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from BUR.

Select	**Airport Code** **(Miles from BUR)**
☑	Ontario International --Midpoint (0 miles)
☑	Mc Carran International (218 miles)
☑	Oakland International --Midpoint (331 miles)
☑	San Francisco Intl--Midpoint (331 miles)
☑	San Jose Muni--Midpoint (331 miles)
☑	Sky Harbor International (354 miles)
☑	Sacramento International (373 miles)
☑	Salt Lake City International (574 miles)
☑	Stapleton International (830 miles)
☑	Portland International (831 miles)
☐	Seattle (950 miles)

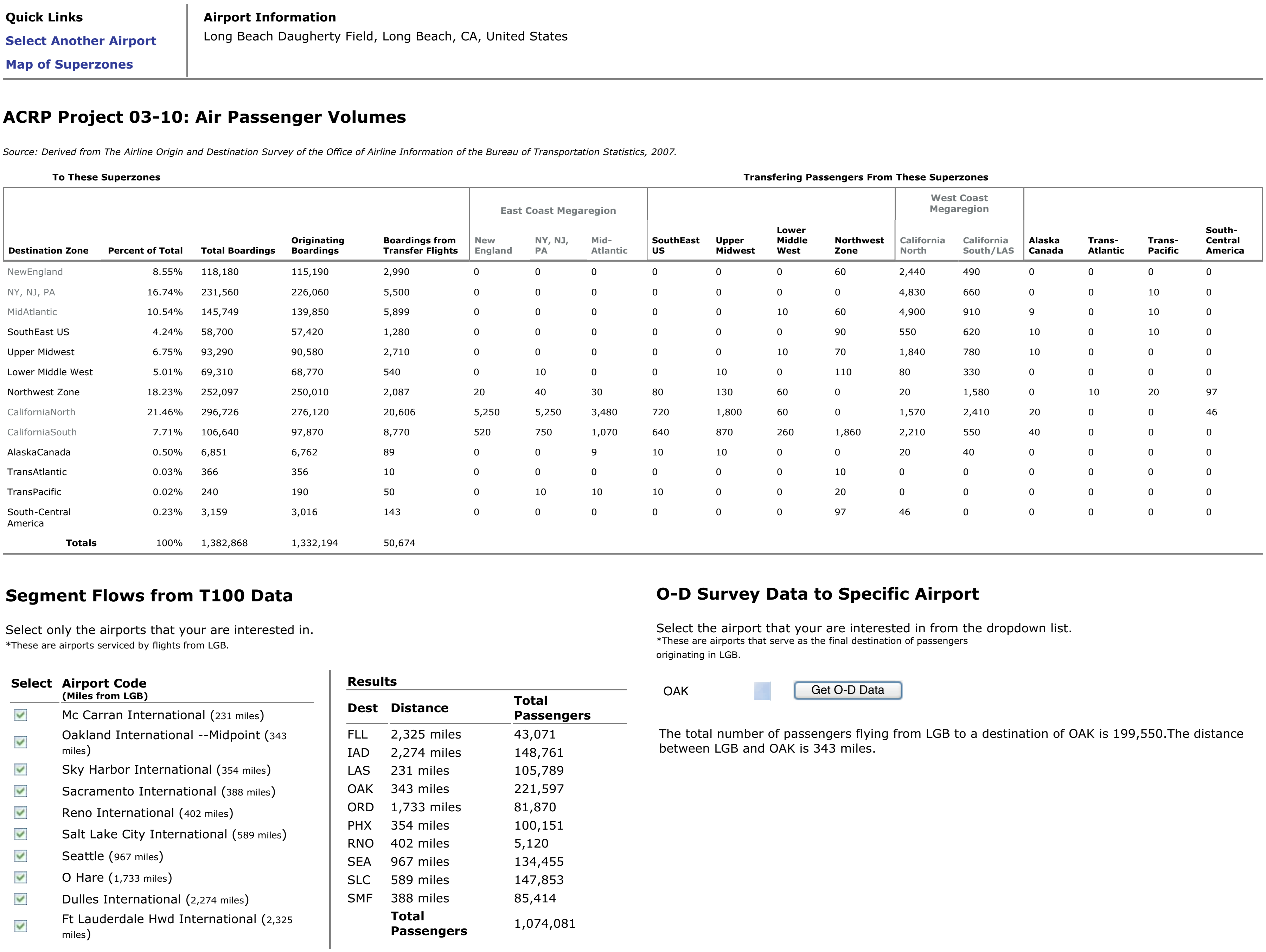
Results

Dest	**Distance**	**Total Passengers**
DEN	830 miles	77,522
LAS	218 miles	489,918
OAK	331 miles	533,864
ONT	0 miles	9,909
PDX	831 miles	80,379
PHX	354 miles	445,695
SFO	331 miles	118,308
SJC	331 miles	281,861
SLC	574 miles	55,048
SMF	373 miles	322,052
	Total Passengers	2,414,556

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in BUR.

The total number of passengers flying from BUR to a destination of OAK is 506,430.The distance between BUR and OAK is 331 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Long Beach Daugherty Field, Long Beach, CA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	8.55%	118,180	115,190	2,990	0	0	0	0	0	0	60	2,440	490	0	0	0	0
NY, NJ, PA	16.74%	231,560	226,060	5,500	0	0	0	0	0	0	0	4,830	660	0	0	10	0
MidAtlantic	10.54%	145,749	139,850	5,899	0	0	0	0	0	10	60	4,900	910	9	0	10	0
SouthEast US	4.24%	58,700	57,420	1,280	0	0	0	0	0	0	90	550	620	10	0	10	0
Upper Midwest	6.75%	93,290	90,580	2,710	0	0	0	0	0	10	70	1,840	780	10	0	0	0
Lower Middle West	5.01%	69,310	68,770	540	0	10	0	0	10	0	110	80	330	0	0	0	0
Northwest Zone	18.23%	252,097	250,010	2,087	20	40	30	80	130	60	0	20	1,580	0	10	20	97
CaliforniaNorth	21.46%	296,726	276,120	20,606	5,250	5,250	3,480	720	1,800	60	0	1,570	2,410	20	0	0	46
CaliforniaSouth	7.71%	106,640	97,870	8,770	520	750	1,070	640	870	260	1,860	2,210	550	40	0	0	0
AlaskaCanada	0.50%	6,851	6,762	89	0	0	9	10	10	0	0	20	40	0	0	0	0
TransAtlantic	0.03%	366	356	10	0	0	0	0	0	0	10	0	0	0	0	0	0
TransPacific	0.02%	240	190	50	0	10	10	10	0	0	20	0	0	0	0	0	0
South-Central America	0.23%	3,159	3,016	143	0	0	0	0	0	0	97	46	0	0	0	0	0
Totals	100%	1,382,868	1,332,194	50,674													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from LGB.

Select	**Airport Code** **(Miles from LGB)**
☑	Mc Carran International (231 miles)
☑	Oakland International --Midpoint (343 miles)
☑	Sky Harbor International (354 miles)
☑	Sacramento International (388 miles)
☑	Reno International (402 miles)
☑	Salt Lake City International (589 miles)
☑	Seattle (967 miles)
☑	O Hare (1,733 miles)
☑	Dulles International (2,274 miles)
☑	Ft Lauderdale Hwd International (2,325 miles)

Results

Dest	**Distance**	**Total Passengers**
FLL	2,325 miles	43,071
IAD	2,274 miles	148,761
LAS	231 miles	105,789
OAK	343 miles	221,597
ORD	1,733 miles	81,870
PHX	354 miles	100,151
RNO	402 miles	5,120
SEA	967 miles	134,455
SLC	589 miles	147,853
SMF	388 miles	85,414
	Total Passengers	1,074,081

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in LGB.

OAK

The total number of passengers flying from LGB to a destination of OAK is 199,550.The distance between LGB and OAK is 343 miles.

Quick Links

Select Another Airport

Map of Superzones

Airport Information

Los Angeles Intl.--Midpoint, Los Angeles, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	2.42%	695,976	553,760	142,216	0	0	0	0	0	480	3,800	37,330	43,450	1,041	125	54,424	1,566
NY, NJ, PA	7.98%	2,290,358	2,000,960	289,398	0	0	0	0	0	1,190	6,080	60,480	68,280	2,577	706	147,290	2,795
MidAtlantic	3.15%	903,372	721,200	182,172	0	0	0	0	0	760	5,520	33,980	54,580	1,408	632	84,279	1,013
SouthEast US	9.15%	2,627,754	2,219,160	408,594	0	0	0	0	0	820	23,800	104,710	100,820	6,969	1,245	168,724	1,506
Upper Midwest	10.12%	2,905,114	2,536,300	368,814	20	0	0	10	0	60	9,020	62,880	93,450	2,156	1,544	194,910	4,764
Lower Middle West	10.00%	2,869,220	2,468,350	400,870	770	2,880	1,020	1,110	1,020	40	16,180	73,330	84,660	3,566	5,151	201,136	10,007
Northwest Zone	5.94%	1,705,073	1,383,390	321,683	2,740	5,490	4,950	24,200	10,860	20,800	10	4,590	80,100	755	10,473	64,424	92,291
CaliforniaNorth	9.15%	2,627,051	1,917,500	709,551	25,330	56,430	32,720	85,620	56,130	75,240	5,670	7,820	109,370	8,774	34,454	105,580	106,413
CaliforniaSouth	6.14%	1,762,497	720,760	1,041,737	33,370	64,250	54,180	90,180	90,300	80,350	80,190	105,130	120,030	30,475	56,957	196,345	39,980
AlaskaCanada	3.22%	925,672	865,391	60,281	1,041	2,577	1,408	6,969	2,156	3,566	755	8,774	30,475	0	0	2,440	120
TransAtlantic	7.09%	2,034,528	1,923,241	111,287	125	706	632	1,245	1,544	5,151	10,473	34,454	56,957	0	0	0	0
TransPacific	16.94%	4,863,465	3,642,293	1,221,172	54,424	147,290	84,279	168,724	194,910	201,136	64,424	105,580	196,345	2,900	0	20	1,140
South-Central America	8.69%	2,495,635	2,233,500	262,135	1,566	2,795	1,013	1,506	4,764	10,007	92,291	106,413	39,980	80	0	1,720	0
Totals	100%	28,705,715	23,185,805	5,519,910													

Segment Flows from T100 Data

Select only the airports that your are interested in.

*These are airports serviced by flights from LAX.

Select	**Airport Code** **(Miles from LAX)**
☑	Ontario International --Midpoint (0 miles)
☑	Orange County (30 miles)
☑	Ventura County (62 miles)
☑	Palomar (81 miles)
☑	Palm Springs International (94 miles)
☑	Santa Barbara Municipal (101 miles)
☑	San Diego International Lindbergh Field (106 miles)
☑	Meadows Field (108 miles)
☑	Inyokern-Kern County (111 miles)
☑	Santa Maria Public (145 miles)

Results

Dest	**Distance**	**Total Passengers**
BFL	108 miles	22,436
CLD	81 miles	33,927
IYK	111 miles	11,676
ONT	0 miles	25,728
OXR	62 miles	20,606
PSP	94 miles	66,153
SAN	106 miles	279,268
SBA	101 miles	103,242
SMX	145 miles	33,458
SNA	30 miles	32,189
	Total Passengers	628,683

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in LAX.

SAN

Get O-D Data

The total number of passengers flying from LAX to a destination of SAN is 23,820.The distance between LAX and SAN is 106 miles.

Quick Links

Select Another Airport

Map of Superzones

Airport Information

Ontario International --Midpoint, Ontario, CA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	1.65%	56,096	54,750	1,346	0	0	0	0	0	30	50	470	680	29	0	80	7
NY, NJ, PA	4.67%	158,449	155,810	2,639	0	0	0	0	0	10	110	680	1,730	0	0	100	9
MidAtlantic	2.71%	91,800	88,860	2,940	0	0	0	0	0	20	90	1,220	1,490	0	0	120	0
SouthEast US	10.42%	353,236	343,890	9,346	0	0	0	0	0	40	570	4,030	4,430	61	40	131	44
Upper Midwest	8.79%	298,198	291,460	6,738	0	0	0	0	0	30	370	2,230	3,900	40	10	158	0
Lower Middle West	18.61%	630,917	620,450	10,467	90	70	70	110	90	0	940	2,060	6,400	59	38	499	41
Northwest Zone	13.36%	453,069	445,190	7,879	110	110	130	730	400	1,220	0	210	4,740	39	19	70	101
CaliforniaNorth	27.77%	941,617	920,390	21,227	530	950	1,910	3,910	2,330	2,670	430	920	6,930	194	48	220	185
CaliforniaSouth	6.96%	236,110	201,140	34,970	960	1,940	1,830	4,790	3,810	6,040	5,000	5,520	4,260	249	47	469	55
AlaskaCanada	0.95%	32,242	31,571	671	29	0	0	61	40	59	39	194	249	0	0	0	0
TransAtlantic	0.38%	12,757	12,555	202	0	0	0	40	10	38	19	48	47	0	0	0	0
TransPacific	1.45%	49,022	47,165	1,857	80	100	120	131	158	499	70	220	469	10	0	0	0
South-Central America	2.28%	77,372	76,930	442	7	9	0	44	0	41	101	185	55	0	0	0	0
Totals	100%	3,390,885	3,290,161	100,724													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from ONT.

Select	**Airport Code** **(Miles from ONT)**
☑	Los Angeles Intl.--Midpoint (0 miles)
☑	Fresno Yosemite International (207 miles)
☑	Mc Carran International (218 miles)
☑	Peninsula (273 miles)
☑	Oakland International --Midpoint (331 miles)
☑	San Francisco Intl--Midpoint (331 miles)
☑	San Jose Muni--Midpoint (331 miles)
☑	Sky Harbor International (354 miles)
☑	Sacramento International (373 miles)
☑	Tucson International (437 miles)
☐	Salt Lake City International (574 miles)

Results

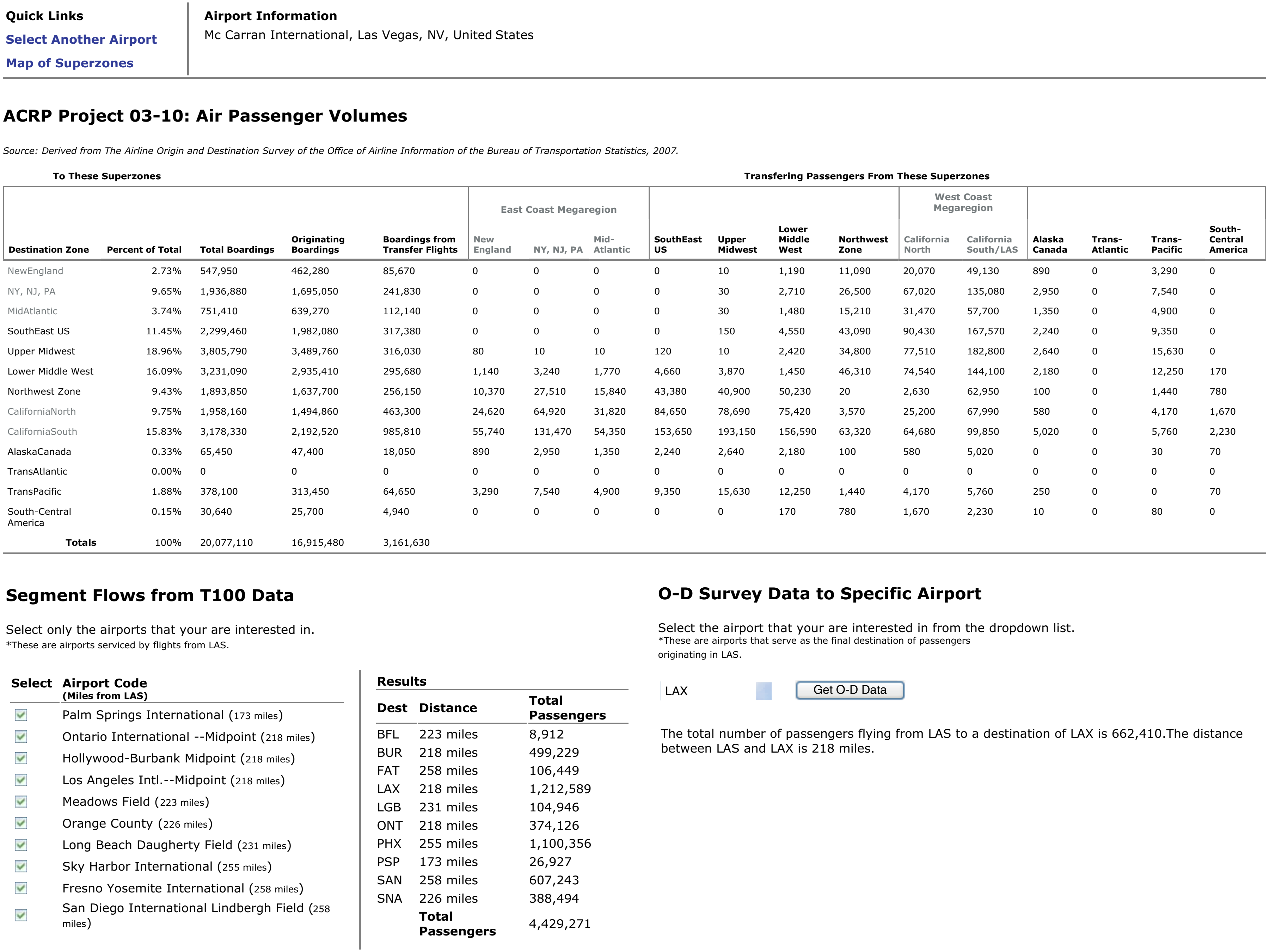
Dest	**Distance**	**Total Passengers**
FAT	207 miles	9,981
LAS	218 miles	368,932
LAX	0 miles	35,484
MRY	273 miles	10,720
OAK	331 miles	384,833
PHX	354 miles	591,682
SFO	331 miles	56,939
SJC	331 miles	239,325
SMF	373 miles	379,282
TUS	437 miles	22,696
	Total Passengers	2,099,874

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in ONT.

PHX [Get O-D Data]

The total number of passengers flying from ONT to a destination of PHX is 207,680.The distance between ONT and PHX is 354 miles.



