1995 ACE PLAN

Aviation Capacity Enhancement

DOT/FAA/ASC-95-01

Los Angeles International Airport

U.S. Department
of Transportation

Federal Aviation
Administration

Prepared by:
Federal Aviation Administration
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of Transportation
**Federal Aviation
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Office of the Administrator

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I am pleased to present to the aviation community the 1995 Aviation Capacity Enhancement Plan. The plan is an important part of the Federal Aviation Administration and Department of Transportation efforts to improve the Nation's transportation system.

The principal goals of the aviation system capacity program are to ensure that: airspace and airport capacity continue to grow to meet user needs cost effectively; capacity resources are fully utilized to meet traffic demand and eliminate capacity related delays; and airport capacities in instrument meteorological conditions (IMC) approach capacities in visual meteorological conditions (VMC).

Improving aviation system capacity is a continuing dynamic process that evolves as user needs change and technology advances. The plan attempts to identify and facilitate actions that can be taken by both the public and private sectors to prevent projected growth in delays while, at the same time, remain flexible and practical to accommodate future change.

The Plan is intended to be a comprehensive "ground-up" view of aviation system requirements and development, starting at the airport level and extending to terminal airspace, en route airspace, and traffic flow management.

System capacity must continue to grow in order to enable the air transportation industry to enhance the level of service quality and allow airline competition to continue. In the 12 years since airline deregulation, airfares have declined. Both the quality and cost of air service are strongly tied to aviation system capacity and will continue to show favorable trends only if aviation system capacity continues to grow to meet demand.

This plan supports the FAA Strategic Plan, which is consistent with the Secretary of Transportation's National Transportation Policy.

David Hinson

David R. Hinson
Administrator

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16. Abstract

A comprehensive review of Federal Aviation Administration programs intended to improve the capacity of the National Air Transportation System. The Plan describes the extent of capacity and delay problems currently associated with air travel in the U.S. and outlines various planned and ongoing FAA projects with the potential to reduce the severity of the problems in the future. The major areas of discussion are:

1) Airport Development
2) Airport Capacity
3) Airspace Capacity
4) New Instrumant Approach Procedures
5) Technology for Capacity Improvement

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Chapter 1

Introduction

1.1 The Need for Aviation System Capacity Improvement

In 1994[1], 23 airports each exceeded 20,000 hours of annual flight delays. With an average aircraft operating cost of about $1,600[2] per hour of delay, this means that each of these 23 airports incurred at least $32 million dollars in annual delay costs. By 2004, the number of airports that will exceed 20,000 hours of annual delay is projected to grow from 23 to 29, unless capacity improvements are made.[3] The purpose of this plan is to identify and facilitate actions that can be taken to prevent the projected growth in delays. These actions include:

- Airport Development.
- New Air Traffic Control Procedures.
- Airspace Development.
- New Technology.

In 1994, 23 airports each exceeded 20,000 hours of annual flight delays. With an average aircraft operating cost of about $1,600 per hour of delay, this means that each of these 23 airports incurred at least $32 million dollars in annual delay costs.

For four consecutive years, the number of flights exceeding 15 minutes of delay has declined. After a decrease of just over 24 percent from 1990 to 1991, flights exceeding 15 minutes of delay decreased 6 percent in 1992, 2 percent in 1993, and 10 percent in 1994. The forecast for 29 airports exceeding 20,000 hours of annual delay in 2004 is eleven less than the 40 airports predicted four years ago for the year 2000. These and other delay statistics reflect four years of declining or almost static aviation activity.

For four consecutive years, the number of flights exceeding 15 minutes of delay has declined.

Prior to 1994, U.S. economic growth had averaged only 1.9 percent annually during the 1990s. This included a three quarter recession in 1990/1991, which slowed economic growth

1. 1994 data is used throughout this plan due to the fact that, at publicaiton time, 1995 data was not verified and available.
2. The actual average aircraft operating cost is $1,587 per hour. The cost for heavy aircraft 300,000 lbs. or more is $4,575 per hour of delay, large aircraft under 300,000 lbs. and small jets, $1,607 per hour, and single-engine and twin-engine aircraft under 12,500 lbs., $42 and $124 per hour respectively. These figures are based on 1987 dollars, the latest data available.
3. For a listing of airports exceeding 20,000 hours of annual delay, see Table 1-4 and Figure 1-5.

to only 0.8 percent over the 2-year period. The recession was followed by a very weak recovery (1.7 percent growth in 1992), whose slow pace was generally recognized as unprecedented in postwar U.S. history. However, the U.S. economy has now grown for 14 consecutive quarters, with real growth averaging 3.2 percent in 1993 and 3.7 percent in 1994.

This stronger economic activity had a major impact on the demand for aviation services. U.S. commercial air carrier passenger enplanements, which had averaged only 1.5 percent annual growth during the preceding 4 years, were up 8.2 percent in 1994, the largest growth since 1987. Air carrier revenue passenger miles were up 5.5 percent in 1994, the strongest growth since 1986.

Over the next twelve years, the economy is expected to sustain a moderate rate of growth averaging 2.5 percent.[4] Gross Domestic Product (GDP) is a significant indicator of business activity, which, in turn, drives aviation activity. Figure 1-1 illustrates the historical growth in GDP and commercial air carrier domestic passenger enplanements since 1989 and the anticipated growth through 2006.

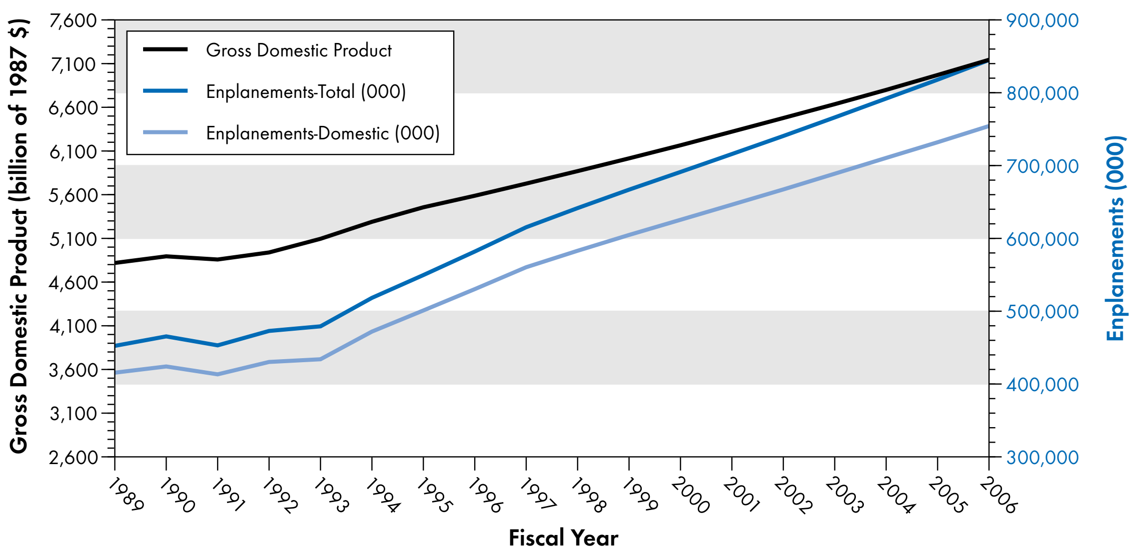


Figure 1-1. Growth in Gross Domestic Product and Domestic Passenger Enplanements, 1989 to 2006

4. *FAA Aviation Forecasts, Fiscal Years 1995-2006,* FAA-APO-95-1, March 1995. The economic projections used in developing the FAA Baseline Aviation Forecasts for the period 1995 to 2000 was provided by the Executive Office of the President, Office of Management and Budget (OMB). For the period 2001 to 2006, the economic scenario uses consensus growth rates of the economic variables prepared by DRI/McGraw-Hill, Inc., Evans Economics, Incl., and the WEFA Group.

According to FAA aviation forecasts, air carrier domestic passenger enplanements are expected to increase at an average annual rate of 4.0 percent between 1995 and 2006, and domestic air carrier aircraft operations are forecast to increase at an average annual rate of 1.9 percent during the same twelve-year period. The higher growth predicted for passenger enplanements relative to aircraft activity is the result of significantly higher load factors, larger seating capacity for air carrier aircraft, and longer passenger trip lengths. International air carrier passenger enplanements are forecast to increase at an annual rate of 5.8 percent, and regional/commuter airline passenger enplanements are expected to grow 6.6 percent annually.

Although the current delay forecasts continue to project serious delays in the absence of capacity improvements, the message contained in succeeding chapters is positive.

Although the current delay forecasts continue to project serious delays in the absence of capacity improvements, the message contained in succeeding chapters is positive. For example, a great deal is being done to improve capacity and reduce delays through new construction projects at airports and recent enhancements in Air Traffic Control (ATC) procedures. Airspace capacity design projects are being undertaken to study the terminal airspace associated with delay-impacted airports across the country. In addition, there are many emerging technologies in the areas of surveillance, communications, and navigation that will further improve the efficiency of new and existing runways and of terminal and en route airspace.

In fact, these capacity-producing improvements are frequently interrelated; changes in one often require changes in the others before all the potential capacity benefits can be realized. Resolving the problem of delay requires an integrated approach that develops capacity improvements throughout the aviation system, while at the same time maintaining or improving the current level of aviation safety. Improvements in capacity — constructing new runways and taxiways, installing enhanced facilities and equipment, applying new technologies — generally require long lead times. We must start preparing now for improvements that take 5 to 10 years to plan, develop, and implement.

1.2 Aviation Capacity Enhancement Plan

The Aviation Capacity Enhancement Plan is an important part of Federal Aviation Administration (FAA) and Department of Transportation (DOT) efforts to improve the Nation's transportation system. The Secretary of Transportation's National Transportation Policy (NTP) describes the enormity of the Nation's transportation infrastructure needs and sets as a major theme the need to maintain and expand the national transportation system. The Federal Aviation Administration Strategic Plan, based on the NTP, provides the goals and objectives towards which the FAA is working. The FAA Operational Concept supports the broad policies and strategies of the Strategic Plan by creating a concept of operations. The concept of operations is the basis for developing the NAS architecture. The architecture provides the structure for specific actions and projects in the numerous operating-level plans which affect the NAS. The FAA Operational Concept delineates the operational capabilities that must be in place to achieve an operating vision of the future in 2010. The NAS architecture represents the road map to 2010. The Air Traffic Service Plan takes a close-in look and provides a description of services between now and 2000. The NAS architecture links the Operational Concept, the Air Traffic Service Plan, and input from the user community, including the operational concepts of free flight, and adds the necessary structure to make capital investment decisions. The Aviation Capacity Enhancement Plan describes capacity and delay reduction measures necessary to support growth in the National Airspace System.

The Secretary of Transportation's National Transportation Policy (NTP) describes the enormity of the Nation's transportation infrastructure needs and sets as a major theme the need to maintain and expand the national transportation system.

The Aviation Capacity Enhancement Plan describes capacity and delay reduction measures necessary to support growth in the National Airspace System.

The Aviation Capacity Enhancement Plan is also linked to other FAA operating-level plans. In particular, it addresses requirements for research, for facilities and equipment, and for airport improvements that can be funded from the FAA's Airport Improvement Program (AIP). Each of these areas is addressed in a major FAA plan. The Research, Engineering, and Development (RE&D) Plan is used to determine which systems and technologies the FAA should use to accomplish agency goals and objectives. The RE&D Plan includes the research needed to validate the new instrument approach procedures detailed in Chapter 3. The Capital Investment Plan (CIP) provides a framework for investment in the facilities and equipment needed to improve the National Airspace System (NAS). The CIP funds the technological improvements described in Chapter 5. The National Plan of Integrated Airport Systems (NPIAS) presents airport improvement projects nationwide that are eligible for AIP funding. Among these are projects to build new airports and to improve existing airports to increase capacity and safety. These projects are discussed in Chapter 2.

The Aviation Capacity Enhancement Plan identifies the causes of delay and quantifies its magnitude. The plan catalogues and summarizes programs that have the potential to enhance capacity and reduce delay. Within the plan, these programs have been organized into broadly related categories that, in turn, parallel chapter development: Airport Development, New Instrument Approach Procedures, Airspace Development, and Technology for Capacity Improvement.

1.3 Level of Aviation Activity

1.3.1 Activity Statistics at the Top 100 Airports

The top 100 airports in the United States, as measured by 1994 passenger enplanements, are shown in Figure 1-2.[5] These 100 airports accounted for over 94 percent of the 555.3 million passengers that enplaned nationally in 1994.

In 2010, 995 million domestic and international passengers are forecast to enplane at these airports.[6] This represents a projected growth in enplanements of nearly 79 percent over the 16 year period of the forecast, an average annual rate of growth of more than 7 percent.

In 1994, over 26 million aircraft operations occurred at the top 100 airports. By 2010, operations are forecast to grow to approximately 34 million at these airports, a projected growth in operations of nearly 30 percent.

Operations data for 1992, 1993, and 1994 and enplanement data for 1992, 1993 and 1994, as well as forecasts of operations and enplanements for 2010 for the top 100 airports, are included in Appendix A.

5. The top 100 airports were chosen based on 1994 passenger enplanements as listed in the FAA's annual report, *Terminal Area Forecasts.*

6. Based on data in the FAA's *Terminal Area Forecasts,* FY92, FY93, and FY94 operations and enplanement data for the top 100 airports, a forecast for the year 2010, and the percentage growth that the forecast represents are shown in Appendix A, as well as a ranking by percentage growth in operations and enplanements.

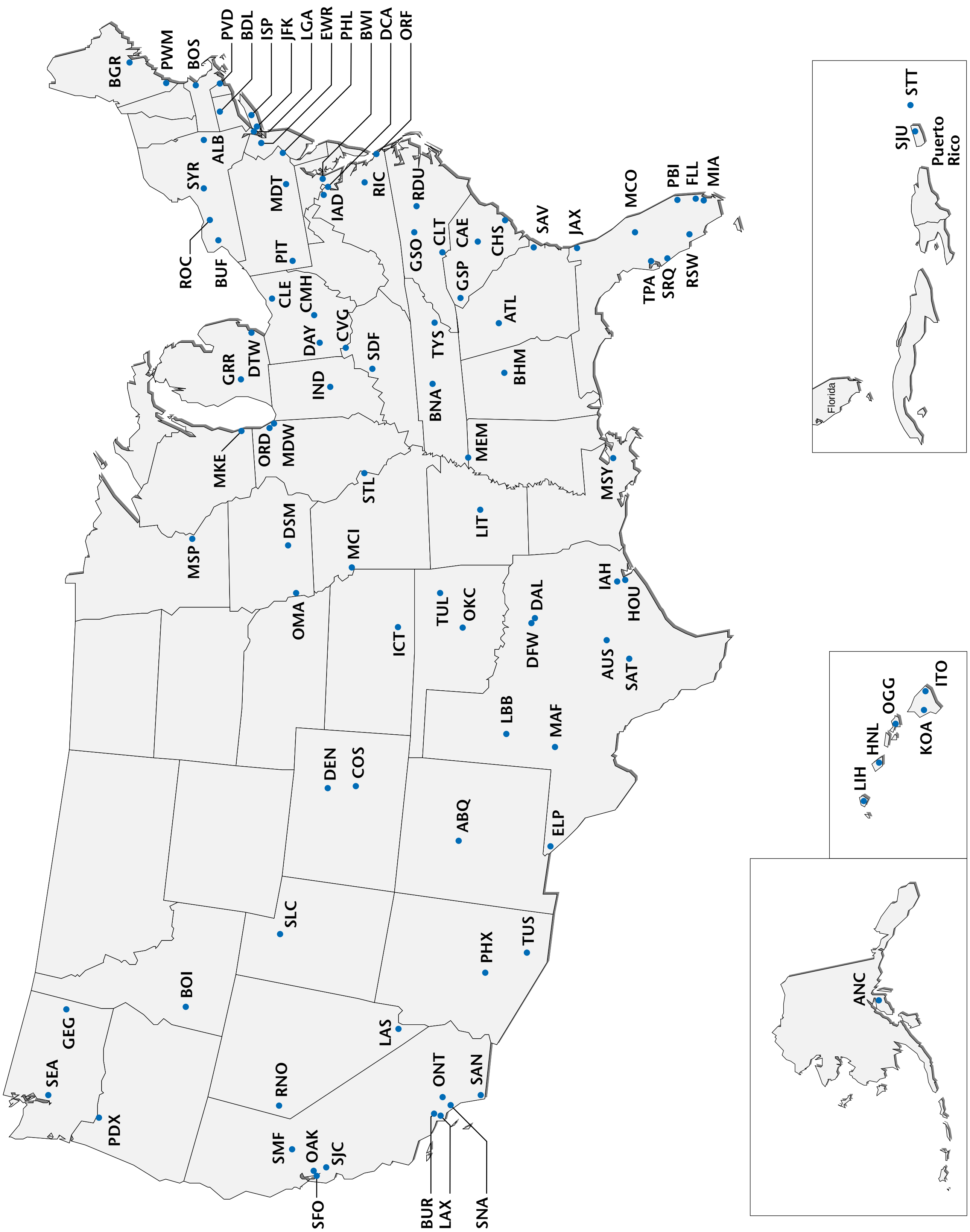


Figure 1-2. Top 100 Airports Based on 1994 Passenger Enplanements

1.3.2 Traffic Volumes in Air Route Traffic Control Centers (ARTCCS)

Air traffic volume statistics for FY94 show that instrument flight rules (IFR) operations increased at 17 of the 20 Continental United States (CONUS) ARTCCS over FY93. In FY94, the number of aircraft flying under IFR handled by ARTCCs totaled 38.8 million, an increase of 3.7 percent over 1993 activity counts.[7] The increase at en route centers in the last 10 years (up 18.7 percent) can be atributed to the growth in commercial aviation activity (up 36.6 percent). The number of commercial aircraft handled at the centers (26.5 million) increased 5.2 percent in FY94. The number of air carrier aircraft handled totaled 20.0 million, while the number of commuter/air taxi aircraft handled totaled 6.5 million (up 5.4 percent). General aviation and military activity rose 0.8 percent for the year.

Aircraft operations at the centers are expected to grow at an average rate of 1.9 percent a year between 1994 and 2006.[8] In absolute numbers, center operations are forecast to increase from 38.8 million aircraft handled in 1994 to 48.9 million in 2006. In 1994, 51.5 percent of the traffic handled at centers were air carrier flights. This proportion is expected to increase only slightly to 53.9 percent in 2006.

Figure 1-3 provides a map of the 20 CONUS ARTCCs. Figure 1-4 compares the number of operations during FY93 and FY94 and provides a forecast for FY06 for each of the 20 CONUS ARTCCS. A breakdown by user group of the traffic handled by the centers in 1993 and 1994, operations data for the individual ARTCCS for 1993 and 1994, and forecasts for 2006 are included in Appendix A.

7. Based on FAA's Forecasts of IFR Aircraft Handled by Air Route Traffic Control Centers Fiscal Years 1995 - 2006, FAA-APO-95-6, May 1995

8. Based on *FAA Aviation Forecasts, Fiscal Years 1995-2006,* FAA-APO-95-1, March 1995

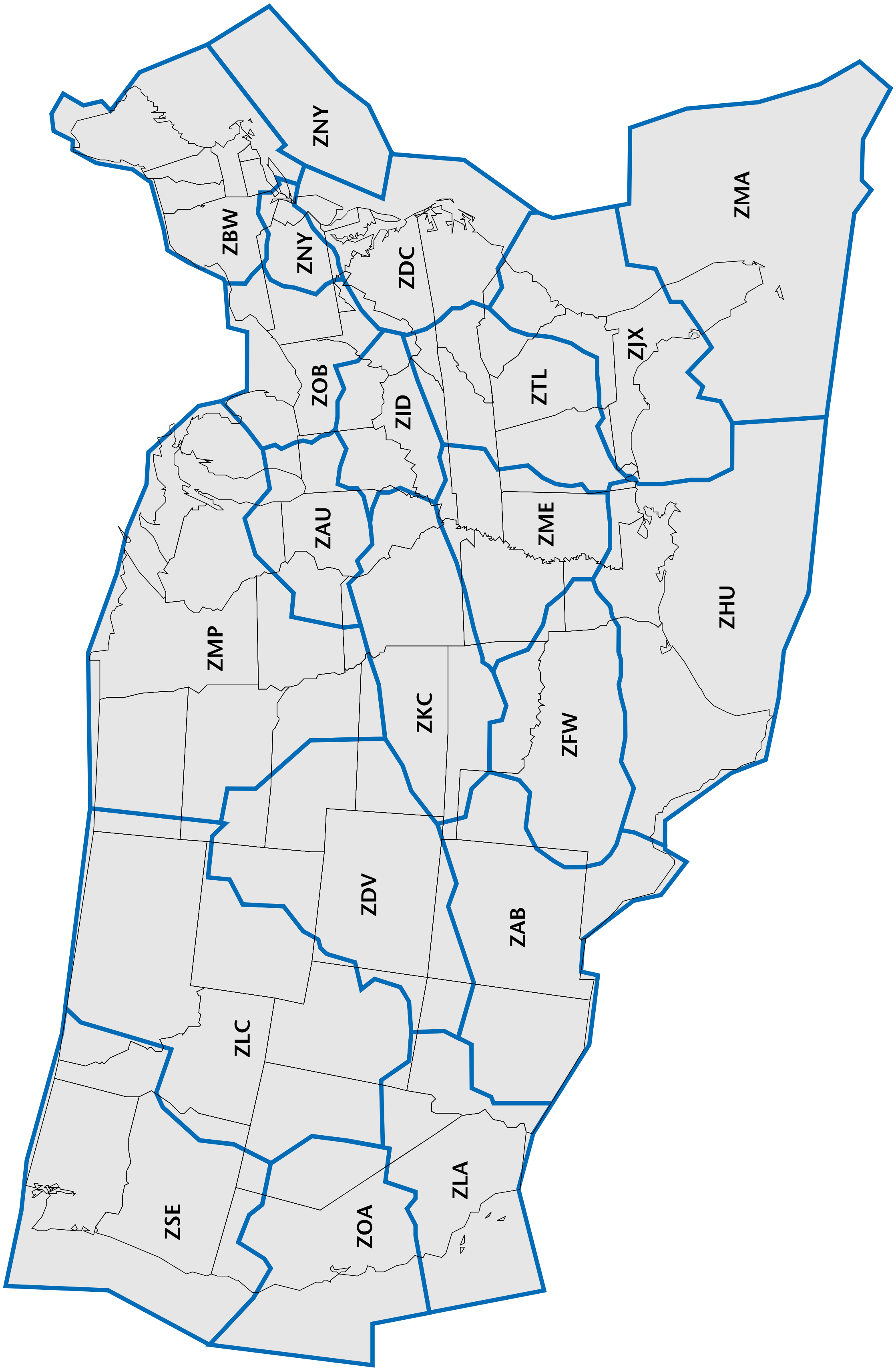


Figure 1-3. Continental Air Route Traffic Control Centers

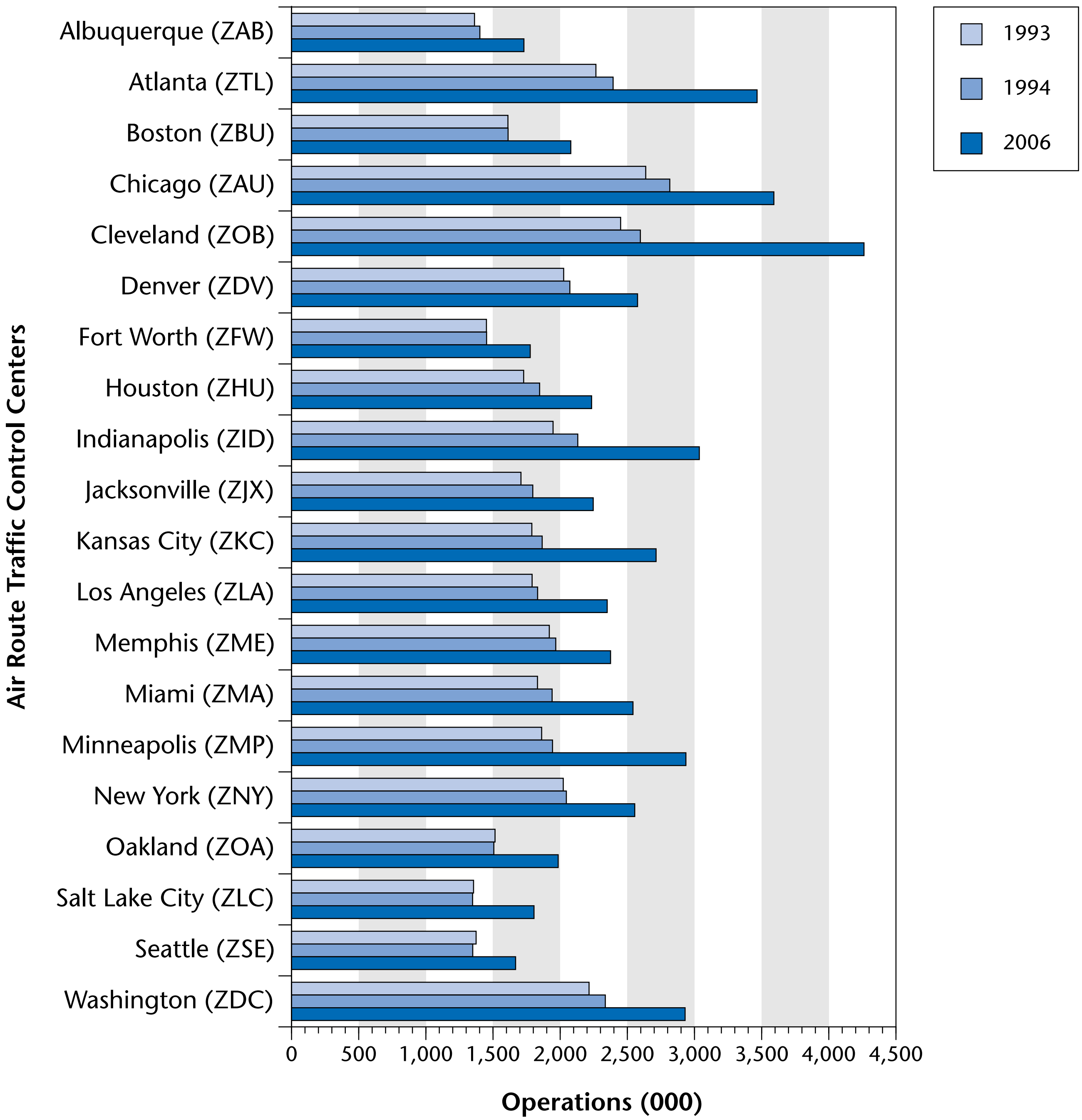


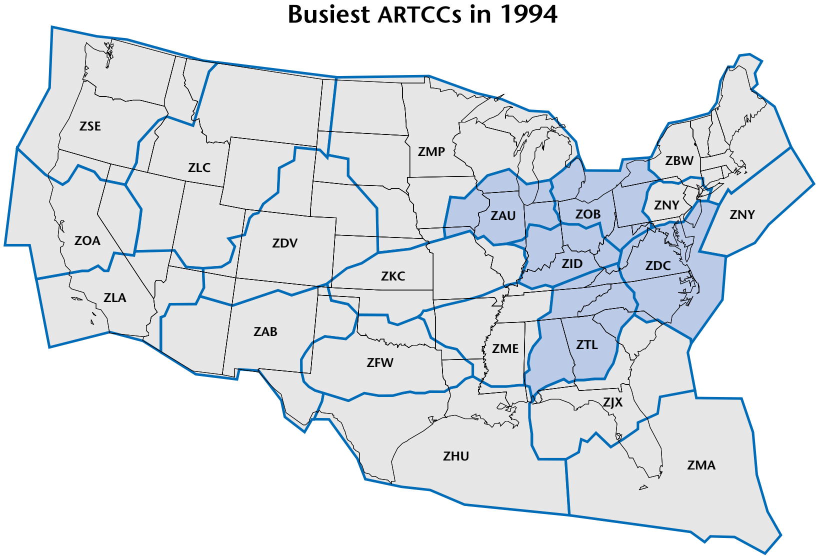
Figure 1-4. Operations at ARTCCs

The busiest ARTCCs in 1994 were: Chicago, Cleveland, Atlanta, Washington, and Indianapolis. Forecasts for 2006 indicate a change in ranking of the busiest ARTCCs to: Cleveland, Chicago, Atlanta, Indianapolis, and Minneapolis. The centers with the highest average annual growth rates are Oakland and Jacksonville, which are projected to grow by 3.9 and 2.8 percent respectively. The relatively high growth at these two centers reflects the projected high growth of domestic traffic demand in the West and South. Oakland Center is forecast to experience the largest absolute growth, from 1.6 million aircraft operations in 1992 to 2.7 million in the year 2005, a 64 percent increase. This reflects the continuing development and strong projected growth on trans-Pacific routes.

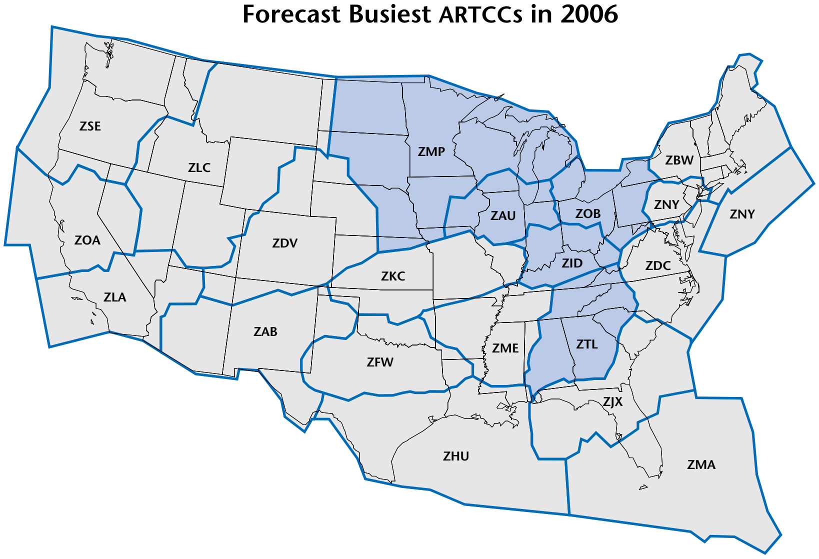
The busiest ARTCCs in 1994 were:
- Chicago
- Cleveland
- Atlanta
- Washington
- Indianapolis

Forecasts for 2006 indicate a change in ranking of the busiest ARTCCs to:
- Cleveland
- Chicago
- Atlanta
- Indianapolis
- Minneapolis

Busiest ARTCCs in 1994



Forecast Busiest ARTCCs in 2006



1.4 Delay[9]

1.4.1 Sources of Delay Data

Delay can be thought of as another system performance parameter, an indicator that capacity is perhaps being reached and even exceeded. Currently, the FAA gathers delay data from two different sources. The first is through the Air Traffic Operations Management System (ATOMS), in which FAA personnel record aircraft that are delayed 15 or more minutes by specific cause (weather, terminal volume, center volume, closed runways or taxiways, and NAS equipment interruptions). Aircraft that are delayed by less than 15 minutes are not recorded in ATOMS.

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The second source of delay data is through the Airline Service Quality Performance (ASQP) data, which is collected, in general, from airlines with one percent or more of the total domestic scheduled service passenger revenue and represents delay by phase of flight (i.e., gate-hold, taxi-out, airborne, or taxi-in delays). Actual departure time, flight duration, and arrival times are reported along with the differences between these and the equivalent data published in the *Official Airline Guide* (OAG) and entered in the Computer Reservation System (CRS). ASQP delays range from 0 minutes to greater than 15 minutes. In the discussion that follows, "delay by cause" refers to ATOMS data, and "delay by phase of flight" refers to ASQP data.

The delay data reported through ATOMS and ASQP are not without their problems. ATOMS is the official FAA delay reporting system. However, it only reports delays of 15 minutes or more; it aggregates flight delays, thus making it impossible to determine if a particular flight was delayed; and it only reports flight delays due to an air traffic problem (i.e., weather, terminal volume, center volume, closed runways or taxiways, and NAS equipment interruptions). ASQP only reports on carriers with at least 1 percent of domestic passenger enplanements for scheduled air carrier flights. ASQP is used primarily for consumer on-time performance reporting and is under DOT control.

9. Although no existing delay reporting system is fully comprehensive, this Plan aims to identify problem areas through available data, such as the following delay information and the previously mentioned aviation activity statistics.

The FAA is developing an improved aircraft delay data system to provide a single, integrated source of data to answer analytical questions about delay at a detailed level. This new system, the Consolidated Operations and Delay Analysis System (CODAS), will use Enhanced Traffic Management System (ETMS), OAG, ASQP, and Aeronautical Radio Incorporated (ARINC) Communications Addressing and Reporting System (ACARS) data to calculate delay by phase of flight and will include weather data from the National Oceanic and Atmospheric Administration (NOAA) for analysis purposes. By combining, comparing, and screening the data from these sources, a refined data source is created, which can be used for accurate delay calculations and model validation. CODAS will not replace ATOMS, which will continue to be the official FAA delay reporting system.

1.4.2 Delay by Cause

Flight delays exceeding 15 or more minutes, as recorded by OPSNET, were experienced on approximately 248,000 flights in 1994, a decrease of 10 percent over 1993. Weather was attributed as the primary cause of 75 percent of operations delayed by 15 minutes or more in 1994, up from 72 percent in 1993. Terminal air traffic volume accounted for 19 percent of delays of 15 or more minutes, down from 22 percent in 1993. Table 1-1 details these and other factors that caused delays of 15 minutes or more and provides a history of this breakdown of delay by primary cause. With the exception of the split between terminal and center volume delays, the basic distribution of delay by cause has remained fairly consistent over the past seven years.

Flight delays exceeding 15 or more minutes, as recorded by OPSNET, were experienced on approximately 248,000 flights in 1994, a decrease of 10 percent over 1993.

More than half of all delays are attributed to adverse weather. These delays are largely the result of instrument approach procedures that are much more restrictive than the visual procedures in effect during better weather conditions. The FAA continues to install new and upgrade existing instrument landing systems (ILSs) to support continued operations during conditions of reduced visibility. During the past few years, the FAA has developed new, capacity-producing approach procedures that take advantage of improving technology while maintaining the current level of safety. These new procedures, and a corresponding estimate of the expected increase in the number of operations per hour, are discussed in Chapter 3.

1.4.3 Delay by Phase of Flight

Based on ASQP data, Table 1-2 presents the average delay in minutes by phase of flight. This table shows, for example, that more delays occur during the taxi-out phase than any other phase and that airborne delays average 4.1 minutes per aircraft. To put this in perspective, there were approximately 6,200,000 air carrier flights in 1992.[10] With an average airborne delay of 4.1 minutes per aircraft, this means that there was a total of over 424,000 hours of airborne delay that year, which, at an estimated $1,600 per hour, cost the airlines $678 million.

Table 1-1. Distribution of Delay Greater Than 15 Minutes by Cause

Distribution of Delay Greater than 15 Minutes by Cause								
Cause	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
Weather	67%	70%	57%	56%	65%	65%	72%	75%
Terminal Volume	11%	9%	29%	35%	27%	27%	22%	19%
Center Volume	13%	12%	8%	2%	0%	0%	0%	0%
Closed Runways/Taxiways	4%	5%	3%	3%	3%	3%	3%	2%
NAS Equipment	4%	3%	2%	1%	2%	2%	2%	2%
Other	1%	1%	1%	4%	3%	3%	3%	2%
Total Operations Delayed (000s)	**356**	**338**	**394**	**393**	**298**	**281**	**276**	**248**
Percent Change from Previous Year	-15%	-5%	+17%	0%	-24%	-6%	-2%	-10%

10. *FAA Aviation Forecasts, Fiscal Years 1994-2005,* FAA-APO-94-1, March 1994

Table 1-2. Average Delay by Phase of Flight[11]

Average Delay by Phase of Flight (minutes per flight)						
Phase	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
Gate-hold	1.0	1.0	1.1	1.1	1.0	1.1
Taxi-out	7.0	7.2	6.9	6.9	6.9	6.8
Airborne	4.3	4.3	4.1	4.1	4.1	4.1
Taxi-in	2.2	2.3	2.2	2.2	2.2	2.2
Total	14.5	14.8	14.3	14.3	14.2	14.2
Mins./Op.	7.3	7.5	7.1	7.1	7.1	7.1

1.4.4 Identification of Delay-Problem Airports

For CY94, compared to 1993, the number of airline flight delays of 15 minutes or more decreased at 29 of the 55 airports at which the FAA collects air traffic delay statistics. Table 1-3 lists the number of operations delayed 15 minutes or more per 1,000 operations from 1990 to 1994 at 51 of these airports. These delays ranged from nearly 75 per 1,000 operations at Newark International Airport to 0.21 per 1,000 at Albuquerque International Airport. Three of the top six airports in delays of 15 or more minutes were in the New York area.

11. **Gate-hold Delay:** The difference between the time that departure of an aircraft is authorized by ATC and the time that the aircraft would have left the gate area in the absence of an ATC gatehold.

    Taxi-Out Delay: The difference between the time of lift-off and the time that the aircraft departed the gate, minus a standard taxi-out time established for a particular type of aircraft and airline at a specific airport.

    Airborne Delay: The difference between the time of lift-off from the origin airport and touchdown, minus the computer-generated optimum profile flight time for a particular flight, based on atmospheric conditions, aircraft loading, etc.

    Taxi-in Delay: The difference between touchdown time and gate arrival time, minus a standard taxi-in time for a particular type of aircraft and airline at a specific airport.

    Mins/op: Average delay in minutes per operation.

Table 1-3. Delays of 15 Minutes or More Per 1,000 Operations at the Top 100 Airports

Airport	ID	1990	1991	1992	1993	1994
Newark International Airport	EWR	84.94	67.26	83.48	87.88	74.29
New York LaGuardia Airport	LGA	86.79	61.63	55.23	38.32	47.37
Dallas-Fort Worth International Airport	DFW	32.02	35.32	29.82	33.71	37.65
New York John F. Kennedy International Airport	JFK	68.33	41.67	41.23	35.68	35.79
Boston Logan International Airport	BOS	32.26	32.84	34.61	39.23	29.79
San Francisco International Airport	SFO	45.79	58.13	30.18	23.79	28.46
Chicago O'Hare International Airport	ORD	64.61	47.94	45.40	47.49	26.83
Lambert St. Louis International Airport	STL	25.24	29.90	14.96	19.54	22.72
Philadelphia International Airport	PHL	35.44	16.87	18.47	18.75	20.85
Hartsfield Atlanta International Airport	ATL	44.08	22.09	29.90	23.28	19.98
Denver Stapleton International Airport	DEN	28.94	28.44	26.26	37.92	18.14
Los Angeles International Airport	LAX	7.11	14.80	19.75	9.15	10.96
Miami International Airport	MIA	8.55	23.96	9.68	10.48	10.47
Washington National Airport	DCA	9.57	5.61	11.03	9.34	10.44
Washington Dulles International Airport	IAD	7.36	9.01	7.33	6.86	8.43
Detroit Metropolitan Wayne County Airport	DTW	19.92	9.26	11.24	9.05	6.95
Greater Cincinnati International Airport	CVG	11.23	5.28	5.95	6.38	6.40
Seattle-Tacoma International Airport	SEA	30.55	18.85	13.19	6.78	6.09
Houston Intercontinental Airport	IAH	12.72	12.62	7.86	8.06	5.52
Orlando International Airport	MCO	7.32	6.42	8.95	4.72	5.37
Baltimore-Washington International Airport	BWI	17.59	5.99	5.80	3.94	5.15
Charlotte/Douglas International Airport	CLT	12.61	9.68	6.19	3.79	4.90
Greater Pittsburgh International Airport	PIT	8.55	5.04	8.04	6.86	4.20
Minneapolis-St. Paul International Airport	MSP	31.93	7.87	4.36	7.16	3.52
Phoenix Sky Harbor International Airport	PHX	9.91	6.68	8.16	2.86	3.48
Tampa International Airport	TPA	4.81	2.88	4.29	3.88	3.22
Chicago Midway Airport	MDW	15.81	7.09	2.12	2.98	3.10
Houston William P. Hobby Airport	HOU	4.57	5.04	2.74	3.49	2.96
Fort Lauderdale-Hollywood International Airport	FLL	3.05	2.09	3.69	3.77	2.92
Salt Lake City International Airport	SLC	3.16	3.73	5.07	3.86	2.79
San Diego International Lindberg Field	SAN	6.40	10.16	3.03	3.91	2.51
Portland International Airport	PDX	1.34	1.42	1.78	1.94	2.41
Kansas City International Airport	MCI	2.31	2.98	0.75	1.26	1.82
Cleveland Hopkins International Airport	CLE	4.69	1.99	1.58	2.37	1.62
Nashville International Airport	BNA	1.71	3.90	2.91	2.72	1.55
Raleigh-Durham International Airport	RDU	2.38	2.00	3.60	1.99	1.25
Bradley International Airport	BDL	3.76	2.36	1.96	0.95	1.15
Ontario International Airport	ONT	1.20	1.62	1.33	1.24	0.96
Memphis International Airport	MEM	2.99	2.43	1.10	1.03	0.79
Las Vegas McCarran International Airport	LAS	1.21	0.42	0.31	0.46	0.78
Dayton International Airport	DAY	1.48	1.05	0.29	0.29	0.76
San Jose International Airport	SJC	11.13	4.29	1.74	0.38	0.72
San Juan Luis Muñoz Marín International Airport	SJU	0.36	0.14	0.56	0.30	0.71
Indianapolis International Airport	IND	0.78	1.02	2.11	0.57	0.45
Palm Beach International Airport	PBI	1.40	1.50	1.02	0.81	0.39
San Antonio International Airport	SAT	0.76	0.32	0.20	0.10	0.35
Anchorage International Airport	ANC	1.96	1.32	0.34	0.74	0.29
New Orleans International Airport	MSY	1.96	1.09	0.62	0.33	0.21
Albuquerque International Airport	ABQ	1.05	0.68	0.69	0.27	0.21
Honolulu International Airport	HNL	0.41	0.38	0.13	0.19	0.08
Kahului Airport	OGG	0.15	0.13	0.13	0.05	0.03

1.4.5 Identification of Forecast Delay-Problem Airports

Forecasts indicate that, without capacity improvements, delays in the system will continue to grow. In 1994, 23 airports each exceeded 20,000 hours of annual aircraft flight delays. Assuming no improvements in airport capacity are made, 29 airports are forecast to each exceed 20,000 hours of annual aircraft flight delays by the year 2004. Table 1-4 lists the airports with 1994 actual and 2004 forecast air carrier delay hours in excess of 20,000 hours. The current forecast for 29 delay-problem airports in 2004 is eleven less than the 40 airports predicted in the forecast of three years ago. This reflects the overall decline in air travel as a result of the recession, and an economic recovery that has been slower than expected.

Figure 1-5 shows the airports exceeding 20,000 hours of annual aircraft delay in 1994 and the airports forecast to exceed 20,000 hours of annual aircraft delay in 2004, assuming there are no capacity improvements.

1.5 The FAA Strategic Plan and the NAS Architecture — A Vision for the Year 2010

A vigorous aviation system is essential for United States economic prosperity, and the entire aviation community must work together in order to maintain what has become the safest, most efficient, and most responsive aviation system in the world. To support this effort, the FAA developed the FAA Strategic Plan and the NAS.Architecture The two documents are a foundation for an iterative process to develop, in cooperation with all the users of the national aviation system, a common vision of the future from which to set policies, strategies, and operational goals for the year 2010.

In the year 2010, more people will be flying, more often, to more places than ever before. U.S. domestic passenger enplanements will double, and commuter and regional enplanements will triple. U.S. airlines will carry more than one billion passengers annually. Operations by general aviation aircraft will increase by 44 percent to 43 million flight hours annually. World revenue passenger miles will increase by 200 percent to reach 3.2 trillion. Larger aircraft sizes and higher load factors will combine to prevent even larger increases. Global air cargo revenue ton miles will grow by 136 percent reaching 130 billion. Helicopters and new tiltrotor and tiltwing

Table 1-4. 1994 Actual and 2004 Forecast Air Carrier Delay Hours

Annual Aircraft Delay in Excess of 20,000 Hours					
1994		2004			
Atlanta Hartsfield	ATL	Atlanta Hartsfield	ATL	New York La Guardia	LGA
Boston Logan	BOS	Boston Logan	BOS	Orlando	MCO
Charlotte/Douglas	CLT	Baltimore-Washington	BWI	Chicago Midway	MDW
Washington National	DCA	Charlotte/Douglas	CLT	Memphis	MEM
Denver Stapleton	DEN	Cincinnati	CVG	Miami	MIA
Dallas-Ft. Worth	DFW	Washington National	DCA	Minneapolis-Saint Paul	MSP
Detroit	DTW	Dallas-Ft. Worth	DFW	Chicago O'Hare	ORD
Newark	EWR	Detroit	DTW	Philadelphia	PHL
Honolulu	HNL	Newark	EWR	Phoenix	PHX
Houston Intercont'l	IAH	Honolulu	HNL	Pittsburgh	PIT
New York John F. Kennedy	JFK	Houston Intercont'l	IAH	San Diego	SAN
Los Angeles	LAX	New York John F. Kennedy	JFK	Seattle-Tacoma	SEA
New York La Guardia	LGA	Las Vegas	LAS	San Francisco	SFO
Orlando	MCO	Los Angeles	LAX	Salt Lake City	SLC
Miami	MIA			St. Louis	STL
Minneapolis-Saint Paul	MSP				
Chicago O'Hare	ORD				
Philadelphia	PHL				
Phoenix	PHX				
Pittsburgh	PIT				
Seattle-Tacoma	SEA				
San Francisco	SFO				
St. Louis	STL				

aircraft will play an increasingly important role in providing short-haul and medium-range passenger service. The market for new aircraft over the next 20 years will be almost one trillion dollars, more than double the market over the past 20 years. The challenge for the year 2010 will be to ensure that flights are conducted with unprecedented levels of safety, security, and efficiency, while conserving natural resources and minimizing the effects on the environment.

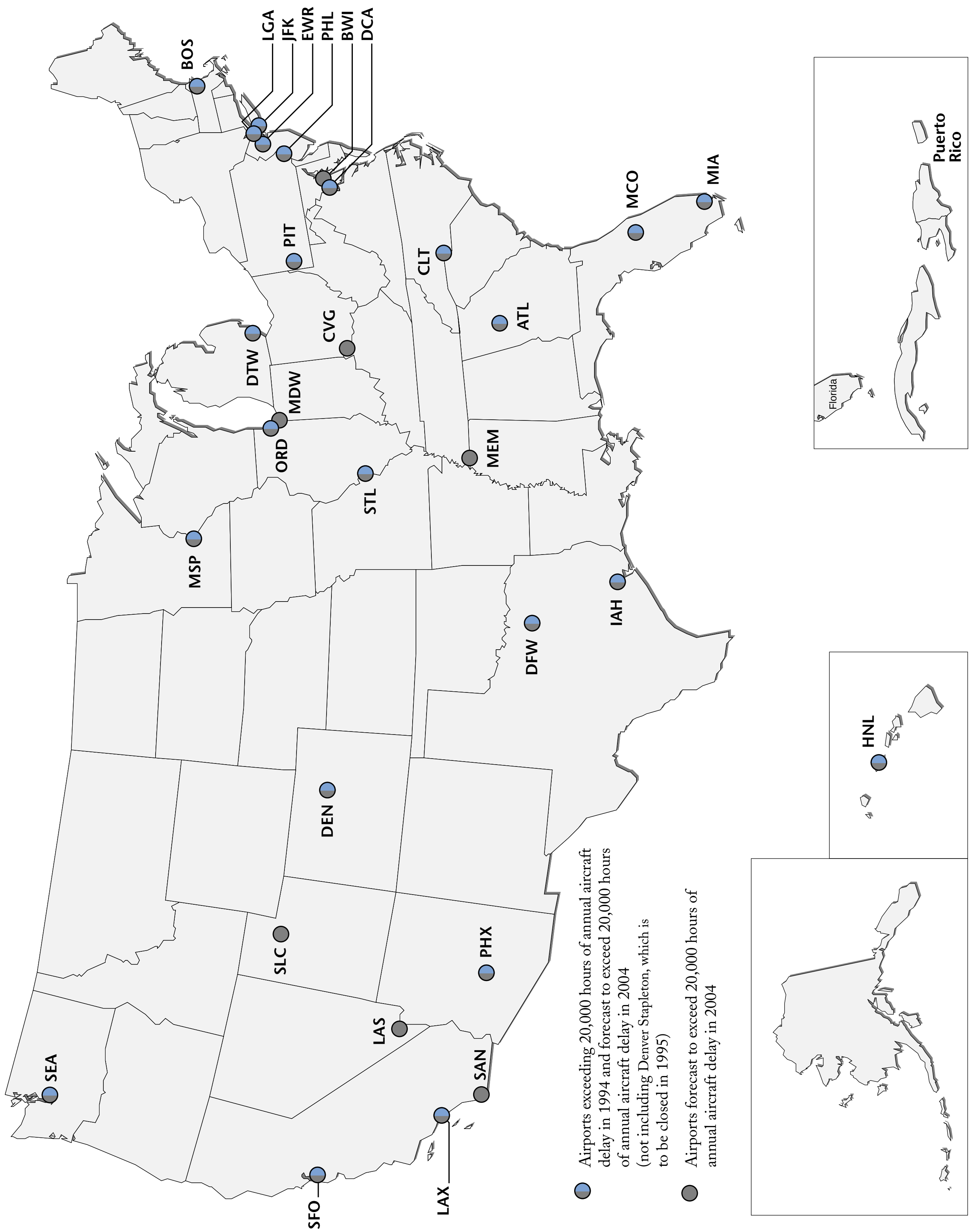

Figure 1-5. Airports Exceeding 20,000 Hours of Annual Delay in 1994 and 2004, Assuming No Capacity Improvements

Source: FAA Office of Policy and Plans

1.5.1 System Capacity Goals and Objectives

The FAA Strategic Plan identifies System Capacity as one of seven strategic issue areas. The principal goals for the aviation system capacity program in Volume II of the FAA Strategic Plan are to ensure that:

- Airspace, airport, and airside capacity continue to grow to meet user needs cost effectively.
- Capacity resources are fully utilized to meet traffic demand and eliminate capacity-related delays.
- Airport capacities in instrument meteorological conditions (IMC) equal capacities in visual meteorological conditions (VMC).

Specific objectives have been developed in the FAA Strategic Plan to support the general goal of the system capacity program to build aviation system capacity that will minimize delays and allow fair access for all types of aviation. The FAA Operational Concept, in turn, lays out specific milestones the FAA will complete over the next five years to achieve these objectives.

- System Capacity Measurement — to identify and define, in concert with the aviation community, standards of success and national capacity indicators that will better target areas for reducing delay and increasing capacity.
- Near-Term Capacity Initiatives — to reduce constraints/limitations at the top 40 delay/operationally impacted airports by timely implementation of system enhancements and capacity increasing technologies and procedures.
- ATC Automation — to improve the automated infrastructure through replacement and enhancements in order to provide the platform for capacity-enhancing technologies and procedures.
- Traffic Flow Management — to create the necessary capabilities that will permit the ATC system to ensure safe separation while imposing minimum constraints on system users and aircraft movement.

- Oceanic Control — to change, in concert with the international aviation community, oceanic air traffic control from its current non-radar control to a tactical control environment much like current domestic radar control.
- Weather Forecasting, Detection, and Communication — to reduce the capacity-impacting consequences of weather phenomena by improved weather forecasts and increased accuracy, resolution, and dissemination of observations both on the ground and in the air.
- Communications, Navigation, and Surveillance (CNS) and Satellite Navigation — to implement CNS and satellite navigation capabilities through an aggressive industry/government partnership that achieves user benefits in all phases of aviation operations.
- Communications/Data Link — to provide a cost-effective communications infrastructure to enhance the safety and effectiveness of air traffic management operations.
- Airport Planning — to improve the national airport planning process by adding a method for prioritizing projects; by linking the national plan to the grant program through an Airport Capital Improvement Program; and by developing the Airport Research, Engineering, and Development (RE&D) program.
- Human Factors — to implement new automation technologies and associated functional improvements in a manner that fully accounts for the proper role of the human in the system.
- Free Flight — accept and implement the 46 recommendations from RTCA Task Force 3 on Free Flight Implementation, in collaboration with the users.

Chapter 2

Airport Development

2.1 Delay and the Need for Airport Development

Most analysts would agree that the economic recovery is about complete and that the air transportation industry may even be showing a profit today. Previously, during the sluggish economic period of the past several years, air traffic delay temporarily slipped from newspaper headlines. The number of flights exceeding 15 minutes of delay declined even while commercial air carrier domestic passenger enplanements increased at an annual rate of less than 1 percent. Still, current forecasts indicate that, without capacity improvements, delays would increase substantially over the next decade, though at a somewhat slower pace than in the 1980s.

Even though the FAA's National Plan of Integrated Airport Systems (NPIAS) shows that, with the new improvements planned, capacity at the majority of the 29 hub airports will be adequate to meet the forecast growth in demand, there are still a few problem airports which are predicted to continue to experience significant delay. These are primarily the large metropolitan area airports on the east and west coasts, principally in the northeast and in California. At these airports, planned improvements are not adequate to meet the projected growth in demand.

While the capacity needed to meet future demand will be available at most of the Nation's busiest airports if the improvements planned continue to be funded and built, it remains essential that the aviation community, both the public and private sector, continues to work together to ensure these improvement projects are completed on time.

While the capacity needed to meet future demand will be available at most of the Nation's busiest airports if the improvements planned continue to be funded and built, it remains essential that the aviation community, both the public and private sector, continues to work together to ensure these improvement projects are completed on time. However, the NPIAS points out that, even though capacity improvements are planned at the few delay-problem airports, they will not be enough to meet forecast demand. Delays there will most likely increase as demand increases.

Airport capacity improvements involve these two priorities: (a) continue to plan, fund and build the projects to keep pace with the projected demand for most of the airports in the country, and (b) renewed emphasis must be given to funding innovative solutions for the few delay-problem airports in the Northeast and in California, and elsewhere.

The work of the Airport Capacity Design Teams, which is described in more detail in this chapter, currently emphasizes the first priority. For the few delay-problem airports of the Northeast, California and elsewhere, other options must be explored. New airports, expanded use of existing commercial-service airports, civilian development of former military bases, and joint civilian and military use of existing military facilities are some areas which must be systematically explored with a view toward developing regional airport systems to serve the expanding needs of these large metropolitan areas.

An FAA report to Congress, Long-Term Availability of Adequate Airport System Capacity (DOT/FAA/pp-92-4, June 1992), describes the probable extent of airport congestion in the future, given current trends. The three assessment techniques used in the study all point to a persistent shortfall in capacity at some of the busiest airports in the country as airport development lags behind the growing demand for air travel. The report acknowledges that some of the shortfall may be corrected by such things as improvements in technology and demand management. However, a significant gap in airport capacity will probably remain, and a major increase in the rate of airport development may be needed, together with measures to maximize the efficient use of existing capacity, and, in the longer term, to supplement air transportation with high-speed ground transportation. Development of new airports and options to maximize the efficiency of existing airports will be discussed in this and subsequent chapters.

2.2 New Airport Development

Naturally, the largest aviation system capacity gains result from the construction of new airports. The Denver International Airport, for example, has increased capacity and reduced delays not only in the Denver area but, to some extent, throughout the aviation system. Considering the cost, almost $3 billion for a new airport like Denver, it remains a challenge to finance and build others. In addition, the development of new airports faces environmental, social, and political constraints.

Bergstrom AFB is currently the only major military airfield being converted for civilian use, designed to replace Robert Mueller Airport in Austin, Texas. The Austin city council authorized the issuance of $363 million in airport revenue bonds to cover the cost of developing Austin-Bergstrom International Airport. This, in combination with investment income, passenger facility charge revenues, and airport system funds, will provide the financial resources necessary to construct the needed airport facilities. Table 2-1 summarizes other major new airports that have been considered in various planning studies by state and local government organizations.

Table 2-1. Major New Airports — Planning Studies or Under Construction

Airport	Purpose	Status
New Denver	Replacement airport for Denver Stapleton (DEN), which will close.	Opened in 1995.
Minneapolis-St. Paul	Replacement airport for MSP. Proposal is to close existing airport.	State legislation was enacted in the Spring of 1996, dropping the option for a new major air carrier airport. Minneapolis-St. Paul will be expanded instead.
West Virginia	Western West VA Regional Airport. Replacement airport for Charleston, Huntington, and Parkersburg.	Feasibility study completed.
Chicago	Supplemental airport.	EA in progress on State of Illinois preferred alternative (Peotone). Estimated completion 8/96.
Seattle-Tacoma	Supplemental airport.	Feasability study completed. Determined that there are no feasable sites for supplemental airport within the 4 county region.
Boston	No active plans for a new airport. Emphasis on greater use of existing outlying airports.	Based on new studies, MASPORT decided not to landbank a new airport.
Atlanta	Supplemental airport.	Satellite study by Atlanta Regional Commission of non-ranked sites completed. Feasibility study by State of Georgia completed.
Northwest Arkansas	Replacement airport for Fayetteville (FYV), which will remain in operation.	Site selection/AMP/EIS completed. Feasibility study completed. Record of Decision signed 8/16/94. Land acquisition underway.
Birmingham, Alabama	Replacement airport. Proposal is to close existing airport.	Site selection completed. Ranked sites and preferred sites identified by State of Alabama.
North Carolina	Cargo/industrial airport.	An existing airport, Kinston, N.C., was selected as the prefered site. EIS process underway.
Eastern Virginia	Supplemental airport.	Regional study by three Councils of Governments.
Austin	Replace Robert Mueller Airport.	Conversion of Bergstrom AFB to civil use.
Phoenix	Regional airport.	Preliminary studies completed. There is no support for establishing a new airport.

2.3 Development of Existing Airports — Airport Capacity Design Teams

As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the United States, an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities. In 1985, the FAA initiated a renewed program of Airport Capacity Design Teams at airports across the country affected by delay. Airport operators, airlines, and other aviation industry representatives work together with FAA representatives to identify and analyze capacity problems at each airport and recommend improvements that have the potential for reducing or eliminating delay. The FAA Technical Center's Aviation Capacity Branch (ACD-130), which has been involved in airport capacity simulation modeling since 1978, provides a ready source of technical expertise.

Aircraft flight delays are generally attributable to one or more conditions, which include weather, traffic volume, restricted runway capability, and NAS equipment limitations. Each of these factors can affect individual airports to varying degrees, but much delay could be eliminated if the specific causes of delay were identified and resources applied to develop the necessary improvements to remove or reduce the deficiency.

Since the renewal of the program in 1985, 38 Airport Capacity Design Team studies have been completed. Currently, four Capacity Team studies are in progress. Table 2-2 provides the status of the program at the airports with Airport Capacity Design Teams, and Figure 2-1 shows the location of each of these airports.

2.3.1 Airport Capacity Design Teams — Recommended Improvements

Airport Capacity Design Teams identify and assess various corrective actions that, if implemented, will increase capacity, improve operational efficiency and reduce delay at the airports under study. These changes may include improvements to the airfield (runways, taxiways, etc.), facilities and equipment (navigational and guidance aids), and operational procedures. The Capacity Teams evaluate each alternative to determine its technical merits. Environmental, socioeconomic, and political issues are not evaluated here but in the master planning process. Alternatives are examined with the assistance of computer simulations provided by the FAA Technical Center at Atlantic

Table 2-2. Status of Airport Capacity Design Teams

Airport Capacity Design Team Status			
Completed			Ongoing
Atlanta	Orlando	Albuquerque	Portland
Boston	Philadelphia	Ft. Lauderdale	Reno/Tahoe
Charlotte/Douglas	Phoenix	Indianapolis	Memphis Update
Chicago	Pittsburgh	Houston Intercont.	Miami Update
Detroit	Raleigh-Durham	Minneapolis-St. Paul	
Honolulu	Salt Lake City	Port Columbus	
Kansas City	San Antonio	Washington-Dulles	
Los Angeles	San Francisco	Oakland	
Memphis	San Jose	St. Louis	
Miami	San Juan, P.R.	New Orleans	
Nashville	**Seattle-Tacoma**	Eastern Virginia	
Cleveland	Las Vegas	Dallas/Ft. Worth	

As of 02-01-96

Items in **bold** indicate that a Capacity Enhancement Update Study has recently been completed. Refer to Section 2.8.

City, New Jersey. In their final report, the Capacity Team recommends certain proposed projects for implementation. However, it should be noted that the presence of a recommended improvement in a Capacity Team report does not obligate the FAA to provide Facilities and Equipment (F&E) or Airport Improvement Program (AIP) funds. Demands for F&E and AIP funds exceed the FAA's limited resources and individual Capacity Team recommended projects must compete with all other projects for these limited funds.

Table 2-3 summarizes these recommendations according to generalized categories of improvements. The Design Teams have developed more than 500 recommendations to increase airport capacity. Proposals to build a third or a fourth parallel runway were recommended by Design Teams at fourteen airports, proposals to build both a third and a fourth parallel runway were recommended at seven airports, proposals to build a new runway and a new taxiway were recommended at seven airports, proposals to build a new taxiway only were recommended at eleven airports, and proposals to build a new taxi-

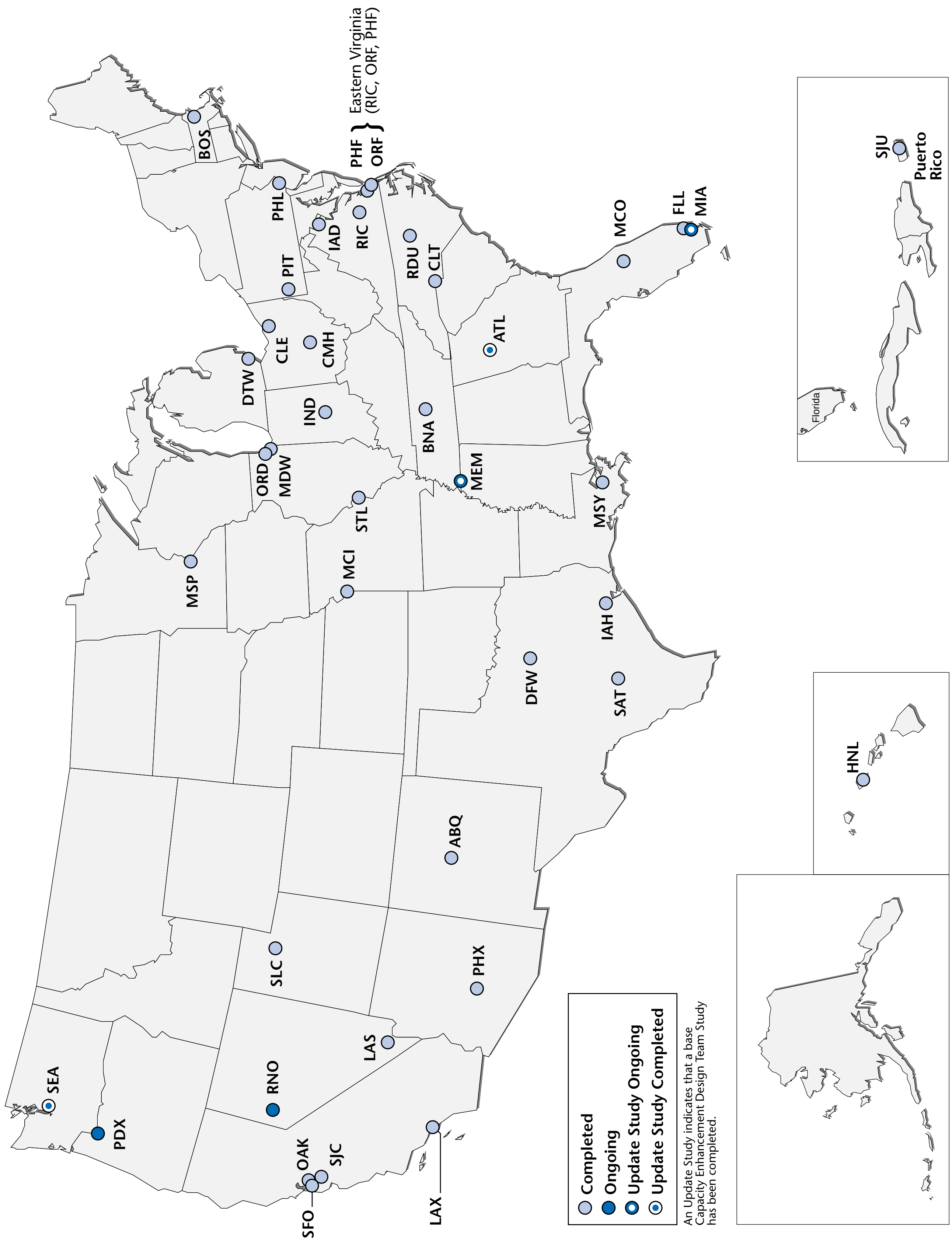

Figure 2-1. Airport Capacity Design Teams in the United States

way and new third and fourth parallel runways were recommended at five airports. Over half the capacity team reports have recommended proposed runway extensions, taxiway extensions, angled/improved exits, or holding pads/improved staging areas.

The only proposed facilities and equipment improvement that was recommended in more than half of the airport studies was the installation or upgrade of Instrument Landing Systems (ILSs) at one or more runways or runway ends, in order to improve runway capacity during IFR operations.

The proposed operational improvements that were recommended in half or more of the studies include improved IFR approach procedures and reduced separation standards for arrivals. One-third of the studies recommended an airspace analysis or restructuring of the airspace. Enhancement of the reliever and general aviation (GA) airport system was recommended at more than half of the airports.

In general, the Capacity Team recommendations demonstrate the FAA's efforts to increase aviation system capacity by making the most use of current airports. In the view of the Airport Capacity Design Teams, the "choke point" most often is found in the runway/taxiway system. Where possible, the construction of a third and even a fourth parallel runway has been proposed. Runway and taxiway extensions, new taxiways, and improved exits and staging areas have been recommended to reduce runway occupancy times and increase the efficiency of the existing runways. In addition to maximizing use of airport land, airports are making the best use of facilities, equipment, and procedures to increase arrival capacity during IFR operations. Equipment is being installed to accommodate arrivals under lower ceiling and visibility minima, including ILSs, RVRs, and improved radar, not to mention new and improved arrival procedures and reduced separation standards for arrivals, both in-trail and laterally.

In general, the Capacity Team recommendations demonstrate the FAA's efforts to increase aviation system capacity by making the most use of current airports.

2.3.2 Airport Capacity Design Teams — Potential Savings Benefits

As can be seen from the summary of Capacity Team recommendations in Table 2-3, the typical Capacity Team will make 20 to 30 recommendations for improvements to reduce delay at each airport. Because of the large number of specific improvements, it is virtually impossible to summarize the expected benefits of each of these recommendations for all the airports. In many cases, however, the recommended improve-

Table 2-3. Summary of Capacity Design Team Recommendations

Airports / Recommended Improvements	Airfield Improvements	Construct third parallel runway	Construct fourth parallel runway	Relocate runway	Construct new taxiway	Runway extension	Taxiway extension	Angled exits/improved exits	Holding pads/improved staging areas	Terminal expansion	Facilities and Equipment Improvements	Install/upgrade ILSs	Install/upgrade RVRs	Install/upgrade lighting system	Install/upgrade VOR	Upgrade terminal approach radar	Install ASDE	Install PRM	New air traffic control tower	Wake vortex advisory system	Operational Improvements	Airspace restructure/analysis	Improve IFR approach procedures	Improve departure sequencing	Reduced separations between arrivals	Intersecting operations with wet runways	Expand TRACON/Establish TCA	Segregate traffic	De-peak airline schedules	Enhance reliever and GA airport system
Richmond						√		√				√	√	√									√		√					
Norfolk						√						√	√	√											√					
Newport News						√		√															√		√					
Washington-Dulles		√			√	√	√		√	√			√	√									√		√				√	√
Seattle-Tacoma *		√						√				√								√			√		√				√	
San Juan, Puerto Rico					√		√	√	√	√				√	√				√	√					√					√
San Jose						√		√	√															√						
San Fransisco		√	√			√	√	√	√															√					√	√
San Antonio		√			√	√	√		√			√	√	√				√		√		√	√		√					√
Salt Lake City		√					√	√	√	√		√	√	√			√	√					√		√					√
St. Louis		√					√	√	√			√		√			√			√			√		√				√	
Raleigh-Durham		√	√	√	√			√	√			√	√				√			√		√	√		√		√			
Pittsburgh			√			√				√		√						√				√								
Phoenix		√			√		√	√	√	√		√		√	√								√	√	√			√	√	√
Philadelphia		√		√		√												√				√	√	√						
Orlando			√		√		√		√			√			√		√	√				√	√					√		√
Oakland					√			√	√																					
New Orleans					√										√				√			√	√		√					√
Nashville			√	√	√	√	√		√			√								√		√	√				√		√	√
Minneapolis-Saint Paul		√	√		√	√		√	√	√		√	√	√	√			√				√			√					√
Miami					√		√	√	√			√	√	√			√						√							√
Memphis		√			√	√	√	√				√											√		√				√	
Los Angeles					√	√	√		√	√		√							√			√								
Las Vegas					√	√	√					√											√			√				√
Kansas City		√	√				√	√	√	√		√	√				√						√		√				√	
Indianapolis		√	√	√	√			√	√			√	√	√			√						√		√					√
Houston Intercontinental		√	√		√	√		√	√	√		√											√						√	√
Honolulu		√				√		√	√	√		√																	√	√
Fort Lauderdale					√	√		√	√	√		√			√	√		√		√		√	√		√				√	√
Port Columbus		√	√	√	√	√		√	√	√		√		√			√	√	√			√	√		√				√	√
Dallas-Ft. Worth					√	√		√															√	√	√					√
Cleveland		√		√	√	√	√	√		√		√			√			√					√	√	√					√
Chicago O'Hare				√	√	√		√	√			√											√			√				
Chicago Midway					√	√			√														√		√					
Charlotte-Douglas		√				√	√	√	√			√		√			√	√								√	√			√
Boston					√	√	√	√	√			√								√			√			√				
Atlanta *					√			√	√	√		√	√	√		√	√			√					√				√	
Albuquerque					√	√	√	√	√	√		√			√								√		√					√

* These recommendations represent options provided in the original Capacity Enhancement Plan for this airport. Since then, a Capacity Enhancement Plan Update Study has been completed. Refer to Section 2.8.

ments to the airfield represent the biggest capacity gains, particularly since they frequently incorporate the benefits of improved procedures and upgraded navigational equipment. Detailed information on specific delay-savings benefits can be found in the final reports of the various Airport Capacity Design Teams.

2.4 Construction of New Runways and Runway Extensions

The construction of new runways and extension of existing runways are the most direct and significant actions that can be taken to improve capacity at existing airports.

The construction of new runways and extension of existing runways are the most direct and significant actions that can be taken to improve capacity at existing airports. Large capacity increases, under both visual flight rules (VFR) and instrument flight rules (IFR), come from the addition of new runways that are properly placed to allow additional independent arrival/departure streams. The resulting increase in capacity is from 33 percent to 100 percent (depending on whether the baseline airport has a single, dual, or triple runway configuration).

Sixty-two of the top 100 airports have proposed new runways or runway extensions to increase airport capacity.

Sixty-two of the top 100 airports have proposed new runways or runway extensions to increase airport capacity.[1] Fifteen of the 23 airports exceeding 20,000 hours of air carrier flight delay in 1994[2] are in the process of constructing or planning the construction of new runways or extensions of existing runways. If no further improvements are made, of the 29 airports forecast to exceed 20,000 hours of annual air carrier delay in 2004, 20 propose to build new runways or runway extensions.

Figure 2-2 shows which of the top 100 airports are planning new runways or runway extensions. Figure 2-3 shows which of the airports forecast to exceed 20,000 hours of annual delay in 2004 are planning new runways or runway extensions. Table 2-4 summarizes new runways and runway extensions that are planned or proposed at the top 100 airports.The total anticipated cost of completing these new runways and runway extensions exceeds $6.0 billion.

1. Airports with runway projects are pictured in Figures 2-2 and 2-3 and summarized in Table 2-4 with the estimated project cost (to the nearest million) and an estimated operational date.
2. At a cost of $1,600 in airline operating expenses per hour of airport delay, 20,000 hours of flight delay translates into $32 million per year.

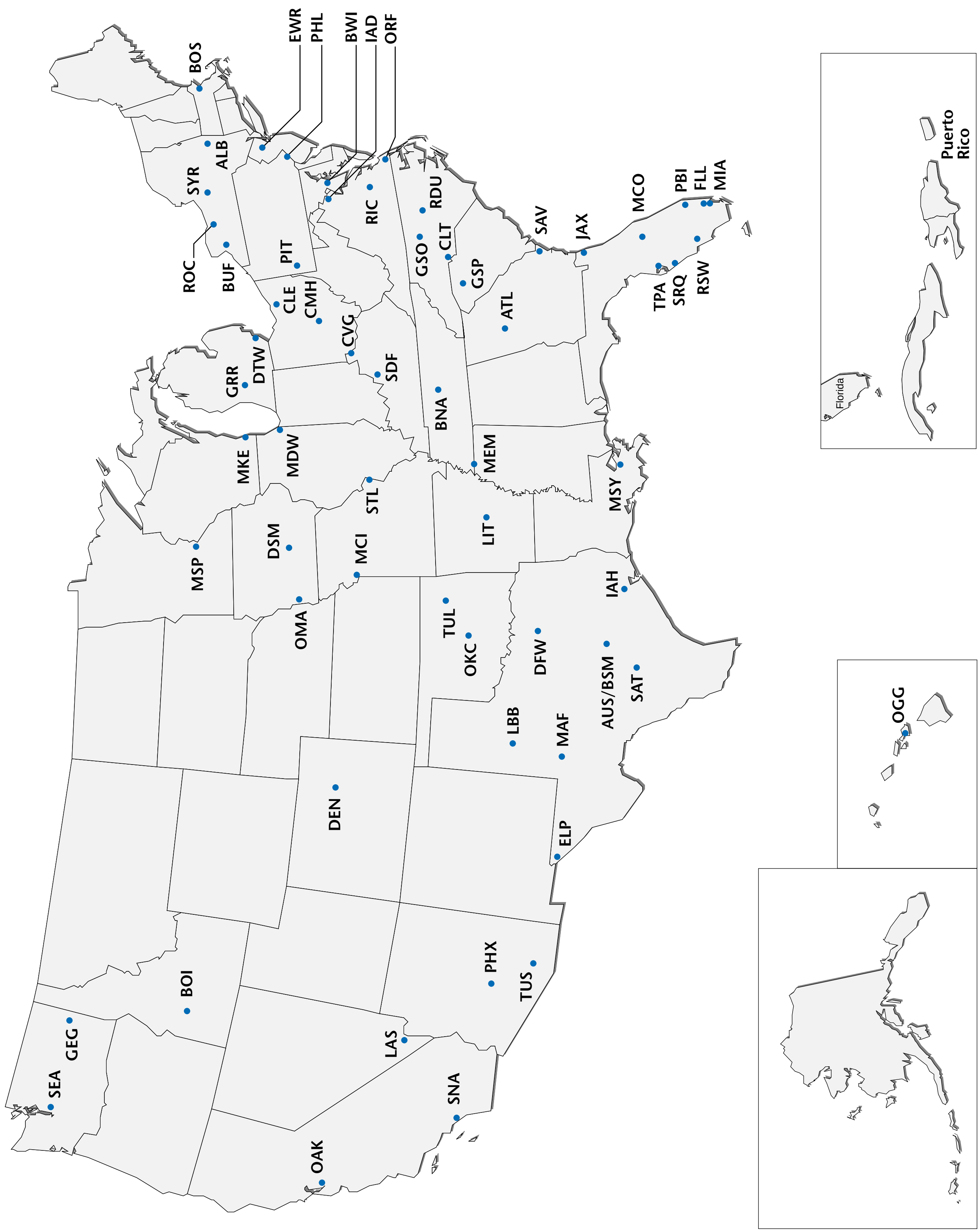

Figure 2-2. New Runways or Runway Extensions Planned or Proposed Among the Top 100 Airports

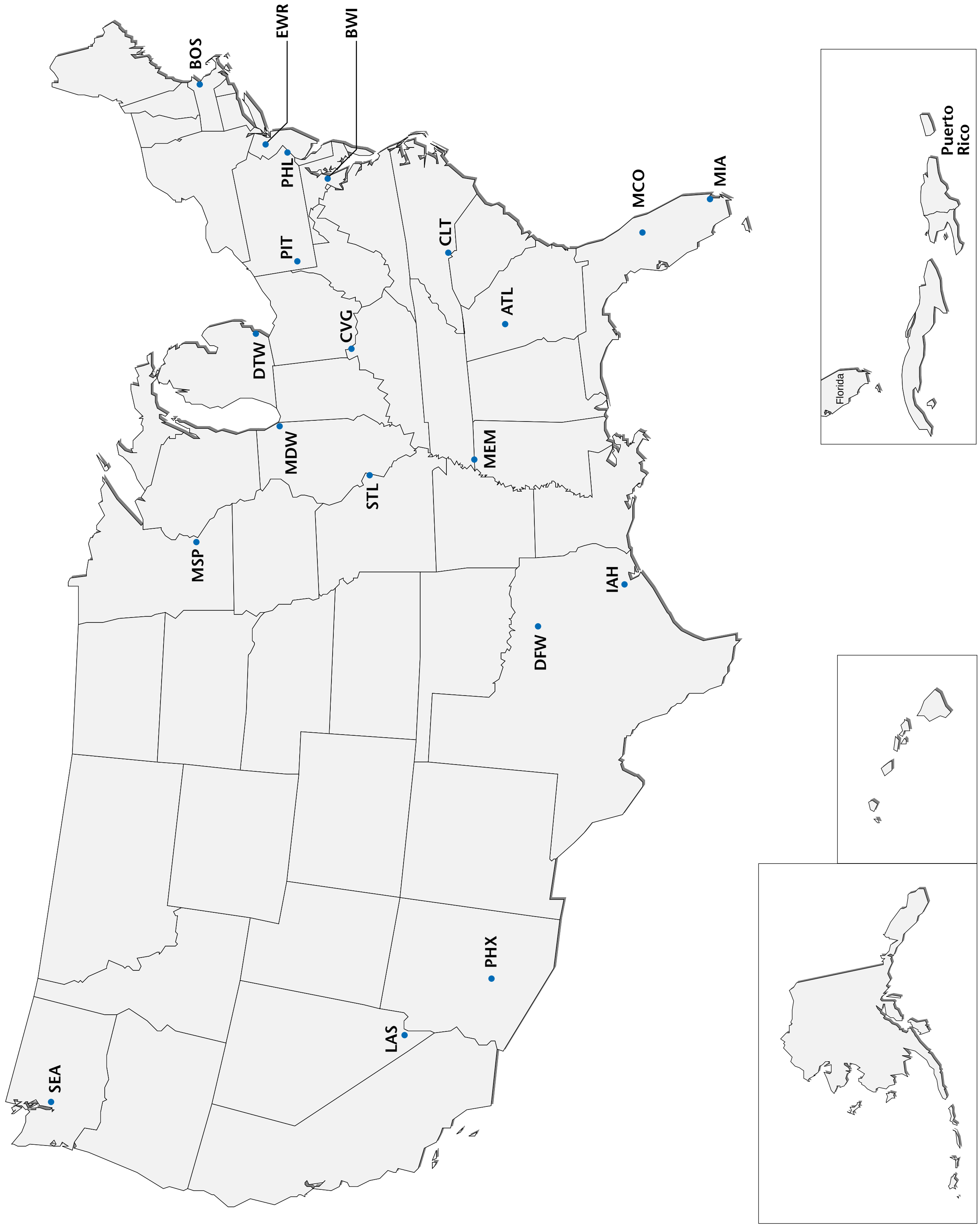

Figure 2-3. New Runways or Extensions Planned/Proposed Among the Airports Forecast to Exceed 20,000 Hours of Annual Aircraft Delay in 2004

Table 2-4. New and Extended Runways Planned or Proposed

Airport	Runway	Est. Cost ($M)	Operational Date
Albany (ALB)	10/28 extension	$5.80	2000
	1R/19L parallel	$7.50	2010
Atlanta (ATL)	5th E/W parallel commuter	$418.00	1999
Austin (BSM) (new airport)	*(see Bergstrom below)*	n/a	n/a
Baltimore (BWI)	10R/28L parallel	n/a	2003
Bergstrom (new Austin)	New airport: 2 Rwys, taxi construction	$447.00	1998
	17L/35R & parallel taxiway	$46.00	1998
	midfield crossfield taxiways	$13.00	1997
	air cargo apron	$4.00	1996
	west runway renovation	$10.00	1996
Boise Trace (BOI)	Rwy 10L/28R extension	$8.00	1998
Boston (BOS)	14/32	n/a	n/a
Buffalo (BUF)	14/32 extension & threshold relocation	$10.00	1998
Charlotte (CLT)	18W/36W 3rd parallel	$70.00	1999
Chicago Midway	4R/22L reconstruction	$32.00	1997
Cincinnati (CVG)	18R/36L extension	$11.00	1996
Cleveland-Hopkins (CLE)	5L/23R replacement	$180.00	1999
	5L/23R extension	$40.00	2001
Port Columbus (CMH)	10L/28R extension & relocation	$22.00	1999
Dallas-Fort Worth (DFW)	18L/36R extension	$25.00	1999
	18R/36L extension	$24.00	1997
	17L/35R new parallel	$300.00	1996
	18R/36L new parallel	$100.00	2001
	17C/35C extension (prev. 17L/35R)	$20.00	1997
Denver International (DEN)	16R/34L parallel	$75.00	2000
Des Moines (DSM)	Rwy 5 extension	$21.50	1999
Detroit (DTW)	4/22 parallel	$116.50	2001
El Paso (ELP)	8/26 parallel	$10.70	n/a
Fort Lauderdale (FLL)	9R/27L extension	$270.00	2002
Fort Myers (RSW)	6R/24L parallel	$87.00	2000
Grand Rapids (GRR)	18/36 extension/realignment to 17/35	$58.00	1997
Greensboro (GSO)	5L/23R parallel	n/a	2010
	14/32 extension	$15.70	2000
Greer (GSP)	3R/21L parallel	$50.00	2015
	Rwy 3 2,000 ft. extension	$25.80	1999
	Rwy 21 1,400 ft. extension	$8.30	1996
Houston Intercontinental (IAH)	14R/32L extension	$8.00	n/a
	8L/26R parallel	$44.00	n/a
	9R/27L parallel	$44.00	n/a
Jacksonville (JAX)	7R/25L parallel	$37.00	2000

Table 2-4. New and Extended Runways Planned or Proposed

Airport	Runway	Est. Cost ($M)	Operational Date
Kahului (OGG)	2/20 extension & strengthen	$40.00	1998
Kansas City (MCI)	1L/19R extension	$12.00	n/a
Las Vegas (LAS)	1L/19R reconstruction	$50.00	1997
Little Rock (LIT)	4L/22R extension & overlay	$31.00	1997
Louisville (SDF)	17R/35L parallel	$59.00	1997
Lubbock (LBB)	8/26 extension	$5.00	2000
Memphis (MEM)	18E/36E new parallel	$146.10	1996
	18C/36C extend/reconstruct (prev. 18L/36R)	$113.70	1999
Miami (MIA)	9N/27N new parallel	$149.00	1999
Midland (MAF)	10/28 extension	$5.00	2008
Milwaukee (MKE)	7R/25L parallel	$5.00	1998
	7L/25R realignment	$5.00	1996
	7L/25R extension	n/a	n/a
Minneapolis (MSP)	17/35 air carrier	$120.00	2002
	4/22 extension	$40.50	1996
Nashville (BNA)	2E/20E parallel	n/a	n/a
	2R/20L extension	$38.60	2000
New Orleans (MSY)	1L/19R parallel	$340.00	2005
	10/28 parallel	$480.00	2020
Newark (EWR)	4L/22R extension	n/a	2000
Norfolk (ORF)	5R/23L parallel	$75.00	2005
Oakland Metropolitan (OAK)	11R/29L parallel	n/a	n/a
	11/29 etension	n/a	n/a
Oklahoma City (OKC)	17L/35R extension	$8.00	2014
	17R/35L extension	$8.00	2014
	17W/35W parallel	$13.00	2004
	13/31 1,200 ft. NW extension	$5.00	2005
Omaha Eppley Field (OMA)	14/32 extension	$9.00	1997
Orlando (MCO)	17L/35R 4th parallel	$137.00	2002
	17R/35L extension	n/a	n/a
Palm Beach (PBI)	9L/27R extension	$8.50	n/a
	13/31 extension	$1.00	1999
	9R/27L extension	$0.50	1997
Philadelphia (PHL)	8/26 parallel-commuter	$220.00	n/a
	9L/27R relocation	n/a	n/a
Phoenix (PHX)	7/25 3rd parallel	$88.00	1998
	8L/26R extension	$7.00	2000
Pittsburgh (PIT)	4th parallel 10/28	$150.00	n/a
	5th parallel 10/28	n/a	n/a

Table 2-4. New and Extended Runways Planned or Proposed

Airport	Runway	Est. Cost ($M)	Operational Date
Raleigh-Durham (RDU)	5R/23L extension & assoc. taxiways	n/a	2005
	3rd parallel	n/a	n/a
Richmond (RIC)	16/34 extension	$45.00	1997
Rochester (ROC)	4R/22L parallel	$10.00	2010
	4/22 extension	$4.00	2000
	10/28 extension	$3.20	2000
St. Louis (STL)	14R/32L	$250.00	n/a
San Antonio (SAT)	12L/30R reconstruction/extension	$20.00	2006
	12N/30N new rwy	$400.00	n/a
Santa Ana (SNA)	1L/19R extension	n/a	n/a
Sarasota-Bradenton (SRQ)	14L/32R parallel	$10.00	2000+
	14/32 extension	$5.10	1998
Savannah (SAV)	9L/27R new parallel	$15.20	2005
	9/27 1,000 ft. extension	$5.00	1999
	18/36 2,000 ft. extension	$3.90	2000
Seattle-Tacoma (SEA)	16W/34W parallel	$400.00	2001
Spokane (GEG)	3L/21R	$11.00	2001
Syracuse (SYR)	10L/28R	$55.00	2000
Tampa (TPA)	18W/36W 3rd parallel	$55.00	2000+
	9/27 reconstruction & extension	n/a	2010+
	18L extension	n/a	2005+
Tucson (TUS)	11R/29L parallel	$30.00	2005
Tulsa (TUL)	18E/36E parallel	$115.00	2005
Washington (IAD)	1L/19R parallel	n/a	2009
	12R/30L parallel	n/a	n/a
	Total of available costs:	$6,472.10	

n/a=no data available at press time

In 1992, Colorado Springs completed construction of a new 13,500 foot parallel runway, and Nashville and Washington Dulles completed runway extensions. In 1993, Detroit Metropolitan Wayne County completed construction of a new 8,500 foot parallel runway, and runway extensions were completed at Dallas-Fort Worth, San Jose, Kailua-Kono Keahole, and Islip Long Island Mac Arthur. In 1993, Memphis began construction of independent parallel runways, and Louisville Standiford Field began construction of two independent parallel runways. In 1994, Jacksonville opened the first 6,000 feet of a new parallel runway, and Kansas City completed construction of a new 9,500 foot independent parallel runway. The third air carrier runway was opened in 1995 at Salt Lake City. It is 12,000 feet long and 150 feet wide.

2.5 Airport Tactical Initiatives

The recommendations by Airport Capacity Design Teams have emphasized constructing new runways and taxiways, extending existing runways, installing enhanced facilities and equipment, and modifying operational procedures. These improvements are normally implemented through established, long-term procedures. The Office of System Capacity (ASC) has recently initiated an effort to identify, evaluate, and implement capacity improvements that are achievable in the near term and will provide more immediate relief for chronic delay-problem airports. Tactical Initiative Teams, made up of representatives from airport operators, air carriers, other airport users, and aviation industry groups together with FAA representatives, are now being established at selected airports to assess near-term, tactical initiatives and guide them through implementation.

The first of these Tactical Initiative Teams completed a study at Los Angeles International Airport with a final report issued in September 1993. The team evaluated the impact on the crossfield taxiway system of proposed new gates on the west side of Tom Bradley International Terminal immediately adjacent to the taxiway system. The study examined airport delays and their causes (with and without the expansion of the west side of the terminal) and evaluated the effect of adding additional crossfield taxiways to mitigate the delays caused by the expansion.

A study at New York's LaGuardia Airport to evaluate the impact of introducing the Boeing 777-200 folding-wing aircraft on airfield operations was completed in 1994. In addition to evaluating the effects of the new aircraft on capacity and efficiency, the study examined the effects on safety, operating minimums, air traffic control procedures, and airway facilities.

A study at Orlando International Airport to evaluate the effects of proposed crossfield taxiways on airfield operations, a study to determine the effects of taxiway system improvements at Charlotte/Douglas International Airport, and a second study at Los Angeles International Airport to assess the impact of proposed remote commuter aircraft aprons on airfield operations were completed in 1995.

2.6 Terminal Airspace Studies

When an Airport Capacity Design Team study is completed, an airport has a recommended plan of action to increase its capacity. This plan will do little good, however, if the airspace in the vicinity of the airport cannot handle the increase in traffic. For this reason, the Office of System Capacity has developed a program of airspace capacity design team studies of the terminal and en route airspace associated with delay-problem airports across the country. Generally, these studies are intended to follow Airport Capacity Design Team studies. The first of these Terminal Airspace Studies was completed at San Bernadino International Airport (the former Norton Air Force Base). Studies are underway at Tampa International Airport, Salt Lake City International Airport, and Minneapolis St. Paul International Airport.

2.7 Regional Capacity Design Teams

Looking beyond the individual airport and its immediate airspace, the Office of System Capacity is planning a series of Regional Capacity Design Team studies. These regional studies will analyze all the major airports in a metropolitan or regional system and model them in the same terminal airspace environment. This regional perspective will show how capacity-producing improvements at one airport will affect air traffic operations at the other airports, and within the associated airspace. The first of these regional studies is planned for the San Francisco Bay area.

2.8 Airport Capacity Design Team Updates

The present Airport Capacity Design Team effort began in 1985. Many of the capacity-producing recommendations made by these Airport Capacity Design Teams have been implemented or are scheduled for completion, others may need to be reevaluated, and still others may no longer be appropriate. For some airports, particularly those with studies completed in the 1980's, conditions may have changed to a considerable extent, and a comprehensive new Airport Capacity Design Team study may be needed to bring the airport up to date. For other airports, changes in one or more of the conditions at the airport may only require a more limited update. An Airport Capacity Design Team Update was conducted at Seattle-Tacoma International Airport to evaluate the impact of a proposed new dependent runway on airport operations and to examine the interaction between operations on the new runway and existing operations at Boeing Field/King County International Airport. A second update was recently completed at Hartsfield Atlanta International Airport. The results of this update study included recommendations for the construction of a new independent runway as well as additional high speed runway exits. Additional Airport Capacity Design Team Updates are in progress at Memphis and Maimi.

Chapter 3

New Instrument Approach Procedures

Although substantial increases in capacity are best achieved through the building of new airports and new runways at existing airports, large projects like these are only completed after a long-term process of planning and construction. In an effort to meet the increasing demands on the aviation system in the near-term, the FAA has initiated improvements in air traffic control procedures designed to increase utilization of multiple runways and provide additional capacity at existing airports, while maintaining or improving the current level of safety in aircraft operations.

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In FY94, more than half of all delays were attributed to adverse weather conditions. These delays are in part the result of instrument approach procedures that are much more restrictive than the visual procedures in effect during better weather conditions. Much of this delay could be eliminated if the approach procedures used during instrument meteorological conditions (IMC) were closer to those observed during visual meteorological conditions (VMC).

During the past few years, the FAA has been developing new capacity-enhancing approach procedures. These are multiple approach procedures aimed at increasing the number of airports and runway combinations that can be used simultaneously, either independently or dependently, in less than visual approach conditions. "Independent" procedures are so called because aircraft arriving along one flight path do not affect arrivals along another flight path. "Dependent" procedures place restrictions between two arrival streams of aircraft because their proximity to each other has the potential for some interference. The testing of these new procedures has been thorough, involving various validation methods, including real-time simulations and live demonstrations at selected airports.

The testing of these new procedures has been thorough, involving various validation methods, including real-time simulations and live demonstrations at selected airports.

As a result of these development efforts, new technologies have been implemented and new national standards have been published that enable the use of these capacity-enhancing approach procedures:

- Simultaneous (independent) parallel approaches using the Precision Runway Monitor (PRM) to runways separated by 3,400 to 4,300 feet — published November 1991. The first PRM was commissioned at Raleigh-Durham International Airport in June 1993.

- Improved dependent parallel approaches to runways separated by 2,500 to 4,299 feet that reduce the required diagonal separation from 2.0 to 1.5 nm — published June 1992.
- Reduced longitudinal separation on wet runways from 3 to 2.5 nm inside the final approach fix (FAF) — published June 1992.
- Dependent converging instrument approaches using the Converging Runway Display Aid (CRDA) — published November 1992. The ARTS IIIA CRDA software upgrade is available for installation.
- Use of Flight Management System (FMS) computers to transition aircraft from the en route phase of flight to existing charted visual flight procedures (CVFP) and instrument landing system (ILS) approaches — published December 1992.
- Simultaneous ILS and localizer directional aid (LDA) approaches — procedures implemented at San Francisco International Airport.

The following sections present a brief description of the most promising approach concepts currently under development, including their estimated benefits, supporting technology, and candidate airports that might benefit from the new procedures.

3.1 Independent Parallel Approaches Using the Precision Runway Monitor (PRM)

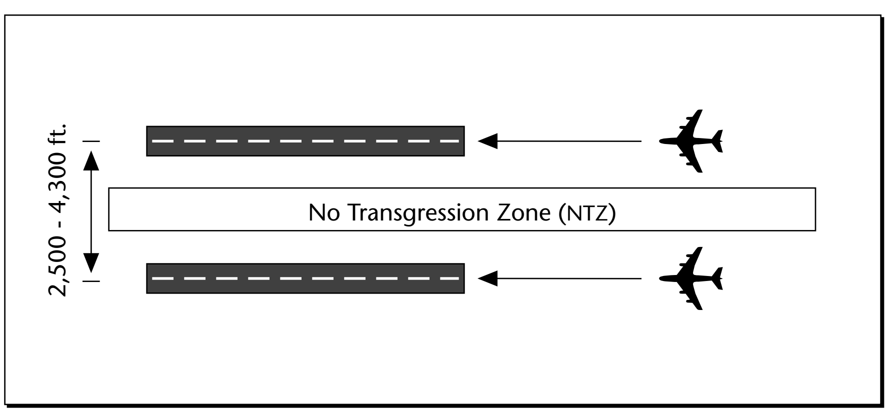
The FAA has authorized independent (simultaneous) instrument approaches to dual parallel runways since 1962, doubling the arrival capacity of an airport when visual approaches cannot be conducted. The spacing between the parallel runways was initially required to be at least 5,000 feet, but was reduced to 4,300 feet in 1974. More than 15 U.S. airports are currently authorized to operate such independent parallel instrument approaches. A new national standard published in November 1991 authorized simultaneous (independent) parallel approaches to runways separated by 3,400 to 4,300 feet when the Precision Runway Monitor is in use.

The PRM system consists of an improved monopulse antenna system that provides high azimuth and range accuracy and higher data rates than the current terminal Airport Surveillance Radar (ASR) systems. The E-Scan radar uses an electronic scanning antenna which is capable of updating an aircraft's position every half second. This update rate is an order of magnitude greater than the current ASR systems. The PRM processing system allows air traffic controllers to monitor the parallel approach courses on high-resolution color displays and generates controller alerts when an aircraft blunders off course.

Demonstrations of PRM technology were conducted at Raleigh-Durham International Airport in 1989 and 1990 using the E-Scan radar. The first PRM system (E-Scan) was commissioned at Raleigh Durham International Airport in June 1993. The second system was delivered to Minneapolis in 1995. Studies are being conducted to determine appropriate sites for the remaining systems.

Simulations were conducted at the FAA Technical Center in attempts to determine the minimum runway spacing between triple parallel runways spaced 4,000 and 5,300 feet apart in 1995 and in 1996 using enhanced procedures. Recommendations on this procedure is expected in 1996. Simulations were also conducted in 1995 on simultaneous ILS approaches to dual parallel runways spaced 3,000 feet apart with one localizer offset 2.5 degrees. This procedure was recommended in 1995 and a final report will be completed in 1996. While the results are pending, if successful, the average capacity gains expected from the use of these improved approaches would be, at a minimum, 12-17 arrivals per hour.

Figure 3-1. Independent Parallel Instrument Approaches Using the Precision Runway Monitor (PRM)



3.2 Independent Parallel Approaches Using the Final Monitor Aid (FMA) with Current Radar Systems

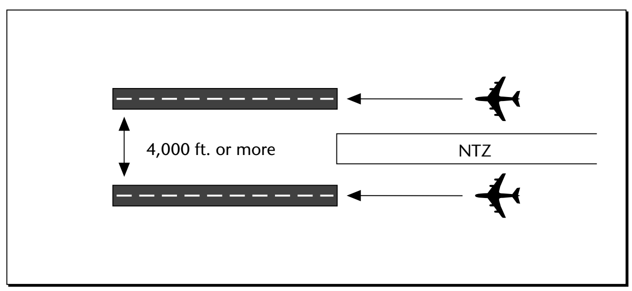
The Final Monitor Aid is a high resolution color display that is equipped with the controller alert hardware and software that is used in the PRM system. The display includes alert algorithms that provide aircraft track predictors; a color change alert when an aircraft penetrates or is predicted to penetrate the no transgression zone (NTZ); a color change alert if the aircraft transponder becomes inoperative; and digital mapping.

Studies revealed that using the fma with current radar systems (4.8 second update rate) would improve the ability of controllers to detect blunders, thereby allowing a reduction in the minimum centerline spacing for independent parallel approaches. Real-time simulations, utilizing a "miss-distance" of 500 feet to allow for the possible effects of wake vortex, were completed at the FAA Technical Center for dual and triple parallel runways spaced 4,300 feet apart. Procedures have been published in an FAA Order. Further simulations will be conducted for parallel runways spaced 4,000 feet apart. Figure 3-2 illustrates parallel instrument approaches using the FMA. Table 3-1 lists airports that have, or plan to have, parallel runways separated by 4,000 feet or more and indicates the average capacity gains expected from these improved approaches.

Table 3-1. Candidate Airports for Independent Parallel Approaches Using the Final Monitor Aid (FMA)

Candidates Among Top 100 Airports Average Capacity Gain 12-17 Arrivals/Hour		
Detroit	Little Rock	Orlando
Grand Rapids	Memphis	Phoenix
	Nashville	Pittsburgh

Figure 3-2. Parallel Instrument Approaches Using the Final Monitor Aid (FMA)



3.3 Independent Parallel Approaches to Triple and Quadruple Runways Using Current Radar Systems

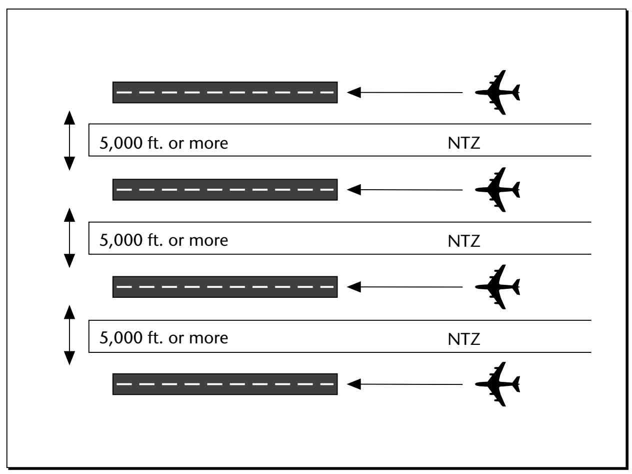
Several airports, including Dallas-Fort Worth, Orlando, and Pittsburgh, are planning to build parallel runways that will give them the capability to conduct triple and quadruple independent parallel approaches. This could result in as much as a 50 percent increase in arrival capacity for triple parallel arrivals and a 100 percent increase for quadruple arrivals.

Procedures allowing triple independent approaches to parallel runways separated by 5,000 feet, at airports with field elevations of less than 1,000 feet with current radar systems, were published in May 1993. Simulations for development of procedures for quadruple approaches are tentatively planned for the future. Figure 3-3 illustrates triple and quadruple parallel approaches. Additional simulations will be conducted to determine the minimum runway spacing (less than 5,000 feet) for independent parallel approaches to triple and quadruple runways. Table 3-2 lists airports that have or plan to have parallel runways separated by 2,500 to 4,300 feet and indicates the average capacity gains expected from these improved approaches.

Table 3-2. Candidate Airports for Independent Parallel Approaches to Triple and Quadruple Runways

Candidates Among Top 100 Airports Average Capacity Gain 30 Arrivals/Hour
Dallas-Ft. Worth Denver Orlando Pittsburgh

Figure 3-3. Triple and Quadruple Parallel Approaches



3.4 Simultaneous Operations on Wet Intersecting Runways

Currently, simultaneous operations on intersecting runways require that the runways be dry. Over the past several years, demonstrations have been conducted at various airports using simultaneous operations on wet runways. Due to the success of these demonstrations, the FAA has initiated action to establish a national standard for allowing simultaneous operations on intersecting wet runways.

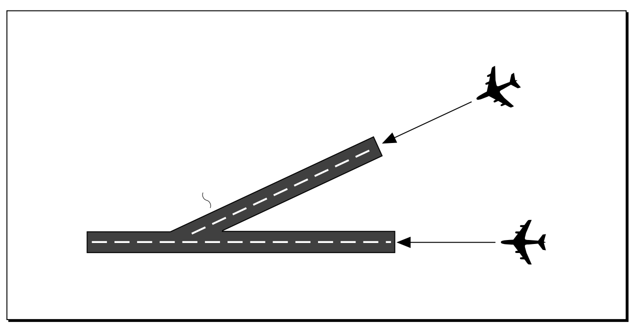
Of the top 100 airports, 60 currently conduct simultaneous operations on intersecting runways. Demonstrations have been ongoing at Boston Logan, Greater Pittsburgh, and Chicago O'Hare. Demonstrations are planned at New York's Kennedy, Philadelphia, and Miami International Airports. At O'Hare, increases of up to 25 percent have been experienced during wet runway operations.

An FAA team is in the process of formalizing procedures for these types of operations so that a national standard for simultaneous operations on wet intersecting runways can be established. The target for implementation is 1996. Figure 3-4 illustrates simultaneous operations on wet intersecting runways. Table 3-3 lists airports that are candidates to conduct simultaneous operations on wet intersecting runways.

Table 3-3. Candidate Airports for Simultaneous Operations on Wet Intersecting Runways

Candidates Among Top 100 Airports Top 13 Candidate Airports		
Boston	Miami	Philadelphia
Charlotte/Douglas	Minneapolis-St. Paul	Pittsburgh
Chicago O'Hare	New York (JFK)	San Francisco
Detroit	New York (LGA)	Washington National
	St. Louis	

Figure 3-4. Simultaneous Operations on Wet Intersecting Runways



3.5 Improved Operations on Parallel Runways Separated by Less Than 2,500 Feet

Current procedures consider parallel runways separated by less than 2,500 feet as a single runway during IFR operations. Simultaneous use of these runways for arrivals and departures is prohibited. This imposes a significant capacity penalty at numerous high-density airports. A recent analysis determined that airports such as Boston Logan International and Philadelphia International could achieve delay savings of over 80,000 hours per year if they were able to run dependent parallel arrivals. Table 3-4 lists airports that are candidates to conduct improved operations on parallel runways separated by less than 2,500 feet.

The FAA's Wake Vortex Program has been redefined to focus directly on the safety requirements for arrival and departure operations to parallel runways separated by less than 2,500 feet. One of the ojectives of the program will be to determine if there is sufficient evidence supporting a reduction in the 2,500 foot requirement.

Table 3-4. Candidate Airports for Improved Operations on Parallel Runways Separated by Less Than 2,500 Feet

Candidates Among Top 100 Airports		
Atlanta	Long Beach	Palm Beach
Boise	Los Angeles	Philadelphia
Boston	Memphis	Phoenix
Chicago Midway	Midland	Pittsburgh
Cincinnati	Milwaukee	Providence
Cleveland	Nashville	Raleigh-Durham
Dallas-Ft. Worth	New Orleans	Reno
Des Moines	New York (JFK)	San Antonio
Detroit	Newark	San Francisco
El Paso	Norfolk	San Jose
Houston Hobby	Oakland	Santa Ana
Houston Intercont'l	Oklahoma City	Seattle-Tacoma
Islip	Omaha	St. Louis
Knoxville	Ontario	Tucson
Las Vegas	Orlando	Washington Dulles

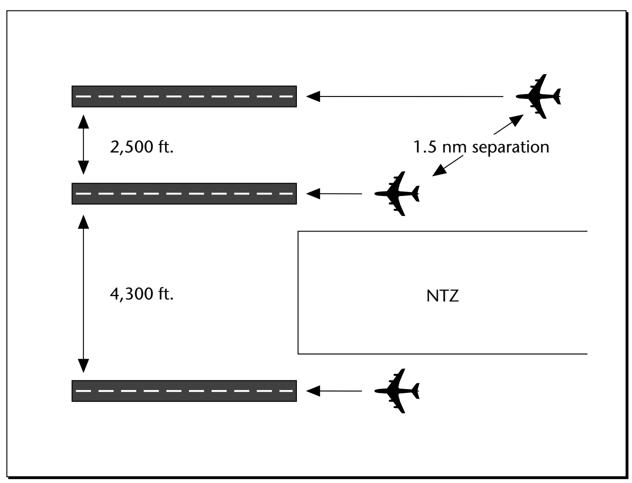
3.6 Dependent Approaches to Three Parallel Runways

Procedures have been proposed that would allow approaches to three parallel runways when two may be operated independently of each other because of sufficient spacing and the third is dependent upon one of the others because of insufficient spacing. Currently, procedures allow simultaneous approaches to runways with centerlines spaced at least 3,400 feet apart, provided a Precision Runway Monitor (PRM) is available. However, those airports with spacing from 2,500 to 3,400 between one set of runways and 3,400 to 4,300 feet or more between the other set are limited to dual runway operations. Real-time simulations will be scheduled in the future to test proposed procedures that will allow triple operations using dependent operations between one set of parallels and independent operations between the other set. Figure 3-5 illustrates independent and dependent parallel approaches, and Table 3-5 lists airports that are candidates for these improved approaches.

Table 3-5. Candidate Airports for Dependent Approaches to Three Parallel Runways

Candidates Among Top 100 Airports Average Capacity Gain 15 Arrivals/Hour		
Charlotte/Douglas	Detroit	Pittsburgh
Chicago O'Hare	Houston Intercont'l	Salt Lake City
Denver	Orlando	Washington Dulles

Figure 3-5. Independent and Dependent Parallel Approaches



3.7 Simultaneous (Independent) Converging Instrument Approaches

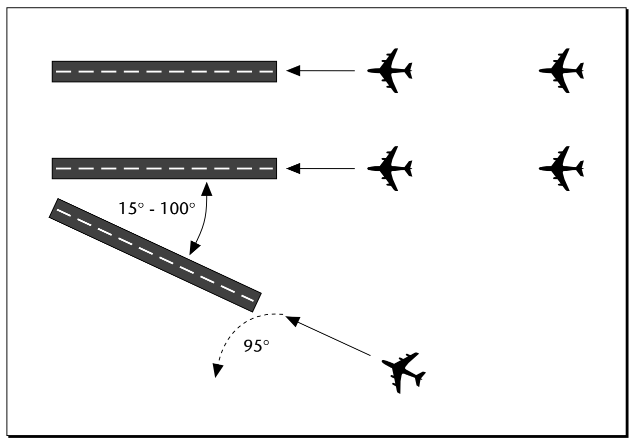
Under VFR conditions, it is common for air traffic control (ATC) to use converging runways for independent streams of arriving aircraft. In 1986, the FAA established a procedure for conducting independent instrument approaches to converging runways under Instrument Meteorological Conditions (IMC). This procedure uses non-overlapping Terminal Instrument Procedures (TERPS) obstacle clearance criteria as a means of providing required separation for aircraft in the event of simultaneous missed approaches to the converging runways. This procedure assumes that each aircraft, in executing a turning missed approach, can keep its course within the limits of its respective "TERPS+3". When the above conditions are satisfied, no dependency between the two aircraft on the converging approaches is required. Hence, the independent nature of the procedure was established.

The requirement to maintain 3 nm distance between MAPS ensuring no TERPS overlap, however, creates restrictions to landing minimums and adds to decision heights. To establish TERPS+3 approach geometry, the MAPS must be moved back away from the runway thresholds. As a result, many runway configurations require decision heights significantly greater than 700 feet in order to satisfy TERPS+3 criteria. This restricts the application of the procedure to operations close to the boundary between visual flight rules (VFR) and instrument flight rules (IFR) and limits the number of airports that

Table 3-6. Candidate Airports for Independent Converging Approaches

Candidates Among Top 100 Airports Average Capacity Gain 30 Arrivals/Hour		
Baltimore	Houston Intercont'l	Oakland
Boston	Indianapolis	Omaha
Charlotte	Jacksonville	Philadlephia
Chicago Midway	Kansas City	Pittsburgh
Chicago O'Hare	Louisville	Portland
Cincinnati	Miami	Providence
Dallas-Ft. Worth	Milwaukee	Rochester
Dayton	Minneapolis	San Antonio
Denver	Nashville	San Francisco
Detroit	New York (JFK)	St. Louis
Ft. Lauderdale	New York (LGA)	Washington Dulles
Honolulu	New Orleans	Windsor Locks
Houston Hobby	Newark	

Figure 3-6. Triple Approaches: Dual Parallels and One Converging



could benefit from the procedure. Finally, the procedure cannot be used if the converging runways intersect unless controllers can establish visual separation, and the ceiling and visibility are at or above 700 feet and 2 statute miles (SM). This requirement increases controller work load.

In an effort to refine the converging approach procedures and obtain greater operational efficiency for the users, the Converging Approach Standards Technical Work Group (CASTWG) was formed. This is a multi-discipline work group chartered to analyze and develop concepts which would result in lower approach minimums and greater capacity for converging operations. A systematic engineering data collection and proof-of-concept testing effort is underway yielding immediate operational benefits. This effort employs testing in state-of-the-art flight simulators using qualified airline crews to validate findings and required TERPS surfaces. The CASTWG work focuses on the use of advanced technology avionics, Flight Management Systems (FMS), and new procedures to achieve optimal operational minimums. Following the data collection phase and real-time simulation, flight testing and demonstrations will validate the new standards. The preliminary analysis of this program's accomplishments to date, indicates significant benefits will be realized at several high density airports in the very near term, with added benefits to many other airports in the immediate future.

Figure 3-6 illustrates the triple approaches, with dual parallels and one converging. Table 3-6 lists airports that are candidates to conduct these independent converging approaches and indicates the average capacity gains expected from these improved approaches.

3.8 Dependent Converging Instrument Approaches

Typically, independent converging IFR approaches using the TERPS+3 criteria are feasible only when ceilings are above 700 feet, depending upon runway geometry. As an alternative precision approach procedure, dependent IFR operations can be conducted to much lower minimums, usually down to Category I, thus expanding the period of time during which the runways can be used. However, to conduct these dependent operations efficiently, controllers need an automated method for ensuring that the aircraft on the different approaches remain safely separated. Without such a method, the separation of aircraft would be so large that little capacity would be gained.

A program was conducted at St. Louis (STL) to evaluate dependent operations using a controller automation aid called the Converging Runway Display Aid (CRDA) (also called ghosting or mirror imaging) to maintain aircraft stagger on approach. The CRDA displays an aircraft at its actual location and simultaneously displays its image at another location on the controllers scope to assist the controller in assessing the relative positions of aircraft that are on different approach paths. Results at St. Louis have shown an increase in arrival rates from 36 arrivals per hour to 48 arrivals per hour. National standards for this procedure were published in November 1992. The CRDA function is implemented in version A3.05 of the ARTS IIIA system.

The CRDA may also have other applications (see Section 5.2.1.1). For example, it could be used at airports with intersecting runways that have insufficient length to allow hold-short operations. Insufficient runway length between the threshold and the intersection with another runway can be ignored if arrivals are staggered such that the first one is clear of the intersection before the second one crosses its respective threshold.

3.9 Traffic Alert and Collision Avoidance System (TCAS)/Cockpit Display of Traffic Information (CDTI) for Separation Assistance

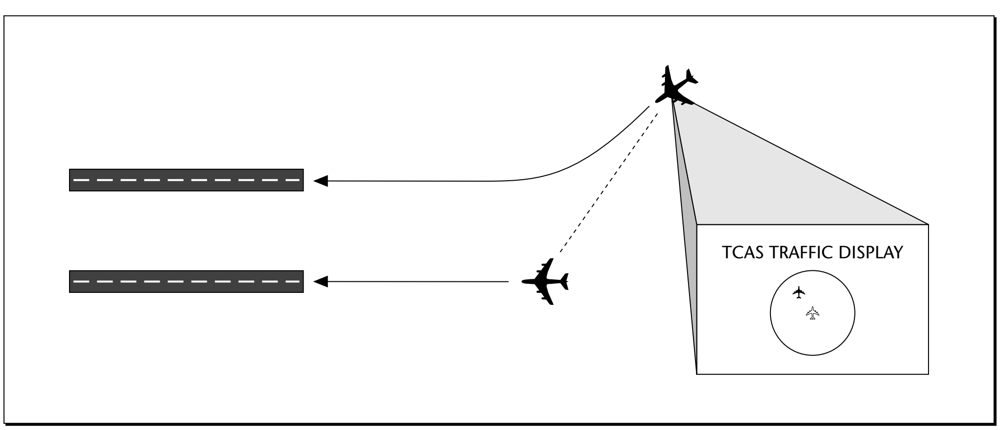
The display of traffic information on the flight deck from sources such as Automatic Dependent Surveillance and tcas offers the potential for flight crews to assist air traffic controllers in monitoring and reducing the spacing requirements during many phases of flight. Figure 3-7 illustrates one example of this use of a tcas/cdti. Use of this information should result in capacity and efficiency improvements beyond those which are available using only radar and voice communications.

A TCAS/CDTI feasibility study that was published in 1991 recommended exploration of this technology to enhance ATC procedures. Under the auspices of the FAA/industry Separation Assistance Working Group (SAWG), concepts for the use of tcas procedural applications were subjected to interactive simulations. Reliability, safety and human factors data was gathered and explored through the use of full motion simulators. Procedures were validated in a simulated environment.

Initial emphasis has been on the use of a TCAS/CDTI to support oceanic in-trail climbs (ITC). In this application, the flight crew of an airplane that is following another along an oceanic route utilized the surveillance and display capabilities of the tcas to determine a minimum safe distance behind the airplane ahead. Once validated, the flight crew provides that information to air traffic control and requests clearance to climb to a higher altitude. This effectively reduces the non-radar in-trail distance necessary to approve the climb from a nominal 100 nm to a minimum of 15 nm. In April 1994, the first two validation flights took place over the Pacific Ocean. By late summer of 1994, two major U.S. airlines began operational trials of the itc procedure in the Anchorage and Oakland Flight Information Regions (FIRs), with more expected to join the trials by early 1996.

Beginning in early 1996, an in-trail descent (ITD), an extension of the ITC, will be introduced into Pacific oceanic operations. The success of the ITC has accelerated software enhancements to TCAS and serves as a cornerstone in the development of the "free flight" concept. Further applications that take advantage of TCAS/CDTI capabilities can be expected to offer additional efficiency and capacity improvements in the foreseeable future.

Figure 3-7. TCAS/CDTI for Separation Assistance



Chapter 4

Airspace Development

Efforts to expand airport capacity or implement improved instrument approach procedures will not be completely effective unless the terminal and en route airspace can handle the increased traffic. Airspace capacity design serves to emphasize the "system" nature of the delay problem and the need for an integrated approach that coordinates the development of capacity-producing alternatives. Airport improvements, enhanced air traffic control procedures, and improvements in terminal and en route airspace are frequently interrelated — changes in one require changes in the others before all of the potential capacity benefits are realized.

Efforts to expand airport capacity or implement improved instrument approach procedures will not be completely effective unless the terminal and en route airspace can handle the increased traffic.

Airspace Capacity Studies are one of several programs underway to improve the efficiency of the airspace system. In a joint effort among the Office of System Capacity, Air Traffic, Office of Environment and Energy, and a contractor that conducts the simulation modeling, 15 Airspace Capacity Studies have been completed, and two are currently in progress. Air Traffic, normally at the Regional level, develops the alternatives that will be tested in the simulation runs, and the proposed alternatives are generally examined in an ARTCC-wide context. Where possible, these studies reflect community involvement and FAA's responsiveness to community-developed alternatives.

A variety of computer models have been used to analyze a broad spectrum of capacity solutions. Since 1986, the Office of System Capacity has been applying SIMMOD, the FAA's Airport and Airspace Simulation Model, to large scale airspace redesign issues. The first such project was an analysis of the Boston ARTCC in support of the expansion of that facility's airspace. Similar studies were initiated at the Los Angeles, Fort Worth, and Chicago ARTCCS, studying issues as diverse as resectorization, special use airspace restrictions, new routings, complete airspace redesign, and new runway construction. Computer modeling has been used to quantify delay, travel time, capacity, sector loading, and aircraft operating cost impacts of the proposed solutions.

Significant solutions to capacity and delay problems have been identified through airspace design. At Dallas-Ft. Worth, for example, effects of the Metroplex plan were studied both with and without new runway construction. Results indicated an immediate savings from airspace changes alone. The airspace design projects completed to date have identified tens of millions of dollars in delay savings, and the vast majority of the airspace improvements identified in these studies either have been or are being implemented.

Table 4-1 summarizes the completed airspace studies by listing the generalized categories of the various alternatives studied. The majority of the studies considered new arrival and departure routes, modifications to ARTCC traffic, and redefinition of TRACON boundaries among their alternatives. Two studies, at Denver and Houston-Austin, analyzed a new airport with its associated airspace, while three studies, at Kansas City, Dallas-Ft. Worth, and Chicago, analyzed new runways at existing airports. Four of the studies, Houston-Austin, Oakland, Dallas-Ft. Worth, and Los Angeles, modeled military traffic, restricted airspace, special use airspace, or the interactions of a military airfield with the civilian airport.

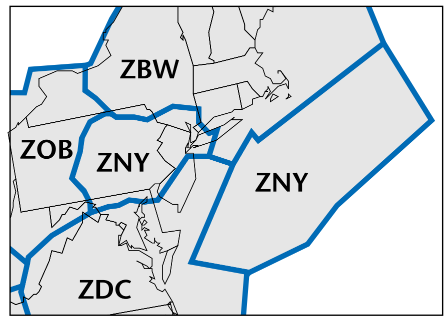
The FAA plans to institutionalize these airspace modeling activities by expanding the capability of its Technical Center in Atlantic City, NJ. Under the direction of the Office of System Capacity (ASC), the Technical Center, and soon the National Simulation Capability (see Section 5.5.1), will provide the FAA with the resources to conduct studies using a variety of models.

Table 4-1. Summary of Airspace Improvement Alternatives Analyzed.

Studied Alternatives / Airspace Regions	Chicago	Dallas-Ft. Worth	Denver	Expanded East Coast Plan	Houston-Austin	Kansas City	Los Angeles	Oakland	New York	Jacksonville	Atlanta	Miami
Relocating arrival fixes	√	√				√					√	
New arrival routes		√	√	√	√	√		√	√	√	√	√
New departure routes	√		√	√	√	√	√	√	√	√	√	√
Modifications to ARTCC traffic		√		√	√	√	√	√	√	√	√	
New airport			√		√							
Hub/non-hub alternatives					√							
Change in metering restrictions	√			√				√				√
Redifining TRACON boundaries		√		√	√		√	√			√	
Redifining sector ceilngs									√	√	√	
Resectorization									√	√	√	√
Military traffic considered		√			√		√	√				
New runways at existing airports	√	√				√						
Specific modeling of 2 or more airports for interactions analysis	√	√				√			√	√	√	√

What follows are excerpts from the last four airspace studies that were completed. The New York and Jacksonville Air Route Traffic Control Centers (ARTCCs) include a description of the alternatives analyzed and the results of the analysis. For the other two studies, Atlanta and Miami ARTCCs, a brief description of the alternatives is included. It should be noted that these studies only considered the technical and operational feasibility of the proposed alternatives. Environmental, socioeconomic, and political issues were outside the scope of the studies and need to be addressed in future planning activities.

4.1 New York Airspace Capacity Project



The objective of the New York Airspace Capacity Project was to evaluate the delay and capacity impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations. The operational area of concern included operations within the New York Center and portions of Boston, Cleveland, and Washington Centers; and at Newark International, White Plains/Westchester County, Islip/Long Island MacArthur, John F. Kennedy International, LaGuardia, Philadelphia International, Newburgh/Stewart International, and Teterboro Airports.

To meet the objective of the New York Airspace Capacity Project, four major simulation analysis tasks were completed. The first task involved analyzing the impact of splitting Liberty Area's East Departure position into a high-low operation and rerouting certain traffic through the new low sector based on aircraft type and/or destination. The second task entailed evaluating air traffic operations under the proposed resectorization of New York Center Area D. The resectorization plan is aimed at relieving complexity and saturation problems associated with operations in New York Center's Sector 75 and involved the realignment of five en route sectors. The third task was an analysis to evaluate traffic loading impacts on the Stewart Area sector for three proposed ceiling realignment options. The fourth task involved an analysis of proposed new south arrival and south departure routings for Newburgh/Stewart International Airport to determine sector traffic loading impacts for potential future traffic growth.

4.1.1 Liberty East Reconfiguration and Rerouting

The first simulation analysis task involved evaluating the impacts of splitting New York TRACON Liberty Area's East Departure position into a high-low operation. The proposed operational alternative entails creating a new controller position and assigning all Liberty East airspace at or below 9,000 feet to the low operation. In addition to the traffic currently operating at 9,000 feet and below, additional flights departing to the northeast would also be rerouted to the new low sector based on destination and/or aircraft type.

Liberty East sector is situated just northeast of Newark International, JFK International, LaGuardia, and Teterboro Airports, northwest of Islip/Long Island MacArthur Airport and directly above White Plains/Westchester County Airport. The current Liberty East sector encompasses, at its maximum, a distance of 35 miles north to south and 45 miles east to west and abuts portions of New York and Boston Center en route airspace. The base of Liberty East airspace commences at 7,000 feet and attains its highest altitude at 17,000 feet. Considerable shelving exists at the lower altitudes where Liberty East interfaces with other New York TRACON sectors.

Proposed airspace changes to Liberty Area's East Departure sector entailed the splitting off of all existing Liberty East airspace at or below 9,000 feet. A new Liberty East low sector is created from the lower portions of the eastern half of the existing Liberty East sector. The remaining Liberty East airspace (referred to as the new Liberty East high sector) is comprised of the Liberty East airspace at and above 10,000 feet. It was assumed that departures which currently transit Liberty East airspace at or below 9,000 feet would, under the reconfigured airspace, be routed at the same existing altitudes, and therefore, be worked by the new Liberty East low sector controller.

Ten operational scenarios were simulated for the Liberty East reconfiguration and rerouting analysis. Nine potential alternatives were simulated for comparison to the baseline "do nothing" case (Alternative 0). Alternative 1 entailed reconfiguration of Liberty East only, without rerouting of any traffic. For Liberty East Alternatives 2 through 9, various combinations of flights currently using altitudes at or above 10,000 feet (i.e., in the new Liberty East high sector) were rerouted to the new Liberty East low sector. Three distance ranges were used in each scenario as criteria for rerouting traffic from new Liberty East high sector to new Liberty East low sector.

Results of the analysis for Alternative 0, or the “do nothing” case, show that traffic is projected to increase 19 percent (98 aircraft) by the year 1997 and 34 percent (173 aircraft) for the year 2003. With current operational conditions requiring potential airspace realignment and rerouting of traffic for Liberty East sector, it is most likely that these future traffic increases projected for Liberty East will result in even greater workload problems and issues.

Alternative 1 considered reconfiguring Liberty East Departure sector into a high-low operation without rerouting any traffic. This alternative provided some degree of relief, but a further redistribution of traffic between new Liberty East high and new Liberty East low sectors is recommended if a more equitable balance between the sectors is to be achieved in both the near and future years. The shift in traffic flows between the new sectors under Alternatives 2 and 4, when compared to Alternative 1 results, tends towards a more balanced distribution of traffic between the two new Liberty East sectors throughout the day. Liberty East departure flights destined for airports within the 126-175 nautical mile range of the New York area are pivotal in redistributing traffic from the new Liberty East high sector into the new Liberty low sector for purposes of balancing traffic loading. The remaining alternatives show even more improvement in reducing the percentage of time that the sectors are saturated during the day (the sector is considered saturated during a 15-minute period if the controller is continuously working the maximum number of aircraft).

4.1.2 Resectorization of New York ARTCC (ZNY) Area D

The second task evaluated air traffic operations under the proposed resectorization of New York Center Area D. The resectorization plan is aimed at relieving complexity and saturation problems associated with operations in ZNY Area D Sector 75. To accomplish the proposed operational changes, significant resectorization of Sector 75 and four other ZNY Area D sectors was necessary (Sectors 74, 91, 92, and 93). ZNY Sector 75 is the focal point of the New York Center Area D resectorization plan. ZNY Area D Sector 75 is located to the north of Sector 73 and directly abuts Cleveland Center airspace. Except for a small portion located in the northeast corner, Sector 75 commences at FL180 and extends up to

FL600. The northeast portion of Sector 75 encompasses airspace from FL180 up to FL230. Sector 75 lateral airspace varies in distance from 40 miles north to south to over 100 miles east to west.

Resectorization of Sector 75 will require a slight extension of the farthest northwest corner of Sector 75 airspace. The only other airspace modification to Sector 75 requires raising the floor from FL180 to FL220. Adjacent Sectors 74 and 93 will acquire the airspace between FL180 and FL220. With the realignment of Sector 75, Newark International and LaGuardia arrivals will be descended to FL220 earlier for hand off to Sector 74. In addition, all Baltimore traffic will be removed from Sector 75 to be worked by Sector 93. Elmira, Binghamton, and Utica arrivals will also be removed from Sector 75 along with any overflight traffic below FL220. Philadelphia International, Allentown, Lancaster, and Harrisburg northbound departures will be assigned to Sector 74, thus bypassing Sector 75.

Results of the analysis show that on the average day, the resectorization of ZNY Area D would result in daily delay savings amounting to 13, 35, and 122 hours per day for the 1991, 1997, and 2003 demand levels, respectively. These delay savings equate to an annual aircraft operating cost savings of $7.6 million, $20.4 million, and $71.2 million, per respective year.

The primary goal of the resectorization of ZNY Area D is to reduce complexity and saturation within Sector 75 by reducing the level of traffic worked by the ZNY Sector 75 controllers during busy periods. For the baseline (1991) year, there was a 17 percent decline in Sector 75 daily operations. The reduction would be 18 percent in 1997 and 18 percent in 2003. By resectorizing ZNY Area D, Sector 75 would realize substantial reduction in 15-minute sector occupancy averages throughout the majority of the day. These declines in sector occupancy averages result from the traffic rerouted from Sector 75 into Sectors 74 and 93, plus the reduction in the time aircraft are worked by Sector 75 due to Sectors 74 and 93 assuming portions of Sector 75 airspace.

4.1.3 Stewart Area Airspace Redesign

The third simulation analysis evaluated air traffic operations under the proposed raising of the ceiling of the southern portion of the New York TRACON Stewart Area. The proposed alternatives consist of Stewart Area ceiling altitude changes of 10,000, 14,000, and 17,000 feet. Under these three ceiling options, traffic loading is evaluated to determine the additional traffic which Stewart Area would acquire if the new ceiling altitudes were implemented.

There are eleven airports located in the Stewart Area with Newburgh/Stewart International (SWF) and Dutchess County (POU) accounting for the majority of traffic. Newburgh/Stewart International Airport is situated 40-50 miles to the north of Newark International, John F. Kennedy International, and LaGuardia Airports. Stewart Area encompasses, at its maximum, a distance of 50 miles north to south and 85 miles east to west. Current Stewart Area ceilings range between 4,000 to 6,000 feet with the northwestern portions of Stewart Area overlying areas of high terrain. Stewart Area airspace underlies portions of both New York and Boston Center en route airspace.

By raising the southern portion of the Stewart Area to 10,000 feet, Stewart Area would acquire 329 additional flights over the busiest periods of the day. This increase in traffic is over a 200 percent increase above current traffic loading in the Stewart Area. A ceiling realignment to 14,000 feet for Stewart Area's southern portion would result in Stewart Area acquiring an additional 113 flights above the number attained with the ceiling realignment at 10,000 feet. Total traffic for Stewart Area with the 14,000 foot ceiling realignment would increase to 593 flights during the busiest periods, an increase over the current traffic level of nearly 400 percent. A 17,000 foot ceiling in the Stewart Area's southern portion would further increase traffic counts for Stewart Area during the busiest periods to a total of 630 flights.

4.1.4 Potential Traffic Growth at Newburgh/Stewart International Airport (SWF)

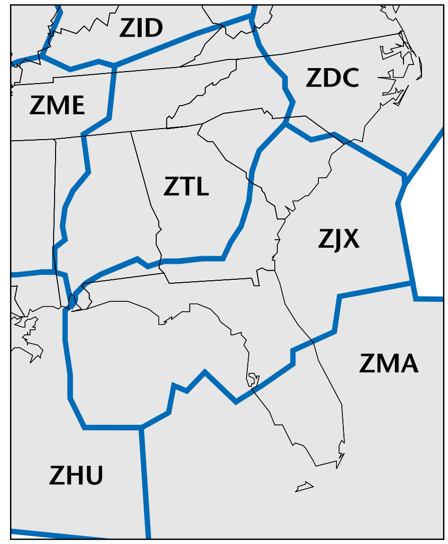
The fourth task analyzed proposed new arrival and departure routings to the south of Newburgh/Stewart International Airport to determine traffic loading implications for potential future traffic growth at SWF. Simulation results were analyzed to evaluate the impact that additional Newburgh/Stewart International departure flights would have on ZNY Sectors 39 and 10, and the impact that additional arrival flights to Newburgh/Stewart International Airport would have on the new proposed Liberty East high sector.

For the Liberty East high sector scenario, it was assumed that the Liberty East Departure sector is split into a new high-low operation and that the Stewart Area southeast ceiling is raised to an altitude allowing new Liberty East high sector to hand off directly to Stewart Area. For the potential Stewart Area Airport growth scenarios, two traffic level increases were simulated for Newburgh/Stewart International Airport south departures and arrivals. The first traffic level increase (medium growth) consisted of 30 additional south arrivals and south departures at Newburgh/Stewart International Airport per day. The second traffic level increase (high growth) consisted of 60 additional south arrivals and departures per day.

ZNY Sectors 39 and 10 would be impacted by potential traffic growth at Newburgh/Stewart International Airport due to traffic utilizing a proposed new south departure route from SWF. Medium traffic growth could potentially impact early morning operations for both Sectors 39 and 10. Under high traffic growth levels at SWF, the early morning traffic flow increases become quite substantial and sustained in duration and would most likely result in workload issues for both Sectors 39 and 10.

The proposed new Liberty East high sector would also be impacted by potential traffic growth at Newburgh/Stewart International Airport due to traffic utilizing a proposed new south arrival route to SWF. The new Liberty East high sector would be slightly impacted during the morning period under medium traffic growth at SWF. Under the high traffic growth scenario, new Liberty East high sector would experience substantial and sustained increases in early morning as well as afternoon traffic flows, potentially resulting in workload considerations for new Liberty East high sector.

4.2 Jacksonville Airspace Capacity Project



The objective of the Jacksonville Airspace Capacity Project was to evaluate the capacity and delay impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations at Jacksonville Center (ZJX), Orlando Approach Control, Tampa Approach Control, and Orlando International (MCO) and Tampa International (TPA) Airports. Measures that could increase capacity and reduce delays were considered solely on a technical basis. Environmental, economic, social, or political issues were beyond the scope of the study.

Five major simulation analysis tasks were completed. The first task involved analyzing the impact on Jacksonville Center traffic resulting from a proposed reconfiguration of the Palatka MOA Complex. The second task entailed an evaluation of the proposed implementation of a jet airway between Charleston VORTAC (CHS) and Ormond Beach VORTAC (OMN). The third task was an evaluation of the impact of a similar proposed jet airway between St. Petersburg VORTAC (PIE) and a point 42 nautical miles (nm) west of Tallahassee VORTAC (TLH). The fourth task involved an analysis of the impact of raising the ceiling of Orlando Approach Control in conjunction with modifying arrival and departure routings. The fifth task entailed an evaluation of an alternative en route airspace design within Jacksonville Center.

4.2.1 The Proposed Palatka MOA/ATCAA Realignment

This first task analyzed a proposal to modify the lateral and vertical limits of the existing Palatka MOAs and redesignating the airspace above the proposed MOA expansion as ATC Assigned Airspace (ATCAA). In scenarios simulating the proposed Palatka MOA/ATCAA Complex, the existing Polatka MOAs were reconfigured to reflect airspace structures extending from 1200 feet AGL (above ground level) up to and including FL430. A substantial expansion of the lateral boundaries of the existing airspace was also required.

The proposed Palatka MOA/ATCAA Complex would require Jacksonville Center to release large portions of several low, high, and ultra-high sectors for special use operations during the hours of activation.

The impact of rerouting Jacksonville Center traffic currently overflying the proposed Palatka MOA/ATCAA results in delay and travel time penalties. Delay time increases account for the majority of the total time penalty realized for the traffic demand schedules evaluated. In the baseline (1991) case, a total daily flight time penalty of 4.1 hours per day is realized with the annual cost penalty equating to $2.4 million. Annual cost penalties increase to $11.0 million and $120.6 million for the 1997 and 2003 traffic demand levels. This proposed alternative would substantially reduce airspace previously available for the vectoring of traffic to relieve congestion. Requiring traffic to be rerouted around the expanded Palatka MOA Complex, significantly reduces the flexibility of controllers to utilize vectors and/or direct routes to expedite traffic movement. Controllers currently use portions of the airspace to be included in the proposed Palatka MOA expansion for sequencing of Orlando Approach Control arrival and departure traffic and vectoring/direct routing of Jacksonville Center overflight traffic.

4.2.2 Rainbow Area Airway

The objective of the Rainbow Area Airway analysis was to evaluate the potential benefits that may be realized by establishing a jet airway between Charleston VORTAC (CHS) and Ormond Beach VORTAC (OMN). The proposed airway would traverse airspace currently designated as special use airspace (SUA), impacting the area commonly known as the "Rainbow Area." In addition to acquiring portions of the Rainbow Area, other requirements necessary to establish the proposed airway would include: releasing all altitudes for the jet airway from special use; incorporating any remaining special use airspace FL180 and above west of the proposed airway boundary and J79; and releasing special use airspace below FL180 located just north of OMN to accommodate the descent and vectoring of arrival traffic into the Orlando terminal area. The proposed airway would require no change to the physical boundaries of any existing Jacksonville Center sector structures, but the usable airspace available for traffic movement within the impacted sectors would be increased. Rerouting of traffic through any new or additional sectors would not be required.

The implementation of a proposed jet airway between Charleston VORTAC (CHS) and Ormond Beach VORTAC (OMN) would reduce flight time and increase available airspace for improved flexibility and efficiency in the movement of air traffic. During Visual Meteorological Conditions (VMC), the proposed jet airway would result in daily travel time and delay savings totaling 1.7, 2.4, and 4.4 hours for the years 1991, 1997, and 2003, respectively. This delay savings would provide $1.0 million, $1.4 million, and $2.6 million in cost savings per traffic demand year. Additional operating cost savings can be realized with the proposed airway during periods when thunderstorms preclude or reduce the availability of current routes. In a year where thunderstorm activity was to occur a total of 60 times, lasting an average duration of two hours, the aircraft operating cost savings realized by having the proposed airway available would total $13.8 million, $23.8 million, and $56.7 million in years 1991, 1997, and 2003, respectively.

4.2.3 Proposed ACMI Thunder Area Airway

The objective of the ACMI/Thunder Area Airway impact analysis was to evaluate the potential benefits that may be realized by establishing an airway between St. Petersburg VORTAC (PIE) and a point 42 NM west of Tallahassee VORTAC (TLH). The proposed airway would traverse portions of the special use airspace designated as the ACMI/Thunder Area. The analysis involves an evaluation of the potential benefits derived by overflight traffic from the implementation of the proposed airway.

The proposed airway would require no change to the physical boundaries of any existing Jacksonville Center sector structures, but the usable airspace available for traffic movement within the sectors with the proposed airway would be increased. Rerouting of traffic through any new or additional sectors would not be required.

The implementation of a jet airway between St. Petersburg VORTAC (PIE) and a point 42 nm west of Tallahassee VORTAC (TLH) would also increase the available airspace for improved movement of traffic within Jacksonville Center. During VMC, the proposed jet airway would result in daily travel time and delay savings totaling 1.6, 2.0, and 6.4 hours for the years 1991, 1997, and 2003, respectively. The delay savings would provide $1.0 million, $1.2 million, and $3.7 million in cost savings per traffic demand year.

The availability of the proposed jet airway (between PIE and a point 42 nm west of TLH) to traffic during periods of thunderstorm activity would also result in significant operating cost savings. For example, if yearly thunderstorm activity were to occur a total of 60 times, lasting an average duration of two hours, the aircraft operating cost savings realized by having the proposed airway available would total $2.1 million, $7.9 million, and $25.1 million in years 1991, 1997, and 2003, respectively.