Airport Information

Mc Carran International, Las Vegas, NV, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	Percent of Total	Total Boardings	Originating Boardings	Boardings from Transfer Flights	New England	NY, NJ, PA	Mid-Atlantic	SouthEast US	Upper Midwest	Lower Middle West	Northwest Zone	California North	California South/LAS	Alaska Canada	Trans-Atlantic	Trans-Pacific	South-Central America
NewEngland	2.73%	547,950	462,280	85,670	0	0	0	0	10	1,190	11,090	20,070	49,130	890	0	3,290	0
NY, NJ, PA	9.65%	1,936,880	1,695,050	241,830	0	0	0	0	30	2,710	26,500	67,020	135,080	2,950	0	7,540	0
MidAtlantic	3.74%	751,410	639,270	112,140	0	0	0	0	30	1,480	15,210	31,470	57,700	1,350	0	4,900	0
SouthEast US	11.45%	2,299,460	1,982,080	317,380	0	0	0	0	150	4,550	43,090	90,430	167,570	2,240	0	9,350	0
Upper Midwest	18.96%	3,805,790	3,489,760	316,030	80	10	10	120	10	2,420	34,800	77,510	182,800	2,640	0	15,630	0
Lower Middle West	16.09%	3,231,090	2,935,410	295,680	1,140	3,240	1,770	4,660	3,870	1,450	46,310	74,540	144,100	2,180	0	12,250	170
Northwest Zone	9.43%	1,893,850	1,637,700	256,150	10,370	27,510	15,840	43,380	40,900	50,230	20	2,630	62,950	100	0	1,440	780
CaliforniaNorth	9.75%	1,958,160	1,494,860	463,300	24,620	64,920	31,820	84,650	78,690	75,420	3,570	25,200	67,990	580	0	4,170	1,670
CaliforniaSouth	15.83%	3,178,330	2,192,520	985,810	55,740	131,470	54,350	153,650	193,150	156,590	63,320	64,680	99,850	5,020	0	5,760	2,230
AlaskaCanada	0.33%	65,450	47,400	18,050	890	2,950	1,350	2,240	2,640	2,180	100	580	5,020	0	0	30	70
TransAtlantic	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TransPacific	1.88%	378,100	313,450	64,650	3,290	7,540	4,900	9,350	15,630	12,250	1,440	4,170	5,760	250	0	0	70
South-Central America	0.15%	30,640	25,700	4,940	0	0	0	0	0	170	780	1,670	2,230	10	0	80	0
Totals	100%	20,077,110	16,915,480	3,161,630													

Segment Flows from T100 Data

Select only the airports that your are interested in.

*These are airports serviced by flights from LAS.

Select	Airport Code (Miles from LAS)
☑	Palm Springs International (173 miles)
☑	Ontario International --Midpoint (218 miles)
☑	Hollywood-Burbank Midpoint (218 miles)
☑	Los Angeles Intl.--Midpoint (218 miles)
☑	Meadows Field (223 miles)
☑	Orange County (226 miles)
☑	Long Beach Daugherty Field (231 miles)
☑	Sky Harbor International (255 miles)
☑	Fresno Yosemite International (258 miles)
☑	San Diego International Lindbergh Field (258 miles)

Results

Dest	Distance	Total Passengers
BFL	223 miles	8,912
BUR	218 miles	499,229
FAT	258 miles	106,449
LAX	218 miles	1,212,589
LGB	231 miles	104,946
ONT	218 miles	374,126
PHX	255 miles	1,100,356
PSP	173 miles	26,927
SAN	258 miles	607,243
SNA	226 miles	388,494
	Total Passengers	4,429,271

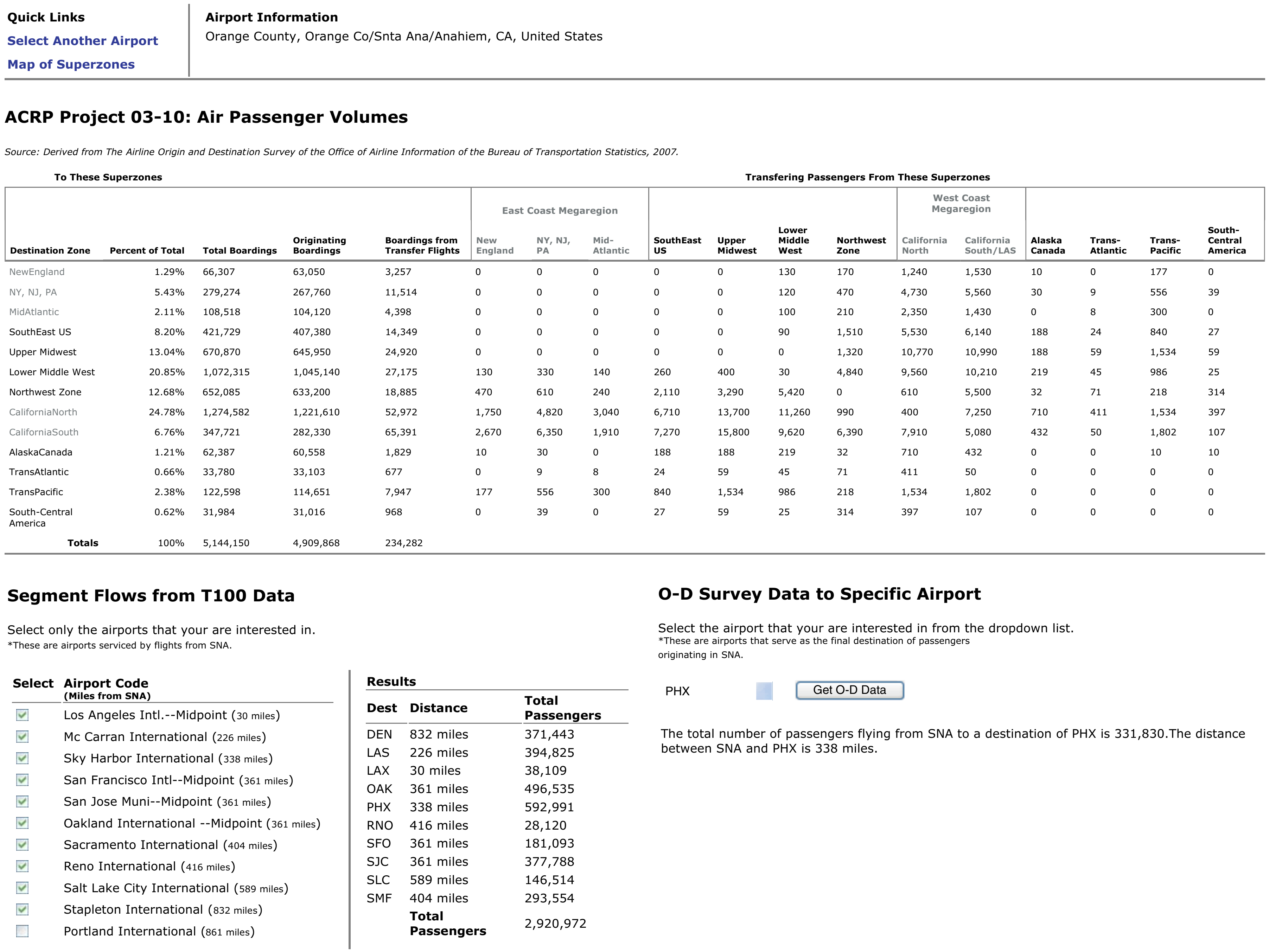
O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.

*These are airports that serve as the final destination of passengers originating in LAS.

LAX

The total number of passengers flying from LAS to a destination of LAX is 662,410.The distance between LAS and LAX is 218 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Orange County, Orange Co/Snta Ana/Anahiem, CA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones | **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	1.29%	66,307	63,050	3,257	0	0	0	0	0	130	170	1,240	1,530	10	0	177	0
NY, NJ, PA	5.43%	279,274	267,760	11,514	0	0	0	0	0	120	470	4,730	5,560	30	9	556	39
MidAtlantic	2.11%	108,518	104,120	4,398	0	0	0	0	0	100	210	2,350	1,430	0	8	300	0
SouthEast US	8.20%	421,729	407,380	14,349	0	0	0	0	0	90	1,510	5,530	6,140	188	24	840	27
Upper Midwest	13.04%	670,870	645,950	24,920	0	0	0	0	0	0	1,320	10,770	10,990	188	59	1,534	59
Lower Middle West	20.85%	1,072,315	1,045,140	27,175	130	330	140	260	400	30	4,840	9,560	10,210	219	45	986	25
Northwest Zone	12.68%	652,085	633,200	18,885	470	610	240	2,110	3,290	5,420	0	610	5,500	32	71	218	314
CaliforniaNorth	24.78%	1,274,582	1,221,610	52,972	1,750	4,820	3,040	6,710	13,700	11,260	990	400	7,250	710	411	1,534	397
CaliforniaSouth	6.76%	347,721	282,330	65,391	2,670	6,350	1,910	7,270	15,800	9,620	6,390	7,910	5,080	432	50	1,802	107
AlaskaCanada	1.21%	62,387	60,558	1,829	10	30	0	188	188	219	32	710	432	0	0	10	10
TransAtlantic	0.66%	33,780	33,103	677	0	9	8	24	59	45	71	411	50	0	0	0	0
TransPacific	2.38%	122,598	114,651	7,947	177	556	300	840	1,534	986	218	1,534	1,802	0	0	0	0
South-Central America	0.62%	31,984	31,016	968	0	39	0	27	59	25	314	397	107	0	0	0	0
Totals	100%	5,144,150	4,909,868	234,282													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from SNA.

Select	**Airport Code** **(Miles from SNA)**
☑	Los Angeles Intl.--Midpoint (30 miles)
☑	Mc Carran International (226 miles)
☑	Sky Harbor International (338 miles)
☑	San Francisco Intl--Midpoint (361 miles)
☑	San Jose Muni--Midpoint (361 miles)
☑	Oakland International --Midpoint (361 miles)
☑	Sacramento International (404 miles)
☑	Reno International (416 miles)
☑	Salt Lake City International (589 miles)
☑	Stapleton International (832 miles)
☐	Portland International (861 miles)

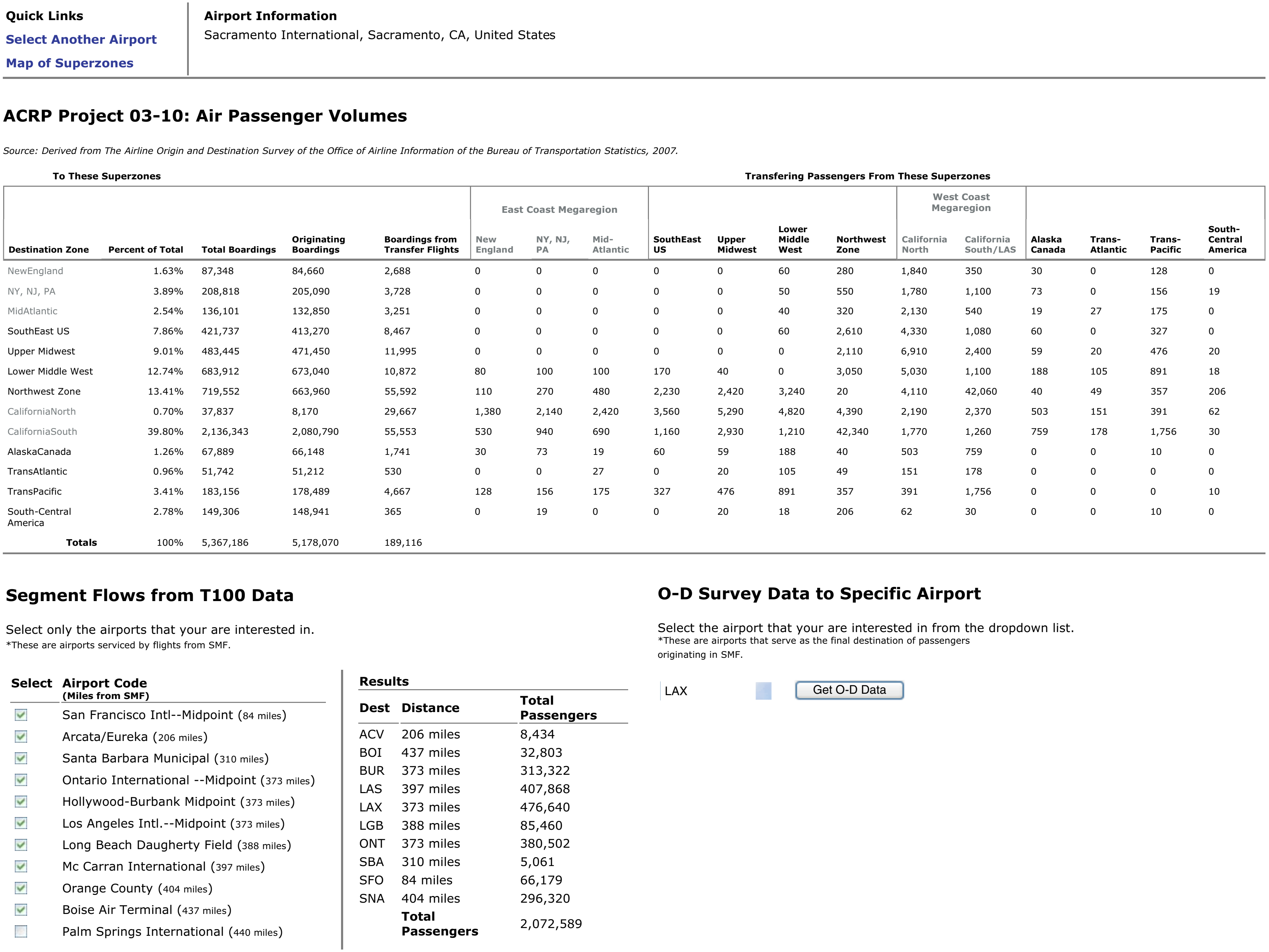
Results

Dest	**Distance**	**Total Passengers**
DEN	832 miles	371,443
LAS	226 miles	394,825
LAX	30 miles	38,109
OAK	361 miles	496,535
PHX	338 miles	592,991
RNO	416 miles	28,120
SFO	361 miles	181,093
SJC	361 miles	377,788
SLC	589 miles	146,514
SMF	404 miles	293,554
	Total Passengers	2,920,972

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in SNA.

The total number of passengers flying from SNA to a destination of PHX is 331,830.The distance between SNA and PHX is 338 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Sacramento International, Sacramento, CA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones | **Transfering Passengers From These Superzones**

Destination Zone	Percent of Total	Total Boardings	Originating Boardings	Boardings from Transfer Flights	East Coast Megaregion: New England	East Coast Megaregion: NY, NJ, PA	East Coast Megaregion: Mid-Atlantic	SouthEast US	Upper Midwest	Lower Middle West	Northwest Zone	West Coast Megaregion: California North	West Coast Megaregion: California South/LAS	Alaska Canada	Trans-Atlantic	Trans-Pacific	South-Central America
NewEngland	1.63%	87,348	84,660	2,688	0	0	0	0	0	60	280	1,840	350	30	0	128	0
NY, NJ, PA	3.89%	208,818	205,090	3,728	0	0	0	0	0	50	550	1,780	1,100	73	0	156	19
MidAtlantic	2.54%	136,101	132,850	3,251	0	0	0	0	0	40	320	2,130	540	19	27	175	0
SouthEast US	7.86%	421,737	413,270	8,467	0	0	0	0	0	60	2,610	4,330	1,080	60	0	327	0
Upper Midwest	9.01%	483,445	471,450	11,995	0	0	0	0	0	0	2,110	6,910	2,400	59	20	476	20
Lower Middle West	12.74%	683,912	673,040	10,872	80	100	100	170	40	0	3,050	5,030	1,100	188	105	891	18
Northwest Zone	13.41%	719,552	663,960	55,592	110	270	480	2,230	2,420	3,240	20	4,110	42,060	40	49	357	206
CaliforniaNorth	0.70%	37,837	8,170	29,667	1,380	2,140	2,420	3,560	5,290	4,820	4,390	2,190	2,370	503	151	391	62
CaliforniaSouth	39.80%	2,136,343	2,080,790	55,553	530	940	690	1,160	2,930	1,210	42,340	1,770	1,260	759	178	1,756	30
AlaskaCanada	1.26%	67,889	66,148	1,741	30	73	19	60	59	188	40	503	759	0	0	10	0
TransAtlantic	0.96%	51,742	51,212	530	0	0	27	0	20	105	49	151	178	0	0	0	0
TransPacific	3.41%	183,156	178,489	4,667	128	156	175	327	476	891	357	391	1,756	0	0	0	10
South-Central America	2.78%	149,306	148,941	365	0	19	0	0	20	18	206	62	30	0	0	10	0
Totals	100%	5,367,186	5,178,070	189,116													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from SMF.