4.2.4 Orlando Approach Control Airspace Modification

The fourth task was to analyze the impact of raising the ceiling of the current Orlando Approach Control airspace, in conjunction with modifying arrival and departure routings. This scenario was conducted to evaluate possible improvement of the traffic flow within Jacksonville Center. The proposed Orlando Approach Control reconfiguration raises the existing ceiling of the approach control from 12,000 to 14,000 feet, expanding terminal airspace in order to provide Jacksonville Center the capability to establish dual jet arrival routes and segregated jet and turboprop departure routes.

Orlando Approach Control currently provides air traffic services in the airspace up to 12,000 feet and out to distances of 50 NM from Orlando International Airport. Orlando Approach Control airspace is located in central Florida and is situated beneath the common boundary between Jacksonville and Miami Centers. The primary airports serviced by Orlando Approach Control include Orlando International (MCO), Orlando Executive (ORL), and Sanford/Central Florida Regional (SFB) Airports.

To raise the ceiling of Orlando Approach Control from 12,000 to 14,000 feet, airspace would have to be acquired from the Jacksonville Center low altitude sectors directly above the current approach control airspace. In conjunction with raising the ceiling, arrival and departure routes within Orlando Approach Control would also have to be modified.

The Orlando Approach Control Airspace modification option realized savings in daily delay and flight time during all three traffic demand levels. The improved efficiency of the en route system results from traffic entering and departing Orlando Approach Control airspace in a less restricted manner, and the utilization of the reduced separation standards available in the expanded terminal environment. Raising the Orlando Approach Control ceiling from 12,000 to 14,000 feet expands terminal airspace, providing the capability for Jacksonville Center to establish both, dual jet arrival routes and segregated jet and turboprop departure routes. The capability to use dual arrival and segregated departure routes under the proposed Orlando Approach Control airspace realignment would result in daily en route delay and travel time savings amounting to

3.5, 4.7, and 22.2 hours per day for the 1991, 1997, and 2003 traffic demand levels, respectively. The combined savings equate to an annual aircraft operating cost savings of $2.0 million, $2.7 million, and $13.0 million, per respective traffic demand year.

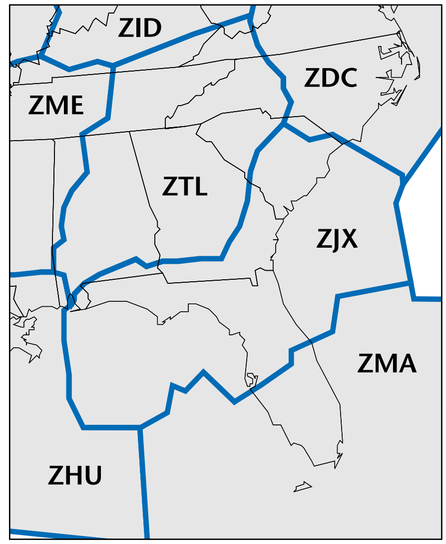
4.2.5 Jacksonville Center Proposed Airspace Redesign Alternative

The final analysis objective of the Jacksonville Airspace Capacity project was to assess the impact and potential benefits of a proposal to modify the floors and ceilings of special sectors within Jacksonville Center. The analysis of the Jacksonville Center Airspace Redesign alternative involved simulating en route airspace operations for existing and proposed sector configurations. Traffic demand levels for the baseline year (1991) and future projected traffic levels for years 1997 and 2003 were simulated.

The Jacksonville Center Airspace Redesign alternative would require airspace realignment for 27 of the 38 en route sectors. The majority of these airspace changes would involve floor and/or ceiling realignments. Four Jacksonville Center low altitude sectors would also require lateral boundary expansions in order to acquire airspace above adjacent approach controls. The proposed realignment of the designated Jacksonville Center sectors would have the effect of redistributing some existing traffic flows from one airspace structure to another. No rerouting of existing traffic flows was proposed.

Results from the simulation indicate that the benefits that may be gained by the realignment of the floors and/or ceilings of sectors within Jacksonville Center include a more balanced traffic distribution, improved intra-facility coordination, added flexibility for the handling of traffic during demand peaks, and improved efficiency in merging traffic.

4.3 Atlanta Center Airspace Capacity Project



The objective of the Atlanta Center Airspace Capacity Project was to evaluate the capacity and delay impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations within Atlanta Center and at Charlotte (CLT), Raleigh-Durham (RDU), and Birmingham (BHM) Approach Controls, and Atlanta, Charlotte/Douglas, and Raleigh-Durham International Airports and Birmingham Airport.

Seven analysis tasks were studied to meet the objectives of the Atlanta Center Airspace Capacity Project. Those analysis tasks are briefly described below.

The first task involved raising the ceiling at Raleigh Approach Control airspace from 10,000 to 12,000 feet. Potential benefits associated with realigning Raleigh Approach Control would be a more efficient traffic merging with Washington Center, a reduction in intra- and inter-facility coordination, an expansion of approach control airspace for more flexible handling of arrival and departure traffic, and relaxation of departure restrictions. Rerouting of existing traffic flows was not required under the Raleigh Approach Control ceiling realignment option. However, certain miles-in-trail and speed restrictions currently in effect were relaxed.

The second task involved raising the ceiling at Charlotte Approach Control from 12,000 to 14,000 feet, at Raleigh Approach Control from 10,000 to 14,000 feet, and those at Greensboro and Fayetteville Approach Controls from 10,000 to 12,000 feet. En route corridors were maintained from 11,000 feet and above across Fayetteville and Greensboro Approach Controls for buzzy and majic arrivals respectively. Rerouting of existing traffic flows was not required under the four ceilings realignment option. However, certain miles-in-trail and speed restrictions currently in effect were relaxed.

The third task analyzed the impact of moving the boundary of Washington Center to the west to assume full control of Raleigh Approach Control and portions of low, high, and ultra-high altitude sectors in Atlanta Center. Extensive routing and terminal airspace changes were also proposed to accommodate rotation of the Bedposts/Cornerposts within Raleigh Approach Control airspace. A second departure gate for Charlotte International Airport southbound jet traffic was also developed. Other related scenarios within the alternative evaluated several approach control ceiling realignments.

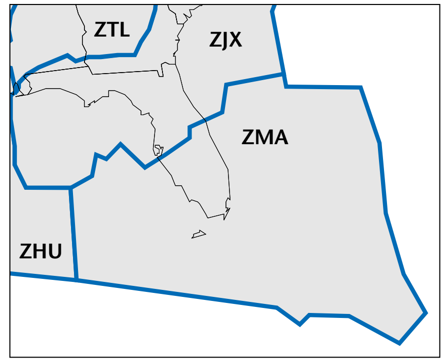
The fourth task involved analyzing the impact of moving the boundary of Atlanta Center to the east along a line crossing approximately over SBV, RDU, and FAY, with Atlanta Center possibly acquiring the equivalent of three low altitude sectors from Washington Center. In this analysis, there was a redefinition of several en route sectors, establishment of new en route sectors, and extensive routing and terminal airspace changes to accommodate rotation of the Bedposts/Cornerposts within Raleigh Approach Control airspace. A second departure gate for Charlotte International Airport southbound jet traffic was also developed. Other related scenarios within this alternative evaluated several approach control ceiling realignments.

The fifth task analyzed the impact of extending the existing Jet Airway 209 and rerouting certain flights currently entering Atlanta Center Airspace between the Meridian (MAW) and Crestview (CEW) VORTACs. The proposed lengthening of J209 required adding a segment to the current airway beginning at Greenwood VORTAC (GRD) and extending southwest to the Columbus VORTAC (CSG). Traffic with specific destinations would be rerouted onto the proposed segment, at a point south of where current J209 traffic flow is merged. To facilitate the airway extension, a proposed modification to the current sectorization within the Atlanta Center high altitude structure, south of Atlanta VORTAC (ATL), was required.

The sixth task analyzed the impact of eliminating Atlanta Center's Birmingham Sector (12) by expanding Rome (01), West Departure (04), and Maxwell (14) sectors' boundaries to encompass airspace and associated traffic within the existing Birmingham Sector (12). The objective of this task was to determine the additional traffic which Rome (01), West Departure (04), and Maxwell (14) sectors would acquire under current and future traffic demand levels if Birmingham Sector (12) was eliminated.

The seventh task evaluated the impact of raising the ceiling of Birmingham Approach Control from 10,000 to 12,000 feet and modifying arrival and departure routings in order to establish Arrival and Departure Transition Areas (ATAS/DTAS).

4.4 Miami Center Airspace Capacity Project



The objective of the Miami Airspace Capacity Project was to evaluate the capacity and delay impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations within Miami Center, at Miami, Orlando, and Tampa Approach Controls, and Miami, Orlando, and Tampa International Airports.

Four analysis tasks were studied to meet the objectives of the Miami Center Airspace Capacity Project. The analysis tasks for this project are briefly described below.

The first analysis task evaluated the impact of a proposed realignment of Miami Center Vero Beach (R3) and Melbourne (R4) Sectors to accommodate projected near term traffic growth at Fort Pierce/St. Lucie County International Airport (FPR). Currently, Vero Beach and Melbourne Sectors are split horizontally. The proposed realignment laterally realigns the existing airspace comprising r3/r4, thus establishing new Vero Beach (R3) and Melbourne (R4) Sectors and segregates vrb/fpr arrivals from VRB/FPR departures.

The second analysis task analyzed the impact of parallel airways through the Orlando corridor. The proposed westside airway would accommodate traffic flying over and west of irq (Colliers), whereas the eastside airway would accommodate the remaining J53 air traffic operating at or above FL330. The establishment of parallel airways would allow relaxation of current in-trail restrictions currently placed on Miami Center departures northbound to Jacksonville Center over orl VORTAC.

The third analysis task evaluated a proposal to establish a new Miami Center Sector R59 by realigning current Miami Center Bimini High (R40) and Georgetown (R60) sectors. No rerouting of air traffic was required. The proposed Sector R59 would primarily accommodate overflight traffic at altitude operating between the mainland U.S. north of Miami Center, and the Caribbean or South America. The new realigned Bimini (R40) sector would still accommodate some north/south overflights as well as the majority of flights that comprise the traffic to and from the Bahamas and south Florida. The new realigned Georgetown (R60) would continue to handle north/south overflights with traffic between south Florida and the Caribbean or South America comprising the majority of the traffic.

The fourth analysis task analyzed the effect of establishing a new airway west of A509/A301 for southbound Miami Center traffic bound for Cuban airspace. Currently, northbound and southbound traffic are required to share A509/A301. The proposed new airway would provide separate routes for Miami area arrivals and departures to and from Cuban airspace.

4.5 Studies in Progress

Currently, the FAA Office of System Capacity has the following airspace projects underway:

- The West Coast Airspace Modernization Analysis. This study is intended to optimize the structure of the airspace encompassed by Los Angeles and Oakland ARTCCs and their internal Approach Controls. The objective is to ensure that the aviation industry receives maximum service as a result of the Agency's investment in the large TRACON technology being fielded in California. Particular emphasis will be placed on the analysis of coastwise traffic between the areas served by SCT and NCT.
- The Chicago MetroPlex Airspace Analysis. This study will compare up to three potential airspace structures to be operated by the new expanded Chicago TRACON. Specifically, the projected study addresses critical capacity and delay problems involving Chicago Center and portions of Minneapolis, Cleveland, Indianapolis, and Kansas City Centers; Chicago and Milwaukee TRACONs, and O'Hare International, Midway, and Milwaukee/General Mitchell International Airports.

Chapter 5

Technology for Capacity Improvement

There are many technological initiatives underway which promise to improve the capacity of an airport, its surrounding terminal airspace, and the en route airspace. When considered individually, the primary focus of a large number of technologies and projects might be other than capacity enhancement, however, these technologies are significant steps in the right direction. The impact of each initiative will be enhanced by an integrated approach to capacity improvement that results in effective coordination of the various programs. At a national level, this integration will be accomplished through the activities of the National Simulation Capability described in Section 5.5.1.

There are many technological initiatives underway which promise to improve the capacity of an airport, its surrounding terminal airspace, and the en route airspace.

Section 5.1 covers technologies applicable to airport surface operations. Section 5.2 discusses programs that apply to the adjacent terminal airspace and directly support the approach procedure improvements discussed in Chapter 3. Section 5.3 discusses technologies applicable to the en route airspace, including oceanic airspace. Section 5.4 addresses capabilities that will support traffic flow managers, both national and local, in maintaining a planned, systematic flow of air traffic. Section 5.5 covers technologies and programs that support planning and integration of the above programs, as well as technologies that will make changes and improvements to the National Airspace System (NAS) easier and more efficient to implement.

The impact of each initiative will be enhanced by an integrated approach to capacity improvement that results in effective coordination of the various programs.

The summaries included in this chapter are meant to be general descriptions of technologies and projects, currently underway or under development, which promise to increase system capacity. Many of these projects are also listed in the FAA's RE&D Plan.

5.1 Airport Surface Capacity Technology

Taxiway interference, separation at intersections, departure sequencing, and the like, all contribute to surface-related flight delays. The Airport Surface Traffic Automation System (ASTA) will provide automation designed to make ground operations safer and more efficient.

Low-visibility procedures and equipment requirements have now been defined in Advisory Circular 120-57A, Surface Movement Guidance and Control Systems. In collaboration with the All Weather Operations Panel of ICAO, operational requirements are being developed for advanced concepts and automation supporting airport surface movement. The ICAO effort is expected to lead to system performance requirements for automation, communications, navigation, and surveillance. The airport surface traffic automation (ASTA) research program is providing the technical research necessary to define performance. The international coordination will provide the operational requirements for improved surface movement by 1997.

5.1.1 Airport Surface Traffic Automation Program (ASTA)

The purpose of the ASTA program is to increase aviation safety by reducing runway incursions and surface collisions in the airport movement area and to provide controllers with automated aids to reduce delays and improve the efficiency of surface movement.

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The ASTA program comprises five elements: a runway status light system, a surveillance data link, aural and visual warnings, data tags, and a traffic planner. The program will develop an enhanced surface safety system using the Airport Surface Detection Equipment (ASDE-3) primary ground sensor radar, Automated Radar Terminal System (ARTS), Global Positioning System (GPS), Airport Movement Area Safety System (AMASS), and other technologies. ASTA will provide controllers with automatically generated alerts and cautions as well as data tags to identify all aircraft and special vehicles on the airport movement area in all-weather conditions. ASTA will also include a traffic planner that will improve the routing of aircraft on the taxiways and reduce taxi delay times. Future enhancements will include the Cockpit Display of Traffic Information (CDTI) for traffic on the surface. This is expected to be integrated with a CDTI capability for airborne traffic. The ASTA program examines the roles and responsibilities of controllers, pilots, and ground vehicle operators when operating on the airport.

The AMASS is an automation enhancement to the ASDE-3 primary ground sensor radar that provides an initial safety capability on runways and connecting taxiways. After determining that a group of ASDE-3 radar returns make up a target, the AMASS then analyzes that target's position and motions with respect to other targets and the defined airport operational configuration to determine if there are any conflicts among targets or with defined operations. If there are conflicts, a verbal and graphic alert is given to the controllers in the tower cab. The AMASS also has an interface with the Automated Radar Terminal System (ARTS) in order to include airborne aircraft on final approach in the check for conflicting target operations on the airport surface. All airports slated to receive ASDE-3/AMASS equipment will also receive ASTA.

The ASTA program will share information with the Terminal Air Traffic Control Automation (TATCA) program to create an interrelated runway incursion prevention and surface traffic management system. When completed, the ASTA program will provide an all-weather, automated capability that allows for safer, higher capacity airport operations.

5.2 Terminal Airspace Capacity Technology

There are a number of programs that will improve the capacity of an airport's surrounding terminal airspace. The Precision Runway Monitor was discussed in Chapter 3 in connection with procedures for improved landing capabilities at airports with multiple runways. The Global Positioning System (GPS) will make precision approach procedures available at more runways at more airports by significantly reducing the siting and frequency congestion problems associated with ILS.

The Center-TRACON Automation System will complement the above systems by aiding the controller in merging traffic as it flows into the terminal area. It will also support enhanced air traffic throughput and avoid undesirable bunching and gaps in the traffic flow on the final approach path. This system and the Converging Runway Display Aid have been combined into the Terminal ATC Automation Program. Finally, the Traffic Alert and Collision Avoidance System has the potential to expand beyond its current role of providing airborne collision avoidance as an independent system. It has the potential to reduce aircraft spacing in a variety of situations, leading to increased capacity.

The purpose of the Terminal ATC Automation Program (TACTA) is to develop automation aids to assist air traffic controllers and Traffic Management Unit (TMU) coordinators in enhancing the terminal area air traffic management process and to facilitate the early implementation of these aids at busy airports.

5.2.1 Terminal ATC Automation (TACTA)

The purpose of the Terminal ATC Automation Program (TACTA) is to develop automation aids to assist air traffic controllers and Traffic Management Unit (TMU) coordinators in enhancing the terminal area air traffic management process and to facilitate the early implementation of these aids at busy airports. The TACTA program consists of two projects: the Converging Runway Display Aid (CRDA)/ Controller Automated Spacing Aid (CASA) and the Center-TRACON Automation System (CTAS). Longer-term TACTA activities include the integration of traffic flow management tools with other air traffic control systems and cockpit automation capabilities.

5.2.1.1 Converging Runway Display Aid/ Controller Automated Spacing Aid

The CRDA displays an aircraft at its actual location and simultaneously displays its image at another location on the controller's scope to assist the controller in assessing the relative positions of aircraft that are on different approach paths.

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Actual operations have shown that CRDA is effective in increasing capacity by allowing multiple runways to be used simultaneously under IFR. At St. Louis, the FAA has conducted a demonstration of this tool to measure its effect on dependent precision converging approaches in near Category I minimums. Results from field testing at St. Louis have shown an increase in arrival rates from 36 arrivals per hour to 48 arrivals per hour, an increase of 33 percent. National standards for CRDA were published in November 1992. Other airports such as Philadelphia International, Boston Logan International, Washington Dulles International, and Greater Cincinnati International are using or developing a use for CRDA.

While the original purpose of CRDA was to support specific procedures for converging approaches, other procedures can be supported by CRDA automation or a variant of that technology. The Controller Automated Spacing Aid (CASA) project is developing these other applications. In general, these new applications support the synchronizing of aircraft in separate streams of traffic. The applications range from support for more effective merging of aircraft in the terminal area prior to the approach phase, to support for taking full advantage of available runway geometry with asymmetrical staggered approaches.

5.2.1.2 Center-TRACON Automation System

Approaches to major terminal areas represent one of the most complex and high-density environments for air traffic control. Arrivals approach from as many as eight directions, with jet arrivals descending from high altitudes while other traffic enters from low altitudes. It is difficult for controllers to foresee how traffic from one approach path will ultimately interact with traffic from other approach paths. This results in traffic arriving either in bunches, which leads to higher controller workload and increased fuel burn to maintain separation, or with significant gaps, which in turn reduces airport capacity. Speed and space restrictions in the terminal area add to the difficulty of maintaining an orderly flow to the runway. Visibility and wind shifts, variations in aircraft mix, wake vortex considerations, missed approaches, runway changes or closings, all add to the difficulty of controlling traffic efficiently and safely in the terminal airspace.

CTAS is designed to improve system performance (e.g., efficiency, capacity, reduce controller workload), while maintaining at least the same level of safety present in today's system, by helping the controller smooth out and coordinate traffic flow efficiently. The earliest CTAS product is the Traffic Management Advisor (TMA). TMA resides in both the ARTCC and TRACON environments. The TMA determines the optimum sequence and schedule for arrival traffic, and coordination between air traffic control facilities such as a Center and a TRACON is managed via the TMAS for the respective facility. Other CTAS products are the Final Approach Spacing Tool (FAST) for the TRACON and a Descent Advisor (DA) for the ARTCC. FAST aids TRACON controllers in merging arrival traffic into an efficient flow to the final approach path and also supports controllers in efficiently merging missed approach and pop-up traffic into the final approach stream. DA assists ARTCC controllers in meeting TMA arrival times efficiently while maintaining separation.

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A CTAS functionality under concept exploration is Expedite Departure Path (EDP). EDP is intended to accurately model aircraft ascent up to cruise altitude. Ultimately this knowledge can be used in the terminal and en route environments to interleave departing aircraft into the existing flow of en route aircraft.

Each of the major components of CTAS, TMA, FAST and DA will be assessed in an operational environment at one or more development sites prior to limited national deployment. Operational assessment of TMA began in 1993 and will continue in 1997. Operational assessments of FAST and DA will begin in 1994 and continue through 1995. Longer-term CTAS activities focus on integration of terminal automation with other ATC automation tools and cockpit automation activities.

5.2.2 Precision Runway Monitor (PRM)

Significant capacity gains can be achieved at airports with closely-spaced parallel runways if the allowable runway spacing for conducting independent parallel instrument approaches can be reduced. (The benefits associated with reduced spacing are discussed in Section 3.1.) Current criteria allow independent approaches to parallel runways separated by 4,300 feet or more. This standard was established based, in part, on the surveillance update rate and accuracy of the airport surveillance radars (ASRs), and the terminal Automated Radar Terminal System (ARTS) capabilities. Analysis and demonstrations have indicated that the separation between parallel runways could be reduced if the surveillance update rate and the radar display accuracy were improved, and special software was developed to provide the monitor controller with alerts. Conventional airport surveillance radars update the target position every 4.8 seconds.

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The FAA fielded engineering models of the PRM system to investigate the reduction in separation associated with these improvements. The PRM consists of an improved antenna system that provides high azimuth and range accuracy, and higher update rates than the current terminal ASR, a processing system that monitors all approaches and generates controller alerts when an aircraft appears to be entering the "no transgression zone" (NTZ) between the runways, and a high resolution display system. The E-Scan PRM uses an electronically scanned antenna that is capable of updating aircraft positions every half a second.

Further efforts are continuing to develop ATC procedures and surveillance/navigation requirements to support independent approaches to dual, triple, and quadruple parallel runways spaced as low as 3,000 feet apart. Five electronically scanned antenna systems are under procurement.

5.2.3 Precision Approach and Landing Systems

The Instrument Landing System (ILS) has provided dependable precision approach service for many years. However, inherent characteristics of the ILS cause difficulties in congested terminal areas. Of particular concern from an air traffic perspective is the long straight-in flight path required by ILS. Although not a major concern for isolated airports without obstruction problems, for closely spaced airports, ILS finals often create conflicts because flight paths may cross in ways that preclude separation by altitude. In these configurations, the airports become interdependent (i.e., preferred operations cannot be conducted simultaneously at the affected airports), causing delays and constraining capacity. In areas such as New York, the curved approach capability provided by either the Microwave Landing System (MLS) or the Global Positioning System (GPS) will provide a solution to the interdependency of proximate airports.

MLS was designed to solve ILS difficulties in the terminal area. In the meantime, various implementations of GPS have shown promise as precision approach and landing systems in research and development flight tests. A GPS system will be based on the Department of Defense's (DOD's) Global Positioning System augmented with ground reference stations and possible additional satellites to provide the accuracy, integrity, continuity, and availability of service required of a precision landing system. GPS will provide many of the same capabilities as MLS at a lower cost. Therefore, MLS systems will be phased out as soon as the GPS is available to provide equivalent service.

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In general, the remote area navigation (RNAV) capability with wide-area coverage provided by GPS will result in more flexibility in the terminal airspace. RNAV will permit the design of instrument approach procedures that more closely approximate traffic patterns used during VMC. Typically these result in shorter flight paths, segregation of aircraft by type, reduction of arrival and departure gaps, and avoidance of noise-sensitive areas.

GPS will also enable the FAA to provide precision approach capability for runways at which an ILS could not be used due to ILS localizer frequency-band congestion or fm radio transmitter interference. For example, it is already difficult to add ILS facilities in congested areas such as Chicago and New York.

It may be possible to achieve lower minimums with GPS than can be achieved with ILS at some sites. Moreover, GPS will relieve surface congestion resulting from restrictions caused by ILS critical area sensitivity to reflecting surfaces such as taxiing and departing aircraft.

Use of GPS for missed approach guidance may help support development of approach procedures for converging runways and triple runway configurations. Use of GPS for departure guidance will help ease airspace limitations and restrictions on aircraft operations due to noise abatement requirements.

GPS does not provide the accuracy, integrity, availability and continuity of service necessary for NAS navigation and landing requirements. To provide this capability, a network of precisely located monitors, reference stations and master control stations is being implemented in the Wide Area Augmentation System (WAAS). WAAS will provide a precision approach service capability and is intended as the primary means of navigation and precision approach when fully implemented. The satellite navigation system could lead to the phase-out of existing NAS ground equipment when fully implemented while maintaining or improving existing service levels. In addition, the GPS based systems have the potential for new navigation and landing services not currently supported. To further improve accuracy and integrity, other augmentations are also planned such as the local area augmentation system (LAAS) to provide high levels of accuracy, continuity, and availability for Category II/III operations.

5.2.4 Traffic Alert and Collision Avoidance System (TCAS) Applications

TCAS is an airborne system that operates independently of ground-based ATC radars to surveil nearby transponder-equipped aircraft and provides relative position and altitude (if an encoder is present) information to the pilot. The TCAS II system, mandated for use in large, passenger carrying airplanes, provides additional information to the pilot in the form of vertical advisory maneuvers when the collision avoidance logic senses the potential for a collision. Since December 1994, the TCAS II system has been installed on all large, passenger carrying airplanes that are operating in and to the United States.

Although the primary role of TCAS is to avoid collisions, the capabilities inherent in its design offer the potential to improve the overall efficiency and safety of routine flight operations. Under the guidance of an FAA/industry Separation Assistance Working Group (SAWG), candidate TCAS applications were explored and an Oceanic In-Trail Climb (ITC) procedure was developed. The ITC enables the flight crew of an airplane that is following another along an oceanic route to utilize the surveillance and display capabilities of the TCAS to request a climb clearance from Air Traffic Control. This effectively reduces the non-radartrail distance necessary to approve the climb from a nominal 100 nm to a minimum of 15 nm. Inlate summer of 1994, two major U.S. airlines began opera-

TCAS is an airborne system that operates independently of ground-based ATC radars to surveil nearby transponder-equipped aircraft and provides relative position and altitude (if an encoder is present) information to the pilot.

tional trials of the ITC procedure in the Anchorage and Oakland Flight Information Regions (FIRs).

Recognized as a cornerstone in the concepts of Free Flight and cooperative air traffic control, the ITC procedure is expected to lead to further applications and enhancements to the TCAS system. Such applications may include reduced departure and arrival spacing, reduced visual approach minima, and in-trail self monitoring.

5.2.5 Wake Vortex Program

A better understanding of wake-vortex strength, duration, and movement could result in the reduction of aircraft separation criteria. Revised wake-vortex separation criteria may increase airport capacity by 12 to 15 percent in instrument meteorological conditions (IMC), thereby enhancing airspace use and decreasing delays.

Several vortex detection and measurement systems will be deployed at selected airports to monitor wake-vortex strength, transport characteristics, and decay. Wake vortex data obtained from these airports will be combined with data from tower fly-by tests already completed to provide a basis for reviewing existing separation standards and recommending modifications to those standards.

Plans include cockpit simulations to determine if separation standards for heavy aircraft operating behind heavy aircraft can be reduced from four miles in trail to three miles. This will be followed by examining the separation for large-behind-large and issues relating to closely spaced runways, departure delays, and departure sequencing which would interconnect with terminal automation.

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5.2.6 Terminal Area Surveillance System

Although air traffic incidents may occur during any phase of flight, the largest percentage occur during takeoff and landing. Currently, there are many airports without surveillance radars, and the airport surveillance radar being procured by the FAA, the Airport Surface Detection Equipment-3 (ASDE-3), will not be available at all airports due to cost considerations. It is important, therefore, to develop affordable sensors to provide a reliable surveillance source for terminal operations and to support automation development and airport capacity initiatives.

Requirements for a new terminal area surveillance radar have been identified and include modular, cost-effective primary and secondary radar systems with application for flexible, high capacity data links, improved surveillance accuracy, improved runway monitoring, improved wind shear detection and dissemination, and improved wake vortex tracking. Efforts will focus on adapting commercial technology in order to develop a radar that meets the validated requirements in a cost-effective manner.

5.3 En Route Airspace Capacity Technology

En route airspace congestion is being identified increasingly as a factor in restricting the flow of traffic at certain airports. One cause of en route airspace congestion is that ATC system users want to travel directly from one airport to another at the best altitude for their aircraft, and hundreds of aircraft have similar performance characteristics. Therefore, some portions of airspace are in very high demand, while others are used very little. This non-uniform demand for airspace translates into the need to devise equitable en route airspace management strategies for distributing the traffic when demand exceeds capacity. Initiatives designed to reduce delays, match traffic flow to demand, and increase users' freedom to fly user-preferred routes are underway.

Automated En Route Air Traffic Control (AERA) is a long-term evolutionary program that will increasingly allow aircraft to fly their preferred routes safely with a minimum of air traffic control intervention.

Automated En Route Air Traffic Control (AERA) is a long-term evolutionary program that will increasingly allow aircraft to fly their preferred routes safely with a minimum of air traffic control intervention. The Advanced Traffic Management System (ATMS) will allow air traffic managers to identify in advance when en route or terminal weather or other factors require intervention to expedite and balance the flow of traffic.

The need for increased efficiency in oceanic airspace is also being addressed. Initiatives that improve the control of this airspace, particularly the more accurate and frequent position reporting resulting from Automatic Dependent Surveillance (ADS) using satellite technology, will make it possible to effect significant reductions in oceanic en route spacing.

Other means of improving en route airspace capacity include reducing the vertical separation requirements at altitudes above FL290 to allow more turbojet aircraft to operate along a given route near their preferred altitudes and reducing the minimum in-trail spacing to increase the flow rate on airways.

5.3.1 Automated En Route Air Traffic Control (AERA)

AERA is a collection of automation capabilities that will support ATC personnel in aircraft conflict detection and resolution of problems along its flight path in coordination with traffic flow management. AERA will help increase airspace capacity by improving the ATC system's ability to manage more densely populated airspace. AERA will also improve the ability of the ATC system to accommodate user preferences. When the most desirable routes are unavailable because of congestion or weather conditions, AERA will assist the controller in finding the open route closest to the preferred one.

AERA is a collection of automation capabilities that will support ATC personnel in aircraft conflict detection and resolution of problems along its flight path in coordination with traffic flow management.

Laboratory facilities for the AERA program were established in 1987. This laboratory has been used for prototyping and analyzing systems and concepts to develop operational and specification requirements, as well as supporting technical documentation. Initial algorithmic and performance specifications were completed in 1991. These specifications were updated in 1992 to reflect the transition strategy adopted to implement AERA capabilities. This strategy will minimize disruption of on-going operations and encourage effective assimilation of AERA capabilities by the controller work force.

In 1993, AERA was integrated into the En Route Automation Strategic Plan, which describes how en route automation programs will be incorporated into the National Airspace System over the next 7 to 10 years. Detailed implementation plans are being prepared to bring an initial AERA operational test capability to the field in late 1995 and to implement initial controller use of the AERA capabilities in late 1997. Full AERA capabilities are planned for initial use in the year 2000.

AERA concepts are being introduced in project planning and development for oceanic system automation, traffic flow management, and integration of en route and terminal ATC. In more advanced AERA applications, the integration of ground-based ATC and cockpit automation will be investigated to fully exploit the potential for computer-aided interactive flight planning between controller and pilot.

5.3.2 Oceanic Automation Program (OAP)

In the Automatic Dependent Surveillance (ADS) System, the information generated by an aircraft's onboard navigation system is automatically relayed from the aircraft, via a satellite data link, to air traffic control facilities. The automatic position reports will be displayed to the air traffic controller in nearly real time. This concept will revolutionize ATC in the oceanic areas that are beyond the range of radar coverage. Currently oceanic ATC is largely manual and procedural and operates with very little, and often delayed, information. It depends upon hourly reports transmitted via High Frequency (HF) voice radio, which is subject to interference. Because of the uncertainty and infrequency of the position reports, large separations are maintained to assure safety. These large separations effectively restrict available airspace, and cause aircraft to operate on less than optimal routes.

ADS will be a part of an OAP to support transoceanic flights over millions of square miles of Pacific and Atlantic airspace. The OAP will provide an automation infrastructure including oceanic flight data processing, a computer-generated situation display, and a strategic conflict probe for alerting controllers to potential conflicts hours before they would occur. The Oceanic Display and Planning System (ODAPS) became operational in the Oakland Air Route Traffic Control Center (ARTCC) in 1989 and in the New York ARTCC in 1992. Real-time position reporting via ADS and a limited set of direct pilot-controller data link messages will be added to the system in 1996, and a complete set of pilot-controller data link messages will be available.

The new Oceanic Automation Program will provide benefits to airspace users in efficiency and capacity. The improved position reporting will allow better use of the existing separation standards.

The new Oceanic Automation Program will provide benefits to airspace users in efficiency and capacity. The improved position reporting will allow better use of the existing separation standards. Air traffic management will be able to begin the process of reducing those standards, thereby increasing the manageable number of aircraft per route. Using the strategic conflict probe, controllers will be able to evaluate traffic situations hours into the future. Ultimately, controllers will be able to grant more fuel-efficient flexible routes, which will have a significant impact on fuel costs and delays.

5.3.3. Communications and Satellite Navigation

New technology enhancements in communications, navigation, and surveillance provide the basis for dramatic improvements in aviation system performance, including improved safety, reduced delay, increased capacity, and greater efficiency. These three functional areas represent key elements of the air traffic management infrastructure.

5.3.3.1 Aeronautical Data Link Communications

Data link services should relieve congestion on voice communications channels and provide controllers with an ability to handle more traffic during peak periods while providing pilots with unambiguous information and clearances. This benefit has been demonstrated by the delivery of pre-departure clearances via data link.

Data link applications are being developed based on inputs from the air traffic and aviation user communities. These applications include weather products, en route, terminal, and tower ATC communications, and other aeronautical services. The Aeronautical Telecommunications Network (ATN) allows use of many data link sub-networks (e.g., satellite, Mode S, VHF, etc.) in a way that is transparent to the users.

Data link applications are being developed based on inputs from the air traffic and aviation user communities. These applications include weather products, en route, terminal, and tower ATC communications, and other aeronautical services.

Domestic standards are being developed with RTCA while the international standards are being developed with ICAO. The en route, terminal, and tower ATC services are being developed and evaluated by a team of air traffic controllers. The operational aspects and benefits of data link applications will be verified using contractor and FAA Technical Center test beds. Pilot inputs will be gathered by connecting cockpit simulators and live aircraft to the test beds during evaluations.

5.3.3.2 Satellite Navigation

Efforts are underway to augment the Department of Defense's Global Positioning System (GPS) to support civil aviation navigation requirements. Procedures and standards are being developed for oceanic and domestic en route, terminal, non-precision approach, precision approach, and airport surface navigation. Satellite ranging signals currently provide three-dimensional position, time, and velocity information that can be used as a supplemental means of navigation for civil users down to non-precision approach. This technology, supplemented to improve system accuracy, availability, and integrity, will eventually provide aircraft the ability to fly direct paths instead of being confined to specific routes, thus providing for more efficient use of airspace. GPS will also allow for increased capacity through reduced separation minimums and provide an accurate position reporting system without separate surveillance systems.

Efforts are underway to augment the Department of Defense's Global Positioning System (GPS) to support civil aviation navigation requirements.

With the declaration of GPS initial operational capability (IOC) in December 1993, the DOD agreed to sustain levels of signal availability and accuracy to meet basic federal radio navigation requirements. Furthermore, the Joint DOD/Department of Transportation (DOT) Task Force Report, released in December 1993, gave the FAA authority to implement a wide-area integrity and availability enhancement to support expanded civil navigation operations. With demonstrated improvements in position accuracy, GPS may prove capable of providing an all-weather landing service by the turn of the century.

5.4 Traffic Flow Management

The development of improved capabilities to support national and local traffic flow managers has received increasing attention in recent years, and a number of efforts are underway to aid in fielding effective and well designed enhancements to the Traffic Flow Management (TFM) System. Two of the most prominent such efforts are the Advanced Traffic Flow Management System (ATMS) and the Operational Traffic Flow Planning (OTFP) Program. Both of these efforts will focus on formulating and developing improvements for the TFM system in consultation with aviation system users, including both the automation infrastructure and the associated air traffic procedures necessary to implement the operational capability.

5.4.1 Advanced Traffic Management System (ATMS)

The purpose of the ATMS effort is to research automation tools to minimize the effects of NAS overload on user preferences without compromising safety. This is accomplished by:

- Monitoring the demand on and capacity of ATC resources.
- Developing alternative strategies to balance demand and capacity to prevent critical entities from being overloaded.
- Coordinating and implementing strategies to assure maximum use of critical resources when a demand/capacity imbalance is predicted or detected.

Automation tools shown to be beneficial through the ATMS research and development program will be implemented and fielded for operational use in the Enhanced Traffic Management System (ETMS).

The Aircraft Situation Display (ASD) was the first capability developed by ATMS. The ASD generates a graphic display that shows current traffic and flight plans for the entire NAS. The ASD is currently deployed at the Air Traffic Control System Command Center (ETMS) and all ARTCCs and at selected TRACONs and Canadian locations. The ASD data has also been provided to commercial air carriers and air taxi operators, and they are using these data to aid in their operations management and planning.

The ASD has helped increase system capacity in several ways. It allows traffic management specialists to observe approaching traffic across ARTCC boundaries. This has allowed the reduction or elimination of many fixed miles-in-trail restrictions (and the resultant delay of aircraft) that were in effect prior to the deployment of ASD. It assists traffic management specialists in planning arrival flows for airports that are close to ARTCC boundaries, resulting in smoother arrival flows and better airport utilization. It allows traffic management specialists to detect and effect solutions to certain congestion problems, such as merging traffic flows, well in advance of problem occurrence and even before the aircraft enter the ARTCC where the congestion problem will occur. Small adjustments to traffic flows made early can avoid large delays associated with last-minute solutions.

The second capability developed by ATMS was the Monitor Alert, which predicts traffic activity several hours in advance. It compares the predicted traffic level to the threshold alert level for air traffic control sectors, fixes, and airports, and highlights predicted problems. It will aid in detecting congestion problems further in advance, enabling solutions to be implemented earlier. The Monitor Alert has recently been implemented at the ATCSCC, all ARTCCS, and several TRACONs.

Four future capabilities that are being developed through ATMS are Automated Demand Resolution, Dynamic Special Use Airspace, Strategy Evaluation, and Automated Execution. Automated Demand Resolution will examine problems predicted by Monitor Alert and suggest several alternative problem resolutions. The suggested resolutions are planned to respond to each problem without creating conflicts or additional problems. Dynamic Special Use Airspace will provide automation to allow consideration of actual and scheduled military operations in the national flow management decision making process. Strategy Evaluation will provide a tool to evaluate alternative flow management strategies. Automated Execution will generate and distribute facility and aircraft-specific directives to implement selected strategies.

In addition to domestic flow management capabilities, research is being conducted for oceanic flow management capabilities. Track Generation will define a set of tracks for a prescribed region of airspace. Track Advisory will advise oceanic traffic managers of the most efficient tracks available to individual aircraft approaching the track system. Oceanic Traffic Display will assist the oceanic traffic manager in routing aircraft. Further development will concentrate on the integration of domestic and oceanic capabilities.

Increasing congestion, delays, and fuel costs require that the FAA take immediate steps to improve airspace use, decrease flight times and controller workload, and increase fuel efficiency. To achieve these objectives the FAA Operational Traffic Flow Planning program will develop near-term, operational traffic planning models and tools.

5.4.2 Operational Traffic Flow Planning (OTFP)

Increasing congestion, delays, and fuel costs require that the FAA take immediate steps to improve airspace use, decrease flight times and controller workload, and increase fuel efficiency. To achieve these objectives the FAA Operational Traffic Flow Planning program will develop near-term, operational traffic planning models and tools. The program will provide software tools to plan daily air traffic flow, predict traffic problems and probable delay locations, assist in joint FAA-user planning and decision-making, and generate routes and corresponding traffic flow strategies which minimize time and fuel for scheduled air traffic. Benefits include improved aviation safety, airspace use, system throughput, and route flexibility. Working directly with commercial aviation interests and other FAA facilities, the Air Traffic Control System Command Center (ATCSCC) can predict problem areas before they occur and generate alternative reroutings and flow procedures. Overall system capacity will be increased over that of the present fixed route and rigid preferred route systems, resulting in increased fuel efficiency, shorter travel times, and reduced delays. Controller workloads will decrease from users' participation in a planned, systematic flow of traffic.

5.5 System Planning, Integration, and Control Technology

The following sections describe technologies that support planning to integrate various improvements into the NAS. Both operational improvements and new technologies need to be evaluated so that they can be developed and implemented effectively, ensuring the interoperability of the elements of the NAS. A large number of models and other technologies will support this integration effort. The National Simulation Capability (NSC), for example, will horizontally integrate many of these new technologies in a laboratory environment. The National Airspace System Performance Analysis Capability (NASPAC) will help identify of demand/capacity imbalances in the NAS and provide a basis for evaluating proposed solutions to those imbalances. Computer-graphics tools, such as the Sector Design Analysis Tool and the Terminal Airspace Visualization Tool, will allow airspace designers to quickly and effectively develop alternative airspace sectors and procedures. They will also reduce the time and effort required to implement these alternatives.

The NSC aids and supports the RE&D and systems engineering missions of the FAA by horizontally integrating the various RE&D program elements across the National Airspace System (NAS) environment.

5.5.1 National Simulation Capability (NSC)

The NSC aids and supports the RE&D and systems engineering missions of the FAA by horizontally integrating the various RE&D program elements across the National Airspace System (NAS) environment. The capability to integrate emerging ATC subsystems during the conceptual stage of each project allows early validation of requirements, identification of problems, development of solutions to those problems, and demonstration of system capabilities. It also permits early injection of human factors and system user inputs into the concept formulation process. The net result is a reduction of risk in the development of products for the NAS, faster infusion of new technology, earlier acceptance of new NAS concepts by system users, and greater efficiency in performing the RE&D and systems engineering missions. The ASTA, CTAS, TCAS, AERA, ATMS, OTFP, Aeronautical Data Link Communications, Terminal Area Surveillance System, and Aviation Weather programs are all actively involved in horizontal system simulations in the NSC.

The NSC is a unique capability that will exploit the latest simulation technology. Horizontal integration brings together diverse system components such as terminal automation, en route automation, oceanic air traffic control, aircraft flight management systems, and mixes of aircraft types and performance in a flexible, interchangeable, and dynamic simulation environment. It provides an ability to assess the suitability and capability of emerging ATC system components before production investment decisions are made. The NSC permits the evaluation of new operational concepts, human interfaces, and failure modes in a realistic, real-time, interactive ATC environment capable of simulating new or modified systems at forecast traffic levels. Simulation capabilities will be expanded through an interface with various remote research centers that possess nationally unique facilities and expertise.

The principal objectives of computer simulation models currently in use and under development are to identify current and future problems in the NAS caused by demand/capacity imbalances and to construct and evaluate potential solutions.

5.5.2 Analysis Tools

A large and growing repertoire of analytical, simulation, and graphical tools and models are being developed and used to help understand and improve the NAS. Some of the more prominent of these are briefly described in the following sections.

The principal objectives of computer simulation models currently in use and under development are to identify current and future problems in the NAS caused by demand/capacity imbalances and to construct and evaluate potential solutions. All of the models rely on a substantial amount of operational data to produce accurate results. The principal models being developed and in use today are described below.

5.5.2.1 Airport Network Simulation Model (AIRNET)

AIRNET is a PC-based tool that is designed to assess the impact of changes in airport facilities, operations, and demand. It is a planning tool that can assess the effects of those changes on passenger costs, noise contours, airports, airlines, and aircraft. It addresses macro trends and interactions for use in policy planning and economic analysis.

5.5.2.2 Airport and Airspace Simulation Model (SIMMOD)

SIMMOD simulates both airports and airspace in a selected geographic area. It aids in the study of en route air traffic, terminal air traffic, and ground operations. It is capable of calculating capacity and delay impacts of a variety of operating alternatives, including runway configurations, airspace routes, sectorization, and separation standards. It is a planning tool for evaluating operational alternatives involving the coordination of airport configurations with airspace configurations. SIMMOD has been used in airspace design studies around major airports. Improvements to SIMMOD include better output displays, automated data-acquisition capability, and a workstation version of the model.

5.5.2.3 Airfield Delay Simulation Model (ADSIM) and Runway Delay Simulation Model (RDSIM)

The Airfield Delay Simulation Model (ADSIM) calculates travel time, delay, and flow rate data to analyze components of an airport, airport operations, and operations in the adjacent airspace. It traces the movement of individual aircraft through gates, taxiways, and runways. The Runway Delay Simulation Model (RDSIM) is a sub-model of ADSIM. RDSIM limits its scope to the final approach, runway, and runway exit.

The Airfield Delay Simulation Model (ADSIM) calculates travel time, delay, and flow rate data to analyze components of an airport, airport operations, and operations in the adjacent airspace.

5.5.2.4 The Airport Machine

The Airport Machine is a PC-based interactive model with graphics that is used to evaluate proposed changes to airfield and terminal configurations, schedules, and aircraft movement patterns. This model has been used in studies of a number of major airports. Its primary output is extensive data on delays to aircraft movement.

5.5.2.5 National Airspace System Performance Analysis Capability (NASPAC)

The NASPAC Project provides a long-term analysis capability to assist the FAA in developing, designing, and managing the Nation's airspace on a system-wide level through the application of operations research methods and computer modeling. The focal point of the NASPAC Project is the NASPAC Simulation Modeling System (SMS). The NASPAC SMS is a simulation of the entire NAS used to estimate flight delays by modeling the progress of individual aircraft as they move through the nationwide network of airports, en route sectors, routes, navigation fixes, and flow control restrictions. The model has been used to study the current and projected performance of the NAS and to study system improvements such as new airports, new runways, and airspace changes, as well as projected demand changes such as the creation of new air carrier hubs and the introduction of civil tiltrotor flights in the Northeast Corridor.

5.5.2.6 Sector Design Analysis Tool (SDAT)

The SDAT is an automated tool to be used by airspace designers at the 20 Air Route Traffic Control Centers (ARTCCs) to evaluate proposed changes in the design of airspace. This computer model allows the user to input either the current design or the proposed replacement. It also allows the user to interactively make changes to the design shown graphically on the computer screen.

The model allows the user to play recorded traffic data against either the actual design or the proposed replacement. It also allows the user to modify traffic data interactively in order to evaluate alternative designs under postulated future traffic loading. The model computes measures of workload and conflict potential for the specified sector or group of sectors. This will allow designers to obtain a better balance in workload between sectors, reducing controller workload and increasing airspace capacity. The model will also be useful for facility traffic flow managers, for it will display cumulative traffic flows under either historic or anticipated future traffic loading.

The development of the SDAT has been underway for approximately two years. Procedures for extracting and displaying (in 2D and 3D) all the requisite data from available FAA data files and computing the expected demand for separation assurance actions,sector traffic loading, and aircraft operating cost have been developed. The development of a fully capable controller workload model is underway. SDAT is being field tested at 13 sites, with expanded deployment planned for FY97. In addition, a version for terminal area design is under development.

5.5.2.7 Terminal Airspace Visualization Tool (TAVT)

Terminal airspace differs from en route airspace in that it tends to have a more varied mix of aircraft and user types, more complicated air traffic rules and procedures, and wider variation in flight paths. A major redesign of terminal airspace currently requires extensive coordination and a task force effort lasting many months or even years. The purpose of the TAVT prototype is to explore the potential for computer-based task force assistance to support a more rapid evaluation of alternatives.

The TAVT prototype displays a three-dimensional representation of the airspace on a large computer screen to allow the user/operator to view the airspace from any perspective. It also provides an easy-to-use interface that permits the user to modify the airspace according to permissible alternatives. The results of this effort are being evaluated for incorporation into the specifications of a follow-on terminal airspace design tool based on SDAT.

5.5.2.8 Graphical Airspace Design Environment (GRADE)

GRADE is a computer graphics tool for displaying, analyzing, and manipulating airspace design and other aviation related data. Radar data (from both ARTS and SAR) are stripped from their recording media and loaded into GRADE's underlying relational database along with the appropriate airspace geometries, terrain maps, National Airspace System (NAS) data, descriptions of routes, and any other data required in the analysis. GRADE can then be used to test proposed terminal instrument procedures (TERPS), standard terminal arrival routes (STARS) and standard instrument departures (SIDS), airspace design changes, and instrument approach procedures.

GRADE can display radar data in three dimensions, along with the attendant flight plan information, for any given time slice. GRADE also includes a set of algorithms designed to measure interactions between the radar data and any other elements of the database. These measurements can then be displayed and compared as histograms. GRADE provides a high quality, three-dimensional presentation, is relatively easy to use, and can be quickly modified to facilitate the comparison of existing and proposed airspace designs and procedures.

GRADE is currently limited to airspace design applications, but could easily be adapted to other applications, such as noise analysis, interaction with existing airport and airspace computer simulation models, accident/incident investigation (particularly for aircraft without flight data recorders), and training in lessons learned and alternate air traffic control techniques.

5.6 Vertical Flight Program

The General Aviation and Vertical Flight (VF) Program will provide a safer and more efficient use of the National Airspace System for the general aviation industry by identifying, initiating, and performing research activities to safely introduce critical technologies applicable to general aviation and vertical flight needs and requirements. Research and development efforts will focus on air traffic system design and advanced operational procedures; heliport/vertiport/intermodal design and planning; aircraft/aircrew certification, training, and human factors; and emerging technological applications. The program will continue to focus on improving the safety, affordability, and efficiency of general aviation and vertical flight avionics and operations and increasing NAS capacity by developing low cost air and ground infrastructures and procedures to permit safe operations under both visual and instrument flight conditions.

Air infrastructure research will focus on the ability to conduct all-weather and IFR operations at heliports and vertiports in terminal airspace without interfering with fixed-wing traffic flow. Future IFR helicopter research will also focus on an intermodal environment for helicopter IFR operations that can benefit the transportation of goods, services, and people in U.S. and international countries as well. Much of the initial work relating to emerging technologies will be done through simulation and validated with actual flight test data as the aircraft become available.

The General Aviation and Vertical Flight (VF) Program will provide a safer and more efficient use of the National Airspace System for the general aviation industry by identifying, initiating, and performing research activities to safely introduce critical technologies applicable to general aviation and vertical flight needs and requirements.

Ground infrastructure research will provide RE&D into heliport and vertiport design and planning issues, including the terminal area facilities and ground-based support systems that will be needed to implement safe, all-weather, 24-hour flight operations. Developing obstacle avoidance capabilities is a critical design-related effort. Research will include applying lessons learned from detailed accident and rotorcraft operations analyses. Simulations will be used to collect data, analyze scenarios, and provide training to facilitate safe operations. These benefits include enhancing public safety services through applications of low altitude communications and surveillance technology.

Aircraft/aircrew research will also develop minimum performance criteria for visual scenes and motion-based simulators; evaluate state-of-the-art flight performance for cockpit design technology; develop improved training techniques employing expert decision making, and develop crew and aircraft performance standards for display and control integration requirements. Research will also be conducted to develop certification standards vor both conventional and advance technology VF aircraft.

Chapter 6

Summary

The Aviation Capacity Enhancement Plan is intended to be a comprehensive "ground-up" view of aviation system requirements and development, starting at the airport level and extending to terminal airspace, en route airspace, and airspace and traffic flow management. The first step in this problem-solving exercise is problem definition.

This plan defines the capacity problem in terms of flight delays, rather than dealing with a more abstract "definition of capacity." While it is relatively simple to compute an airport's hourly throughput capacity (the number of flight operations which can be handled under IFR or VFR for a given runway operating configuration), that throughput can change each hour as weather, aircraft fleet mix, and runway configurations change. Annualizing airport capacity is thus a difficult task.

In 1994, 23 of the top 100 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports which could exceed 20,000 hours of annual aircraft delay in the year 2004 is projected to grow from 23 to 29.

While it is common for demand to exceed hourly capacity at some airports, there are ways of accommodating that demand. For example, air traffic management can regulate departures and slow down en route traffic, so flights are shifted into times of less congestion. However, this is only a temporary solution, because, as traffic increases at a given airport, there will be fewer off-peak hours into which flights might be shifted.

There are several techniques under investigation to manage demand at delay-problem airports. One is to improve the reliever and general aviation (GA) airport system so that small aircraft prefer to use them. There could be significant reduction in flight delays if a percentage of small/slow aircraft operations shifted to reliever airports. However, some of the forecast delay-problem airports have a low percentage of small aircraft operations. Those airports are largely "relieved," and a further reduction in the operations of small/slow aircraft would be of marginal significance in the reduction of flight delays.

Having first identified forecast delay-problem airports, this Plan next attempts to document planned or technologically feasible capacity development at those airports. The FAA cosponsors Airport Capacity Design Team Studies at major airports to assess how airport development and new technology could "optimize" capacity on a site-specific basis.

Moving from "the ground up," this Plan identifies new terminal airspace procedures which will increase capacity for existing or new runway configurations. Of the top 100 airports, 8 could benefit from independent parallel approaches using the Final Monitor Aid (FMA) with current radar systems, 4 could benefit from independent parallel approaches to triple and quadruple runways using current radar systems, 13 could benefit from simultaneous operations on wet intersecting runways, 45 could benefit from improved operations on parallel runways separated by less than 2,500 feet, 9 could benefit from dependent approaches to three parallel runways, and 38 could benefit from independent converging approaches. Demonstration programs have been completed or are underway for these new approach procedures.

Some of the new approach procedures and airport capacity projects require new technology and new systems and equipment. This Plan outlines the progress of FAA RE&D and F&E programs currently under way to provide that new technology.

Many of the technology programs are designed to reduce the capacity differential between IFR and VFR operations. Delays attributable to weather (resulting in large part from the difference in VFR and IFR separation standards) accounted for 75 percent of all flights delayed 15 minutes or more in 1994. Significant gains in capacity may be achieved with the use of new electronic guidance and control equipment if two or three flight arrival streams can be maintained in IFR, rather than being reduced to one or two arrival streams. These programs are the Precision Runway Monitor (PRM), Converging Runway Display Aid (CRDA), Triple and Quadruple Instrument Approaches, and the Global Positioning System (GPS).

Some of the new technology programs are designed to provide more information to air traffic controllers, such as the Center-TRACON Automation System (CTAS), or to pilots, such as the Traffic Alert Collision and Avoidance System (TCAS), with improved visual displays and non-voice communications. Those programs may not show as large an increase in capacity as those programs providing multiple flight arrival and departure streams, but they are significant nonetheless.

Some of the technology programs are designed to improve the efficiency of aircraft movement on the airport surface. The Airport Surface Traffic Automation (ASTA) program, for example, will expedite surface movement while reducing the number of runway incursions.

Some of the technology programs are computer simulation tools to help in airfield and airspace analysis. For example, the Airport and Airspace Simulation Model (SIMMOD), National Airspace Performance Analysis Capability (NASPAC), Sector Design Analysis Tool (SDAT), and Terminal Airspace Visualization Tool (TAVT) will help in the evaluation of various alternatives. Some technology programs are designed to "optimize" the aviation system through better planning and improved prediction capability in a laboratory environment such as the National Simulation Capability (NSC).

The "ground up" view encompasses en route airspace. This Plan outlines programs designed to increase en route airspace capacity, including Automated En Route Air Traffic Control (AERA), Advanced Traffic Management System (ATMS), Automatic Dependent Surveillance (ADS), and Oceanic Display and Planning System (ODAPS).

Airspace Capacity Design Team projects have been established to analyze and optimize airspace procedures. Projects have been accomplished in Los Angeles, Dallas-Ft. Worth, Chicago, Kansas City, Houston/Austin, Oakland, New York, Jacksonville, Miami, and Atlanta. Results summaries are included in this plan.

From a "ground up" view, after optimizing existing airport capacity, terminal airspace procedures, and en route airspace capacity using new technology, the next level is adding "supplemental" airports for additional aviation system capacity. "Supplemental" airports are existing or new commercial service airports that could provide relief for delay-problem airports.

The largest capacity gains come from building new airports and new or extended runways at existing airports. One such project was the construction of a new international airport at Denver. Construction began in late 1989. In 1992, Colorado Springs completed construction of a new parallel runway, and Nashville and Washington Dulles completed runway extensions. In 1993, Detroit Metropolitan Wayne County completed construction of a new parallel runway, and runway extensions were completed at Dallas-Fort Worth, San Jose, Kailua-Kono Keahole, and Islip Long Island Mac Arthur. In 1993, Memphis began construction of an independent parallel runway and Louisville Standiford Field began construction of two independent parallel runways. In 1994, Kansas City completed construction of a new independent parallel runway. Salt Lake City opened its third air carrier runway in 1995.

Of the top 100 airports, 62 have proposed new runways or extensions to existing runways. Of the 23 delay-problem airports in 1994, 15 are in the process of constructing or planning the construction of new runways or extensions to existing runways. Of the 29 delay-problem airports forecast for the year 2004, 20 propose to build new runways or runway extensions. The total anticipated cost of completing these new runways and runway extensions exceeds $6.0 billion.

While much has been done and more is planned to increase system-wide capacity, it should be noted that the FAA's resources are limited. The demand for Facilities and Equipment (F&E) and Airport Improvement Program (AIP) funds far exceeds availability. However, the FAA will continue to explore innovative methods of increasing system capacity.

System capacity must continue to grow in order to enable the air transportation industry to maintain the same level of service quality and allow airline competition to continue. In the dozen years since airline deregulation, real air fares have declined. Both the quality and cost of air service are strongly tied to aviation system capacity and will continue to show favorable trends only if aviation system capacity continues to grow to meet demand.

1995 ACE PLAN

Aviation Capacity Enhancement

Appendices

Appendix A

Aviation Statistics

Table A-1. Airport Operations and Enplanements, 1992, 1993, and 1994[1]

City-Airport	Airport ID	Rank	Enplanements FY92	Enplanements FY 93	Enplanements FY94	Operations FY92	Operations FY93	Operations FY94
Chicago O'Hare Int'l Airport	ORD	1	29,977,166	30,252,671	30,549,625	838,093	851,865	883,480
Dallas-Fort Worth Int'l Airport	DFW	2	25,714,727	25,143,882	25,514,422	763,372	789,183	831,135
Hartsfield Atlanta Int'l Airport	ATL	3	20,154,271	22,279,277	25,364,630	611,889	658,414	699,400
Los Angeles Int'l Airport	LAX	4	22,942,945	23,019,470	24,457,010	678,398	681,845	687,627
San Francisco Int'l Airport	SFO	5	15,259,820	15,183,917	16,146,552	424,829	423,404	430,380
Denver Stapleton Int'l Airport	DEN	6	14,489,862	15,032,318	15,755,747	499,001	552,238	546,305
Miami Int'l Airport	MIA	7	12,587,420	13,691,750	14,561,222	486,222	527,545	550,194
New York John F. Kennedy Int'l Airport	JFK	8	13,457,175	12,960,386	13,627,089	328,528	351,205	352,494
Newark Int'l Airport	EWR	9	12,002,142	12,413,976	13,564,615	403,978	431,944	441,997
Detroit Metropolitan Airport	DTW	10	10,991,691	11,408,450	12,666,331	413,544	460,009	479,738
Phoenix Sky Harbor Int'l Airport	PHX	11	10,958,285	11,273,726	12,397,443	487,615	520,403	507,698
Las Vegas McCarran Int'l Airport	LAS	12	9,883,375	10,282,461	12,321,672	407,668	439,393	488,347
Boston Logan Int'l Airport	BOS	13	10,974,082	11,067,239	11,789,385	482,582	495,347	478,660
Honolulu Int'l Airport	HNL	14	11,224,612	11,002,537	11,425,428	413,725	365,195	357,116
Minneapolis-St. Paul Int'l Airport	MSP	15	10,639,116	10,865,387	11,410,274	404,243	442,341	454,441
Lambert St. Louis Int'l Airport	STL	16	10,476,861	9,673,790	11,084,346	429,473	441,142	466,639
Orlando Int'l Airport	MCO	17	9,989,092	10,258,281	10,531,965	294,387	327,199	344,213
New York LaGuardia Airport	LGA	18	9,853,796	9,635,072	10,192,077	337,279	335,071	335,539
Seattle-Tacoma Int'l Airport	SEA	19	8,773,365	8,843,265	10,138,818	346,180	339,968	345,052
Houston Intercontinental Airport	IAH	20	8,977,522	9,378,643	10,118,565	320,243	352,340	352,385
Charlotte/Douglas Int'l Airport	CLT	21	9,099,577	8,450,749	9,978,607	466,351	446,315	471,128
Greater Pittsburgh Int'l Airport	PIT	22	9,350,221	9,040,795	9,743,873	421,903	419,581	435,433
Philadelphia Int'l Airport	PHL	23	7,898,926	7,985,716	8,352,442	377,033	390,736	402,845
Salt Lake City Int'l Airport	SLC	24	6,510,026	6,873,589	8,094,932	316,783	324,595	343,807
Washington National Airport	DCA	25	7,350,639	7,552,956	7,553,357	312,014	316,762	316,790
Greater Cincinnati Int'l Airport	CVG	26	5,780,241	5,998,493	6,613,563	304,214	306,811	333,832
San Diego Int'l Lindberg Field	SAN	27	5,923,072	5,833,845	6,277,920	214,844	209,267	215,215
Baltimore-Washington Int'l Airport	BWI	28	4,397,927	4,330,738	5,987,160	265,844	261,674	286,392
Tampa Int'l Airport	TPA	29	4,793,304	4,807,050	5,890,451	229,470	240,425	263,541
Washington Dulles Int'l Airport	IAD	30	5,351,969	5,204,382	5,473,123	287,111	277,483	296,201
Ft. Lauderdale-Hollywood Int'l	FLL	31	4,109,796	4,335,601	5,267,460	204,183	217,786	233,044
Cleveland Hopkins Int'l Airport	CLE	32	4,275,301	4,305,049	5,059,209	237,216	247,502	260,485
Portland Int'l Airport	PDX	33	3,488,096	4,125,162	4,845,429	269,445	280,263	277,000
Raleigh-Durham Int'l Airport	RDU	34	4,939,336	4,849,312	4,562,270	289,462	294,066	283,713
San Juan Luis Muìoz Marîn Int'l	SJU	35	4,192,629	4,359,528	4,524,337	205,560	180,567	174,598
Kansas City Int'l Airport	MCI	36	3,697,822	3,845,223	4,347,493	176,754	184,848	198,274
Nashville Int'l Airport	BNA	37	5,068,030	4,667,875	4,261,810	302,030	318,886	295,558
Chicago Midway Airport	MDW	38	2,029,154	2,688,126	4,032,093	184,000	189,755	254,570
San Jose Int'l Airport	SJC	39	3,472,459	3,250,227	3,969,405	342,918	312,405	298,220
Memphis Int'l Airport	MEM	40	3,958,537	3,737,696	3,966,916	344,655	337,608	345,534
Houston William P. Hobby Airport	HOU	41	4,008,376	4,073,080	3,915,653	242,999	239,634	236,683
Metropolitan Oakland Int'l Airport	OAK	42	3,194,132	3,465,242	3,888,728	419,233	439,214	470,901

1. At the top 100 airports, ranked by 1994 enplanements.

Table A-1. Airport Operations and Enplanements, 1992, 1993, and 1994[1]

City-Airport	Airport ID	Rank	Enplanements FY92	Enplanements FY 93	Enplanements FY94	Operations FY92	Operations FY93	Operations FY94
New Orleans Int'l Airport	MSY	43	3,353,301	3,351,524	3,886,126	137,373	141,384	167,375
Dallas-Love Field	DAL	44	2,944,999	3,117,194	3,374,457	212,049	212,854	217,331
Santa Ana John Wayne Airport	SNA	45	2,769,936	2,861,867	3,281,861	557,442	494,378	509,220
Ontario Int'l Airport	ONT	46	3,042,508	3,039,228	3,178,766	152,935	152,914	158,635
Indianapolis Int'l Airport	IND	47	3,139,736	2,971,961	3,051,267	247,553	238,789	237,937
Albuquerque Int'l Airport	ABQ	48	2,626,486	2,731,804	2,989,398	211,601	209,567	220,914
San Antonio Int'l Airport	SAT	49	2,730,976	2,791,944	2,950,234	210,063	219,305	238,277
Sacramento Metropolitan Airport	SMF	50	2,552,734	2,575,203	2,813,709	162,995	169,272	149,053
Port Columbus Int'l Airport	CMH	51	2,358,548	2,453,287	2,759,950	224,598	217,049	223,633
Palm Beach Int'l Airport	PBI	52	2,514,095	2,458,672	2,747,903	225,784	230,903	216,480
Kahului Airport	OGG	53	2,385,649	2,492,404	2,597,947	179,808	173,002	176,209
Reno Cannon Int'l Airport	RNO	54	1,859,191	2,233,912	2,539,035	161,839	162,441	161,190
Austin Robert Mueller Municipal	AUS	55	2,169,135	2,263,168	2,461,562	186,796	188,026	192,040
Milwaukee Int'l Airport	MKE	56	2,157,207	2,192,294	2,421,191	202,286	198,529	213,602
Burbank-Glendale-Pasadena Airport	BUR	57	1,913,912	2,065,167	2,363,029	214,361	207,460	194,264
Bradley Int'l Airport	BDL	58	2,326,590	2,279,198	2,310,816	175,109	166,889	163,180
Anchorage Int'l Airport	ANC	59	2,207,769	2,150,031	2,262,242	236,719	218,279	215,641
Fort Myers SW Florida Regional	RSW	60	1,692,442	1,765,317	1,923,630	62,578	66,004	64,849
Jacksonville Int'l Airport	JAX	61	1,340,963	1,323,935	1,889,410	146,436	129,683	142,821
El Paso Int'l Airport	ELP	62	1,702,205	1,752,724	1,813,373	159,710	151,284	157,984
Greater Buffalo Int'l Airport	BUF	63	1,652,888	1,542,765	1,799,528	136,043	142,136	145,221
Greensboro Int'l Airport	GSO	64	924,267	924,014	1,765,586	130,026	126,446	157,401
Norfolk Int'l Airport	ORF	65	1,261,896	1,242,831	1,687,526	138,084	134,564	141,861
Oklahoma City Airport	OKC	66	1,543,566	1,517,153	1,609,280	163,336	142,492	146,759
Tucson Int'l Airport	TUS	67	1,254,597	1,252,877	1,574,478	235,309	228,877	249,729
Louisville Standiford Field	SDF	68	1,036,889	1,120,238	1,529,744	156,083	155,941	179,921
Tulsa Int'l Airport	TUL	69	1,459,558	1,452,482	1,499,641	196,835	188,009	198,332
Spokane Int'l Airport	GEG	70	922,609	1,045,450	1,314,183	124,506	122,350	122,615
Greater Rochester Int'l Airport	ROC	71	1,181,284	1,156,295	1,257,907	194,764	188,072	189,372
Dayton Int'l Airport	DAY	72	1,099,107	1,033,601	1,230,863	149,879	132,234	154,481
Little Rock Adams Field	LIT	73	1,044,502	1,092,665	1,200,138	162,439	171,399	173,126
Providence Green State Airport	PVD	74	1,155,961	1,111,990	1,192,157	146,937	125,442	123,195
Omaha Eppley Airfield	OMA	75	1,085,448	1,046,753	1,161,797	155,058	143,739	154,154
Kailua-Kona Keahole	KOA	76	1,022,344	1,117,538	1,106,614	61,172	60,393	66,821
Birmingham Airport	BHM	77	981,175	1,018,261	1,099,815	175,986	168,074	161,638
Lihue Airport	LIH	78	1,111,730	768,822	1,084,800	123,105	57,686	92,542
Richmond Int'l Airport	RIC	79	965,661	996,126	1,077,193	145,079	154,925	153,589
Bangor Int'l Airport	BGR	80	1,032,756	1,026,173	1,074,098	112,955	107,657	93,048
Albany County Airport	ALB	81	1,047,000	1,022,257	1,062,679	162,225	160,587	158,658
Syracuse Hancock Int'l Airport	SYR	82	1,133,554	1,085,866	1,045,438	176,567	180,936	158,677
Boise Air Terminal	BOI	83	647,554	697,665	903,673	161,434	155,166	163,306
Sarasota Bradenton Airport	SRQ	84	882,365	876,042	859,917	161,749	152,722	147,115
Charleston AFB Int'l Airport	CHS	85	645,762	629,901	851,276	135,599	114,427	151,674

1. At the top 100 airports, ranked by 1994 enplanements.

Table A-1. Airport Operations and Enplanements, 1992, 1993, and 1994[1]

City-Airport	Airport ID	Rank	Enplanements FY92	Enplanements FY 93	Enplanements FY94	Operations FY92	Operations FY93	Operations FY94
Colorado Springs Municipal Airport	COS	86	712,144	733,632	786,073	228,714	246,732	239,885
Grand Rapids Kent County Int'l	GRR	87	699,669	708,617	754,480	152,260	150,313	154,264
Greer Greenville-Spartanburg Airport	GSP	88	553,026	574,846	708,165	60,561	56,855	62,526
Hilo Int'l Airport	ITO	89	703,736	664,337	702,798	89,284	91,903	90,802
Harrisburg Int'l Airport	MDT	90	663,462	671,998	676,968	95,916	86,427	82,405
Des Moines Int'l Airport	DSM	91	715,603	663,453	675,356	139,135	128,797	133,954
Knoxville McGhee-Tyson Airport	TYS	92	628,219	642,658	647,019	130,640	130,368	128,032
Charlotte Amalie St. Thomas	STT	93	583,817	630,855	620,085	108,796	105,217	109,958
Lubbock Int'l Airport	LBB	94	583,156	596,088	600,773	113,035	103,112	104,968
Islip Long Island Mac Arthur Airport	ISP	95	571,314	546,102	600,529	202,008	195,198	189,663
Portland Int'l Jetport	PWM	96	608,208	570,925	582,069	117,121	126,353	114,162
Midland Int'l Airport	MAF	97	532,202	544,189	551,273	92,464	93,294	92,853
Savannah Int'l Airport	SAV	98	503,890	483,833	549,891	110,621	104,681	97,509
Columbia Metropolitan Airport	CAE	99	512,586	491,472	549,377	105,585	103,202	108,410
Wichita Mid-Continent Airport	ICT	100	602,048	592,633	544,439	178,853	174,527	167,757

Totals:
1992 Enplanements 474,270,830
1993 Enplanements 480,211,169
1994 Enplanements 522,376,979
1992 Operations 25,283,469
1993 Operations 25,381,499
1994 Operations 26,107,622

1. At the top 100 airports, ranked by 1994 enplanements.

Table A-2. Airport Enplanements, 1994 and Forecast 2010[2]

City-Airport	Airport ID	Rank	Enplanements FY94	Enplanements FY2010	% Growth
Chicago O'Hare Int'l Airport	ORD	1	30,549,625	55,945,000	83.1
Dallas-Fort Worth Int'l Airport	DFW	2	25,514,422	51,830,000	103.1
William B. Hartsfield Atlanta Int'l Airport	ATL	3	25,364,630	40,991,000	61.6
Los Angeles Int'l Airport	LAX	4	24,457,010	36,326,000	48.5
San Francisco Int'l Airport	SFO	5	16,146,552	28,854,000	78.7
Denver Stapleton Int'l Airport [3]	DEN	6	15,755,747	26,222,000	66.4
Miami Int'l Airport	MIA	7	14,561,222	26,397,000	81.3
New York John F. Kennedy Int'l Airport	JFK	8	13,627,089	19,797,000	45.3
Newark Int'l Airport	EWR	9	13,564,615	20,186,000	48.8
Detroit Metropolitan Wayne County Airport	DTW	10	12,666,331	27,449,000	116.7
Phoenix Sky Harbor Int'l Airport	PHX	11	12,397,443	26,992,000	117.7
Las Vegas McCarran Int'l Airport	LAS	12	12,321,672	24,834,000	101.5
Boston Logan Int'l Airport	BOS	13	11,789,385	20,200,000	71.3
Honolulu Int'l Airport	HNL	14	11,425,428	21,820,000	91.0
Minneapolis-St. Paul Int'l Airport	MSP	15	11,410,274	22,058,000	93.3
Lambert St. Louis Int'l Airport	STL	16	11,084,346	19,602,000	76.8
Orlando Int'l Airport	MCO	17	10,531,965	25,269,000	139.9
New York LaGuardia Airport	LGA	18	10,192,077	18,096,000	77.5
Seattle-Tacoma Int'l Airport	SEA	19	10,138,818	19,282,000	90.2
Houston Intercontinental Airport	IAH	20	10,118,565	19,226,000	90.0
Charlotte/Douglas Int'l Airport	CLT	21	9,978,607	21,525,000	115.7
Greater Pittsburgh Int'l Airport	PIT	22	9,743,873	16,560,000	70.0
Philadelphia Int'l Airport	PHL	23	8,352,442	18,972,000	127.1
Salt Lake City Int'l Airport	SLC	24	8,094,932	19,325,000	138.7
Washington National Airport	DCA	25	7,553,357	10,028,000	32.8
Greater Cincinnati Int'l Airport	CVG	26	6,613,563	16,152,000	144.2
San Diego Int'l Lindberg Field	SAN	27	6,277,920	11,177,000	78.0
Baltimore-Washington Int'l Airport	BWI	28	5,987,160	13,257,000	121.4
Tampa Int'l Airport	TPA	29	5,890,451	10,361,000	75.9
Washington Dulles Int'l Airport	IAD	30	5,473,123	12,577,000	129.8
Fort Lauderdale-Hollywood Int'l Airport	FLL	31	5,267,460	10,058,000	90.9
Cleveland Hopkins Int'l Airport	CLE	32	5,059,209	9,615,000	90.0
Portland Int'l Airport	PDX	33	4,845,429	9,827,000	102.8
Raleigh-Durham Int'l Airport	RDU	34	4,562,270	5,232,000	14.7
San Juan Luis Muñoz Marín Int'l Airport	SJU	35	4,524,337	7,933,000	75.3
Kansas City Int'l Airport	MCI	36	4,347,493	6,574,000	51.2
Nashville Int'l Airport	BNA	37	4,261,810	9,909,000	132.5
Chicago Midway Airport	MDW	38	4,032,093	10,830,000	168.6
San Jose Int'l Airport	SJC	39	3,969,405	9,105,000	129.4
Memphis Int'l Airport	MEM	40	3,966,916	11,123,000	180.4
Houston William P. Hobby Airport	HOU	41	3,915,653	10,011,000	155.7
Metropolitan Oakland Int'l Airport	OAK	42	3,888,728	6,839,000	75.9

2. At the top 100 airports, ranked by 1994 enplanements.
3. Stats are for Denver Stapleton, as the new Denver International has not been operational for a full fiscal year.