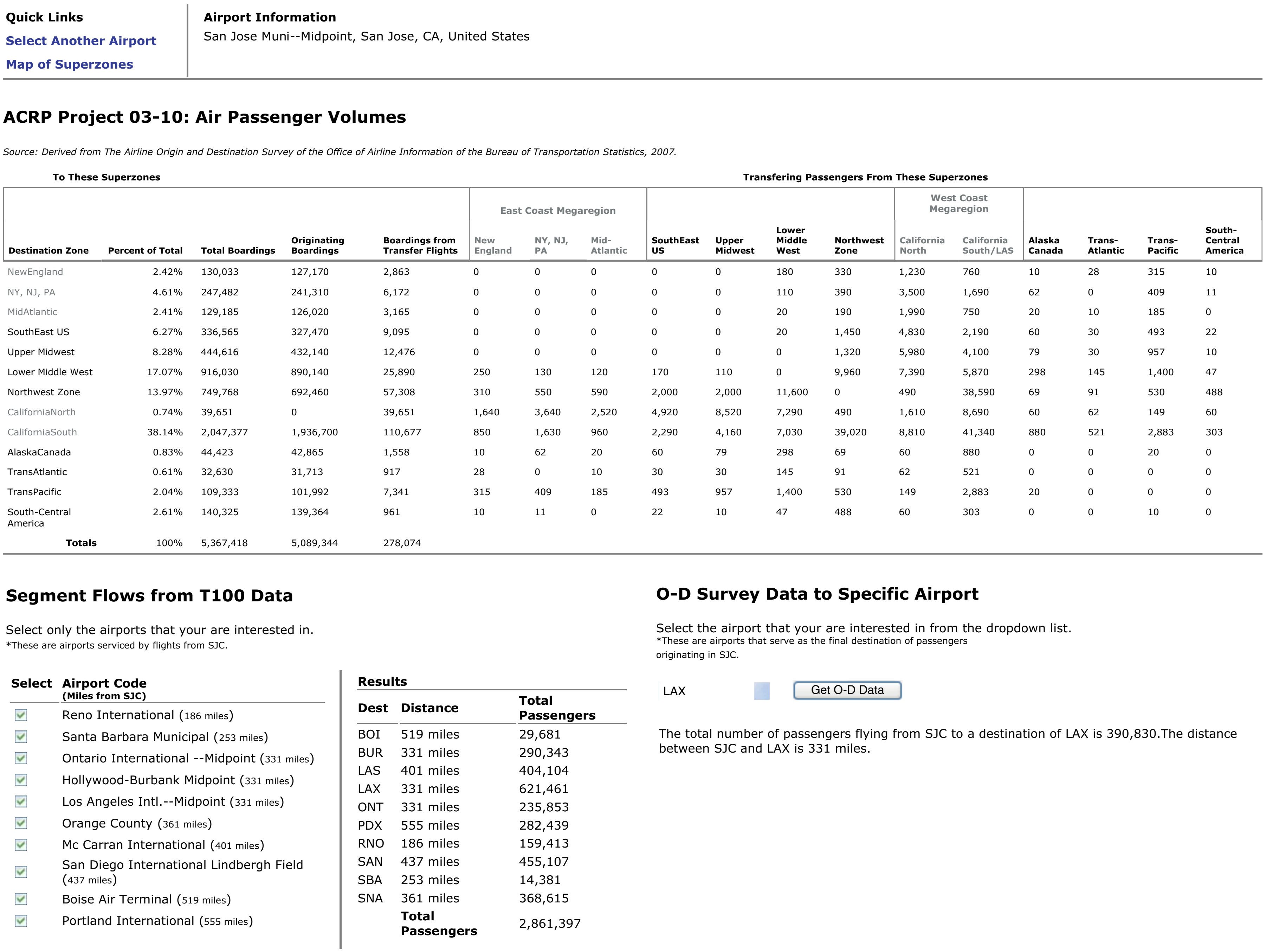
Select	Airport Code (Miles from SMF)
☑	San Francisco Intl--Midpoint (84 miles)
☑	Arcata/Eureka (206 miles)
☑	Santa Barbara Municipal (310 miles)
☑	Ontario International --Midpoint (373 miles)
☑	Hollywood-Burbank Midpoint (373 miles)
☑	Los Angeles Intl.--Midpoint (373 miles)
☑	Long Beach Daugherty Field (388 miles)
☑	Mc Carran International (397 miles)
☑	Orange County (404 miles)
☑	Boise Air Terminal (437 miles)
☐	Palm Springs International (440 miles)

Results

Dest	Distance	Total Passengers
ACV	206 miles	8,434
BOI	437 miles	32,803
BUR	373 miles	313,322
LAS	397 miles	407,868
LAX	373 miles	476,640
LGB	388 miles	85,460
ONT	373 miles	380,502
SBA	310 miles	5,061
SFO	84 miles	66,179
SNA	404 miles	296,320
	Total Passengers	2,072,589

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in SMF.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

San Jose Muni--Midpoint, San Jose, CA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**New England**	**NY, NJ, PA**	**Mid-Atlantic**	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	**California North**	**California South/LAS**	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	2.42%	130,033	127,170	2,863	0	0	0	0	0	180	330	1,230	760	10	28	315	10
NY, NJ, PA	4.61%	247,482	241,310	6,172	0	0	0	0	0	110	390	3,500	1,690	62	0	409	11
MidAtlantic	2.41%	129,185	126,020	3,165	0	0	0	0	0	20	190	1,990	750	20	10	185	0
SouthEast US	6.27%	336,565	327,470	9,095	0	0	0	0	0	20	1,450	4,830	2,190	60	30	493	22
Upper Midwest	8.28%	444,616	432,140	12,476	0	0	0	0	0	0	1,320	5,980	4,100	79	30	957	10
Lower Middle West	17.07%	916,030	890,140	25,890	250	130	120	170	110	0	9,960	7,390	5,870	298	145	1,400	47
Northwest Zone	13.97%	749,768	692,460	57,308	310	550	590	2,000	2,000	11,600	0	490	38,590	69	91	530	488
CaliforniaNorth	0.74%	39,651	0	39,651	1,640	3,640	2,520	4,920	8,520	7,290	490	1,610	8,690	60	62	149	60
CaliforniaSouth	38.14%	2,047,377	1,936,700	110,677	850	1,630	960	2,290	4,160	7,030	39,020	8,810	41,340	880	521	2,883	303
AlaskaCanada	0.83%	44,423	42,865	1,558	10	62	20	60	79	298	69	60	880	0	0	20	0
TransAtlantic	0.61%	32,630	31,713	917	28	0	10	30	30	145	91	62	521	0	0	0	0
TransPacific	2.04%	109,333	101,992	7,341	315	409	185	493	957	1,400	530	149	2,883	20	0	0	0
South-Central America	2.61%	140,325	139,364	961	10	11	0	22	10	47	488	60	303	0	0	10	0
Totals	100%	5,367,418	5,089,344	278,074													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from SJC.

Select	**Airport Code** **(Miles from SJC)**
☑	Reno International (186 miles)
☑	Santa Barbara Municipal (253 miles)
☑	Ontario International --Midpoint (331 miles)
☑	Hollywood-Burbank Midpoint (331 miles)
☑	Los Angeles Intl.--Midpoint (331 miles)
☑	Orange County (361 miles)
☑	Mc Carran International (401 miles)
☑	San Diego International Lindbergh Field (437 miles)
☑	Boise Air Terminal (519 miles)
☑	Portland International (555 miles)

Results

Dest	**Distance**	**Total Passengers**
BOI	519 miles	29,681
BUR	331 miles	290,343
LAS	401 miles	404,104
LAX	331 miles	621,461
ONT	331 miles	235,853
PDX	555 miles	282,439
RNO	186 miles	159,413
SAN	437 miles	455,107
SBA	253 miles	14,381
SNA	361 miles	368,615
	Total Passengers	2,861,397

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in SJC.

The total number of passengers flying from SJC to a destination of LAX is 390,830.The distance between SJC and LAX is 331 miles.

Quick Links

Select Another Airport

Map of Superzones

Airport Information

San Francisco Intl--Midpoint, San Francisco, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones | **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	3.65%	603,268	516,380	86,888	0	0	0	0	0	400	13,440	8,510	15,770	1,233	143	47,291	101
NY, NJ, PA	9.94%	1,641,511	1,460,490	181,021	0	0	0	0	0	780	21,110	17,630	39,930	2,268	397	98,681	225
MidAtlantic	3.32%	548,582	433,310	115,272	0	0	0	0	0	90	15,300	12,100	27,500	1,481	449	58,240	112
SouthEast US	7.50%	1,238,623	1,115,240	123,383	0	0	0	0	10	110	19,900	16,250	19,650	3,569	631	63,148	115
Upper Midwest	9.91%	1,636,662	1,468,400	168,262	0	0	0	10	0	10	16,710	20,460	30,800	1,827	792	97,406	247
Lower Middle West	7.84%	1,294,802	1,073,320	221,482	670	1,100	690	500	330	0	32,570	18,420	24,740	3,937	2,256	134,849	1,420
Northwest Zone	7.37%	1,217,083	700,400	516,683	12,830	17,620	13,930	22,240	18,130	33,710	530	24,690	185,610	2,997	21,826	133,371	29,199
CaliforniaNorth	1.93%	318,233	22,280	295,953	10,720	17,560	11,260	19,870	22,220	19,030	25,590	9,150	73,590	8,863	11,962	61,233	4,905
CaliforniaSouth	14.57%	2,405,822	1,614,370	791,452	16,790	33,060	22,400	20,480	33,260	24,220	175,030	75,460	52,260	58,873	45,709	226,042	7,868
AlaskaCanada	3.85%	635,769	550,121	85,648	1,233	2,268	1,481	3,569	1,827	3,937	2,997	8,863	58,873	0	0	600	0
TransAtlantic	9.11%	1,503,667	1,419,502	84,165	143	397	449	631	792	2,256	21,826	11,962	45,709	0	0	0	0
TransPacific	16.76%	2,767,323	1,846,162	921,161	47,291	98,681	58,240	63,148	97,406	134,849	133,371	61,233	226,042	670	0	10	220
South-Central America	4.22%	696,748	652,236	44,512	101	225	112	115	247	1,420	29,199	4,905	7,868	0	0	320	0
Totals	100%	16,508,093	12,872,211	3,635,882													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from SFO.

Select	**Airport Code** **(Miles from SFO)**
☑	Modesto City County (66 miles)
☑	Peninsula (70 miles)
☑	Sacramento International (84 miles)
☑	Fresno Yosemite International (145 miles)
☑	Chico Municipal (155 miles)
☑	San Luis Obispo County (182 miles)
☑	Reno International (186 miles)
☑	Redding Municipal (203 miles)
☑	Meadows Field (227 miles)
☑	Santa Barbara Municipal (253 miles)
☐	Arcata/Eureka (257 miles)

Results

Dest	**Distance**	**Total Passengers**
BFL	227 miles	18,350
CIC	155 miles	26,330
FAT	145 miles	52,529
MOD	66 miles	24,055
MRY	70 miles	44,465
RDD	203 miles	37,217
RNO	186 miles	114,712
SBA	253 miles	71,797
SBP	182 miles	33,797
SMF	84 miles	64,071
	Total Passengers	487,323

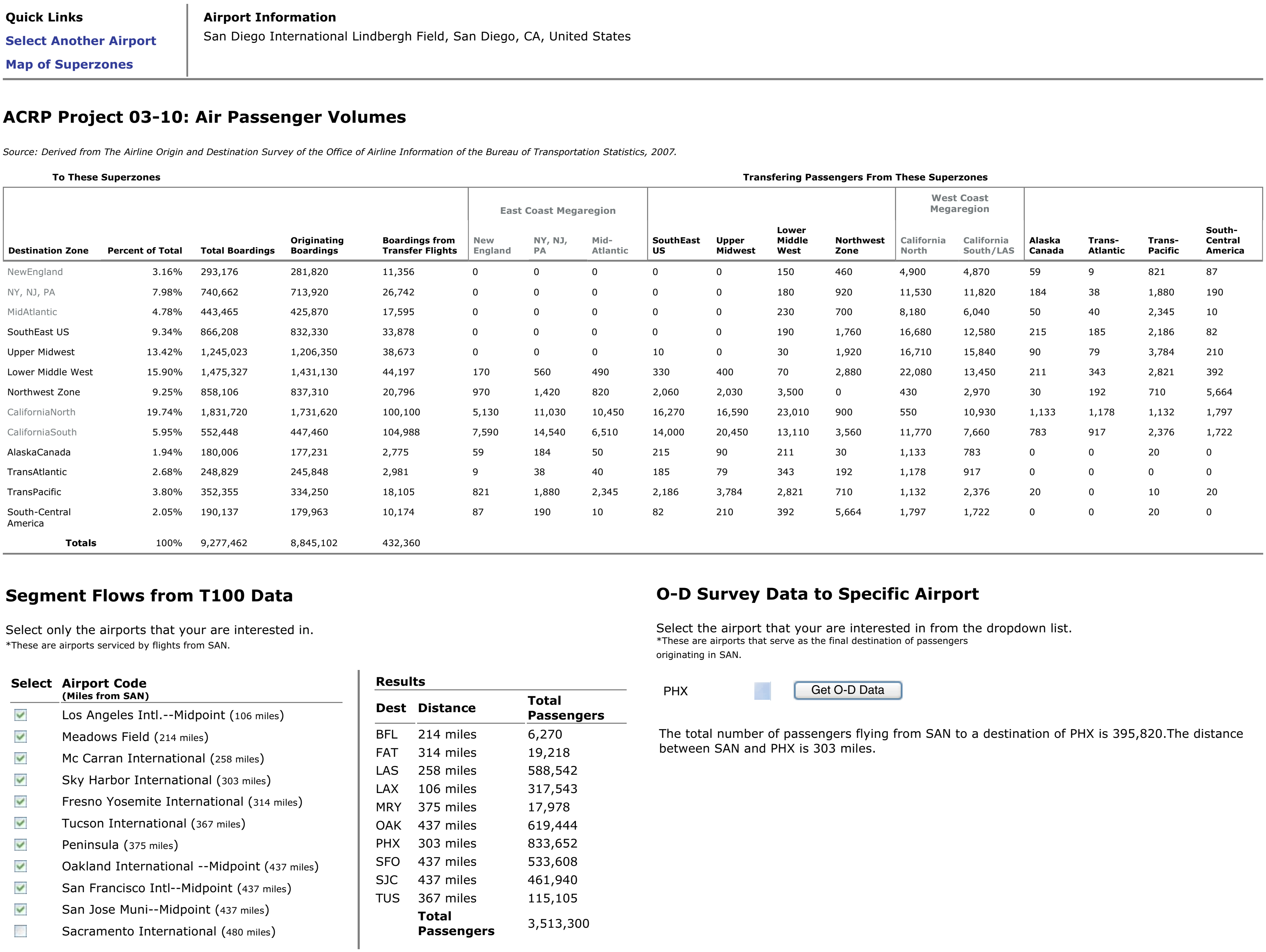
O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in SFO.

RNO

Get O-D Data

The total number of passengers flying from SFO to a destination of RNO is 20,200.The distance between SFO and RNO is 186 miles.



Airport Information

San Diego International Lindbergh Field, San Diego, CA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones — **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	3.16%	293,176	281,820	11,356	0	0	0	0	0	150	460	4,900	4,870	59	9	821	87
NY, NJ, PA	7.98%	740,662	713,920	26,742	0	0	0	0	0	180	920	11,530	11,820	184	38	1,880	190
MidAtlantic	4.78%	443,465	425,870	17,595	0	0	0	0	0	230	700	8,180	6,040	50	40	2,345	10
SouthEast US	9.34%	866,208	832,330	33,878	0	0	0	0	0	190	1,760	16,680	12,580	215	185	2,186	82
Upper Midwest	13.42%	1,245,023	1,206,350	38,673	0	0	0	10	0	30	1,920	16,710	15,840	90	79	3,784	210
Lower Middle West	15.90%	1,475,327	1,431,130	44,197	170	560	490	330	400	70	2,880	22,080	13,450	211	343	2,821	392
Northwest Zone	9.25%	858,106	837,310	20,796	970	1,420	820	2,060	2,030	3,500	0	430	2,970	30	192	710	5,664
CaliforniaNorth	19.74%	1,831,720	1,731,620	100,100	5,130	11,030	10,450	16,270	16,590	23,010	900	550	10,930	1,133	1,178	1,132	1,797
CaliforniaSouth	5.95%	552,448	447,460	104,988	7,590	14,540	6,510	14,000	20,450	13,110	3,560	11,770	7,660	783	917	2,376	1,722
AlaskaCanada	1.94%	180,006	177,231	2,775	59	184	50	215	90	211	30	1,133	783	0	0	20	0
TransAtlantic	2.68%	248,829	245,848	2,981	9	38	40	185	79	343	192	1,178	917	0	0	0	0
TransPacific	3.80%	352,355	334,250	18,105	821	1,880	2,345	2,186	3,784	2,821	710	1,132	2,376	20	0	10	20
South-Central America	2.05%	190,137	179,963	10,174	87	190	10	82	210	392	5,664	1,797	1,722	0	0	20	0
Totals	100%	9,277,462	8,845,102	432,360													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from SAN.

Select	**Airport Code** **(Miles from SAN)**
☑	Los Angeles Intl.--Midpoint (106 miles)
☑	Meadows Field (214 miles)
☑	Mc Carran International (258 miles)
☑	Sky Harbor International (303 miles)
☑	Fresno Yosemite International (314 miles)
☑	Tucson International (367 miles)
☑	Peninsula (375 miles)
☑	Oakland International --Midpoint (437 miles)
☑	San Francisco Intl--Midpoint (437 miles)
☑	San Jose Muni--Midpoint (437 miles)
☐	Sacramento International (480 miles)

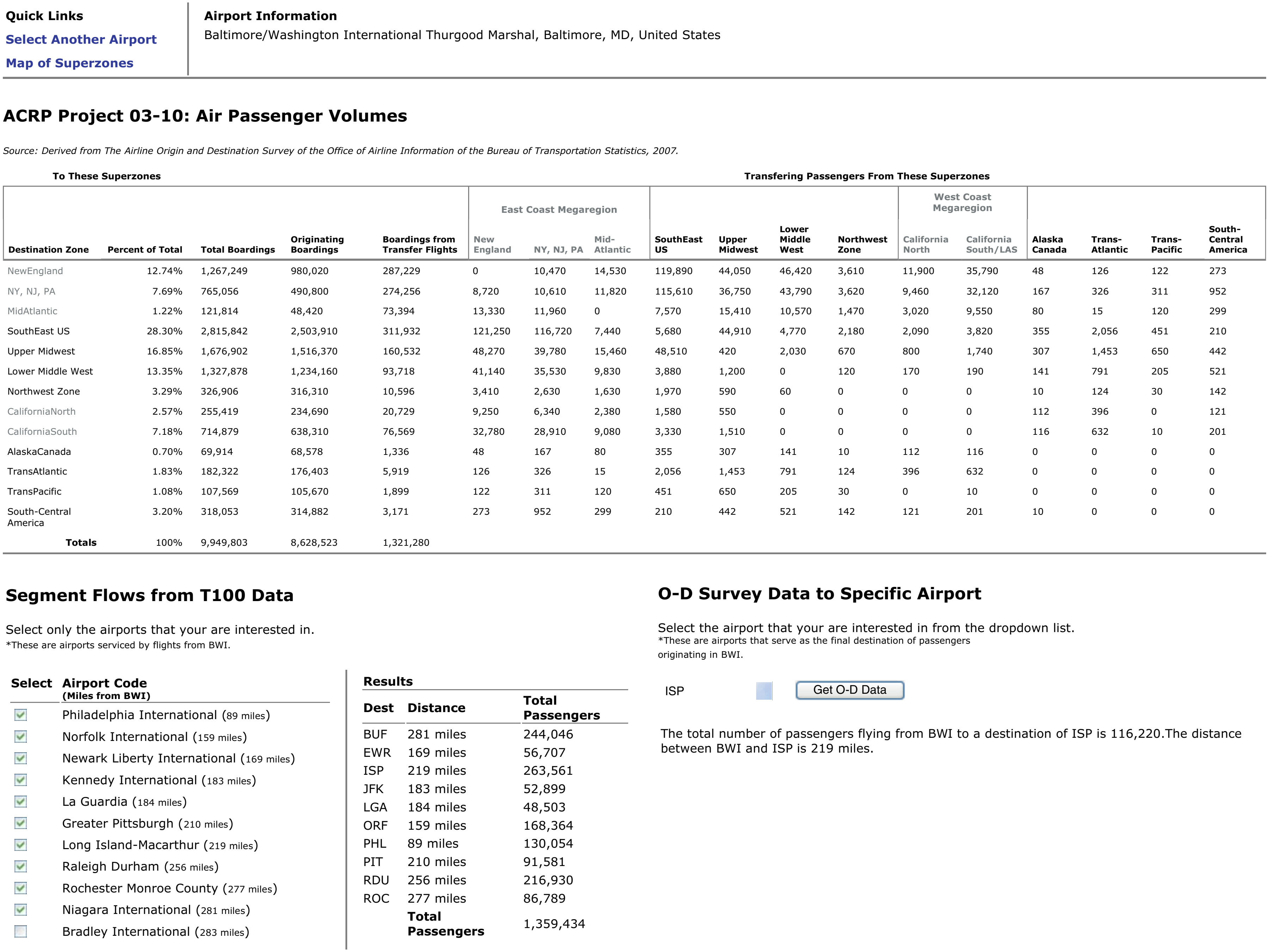
Results

Dest	**Distance**	**Total Passengers**
BFL	214 miles	6,270
FAT	314 miles	19,218
LAS	258 miles	588,542
LAX	106 miles	317,543
MRY	375 miles	17,978
OAK	437 miles	619,444
PHX	303 miles	833,652
SFO	437 miles	533,608
SJC	437 miles	461,940
TUS	367 miles	115,105
	Total Passengers	3,513,300

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in SAN.

The total number of passengers flying from SAN to a destination of PHX is 395,820.The distance between SAN and PHX is 303 miles.



Airport Information

Baltimore/Washington International Thurgood Marshal, Baltimore, MD, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	12.74%	1,267,249	980,020	287,229	0	10,470	14,530	119,890	44,050	46,420	3,610	11,900	35,790	48	126	122	273
NY, NJ, PA	7.69%	765,056	490,800	274,256	8,720	10,610	11,820	115,610	36,750	43,790	3,620	9,460	32,120	167	326	311	952
MidAtlantic	1.22%	121,814	48,420	73,394	13,330	11,960	0	7,570	15,410	10,570	1,470	3,020	9,550	80	15	120	299
SouthEast US	28.30%	2,815,842	2,503,910	311,932	121,250	116,720	7,440	5,680	44,910	4,770	2,180	2,090	3,820	355	2,056	451	210
Upper Midwest	16.85%	1,676,902	1,516,370	160,532	48,270	39,780	15,460	48,510	420	2,030	670	800	1,740	307	1,453	650	442
Lower Middle West	13.35%	1,327,878	1,234,160	93,718	41,140	35,530	9,830	3,880	1,200	0	120	170	190	141	791	205	521
Northwest Zone	3.29%	326,906	316,310	10,596	3,410	2,630	1,630	1,970	590	60	0	0	0	10	124	30	142
CaliforniaNorth	2.57%	255,419	234,690	20,729	9,250	6,340	2,380	1,580	550	0	0	0	0	112	396	0	121
CaliforniaSouth	7.18%	714,879	638,310	76,569	32,780	28,910	9,080	3,330	1,510	0	0	0	0	116	632	10	201
AlaskaCanada	0.70%	69,914	68,578	1,336	48	167	80	355	307	141	10	112	116	0	0	0	0
TransAtlantic	1.83%	182,322	176,403	5,919	126	326	15	2,056	1,453	791	124	396	632	0	0	0	0
TransPacific	1.08%	107,569	105,670	1,899	122	311	120	451	650	205	30	0	10	0	0	0	0
South-Central America	3.20%	318,053	314,882	3,171	273	952	299	210	442	521	142	121	201	10	0	0	0
Totals	100%	9,949,803	8,628,523	1,321,280													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from BWI.

Select	**Airport Code** **(Miles from BWI)**
☑	Philadelphia International (89 miles)
☑	Norfolk International (159 miles)
☑	Newark Liberty International (169 miles)
☑	Kennedy International (183 miles)
☑	La Guardia (184 miles)
☑	Greater Pittsburgh (210 miles)
☑	Long Island-Macarthur (219 miles)
☑	Raleigh Durham (256 miles)
☑	Rochester Monroe County (277 miles)
☑	Niagara International (281 miles)
☐	Bradley International (283 miles)

Results

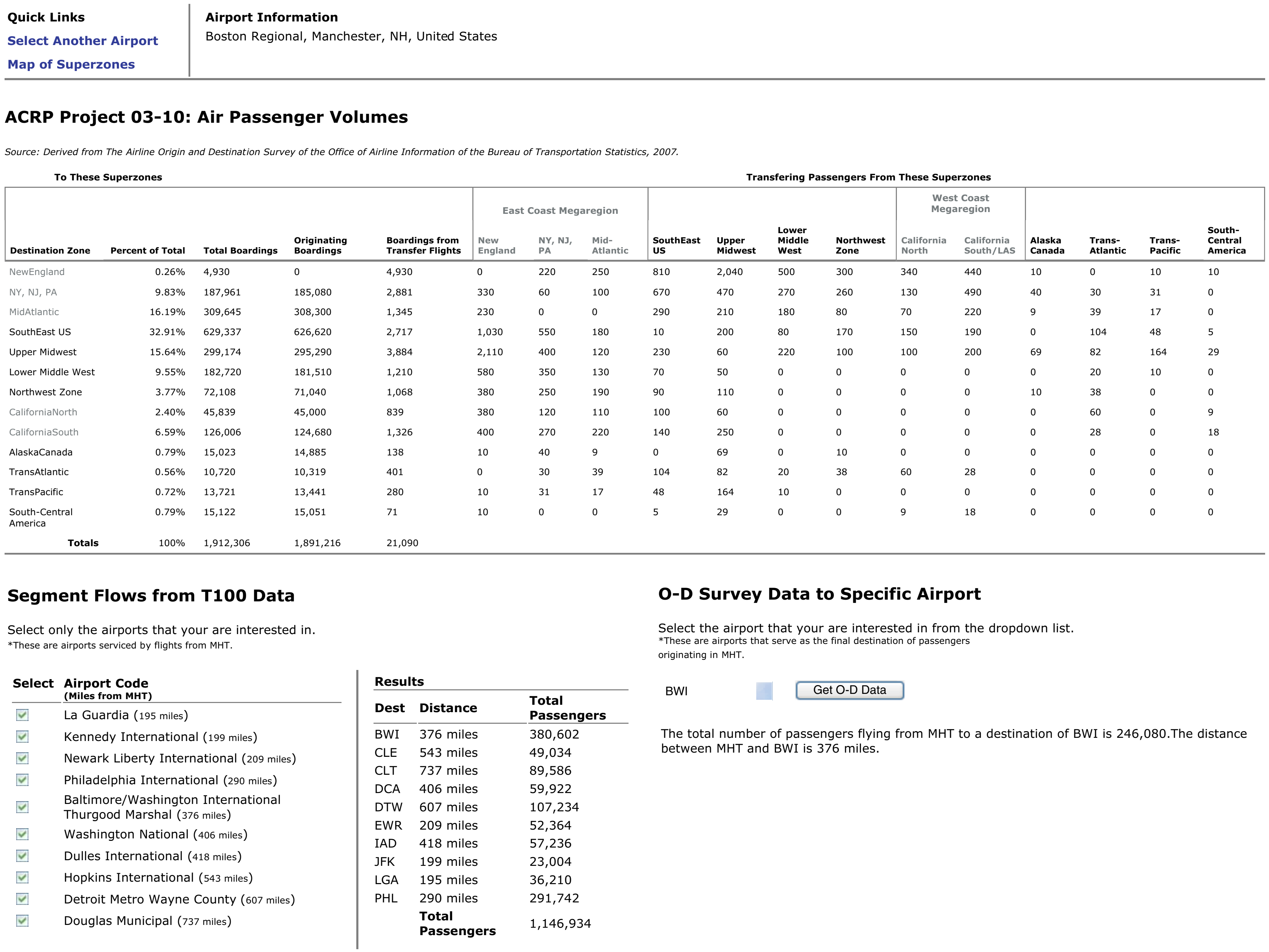
Dest	**Distance**	**Total Passengers**
BUF	281 miles	244,046
EWR	169 miles	56,707
ISP	219 miles	263,561
JFK	183 miles	52,899
LGA	184 miles	48,503
ORF	159 miles	168,364
PHL	89 miles	130,054
PIT	210 miles	91,581
RDU	256 miles	216,930
ROC	277 miles	86,789
	Total Passengers	1,359,434

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in BWI.

ISP

The total number of passengers flying from BWI to a destination of ISP is 116,220.The distance between BWI and ISP is 219 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Boston Regional, Manchester, NH, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	0.26%	4,930	0	4,930	0	220	250	810	2,040	500	300	340	440	10	0	10	10
NY, NJ, PA	9.83%	187,961	185,080	2,881	330	60	100	670	470	270	260	130	490	40	30	31	0
MidAtlantic	16.19%	309,645	308,300	1,345	230	0	0	290	210	180	80	70	220	9	39	17	0
SouthEast US	32.91%	629,337	626,620	2,717	1,030	550	180	10	200	80	170	150	190	0	104	48	5
Upper Midwest	15.64%	299,174	295,290	3,884	2,110	400	120	230	60	220	100	100	200	69	82	164	29
Lower Middle West	9.55%	182,720	181,510	1,210	580	350	130	70	50	0	0	0	0	0	20	10	0
Northwest Zone	3.77%	72,108	71,040	1,068	380	250	190	90	110	0	0	0	0	10	38	0	0
CaliforniaNorth	2.40%	45,839	45,000	839	380	120	110	100	60	0	0	0	0	0	60	0	9
CaliforniaSouth	6.59%	126,006	124,680	1,326	400	270	220	140	250	0	0	0	0	0	28	0	18
AlaskaCanada	0.79%	15,023	14,885	138	10	40	9	0	69	0	10	0	0	0	0	0	0
TransAtlantic	0.56%	10,720	10,319	401	0	30	39	104	82	20	38	60	28	0	0	0	0
TransPacific	0.72%	13,721	13,441	280	10	31	17	48	164	10	0	0	0	0	0	0	0
South-Central America	0.79%	15,122	15,051	71	10	0	0	5	29	0	0	9	18	0	0	0	0
Totals	100%	1,912,306	1,891,216	21,090													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from MHT.

Select	Airport Code (Miles from MHT)
☑	La Guardia (195 miles)
☑	Kennedy International (199 miles)
☑	Newark Liberty International (209 miles)
☑	Philadelphia International (290 miles)
☑	Baltimore/Washington International Thurgood Marshal (376 miles)
☑	Washington National (406 miles)
☑	Dulles International (418 miles)
☑	Hopkins International (543 miles)
☑	Detroit Metro Wayne County (607 miles)
☑	Douglas Municipal (737 miles)

Results

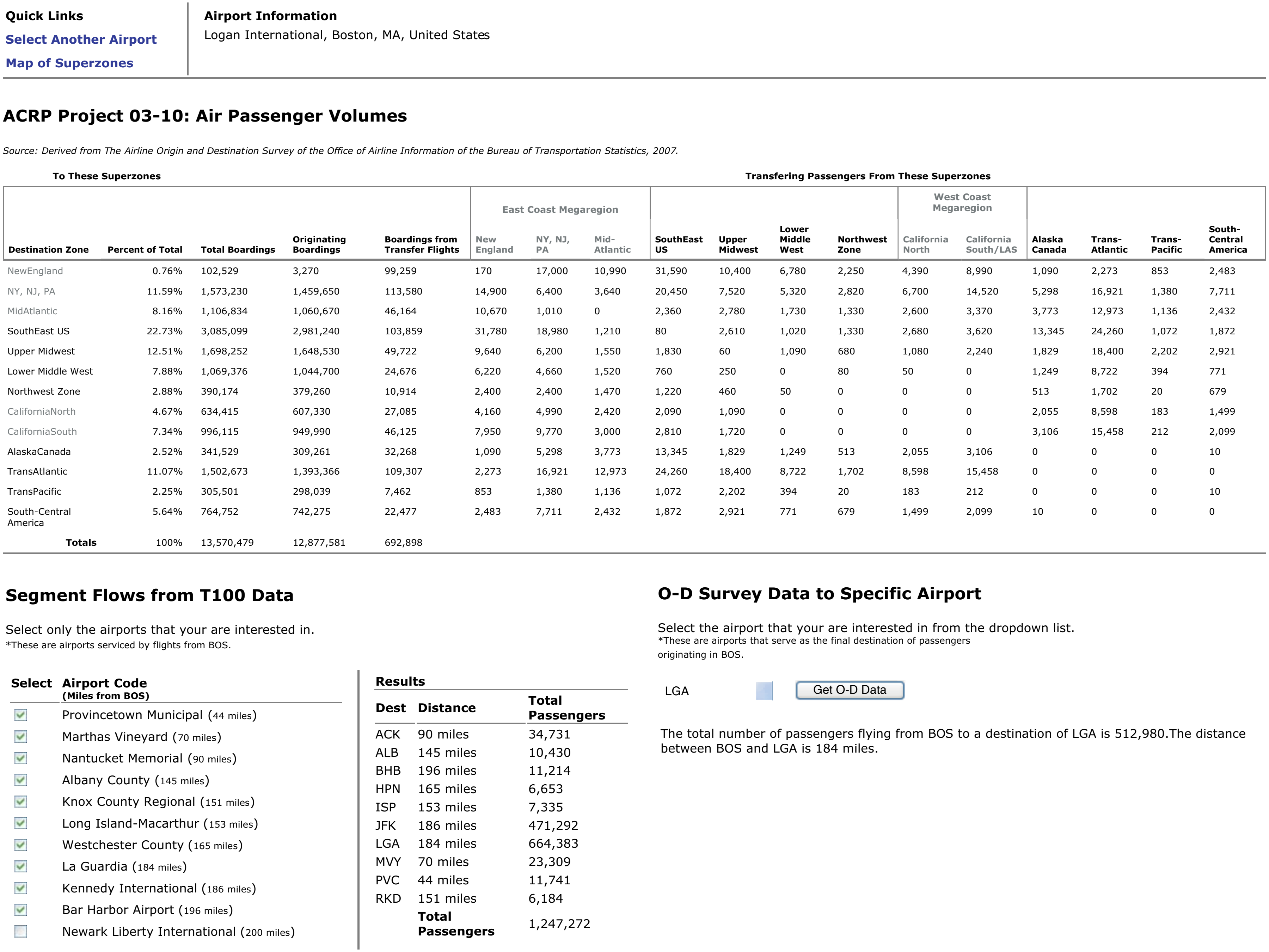
Dest	Distance	Total Passengers
BWI	376 miles	380,602
CLE	543 miles	49,034
CLT	737 miles	89,586
DCA	406 miles	59,922
DTW	607 miles	107,234
EWR	209 miles	52,364
IAD	418 miles	57,236
JFK	199 miles	23,004
LGA	195 miles	36,210
PHL	290 miles	291,742
	Total Passengers	1,146,934

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in MHT.

BWI

The total number of passengers flying from MHT to a destination of BWI is 246,080.The distance between MHT and BWI is 376 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Logan International, Boston, MA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones | **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	**New England**	**NY, NJ, PA**	**Mid-Atlantic**	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	**California North**	**California South/LAS**	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	0.76%	102,529	3,270	99,259	170	17,000	10,990	31,590	10,400	6,780	2,250	4,390	8,990	1,090	2,273	853	2,483
NY, NJ, PA	11.59%	1,573,230	1,459,650	113,580	14,900	6,400	3,640	20,450	7,520	5,320	2,820	6,700	14,520	5,298	16,921	1,380	7,711
MidAtlantic	8.16%	1,106,834	1,060,670	46,164	10,670	1,010	0	2,360	2,780	1,730	1,330	2,600	3,370	3,773	12,973	1,136	2,432
SouthEast US	22.73%	3,085,099	2,981,240	103,859	31,780	18,980	1,210	80	2,610	1,020	1,330	2,680	3,620	13,345	24,260	1,072	1,872
Upper Midwest	12.51%	1,698,252	1,648,530	49,722	9,640	6,200	1,550	1,830	60	1,090	680	1,080	2,240	1,829	18,400	2,202	2,921
Lower Middle West	7.88%	1,069,376	1,044,700	24,676	6,220	4,660	1,520	760	250	0	80	50	0	1,249	8,722	394	771
Northwest Zone	2.88%	390,174	379,260	10,914	2,400	2,400	1,470	1,220	460	50	0	0	0	513	1,702	20	679
CaliforniaNorth	4.67%	634,415	607,330	27,085	4,160	4,990	2,420	2,090	1,090	0	0	0	0	2,055	8,598	183	1,499
CaliforniaSouth	7.34%	996,115	949,990	46,125	7,950	9,770	3,000	2,810	1,720	0	0	0	0	3,106	15,458	212	2,099
AlaskaCanada	2.52%	341,529	309,261	32,268	1,090	5,298	3,773	13,345	1,829	1,249	513	2,055	3,106	0	0	0	10
TransAtlantic	11.07%	1,502,673	1,393,366	109,307	2,273	16,921	12,973	24,260	18,400	8,722	1,702	8,598	15,458	0	0	0	0
TransPacific	2.25%	305,501	298,039	7,462	853	1,380	1,136	1,072	2,202	394	20	183	212	0	0	0	10
South-Central America	5.64%	764,752	742,275	22,477	2,483	7,711	2,432	1,872	2,921	771	679	1,499	2,099	10	0	0	0
Totals	100%	13,570,479	12,877,581	692,898													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from BOS.

Select	**Airport Code** (Miles from BOS)
☑	Provincetown Municipal (44 miles)
☑	Marthas Vineyard (70 miles)
☑	Nantucket Memorial (90 miles)
☑	Albany County (145 miles)
☑	Knox County Regional (151 miles)
☑	Long Island-Macarthur (153 miles)
☑	Westchester County (165 miles)
☑	La Guardia (184 miles)
☑	Kennedy International (186 miles)
☑	Bar Harbor Airport (196 miles)
☐	Newark Liberty International (200 miles)

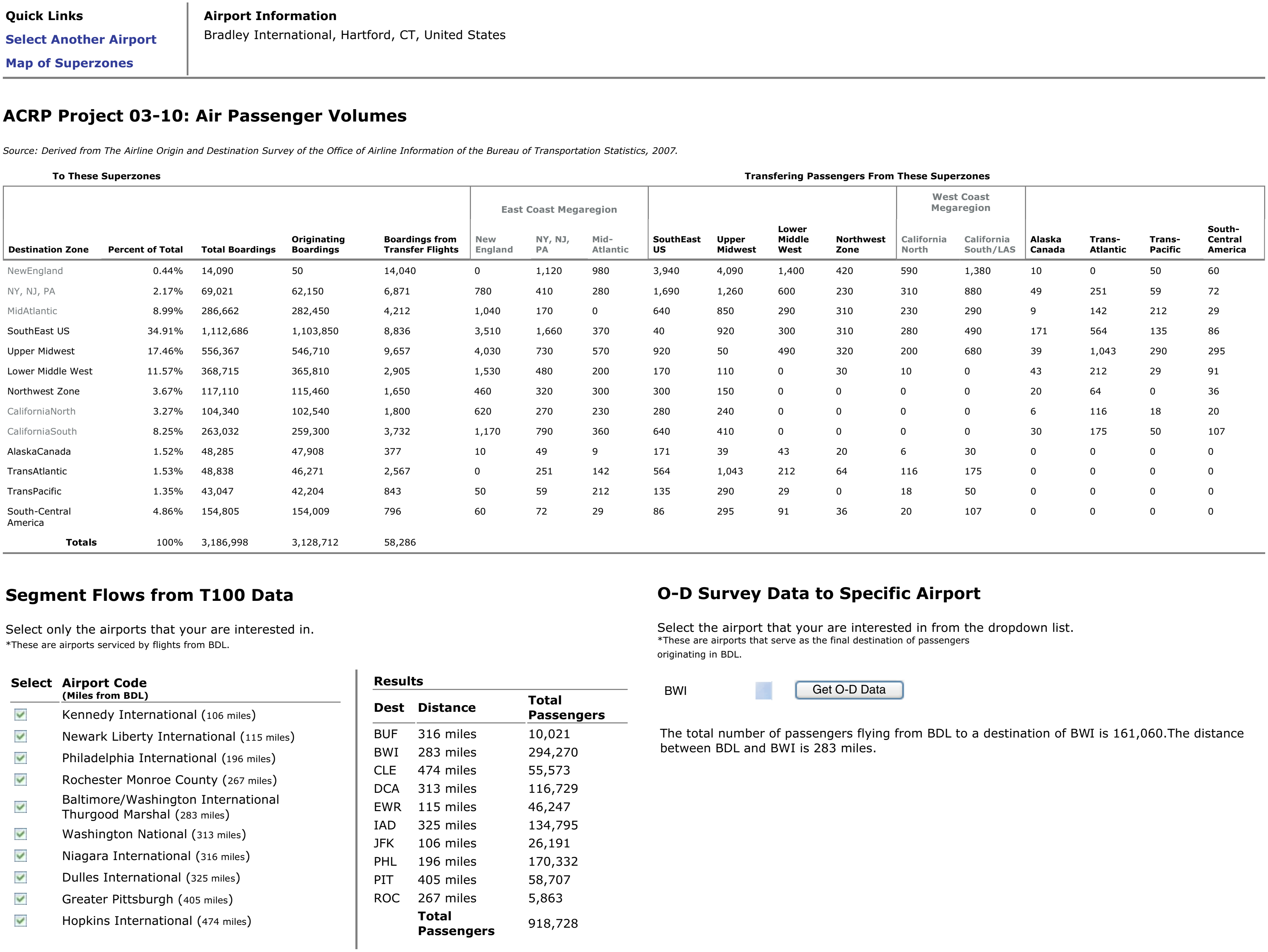
Results

Dest	**Distance**	**Total Passengers**
ACK	90 miles	34,731
ALB	145 miles	10,430
BHB	196 miles	11,214
HPN	165 miles	6,653
ISP	153 miles	7,335
JFK	186 miles	471,292
LGA	184 miles	664,383
MVY	70 miles	23,309
PVC	44 miles	11,741
RKD	151 miles	6,184
	Total Passengers	1,247,272

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in BOS.