Table A-2. Airport Enplanements, 1994 and Forecast 2010[2]

City-Airport	Airport ID	Rank	Enplanements FY94	Enplanements FY2010	% Growth
New Orleans Int'l Airport	MSY	43	3,886,126	5,591,000	43.9
Dallas-Love Field	DAL	44	3,374,457	7,381,000	118.7
Santa Ana John Wayne Airport	SNA	45	3,281,861	8,228,000	150.7
Ontario Int'l Airport	ONT	46	3,178,766	8,193,000	157.7
Indianapolis Int'l Airport	IND	47	3,051,267	6,475,000	112.2
Albuquerque Int'l Airport	ABQ	48	2,989,398	5,989,000	100.3
San Antonio Int'l Airport	SAT	49	2,950,234	5,410,000	83.4
Sacramento Metropolitan Airport	SMF	50	2,813,709	5,282,000	87.7
Port Columbus Int'l Airport	CMH	51	2,759,950	4,644,000	68.3
Palm Beach Int'l Airport	PBI	52	2,747,903	5,225,000	90.1
Kahului Airport	OGG	53	2,597,947	4,568,000	75.8
Reno Cannon Int'l Airport	RNO	54	2,539,035	6,125,000	141.2
Austin Robert Mueller Municipal Airport	AUS	55	2,461,562	4,978,000	102.2
Milwaukee General Mitchell Int'l Airport	MKE	56	2,421,191	4,633,000	91.4
Burbank-Glendale-Pasadena Airport	BUR	57	2,363,029	4,135,000	75.0
Bradley Int'l Airport	BDL	58	2,310,816	4,572,000	97.9
Anchorage Int'l Airport	ANC	59	2,262,242	4,143,000	83.1
Fort Myers Southwest Florida Regional Airport	RSW	60	1,923,630	5,255,000	173.2
Jacksonville Int'l Airport	JAX	61	1,889,410	3,719,000	96.8
El Paso Int'l Airport	ELP	62	1,813,373	3,199,000	76.4
Greater Buffalo Int'l Airport	BUF	63	1,799,528	3,069,000	70.5
Greensboro Piedmont Triad Int'l Airport	GSO	64	1,765,586	3,690,000	109.0
Norfolk Int'l Airport	ORF	65	1,687,526	3,148,000	86.5
Oklahoma City Will Rogers World Airport	OKC	66	1,609,280	2,662,000	65.4
Tucson Int'l Airport	TUS	67	1,574,478	2,726,000	73.1
Louisville Standiford Field	SDF	68	1,529,744	2,995,000	95.8
Tulsa Int'l Airport	TUL	69	1,499,641	2,768,000	84.6
Spokane Int'l Airport	GEG	70	1,314,183	2,056,000	56.4
Greater Rochester Int'l Airport	ROC	71	1,257,907	3,019,000	140.0
Dayton Int'l Airport	DAY	72	1,230,863	3,689,000	199.7
Little Rock Adams Field	LIT	73	1,200,138	2,559,000	113.2
Providence Theodore Francis Green State Airport	PVD	74	1,192,157	2,710,000	127.3
Omaha Eppley Airfield	OMA	75	1,161,797	2,019,000	73.8
Kailua-Kona Keahole	KOA	76	1,106,614	3,267,000	195.2
Birmingham Airport	BHM	77	1,099,815	2,208,000	100.8
Lihue Airport	LIH	78	1,084,800	2,063,000	90.2
Richmond Int'l Airport	RIC	79	1,077,193	2,273,000	111.0
Bangor Int'l Airport	BGR	80	1,074,098	1,810,000	68.5
Albany County Airport	ALB	81	1,062,679	1,933,000	81.9
Syracuse Hancock Int'l Airport	SYR	82	1,045,438	2,585,000	147.3
Boise Air Terminal	BOI	83	903,673	1,999,000	121.2

2. At the top 100 airports, ranked by 1994 enplanements.

Table A-2. Airport Enplanements, 1994 and Forecast 2010[2]

City-Airport	Airport ID	Rank	Enplanements FY94	Enplanements FY2010	% Growth
Sarasota Bradenton Airport	SRQ	84	859,917	1,254,000	45.8
Charleston AFB Int'l Airport	CHS	85	851,276	1,679,000	97.2
Colorado Springs Municipal Airport	COS	86	786,073	1,645,000	109.3
Grand Rapids Kent County Int'l Airport	GRR	87	754,480	1,543,000	104.5
Greer Greenville-Spartanburg Airport	GSP	88	708,165	1,668,000	135.5
Hilo Int'l Airport	ITO	89	702,798	1,834,000	161.0
Harrisburg Int'l Airport	MDT	90	676,968	1,320,000	95.0
Des Moines Int'l Airport	DSM	91	675,356	1,325,000	96.2
Knoxville McGhee-Tyson Airport	TYS	92	647,019	1,178,000	82.1
Charlotte Amalie St. Thomas, Virgin Islands	STT	93	620,085	1,306,000	110.6
Lubbock Int'l Airport	LBB	94	600,773	900,000	49.8
Islip Long Island Mac Arthur Airport	ISP	95	600,529	1,589,000	164.6
Portland Int'l Jetport	PWM	96	582,069	1,526,000	162.2
Midland Int'l Airport	MAF	97	551,273	1,062,000	92.6
Savannah Int'l Airport	SAV	98	549,891	1,291,000	134.8
Columbia Metropolitan Airport	CAE	99	549,377	1,274,000	131.9
Wichita Mid-Continent Airport	ICT	100	544,439	1,049,000	92.7

Totals:
1994 Enplanements 522,376,979
2010 Enplanements 994,802,000
Average forecast growth at the top 100 airports for the 16 year period 90.4

2. At the top 100 airports, ranked by 1994 enplanements.

Table A-3. Total Airport Operations, 1994 and Forecast 2010[4]

City-Airport	Airport ID	Rank	Operations FY94	FY2010	% Growth
Chicago O'Hare Int'l Airport	ORD	1	883,480	966,000	9.3
Dallas-Fort Worth Int'l Airport	DFW	2	831,135	1,118,000	34.5
William B. Hartsfield Atlanta Int'l Airport	ATL	3	699,400	1,012,000	44.7
Los Angeles Int'l Airport	LAX	4	687,627	905,000	31.6
Miami Int'l Airport	MIA	5	550,194	802,000	45.8
Denver Stapleton Int'l Airport	DEN	6	546,305	633,000	15.9
Santa Ana John Wayne Airport	SNA	7	509,220	631,000	23.9
Phoenix Sky Harbor Int'l Airport	PHX	8	507,698	677,000	33.3
Las Vegas McCarran Int'l Airport	LAS	9	488,347	729,000	49.3
Detroit Metropolitan Wayne County Airport	DTW	10	479,738	721,000	50.3
Boston Logan Int'l Airport	BOS	11	478,660	585,000	22.2
Charlotte/Douglas Int'l Airport	CLT	12	471,128	728,000	54.5
Metropolitan Oakland Int'l Airport	OAK	13	470,901	553,000	17.4
Lambert St. Louis Int'l Airport	STL	14	466,639	585,000	25.4
Minneapolis-St. Paul Int'l Airport	MSP	15	454,441	693,000	52.5
Newark Int'l Airport	EWR	16	441,997	485,000	9.7
Greater Pittsburgh Int'l Airport	PIT	17	435,433	568,000	30.4
San Francisco Int'l Airport	SFO	18	430,380	540,000	25.5
Philadelphia Int'l Airport	PHL	19	402,845	574,000	42.5
Honolulu Int'l Airport	HNL	20	357,116	497,000	39.2
New York John F. Kennedy Int'l Airport	JFK	21	352,494	411,000	16.6
Houston Intercontinental Airport	IAH	22	352,385	467,000	32.5
Memphis Int'l Airport	MEM	23	345,534	469,000	35.7
Seattle-Tacoma Int'l Airport	SEA	24	345,052	499,000	44.6
Orlando Int'l Airport	MCO	25	344,213	601,000	74.6
Salt Lake City Int'l Airport	SLC	26	343,807	500,000	45.4
New York LaGuardia Airport	LGA	27	335,539	361,000	7.6
Greater Cincinnati Int'l Airport	CVG	28	333,832	619,000	85.4
Washington National Airport	DCA	29	316,790	345,000	8.9
San Jose Int'l Airport	SJC	30	298,220	308,000	3.3
Washington Dulles Int'l Airport	IAD	31	296,201	490,000	65.4
Nashville Int'l Airport	BNA	32	295,558	409,000	38.4
Baltimore-Washington Int'l Airport	BWI	33	286,392	397,000	38.6
Raleigh-Durham Int'l Airport	RDU	34	283,713	216,000	-23.9
Portland Int'l Airport	PDX	35	277,000	404,000	45.8
Tampa Int'l Airport	TPA	36	263,541	325,000	23.3
Cleveland Hopkins Int'l Airport	CLE	37	260,485	374,000	43.6
Chicago Midway Airport	MDW	38	254,570	372,000	46.1
Tucson Int'l Airport	TUS	39	249,729	257,000	2.9
Colorado Springs Municipal Airport	COS	40	239,885	377,000	57.2
San Antonio Int'l Airport	SAT	41	238,277	263,000	10.4
Indianapolis Int'l Airport	IND	42	237,937	341,000	43.3

4. At the top 100 airports, ranked by 1994 operations.

Table A-3. Total Airport Operations, 1994 and Forecast 2010[4]

City-Airport	Airport ID	Rank	Operations FY94	Operations FY2010	% Growth
Houston William P. Hobby Airport	HOU	43	236,683	347,000	46.6
Fort Lauderdale-Hollywood Int'l Airport	FLL	44	233,044	306,000	31.3
Port Columbus Int'l Airport	CMH	45	223,633	300,000	34.1
Albuquerque Int'l Airport	ABQ	46	220,914	249,000	12.7
Dallas-Love Field	DAL	47	217,331	224,000	3.1
Palm Beach Int'l Airport	PBI	48	216,480	249,000	15.0
Anchorage Int'l Airport	ANC	49	215,641	267,000	23.8
San Diego Int'l Lindberg Field	SAN	50	215,215	322,000	49.6
Milwaukee General Mitchell Int'l Airport	MKE	51	213,602	278,000	30.1
Tulsa Int'l Airport	TUL	52	198,332	174,000	-12.3
Kansas City Int'l Airport	MCI	53	198,274	233,000	17.5
Burbank-Glendale-Pasadena Airport	BUR	54	194,264	247,000	27.1
Austin Robert Mueller Municipal Airport	AUS	55	192,040	245,000	27.6
Islip Long Island Mac Arthur Airport	ISP	56	189,663	178,000	-6.1
Greater Rochester Int'l Airport	ROC	57	189,372	213,000	12.5
Louisville Standiford Field	SDF	58	179,921	247,000	37.3
Kahului Airport	OGG	59	176,209	195,000	10.7
San Juan Luis Muñoz Marín Int'l Airport	SJU	60	174,598	200,000	14.5
Little Rock Adams Field	LIT	61	173,126	195,000	12.6
Wichita Mid-Continent Airport	ICT	62	167,757	242,000	44.3
New Orleans Int'l Airport	MSY	63	167,375	200,000	19.5
Boise Air Terminal	BOI	64	163,306	268,000	64.1
Bradley Int'l Airport	BDL	65	163,180	206,000	26.2
Birmingham Airport	BHM	66	161,638	174,000	7.6
Reno Cannon Int'l Airport	RNO	67	161,190	222,000	37.7
Syracuse Hancock Int'l Airport	SYR	68	158,677	198,000	24.8
Albany County Airport	ALB	69	158,658	184,000	16.0
Ontario Int'l Airport	ONT	70	158,635	261,000	64.5
El Paso Int'l Airport	ELP	71	157,984	166,000	5.1
Greensboro Piedmont Triad Int'l Airport	GSO	72	157,401	201,000	27.7
Dayton Int'l Airport	DAY	73	154,481	215,000	39.2
Grand Rapids Kent County Int'l Airport	GRR	74	154,264	217,000	40.7
Omaha Eppley Airfield	OMA	75	154,154	187,000	21.3
Richmond Int'l Airport	RIC	76	153,589	179,000	16.5
Charleston AFB Int'l Airport	CHS	77	151,674	159,000	4.8
Sacramento Metropolitan Airport	SMF	78	149,053	198,000	32.8
Sarasota Bradenton Airport	SRQ	79	147,115	162,000	10.1
Oklahoma City Will Rogers World Airport	OKC	80	146,759	147,000	0.2
Greater Buffalo Int'l Airport	BUF	81	145,221	181,000	24.6
Jacksonville Int'l Airport	JAX	82	142,821	182,000	27.4
Norfolk Int'l Airport	ORF	83	141,861	161,000	13.5
Des Moines Int'l Airport	DSM	84	133,954	160,000	19.4

4. At the top 100 airports, ranked by 1994 operations.

Table A-3. Total Airport Operations, 1994 and Forecast 2010[4]

City-Airport	Airport ID	Rank	Operations FY94	FY2010	% Growth
Knoxville McGhee-Tyson Airport	TYS	85	128,032	148,000	15.6
Providence Green State Airport	PVD	86	123,195	139,000	12.8
Spokane Int'l Airport	GEG	87	122,615	142,000	15.8
Portland Int'l Jetport	PWM	88	114,162	135,000	18.3
Charlotte Amalie St. Thomas, Virgin Islands	STT	89	109,958	150,000	36.4
Columbia Metropolitan Airport	CAE	90	108,410	117,000	7.9
Lubbock Int'l Airport	LBB	91	104,968	109,000	3.8
Savannah Int'l Airport	SAV	92	97,509	116,000	19.0
Bangor Int'l Airport	BGR	93	93,048	109,000	17.1
Midland Int'l Airport	MAF	94	92,853	72,000	-22.5
Lihue Airport	LIH	95	92,542	110,000	18.9
Hilo Int'l Airport	ITO	96	90,802	137,000	50.9
Harrisburg Int'l Airport	MDT	97	82,405	91,000	10.4
Kailua-Kona Keahole	KOA	98	66,821	126,000	88.6
Fort Myers SWFlorida Regional Airport	RSW	99	64,849	122,000	88.1
Greer Greenville-Spartanburg Airport	GSP	100	62,526	78,000	24.7

Totals: 1994 Operations 26,107,622
2010 Operations 33,847,000
Average forecast growth at the top 100 airports for the 16 year period 29.6

4. At the top 100 airports, ranked by 1994 operations.

Table A-4. Growth in Enplanements From 1993 to 1994[5]

City-Airport	Airport ID	Rank	Enplanements FY93	Enplanements FY94	% Growth
Greensboro Piedmont Triad Int'l Airport	GSO	1	924,014	1,765,586	91.1
Chicago Midway Airport	MDW	2	2,688,126	4,032,093	50.0
Jacksonville Int'l Airport	JAX	3	1,323,935	1,889,410	42.7
Lihue Airport	LIH	4	768,822	1,084,800	41.1
Baltimore-Washington Int'l Airport	BWI	5	4,330,738	5,987,160	38.2
Louisville Standiford Field	SDF	6	1,120,238	1,529,744	36.6
Norfolk Int'l Airport	ORF	7	1,242,831	1,687,526	35.8
Charleston AFB Int'l Airport	CHS	8	629,901	851,276	35.1
Boise Air Terminal	BOI	9	697,665	903,673	29.5
Spokane Int'l Airport	GEG	10	1,045,450	1,314,183	25.7
Tucson Int'l Airport	TUS	11	1,252,877	1,574,478	25.7
Greer Greenville-Spartanburg Airport	GSP	12	574,846	708,165	23.2
Tampa Int'l Airport	TPA	13	4,807,050	5,890,451	22.5
San Jose Int'l Airport	SJC	14	3,250,227	3,969,405	22.1
Fort Lauderdale-Hollywood Int'l Airport	FLL	15	4,335,601	5,267,460	21.5
Las Vegas McCarran Int'l Airport	LAS	16	10,282,461	12,321,672	19.8
Dayton Int'l Airport	DAY	17	1,033,601	1,230,863	19.1
Charlotte/Douglas Int'l Airport	CLT	18	8,450,749	9,978,607	18.1
Salt Lake City Int'l Airport	SLC	19	6,873,589	8,094,932	17.8
Cleveland Hopkins Int'l Airport	CLE	20	4,305,049	5,059,209	17.5
Portland Int'l Airport	PDX	21	4,125,162	4,845,429	17.5
Greater Buffalo Int'l Airport	BUF	22	1,542,765	1,799,528	16.6
New Orleans Int'l Airport	MSY	23	3,351,524	3,886,126	16.0
Santa Ana John Wayne Airport	SNA	24	2,861,867	3,281,861	14.7
Seattle-Tacoma Int'l Airport	SEA	25	8,843,265	10,138,818	14.7
Lambert St. Louis Int'l Airport	STL	26	9,673,790	11,084,346	14.6
Burbank-Glendale-Pasadena Airport	BUR	27	2,065,167	2,363,029	14.4
William B. Hartsfield Atlanta Int'l Airport	ATL	28	22,279,277	25,364,630	13.8
Reno Cannon Int'l Airport	RNO	29	2,233,912	2,539,035	13.7
Savannah Int'l Airport	SAV	30	483,833	549,891	13.7
Kansas City Int'l Airport	MCI	31	3,845,223	4,347,493	13.1
Port Columbus Int'l Airport	CMH	32	2,453,287	2,759,950	12.5
Metropolitan Oakland Int'l Airport	OAK	33	3,465,242	3,888,728	12.2
Columbia Metropolitan Airport	CAE	34	491,472	549,377	11.8
Palm Beach Int'l Airport	PBI	35	2,458,672	2,747,903	11.8
Detroit Metropolitan Wayne County Airport	DTW	36	11,408,450	12,666,331	11.0
Omaha Eppley Airfield	OMA	37	1,046,753	1,161,797	11.0
Milwaukee General Mitchell Int'l Airport	MKE	38	2,192,294	2,421,191	10.4
Greater Cincinnati Int'l Airport	CVG	39	5,998,493	6,613,563	10.3
Phoenix Sky Harbor Int'l Airport	PHX	40	11,273,726	12,397,443	10.0
Islip Long Island Mac Arthur Airport	ISP	41	546,102	600,529	10.0
Little Rock Adams Field	LIT	42	1,092,665	1,200,138	9.8

5. At the top 100 airports, ranked by growth in total enplanments.

Table A-4. Growth in Enplanements From 1993 to 1994[5]

City-Airport	Airport ID	Rank	Enplanements FY93	Enplanements FY94	% Growth
Albuquerque Int'l Airport	ABQ	43	2,731,804	2,989,398	9.4
Newark Int'l Airport	EWR	44	12,413,976	13,564,615	9.3
Sacramento Metropolitan Airport	SMF	45	2,575,203	2,813,709	9.3
Fort Myers SW Florida Regional Airport	RSW	46	1,765,317	1,923,630	9.0
Greater Rochester Int'l Airport	ROC	47	1,156,295	1,257,907	8.8
Austin Robert Mueller Municipal Airport	AUS	48	2,263,168	2,461,562	8.8
Dallas-Love Field	DAL	49	3,117,194	3,374,457	8.3
Richmond Int'l Airport	RIC	50	996,126	1,077,193	8.1
Birmingham Airport	BHM	51	1,018,261	1,099,815	8.0
Houston Intercontinental Airport	IAH	52	9,378,643	10,118,565	7.9
Greater Pittsburgh Int'l Airport	PIT	53	9,040,795	9,743,873	7.8
San Diego Int'l Lindberg Field	SAN	54	5,833,845	6,277,920	7.6
Providence Green State Airport	PVD	55	1,111,990	1,192,157	7.2
Colorado Springs Municipal Airport	COS	56	733,632	786,073	7.1
Boston Logan Int'l Airport	BOS	57	11,067,239	11,789,385	6.5
Grand Rapids Kent County Int'l Airport	GRR	58	708,617	754,480	6.5
Miami Int'l Airport	MIA	59	13,691,750	14,561,222	6.4
San Francisco Int'l Airport	SFO	60	15,183,917	16,146,552	6.3
Los Angeles Int'l Airport	LAX	61	23,019,470	24,457,010	6.2
Memphis Int'l Airport	MEM	62	3,737,696	3,966,916	6.1
Oklahoma City Will Rogers World Airport	OKC	63	1,517,153	1,609,280	6.1
Hilo Int'l Airport	ITO	64	664,337	702,798	5.8
New York LaGuardia Airport	LGA	65	9,635,072	10,192,077	5.8
San Antonio Int'l Airport	SAT	66	2,791,944	2,950,234	5.7
Anchorage Int'l Airport	ANC	67	2,150,031	2,262,242	5.2
Washington Dulles Int'l Airport	IAD	68	5,204,382	5,473,123	5.2
New York John F. Kennedy Int'l Airport	JFK	69	12,960,386	13,627,089	5.1
Minneapolis-St. Paul Int'l Airport	MSP	70	10,865,387	11,410,274	5.0
Denver Stapleton Int'l Airport	DEN	71	15,032,318	15,755,747	4.8
Bangor Int'l Airport	BGR	72	1,026,173	1,074,098	4.7
Philadelphia Int'l Airport	PHL	73	7,985,716	8,352,442	4.6
Ontario Int'l Airport	ONT	74	3,039,228	3,178,766	4.6
Kahului Airport	OGG	75	2,492,404	2,597,947	4.2
Albany County Airport	ALB	76	1,022,257	1,062,679	4.0
Honolulu Int'l Airport	HNL	77	11,002,537	11,425,428	3.8
San Juan Luis Muñoz Marín Int'l Airport	SJU	78	4,359,528	4,524,337	3.8
El Paso Int'l Airport	ELP	79	1,752,724	1,813,373	3.5
Tulsa Int'l Airport	TUL	80	1,452,482	1,499,641	3.2
Indianapolis Int'l Airport	IND	81	2,971,961	3,051,267	2.7
Orlando Int'l Airport	MCO	82	10,258,281	10,531,965	2.7
Portland Int'l Jetport	PWM	83	570,925	582,069	2.0
Des Moines Int'l Airport	DSM	84	663,453	675,356	1.8

5. At the top 100 airports, ranked by growth in total enplanments.

Table A-4. Growth in Enplanements From 1993 to 1994[5]

City-Airport	Airport ID	Rank	Enplanements FY93	Enplanements FY94	% Growth
Dallas-Fort Worth Int'l Airport	DFW	85	25,143,882	25,514,422	1.5
Bradley Int'l Airport	BDL	86	2,279,198	2,310,816	1.4
Midland Int'l Airport	MAF	87	544,189	551,273	1.3
Chicago O'Hare Int'l Airport	ORD	88	30,252,671	30,549,625	1.0
Lubbock Int'l Airport	LBB	89	596,088	600,773	0.8
Harrisburg Int'l Airport	MDT	90	671,998	676,968	0.7
Knoxville McGhee-Tyson Airport	TYS	91	642,658	647,019	0.7
Washington National Airport	DCA	92	7,552,956	7,553,357	0.0
Kailua-Kona Keahole	KOA	93	1,117,538	1,106,614	-1.0
Charlotte Amalie St. Thomas, Virgin Islands	STT	94	630,855	620,085	-1.7
Sarasota Bradenton Airport	SRQ	95	876,042	859,917	-1.8
Syracuse Hancock Int'l Airport	SYR	96	1,085,866	1,045,438	-3.7
Houston William P. Hobby Airport	HOU	97	4,073,080	3,915,653	-3.9
Raleigh-Durham Int'l Airport	RDU	98	4,849,312	4,562,270	-5.9
Wichita Mid-Continent Airport	ICT	99	592,633	544,439	-8.1
Nashville Int'l Airport	BNA	100	4,667,875	4,261,810	-8.7

Totals: 1993 Enplanements 480,211,169
1994 Enplanements 522,376,979
Average forecast growth at the top 100 airports 8.8

5. At the top 100 airports, ranked by growth in total enplanments.

Table A-5. Growth in Operations From 1993 to 1994[6]

City-Airport	Airport ID	Rank	Operations FY93	Operations FY94	% Growth
Lihue Airport	LIH	1	57,686	92,542	60.4
Chicago Midway Airport	MDW	2	189,755	254,570	34.2
Charleston AFB Int'l Airport	CHS	3	114,427	151,674	32.6
Greensboro Piedmont Triad Int'l Airport	GSO	4	126,446	157,401	24.5
New Orleans Int'l Airport	MSY	5	141,384	167,375	18.4
Dayton Int'l Airport	DAY	6	132,234	154,481	16.8
Louisville Standiford Field	SDF	7	155,941	179,921	15.4
Las Vegas McCarran Int'l Airport	LAS	8	439,393	488,347	11.1
Kailua-Kona Keahole	KOA	9	60,393	66,821	10.6
Jacksonville Int'l Airport	JAX	10	129,683	142,821	10.1
Greer Greenville-Spartanburg Airport	GSP	11	56,855	62,526	10.0
Tampa Int'l Airport	TPA	12	240,425	263,541	9.6
Baltimore-Washington Int'l Airport	BWI	13	261,674	286,392	9.4
Tucson Int'l Airport	TUS	14	228,877	249,729	9.1
Greater Cincinnati Int'l Airport	CVG	15	306,811	333,832	8.8
San Antonio Int'l Airport	SAT	16	219,305	238,277	8.7
Milwaukee General Mitchell Int'l Airport	MKE	17	198,529	213,602	7.6
Kansas City Int'l Airport	MCI	18	184,848	198,274	7.3
Omaha Eppley Airfield	OMA	19	143,739	154,154	7.2
Metropolitan Oakland Int'l Airport	OAK	20	439,214	470,901	7.2
Fort Lauderdale-Hollywood Int'l Airport	FLL	21	217,786	233,044	7.0
Washington Dulles Int'l Airport	IAD	22	277,483	296,201	6.7
William B. Hartsfield Atlanta Int'l Airport	ATL	23	658,414	699,400	6.2
Salt Lake City Int'l Airport	SLC	24	324,595	343,807	5.9
Lambert St. Louis Int'l Airport	STL	25	441,142	466,639	5.8
Charlotte/Douglas Int'l Airport	CLT	26	446,315	471,128	5.6
Tulsa Int'l Airport	TUL	27	188,009	198,332	5.5
Norfolk Int'l Airport	ORF	28	134,564	141,861	5.4
Albuquerque Int'l Airport	ABQ	29	209,567	220,914	5.4
Dallas-Fort Worth Int'l Airport	DFW	30	789,183	831,135	5.3
Boise Air Terminal	BOI	31	155,166	163,306	5.2
Cleveland Hopkins Int'l Airport	CLE	32	247,502	260,485	5.2
Orlando Int'l Airport	MCO	33	327,199	344,213	5.2
Columbia Metropolitan Airport	CAE	34	103,202	108,410	5.0
Charlotte Amalie St. Thomas, Virgin Islands	STT	35	105,217	109,958	4.5
El Paso Int'l Airport	ELP	36	151,284	157,984	4.4
Miami Int'l Airport	MIA	37	527,545	550,194	4.3
Detroit Metropolitan Wayne County Airport	DTW	38	460,009	479,738	4.3
Des Moines Int'l Airport	DSM	39	128,797	133,954	4.0
Greater Pittsburgh Int'l Airport	PIT	40	419,581	435,433	3.8
Ontario Int'l Airport	ONT	41	152,914	158,635	3.7
Chicago O'Hare Int'l Airport	ORD	42	851,865	883,480	3.7

6. At the top 100 airports, ranked by growth in total operations.

Table A-5. Growth in Operations From 1993 to 1994[6]

City-Airport	Airport ID	Rank	Operations FY93	FY94	% Growth
Philadelphia Int'l Airport	PHL	43	390,736	402,845	3.1
Port Columbus Int'l Airport	CMH	44	217,049	223,633	3.0
Santa Ana John Wayne Airport	SNA	45	494,378	509,220	3.0
Oklahoma City Will Rogers World Airport	OKC	46	142,492	146,759	3.0
San Diego Int'l Lindberg Field	SAN	47	209,267	215,215	2.8
Minneapolis-St. Paul Int'l Airport	MSP	48	442,341	454,441	2.7
Grand Rapids Kent County Int'l Airport	GRR	49	150,313	154,264	2.6
Memphis Int'l Airport	MEM	50	337,608	345,534	2.3
Newark Int'l Airport	EWR	51	431,944	441,997	2.3
Greater Buffalo Int'l Airport	BUF	52	142,136	145,221	2.2
Austin Robert Mueller Municipal Airport	AUS	53	188,026	192,040	2.1
Dallas-Love Field	DAL	54	212,854	217,331	2.1
Kahului Airport	OGG	55	173,002	176,209	1.9
Lubbock Int'l Airport	LBB	56	103,112	104,968	1.8
San Francisco Int'l Airport	SFO	57	423,404	430,380	1.6
Seattle-Tacoma Int'l Airport	SEA	58	339,968	345,052	1.5
Little Rock Adams Field	LIT	59	171,399	173,126	1.0
Los Angeles Int'l Airport	LAX	60	681,845	687,627	0.8
Greater Rochester Int'l Airport	ROC	61	188,072	189,372	0.7
New York John F. Kennedy Int'l Airport	JFK	62	351,205	352,494	0.4
Spokane Int'l Airport	GEG	63	122,350	122,615	0.2
New York LaGuardia Airport	LGA	64	335,071	335,539	0.1
Houston Intercontinental Airport	IAH	65	352,340	352,385	0.0
Washington National Airport	DCA	66	316,762	316,790	0.0
Indianapolis Int'l Airport	IND	67	238,789	237,937	-0.4
Midland Int'l Airport	MAF	68	93,294	92,853	-0.5
Reno Cannon Int'l Airport	RNO	69	162,441	161,190	-0.8
Richmond Int'l Airport	RIC	70	154,925	153,589	-0.9
Denver Stapleton Int'l Airport	DEN	71	552,238	546,305	-1.1
Portland Int'l Airport	PDX	72	280,263	277,000	-1.2
Hilo Int'l Airport	ITO	73	91,903	90,802	-1.2
Albany County Airport	ALB	74	160,587	158,658	-1.2
Anchorage Int'l Airport	ANC	75	218,279	215,641	-1.2
Houston William P. Hobby Airport	HOU	76	239,634	236,683	-1.2
Fort Myers SW Florida Regional Airport	RSW	77	66,004	64,849	-1.7
Providence Green State Airport	PVD	78	125,442	123,195	-1.8
Knoxville McGhee-Tyson Airport	TYS	79	130,368	128,032	-1.8
Honolulu Int'l Airport	HNL	80	365,195	357,116	-2.2
Bradley Int'l Airport	BDL	81	166,889	163,180	-2.2
Phoenix Sky Harbor Int'l Airport	PHX	82	520,403	507,698	-2.4
Colorado Springs Municipal Airport	COS	83	246,732	239,885	-2.8
Islip Long Island Mac Arthur Airport	ISP	84	195,198	189,663	-2.8

6. At the top 100 airports, ranked by growth in total operations.

Table A-5. Growth in Operations From 1993 to 1994[6]

City-Airport	Airport ID	Rank	Operations FY93	FY94	% Growth
San Juan Luis Muñoz Marín Int'l Airport	SJU	85	180,567	174,598	-3.3
Boston Logan Int'l Airport	BOS	86	495,347	478,660	-3.4
Raleigh-Durham Int'l Airport	RDU	87	294,066	283,713	-3.5
Sarasota Bradenton Airport	SRQ	88	152,722	147,115	-3.7
Birmingham Airport	BHM	89	168,074	161,638	-3.8
Wichita Mid-Continent Airport	ICT	90	174,527	167,757	-3.9
San Jose Int'l Airport	SJC	91	312,405	298,220	-4.5
Harrisburg Int'l Airport	MDT	92	86,427	82,405	-4.7
Palm Beach Int'l Airport	PBI	93	230,903	216,480	-6.2
Burbank-Glendale-Pasadena Airport	BUR	94	207,460	194,264	-6.4
Savannah Int'l Airport	SAV	95	104,681	97,509	-6.9
Nashville Int'l Airport	BNA	96	318,886	295,558	-7.3
Portland Int'l Jetport	PWM	97	126,353	114,162	-9.6
Sacramento Metropolitan Airport	SMF	98	169,272	149,053	-11.9
Syracuse Hancock Int'l Airport	SYR	99	180,936	158,677	-12.3
Bangor Int'l Airport	BGR	100	107,657	93,048	-13.6

Totals: 1993 Operations 25,381,499
1994 Operations 26,107,622
Average forecast growth at the top 100 airports 2.9

6. At the top 100 airports, ranked by growth in total operations.

Table A-6. Growth in Operations and Enplanements[7]

City-Airport	Airport ID	% Growth in Enplanements FY93-FY94	% Growth in Enplanements FY94-FY2010	% Growth in Operations FY93-FY94	% Growth in Operations FY94-FY2010
Albuquerque Int'l Airport	ABQ	9.4	100.3	5.4	12.7
Albany County Airport	ALB	4	81.9	-1.2	16
Anchorage Int'l Airport	ANC	5.2	83.1	-1.2	23.8
William B. Hartsfield Atlanta Int'l Airport	ATL	13.8	61.6	6.2	44.7
Austin Robert Mueller Municipal Airport	AUS	8.8	102.2	2.1	27.6
Bradley Int'l Airport	BDL	1.4	97.9	-2.2	26.2
Bangor Int'l Airport	BGR	4.7	68.5	-13.6	17.1
Birmingham Airport	BHM	8	100.8	-3.8	7.6
Nashville Int'l Airport	BNA	-8.7	132.5	-7.3	38.4
Boise Air Terminal	BOI	29.5	121.2	5.2	64.1
Boston Logan Int'l Airport	BOS	6.5	71.3	-3.4	22.2
Greater Buffalo Int'l Airport	BUF	16.6	70.5	2.2	24.6
Burbank-Glendale-Pasadena Airport	BUR	14.4	75	-6.4	27.1
Baltimore-Washington Int'l Airport	BWI	38.2	121.4	9.4	38.6
Columbia Metropolitan Airport	CAE	11.8	131.9	5	7.9
Charleston AFB Int'l Airport	CHS	35.1	97.2	32.6	4.8
Cleveland Hopkins Int'l Airport	CLE	17.5	90	5.2	43.6
Charlotte/Douglas Int'l Airport	CLT	18.1	115.7	5.6	54.5
Port Columbus Int'l Airport	CMH	12.5	68.3	3	34.1
Colorado Springs Municipal Airport	COS	7.1	109.3	-2.8	57.2
Greater Cincinnati Int'l Airport	CVG	10.3	144.2	8.8	85.4
Dallas-Love Field	DAL	8.3	118.7	2.1	3.1
Dayton Int'l Airport	DAY	19.1	199.7	16.8	39.2
Washington National Airport	DCA	0	32.8	0	8.9
Denver Stapleton Int'l Airport	DEN	4.8	66.4	-1.1	15.9
Dallas-Fort Worth Int'l Airport	DFW	1.5	103.1	5.3	34.5
Des Moines Int'l Airport	DSM	1.8	96.2	4	19.4
Detroit Metropolitan Wayne County Airport	DTW	11	116.7	4.3	50.3
El Paso Int'l Airport	ELP	3.5	76.4	4.4	5.1
Newark Int'l Airport	EWR	9.3	48.8	2.3	9.7
Fort Lauderdale-Hollywood Int'l Airport	FLL	21.5	90.9	7	31.3
Spokane Int'l Airport	GEG	25.7	56.4	0.2	15.8
Grand Rapids Kent County Int'l Airport	GRR	6.5	104.5	2.6	40.7
Greensboro Piedmont Triad Int'l Airport	GSO	91.1	109	24.5	27.7
Greer Greenville-Spartanburg Airport	GSP	23.2	135.5	10	24.7
Honolulu Int'l Airport	HNL	3.8	91	-2.2	39.2
Houston William P. Hobby Airport	HOU	-3.9	155.7	-1.2	46.6
Washington Dulles Int'l Airport	IAD	5.2	129.8	6.7	65.4
Houston Intercontinental Airport	IAH	7.9	90	0	32.5
Wichita Mid-Continent Airport	ICT	-8.1	92.7	-3.9	44.3
Indianapolis Int'l Airport	IND	2.7	112.2	-0.4	43.3
Islip Long Island Mac Arthur Airport	ISP	10	164.6	-2.8	-6.1

7. At the top 100 airports, listed in alphabetical order by Airport Identifier.

Table A-6. Growth in Operations and Enplanements[7]

City-Airport	Airport ID	% Growth in Enplanements FY93-FY94	% Growth in Enplanements FY94-FY2010	% Growth in Operations FY93-FY94	% Growth in Operations FY94-FY2010
Hilo Int'l Airport	ITO	5.8	161	-1.2	50.9
Jacksonville Int'l Airport	JAX	42.7	96.8	10.1	27.4
New York John F. Kennedy Int'l Airport	JFK	5.1	45.3	0.4	16.6
Kailua-Kona Keahole	KOA	-1	195.2	10.6	88.6
Las Vegas McCarran Int'l Airport	LAS	19.8	101.5	11.1	49.3
Los Angeles Int'l Airport	LAX	6.2	48.5	0.8	31.6
Lubbock Int'l Airport	LBB	0.8	49.8	1.8	3.8
New York LaGuardia Airport	LGA	5.8	77.5	0.1	7.6
Lihue Airport	LIH	41.1	90.2	60.4	18.9
Little Rock Adams Field	LIT	9.8	113.2	1	12.6
Midland Int'l Airport	MAF	1.3	92.6	-0.5	-22.5
Kansas City Int'l Airport	MCI	13.1	51.2	7.3	17.5
Orlando Int'l Airport	MCO	2.7	139.9	5.2	74.6
Harrisburg Int'l Airport	MDT	0.7	95	-4.7	10.4
Chicago Midway Airport	MDW	50	168.6	34.2	46.1
Memphis Int'l Airport	MEM	6.1	180.4	2.3	35.7
Miami Int'l Airport	MIA	6.4	81.3	4.3	45.8
Milwaukee General Mitchell Int'l Airport	MKE	10.4	91.4	7.6	30.1
Minneapolis-St. Paul Int'l Airport	MSP	5	93.3	2.7	52.5
New Orleans Int'l Airport	MSY	16	43.9	18.4	19.5
Metropolitan Oakland Int'l Airport	OAK	12.2	75.9	7.2	17.4
Kahului Airport	OGG	4.2	75.8	1.9	10.7
Oklahoma City Will Rogers World Airport	OKC	6.1	65.4	3	0.2
Omaha Eppley Airfield	OMA	11	73.8	7.2	21.3
Ontario Int'l Airport	ONT	4.6	157.7	3.7	64.5
Chicago O'Hare Int'l Airport	ORD	1	83.1	3.7	9.3
Norfolk Int'l Airport	ORF	35.8	86.5	5.4	13.5
Palm Beach Int'l Airport	PBI	11.8	90.1	-6.2	15
Portland Int'l Airport	PDX	17.5	102.8	-1.2	45.8
Philadelphia Int'l Airport	PHL	4.6	127.1	3.1	42.5
Phoenix Sky Harbor Int'l Airport	PHX	10	117.7	-2.4	33.3
Greater Pittsburgh Int'l Airport	PIT	7.8	70	3.8	30.4
Providence Green State Airport	PVD	7.2	127.3	-1.8	12.8
Portland Int'l Jetport	PWM	2	162.2	-9.6	18.3
Raleigh-Durham Int'l Airport	RDU	-5.9	14.7	-3.5	-23.9
Richmond Int'l Airport	RIC	8.1	111	-0.9	16.5
Reno Cannon Int'l Airport	RNO	13.7	141.2	-0.8	37.7
Greater Rochester Int'l Airport	ROC	8.8	140	0.7	12.5
Fort Myers SW Florida Regional Airport	RSW	9	173.2	-1.7	88.1
San Diego Int'l Lindberg Field	SAN	7.6	78	2.8	49.6
San Antonio Int'l Airport	SAT	5.7	83.4	8.7	10.4
Savannah Int'l Airport	SAV	13.7	134.8	-6.9	19

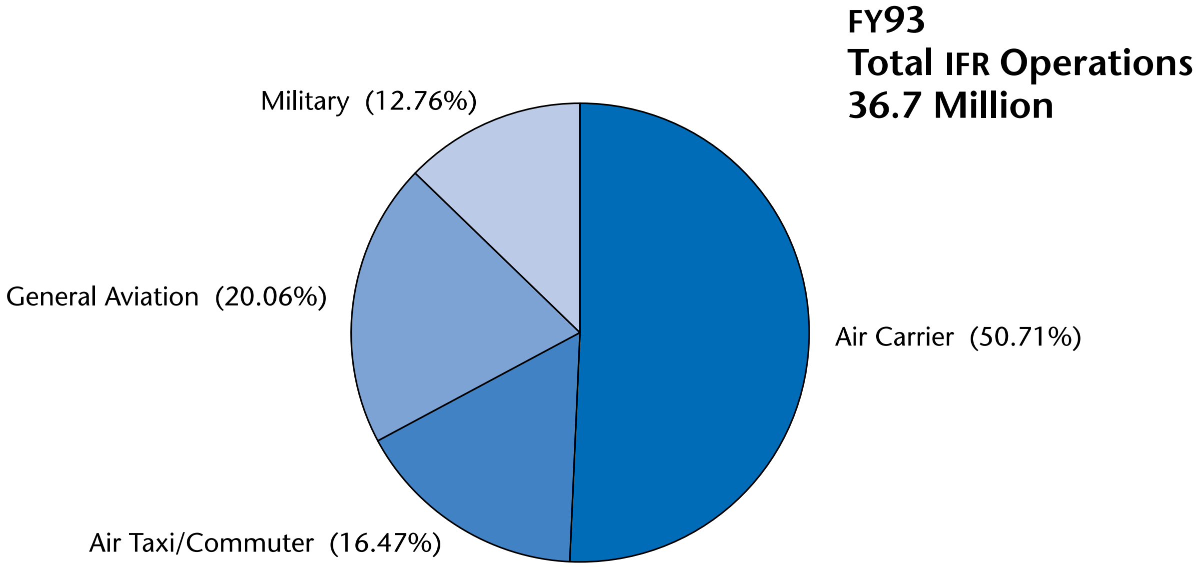
7. At the top 100 airports, listed in alphabetical order by Airport Identifier.

Table A-6. Growth in Operations and Enplanements[7]

City-Airport	Airport ID	% Growth in Enplanements FY93-FY94	% Growth in Enplanements FY94-FY2010	% Growth in Operations FY93-FY94	% Growth in Operations FY94-FY2010
Louisville Standiford Field	SDF	36.6	95.8	15.4	37.3
Seattle-Tacoma Int'l Airport	SEA	14.7	90.2	1.5	44.6
San Francisco Int'l Airport	SFO	6.3	78.7	1.6	25.5
San Jose Int'l Airport	SJC	22.1	129.4	-4.5	3.3
San Juan Luis Muñoz Marín Int'l Airport	SJU	3.8	75.3	-3.3	14.5
Salt Lake City Int'l Airport	SLC	17.8	138.7	5.9	45.4
Sacramento Metropolitan Airport	SMF	9.3	87.7	-11.9	32.8
Santa Ana John Wayne Airport	SNA	14.7	150.7	3	23.9
Sarasota Bradenton Airport	SRQ	-1.8	45.8	-3.7	10.1
Lambert St. Louis Int'l Airport	STL	14.6	76.8	5.8	25.4
Charlotte Amalie St. Thomas, Virgin Islands	STT	-1.7	110.6	4.5	36.4
Syracuse Hancock Int'l Airport	SYR	-3.7	147.3	-12.3	24.8
Tampa Int'l Airport	TPA	22.5	75.9	9.6	23.3
Tulsa Int'l Airport	TUL	3.2	84.6	5.5	-12.3
Tucson Int'l Airport	TUS	25.7	73.1	9.1	2.9
Knoxville McGhee-Tyson Airport	TYS	0.7	82.1	-1.8	15.6

Totals: Average growth at the top 100 airports .... 8.8 .... 2.9
Average forecast growth at the top 100 airports for the 16 year period ...... 90.4 .... 29.6

7. At the top 100 airports, listed in alphabetical order by Airport Identifier.



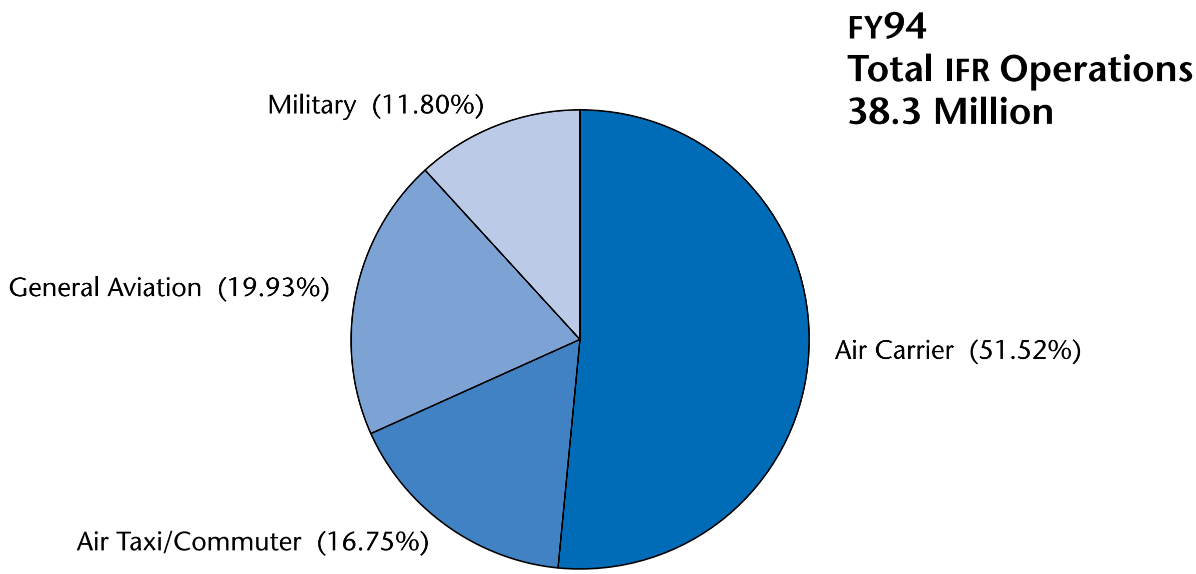
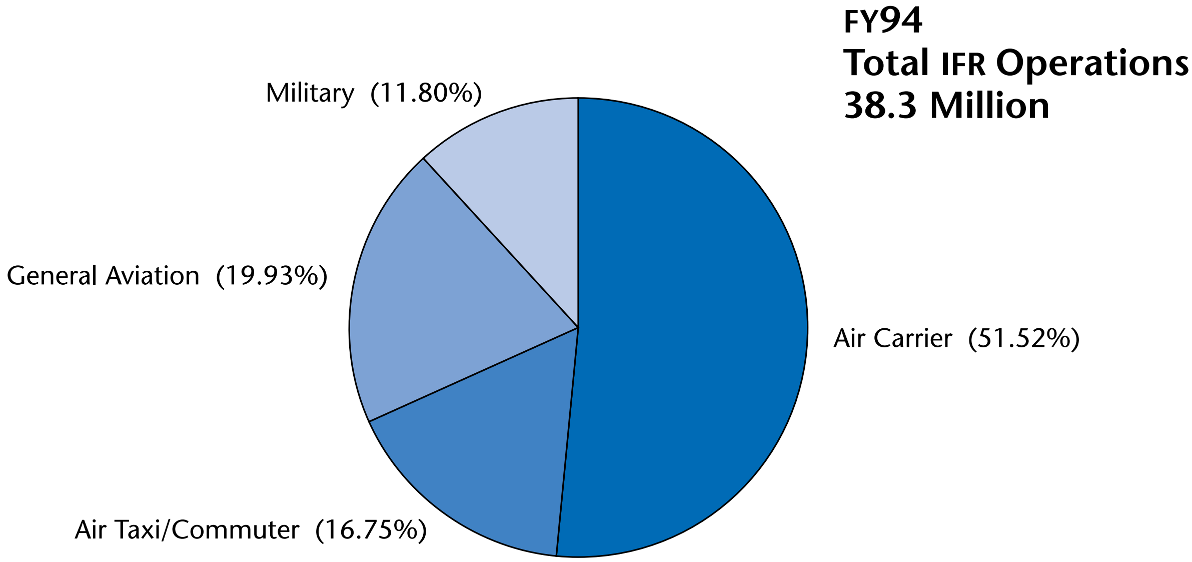


Figure A-1. Traffic Handled by ARTCCS, FY93 and FY94



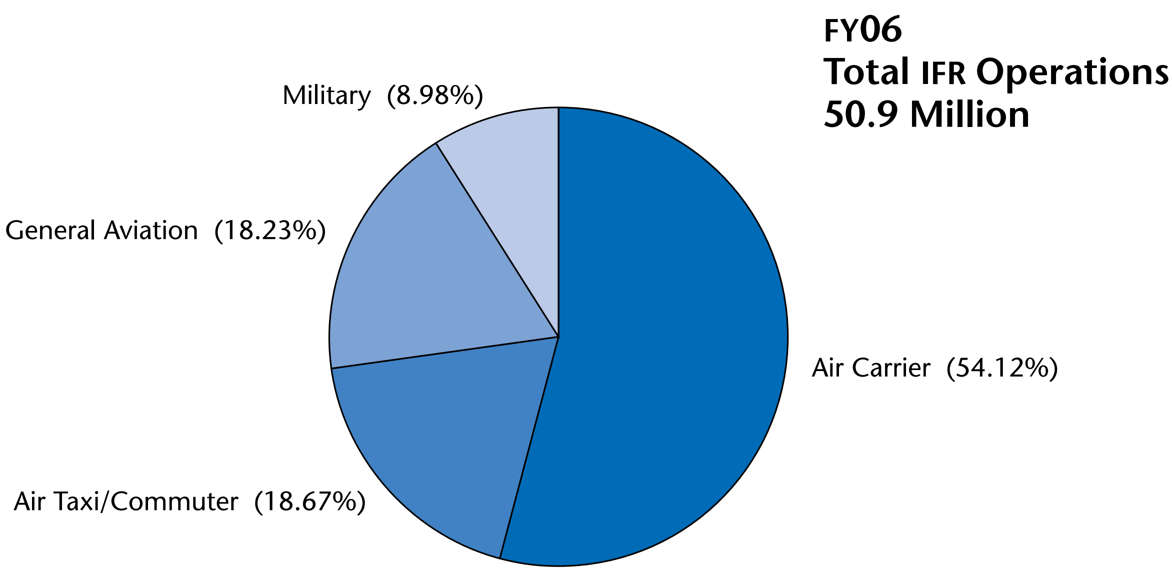


Figure A-2. Traffic Handled by ARTCCs, FY94 and Forecast FY06

Table A-7. Total IFR Aircraft Handled at ARTCCs

	Operations (000)			
Center	FY93	FY94	FY06	% Growth '94-'06
Albuquerque (ZAB)	1,362	1,402	1,730	23.4
Atlanta (ZTL)	2,266	2,394	3,466	44.8
Boston (ZBU)	1,611	1,612	2,079	29.0
Chicago (ZAU)	2,637	2,816	3,591	27.5
Cleveland (ZOB)	2,450	2,597	4,262	64.1
Fort Worth (ZFW)	2,026	2,072	2,576	24.3
Denver (ZDV)	1,451	1,452	1,777	22.4
Houston (ZHU)	1,728	1,847	2,234	21.0
Indianapolis (ZID)	1,947	2,131	3,036	42.5
Jacksonville (ZJX)	1,708	1,796	2,246	25.1
Kansas City (ZKC)	1,789	1,866	2,714	45.4
Los Angeles (ZLA)	1,791	1,832	2,350	28.3
Memphis (ZME)	1,919	1,967	2,375	20.7
Miami (ZMA)	1,831	1,940	2,542	31.0
Minneapolis (ZMP)	1,862	1,943	2,936	51.1
New York (ZNY)	2,023	2,046	2,555	24.9
Oakland (ZOA)	1,515	1,506	1,985	31.8
Salt Lake City (ZLC)	1,355	1,348	1,805	33.9
Seattle (ZSE)	1,374	1,349	1,668	23.6
Washington (ZDC)	2,215	2,336	2,930	25.4

Source: *Forecast of IFR Aircraft Handled by ARTCC FY95-06, May 1995*

Appendix B

Airport Diagram Directory

State	Airport	ID	Where
Alaska	Anchorage Int'l	ANC	Appendix E
Alabama	Birmingham Municipal	BHM	Appendix E
Arkansas	Little Rock Adams Field	LIT	Appendix D
Arizona	Phoenix Sky Harbor Int'l	PHX	Appendix D
	Tucson Int'l	TUS	Appendix D
California	Burbank-Glendale-Pasadena	BUR	Appendix E
	Los Angeles Int'l	LAX	Appendix E
	Oakland Metro Int'l	OAK	Appendix D
	Ontario Int'l	ONT	Appendix E
	Sacramento Int'l	SMF	Appendix E
	San Diego Int'-Lindbergh Field	SAN	Appendix E
	San Francisco Int'l	SFO	Appendix E
	San Jose Int'l	SJC	Appendix E
	Santa Ana/John Wayne Airport	SNA	Appendix D

State	Airport	ID	Where
Colorado	Colorado Springs Municipal	COS	Appendix E
	Denver Int'l Airport	DEN	Appendix D
	Denver Stapleton Int'l (closed)	DEN	Appendix E
Connecticut	Windsor Locks Bradley Int'l	BDL	Appendix E
District of Columbia	Washington Dulles Int'l	IAD	Appendix D
	Washington National	DCA	Appendix E
Florida	Fort Lauderdale Int'l	FLL	Appendix D
	Fort Myers SW Florida Regional	RSW	Appendix D
	Jacksonville Int'l	JAX	Appendix D
	Miami Int'l	MIA	Appendix D
	Orlando Int'l	MCO	Appendix D
	Sarasota-Bradenton	SRQ	Appendix D
	Tampa Int'l	TPA	Appendix D
	West Palm Beach Int'l	PBI	Appendix D
Georgia	Atlanta Hartsfield Int'l	ATL	Appendix D
	Savanah Airport	SAV	Appendix D
Hawaii	Hilo General Lyman	ITO	Appendix E
	Honolulu Int'l	HNL	Appendix E
	Kahului	OGG	Appendix D
	Kailua-Kona Keahole	KOA	Appendix E
	Lihue	LIH	Appendix E
Iowa	Des Moines Int'l	DSM	Appendix D
Idaho	Boise Air-Terminal	BOI	Appendix D
Illinois	Chicago Midway	MDW	Appendix D
	Chicago O'Hare Int'l	ORD	Appendix E
Indiana	Indianapolis Int'l	IND	Appendix E
Kansas	Wichita Mid-Continent	ICT	Appendix E
Kentucky	Louisville Standiford Field	SDF	Appendix D
Louisiana	New Orleans Int'l	MSY	Appendix D
Massachusetts	Boston Logan Int'l	BOS	Appendix D
Maryland	Baltimore-Washington Int'l	BWI	Appendix D
Maine	Bangor International Airport	BGR	Appendix E
	Portland Int'l Jetport	PWM	Appendix E
Michigan	Detroit Metro Wayne County	DTW	Appendix D
	Grand Rapids Kent County Int'l	GRR	Appendix D
Minnesota	Minneapolis-St. Paul Int'l	MSP	Appendix D
Missouri	Kansas City Int'l	MCI	Appendix D
	Lambert St. Louis Int'l	STL	Appendix D
North Carolina	Charlotte/Douglas Int'l	CLT	Appendix D
	Greensboro Piedmont Int'l	GSO	Appendix D
	Raleigh-Durham Int'l	RDU	Appendix D
Nebraska	Omaha Eppley Airfield	OMA	Appendix D
New Jersey	Newark Int'l	EWR	Appendix D
New Mexico	Albuquerque Int'l	ABQ	Appendix E

State	Airport	ID	Where
Nevada	Las Vegas McCarran Int'l	LAS	Appendix D
	Reno/Tahoe Int'l	RNO	Appendix E
New York	Albany County	ALB	Appendix D
	Buffalo Int'l	BUF	Appendix D
	Islip Long Island	ISP	Appendix E
	John F. Kennedy Int'l	JFK	Appendix E
	LaGuardia	LGA	Appendix E
	Rochester Monroe County	ROC	Appendix D
	Syracuse Hancock Int'l	SYR	Appendix D
Ohio	Cincinnati Int'l	CVG	Appendix D
	Cleveland Hopkins Int'l	CLE	Appendix D
	Dayton Int'l	DAY	Appendix E
	Port Columbus Int'l	CMH	Appendix D
Oklahoma	Oklahoma City Will Rogers	OKC	Appendix D
	Tulsa Int'l	TUL	Appendix D
Oregon	Portland Int'l	PDX	Appendix E
Pennsylvania	Harrisburg Int'l	MDT	Appendix E
	Philadelphia Int'l	PHL	Appendix D
	Pittsburgh Int'l	PIT	Appendix D
Rhode Island	Providence Green State	PVD	Appendix E
South Carolina	Charleston Int'l	CHS	Appendix E
	Columbia Metropolitan	CAE	Appendix E
	Greer Greenville-Spartanburg	GSP	Appendix D
Tennessee	Knoxville McGhee-Tyson	TYS	Appendix E
	Memphis Int'l	MEM	Appendix D
	Nashville Int'l	BNA	Appendix D
Texas	Austin Robert Mueller Municipal	AUS	Appendix E
	Bergstrom AFB (new Austin)	BSM	Appendix D
	Dallas-Fort Worth Int'l	DFW	Appendix D
	Dallas Love Field	DAL	Appendix E
	El Paso Int'l	ELP	Appendix D
	Houston Hobby	HOU	Appendix E
	Houston Intercontinental	IAH	Appendix D
	Lubbock Int'l	LBB	Appendix D
	Midland Int'l	MAF	Appendix D
	San Antonio Int'l	SAT	Appendix D
Utah	Salt Lake City Int'l	SLC	Appendix E
Virginia	Norfolk Int'l	ORF	Appendix D
	Richmond Int'l	RIC	Appendix D
Washington	Seattle-Tacoma Int'l	SEA	Appendix D
	Spokane Int'l	GEG	Appendix D
Wisconsin	Milwaukee Mitchell Int'l	MKE	Appendix D
Puerto Rico	San Juan Luis Muñoz Marín Int'l	SJU	Appendix E
Virgin Islands	Charlotte Amalie St. Thomas	STT	Appendix E

Appendix C

Airport Capacity Design Team Program[1]

Background

Recognizing the problems posed by congestion and delay within the National Airspace System, the Federal Aviation Administration (FAA) asked the aviation community to study the problem of airport congestion through the Industry Task Force on Airport Capacity Improvement and Delay Reduction chaired by the Airport Operators Council International.

By 1984, aircraft delays recorded throughout the system highlighted the need for more centralized management and coordination of activities to relieve airport congestion. In response, the FAA established the Airport Capacity Program Office, now called the Office of System Capacity (ASC). The goal of this office and its capacity enhancement program is to identify and evaluate initiatives that have the potential to increase capacity, so that current and projected levels of demand can be accommodated within the system with a minimum of delay and without compromising safety or the environment.

In 1985, the FAA initiated a renewed program of Airport Capacity Design Teams at various major air carrier airports throughout the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand and works to develop a coordinated action plan for reducing airport delay. Over 35 Airport Capacity Design Teams have either completed their studies or have work in progress.

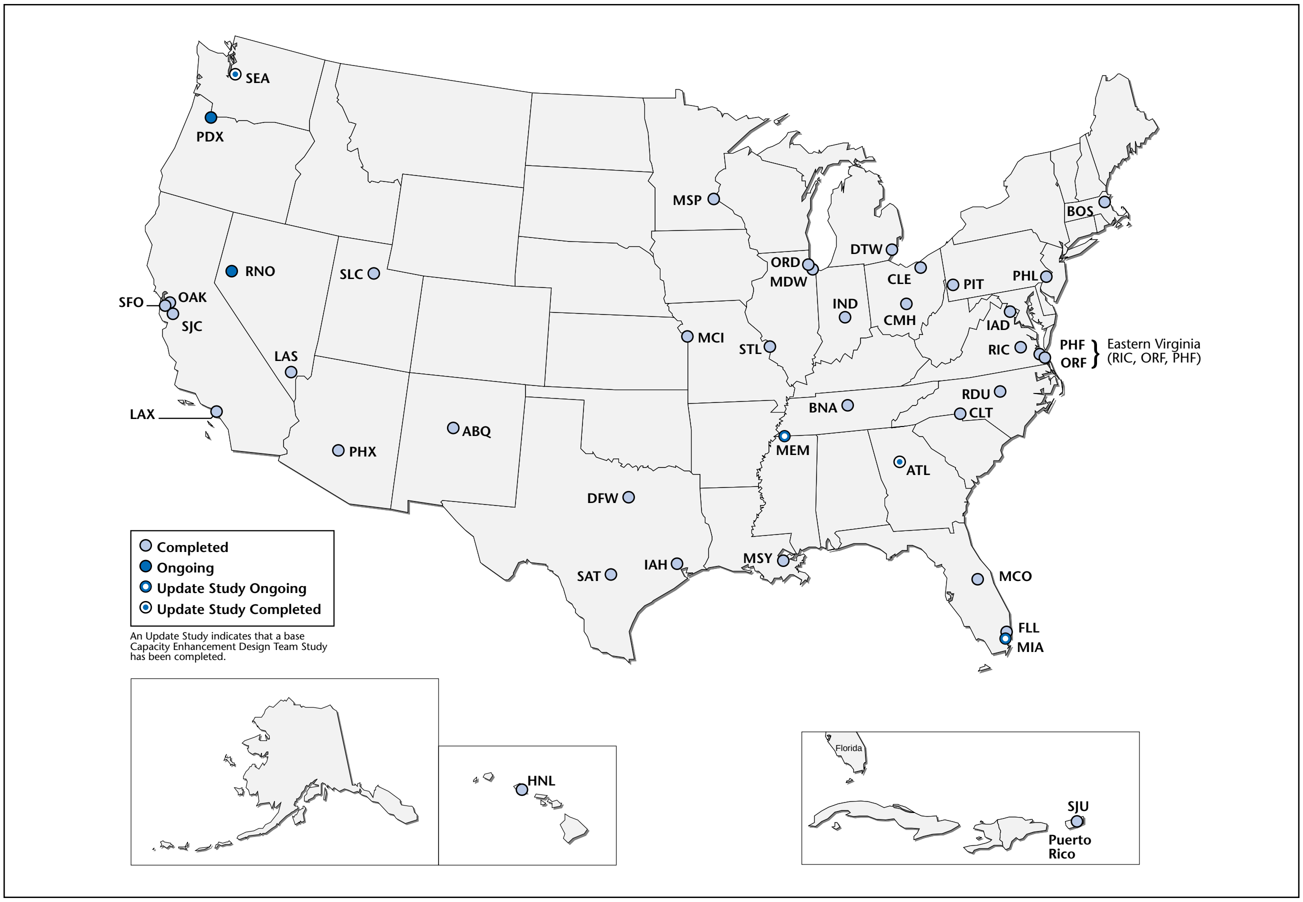
The need for this program continues. In 1994, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 29 by 2004. The challenge for the air transportation industry in the nineties is to enhance existing airport and airspace capacity and to develop new facilities to handle future demand. As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the U.S., an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

Objectives

The major goal of a Capacity Team is to identify and evaluate proposals to increase airport capacity, improve airport efficiency, and reduce aircraft delays while maintaining or improving aviation safety. To achieve this objective, the Capacity Team:

- Assesses the current airport capacity.
- Examines the causes of delay associated with the airfield, the immediate airspace, and the apron and gate-area operations.
- Evaluates capacity and delay benefits of alternative air traffic control (ATC) procedures, navigational improvements, airfield development, and operational improvements.

1. As of 02-01-96.



Scope

The Capacity Team limits its analyses to aircraft activity within the terminal area airspace and on the airfield. They consider the operational benefits of the proposed airfield improvements, but do not address environmental, socioeconomic, or political issues regarding airport development. These issues need to be addressed in future airport planning studies, and the data generated by the Capacity Team can be used in such studies.

Methodology

The Capacity Team, which includes representatives from the FAA, the airport authority of the airport under study, the appropriate State Department of Transportation, various aviation industry groups, and members of the local general aviation community meet periodically for review and coordination. The Capacity Team members consider suggested capacity improvement alternatives proposed by the FAA's Office of System Capacity, FAA Technical Center, Regional Aviation Capacity Program Manager, and by other members of the Team. Alternatives which are considered practicable are developed into experiments which can be tested by simulation modeling. The FAA Technical Center's Aviation Capacity Branch provides expertise in airport simulation modeling. The Capacity Team validates the data used as input for the simulation modeling and analysis and reviews the interpretation of the simulation results. The data, assumptions, alternatives, and experiments are continually reevaluated, and modified where necessary, as the study progresses. A primary goal of the study is to develop a set of capacity-producing recommendations, complete with planning and implementation time horizons.

Initial work consists of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions are based on actual field observations at the target airport. Proposed improvements are analyzed in relation to current and future demands with the help of FAA computer models, the Airport and Airspace Simulation Model (SIMMOD), the Runway Delay Simulation Model (RDSIM), and the Airfield Delay Simulator (ADSIM).

The simulation models consider Air Traffic Control procedures, airfield improvements, and traffic demands. Alternative airfield configurations are prepared from present and proposed airport layout plans. Various configurations are evaluated to assess the benefit of projected improvements. Air Traffic Control procedures and system improvements determine the aircraft separations to be used for simulations under both VFR and IFR.

Air traffic demand levels are derived from *Official Airline Guide* data, historical data, and Capacity Team and other forecasts. Aircraft volume, fleet mix, and peaking characteristics are considered for each of the three different demand forecast levels (Baseline, Future 1, and Future 2). From this, annual delay estimates are determined based on implementing various improvements. These estimates take into account historic variations in runway configuration, weather, and demand. Annual delay estimates for each configuration are then compared to identify delay reductions resulting from the improvements. Following the evaluation, the Capacity Team develops a plan of recommended alternatives for consideration.

Reports

Since the renewal of the program in 1985, 39 Airport Capacity Design Team studies have been completed. Currently, four Capacity Design Team studies or updates are in progress. The following listing provides locations and dates for completed studies.

Design Team Completion Dates

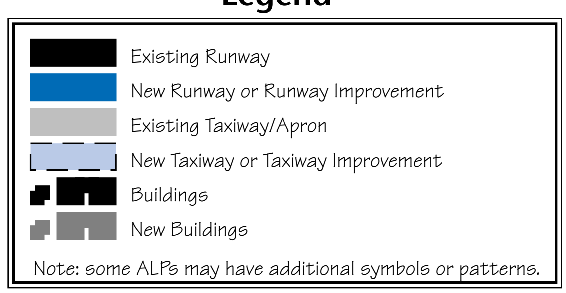
Albuquerque Int'l	1993
Boston Logan Int'l	1992
Charlotte/Douglas Int'l	1991
Chicago Midway	1991
Chicago O'Hare Int'l	1991
Cleveland-Hopkins Int'l	1994
Dallas-Ft. Worth Int'l	1994
Detroit Metropolitan Wayne County	1988
Eastern Virginia Region	1994
Fort Lauderdale-Hollywood Int'l	1993
Greater Pittsburgh Int'l	1991
Hartsfield Atlanta Int'l	1987
Hartsfield Atlanta Int'l Update	1995
Honolulu Int'l	1992
Houston Intercontinental	1993
Indianapolis Int'l	1993
Kansas City Int'l	1990
Lambert St. Louis Int'l	1988
Las Vegas McCarran Int'l	1994
Los Angeles Int'l	1991
Memphis Int'l	1988
Metropolitan Orlando Int'l	1990
Miami Int'l	1989
Minneapolis-Saint Paul Int'l	1993
Nashville Int'l	1991
New Orleans Int'l	1992
Oakland Int'l	1987
Philadelphia Int'l	1991
Phoenix Sky Harbor Int'l	1989
Port Columbus Int'l	1993
Raleigh-Durham Int'l	1991
Salt Lake City Int'l	1991
San Antonio Int'l	1992
San Francisco Int'l	1987
San Jose Int'l	1987
San Juan Luis Muñoz Marín Int'l	1991
Seattle-Tacoma Int'l	1991
Seattle-Tacoma Int'l Udate	1995
Washington Dulles Int'l	1990

Appendix D

New Runway & Runway Extension Construction

Appendix D contains current airport diagrams for those airports among the top 100 airports[1] that are considering or have plans for the construction of new runways or extensions to existing runways. The airport diagrams show simplified drawings of the existing airports, with proposed runway and runway extension projects indicated in blue. Airport layouts for the remainder of the top 100 airports are contained in Appendix E.

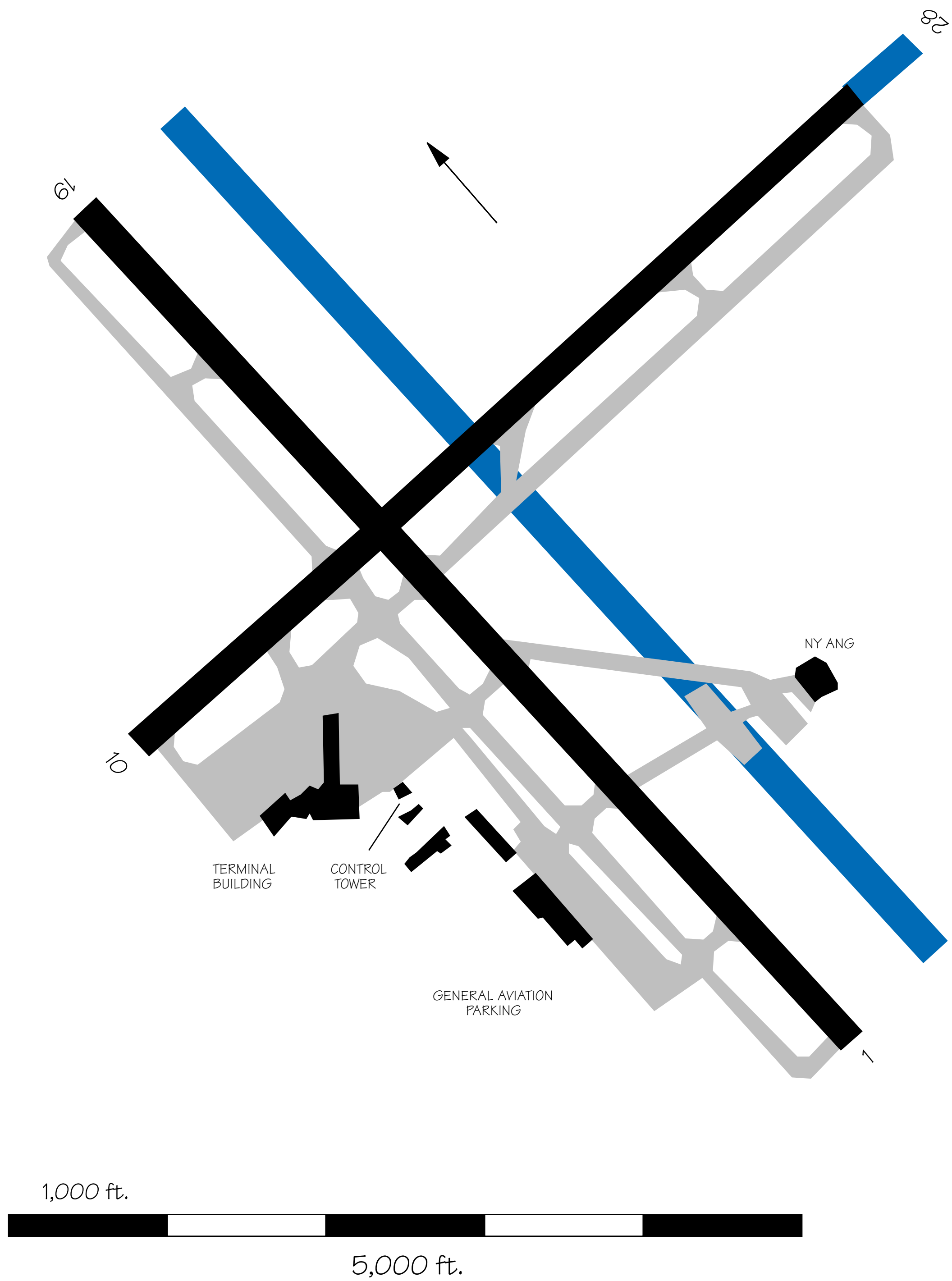
Legend



1. Based on 1994 passenger enplanements (see Appendix A, Table A-1).

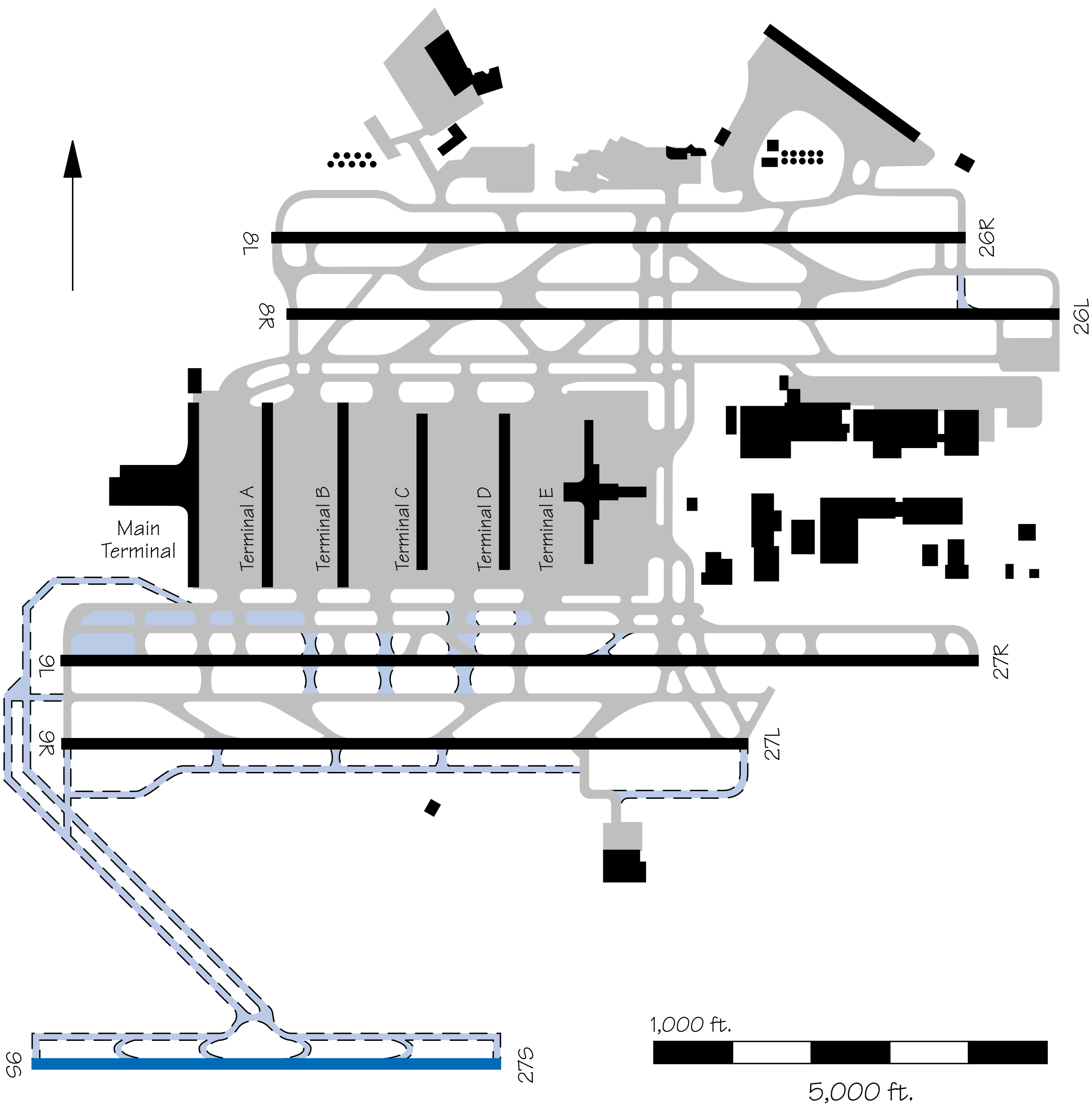
ALB — Albany County Airport

Construction of an extension to Runway 10/28 is planned. The estimated cost of construction is $5.8 million. A new parallel Runway 1R/19L is also planned. The estimated cost is $7.5 million.



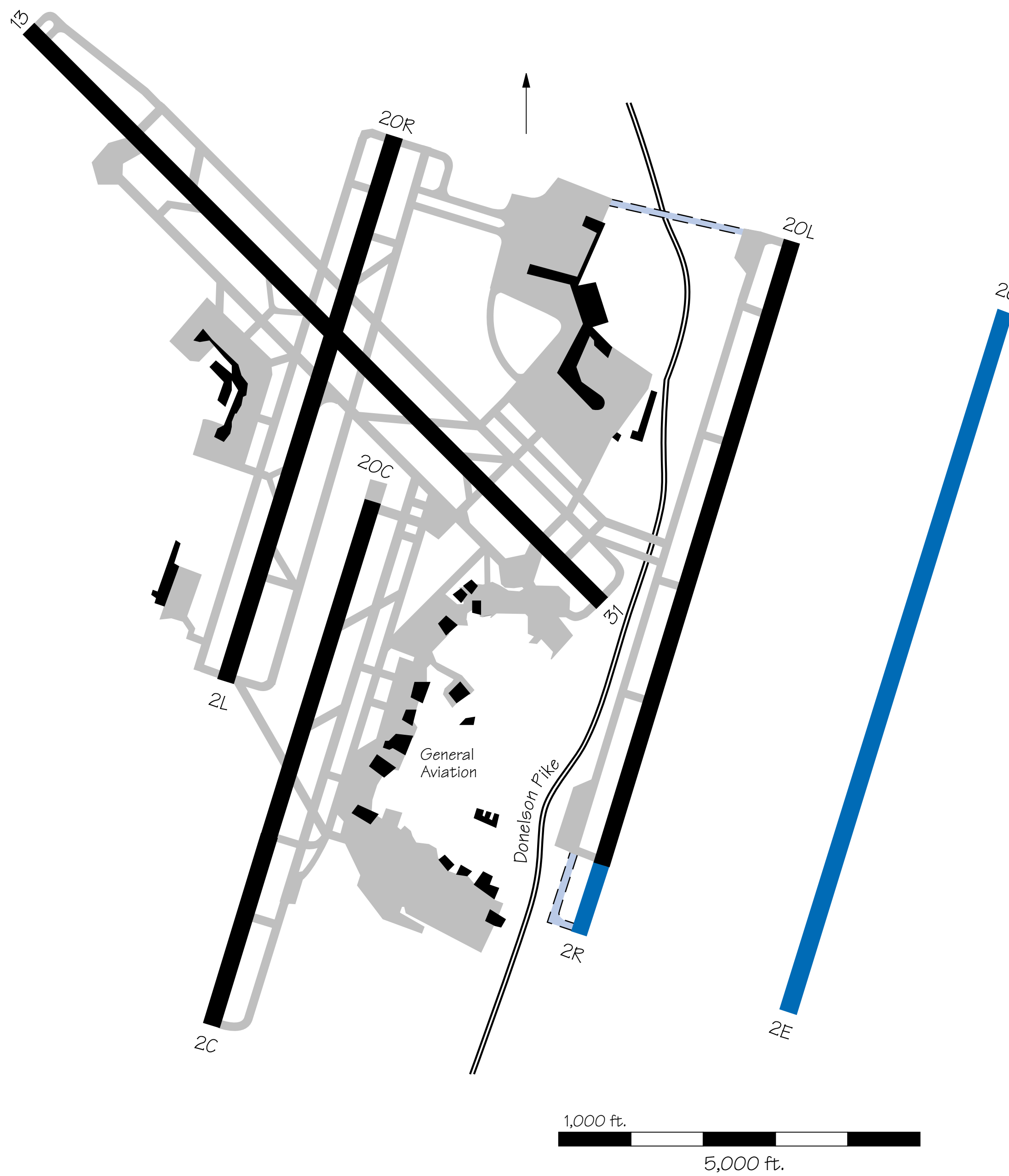
ATL — Hartsfield Atlanta International Airport

A fifth parallel commuter runway, 6,000 feet long and approximately 4,200 feet south of Runway 9R/27L, is being planned. The runway will permit triple independent IFR approaches using the PRM. The total estimated cost is $418 million. The estimated operational date is 1999.



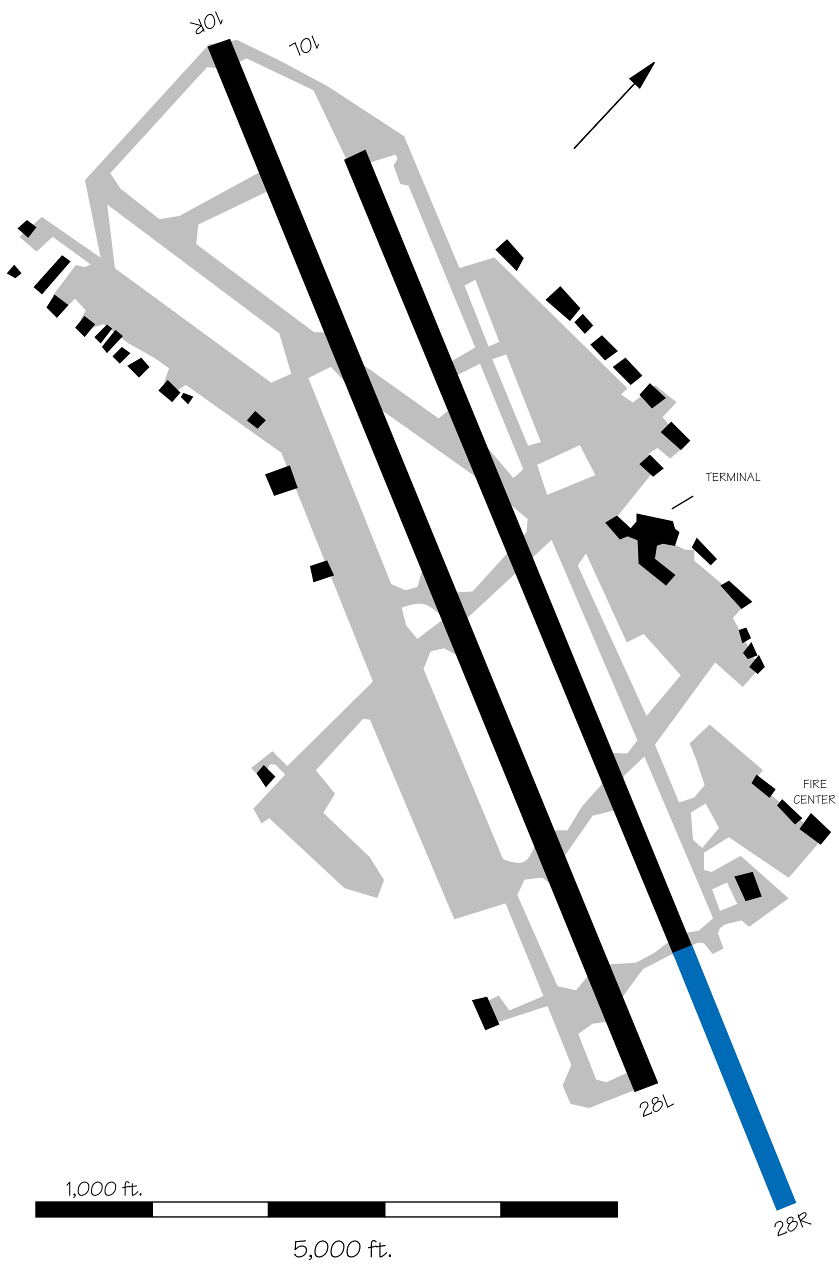
BNA — Nashville International Airport

A new Runway 2E/20E is planned for the future between 1,500 and 3,500 feet from Runway 2R/20L. In addition, an extension to Runway 2R/20L is planned. It is expected to be completed by 2000, at an estimated cost of $38.6 million.



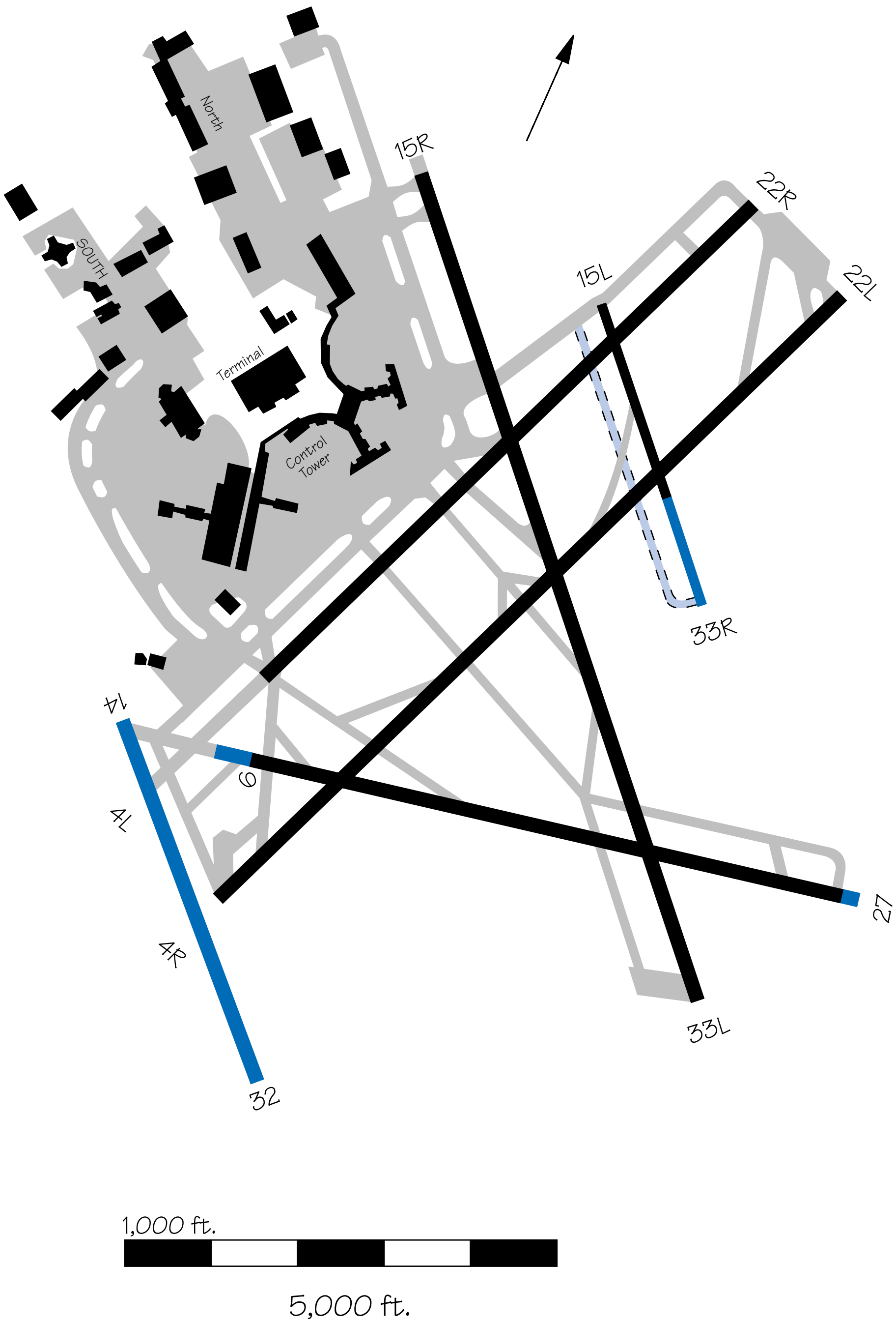
BOI — Boise Air Terminal

A 2,300 foot extension to the east end of Runway 10L/28R in planned. It is expected to be operational by 1998, at a cost of $8 million.



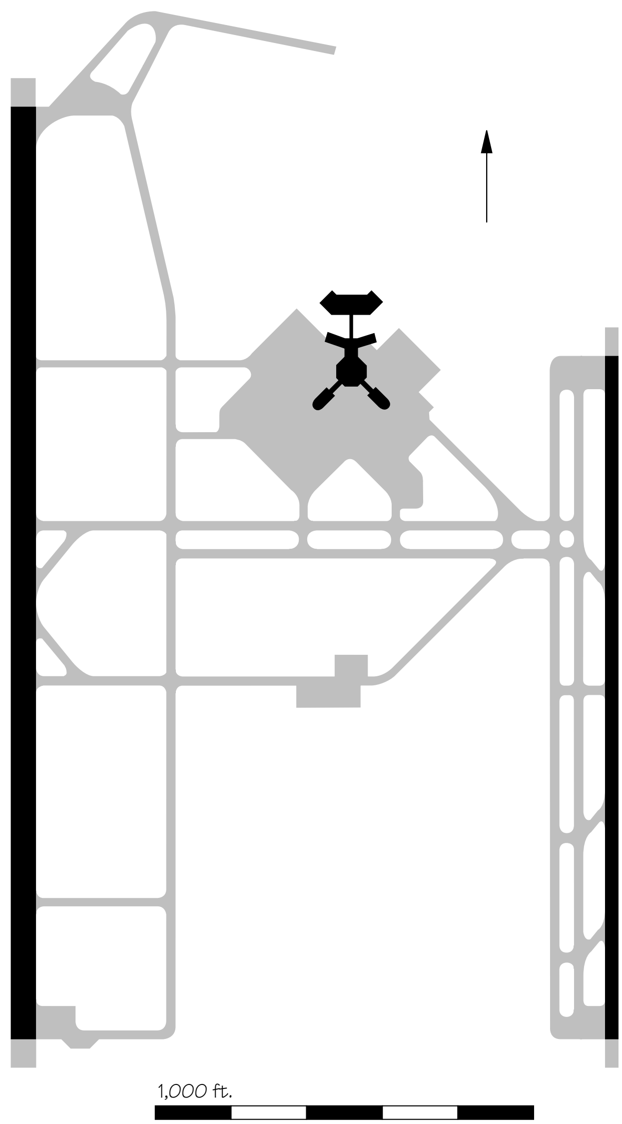
BOS — Boston Logan International Airport

A new uni-directional commuter runway (Runway 14/32) 4,300 feet from Runway 15R/33L, an extension of Runway 15L/33R to 3,500 feet, and a 400-foot extension of Runway 9 are being studied. An Environmental Impact Study is currently in progress for the new runway.



BSM — Bergstrom AFB (new Austin)

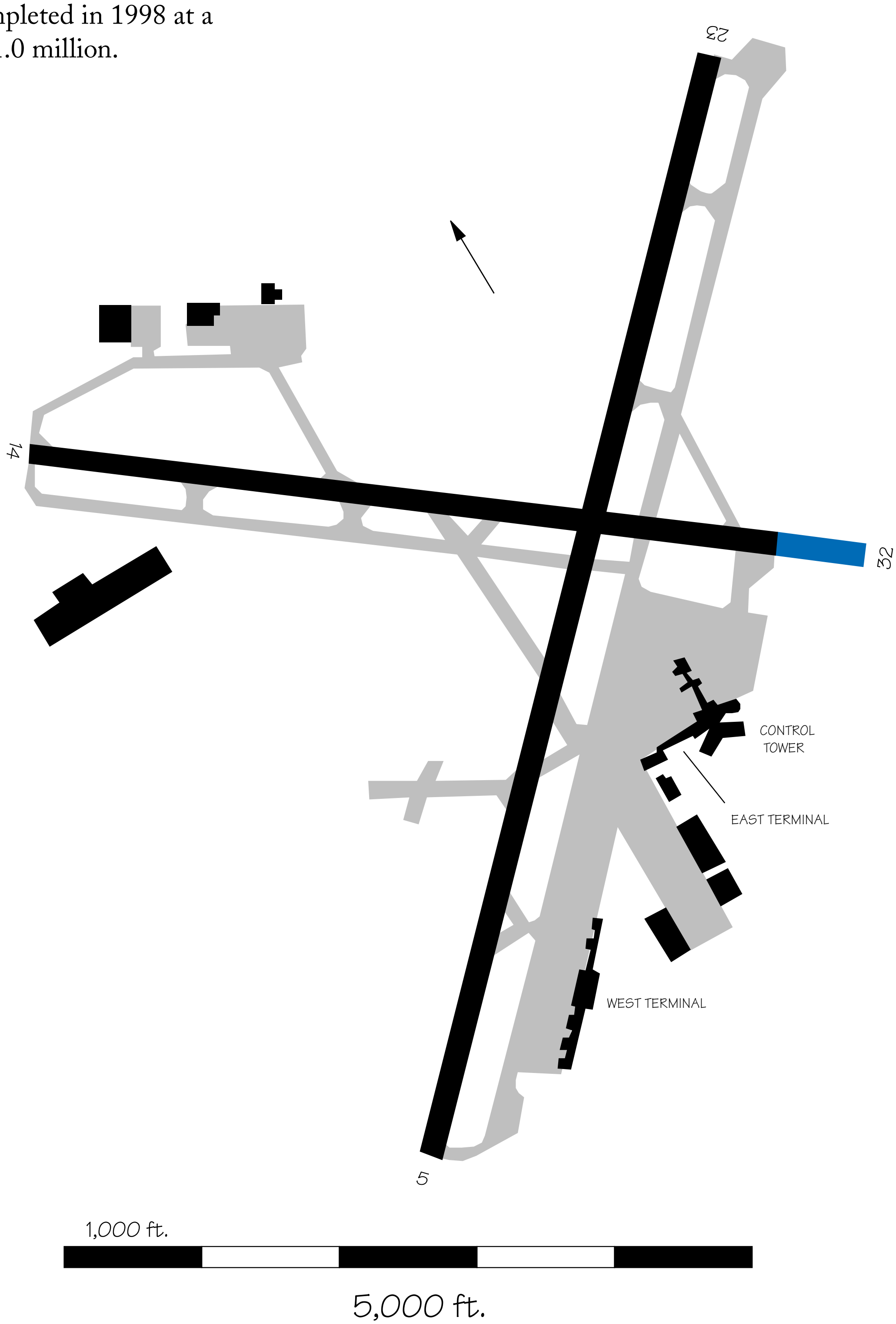
The community has approved the sale of revenue bonds for the development of a new airport. The present Robert Mueller Airport cannot be expanded. Bergstrom Air Force Base (AFB) was transferred to the city on October 1, 1993, and the city is now planning to construct a new parallel runway and relocate all commercial activity there in 1998. The total estimated project cost is $520 million. The city has an Airport Master Plan under development. Environmental studies are in progress by the Air Force and the city. Since Robert Mueller Airport will close upon completion of the new airport, no capacity enhancements are planned at Mueller. Some of the construction projects include a new Runway 17L/35R and associated taxiways, new midfield cross taxiways, a new air cargo apron, and renovation of Runway 17R/35L to bring it up to FAA CAT III standards.



Bergstrom Air Force Base Conversion
Opening Day Layout Plan
as of 1-31-95

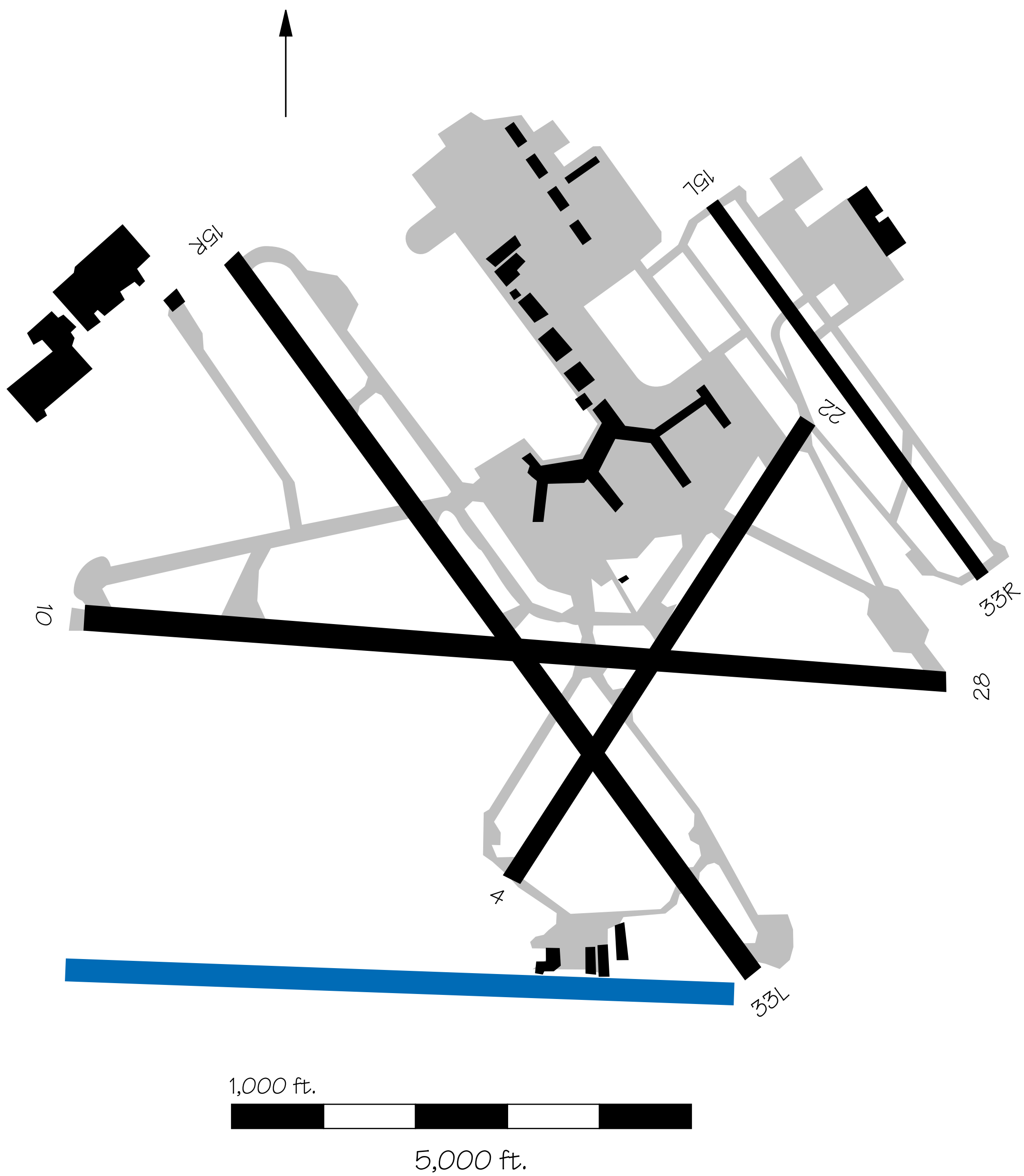
BUF — Greater Buffalo International Airport

Construction is expected to start in 1996 on a extension to Runway 14/32, along with relocating the runway threshold. The project is scheduled to be completed in 1998 at a cost of $1.0 million.



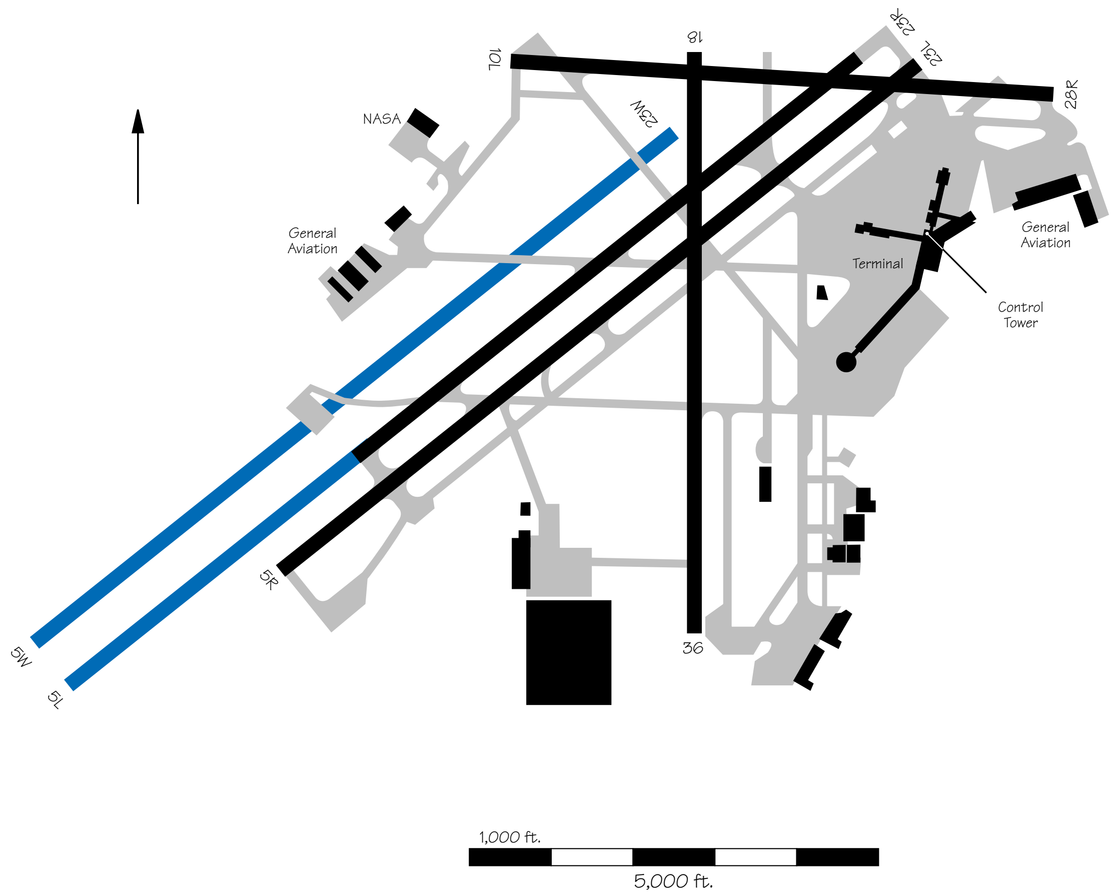
BWI — Baltimore-Washington International Airport

A new 7,800-foot runway, Runway 10R/28L, is planned to be constructed by 2003, 3,500 feet south of Runway 10/28. When Runway 10R/28L is constructed, Runway 4/22 will be converted to a taxiway.



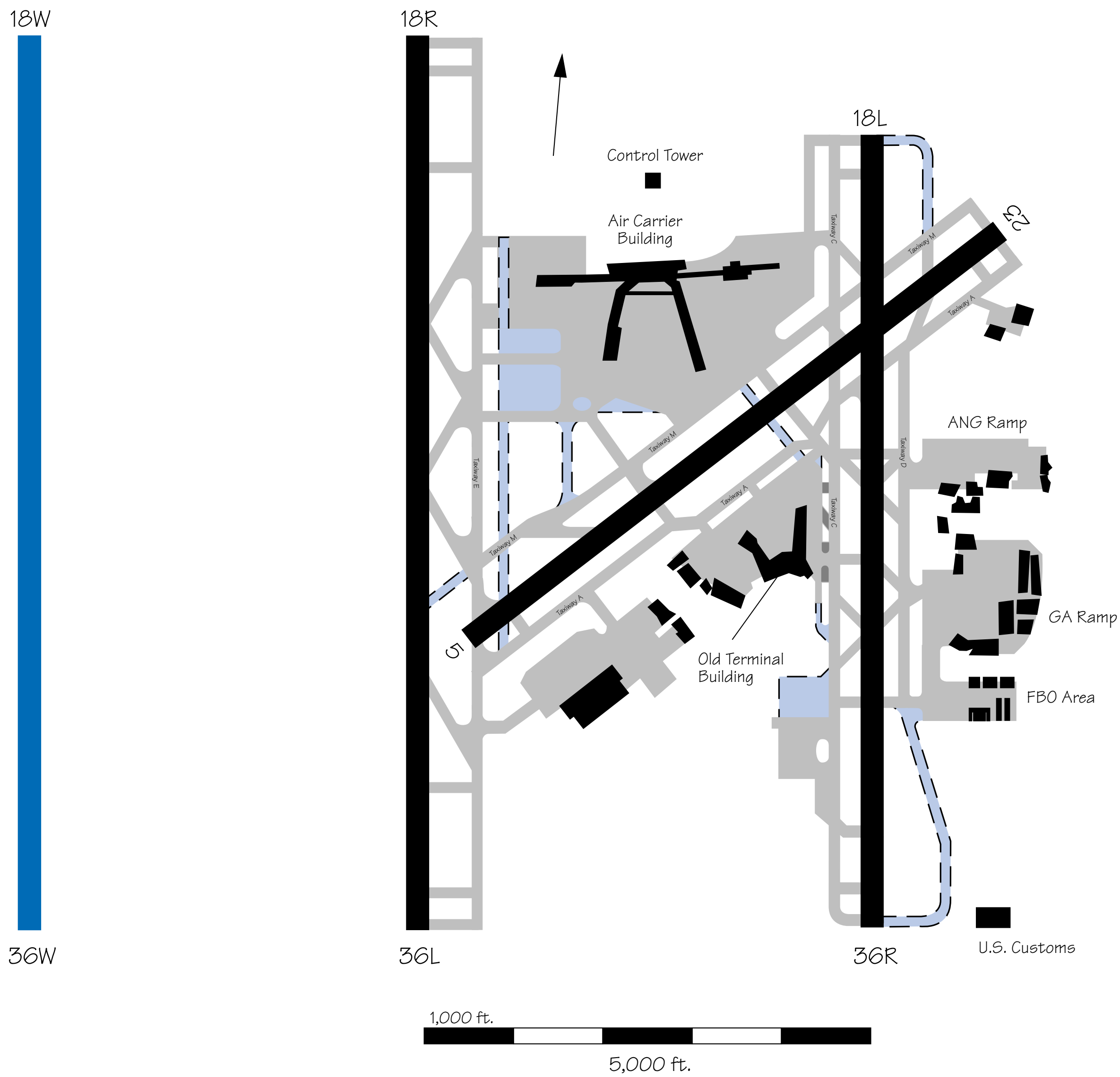
CLE — Cleveland Hopkins International Airport

A Master Plan Update is currently being coordinated. The preliminary Airport Layout Plan shows construction of a new Runway 5W/23W that would be 9,600 feet long and 150 feet wide. Construction is expected to be completed in 1999 at a cost of $180 million. Also included in the development plan is an extension of the existing Runway 5L/23R from 7,095 feet to 12,000 feet at an estimated cost of $40 million and conversion of the existing Runway 5R/23L to a parallel taxiway at a cost of $3 million. All of this work is scheduled for completion in 2000.



CLT — Charlotte/Douglas International Airport

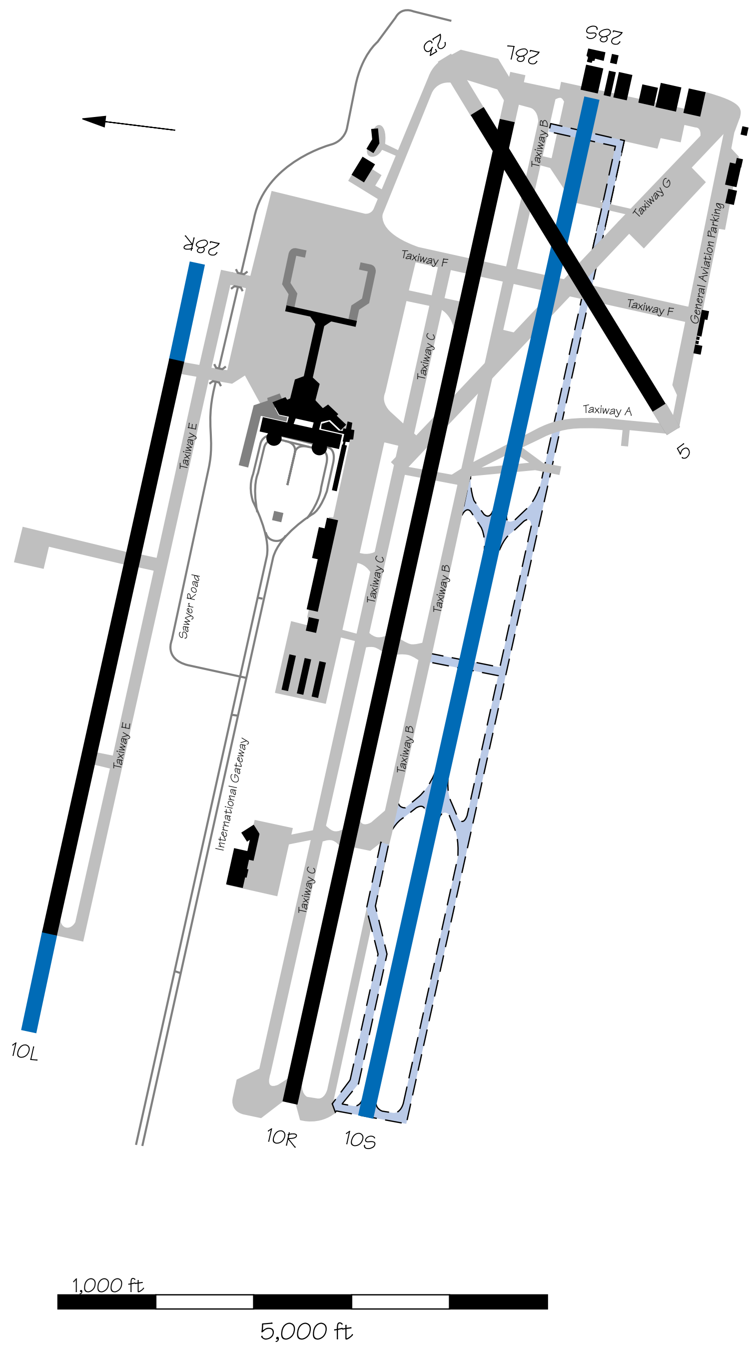
Plans to open a third parallel 8,000-foot runway west of Runway 18R/36L that would permit triple IFR approaches (dependent or independent, based on final separation) is being considered. An Environmental Impact Study is underway. While construction has not begun, it is estimated to be completed in 1999, with an estimated cost of $70 million.



CMH — Port Columbus International Airport

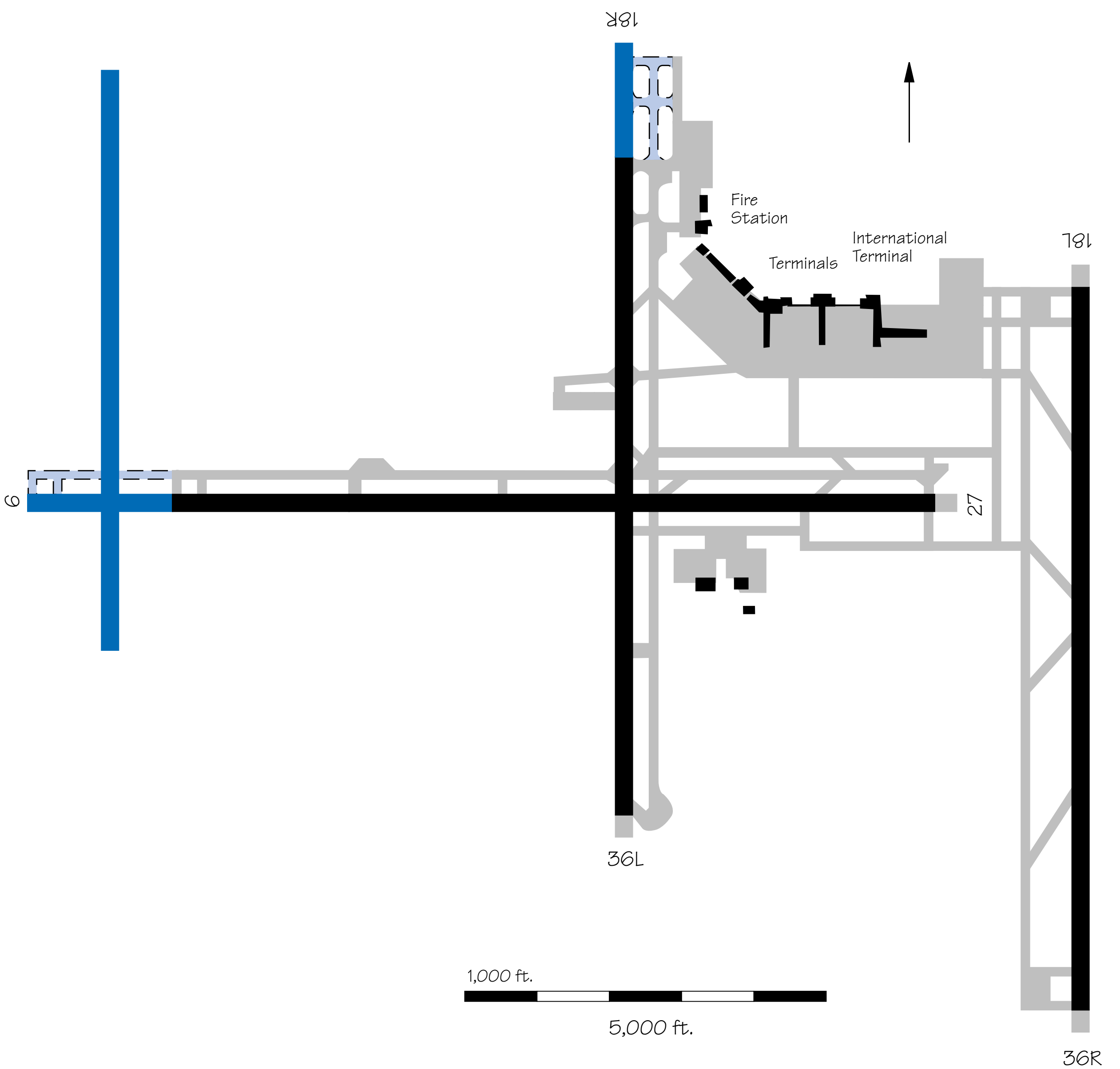
The Airport Layout Plan has been coordinated to show a third parallel Runway 10S/ 28S constructed 800 feet south of the existing Runway 10R/ 28L. This runway will be 10,250 feet long and 150 feet wide, with two high speed exits, a 90 degree exit at the center, and a 90 degree bypass taxiway at each end. This would provide a 3,650 foot separation between the proposed Runway 10S/28S and the existing Runway 10L/28R. With the installation of the Precision Runway Monitor (PRM), the existing Runway 10L/28R and the proposed Runway 10S/28S could be used for arrival air traffic. Runway 10R/28L would be used as the departure runway.

The exiting Runway 28R is being extended 1,000 feet and will be completed in 1996. A 1,000 foot extension to Runway 10L is proposed for 1997. Upon competion, Runway 10L/28R will be 8,000 feet long and 150 fet wide.



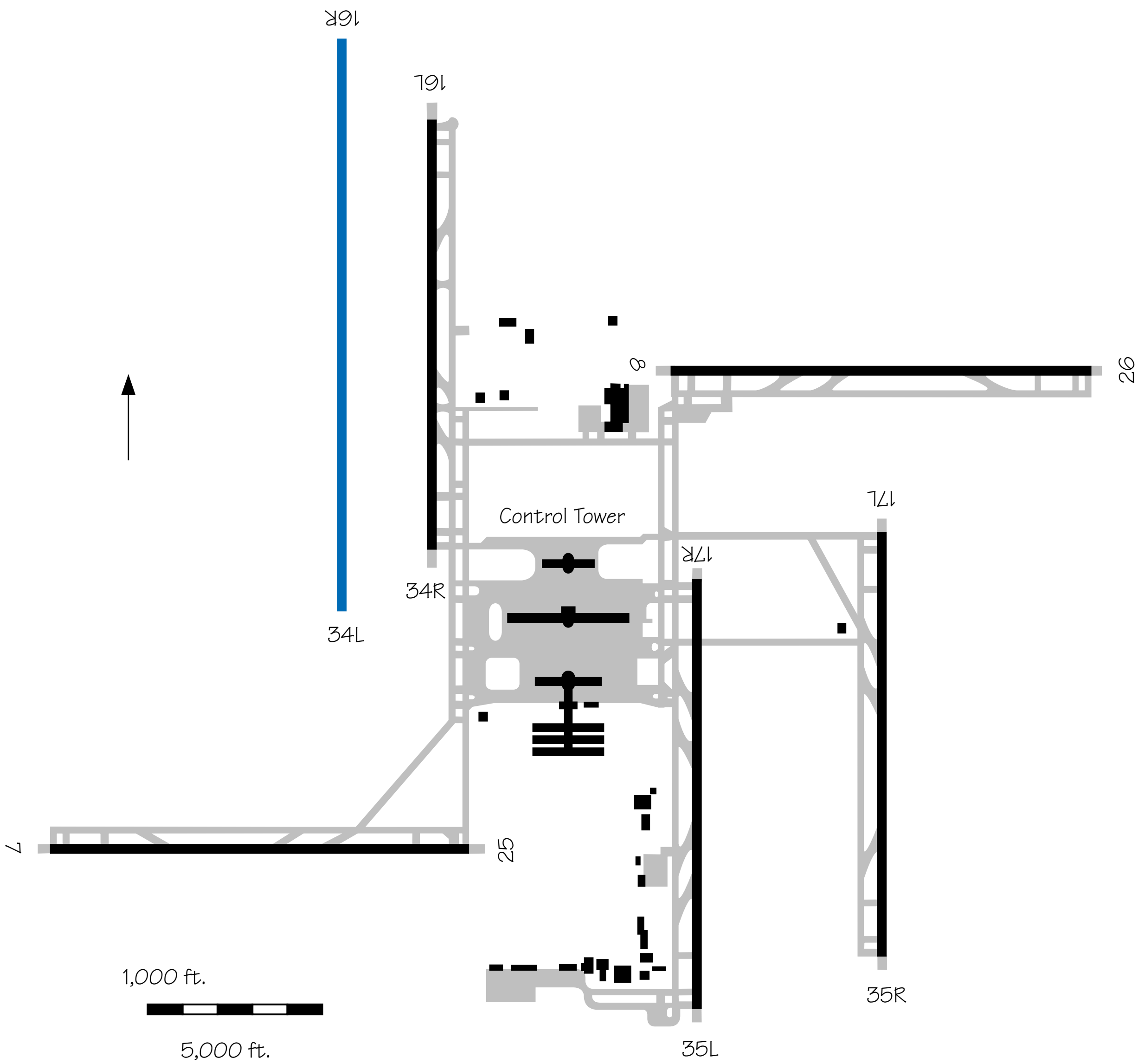
CVG — Greater Cincinnati International Airport

An extension of Runway 18R/36L is under construction. It will allow aircraft to land on Runway 18R and hold short of Runway 27 and will add capacity during noise abatement hours. The estimated cost of construction is $11 million, and the estimated operational date is 1996. The extension of Runway 9/27 was completed in 1995. An additional 2,000 ft. extension is planned for after 2000, with an estimated cost of $30 million. A third parallel runway is planned for after the year 2000, west of the existing parallels. Estimated cost for the new runway is $232.7 million.



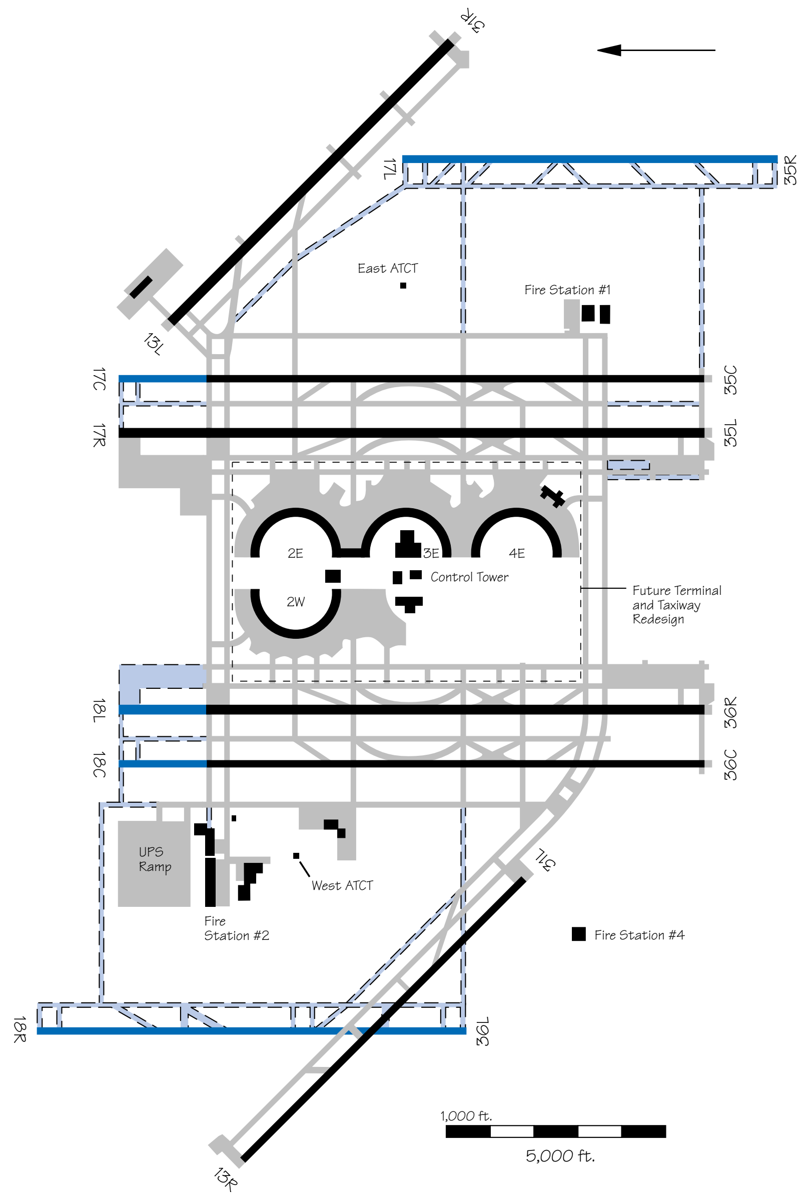
DEN — Denver International Airport

Runway 16R/34L is the last of the six original runways to be built at the new airport. It will be separated 2,600 feet from Runway 16L/34R, and be 16,000 feet in length. The runway is expected to be completed in 2000, at an estimated cost of $75 million.



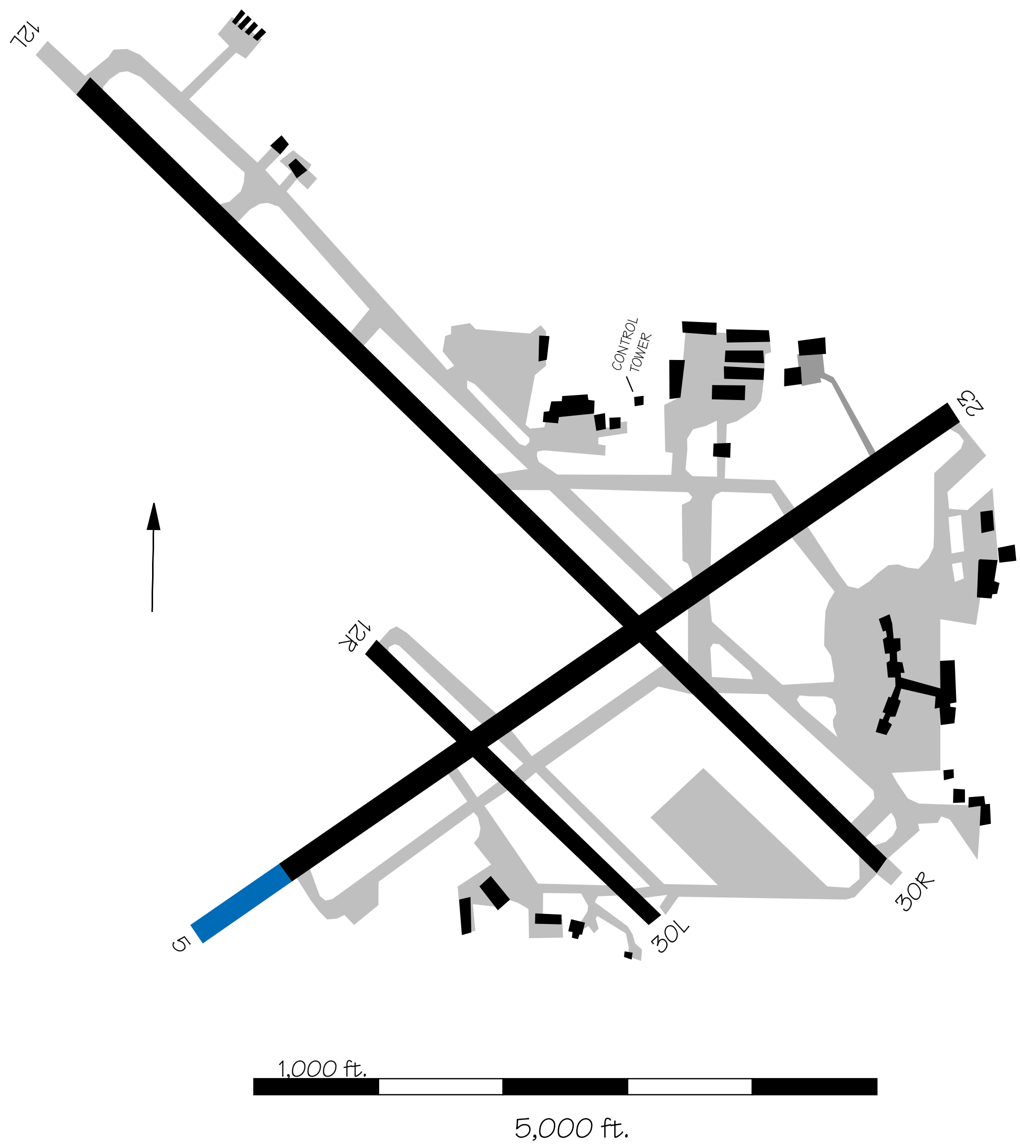
DFW — Dallas-Fort Worth International Airport

Proposed 2,000-foot extensions to all of the north/south parallel runways will provide an overall length of 13,400 feet for each. The estimated cost of each extension is $25 million. The extension of Runway 17R/35L has been completed and was operational September 16, 1993. Also planned are two more parallel runways, Runway 17L/35R and Runway 18R/36L. The east runway, Runway 17L/35R, will be 8,500 feet in length. It will be located 5,000 feet east of and parallel to Runway 17C/35C (previously 17L/35R). The estimated cost is $300 million. It is anticipated that the east runway will be operational by 1996. Construction on the west runway, Runway 18R/36L, will begin when warranted by aviation demand. It could be available as early as 2001. The estimated cost is $100 million. It will be located 5,800 feet west of Runway 18R/36L (to be renamed 18C/36C). Runway 18R/36L may be constructed in phases, with the first phase a 6,000 foot runway located north of Runway 13R/31L. The second phase extension to 9,760 feet would intersect and continue south of Runway 13R/31L. These runways could potentially permit triple or quadruple IFR arrival operations if the multiple approach concepts are approved.



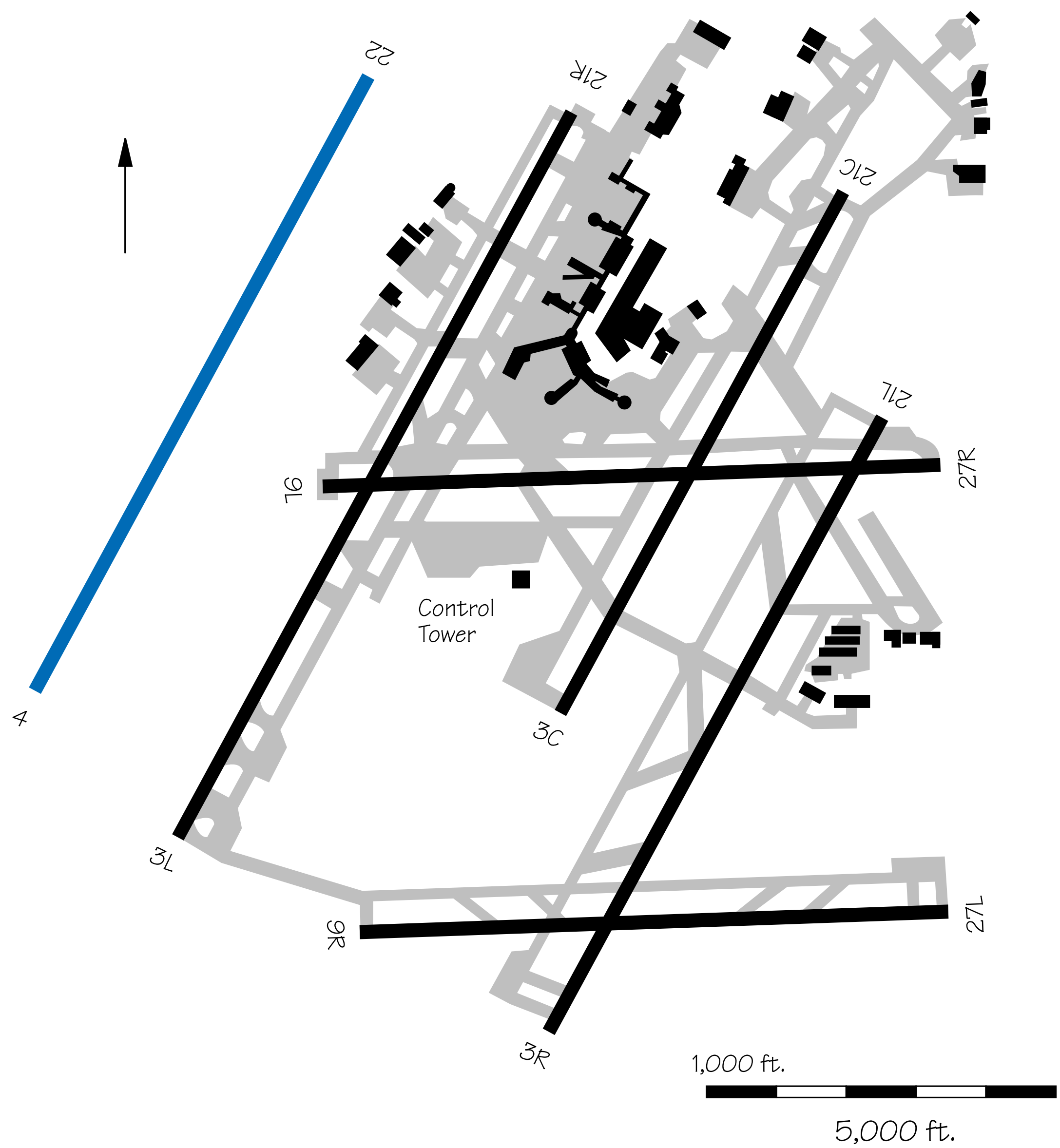
DSM — Des Moines International Airport

An Environmental Impact Study was recently completed on a southwest extension of Runway 5/23. Construction is planned to begin in 1997, and is expected to be completed in 1999. Cost for construction is estimated at $21.5 million, with an estimated additional $24 million for road relocation.