The total number of passengers flying from BOS to a destination of LGA is 512,980.The distance between BOS and LGA is 184 miles.



Airport Information

Bradley International, Hartford, CT, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	0.44%	14,090	50	14,040	0	1,120	980	3,940	4,090	1,400	420	590	1,380	10	0	50	60
NY, NJ, PA	2.17%	69,021	62,150	6,871	780	410	280	1,690	1,260	600	230	310	880	49	251	59	72
MidAtlantic	8.99%	286,662	282,450	4,212	1,040	170	0	640	850	290	310	230	290	9	142	212	29
SouthEast US	34.91%	1,112,686	1,103,850	8,836	3,510	1,660	370	40	920	300	310	280	490	171	564	135	86
Upper Midwest	17.46%	556,367	546,710	9,657	4,030	730	570	920	50	490	320	200	680	39	1,043	290	295
Lower Middle West	11.57%	368,715	365,810	2,905	1,530	480	200	170	110	0	30	10	0	43	212	29	91
Northwest Zone	3.67%	117,110	115,460	1,650	460	320	300	300	150	0	0	0	0	20	64	0	36
CaliforniaNorth	3.27%	104,340	102,540	1,800	620	270	230	280	240	0	0	0	0	6	116	18	20
CaliforniaSouth	8.25%	263,032	259,300	3,732	1,170	790	360	640	410	0	0	0	0	30	175	50	107
AlaskaCanada	1.52%	48,285	47,908	377	10	49	9	171	39	43	20	6	30	0	0	0	0
TransAtlantic	1.53%	48,838	46,271	2,567	0	251	142	564	1,043	212	64	116	175	0	0	0	0
TransPacific	1.35%	43,047	42,204	843	50	59	212	135	290	29	0	18	50	0	0	0	0
South-Central America	4.86%	154,805	154,009	796	60	72	29	86	295	91	36	20	107	0	0	0	0
Totals	100%	3,186,998	3,128,712	58,286													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from BDL.

Select	**Airport Code** (Miles from BDL)
☑	Kennedy International (106 miles)
☑	Newark Liberty International (115 miles)
☑	Philadelphia International (196 miles)
☑	Rochester Monroe County (267 miles)
☑	Baltimore/Washington International Thurgood Marshal (283 miles)
☑	Washington National (313 miles)
☑	Niagara International (316 miles)
☑	Dulles International (325 miles)
☑	Greater Pittsburgh (405 miles)
☑	Hopkins International (474 miles)

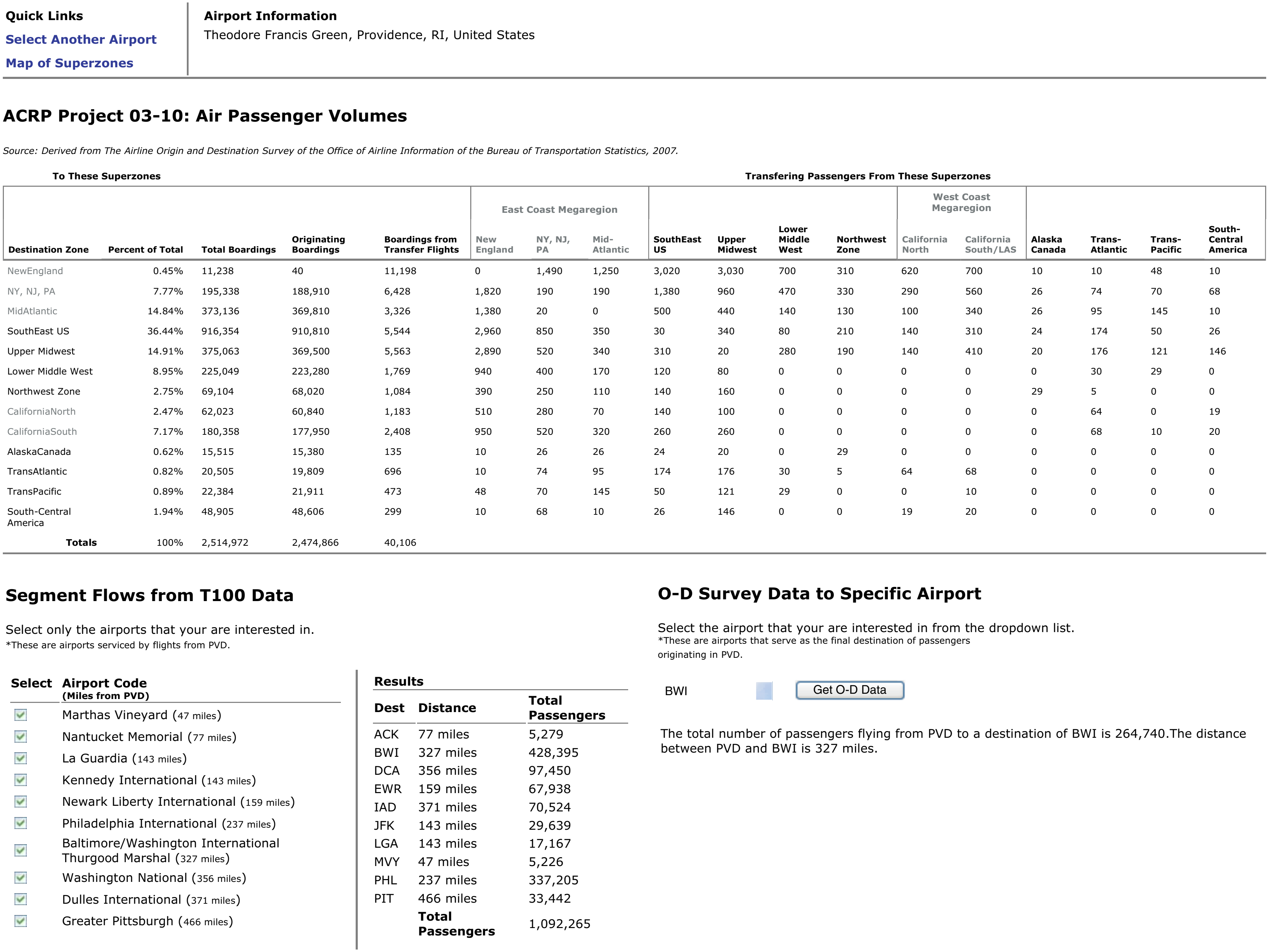
Results

Dest	**Distance**	**Total Passengers**
BUF	316 miles	10,021
BWI	283 miles	294,270
CLE	474 miles	55,573
DCA	313 miles	116,729
EWR	115 miles	46,247
IAD	325 miles	134,795
JFK	106 miles	26,191
PHL	196 miles	170,332
PIT	405 miles	58,707
ROC	267 miles	5,863
	Total Passengers	918,728

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in BDL.

The total number of passengers flying from BDL to a destination of BWI is 161,060.The distance between BDL and BWI is 283 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Theodore Francis Green, Providence, RI, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones | **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	0.45%	11,238	40	11,198	0	1,490	1,250	3,020	3,030	700	310	620	700	10	10	48	10
NY, NJ, PA	7.77%	195,338	188,910	6,428	1,820	190	190	1,380	960	470	330	290	560	26	74	70	68
MidAtlantic	14.84%	373,136	369,810	3,326	1,380	20	0	500	440	140	130	100	340	26	95	145	10
SouthEast US	36.44%	916,354	910,810	5,544	2,960	850	350	30	340	80	210	140	310	24	174	50	26
Upper Midwest	14.91%	375,063	369,500	5,563	2,890	520	340	310	20	280	190	140	410	20	176	121	146
Lower Middle West	8.95%	225,049	223,280	1,769	940	400	170	120	80	0	0	0	0	0	30	29	0
Northwest Zone	2.75%	69,104	68,020	1,084	390	250	110	140	160	0	0	0	0	29	5	0	0
CaliforniaNorth	2.47%	62,023	60,840	1,183	510	280	70	140	100	0	0	0	0	0	64	0	19
CaliforniaSouth	7.17%	180,358	177,950	2,408	950	520	320	260	260	0	0	0	0	0	68	10	20
AlaskaCanada	0.62%	15,515	15,380	135	10	26	26	24	20	0	29	0	0	0	0	0	0
TransAtlantic	0.82%	20,505	19,809	696	10	74	95	174	176	30	5	64	68	0	0	0	0
TransPacific	0.89%	22,384	21,911	473	48	70	145	50	121	29	0	0	10	0	0	0	0
South-Central America	1.94%	48,905	48,606	299	10	68	10	26	146	0	0	19	20	0	0	0	0
Totals	100%	2,514,972	2,474,866	40,106													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from PVD.

Select	**Airport Code** **(Miles from PVD)**
☑	Marthas Vineyard (47 miles)
☑	Nantucket Memorial (77 miles)
☑	La Guardia (143 miles)
☑	Kennedy International (143 miles)
☑	Newark Liberty International (159 miles)
☑	Philadelphia International (237 miles)
☑	Baltimore/Washington International Thurgood Marshal (327 miles)
☑	Washington National (356 miles)
☑	Dulles International (371 miles)
☑	Greater Pittsburgh (466 miles)

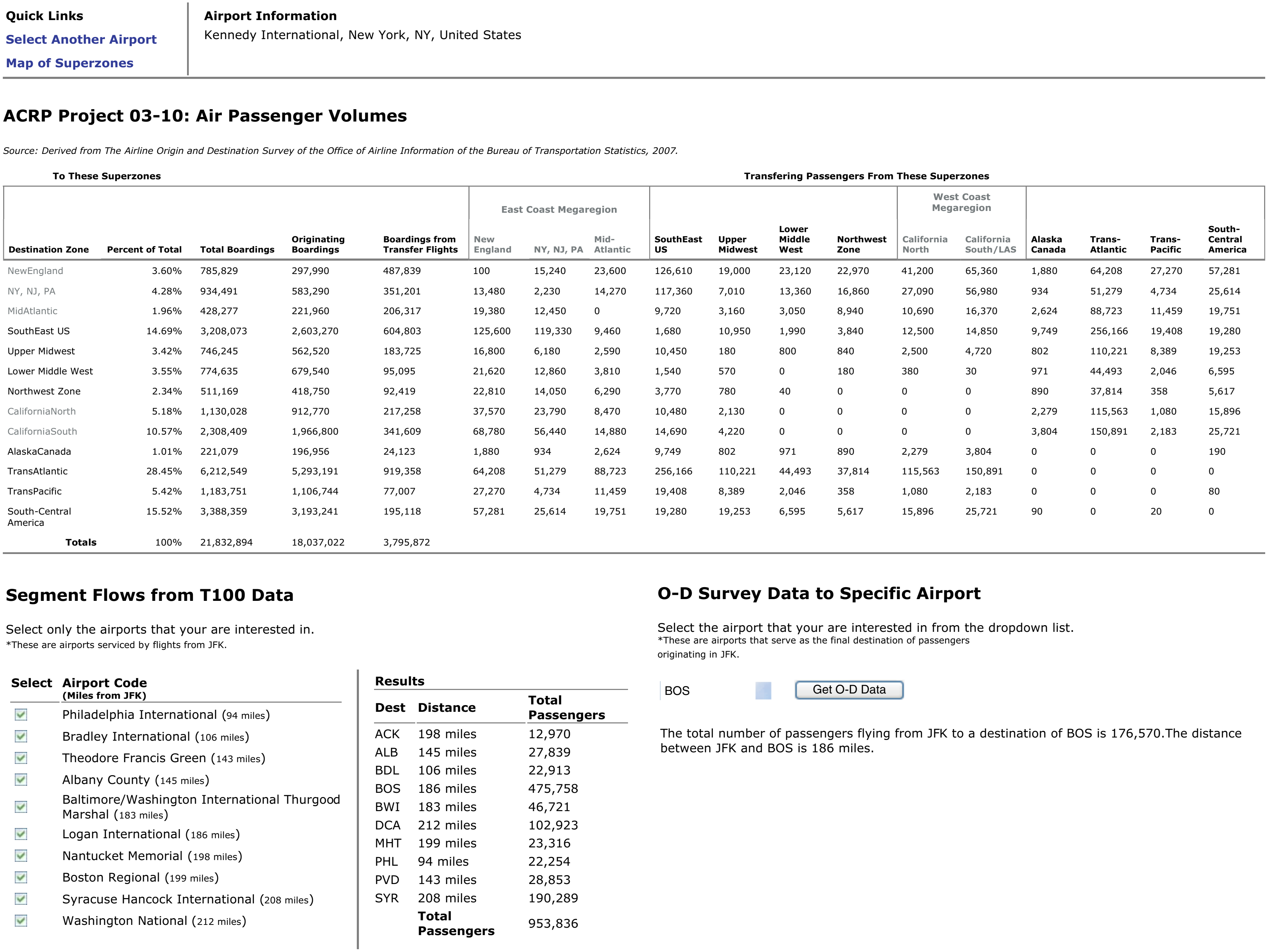
Results

Dest	**Distance**	**Total Passengers**
ACK	77 miles	5,279
BWI	327 miles	428,395
DCA	356 miles	97,450
EWR	159 miles	67,938
IAD	371 miles	70,524
JFK	143 miles	29,639
LGA	143 miles	17,167
MVY	47 miles	5,226
PHL	237 miles	337,205
PIT	466 miles	33,442
	Total Passengers	1,092,265

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in PVD.

The total number of passengers flying from PVD to a destination of BWI is 264,740.The distance between PVD and BWI is 327 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Kennedy International, New York, NY, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	3.60%	785,829	297,990	487,839	100	15,240	23,600	126,610	19,000	23,120	22,970	41,200	65,360	1,880	64,208	27,270	57,281
NY, NJ, PA	4.28%	934,491	583,290	351,201	13,480	2,230	14,270	117,360	7,010	13,360	16,860	27,090	56,980	934	51,279	4,734	25,614
MidAtlantic	1.96%	428,277	221,960	206,317	19,380	12,450	0	9,720	3,160	3,050	8,940	10,690	16,370	2,624	88,723	11,459	19,751
SouthEast US	14.69%	3,208,073	2,603,270	604,803	125,600	119,330	9,460	1,680	10,950	1,990	3,840	12,500	14,850	9,749	256,166	19,408	19,280
Upper Midwest	3.42%	746,245	562,520	183,725	16,800	6,180	2,590	10,450	180	800	840	2,500	4,720	802	110,221	8,389	19,253
Lower Middle West	3.55%	774,635	679,540	95,095	21,620	12,860	3,810	1,540	570	0	180	380	30	971	44,493	2,046	6,595
Northwest Zone	2.34%	511,169	418,750	92,419	22,810	14,050	6,290	3,770	780	40	0	0	0	890	37,814	358	5,617
CaliforniaNorth	5.18%	1,130,028	912,770	217,258	37,570	23,790	8,470	10,480	2,130	0	0	0	0	2,279	115,563	1,080	15,896
CaliforniaSouth	10.57%	2,308,409	1,966,800	341,609	68,780	56,440	14,880	14,690	4,220	0	0	0	0	3,804	150,891	2,183	25,721
AlaskaCanada	1.01%	221,079	196,956	24,123	1,880	934	2,624	9,749	802	971	890	2,279	3,804	0	0	0	190
TransAtlantic	28.45%	6,212,549	5,293,191	919,358	64,208	51,279	88,723	256,166	110,221	44,493	37,814	115,563	150,891	0	0	0	0
TransPacific	5.42%	1,183,751	1,106,744	77,007	27,270	4,734	11,459	19,408	8,389	2,046	358	1,080	2,183	0	0	0	80
South-Central America	15.52%	3,388,359	3,193,241	195,118	57,281	25,614	19,751	19,280	19,253	6,595	5,617	15,896	25,721	90	0	20	0
Totals	100%	21,832,894	18,037,022	3,795,872													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from JFK.

Select	**Airport Code** **(Miles from JFK)**
☑	Philadelphia International (94 miles)
☑	Bradley International (106 miles)
☑	Theodore Francis Green (143 miles)
☑	Albany County (145 miles)
☑	Baltimore/Washington International Thurgood Marshal (183 miles)
☑	Logan International (186 miles)
☑	Nantucket Memorial (198 miles)
☑	Boston Regional (199 miles)
☑	Syracuse Hancock International (208 miles)
☑	Washington National (212 miles)

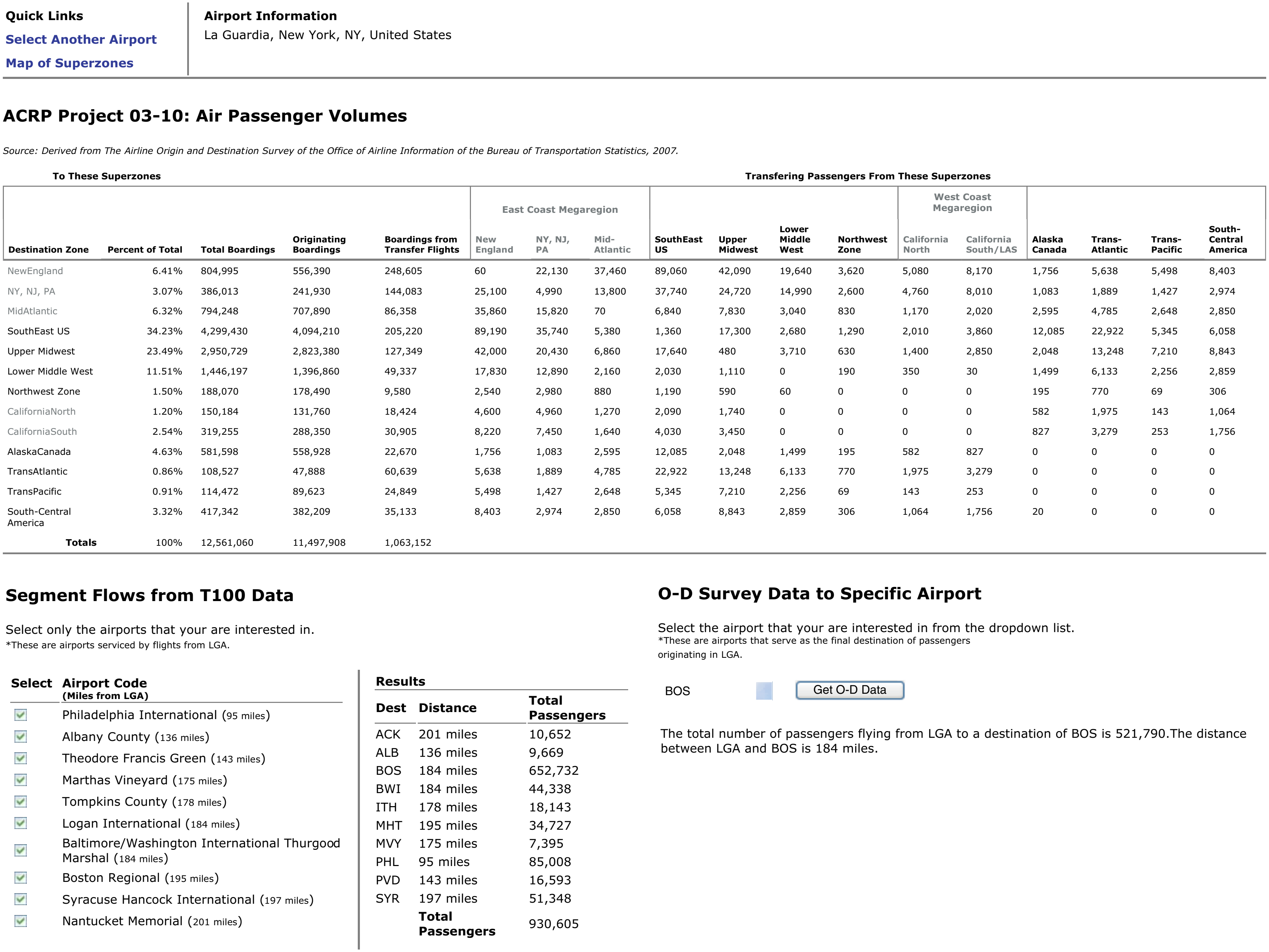
Results

Dest	**Distance**	**Total Passengers**
ACK	198 miles	12,970
ALB	145 miles	27,839
BDL	106 miles	22,913
BOS	186 miles	475,758
BWI	183 miles	46,721
DCA	212 miles	102,923
MHT	199 miles	23,316
PHL	94 miles	22,254
PVD	143 miles	28,853
SYR	208 miles	190,289
	Total Passengers	953,836

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in JFK.

The total number of passengers flying from JFK to a destination of BOS is 176,570.The distance between JFK and BOS is 186 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

La Guardia, New York, NY, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones

Transfering Passengers From These Superzones

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	6.41%	804,995	556,390	248,605	60	22,130	37,460	89,060	42,090	19,640	3,620	5,080	8,170	1,756	5,638	5,498	8,403
NY, NJ, PA	3.07%	386,013	241,930	144,083	25,100	4,990	13,800	37,740	24,720	14,990	2,600	4,760	8,010	1,083	1,889	1,427	2,974
MidAtlantic	6.32%	794,248	707,890	86,358	35,860	15,820	70	6,840	7,830	3,040	830	1,170	2,020	2,595	4,785	2,648	2,850
SouthEast US	34.23%	4,299,430	4,094,210	205,220	89,190	35,740	5,380	1,360	17,300	2,680	1,290	2,010	3,860	12,085	22,922	5,345	6,058
Upper Midwest	23.49%	2,950,729	2,823,380	127,349	42,000	20,430	6,860	17,640	480	3,710	630	1,400	2,850	2,048	13,248	7,210	8,843
Lower Middle West	11.51%	1,446,197	1,396,860	49,337	17,830	12,890	2,160	2,030	1,110	0	190	350	30	1,499	6,133	2,256	2,859
Northwest Zone	1.50%	188,070	178,490	9,580	2,540	2,980	880	1,190	590	60	0	0	0	195	770	69	306
CaliforniaNorth	1.20%	150,184	131,760	18,424	4,600	4,960	1,270	2,090	1,740	0	0	0	0	582	1,975	143	1,064
CaliforniaSouth	2.54%	319,255	288,350	30,905	8,220	7,450	1,640	4,030	3,450	0	0	0	0	827	3,279	253	1,756
AlaskaCanada	4.63%	581,598	558,928	22,670	1,756	1,083	2,595	12,085	2,048	1,499	195	582	827	0	0	0	0
TransAtlantic	0.86%	108,527	47,888	60,639	5,638	1,889	4,785	22,922	13,248	6,133	770	1,975	3,279	0	0	0	0
TransPacific	0.91%	114,472	89,623	24,849	5,498	1,427	2,648	5,345	7,210	2,256	69	143	253	0	0	0	0
South-Central America	3.32%	417,342	382,209	35,133	8,403	2,974	2,850	6,058	8,843	2,859	306	1,064	1,756	20	0	0	0
Totals	100%	12,561,060	11,497,908	1,063,152													

Segment Flows from T100 Data

Select only the airports that your are interested in.

*These are airports serviced by flights from LGA.

Select	**Airport Code (Miles from LGA)**
☑	Philadelphia International (95 miles)
☑	Albany County (136 miles)
☑	Theodore Francis Green (143 miles)
☑	Marthas Vineyard (175 miles)
☑	Tompkins County (178 miles)
☑	Logan International (184 miles)
☑	Baltimore/Washington International Thurgood Marshal (184 miles)
☑	Boston Regional (195 miles)
☑	Syracuse Hancock International (197 miles)
☑	Nantucket Memorial (201 miles)

Results

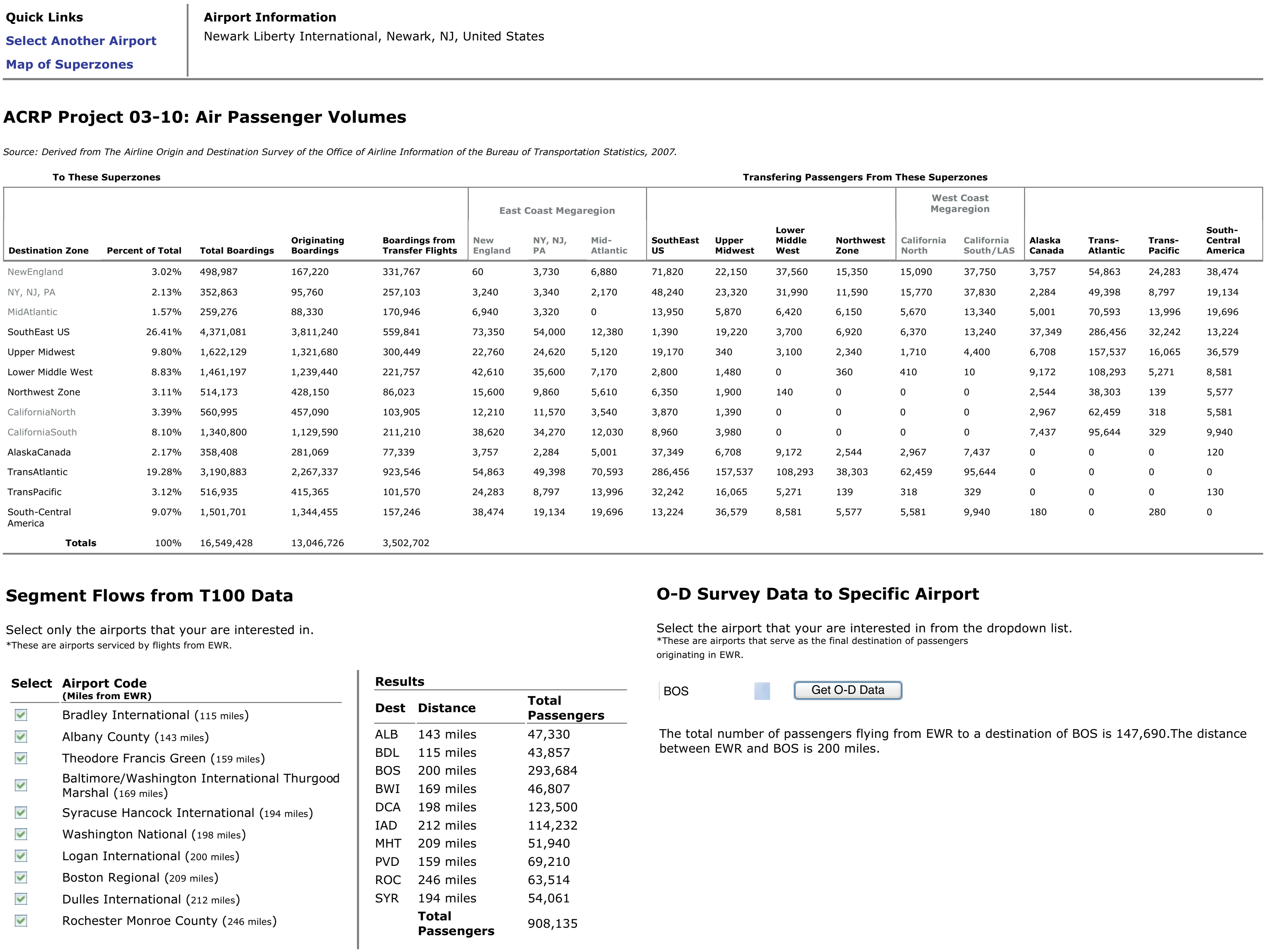
Dest	**Distance**	**Total Passengers**
ACK	201 miles	10,652
ALB	136 miles	9,669
BOS	184 miles	652,732
BWI	184 miles	44,338
ITH	178 miles	18,143
MHT	195 miles	34,727
MVY	175 miles	7,395
PHL	95 miles	85,008
PVD	143 miles	16,593
SYR	197 miles	51,348
	Total Passengers	930,605

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.

*These are airports that serve as the final destination of passengers originating in LGA.

The total number of passengers flying from LGA to a destination of BOS is 521,790.The distance between LGA and BOS is 184 miles.



Airport Information

Newark Liberty International, Newark, NJ, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	3.02%	498,987	167,220	331,767	60	3,730	6,880	71,820	22,150	37,560	15,350	15,090	37,750	3,757	54,863	24,283	38,474
NY, NJ, PA	2.13%	352,863	95,760	257,103	3,240	3,340	2,170	48,240	23,320	31,990	11,590	15,770	37,830	2,284	49,398	8,797	19,134
MidAtlantic	1.57%	259,276	88,330	170,946	6,940	3,320	0	13,950	5,870	6,420	6,150	5,670	13,340	5,001	70,593	13,996	19,696
SouthEast US	26.41%	4,371,081	3,811,240	559,841	73,350	54,000	12,380	1,390	19,220	3,700	6,920	6,370	13,240	37,349	286,456	32,242	13,224
Upper Midwest	9.80%	1,622,129	1,321,680	300,449	22,760	24,620	5,120	19,170	340	3,100	2,340	1,710	4,400	6,708	157,537	16,065	36,579
Lower Middle West	8.83%	1,461,197	1,239,440	221,757	42,610	35,600	7,170	2,800	1,480	0	360	410	10	9,172	108,293	5,271	8,581
Northwest Zone	3.11%	514,173	428,150	86,023	15,600	9,860	5,610	6,350	1,900	140	0	0	0	2,544	38,303	139	5,577
CaliforniaNorth	3.39%	560,995	457,090	103,905	12,210	11,570	3,540	3,870	1,390	0	0	0	0	2,967	62,459	318	5,581
CaliforniaSouth	8.10%	1,340,800	1,129,590	211,210	38,620	34,270	12,030	8,960	3,980	0	0	0	0	7,437	95,644	329	9,940
AlaskaCanada	2.17%	358,408	281,069	77,339	3,757	2,284	5,001	37,349	6,708	9,172	2,544	2,967	7,437	0	0	0	120
TransAtlantic	19.28%	3,190,883	2,267,337	923,546	54,863	49,398	70,593	286,456	157,537	108,293	38,303	62,459	95,644	0	0	0	0
TransPacific	3.12%	516,935	415,365	101,570	24,283	8,797	13,996	32,242	16,065	5,271	139	318	329	0	0	0	130
South-Central America	9.07%	1,501,701	1,344,455	157,246	38,474	19,134	19,696	13,224	36,579	8,581	5,577	5,581	9,940	180	0	280	0
Totals	100%	16,549,428	13,046,726	3,502,702													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from EWR.

Select	Airport Code (Miles from EWR)
☑	Bradley International (115 miles)
☑	Albany County (143 miles)
☑	Theodore Francis Green (159 miles)
☑	Baltimore/Washington International Thurgood Marshal (169 miles)
☑	Syracuse Hancock International (194 miles)
☑	Washington National (198 miles)
☑	Logan International (200 miles)
☑	Boston Regional (209 miles)
☑	Dulles International (212 miles)
☑	Rochester Monroe County (246 miles)

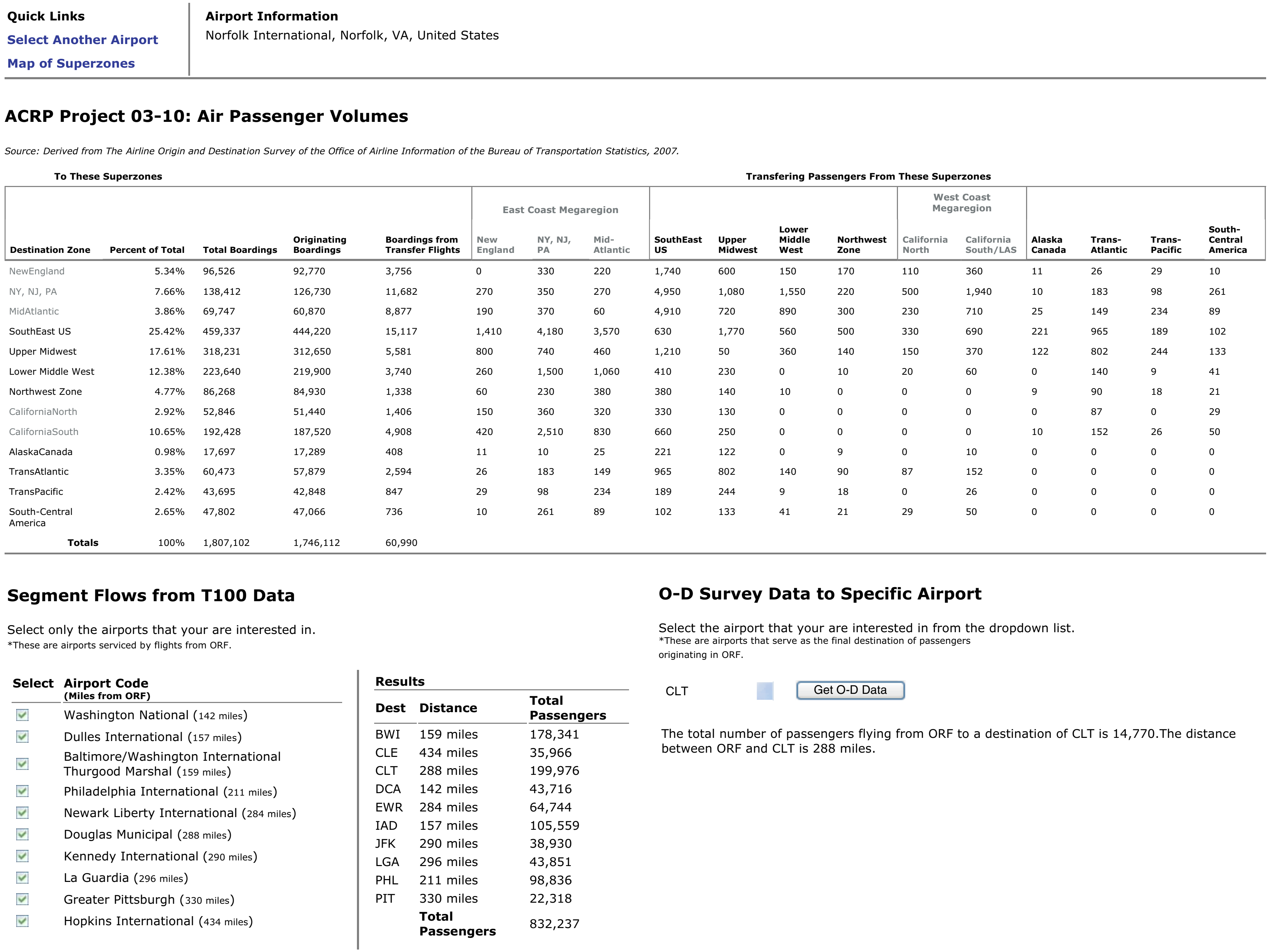
Results

Dest	Distance	Total Passengers
ALB	143 miles	47,330
BDL	115 miles	43,857
BOS	200 miles	293,684
BWI	169 miles	46,807
DCA	198 miles	123,500
IAD	212 miles	114,232
MHT	209 miles	51,940
PVD	159 miles	69,210
ROC	246 miles	63,514
SYR	194 miles	54,061
	Total Passengers	908,135

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in EWR.