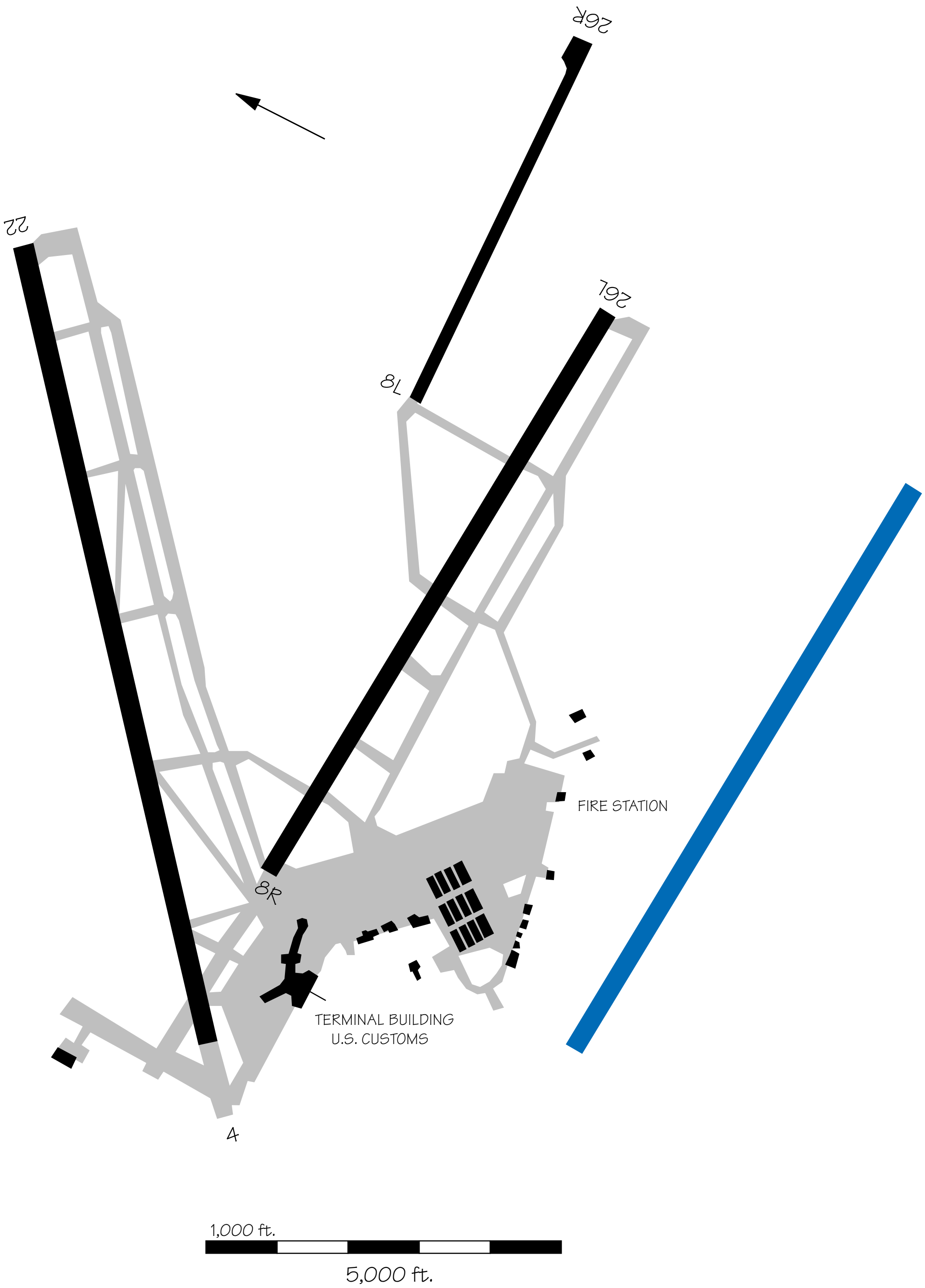
DTW — Detroit Metropolitan Wayne County Airport

A fourth north-south parallel, Runway 4/22, 2,667 feet west of Runway 3L/21R, is planned. Construction is expected to begin in 1999 and should be completed in 2001. The estimated cost of construction is $116.5 million. This runway could potentially permit triple IFR arrivals with one dependent and one independent pairing. An environmental assessment was submitted in September 1989, and a record of decision was issued in March 1990. Land acquisition is currently in progress.



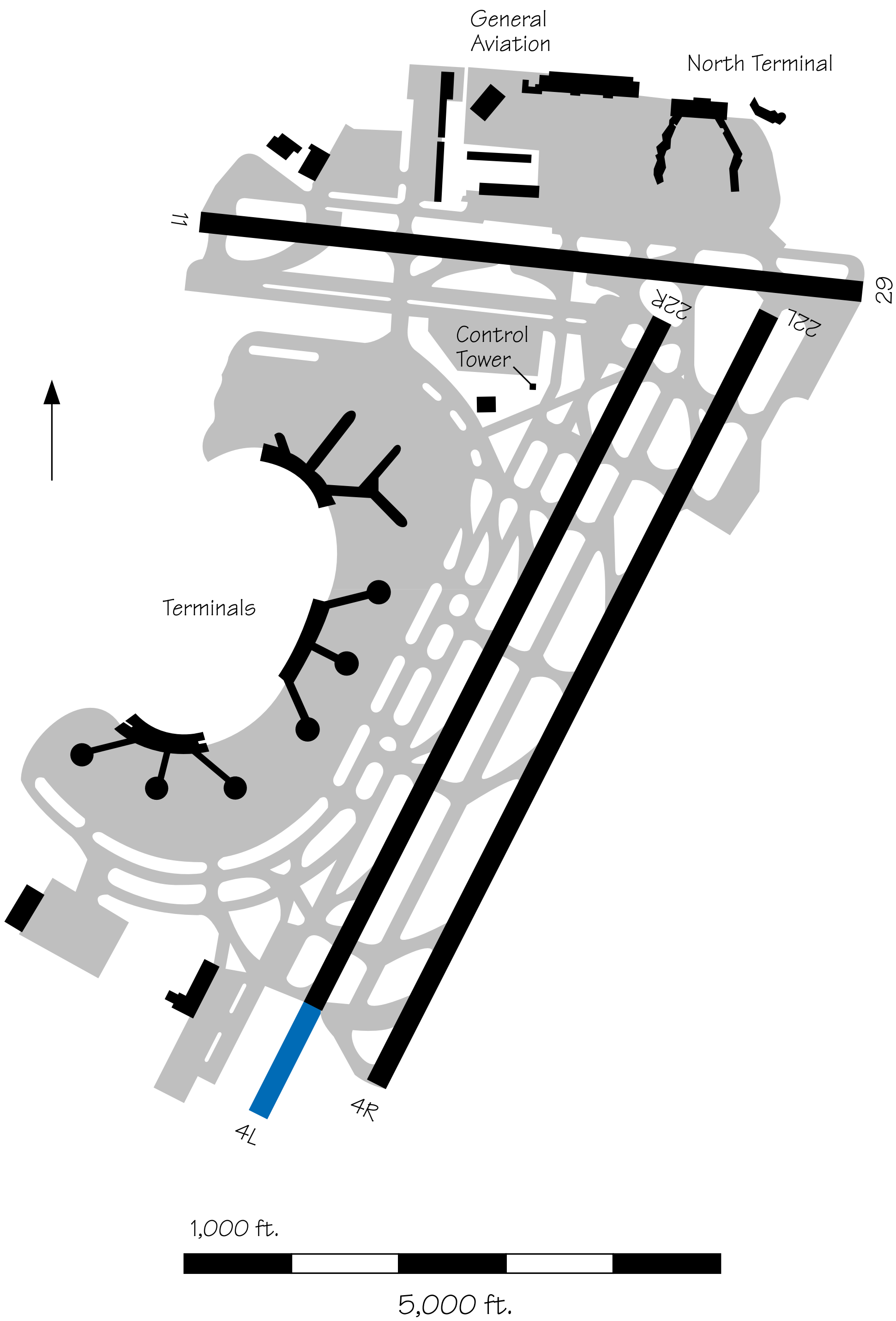
ELP — El Paso International Airport

A new parallel Runway 8/26 is planned in conjunction with a taxiway between the airport and Fort Biggs. Construction is expected to begin in 1999 with an estimated cost of $10.7 million.



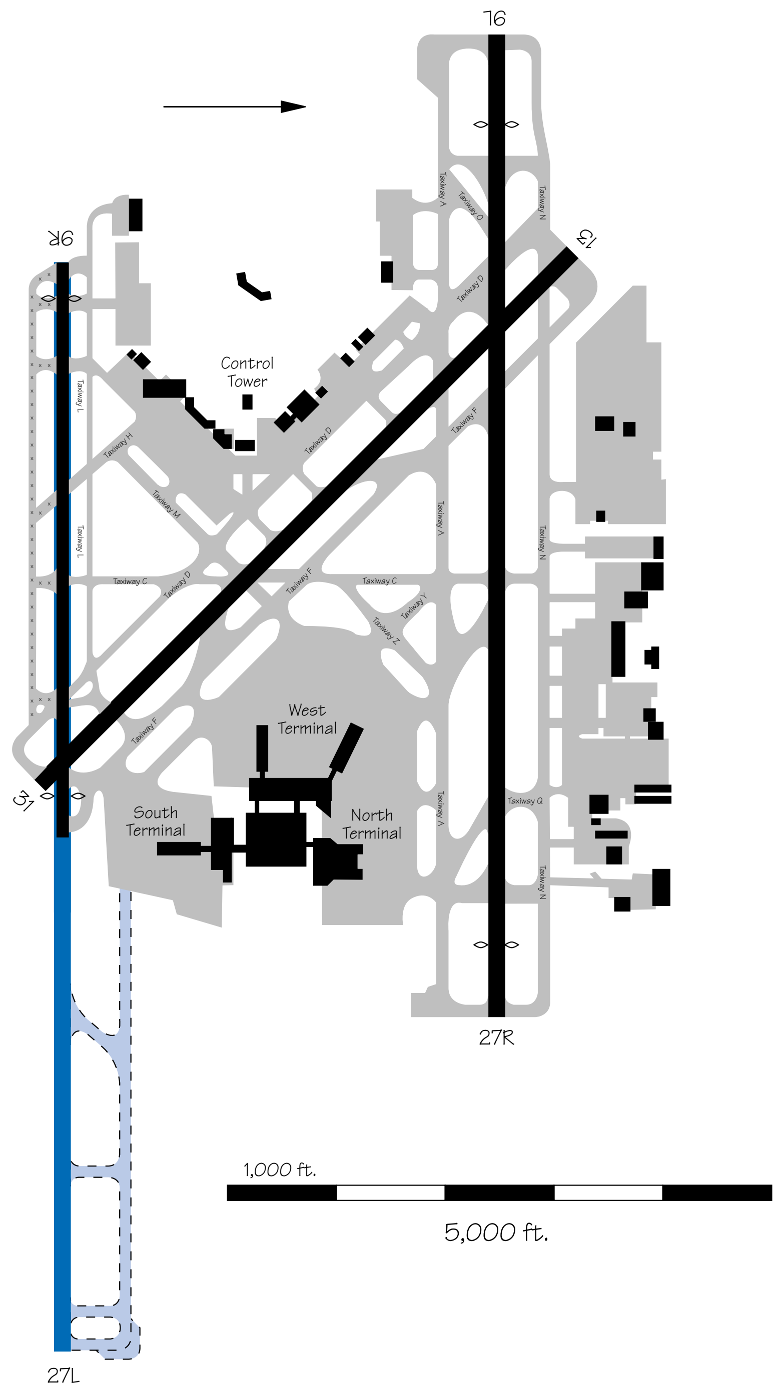
EWR — Newark International Airport

An extension to Runway 4L/22R is in the preliminary planning stage. The estimated operational date is 2000.



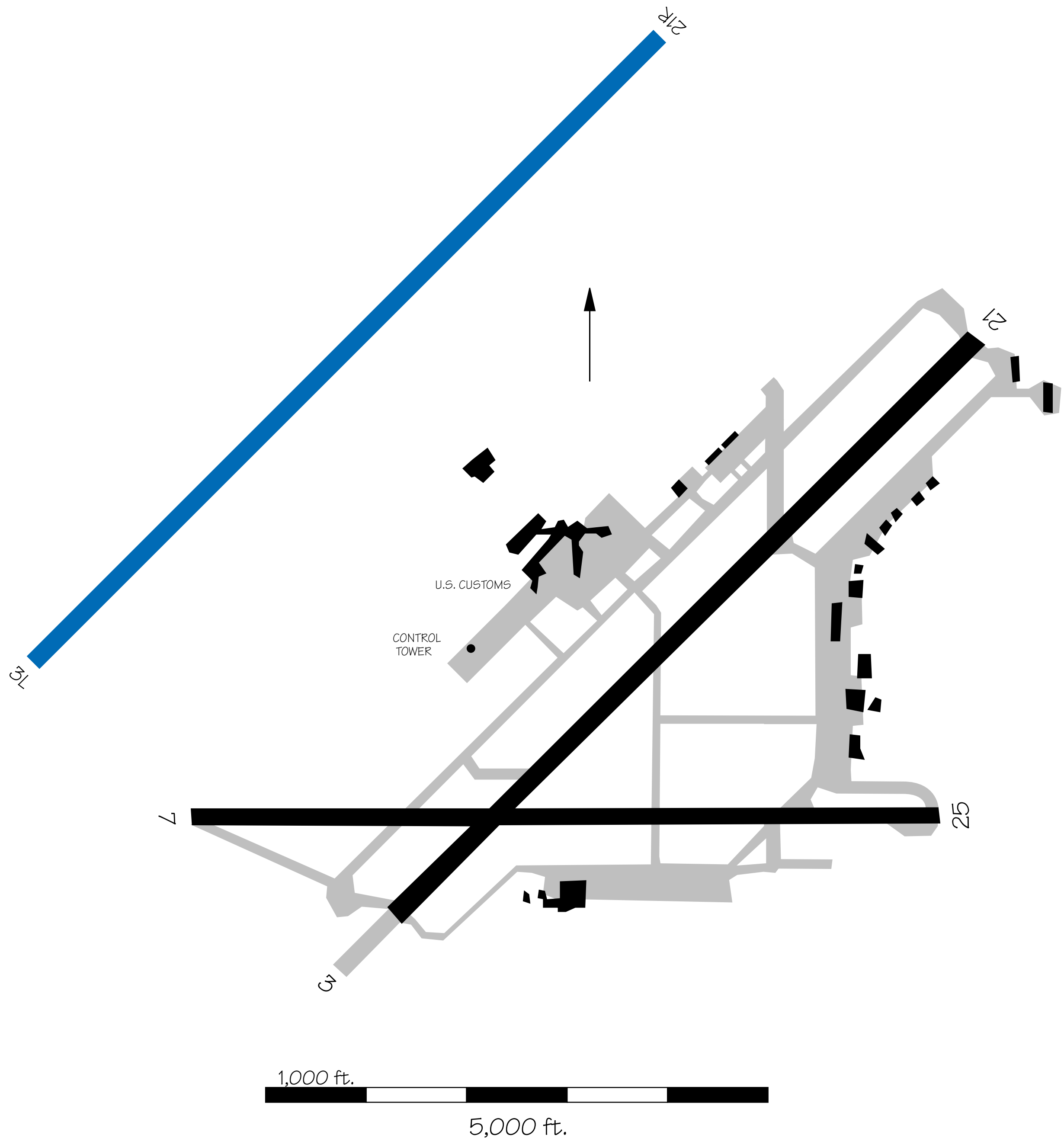
FLL — Fort Lauderdale-Hollywood International Airport

An extension of the short parallel Runway 9R/27L to 10,000 feet long by 150 feet wide is planned to provide the airport with a second parallel air carrier runway. Construction is expected to begin in 1997. The estimated cost of construction is $270 million. The anticipated operational date is 2002. An EIS is underway and expected to be completed in the fall of 1996.



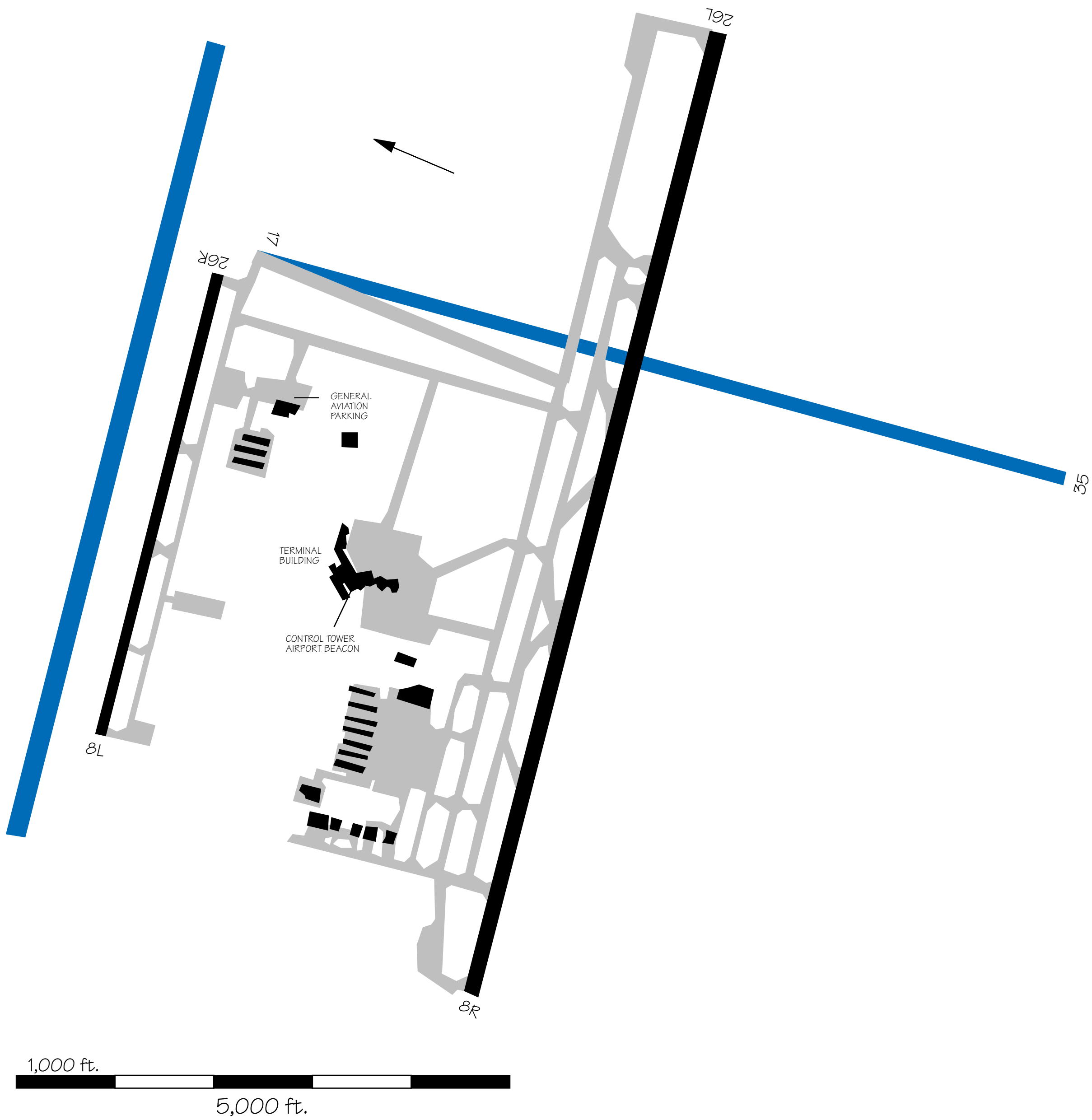
GEG — Spokane International Airport

Future projects include the construction of a new parallel Runway 3L/21R. The new runway will be 8,800 feet long by 150 feet wide and will be separated from Runway 3R/21L by 4,300 feet. This would enable independent parallel operations, doubling hourly IFR arrival capacity. The estimated cost of construction of the new runway is approximately $11 million. Construction could be started as early as 1999.



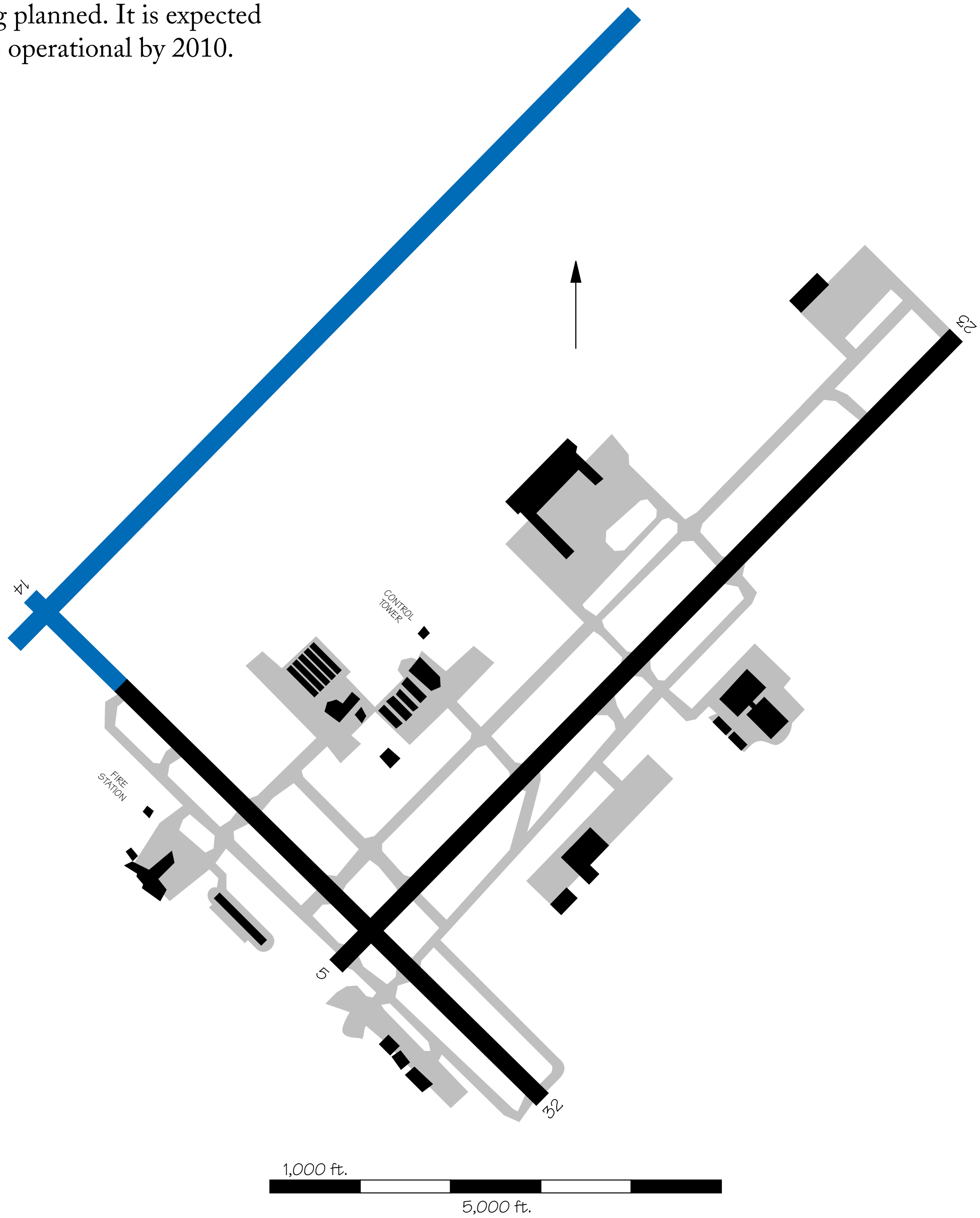
GRR — Grand Rapids Kent County International Airport

An extension to 8,500 feet and realignment for the crosswind Runway 18/36 (17/35) is under construction. Estimated cost is $58 million. The runway will provide wind coverage, noise relief, and reduce winter weather related delays by providing a second air carrier runway. Construction is expected to be complete in 1997. A new 7,000 foot parallel Runway 8L/26R is planned for future development. The current 8L/26R would be converted into a taxiway at that time.



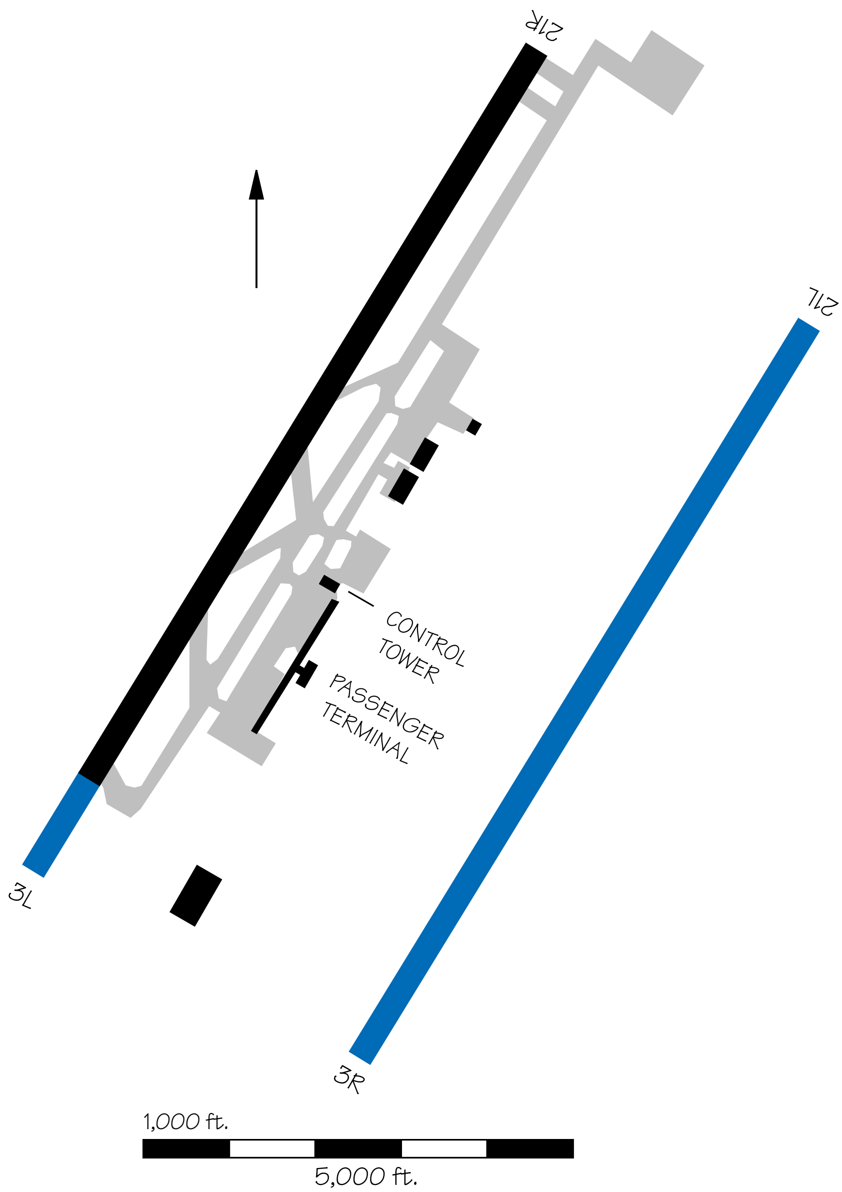
GSO — Greensboro Piedmont Triad International Airport

An extension of Runway 14/32 is planned. It is expected to be operational by 2000, at a cost of $15.7 million. Construction of a new parallel Runway 5L/23R, 5,300 feet north of Runway 5/23, is also being planned. It is expected to be operational by 2010.



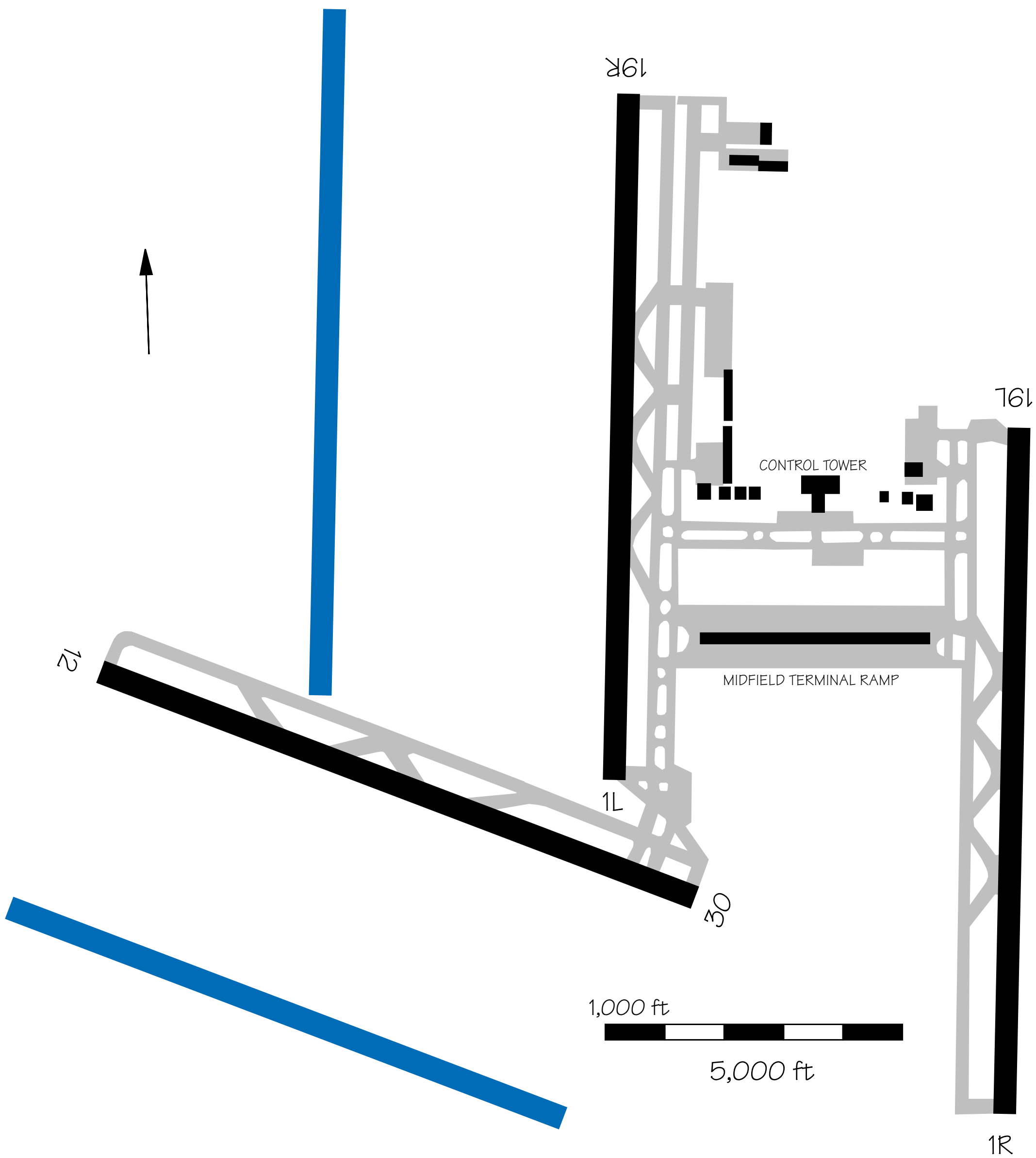
GSP — Greer Greenville-Spartanburg Airport

A new parallel runway, Runway 3R/21L, is anticipated in 2015 at an estimated cost of $50 million. Presently, its planned length is 10,000 feet with a 4,350 foot separation from Runway 3/21. This would potentially double hourly IFR arrival capacity Also, an extension of Runway 3L/21R to 12,200 feet is planned. Construction is expected to be completed by 1999 at a cost of $34.1 million.



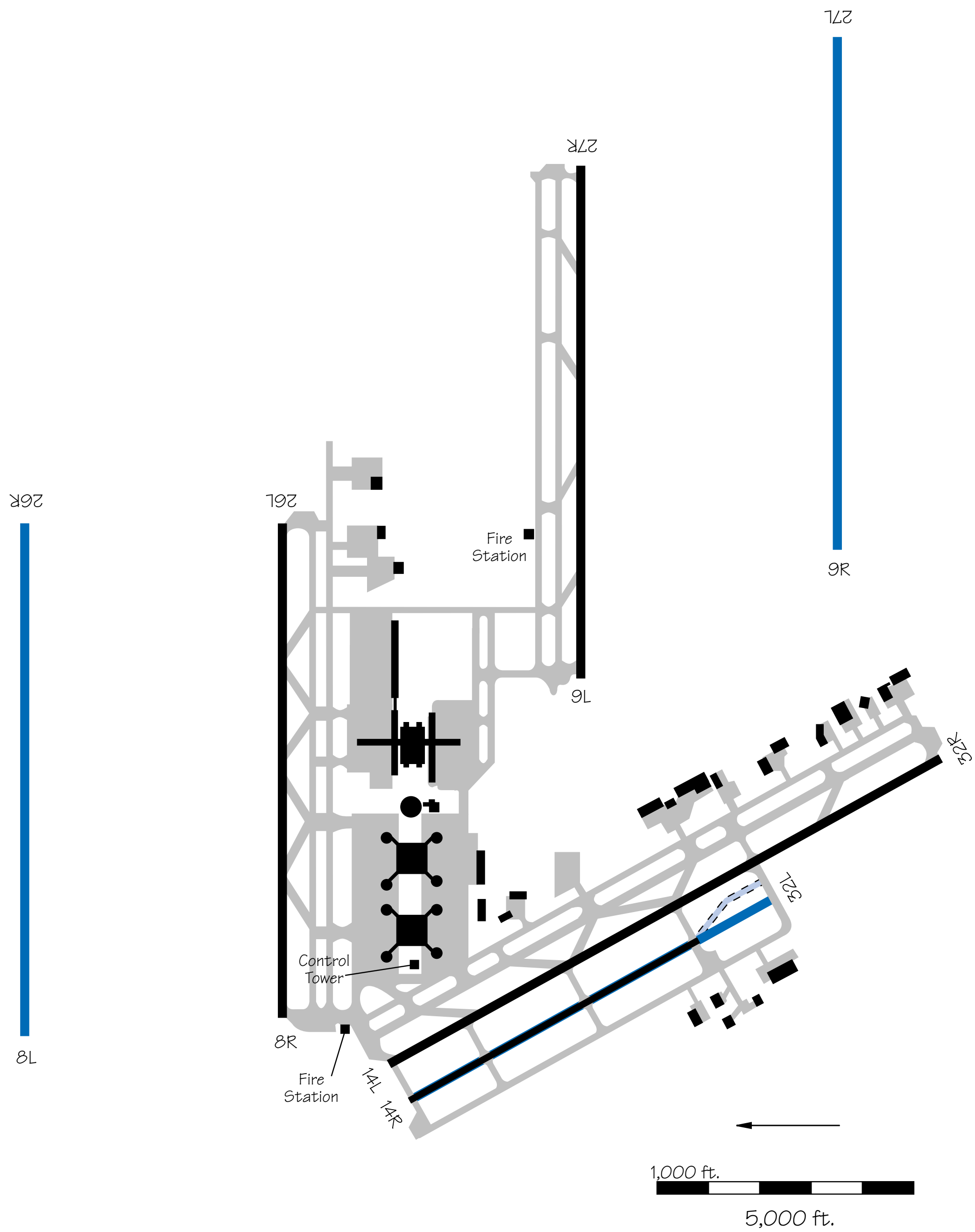
IAD — Washington Dulles International Airport

Two new parallel runways are under consideration. A north-south parallel, Runway 1W/19W, would be located 5,000 feet west of the existing parallels and north of Runway 12/30. Estimated opening data is 2009. This could provide triple independent parallel approaches, if they are approved. A second parallel Runway 12R/30L has been proposed for location 4,300 feet southwest of Runway 12/30. The runway is expected to be completed by 2010.



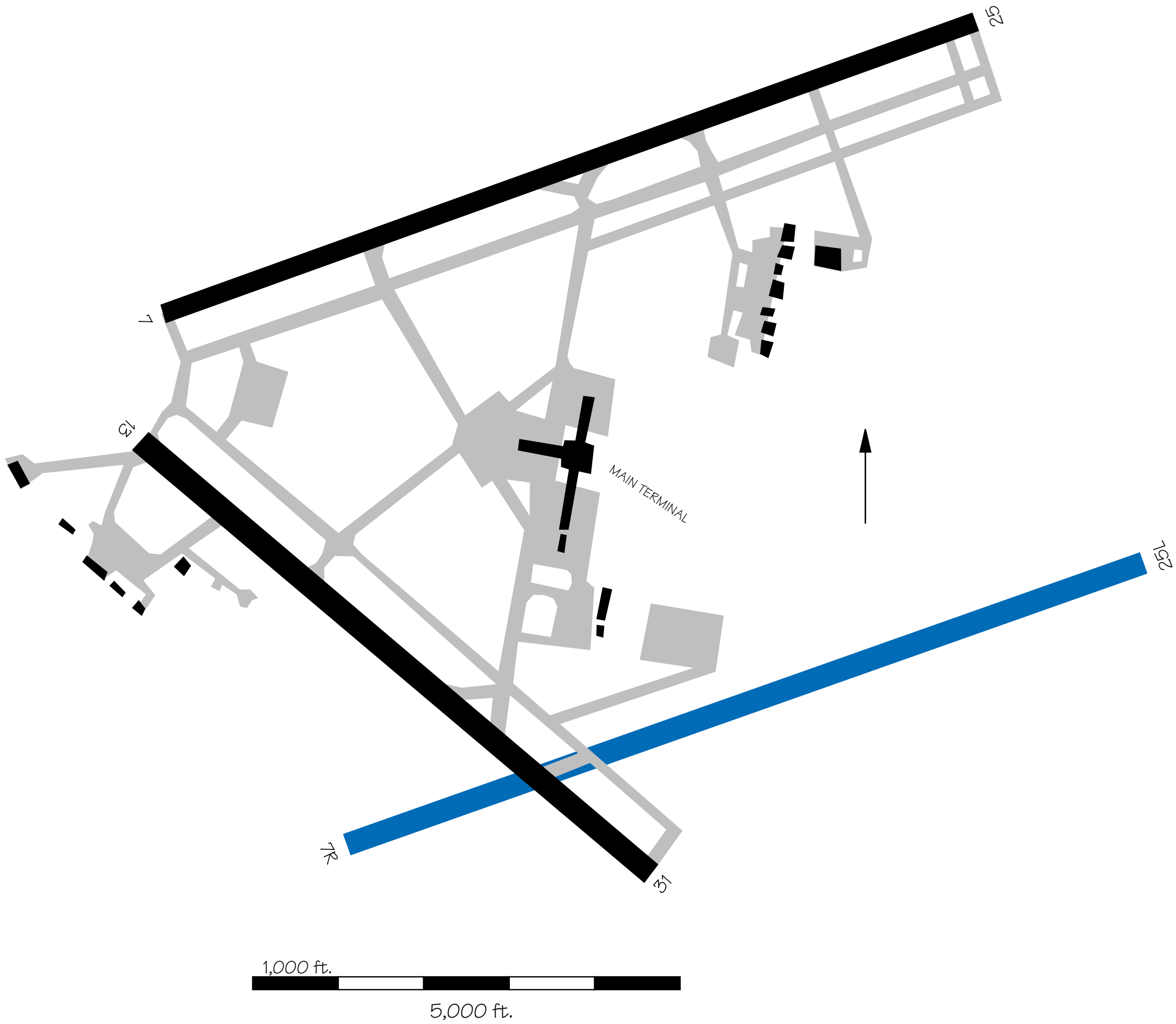
IAH — Houston Intercontinental Airport

An $8 million 2,000-foot extension to Runway 14R/32L is planned to be operational in 1997. Construction is expected to begin in 1996. A new Runway 8L/26R is planned to be parallel to and north of the existing Runway 8/26. Runway 8L/26R, in conjunction with Runways 9/27 and 8/26, has the potential to support triple IFR approaches, if approved. Another new runway, parallel to and south of Runway 9/27, is also planned. Construction is expected to cost $44 million for each new runway.



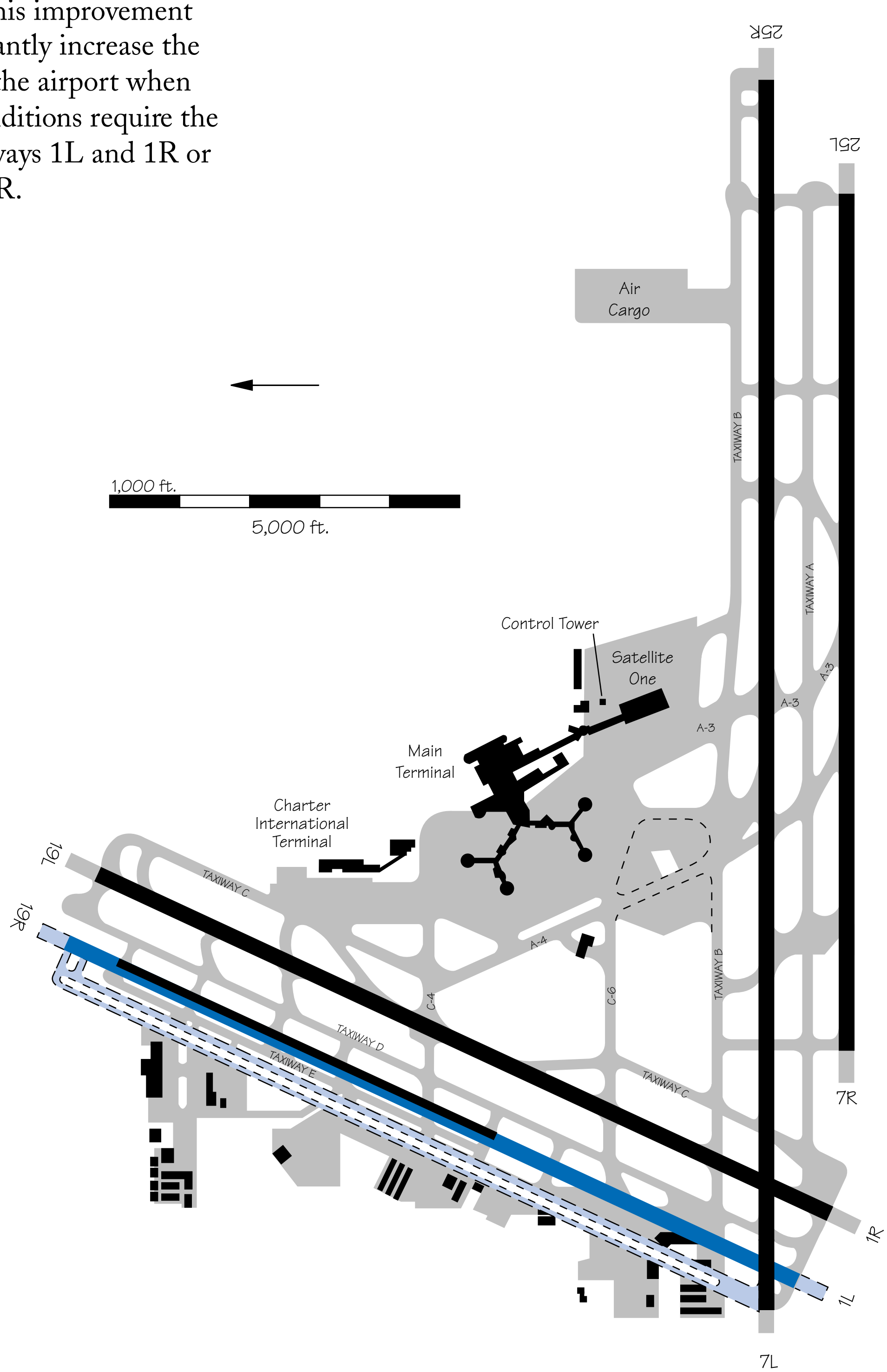
JAX — Jacksonville International Airport

A new parallel Runway 7R/25L is being planned. It will be 6,500 feet south of the existing Runway 7/25, permitting independent parallel IFR operations and potentially doubling Jacksonville's hourly IFR arrival capacity. Construction is scheduled to begin in 1999, with completion expected in 2000. Estimated cost of construction is $37 million.



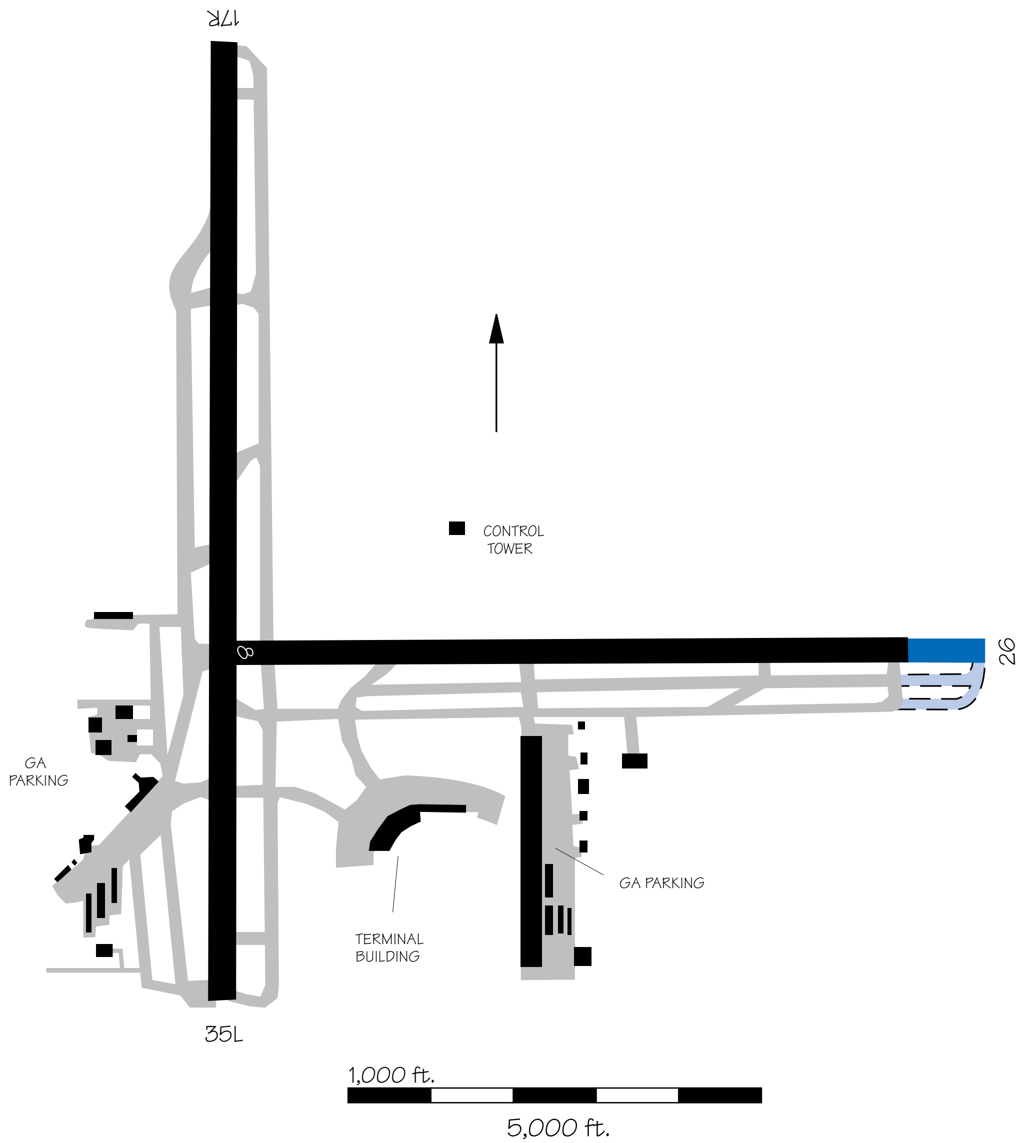
LAS — Las Vegas McCarran International Airport

An upgrade of Runway 1L/19R to accommodate air carrier aircraft is being planned for 1997. This improvement will significantly increase the capacity of the airport when weather conditions require the use of Runways 1L and 1R or 19L and 19R.



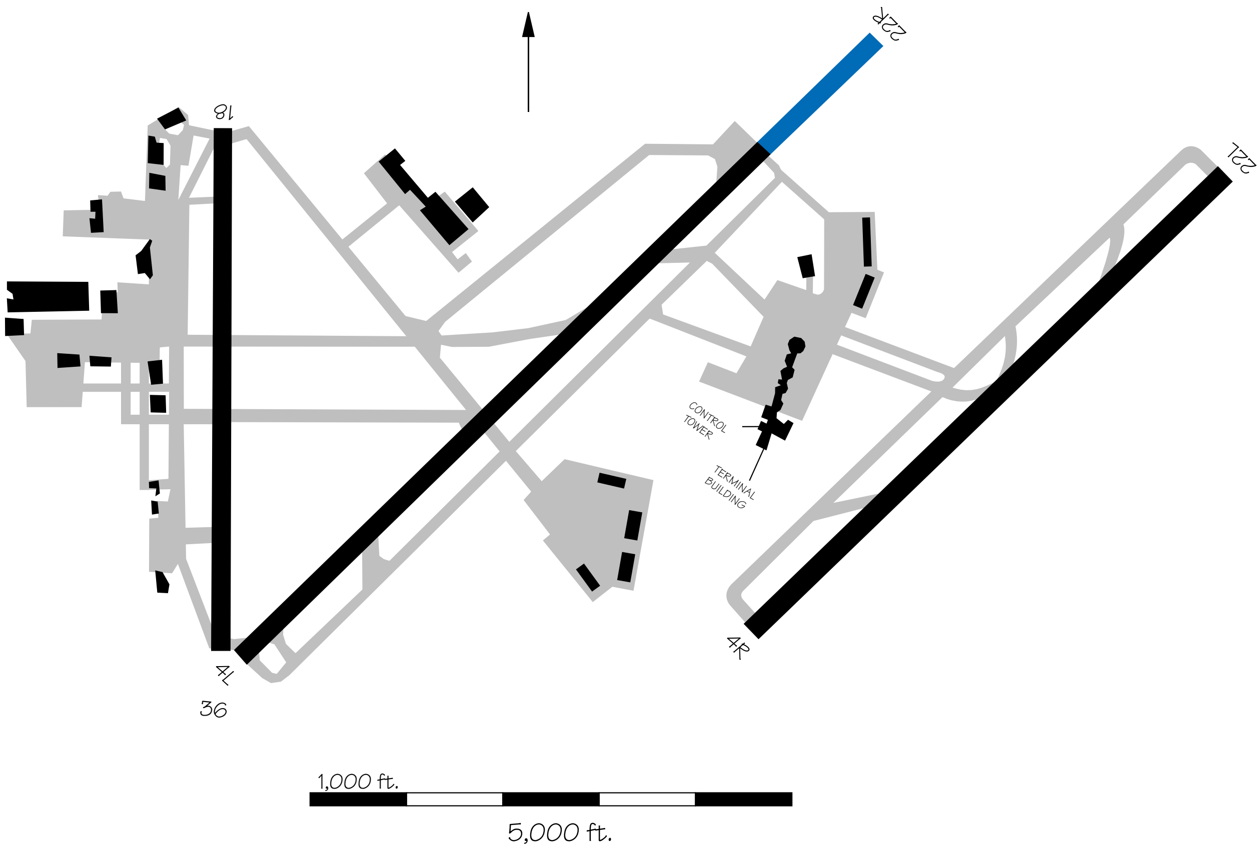
LBB — Lubbock International Airport

An extension to Runway 8/26 is planned. The start of construction is scheduled for 1999 and the estimated cost is $5 million. It is anticipated that the extension will be operational in 2000.



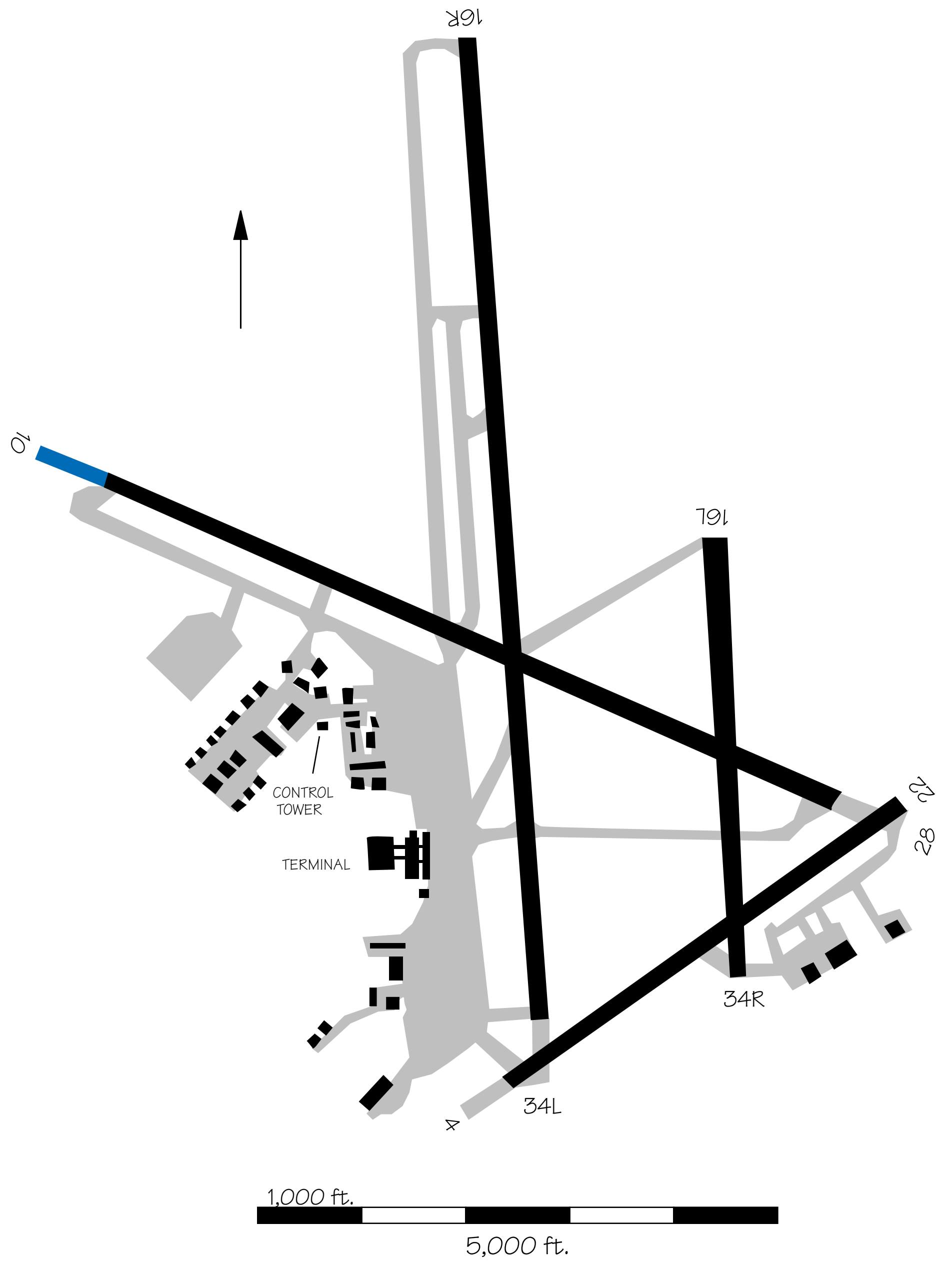
LIT — Little Rock Adams Field

An extension of Runway 4L/22R is underway, and should be operational in 1997. The estimated cost of construction is $31 million, including the resurfacing/reconstruction of the existing runway.



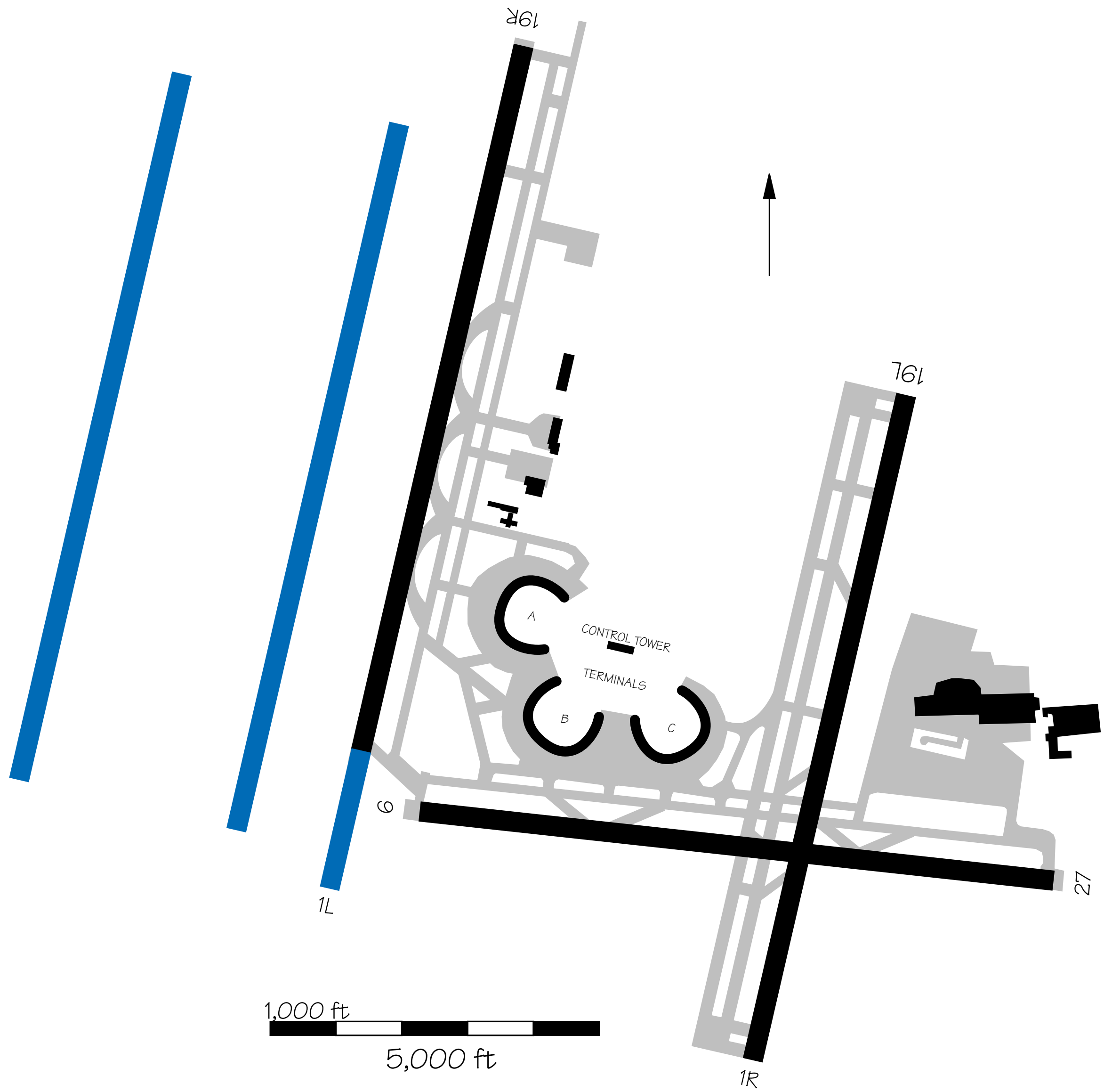
MAF — Midland International Airport

An extension to Runway 10/28 is planned, and construction is scheduled to begin in 2007.



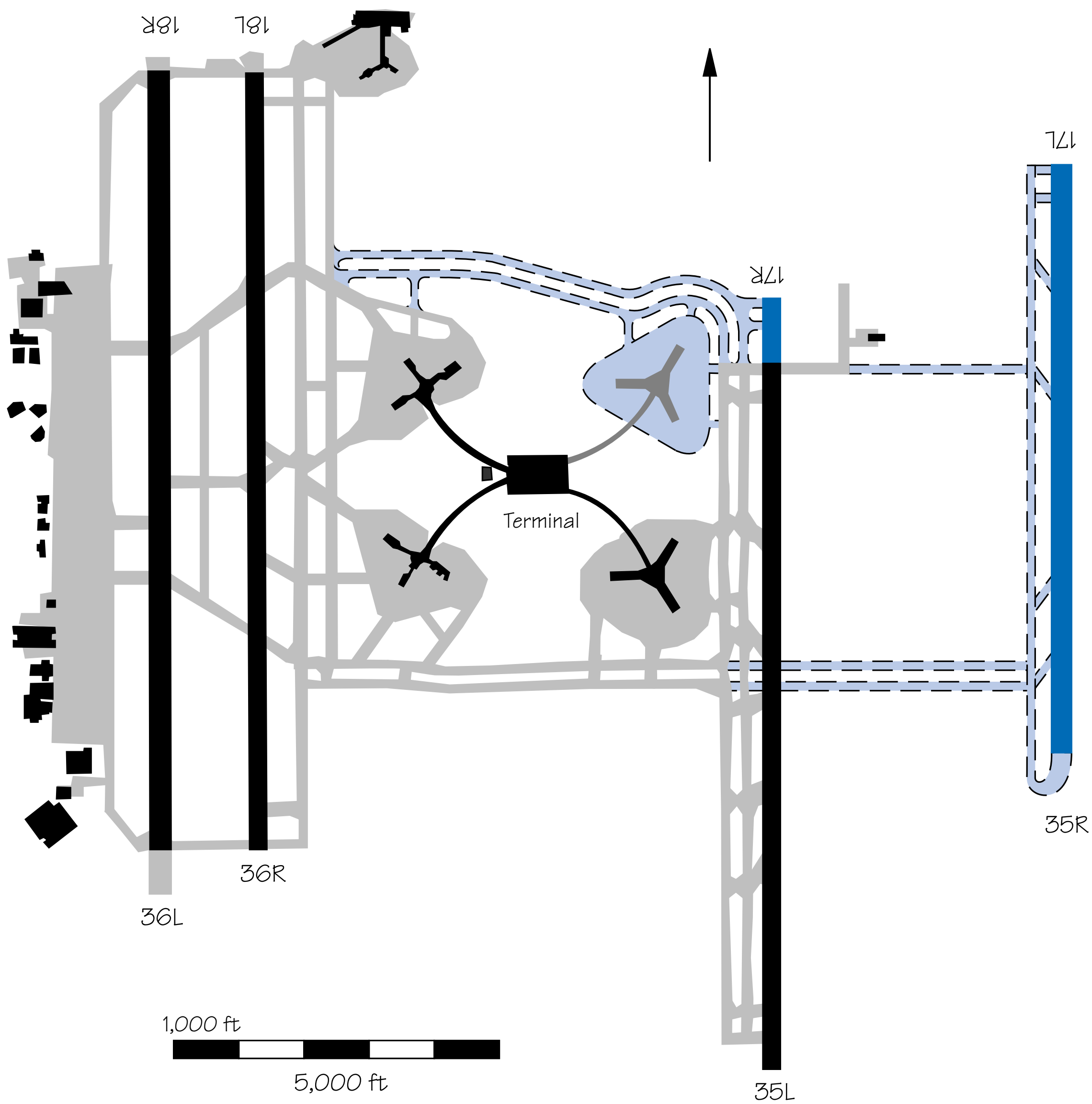
MCI — Kansas City International Airport

In accordance with the Airport Master Plan, an extension of Runway 1L/19R is currently planned. Additional parallel runways west of the existing north-south runway are being considered.



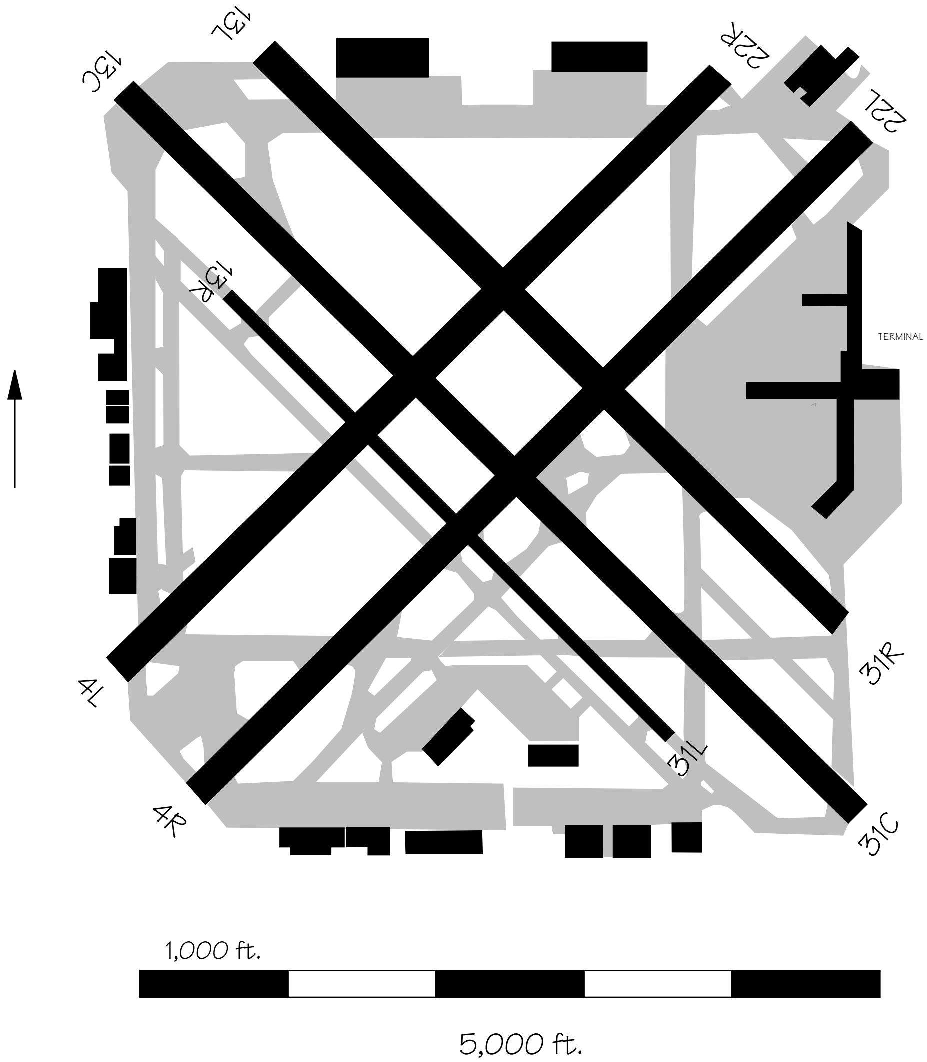
MCO — Orlando International Airport

Environmental mitigation for a fourth north-south runway, Runway 17L/35R, began October 10, 1990. The runway is expected to be operational in 2002. It will be located 4,300 feet east of Runway 17R/35L. This may permit triple independent IFR operations. The estimated cost of construction of this runway is $137 million. Also planned is a 1,000 ft. extension to Runway 17R/35L.



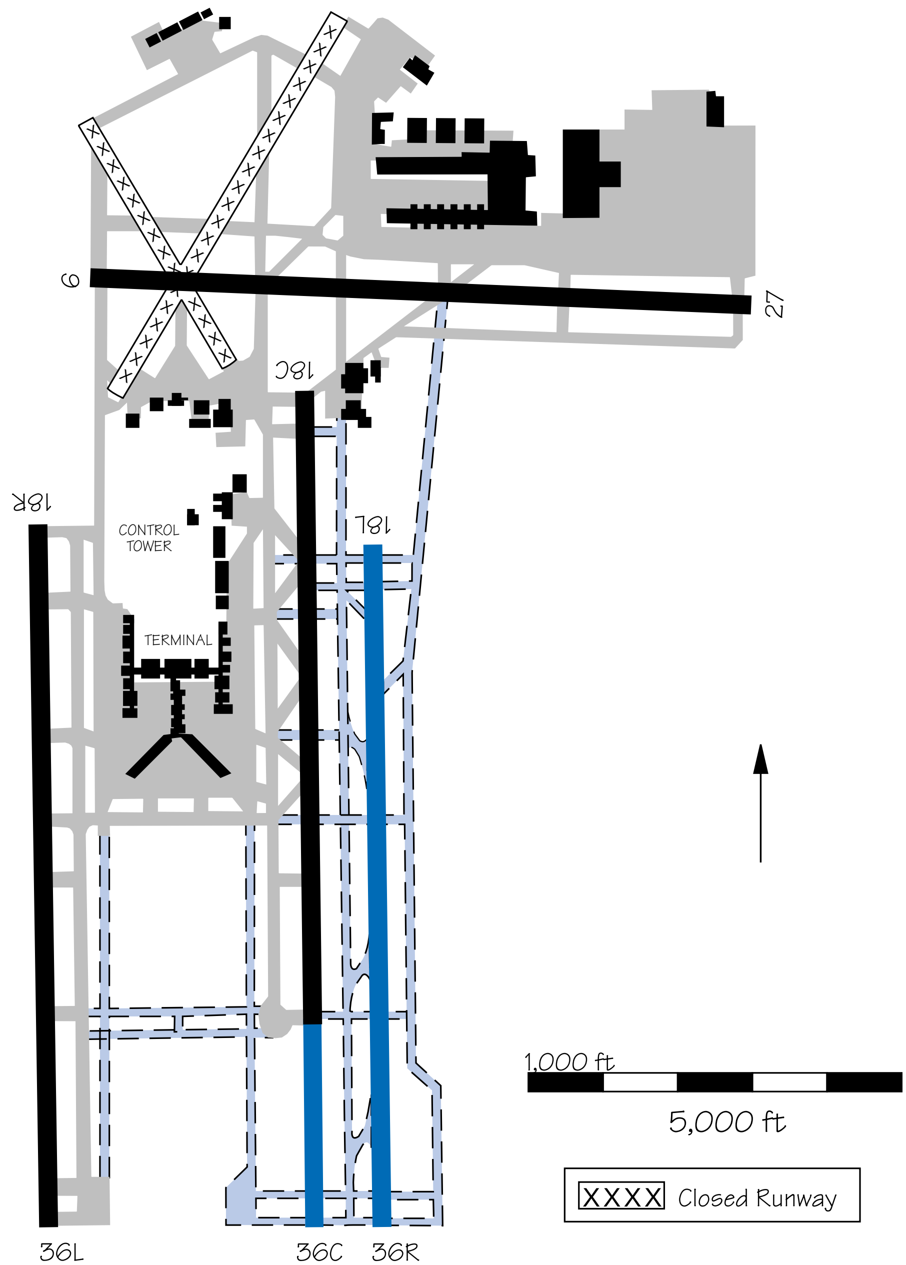
MDW — Chicago Midway Airport

Reconstruction of Runway 4R/22L is scheduled to start in 1997, with a projected cost of $32 million. The project is expected to be completed that same year.



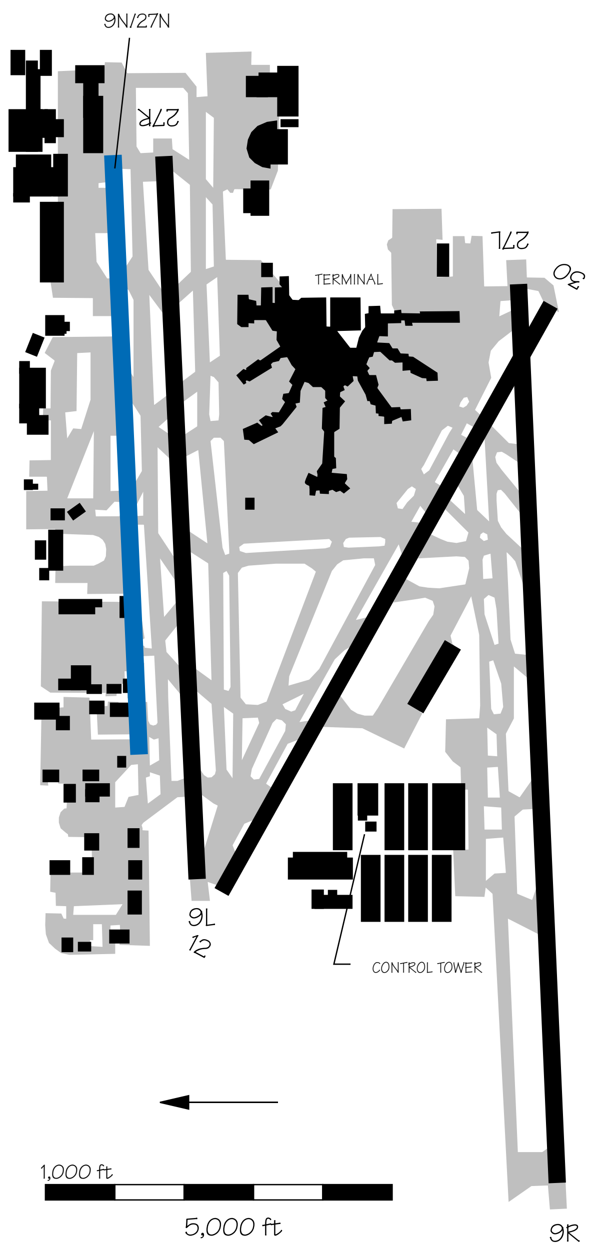
MEM — Memphis International Airport

Construction of a new north-south parallel Runway 18L/36R began in 1993. It will be located about 900 feet east of Runway 18C/36C (old 18L/36R) and 4,300 feet from Runway 18R/36L, thus allowing independent parallel approaches. This will increase present hourly IFR arrival capacity by about 33 percent. The new runway should be operational in 1996. The estimated cost is $146.1 million. A reconstruction and extension of Runway 18L/36R is also planned. Construction is expected to start in 1997 and be completed by 1999 at a cost of $113.7 million.



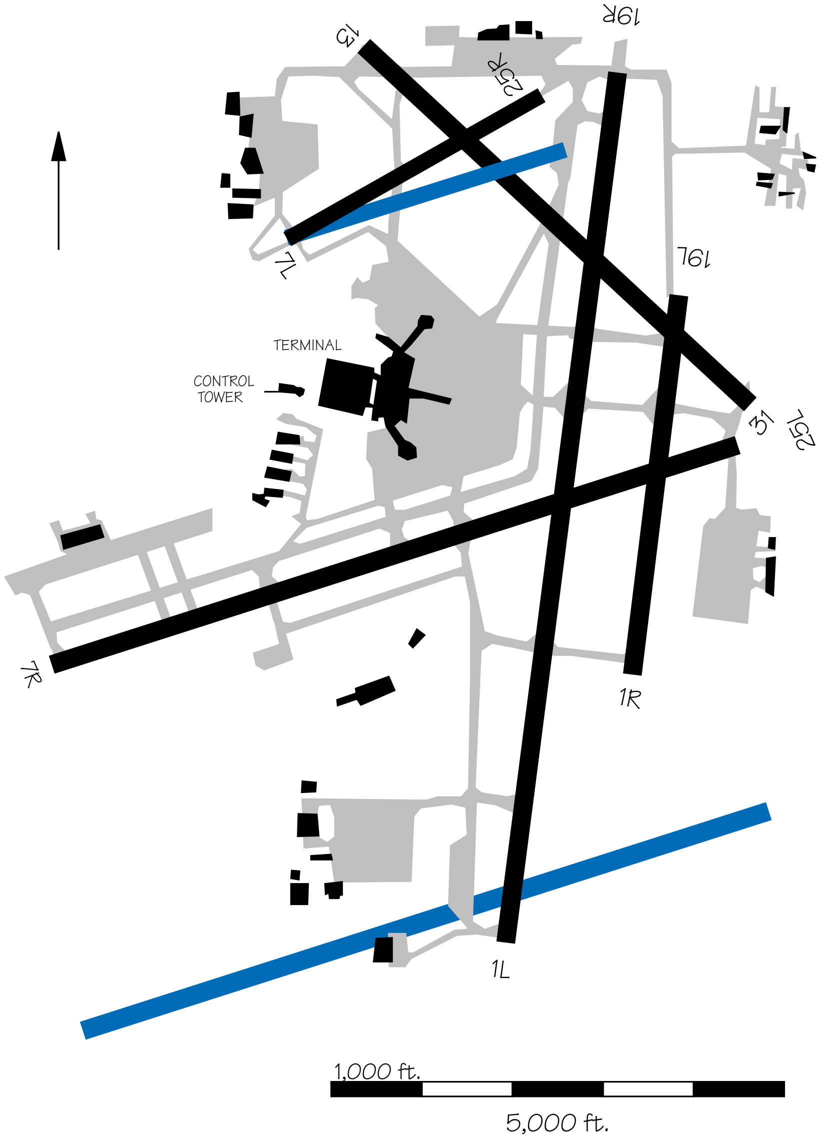
MIA — Miami International Airport

Construction of a new air carrier runway 8,600 feet long and 800 feet north of existing Runway 9L/27R is expected to start in 1997 and be completed by late 1999. The estimated cost of construction is $149 million. An EIS is expected to be completed in mid-1996



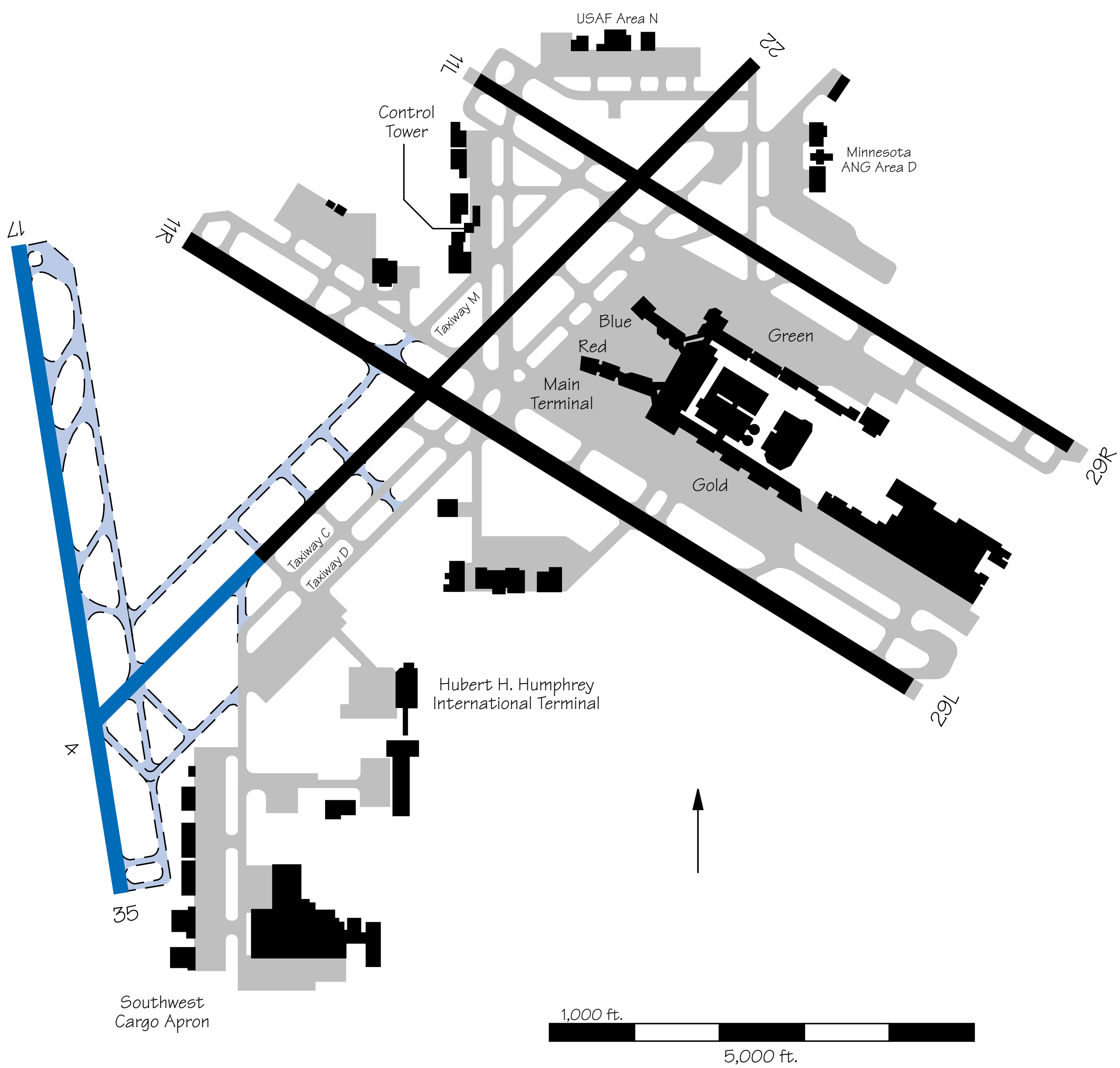
MKE — Milwaukee General Mitchell International Airport

A capacity demand analysis will be done to determine when construction of a new parallel Runway 7R/25L, 3,500 feet south of the existing runway, is needed. An EIS is in progress for the extension of Runway 7L/25R. Realignment of Runway 7L/25R is under grant for construction in 1996, at an estimated cost of $3.5 million.



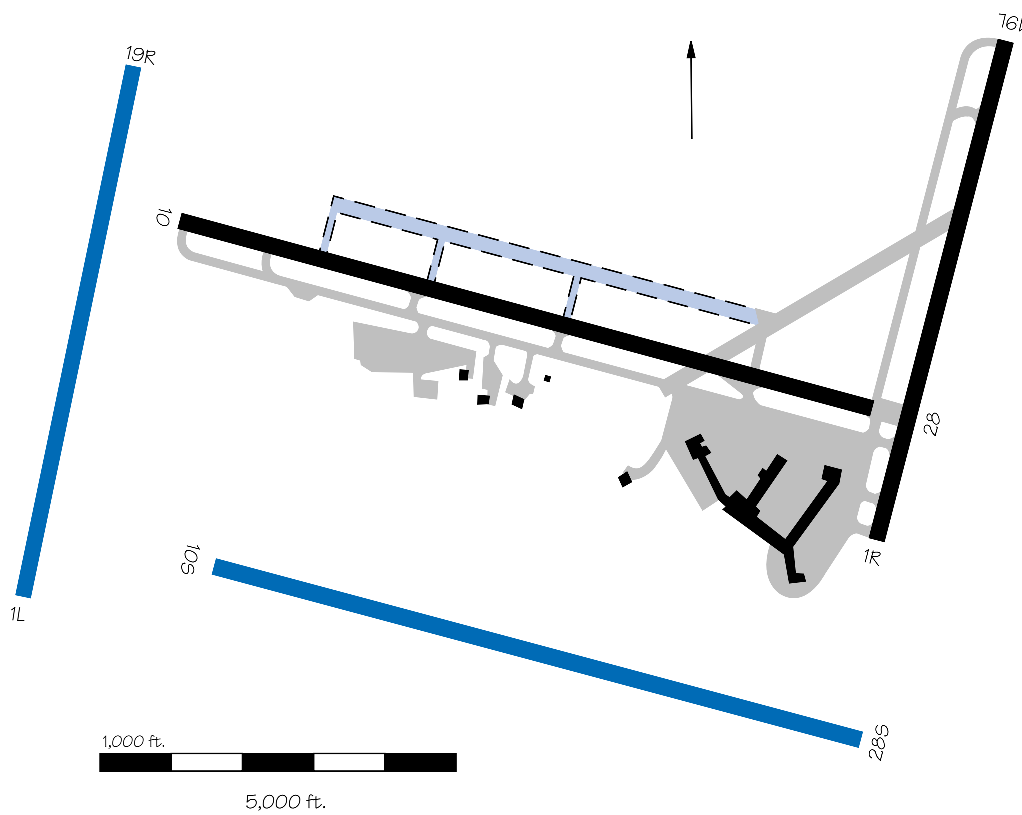
MSP — Minneapolis-St. Paul International Airport

An extension of Runway 4/22, 2,750 feet to the southwest, is proposed, which would bring the runway length to 11,000 feet. Construction began in late 1995, and the extension should be operational in 1996. The estimated cost of construction is $40.2 million, including associated taxiway improvements and noise mitigation for the runway. A new air carrier runway, Runway 17/35, is planned for 2002, at an estimated cost of $120 million.



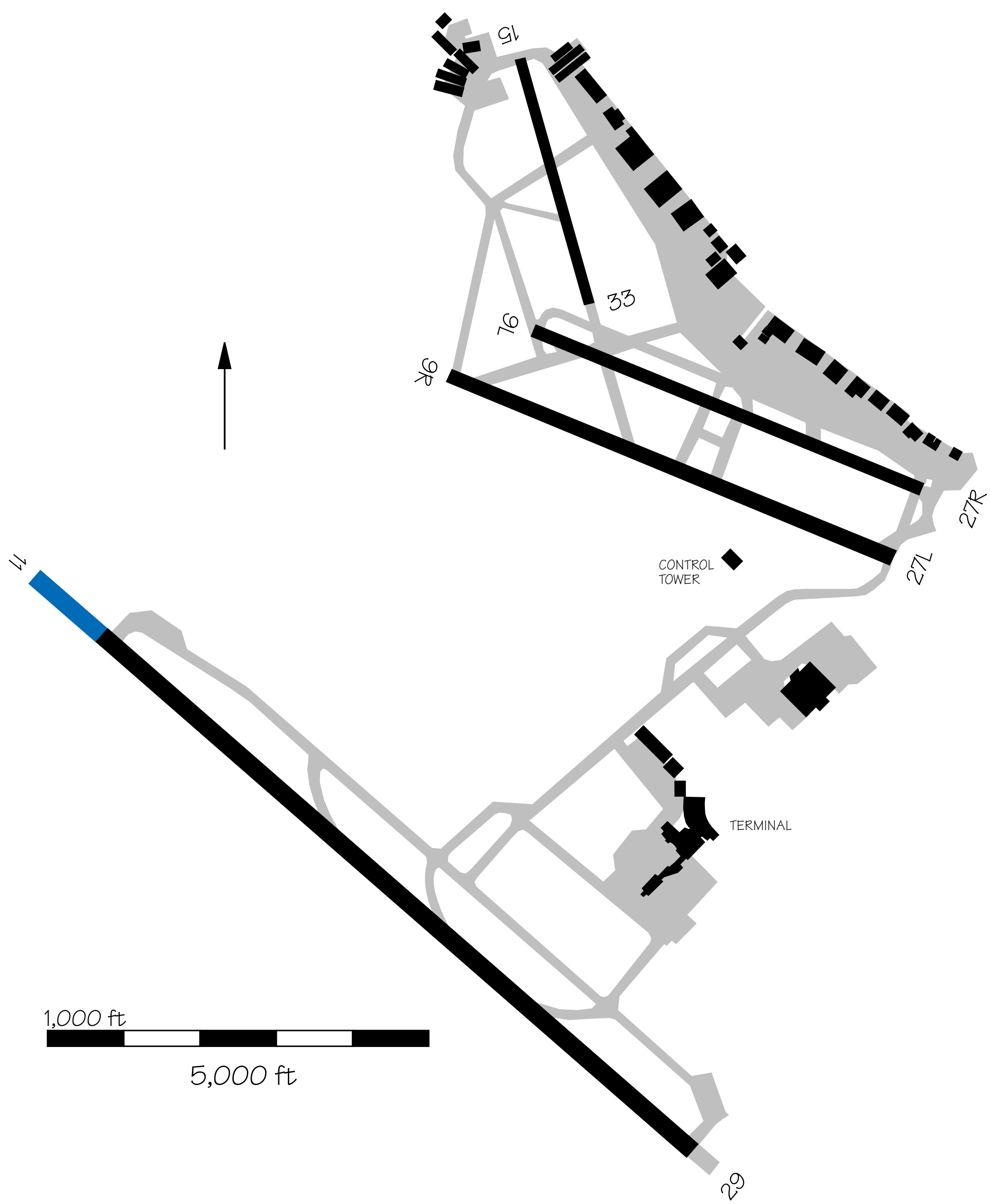
MSY — New Orleans International Airport

A new north-south runway, Runway 1L/19R, is planned. This new runway will be parallel to the existing Runway 1/19 and will be located west of the threshold of Runway 10, approximately 11,000 feet away from Runway 1/19. This will allow independent parallel operations, doubling IFR hourly arrival capacity. Pending environmental approvals, construction could begin as early as 1998 and be completed in 2005, at an approximate cost of $340 million. As an alternative to this north-south runway, the airport is considering the construction of an east/west parallel runway, Runway 10S/28S, 4,300 feet to the south of existing Runway 10/28, off of present airport property. The airport is also planning to construct a north parallel east/west taxiway approximately 800 feet north of and parallel to the existing Runway 10/28, which could later be converted into a 6,000-foot commuter and general aviation runway. The estimated cost of construction is $34 million, and the expected operational date is 1998.



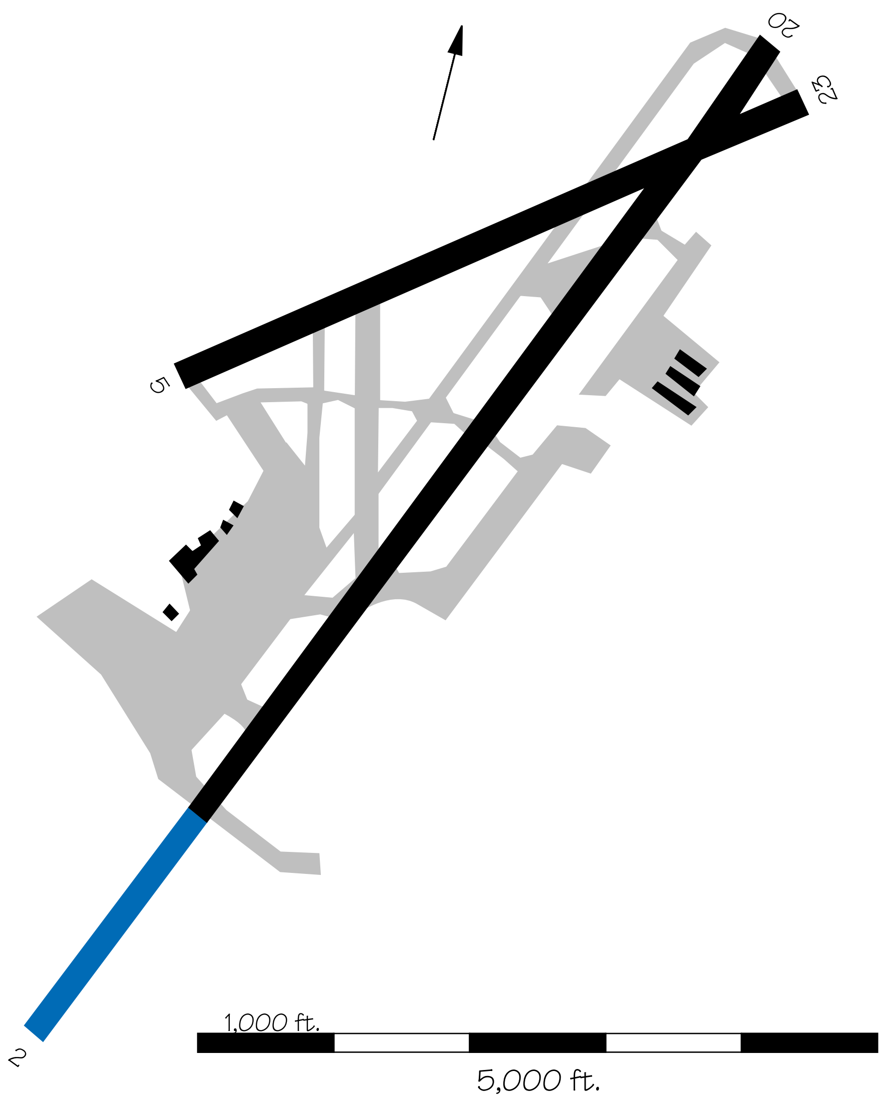
OAK — Metropolitan Oakland International Airport

An extension to Runway 11/29 is planned for ultimate development.



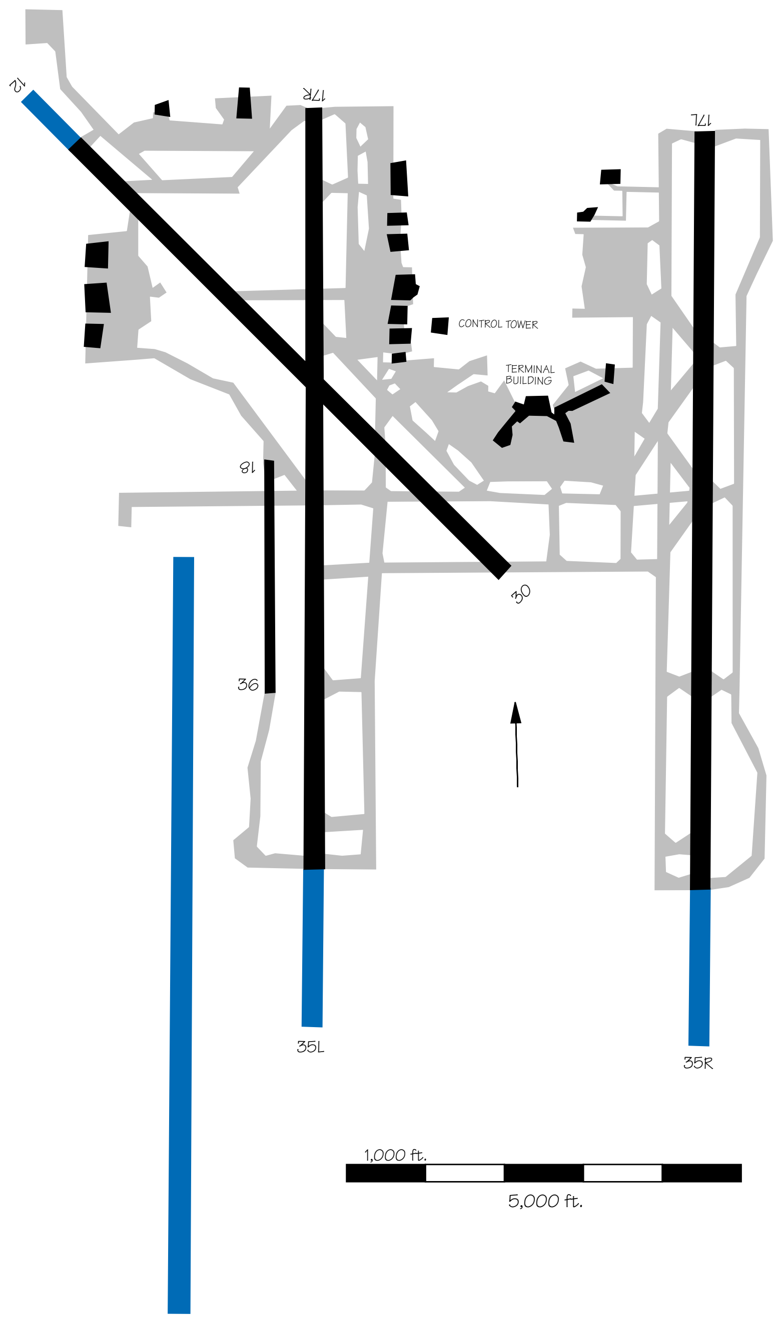
OGG — Kahului Airport

An extension of Runway 2/20 is being planned. An EIS is underway, and the extension could be operational by mid-1998, at a cost of $40 million.



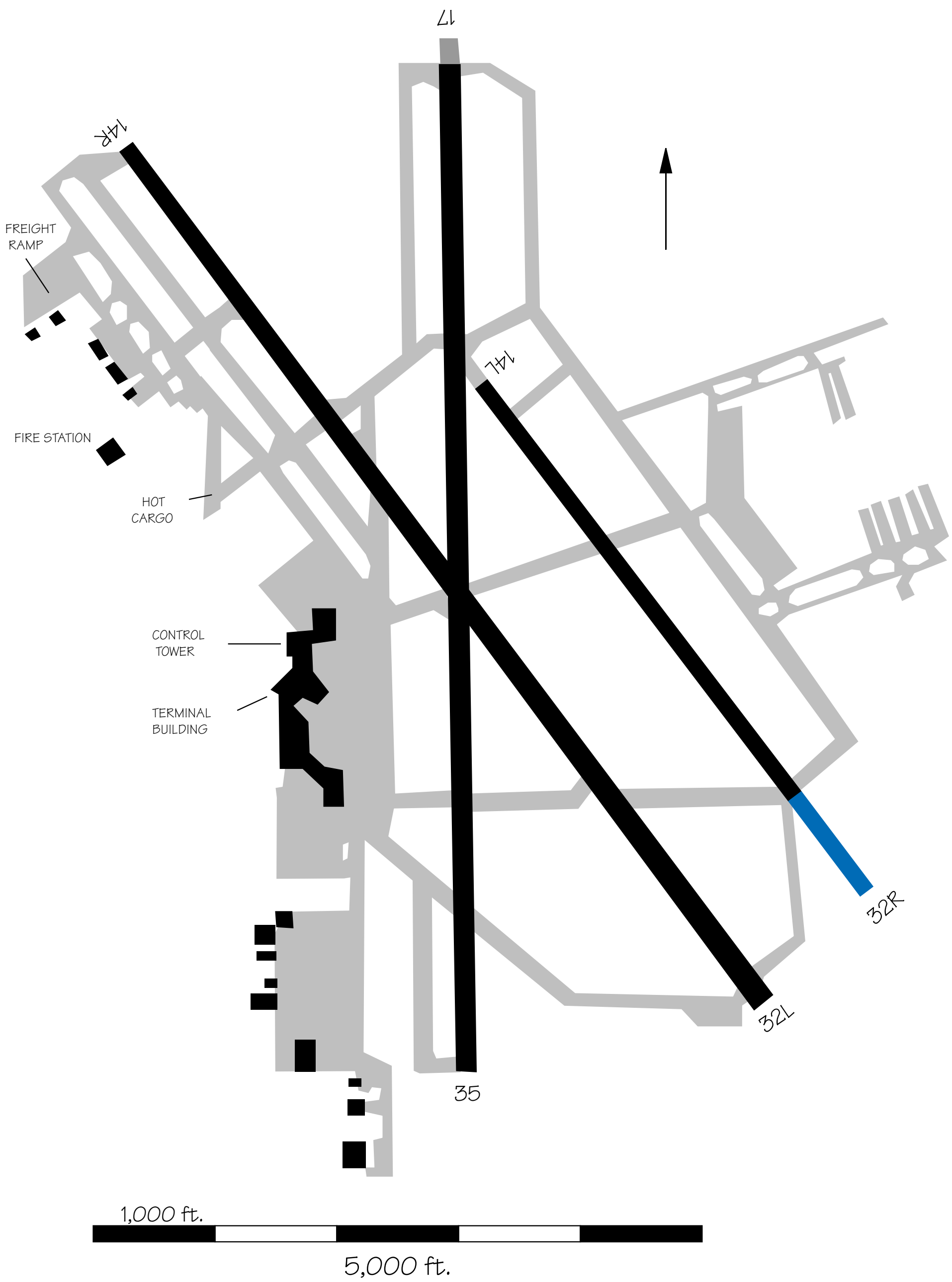
OKC — Oklahoma City Will Rogers World Airport

Construction of a new west parallel runway 1,600 feet west of Runway 17R/35L is planned to be operational by 2004. Estimated cost of construction is $13 million. Extensions to both north/south runways, Runways 17L/35R and 17R/35L, are also planned. The estimated costs of extending the runways is $8 million each. Construction of the extension to Runway 17R/35L is expected to start in 2001 and be completed by 2014. A 1,200 foot extension to the northwest of Runway 13/31 is planned as well. Construction is stated to begin in 2003, be completed in 2005, and cost $5 million.



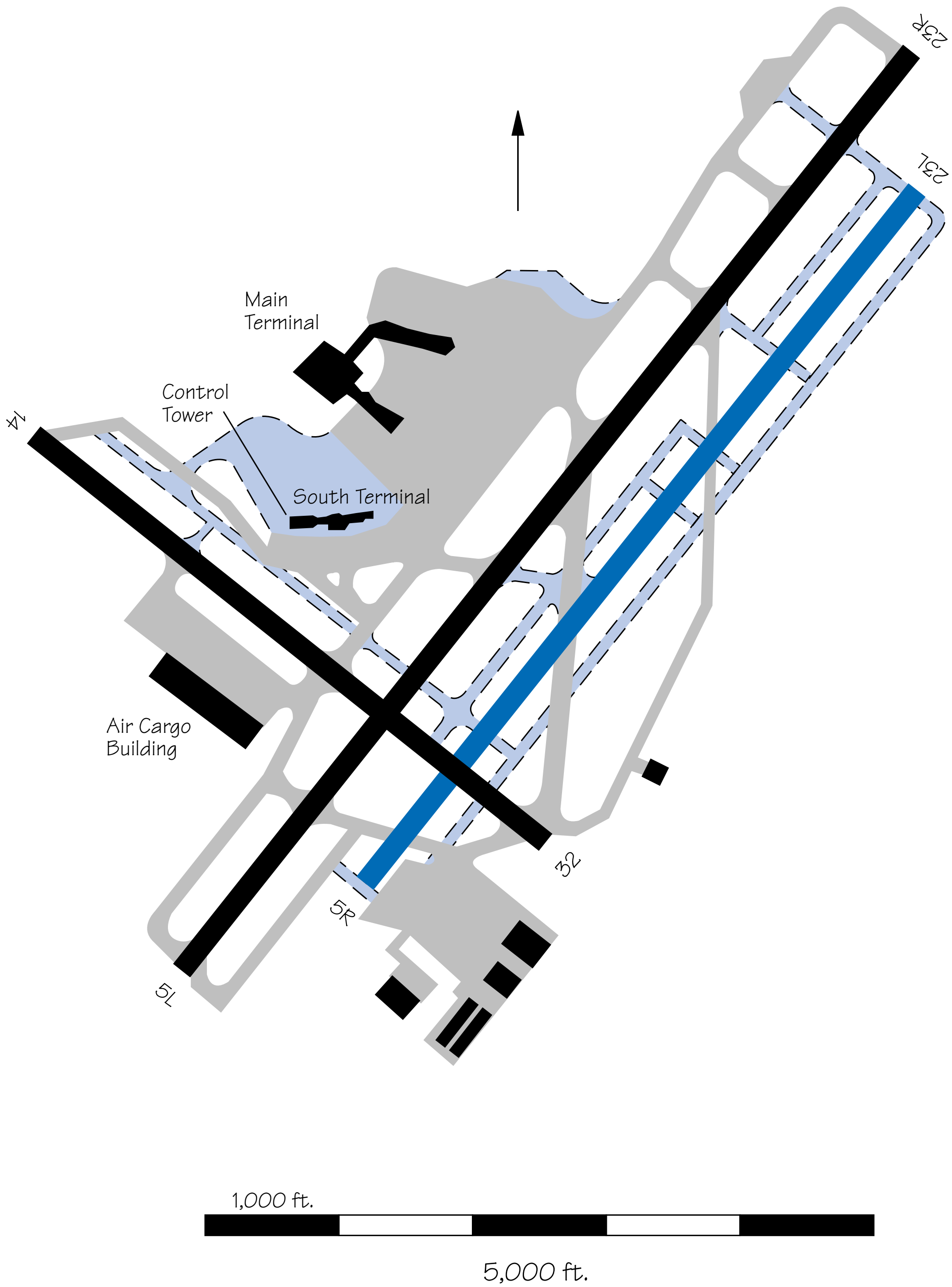
OMA — Omaha Eppley Airfield

A 1,000 foot extension of Runway 14L/32R is planned to begin construction in mid-1996. Expected operational date is mid-1997, with a cost of $9 million, including the relocation of ILS equipment.



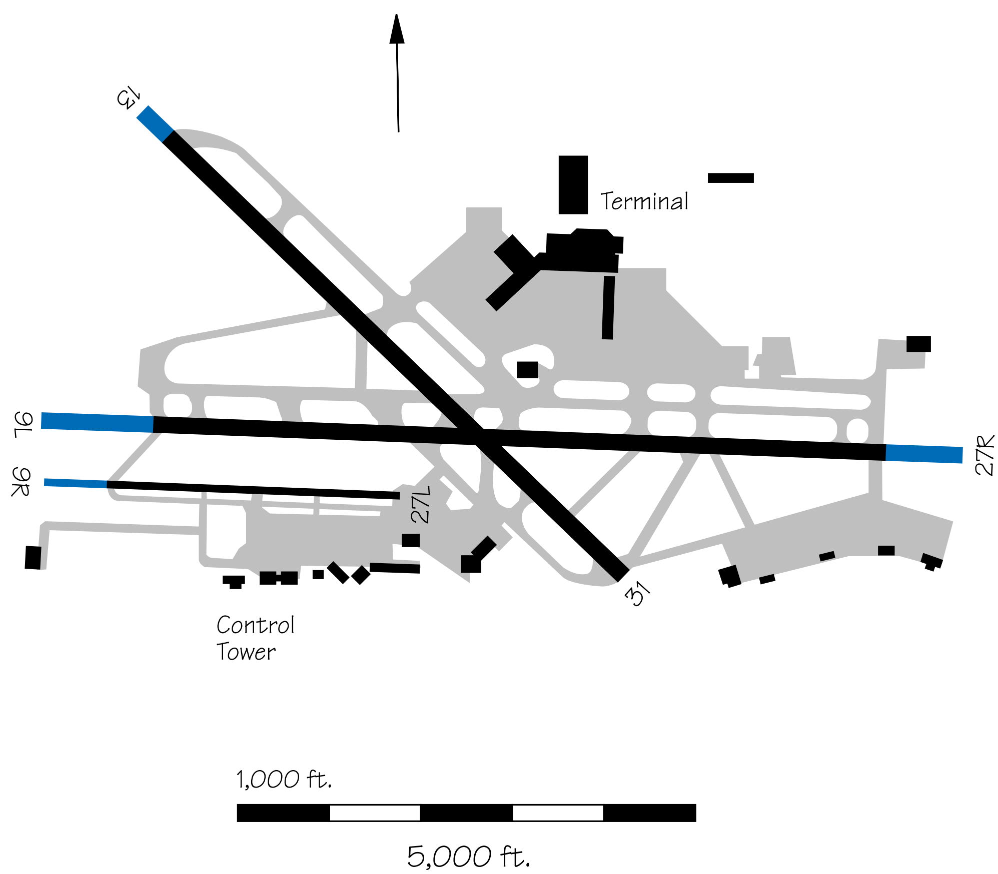
ORF — Norfolk International Airport

A new air carrier runway, Runway 5R/23L, 800 feet south of Runway 5/23 was recommended by the Eastern Region Capacity Design Team. A Master Plan Update is currently underway. The runway could be operational by 2005, at en estimated cost of $75 million, providing the airport can acquire the small amount of additional land required.



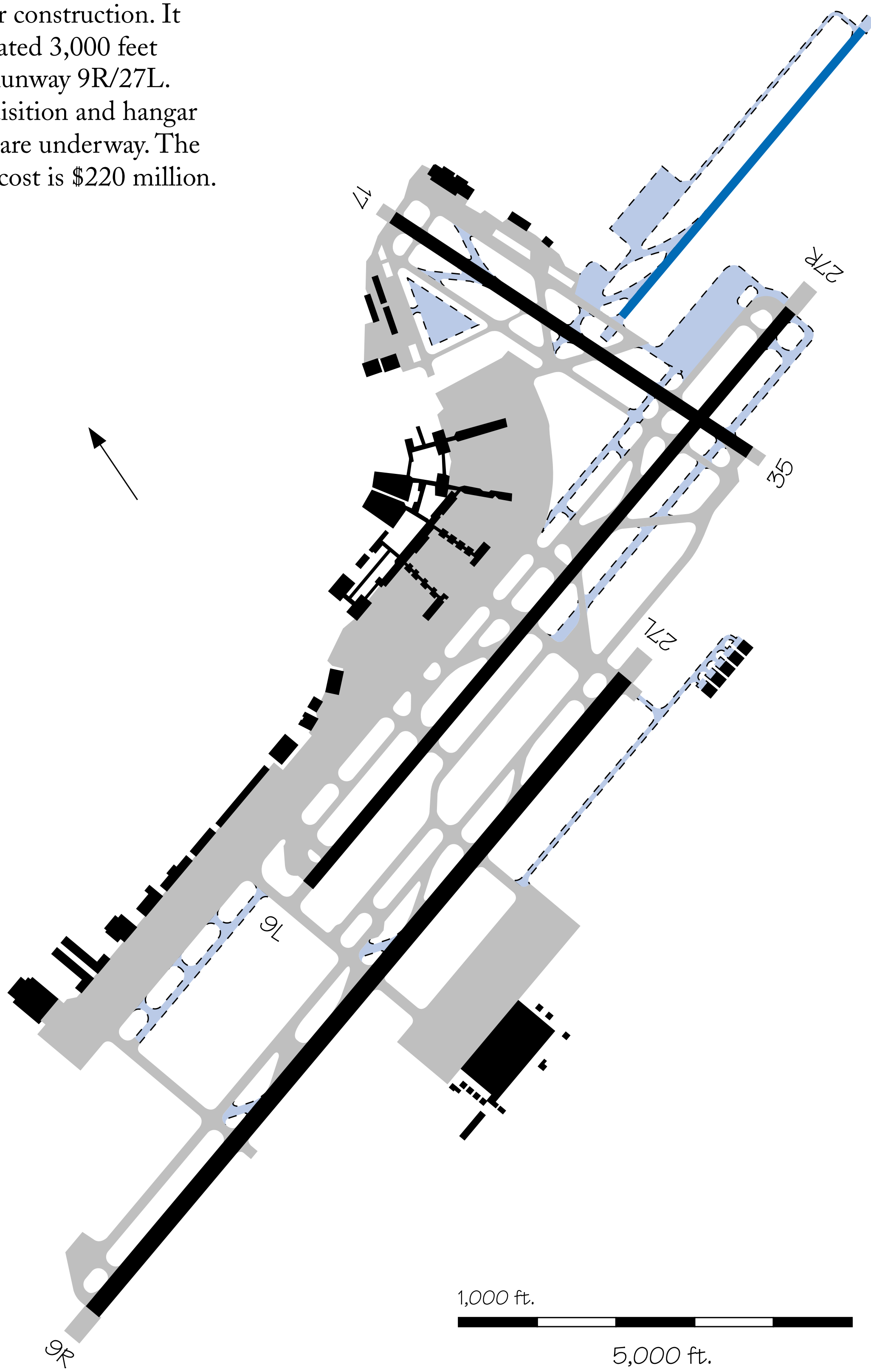
PBI — Palm Beach International Airport

Runway 9L/27R is planned to be extended 1,200 feet to the west and 811 feet to the east, for a total length of 10,000 feet. The total estimated project cost is $8.5 million. In addition, a 250 ft. northwest extension of Runway 13/31 is planned to be completed in 1999 at a cost of $1 million. Finally, a 700 foot extension of Runway 9R/27L is also being considered for completion in 1997 at a cost of $0.5 million.



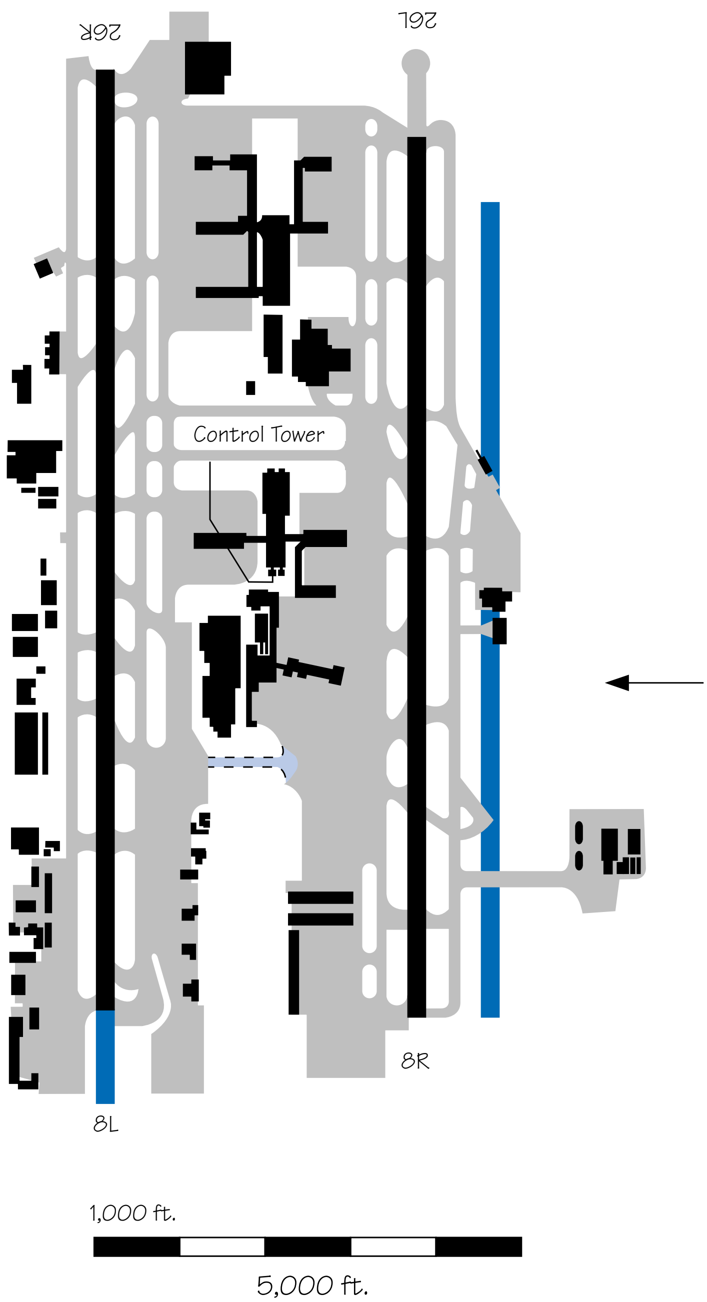
PHL — Philadelphia International Airport

A new 5,000-foot parallel commuter runway, Runway 8/26 is under construction. It will be located 3,000 feet north of Runway 9R/27L. Land acquisition and hangar relocation are underway. The estimated cost is $220 million.



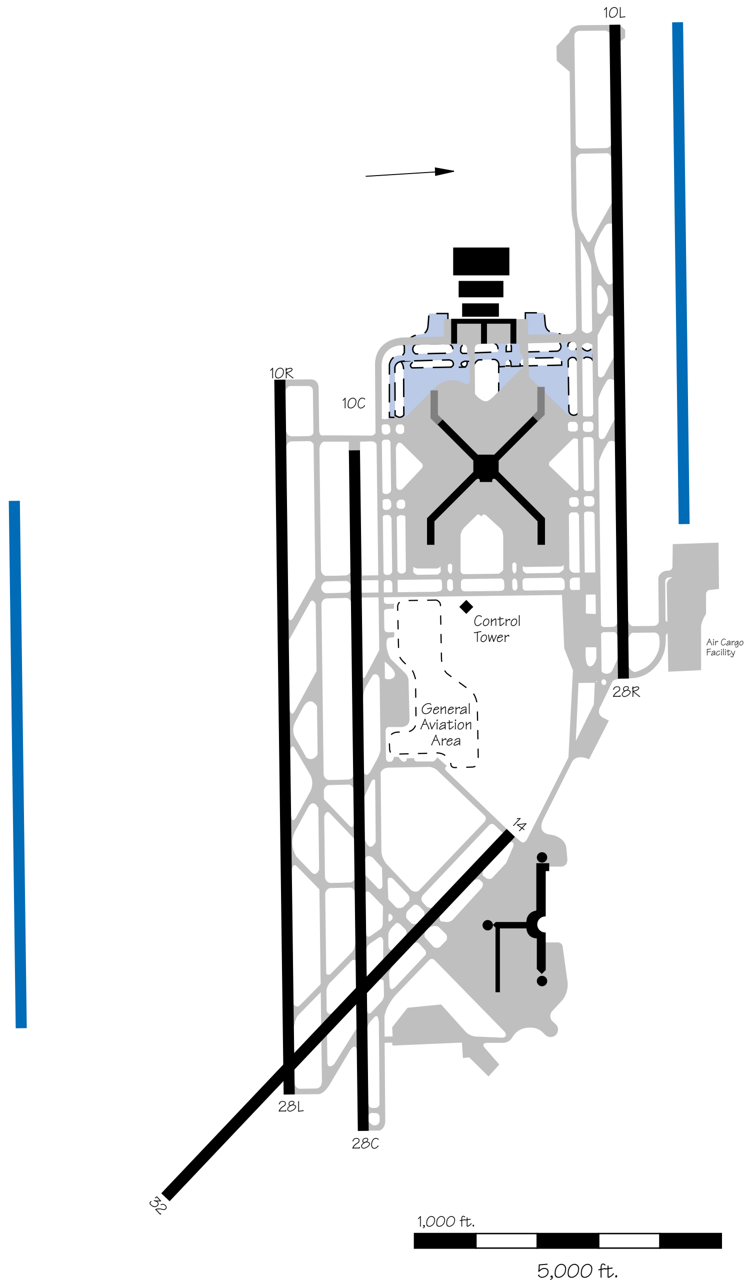
PHX — Phoenix Sky Harbor International Airport

A new 9,500-foot third parallel runway, Runway 7/25, is proposed 800 feet south of Runway 8R/26L. The estimated cost of construction is $88 million. The estimated operational date for the first 7,800 feet of Runway 7/25 is 1997; the remaining 1,700 feet of the runway is not scheduled at this time. In addition, an extension of Runway 8L/26R is under consideration. The estimated cost of construction is $7.0.



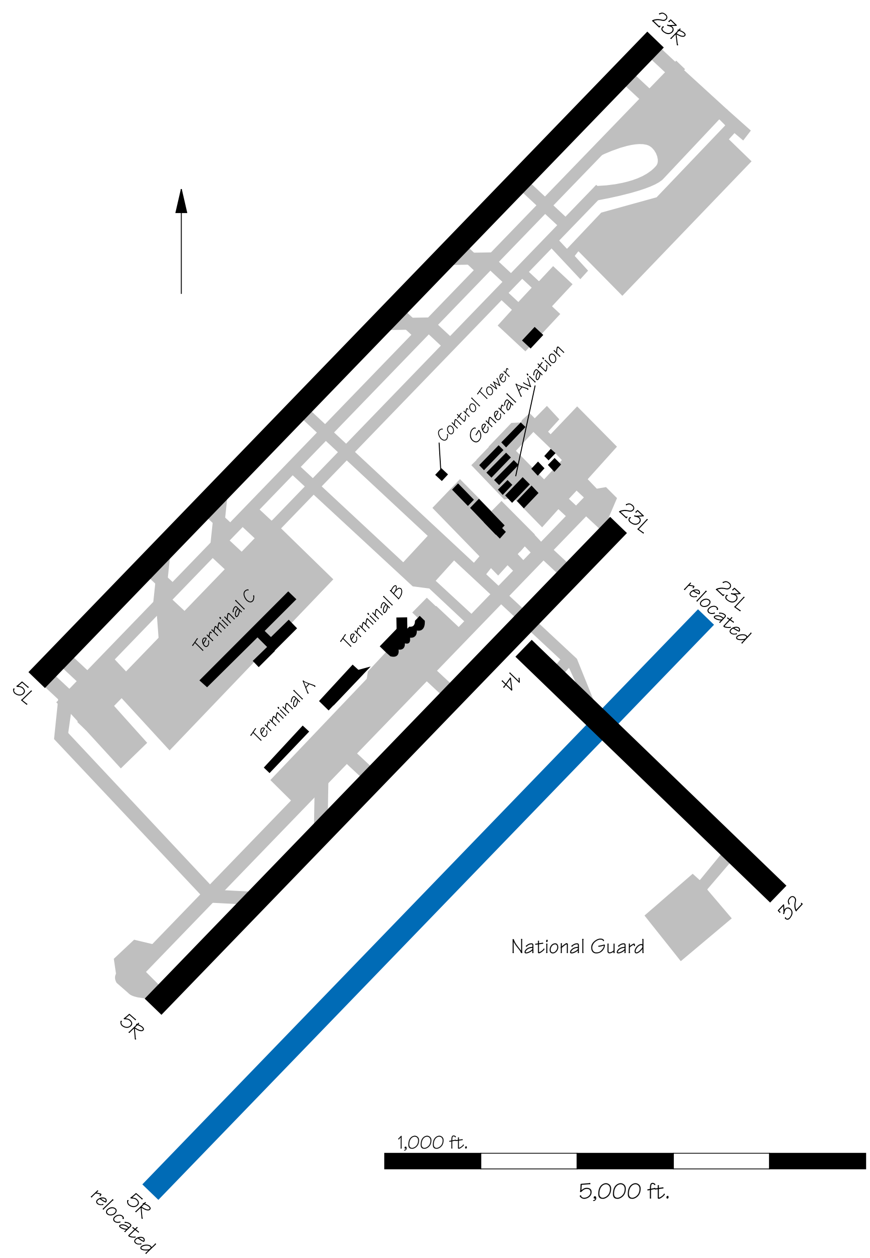
PIT — Greater Pittsburgh International Airport

A recently completed Master Plan has recommended that at least two new runways will be needed within a twenty year planning period to accommodate projected Baseline (normal growth) forecast demands and achieve acceptable aircraft delay times and associated delay costs. Construction of the two east/west runways include a northern parallel and a southern parallel, with the latter as the preferred first-build runway. The southern parallel will be located approximately 4,300 feet south of existing Runway 10R/28L and should be operational by the time the airport reaches 495,000 annual aircraft operations. The northern parallel runway will be located 1,000 feet north of existing Runway 10L/28R and should be operational by the time the airport reaches 522,000 annual aircraft operations.



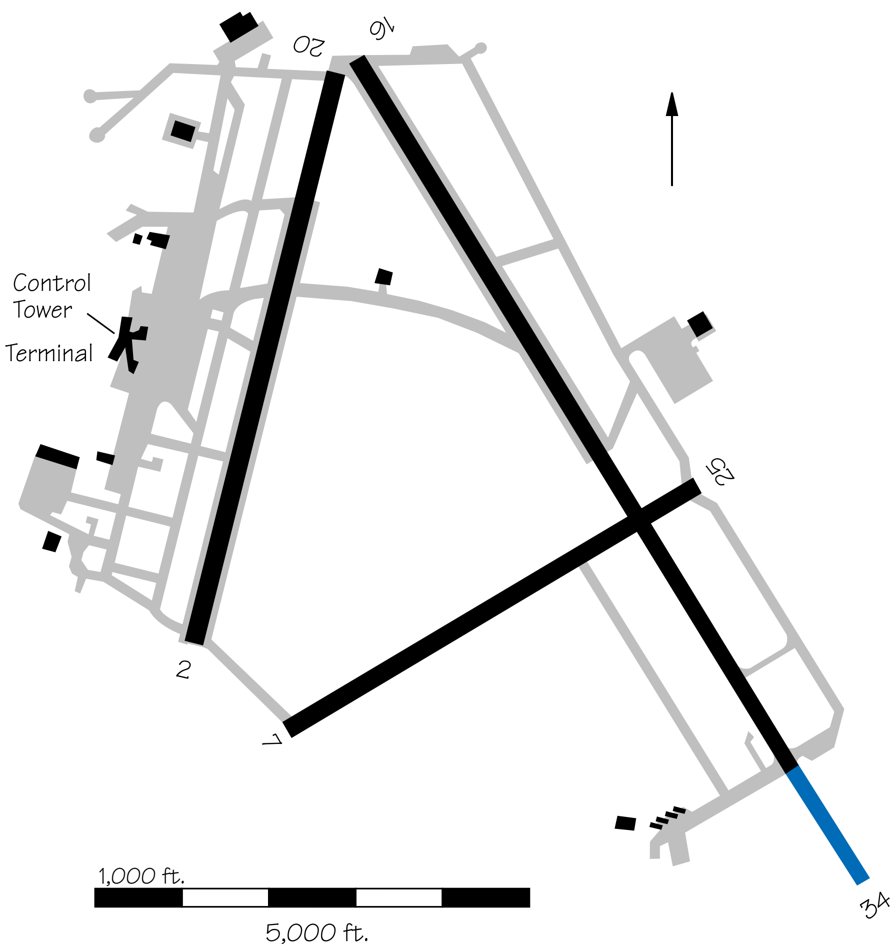
RDU — Raleigh-Durham International Airport

The relocation of Runway 5R/23L and its associated taxiways is being considered. The new runway will be parallel to and approximately 450-1,200 feet southeast of existing Runway 5R/23L. It will be a 9,000-foot long air carrier runway. It is planned to be operational bt 2005.



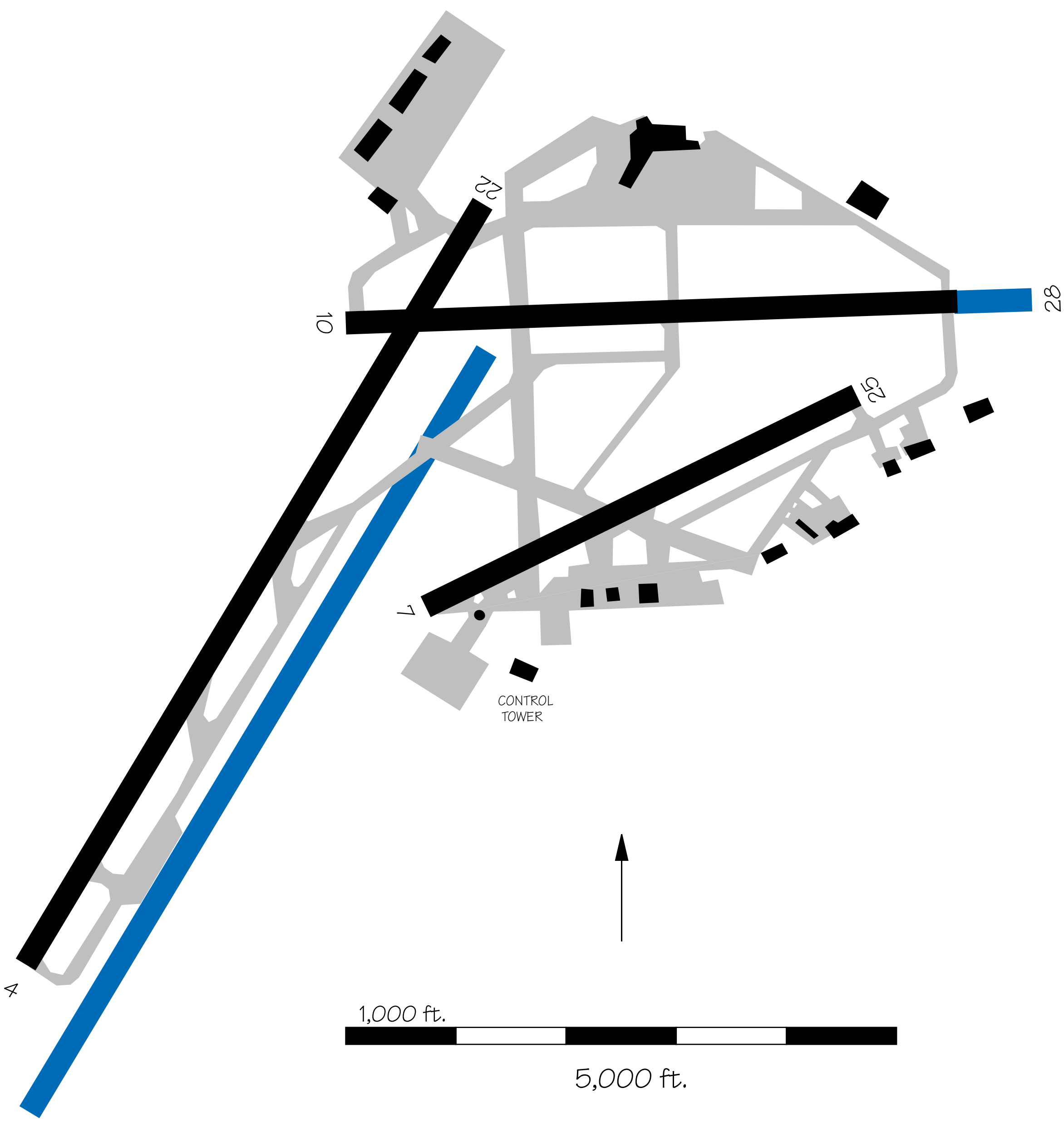
RIC — Richmond International Airport

An extension of Runway 16/34 is planned for an operational date of early 1997. The estimated cost of construction is $45 million.



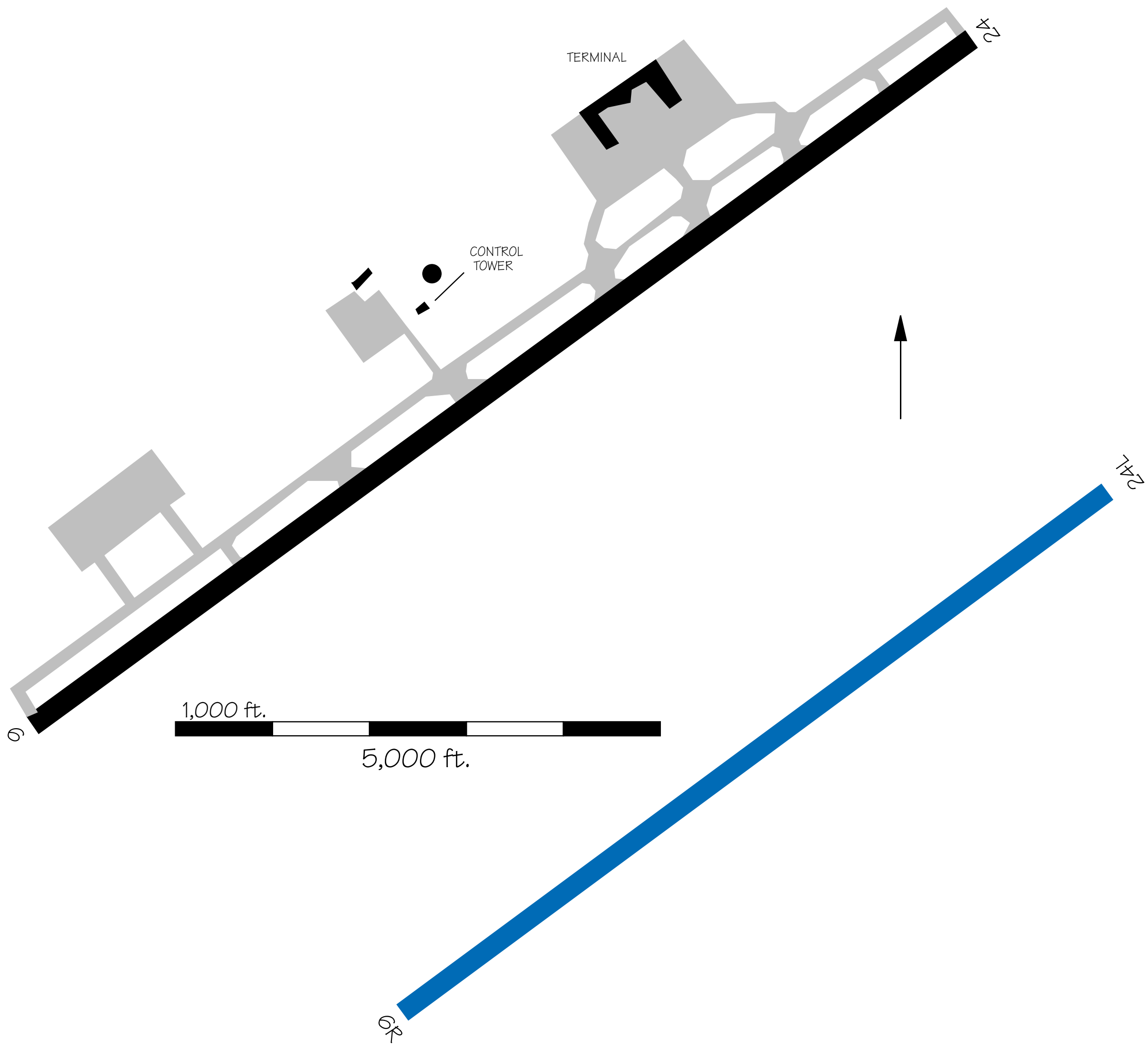
ROC — Greater Rochester International Airport

Construction of an extension to Runway 10/28 is being considered. The estimated cost of construction is $3.2 million. An extension to Runway 4/22 is also being considered, and is expected to cost $4 million. Construction of a new parallel Runway 4R/22L 700 feet southeast of Runway 4/22 is estimated to cost $10 million. These runway improvements are anticipated post 2000. Environmental assessments have not yet been started for these projects.



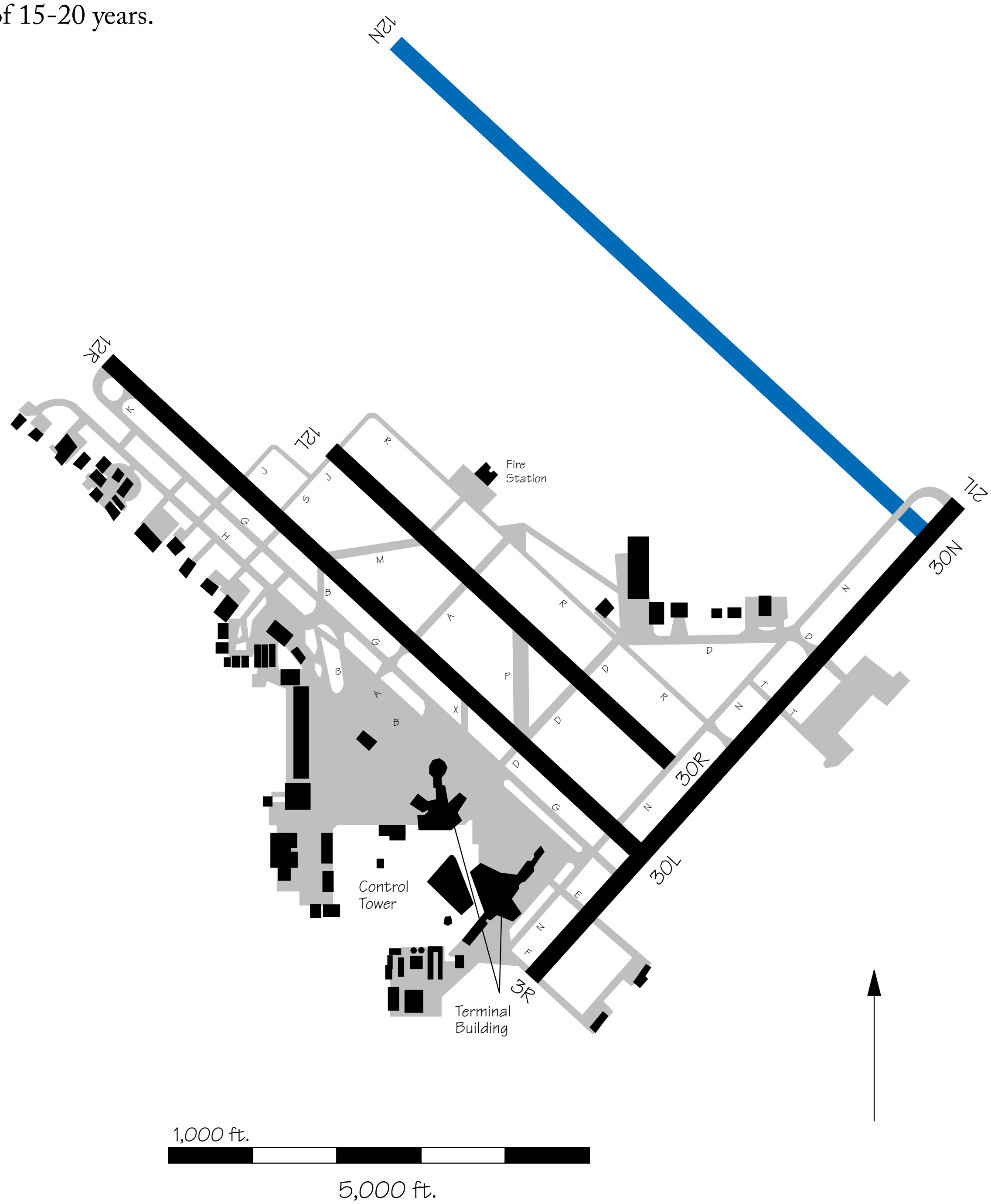
RSW — Fort Myers Southwest Florida Regional Airport

Planning has begun for a new 9,100 foot parallel runway, Runway 6R/24L, 4,300 feet or more southeast of Runway 6/24. Construction is expected to begin in 1998. The new runway should be operational by 2000. The estimated cost of the project is $87 million. This new runway will support independent parallel operations.



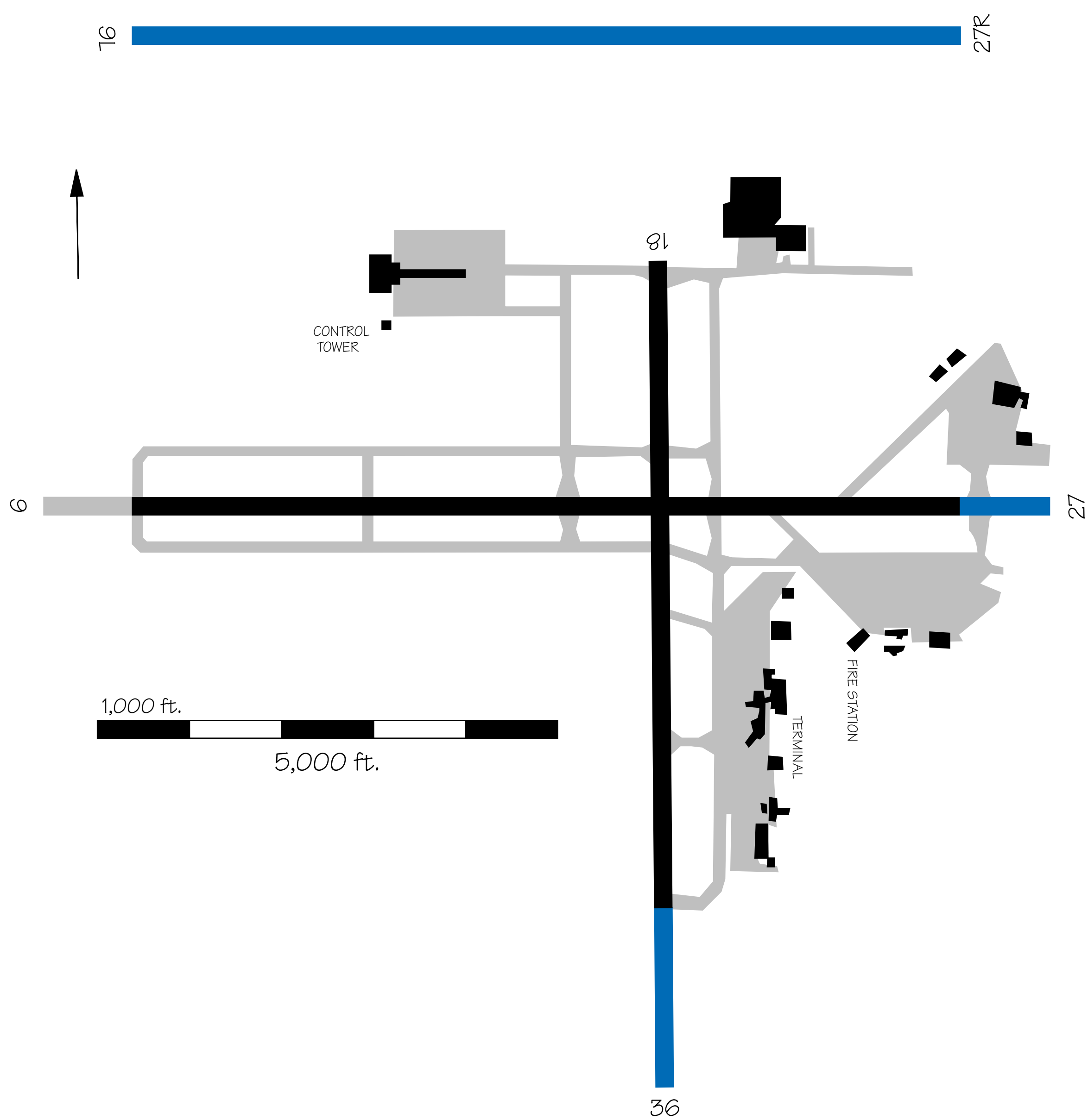
SAT — San Antonio International Airport

Reconstruction and extension of Runway 12L/30R for air carrier operations is being planned for beyond 2000, as demand warrants. A third parallel runway, Runway 12N/30N, is in the long term planning as well, with a time frame of 15-20 years.