The total number of passengers flying from EWR to a destination of BOS is 147,690.The distance between EWR and BOS is 200 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Norfolk International, Norfolk, VA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones — **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	5.34%	96,526	92,770	3,756	0	330	220	1,740	600	150	170	110	360	11	26	29	10
NY, NJ, PA	7.66%	138,412	126,730	11,682	270	350	270	4,950	1,080	1,550	220	500	1,940	10	183	98	261
MidAtlantic	3.86%	69,747	60,870	8,877	190	370	60	4,910	720	890	300	230	710	25	149	234	89
SouthEast US	25.42%	459,337	444,220	15,117	1,410	4,180	3,570	630	1,770	560	500	330	690	221	965	189	102
Upper Midwest	17.61%	318,231	312,650	5,581	800	740	460	1,210	50	360	140	150	370	122	802	244	133
Lower Middle West	12.38%	223,640	219,900	3,740	260	1,500	1,060	410	230	0	10	20	60	0	140	9	41
Northwest Zone	4.77%	86,268	84,930	1,338	60	230	380	380	140	10	0	0	0	9	90	18	21
CaliforniaNorth	2.92%	52,846	51,440	1,406	150	360	320	330	130	0	0	0	0	0	87	0	29
CaliforniaSouth	10.65%	192,428	187,520	4,908	420	2,510	830	660	250	0	0	0	0	10	152	26	50
AlaskaCanada	0.98%	17,697	17,289	408	11	10	25	221	122	0	9	0	10	0	0	0	0
TransAtlantic	3.35%	60,473	57,879	2,594	26	183	149	965	802	140	90	87	152	0	0	0	0
TransPacific	2.42%	43,695	42,848	847	29	98	234	189	244	9	18	0	26	0	0	0	0
South-Central America	2.65%	47,802	47,066	736	10	261	89	102	133	41	21	29	50	0	0	0	0
Totals	100%	1,807,102	1,746,112	60,990													

Segment Flows from T100 Data

Select only the airports that your are interested in.

*These are airports serviced by flights from ORF.

Select	**Airport Code** **(Miles from ORF)**
☑	Washington National (142 miles)
☑	Dulles International (157 miles)
☑	Baltimore/Washington International Thurgood Marshal (159 miles)
☑	Philadelphia International (211 miles)
☑	Newark Liberty International (284 miles)
☑	Douglas Municipal (288 miles)
☑	Kennedy International (290 miles)
☑	La Guardia (296 miles)
☑	Greater Pittsburgh (330 miles)
☑	Hopkins International (434 miles)

Results

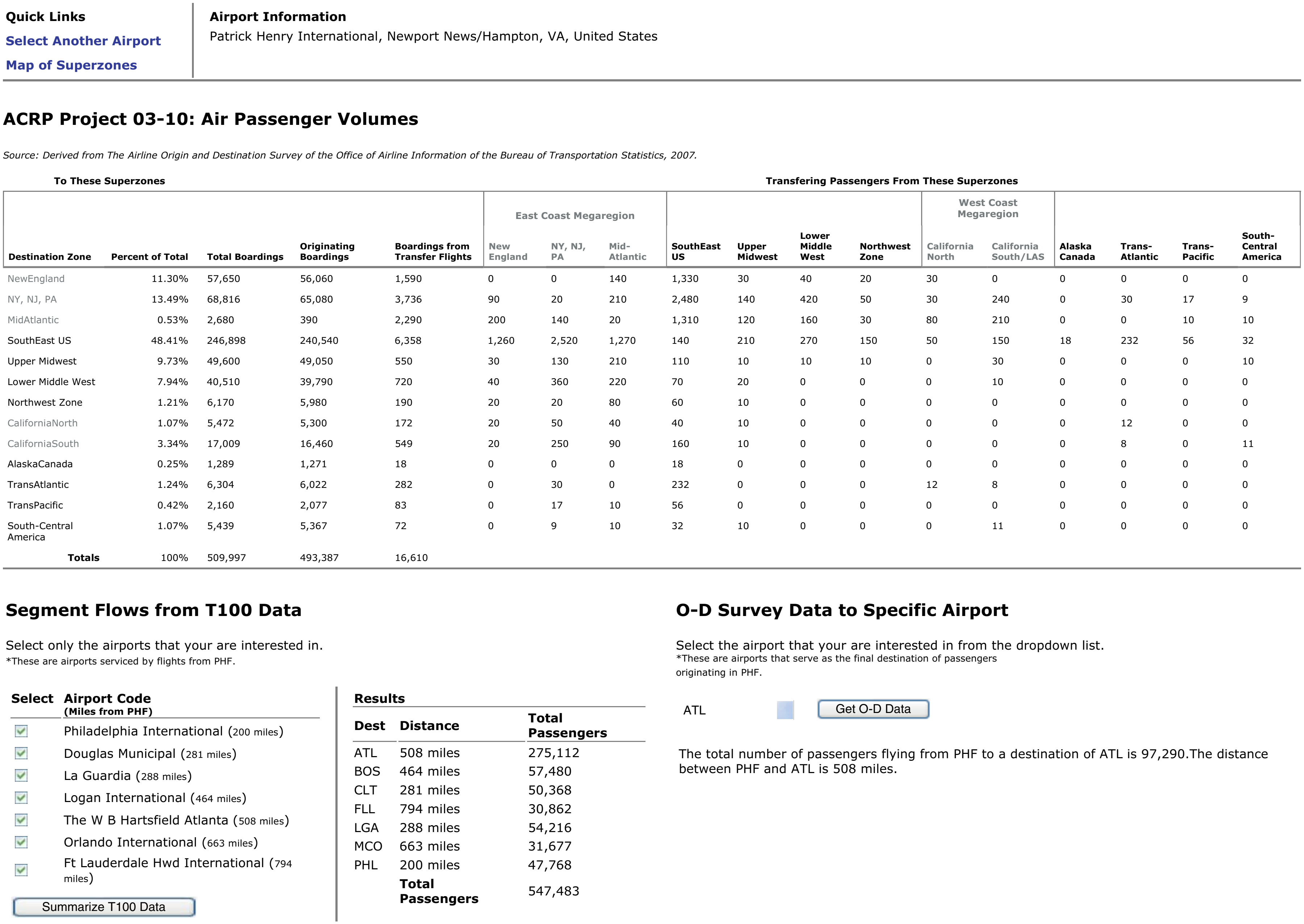
Dest	**Distance**	**Total Passengers**
BWI	159 miles	178,341
CLE	434 miles	35,966
CLT	288 miles	199,976
DCA	142 miles	43,716
EWR	284 miles	64,744
IAD	157 miles	105,559
JFK	290 miles	38,930
LGA	296 miles	43,851
PHL	211 miles	98,836
PIT	330 miles	22,318
	Total Passengers	832,237

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.

*These are airports that serve as the final destination of passengers originating in ORF.

The total number of passengers flying from ORF to a destination of CLT is 14,770.The distance between ORF and CLT is 288 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Patrick Henry International, Newport News/Hampton, VA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones | **Transfering Passengers From These Superzones**

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	11.30%	57,650	56,060	1,590	0	0	140	1,330	30	40	20	30	0	0	0	0	0
NY, NJ, PA	13.49%	68,816	65,080	3,736	90	20	210	2,480	140	420	50	30	240	0	30	17	9
MidAtlantic	0.53%	2,680	390	2,290	200	140	20	1,310	120	160	30	80	210	0	0	10	10
SouthEast US	48.41%	246,898	240,540	6,358	1,260	2,520	1,270	140	210	270	150	50	150	18	232	56	32
Upper Midwest	9.73%	49,600	49,050	550	30	130	210	110	10	10	10	0	30	0	0	0	10
Lower Middle West	7.94%	40,510	39,790	720	40	360	220	70	20	0	0	0	10	0	0	0	0
Northwest Zone	1.21%	6,170	5,980	190	20	20	80	60	10	0	0	0	0	0	0	0	0
CaliforniaNorth	1.07%	5,472	5,300	172	20	50	40	40	10	0	0	0	0	0	12	0	0
CaliforniaSouth	3.34%	17,009	16,460	549	20	250	90	160	10	0	0	0	0	0	8	0	11
AlaskaCanada	0.25%	1,289	1,271	18	0	0	0	18	0	0	0	0	0	0	0	0	0
TransAtlantic	1.24%	6,304	6,022	282	0	30	0	232	0	0	0	12	8	0	0	0	0
TransPacific	0.42%	2,160	2,077	83	0	17	10	56	0	0	0	0	0	0	0	0	0
South-Central America	1.07%	5,439	5,367	72	0	9	10	32	10	0	0	0	11	0	0	0	0
Totals	100%	509,997	493,387	16,610													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from PHF.

Select	**Airport Code** **(Miles from PHF)**
☑	Philadelphia International (200 miles)
☑	Douglas Municipal (281 miles)
☑	La Guardia (288 miles)
☑	Logan International (464 miles)
☑	The W B Hartsfield Atlanta (508 miles)
☑	Orlando International (663 miles)
☑	Ft Lauderdale Hwd International (794 miles)

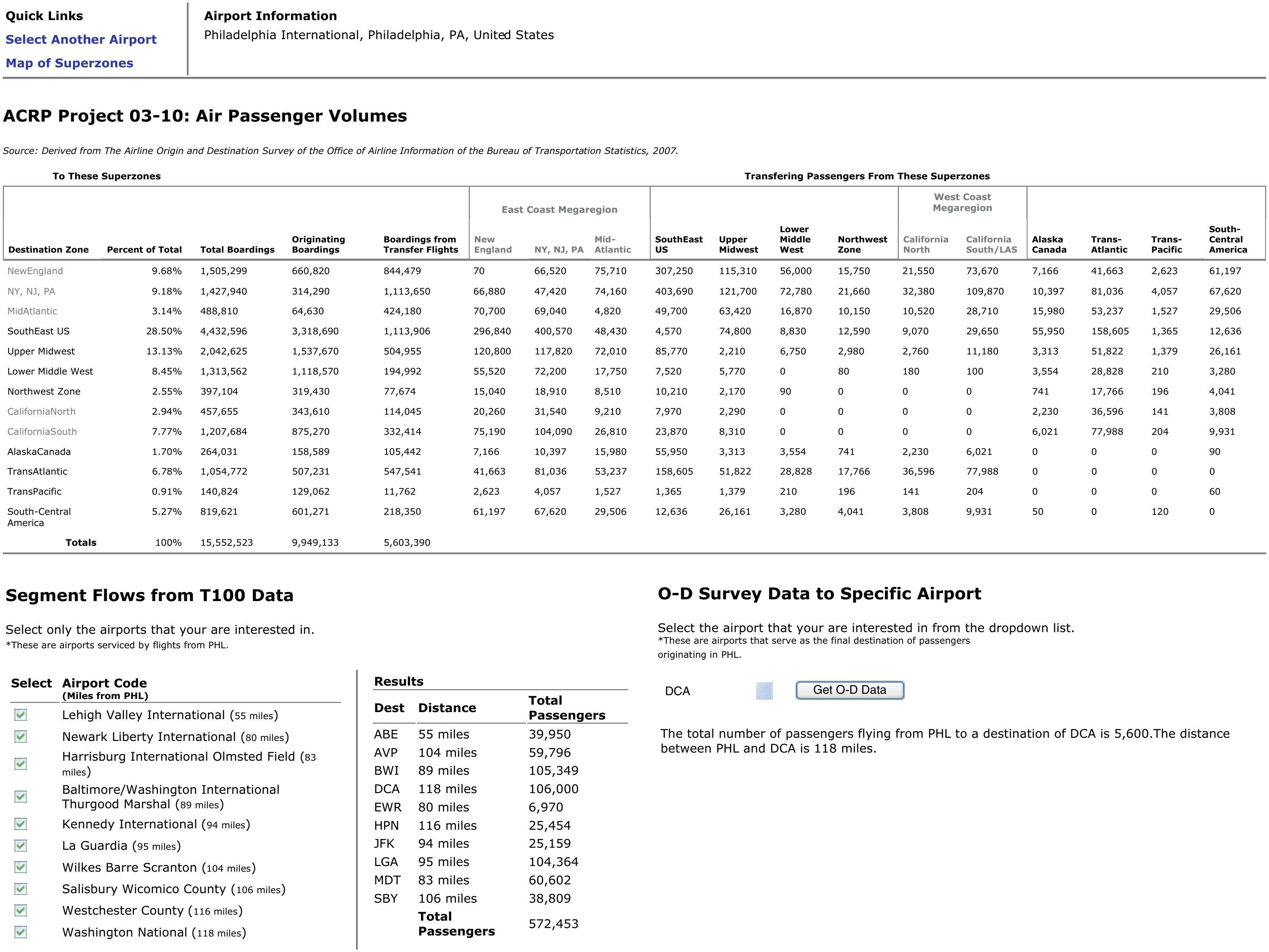
Results

Dest	**Distance**	**Total Passengers**
ATL	508 miles	275,112
BOS	464 miles	57,480
CLT	281 miles	50,368
FLL	794 miles	30,862
LGA	288 miles	54,216
MCO	663 miles	31,677
PHL	200 miles	47,768
	Total Passengers	547,483

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in PHF.

The total number of passengers flying from PHF to a destination of ATL is 97,290.The distance between PHF and ATL is 508 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Philadelphia International, Philadelphia, PA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones

Transfering Passengers From These Superzones

					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	9.68%	1,505,299	660,820	844,479	70	66,520	75,710	307,250	115,310	56,000	15,750	21,550	73,670	7,166	41,663	2,623	61,197
NY, NJ, PA	9.18%	1,427,940	314,290	1,113,650	66,880	47,420	74,160	403,690	121,700	72,780	21,660	32,380	109,870	10,397	81,036	4,057	67,620
MidAtlantic	3.14%	488,810	64,630	424,180	70,700	69,040	4,820	49,700	63,420	16,870	10,150	10,520	28,710	15,980	53,237	1,527	29,506
SouthEast US	28.50%	4,432,596	3,318,690	1,113,906	296,840	400,570	48,430	4,570	74,800	8,830	12,590	9,070	29,650	55,950	158,605	1,365	12,636
Upper Midwest	13.13%	2,042,625	1,537,670	504,955	120,800	117,820	72,010	85,770	2,210	6,750	2,980	2,760	11,180	3,313	51,822	1,379	26,161
Lower Middle West	8.45%	1,313,562	1,118,570	194,992	55,520	72,200	17,750	7,520	5,770	0	80	180	100	3,554	28,828	210	3,280
Northwest Zone	2.55%	397,104	319,430	77,674	15,040	18,910	8,510	10,210	2,170	90	0	0	0	741	17,766	196	4,041
CaliforniaNorth	2.94%	457,655	343,610	114,045	20,260	31,540	9,210	7,970	2,290	0	0	0	0	2,230	36,596	141	3,808
CaliforniaSouth	7.77%	1,207,684	875,270	332,414	75,190	104,090	26,810	23,870	8,310	0	0	0	0	6,021	77,988	204	9,931
AlaskaCanada	1.70%	264,031	158,589	105,442	7,166	10,397	15,980	55,950	3,313	3,554	741	2,230	6,021	0	0	0	90
TransAtlantic	6.78%	1,054,772	507,231	547,541	41,663	81,036	53,237	158,605	51,822	28,828	17,766	36,596	77,988	0	0	0	0
TransPacific	0.91%	140,824	129,062	11,762	2,623	4,057	1,527	1,365	1,379	210	196	141	204	0	0	0	60
South-Central America	5.27%	819,621	601,271	218,350	61,197	67,620	29,506	12,636	26,161	3,280	4,041	3,808	9,931	50	0	120	0
Totals	100%	15,552,523	9,949,133	5,603,390													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from PHL.

Select	**Airport Code** **(Miles from PHL)**
☑	Lehigh Valley International (55 miles)
☑	Newark Liberty International (80 miles)
☑	Harrisburg International Olmsted Field (83 miles)
☑	Baltimore/Washington International Thurgood Marshal (89 miles)
☑	Kennedy International (94 miles)
☑	La Guardia (95 miles)
☑	Wilkes Barre Scranton (104 miles)
☑	Salisbury Wicomico County (106 miles)
☑	Westchester County (116 miles)
☑	Washington National (118 miles)

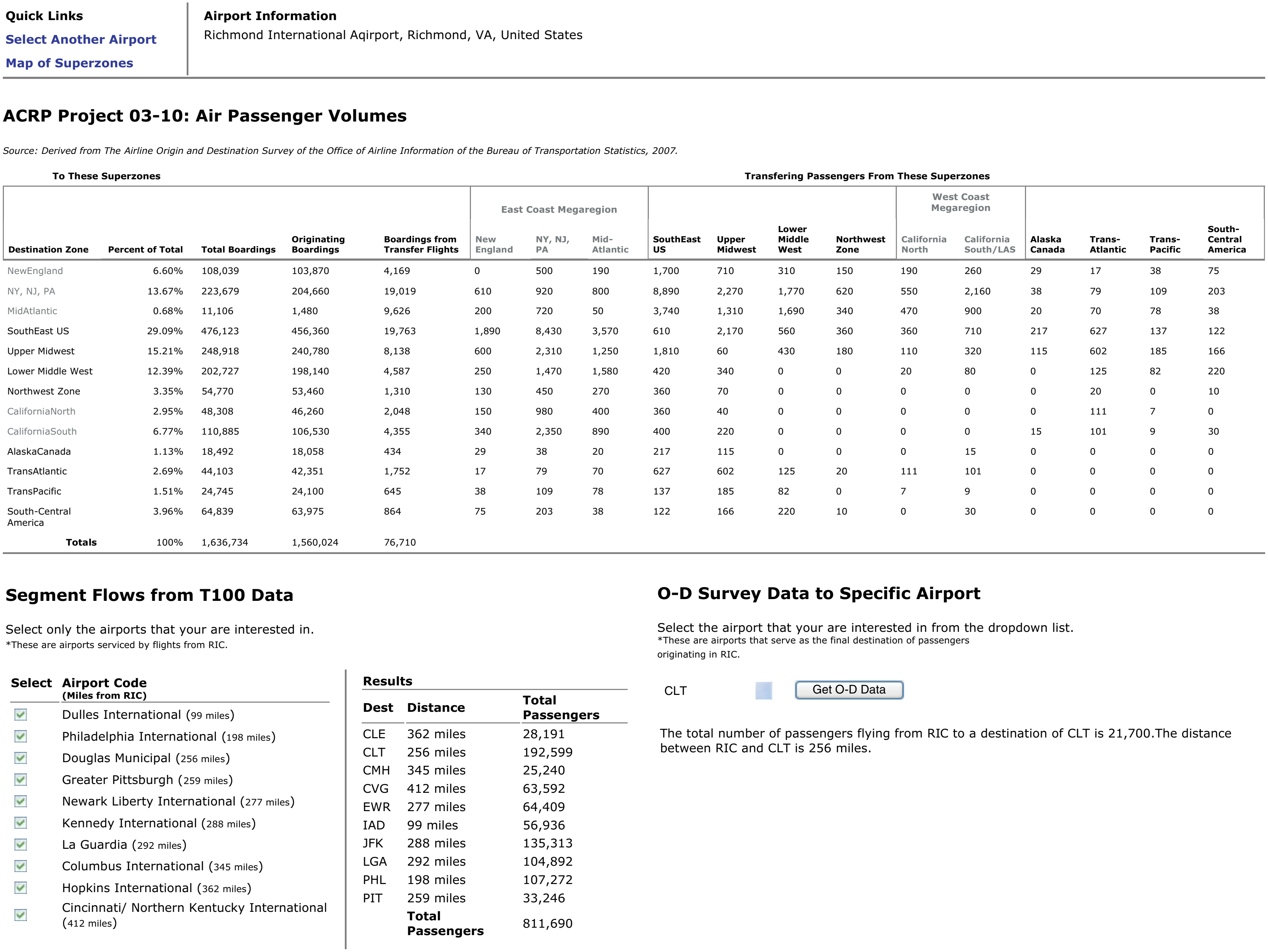
Results

Dest	**Distance**	**Total Passengers**
ABE	55 miles	39,950
AVP	104 miles	59,796
BWI	89 miles	105,349
DCA	118 miles	106,000
EWR	80 miles	6,970
HPN	116 miles	25,454
JFK	94 miles	25,159
LGA	95 miles	104,364
MDT	83 miles	60,602
SBY	106 miles	38,809
	Total Passengers	572,453

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in PHL.