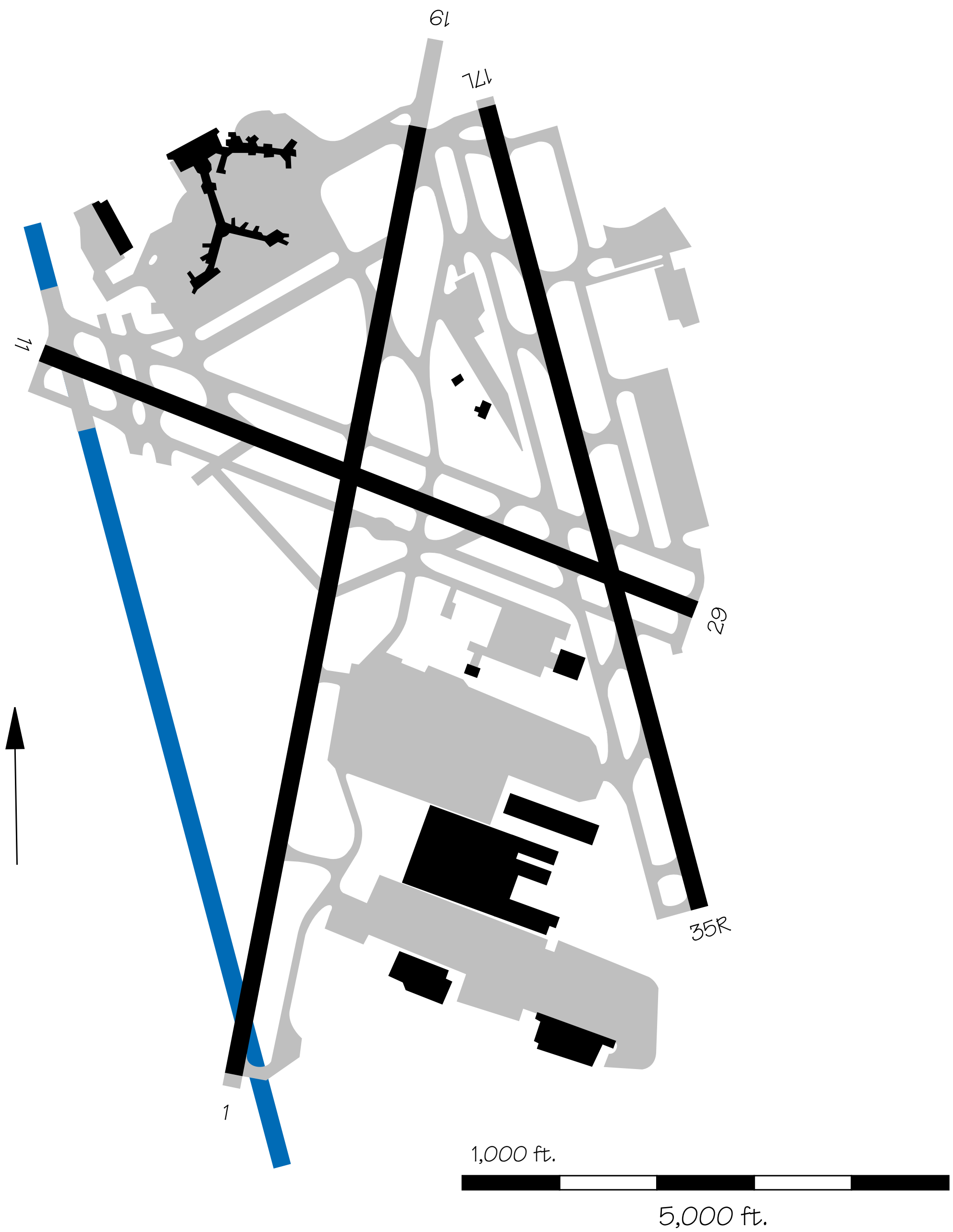
SAV — Savannah International Airport

Three runway construction projects are being planned. A 2,000-foot extension to Runway 18/36 is planned for the year 2000, at a cost of $3.9 million. A new 9,000-foot parallel runway, Runway 9L/27R, approximately 5,000 feet north of Runway 9/27, is expected to be constructed in 2005, with an estimated cost of $15.2 million. Also, an extension to the existing Runway 9/27 is planned to begin in 1999, at a cost of $5 million.



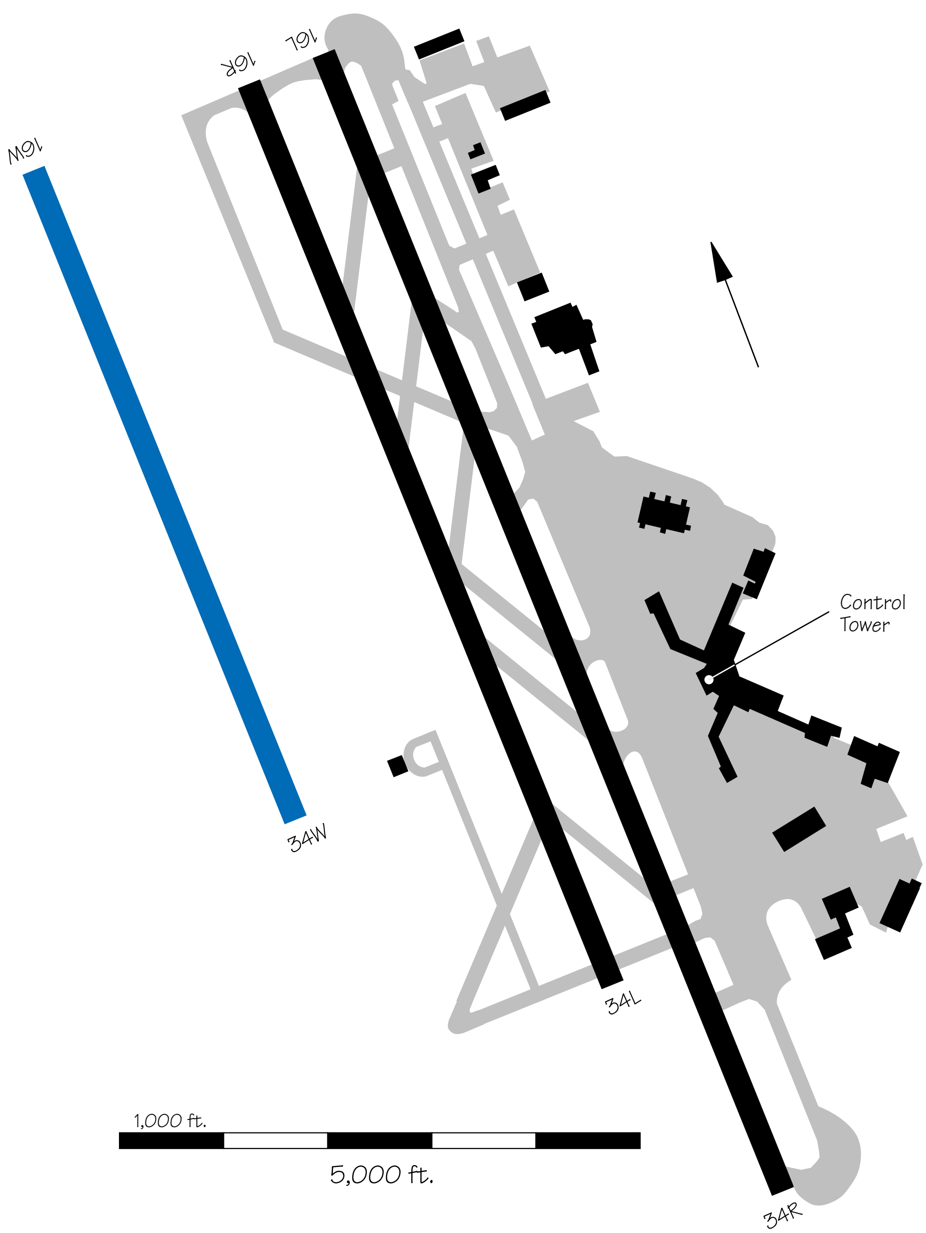
SDF — Louisville Standiford Field

Construction is underway for two new parallel runways, 4,950 feet apart. They will be numbered Runways 17R/35L and 17L/35R and will be 10,000 and 8,580 feet long, respectively. They will replace Runway 1/19, which will be closed. The estimated cost of construction is $59 million for Runway 17R/35L. Runway 17L/35R is complete, and Runway 17R/35L is expected to be completed in 1997. The two runways will permit independent parallel IFR operations.



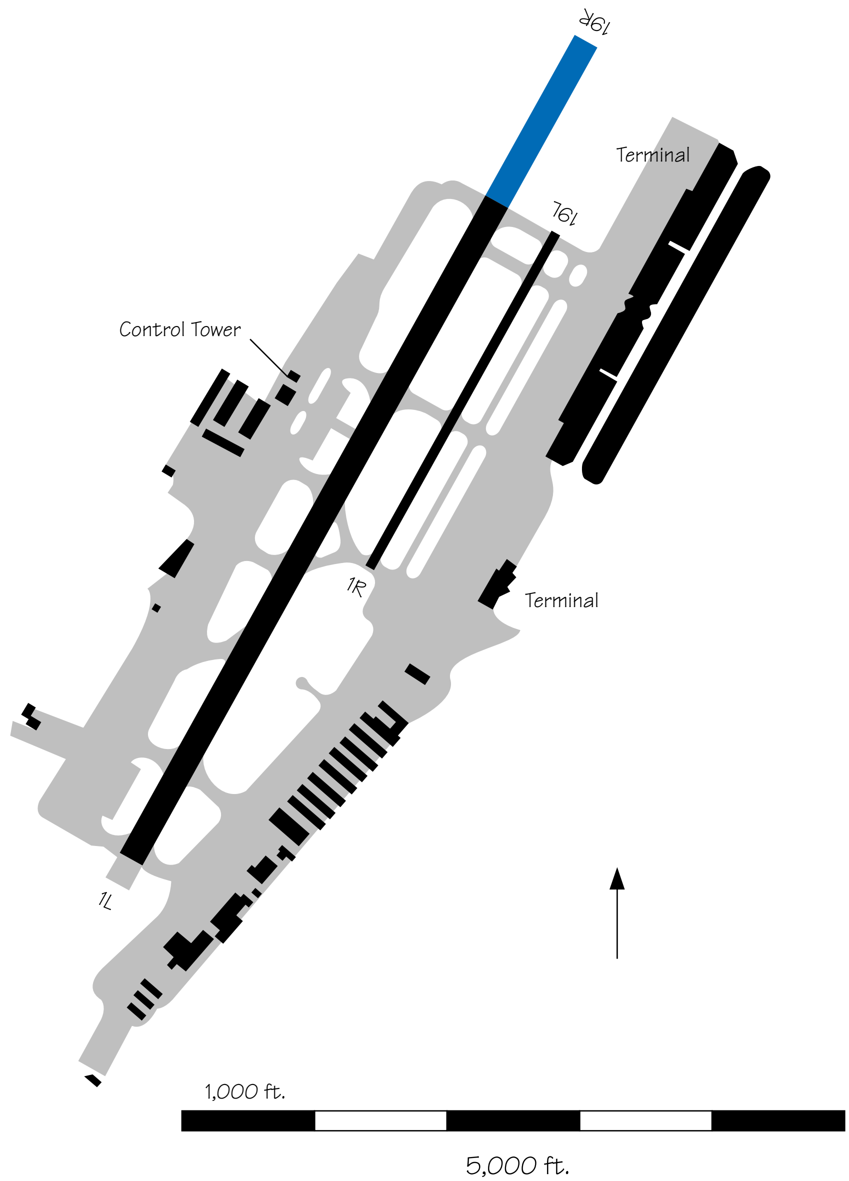
SEA — Seattle-Tacoma International Airport

Potential airport improvements include a new Runway 16W/34W, up to 8,500 feet in length, which will be located 2,500 feet from Runway 16L/34R. A decision on construction will be made in 1996, and the estimated cost of construction is $400 million.



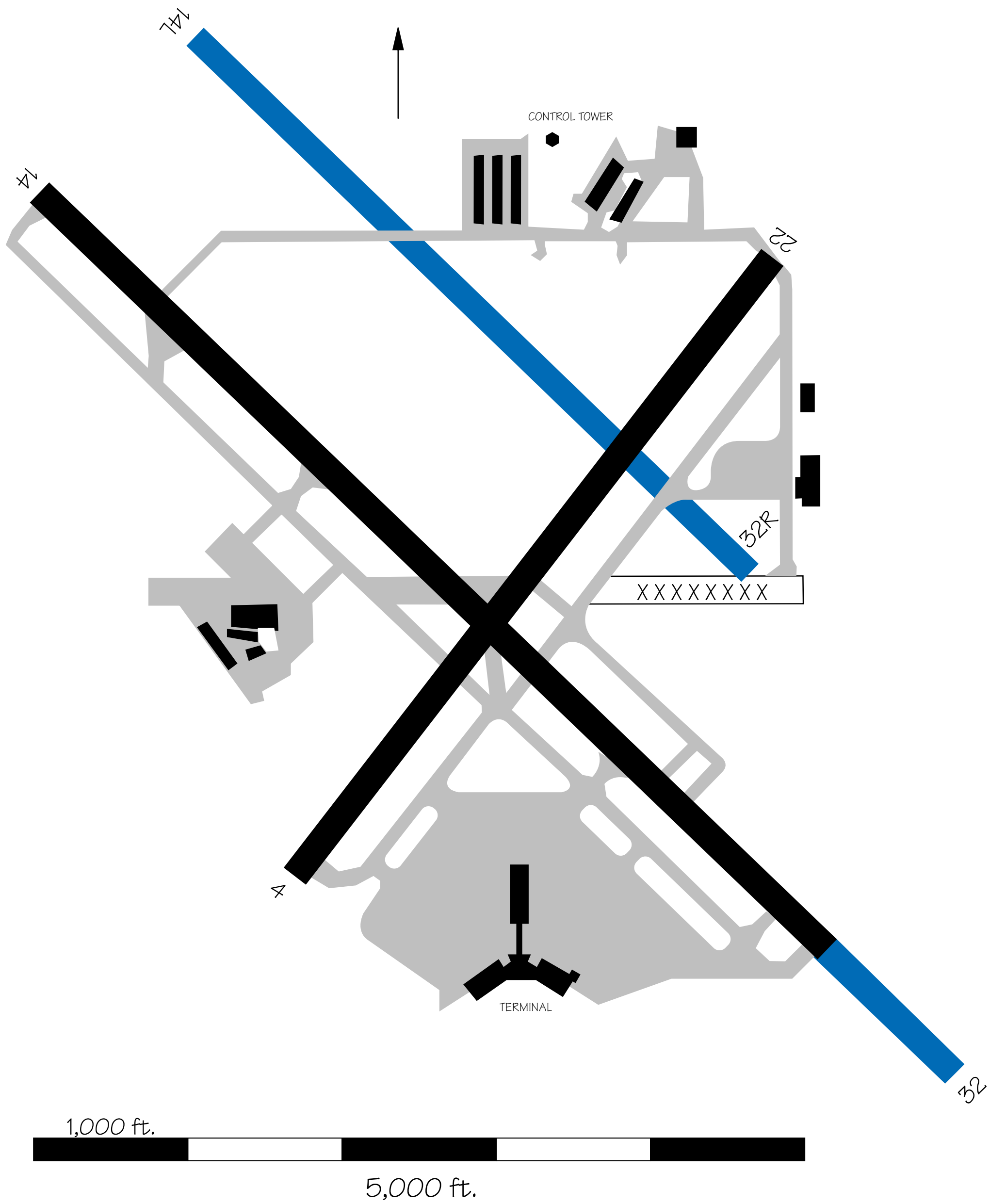
SNA — Santa Ana/John Wayne Airport - Orange County

An extension of Runway 1L/19R is under consideration.



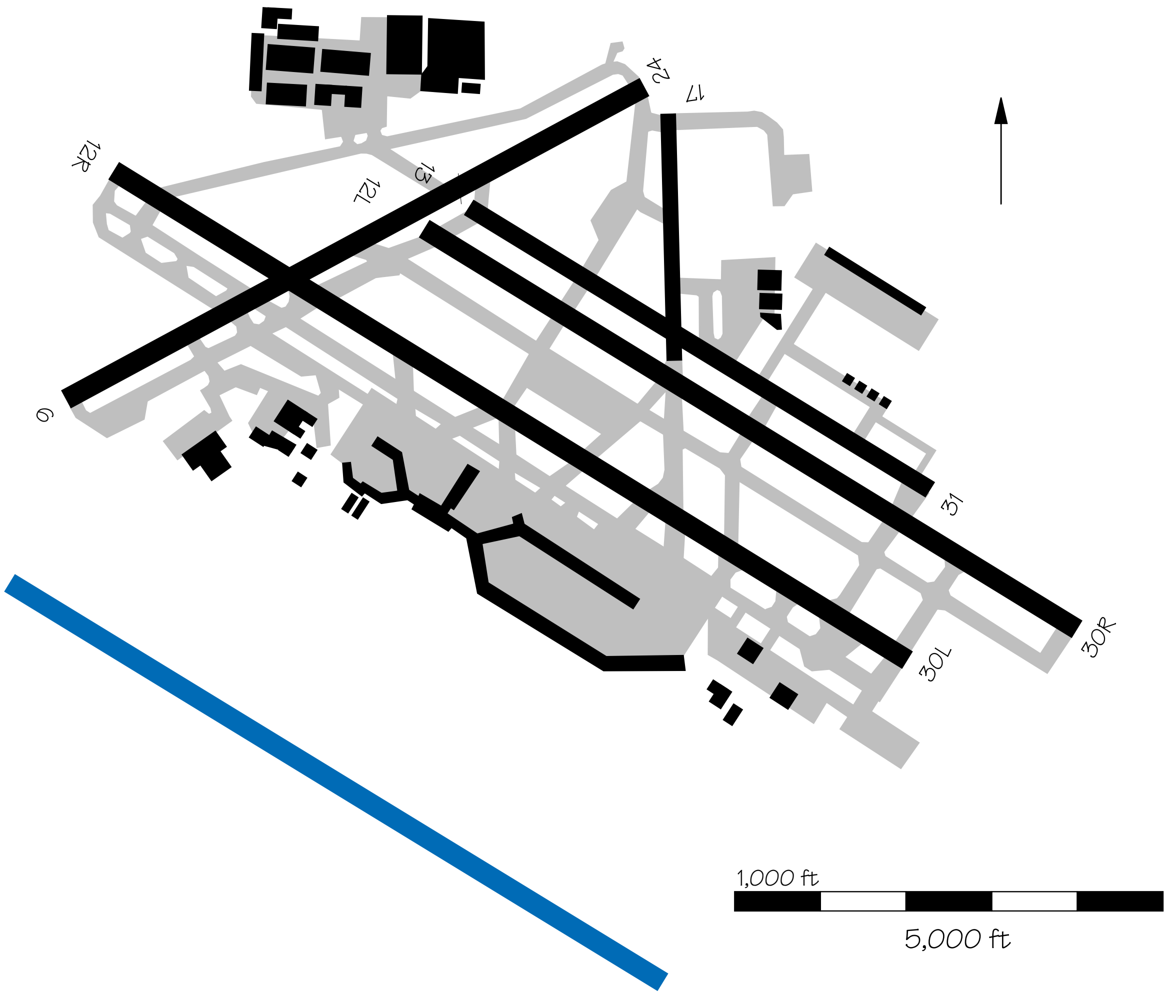
SRQ — Sarasota Bradenton Airport

A new parallel Runway 14L/32R 1,230 feet northwest of Runway 14/32 is being planned at an estimated cost of $10 million. It is expected to be operational beyond 2000. In addition, an extension of the existing Runway 14/32 is planned at a cost of $5.1 million. It is expected to be complete in 1998.



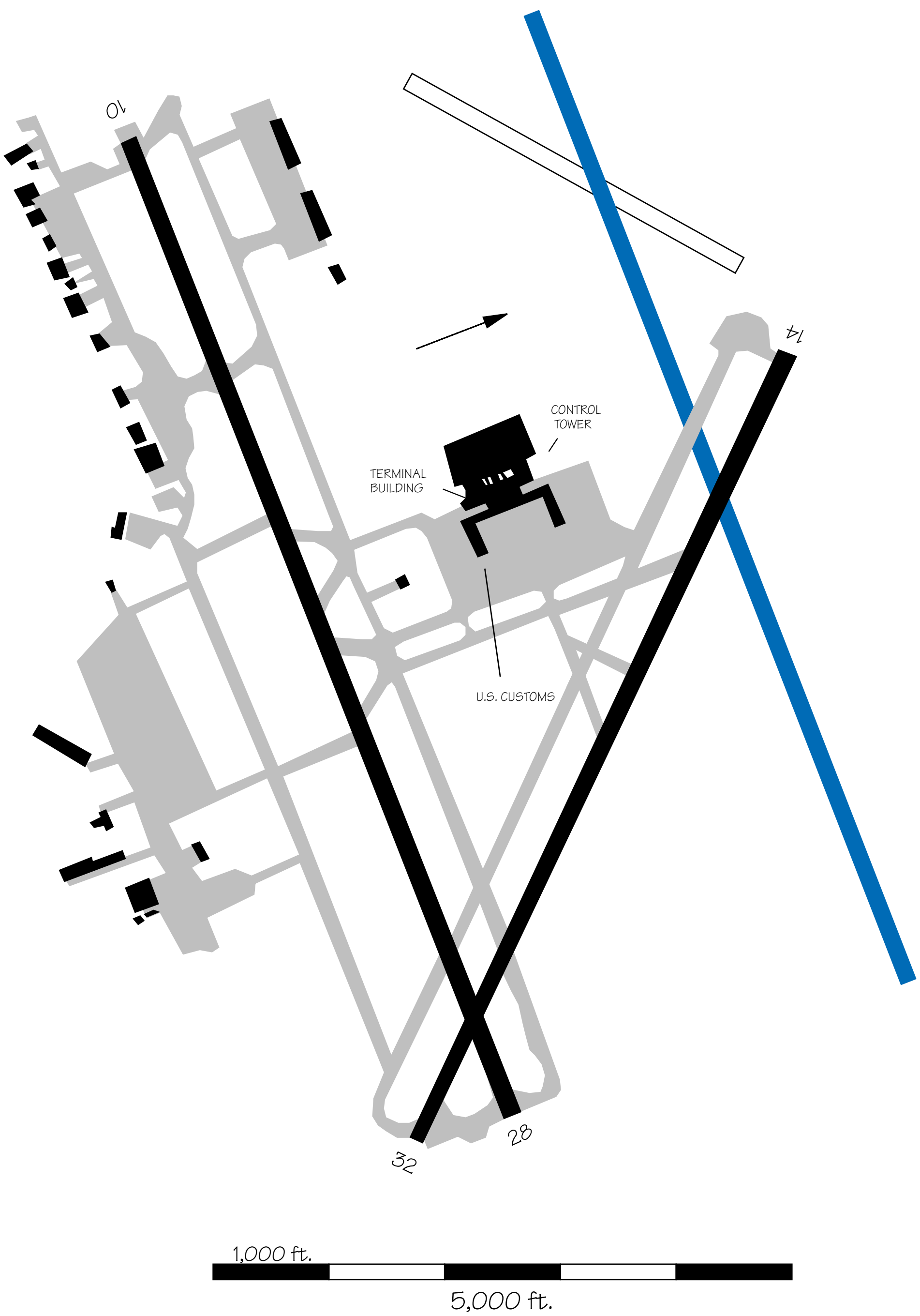
STL — Lambert St. Louis International Airport

A new parallel Runway 12R/30L in several configurations had been recommended by the St. Louis Airport Capacity Design Team. A Master Plan Update is underway, and the entire airport layout may change as a result. The new plan will probably call for three parallel runways, with at least two supporting independent IFR operations. An EIS is also underway. The Master Plan Update and the EIS are anticipated to be completed in 1996. A new Runway 14R/32L is planned as the first phase of the airport expansion. Construction of the runway could occur beginning in 1997, subject to environmental approval.



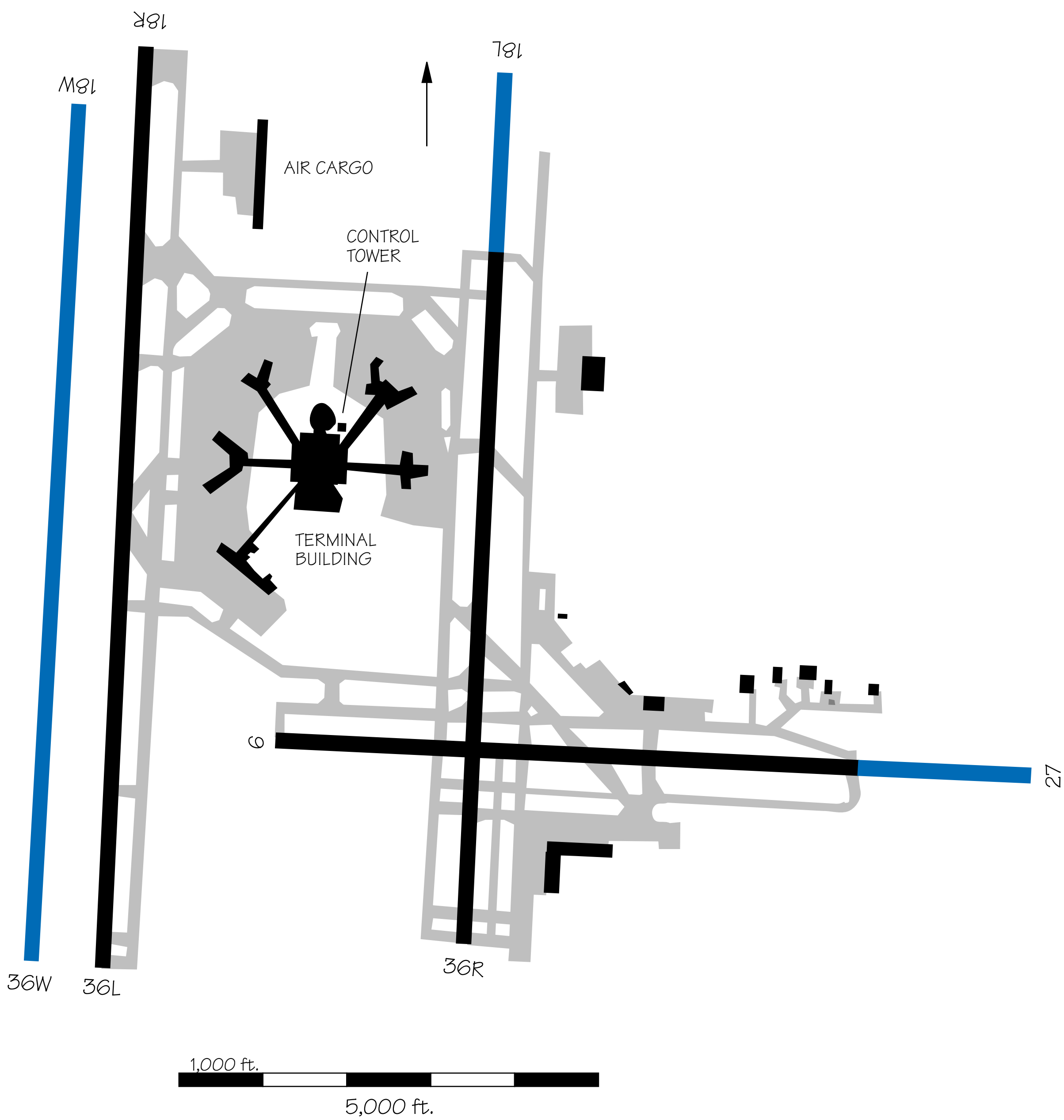
SYR — Syracuse Hancock International Airport

A new parallel Runway 10L/28R, 9,000 feet long and separated from the existing Runway 10/28 by 3,400 feet is being considered. It would provide independent parallel IFR operations, doubling hourly IFR arrival capacity. The expected operational date is 2000. The cost of construction is estimated to be $55 million for the first phase of the new runway, which would be 7,500 feet long, including a parallel taxiway and connections to the ramp. The final length of the runway will be 9,000 feet.



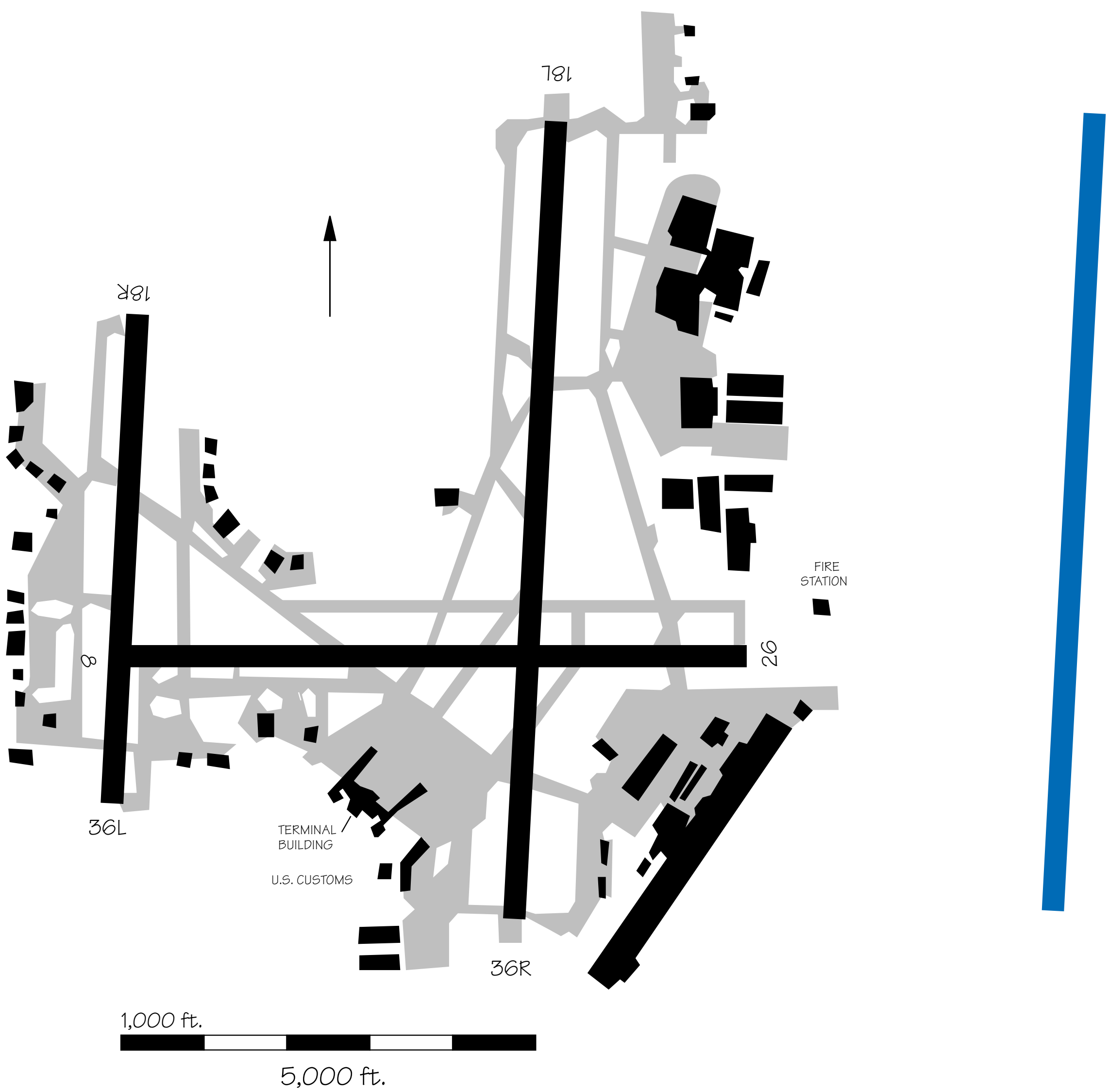
TPA — Tampa International Airport

A third parallel Runway 18W/36W 9,650 feet long and 700 feet west of Runway 18R/36L is being considered. Construction is expected to be completed by 2000, and the estimated cost of construction is $55 million. An extension of Runway 18L is also being considered for the time frame beyond 2005, and reconstruction and extension of Runway 27, for the time frame beyond 2010.



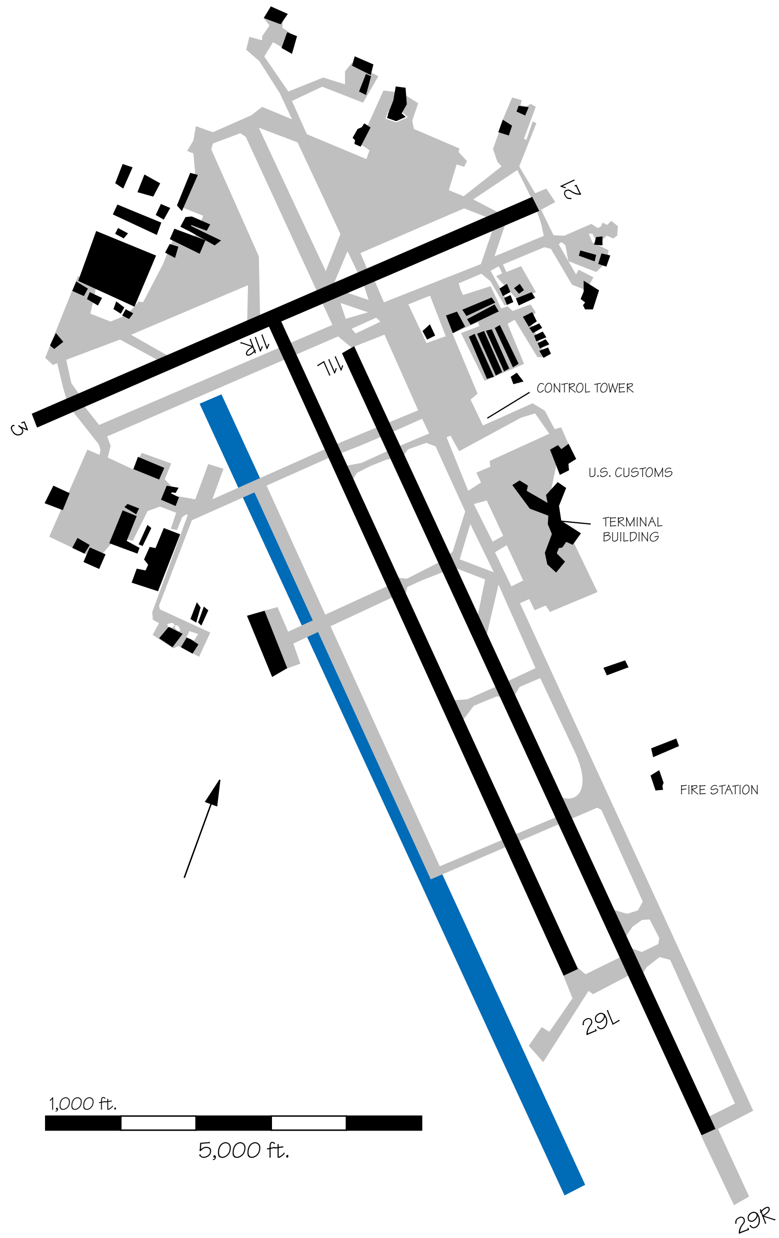
TUL — Tulsa International Airport

A new parallel runway, Runway 18L/36R, located 6,400 feet east of the present 18L/36R and 9,600 feet long, is being considered. The new runway would permit IFR triple independent approaches, if approved, to Runways 18L, 18C, and 18R.



TUS — Tucson International Airport

An additional parallel air carrier runway, Runway 11R/29L, has been proposed. Upon completion of the new runway, the current Runway 11R/29L, a general aviation runway, will revert to its original taxiway status. It is not anticipated that the sponsor will proceed before 1998. Current plans call for construction to start in 2003 to be operational in 2005. The cost of construction is estimated to be $30 million.

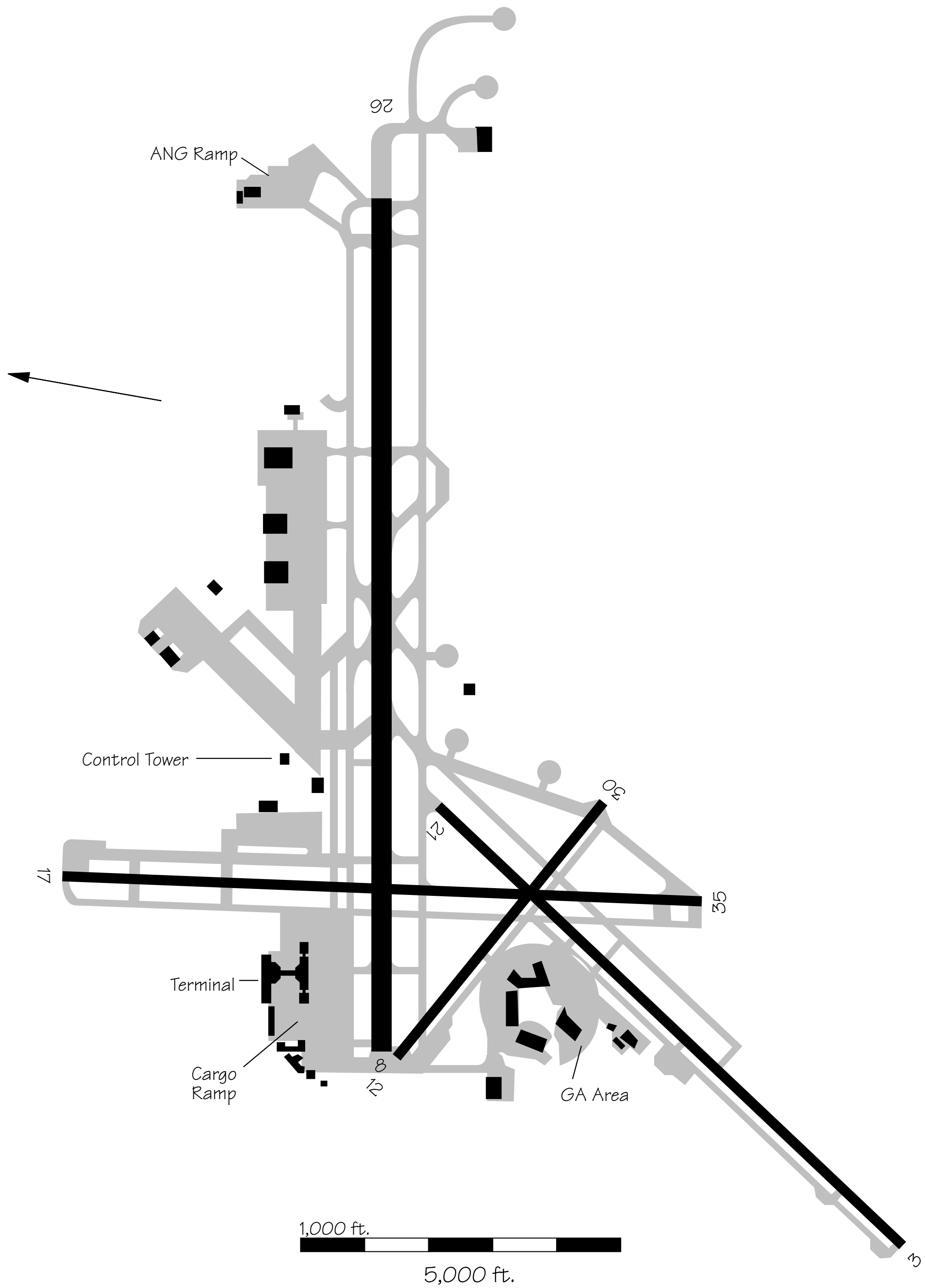


Appendix E

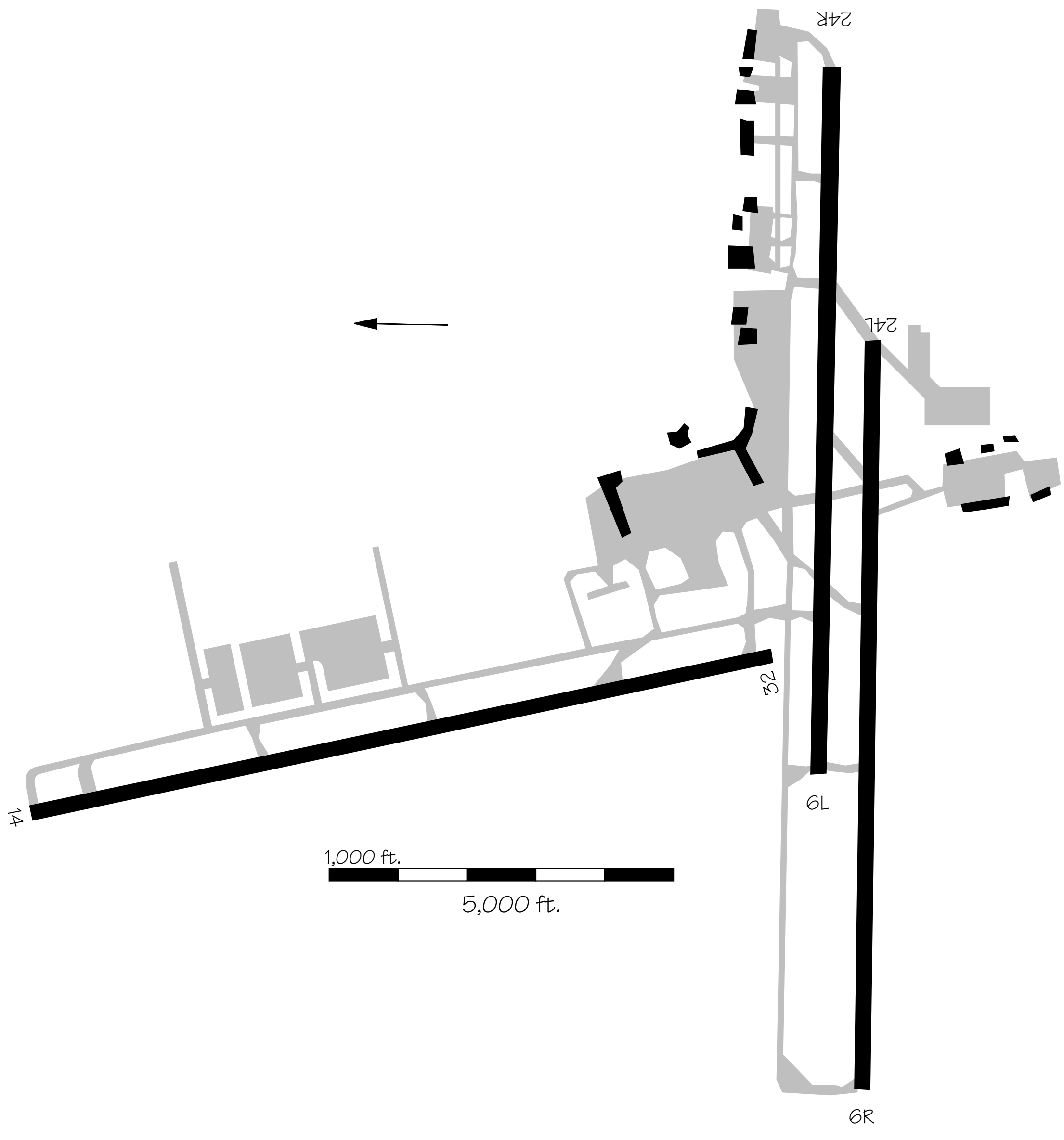
Diagrams of the Remaining Top 100 Airports

Appendix E contains current airport diagrams for those airports among the top 100 airports[1] that are not considering construction of new runways or extensions to existing runways at the present time. The airport diagrams show simplified drawings of the existing airports. Airport diagrams for those airports that are considering or have plans for new runways or runway extension projects are contained in Appendix D.

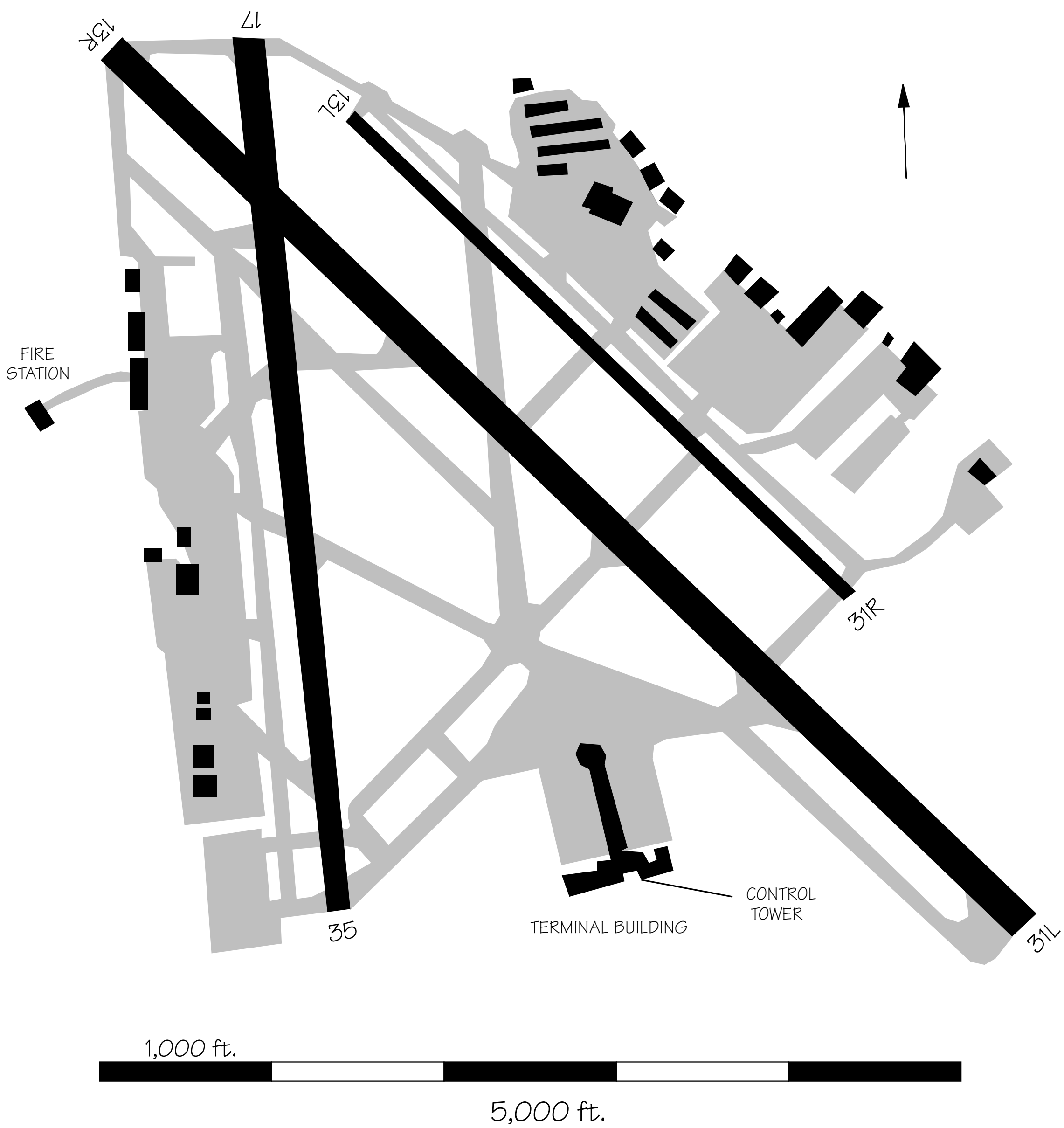
1. Based on 1994 passenger enplanements (see Appendix A, Table A-1).



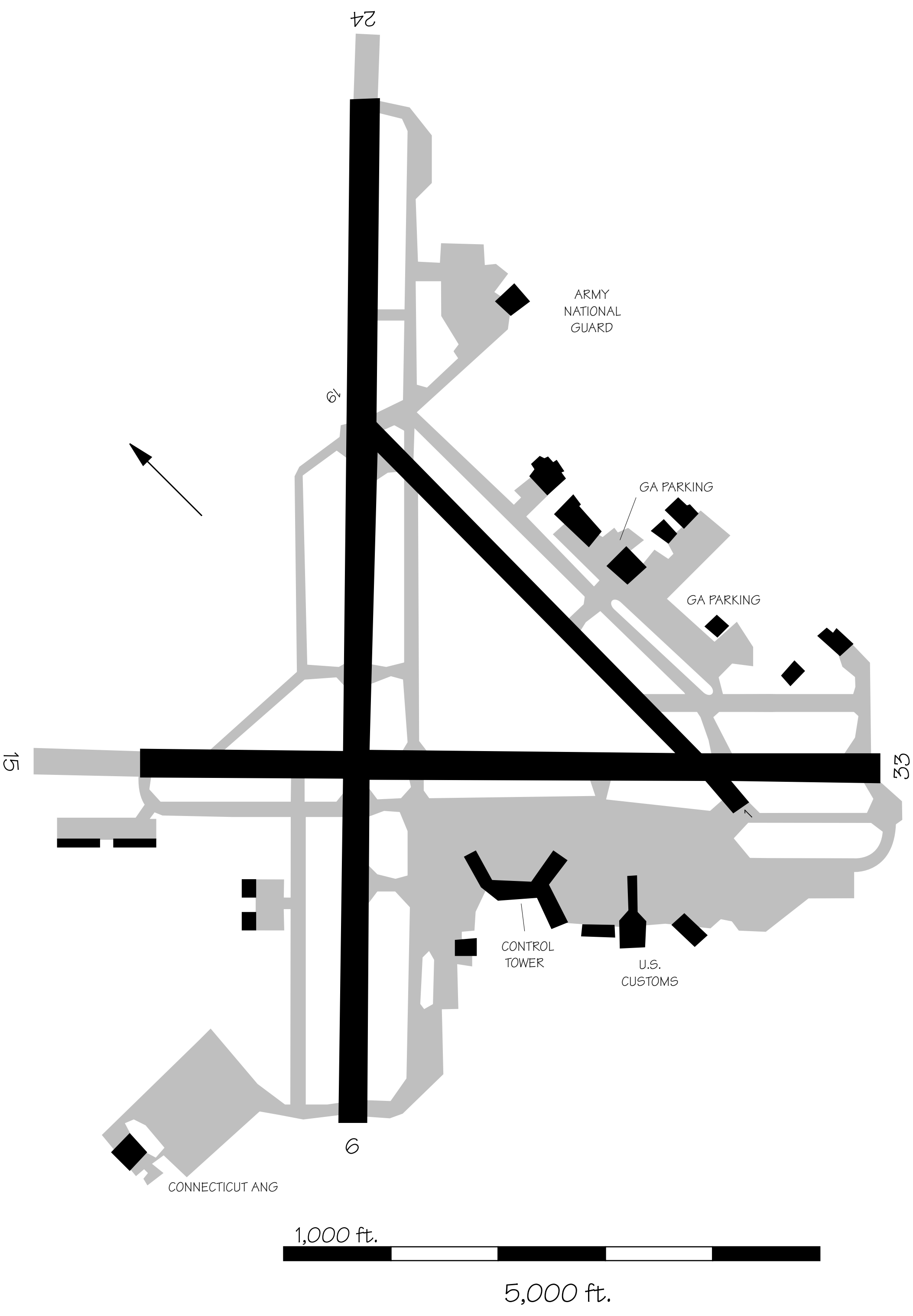
ABQ — Albuquerque International Airport



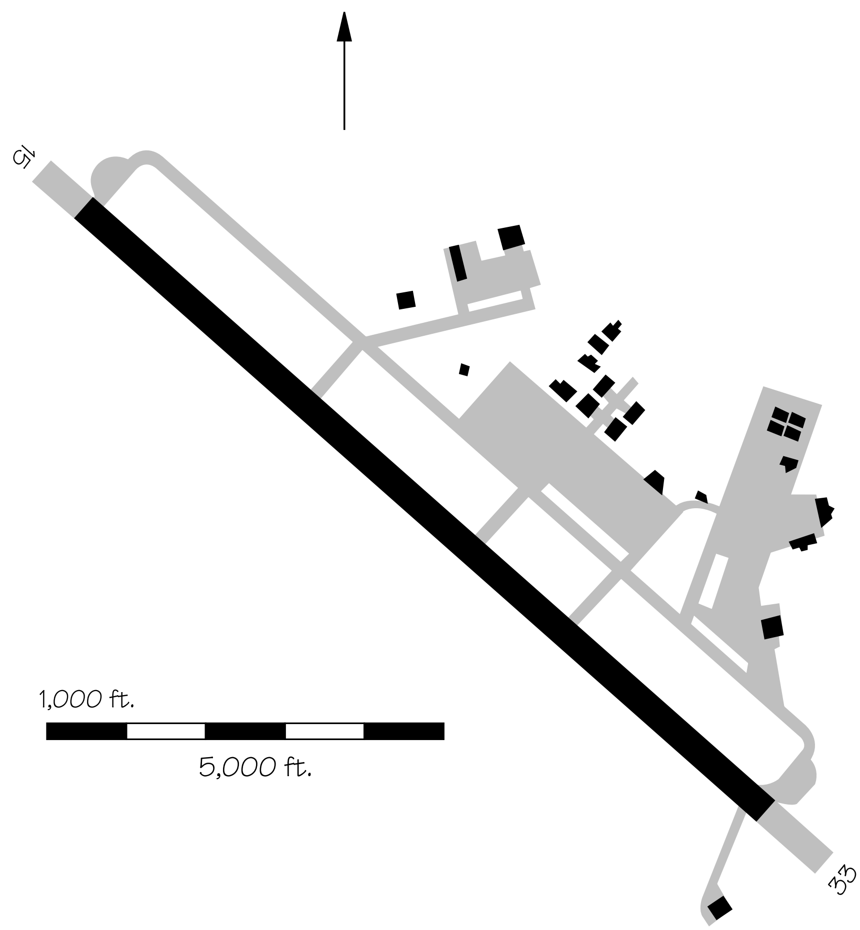
ANK — Anchorage International Airport



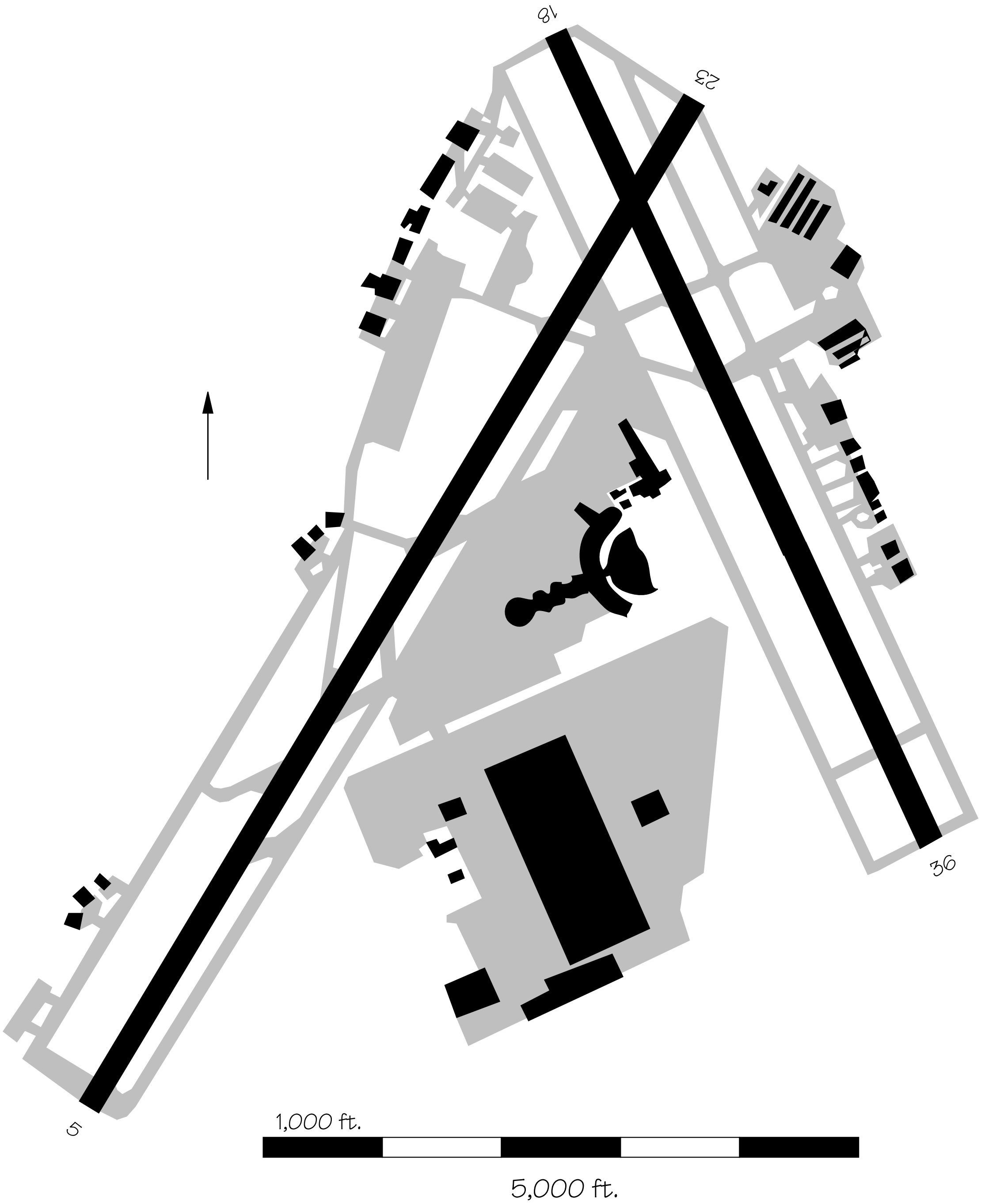
AUS — Austin Robert Mueller Airport



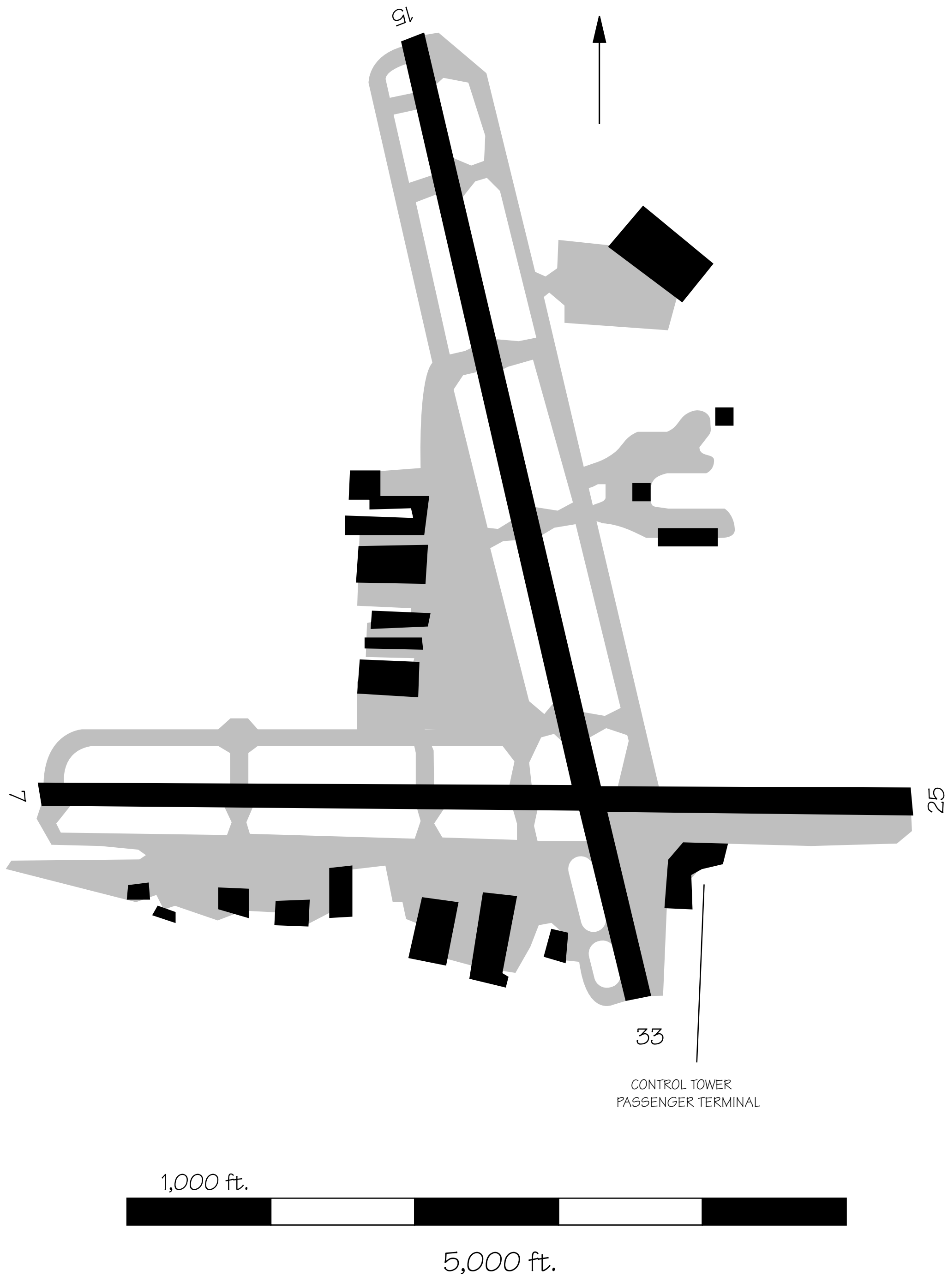
BDL — Bradley International Airport



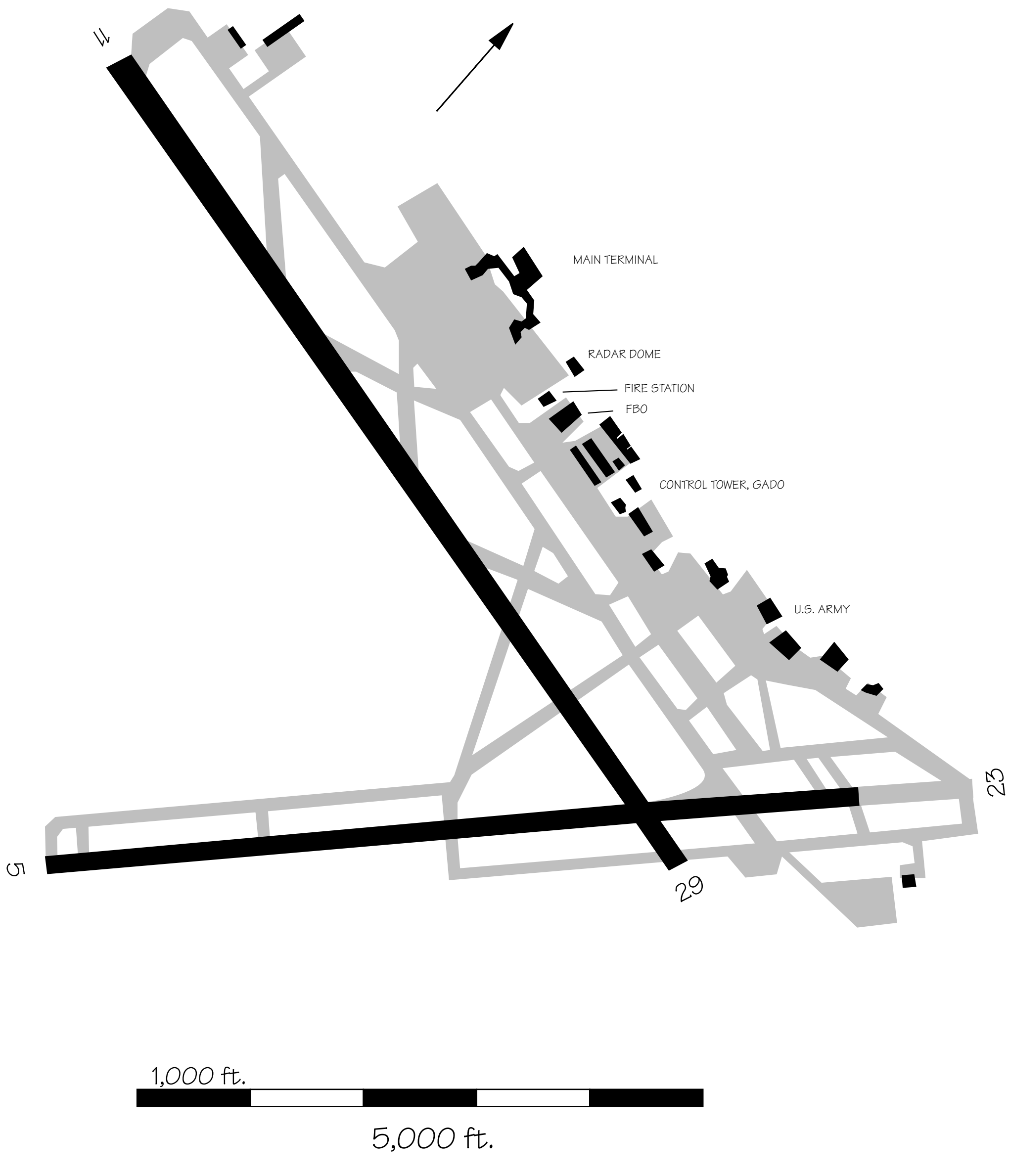
BGR — Bangor International Airport



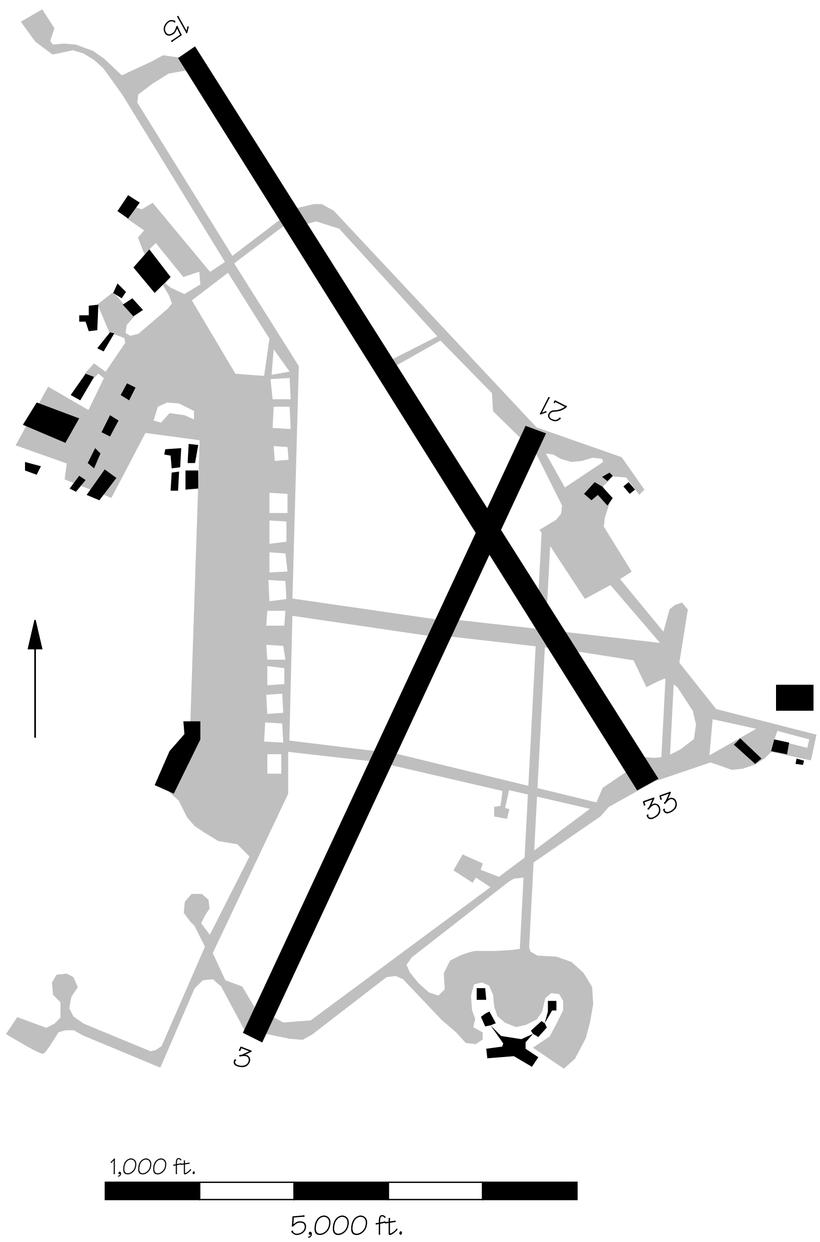
BHM — Birmingham Airport