The total number of passengers flying from PHL to a destination of DCA is 5,600.The distance between PHL and DCA is 118 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Richmond International Aqirport, Richmond, VA, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	6.60%	108,039	103,870	4,169	0	500	190	1,700	710	310	150	190	260	29	17	38	75
NY, NJ, PA	13.67%	223,679	204,660	19,019	610	920	800	8,890	2,270	1,770	620	550	2,160	38	79	109	203
MidAtlantic	0.68%	11,106	1,480	9,626	200	720	50	3,740	1,310	1,690	340	470	900	20	70	78	38
SouthEast US	29.09%	476,123	456,360	19,763	1,890	8,430	3,570	610	2,170	560	360	360	710	217	627	137	122
Upper Midwest	15.21%	248,918	240,780	8,138	600	2,310	1,250	1,810	60	430	180	110	320	115	602	185	166
Lower Middle West	12.39%	202,727	198,140	4,587	250	1,470	1,580	420	340	0	0	20	80	0	125	82	220
Northwest Zone	3.35%	54,770	53,460	1,310	130	450	270	360	70	0	0	0	0	0	20	0	10
CaliforniaNorth	2.95%	48,308	46,260	2,048	150	980	400	360	40	0	0	0	0	0	111	7	0
CaliforniaSouth	6.77%	110,885	106,530	4,355	340	2,350	890	400	220	0	0	0	0	15	101	9	30
AlaskaCanada	1.13%	18,492	18,058	434	29	38	20	217	115	0	0	0	15	0	0	0	0
TransAtlantic	2.69%	44,103	42,351	1,752	17	79	70	627	602	125	20	111	101	0	0	0	0
TransPacific	1.51%	24,745	24,100	645	38	109	78	137	185	82	0	7	9	0	0	0	0
South-Central America	3.96%	64,839	63,975	864	75	203	38	122	166	220	10	0	30	0	0	0	0
Totals	100%	1,636,734	1,560,024	76,710													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from RIC.

Select	**Airport Code** **(Miles from RIC)**
☑	Dulles International (99 miles)
☑	Philadelphia International (198 miles)
☑	Douglas Municipal (256 miles)
☑	Greater Pittsburgh (259 miles)
☑	Newark Liberty International (277 miles)
☑	Kennedy International (288 miles)
☑	La Guardia (292 miles)
☑	Columbus International (345 miles)
☑	Hopkins International (362 miles)
☑	Cincinnati/ Northern Kentucky International (412 miles)

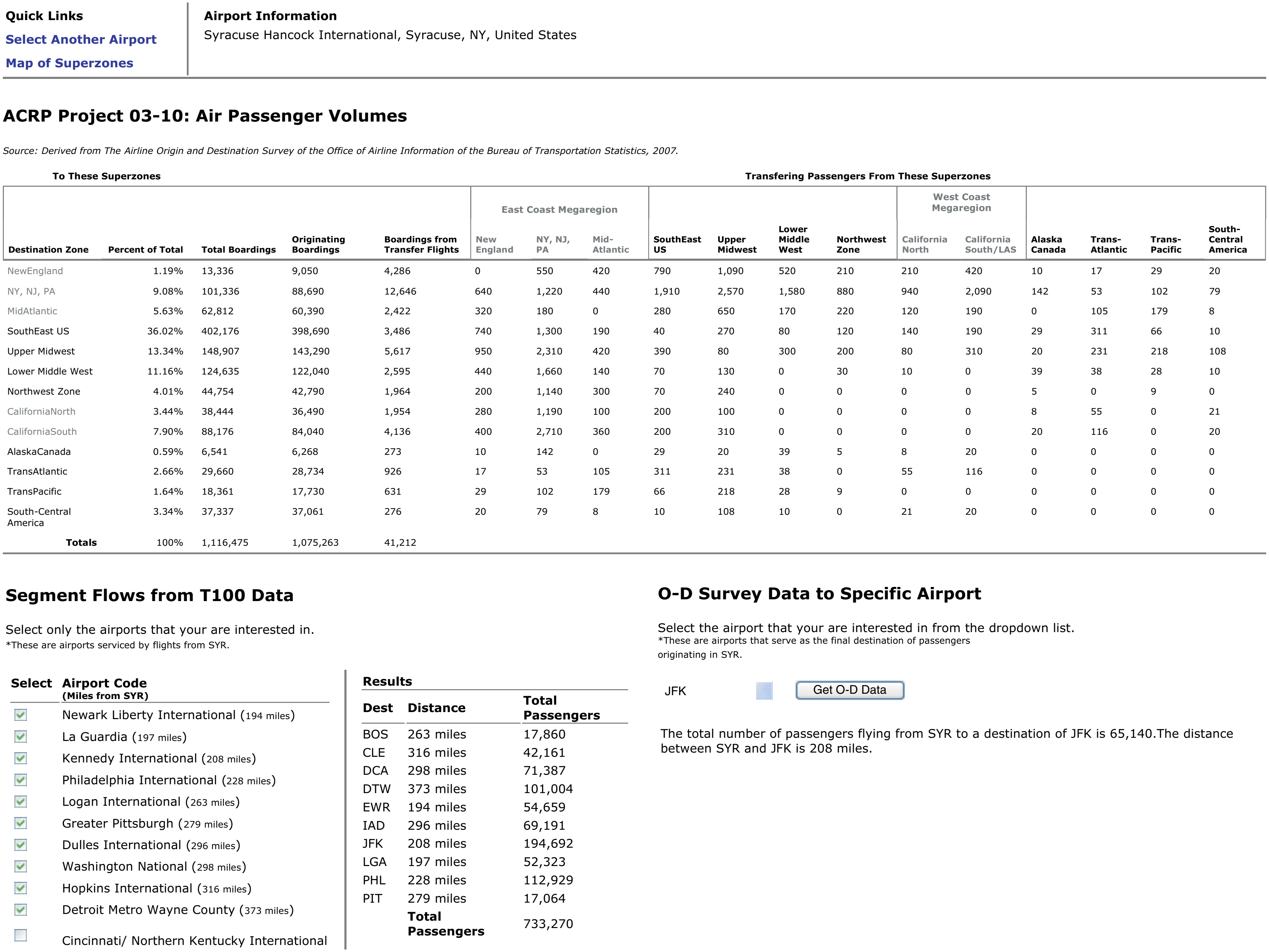
Results

Dest	**Distance**	**Total Passengers**
CLE	362 miles	28,191
CLT	256 miles	192,599
CMH	345 miles	25,240
CVG	412 miles	63,592
EWR	277 miles	64,409
IAD	99 miles	56,936
JFK	288 miles	135,313
LGA	292 miles	104,892
PHL	198 miles	107,272
PIT	259 miles	33,246
	Total Passengers	811,690

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in RIC.

The total number of passengers flying from RIC to a destination of CLT is 21,700.The distance between RIC and CLT is 256 miles.



Airport Information

Syracuse Hancock International, Syracuse, NY, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones												
					East Coast Megaregion							West Coast Megaregion					
Destination Zone	**Percent of Total**	**Total Boardings**	**Originating Boardings**	**Boardings from Transfer Flights**	New England	NY, NJ, PA	Mid-Atlantic	**SouthEast US**	**Upper Midwest**	**Lower Middle West**	**Northwest Zone**	California North	California South/LAS	**Alaska Canada**	**Trans-Atlantic**	**Trans-Pacific**	**South-Central America**
NewEngland	1.19%	13,336	9,050	4,286	0	550	420	790	1,090	520	210	210	420	10	17	29	20
NY, NJ, PA	9.08%	101,336	88,690	12,646	640	1,220	440	1,910	2,570	1,580	880	940	2,090	142	53	102	79
MidAtlantic	5.63%	62,812	60,390	2,422	320	180	0	280	650	170	220	120	190	0	105	179	8
SouthEast US	36.02%	402,176	398,690	3,486	740	1,300	190	40	270	80	120	140	190	29	311	66	10
Upper Midwest	13.34%	148,907	143,290	5,617	950	2,310	420	390	80	300	200	80	310	20	231	218	108
Lower Middle West	11.16%	124,635	122,040	2,595	440	1,660	140	70	130	0	30	10	0	39	38	28	10
Northwest Zone	4.01%	44,754	42,790	1,964	200	1,140	300	70	240	0	0	0	0	5	0	9	0
CaliforniaNorth	3.44%	38,444	36,490	1,954	280	1,190	100	200	100	0	0	0	0	8	55	0	21
CaliforniaSouth	7.90%	88,176	84,040	4,136	400	2,710	360	200	310	0	0	0	0	20	116	0	20
AlaskaCanada	0.59%	6,541	6,268	273	10	142	0	29	20	39	5	8	20	0	0	0	0
TransAtlantic	2.66%	29,660	28,734	926	17	53	105	311	231	38	0	55	116	0	0	0	0
TransPacific	1.64%	18,361	17,730	631	29	102	179	66	218	28	9	0	0	0	0	0	0
South-Central America	3.34%	37,337	37,061	276	20	79	8	10	108	10	0	21	20	0	0	0	0
Totals	100%	1,116,475	1,075,263	41,212													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from SYR.

Select	**Airport Code** (Miles from SYR)
☑	Newark Liberty International (194 miles)
☑	La Guardia (197 miles)
☑	Kennedy International (208 miles)
☑	Philadelphia International (228 miles)
☑	Logan International (263 miles)
☑	Greater Pittsburgh (279 miles)
☑	Dulles International (296 miles)
☑	Washington National (298 miles)
☑	Hopkins International (316 miles)
☑	Detroit Metro Wayne County (373 miles)
☐	Cincinnati/ Northern Kentucky International

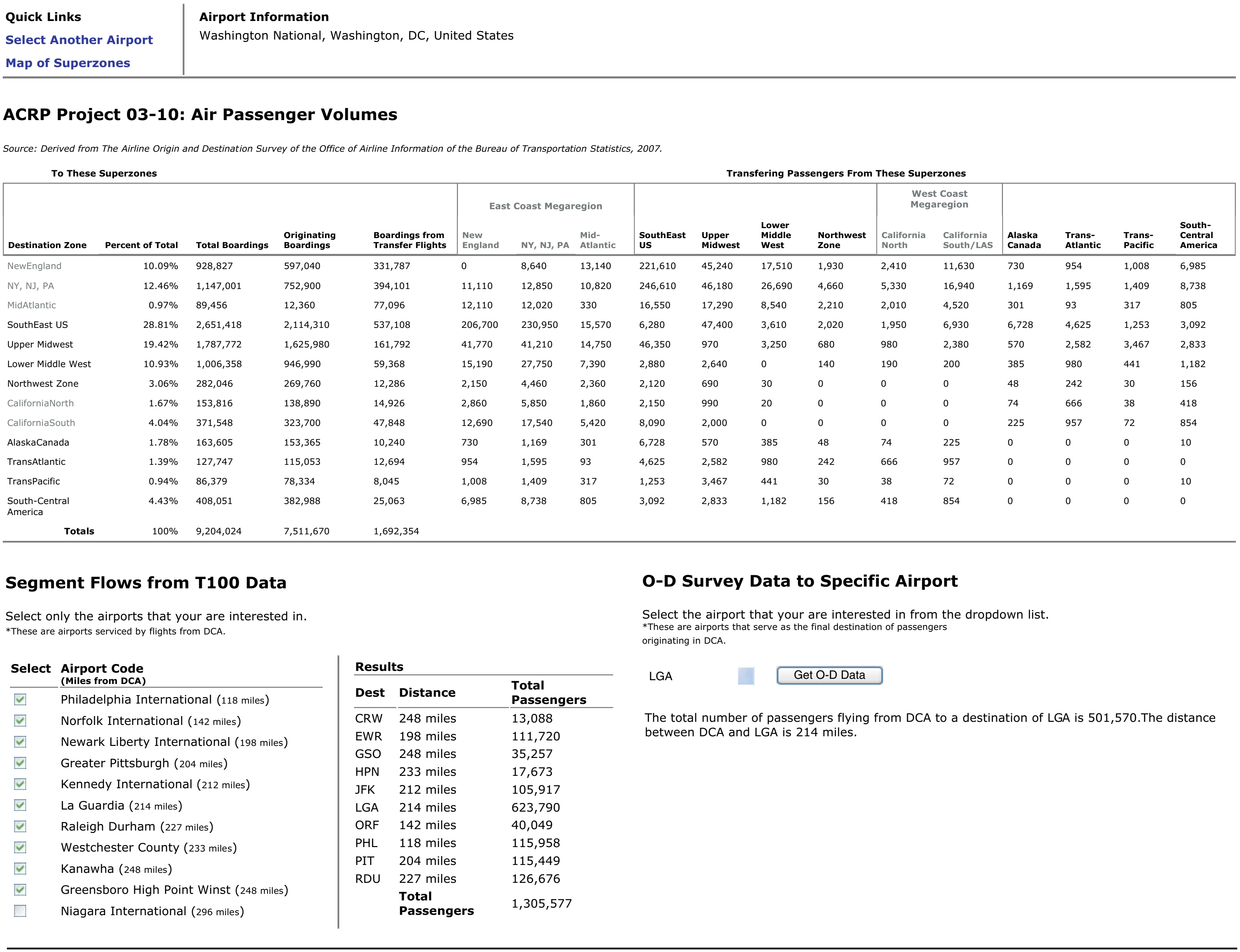
Results

Dest	**Distance**	**Total Passengers**
BOS	263 miles	17,860
CLE	316 miles	42,161
DCA	298 miles	71,387
DTW	373 miles	101,004
EWR	194 miles	54,659
IAD	296 miles	69,191
JFK	208 miles	194,692
LGA	197 miles	52,323
PHL	228 miles	112,929
PIT	279 miles	17,064
	Total Passengers	733,270

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in SYR.

The total number of passengers flying from SYR to a destination of JFK is 65,140.The distance between SYR and JFK is 208 miles.



Quick Links

Select Another Airport

Map of Superzones

Airport Information

Washington National, Washington, DC, United States

ACRP Project 03-10: Air Passenger Volumes

Source: Derived from The Airline Origin and Destination Survey of the Office of Airline Information of the Bureau of Transportation Statistics, 2007.

To These Superzones					Transfering Passengers From These Superzones													
					East Coast Megaregion							West Coast Megaregion						
Destination Zone	Percent of Total	Total Boardings	Originating Boardings	Boardings from Transfer Flights	New England	NY, NJ, PA	Mid-Atlantic	SouthEast US	Upper Midwest	Lower Middle West	Northwest Zone	California North	California South/LAS	Alaska Canada	Trans-Atlantic	Trans-Pacific	South-Central America
NewEngland	10.09%	928,827	597,040	331,787	0	8,640	13,140	221,610	45,240	17,510	1,930	2,410	11,630	730	954	1,008	6,985
NY, NJ, PA	12.46%	1,147,001	752,900	394,101	11,110	12,850	10,820	246,610	46,180	26,690	4,660	5,330	16,940	1,169	1,595	1,409	8,738
MidAtlantic	0.97%	89,456	12,360	77,096	12,110	12,020	330	16,550	17,290	8,540	2,210	2,010	4,520	301	93	317	805
SouthEast US	28.81%	2,651,418	2,114,310	537,108	206,700	230,950	15,570	6,280	47,400	3,610	2,020	1,950	6,930	6,728	4,625	1,253	3,092
Upper Midwest	19.42%	1,787,772	1,625,980	161,792	41,770	41,210	14,750	46,350	970	3,250	680	980	2,380	570	2,582	3,467	2,833
Lower Middle West	10.93%	1,006,358	946,990	59,368	15,190	27,750	7,390	2,880	2,640	0	140	190	200	385	980	441	1,182
Northwest Zone	3.06%	282,046	269,760	12,286	2,150	4,460	2,360	2,120	690	30	0	0	0	48	242	30	156
CaliforniaNorth	1.67%	153,816	138,890	14,926	2,860	5,850	1,860	2,150	990	20	0	0	0	74	666	38	418
CaliforniaSouth	4.04%	371,548	323,700	47,848	12,690	17,540	5,420	8,090	2,000	0	0	0	0	225	957	72	854
AlaskaCanada	1.78%	163,605	153,365	10,240	730	1,169	301	6,728	570	385	48	74	225	0	0	0	10
TransAtlantic	1.39%	127,747	115,053	12,694	954	1,595	93	4,625	2,582	980	242	666	957	0	0	0	0
TransPacific	0.94%	86,379	78,334	8,045	1,008	1,409	317	1,253	3,467	441	30	38	72	0	0	0	10
South-Central America	4.43%	408,051	382,988	25,063	6,985	8,738	805	3,092	2,833	1,182	156	418	854	0	0	0	0
Totals	100%	9,204,024	7,511,670	1,692,354													

Segment Flows from T100 Data

Select only the airports that your are interested in.
*These are airports serviced by flights from DCA.

Select	**Airport Code** (Miles from DCA)
☑	Philadelphia International (118 miles)
☑	Norfolk International (142 miles)
☑	Newark Liberty International (198 miles)
☑	Greater Pittsburgh (204 miles)
☑	Kennedy International (212 miles)
☑	La Guardia (214 miles)
☑	Raleigh Durham (227 miles)
☑	Westchester County (233 miles)
☑	Kanawha (248 miles)
☑	Greensboro High Point Winst (248 miles)
☐	Niagara International (296 miles)

Results

Dest	Distance	Total Passengers
CRW	248 miles	13,088
EWR	198 miles	111,720
GSO	248 miles	35,257
HPN	233 miles	17,673
JFK	212 miles	105,917
LGA	214 miles	623,790
ORF	142 miles	40,049
PHL	118 miles	115,958
PIT	204 miles	115,449
RDU	227 miles	126,676
	Total Passengers	1,305,577

O-D Survey Data to Specific Airport

Select the airport that your are interested in from the dropdown list.
*These are airports that serve as the final destination of passengers originating in DCA.

The total number of passengers flying from DCA to a destination of LGA is 501,570.The distance between DCA and LGA is 214 miles.

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation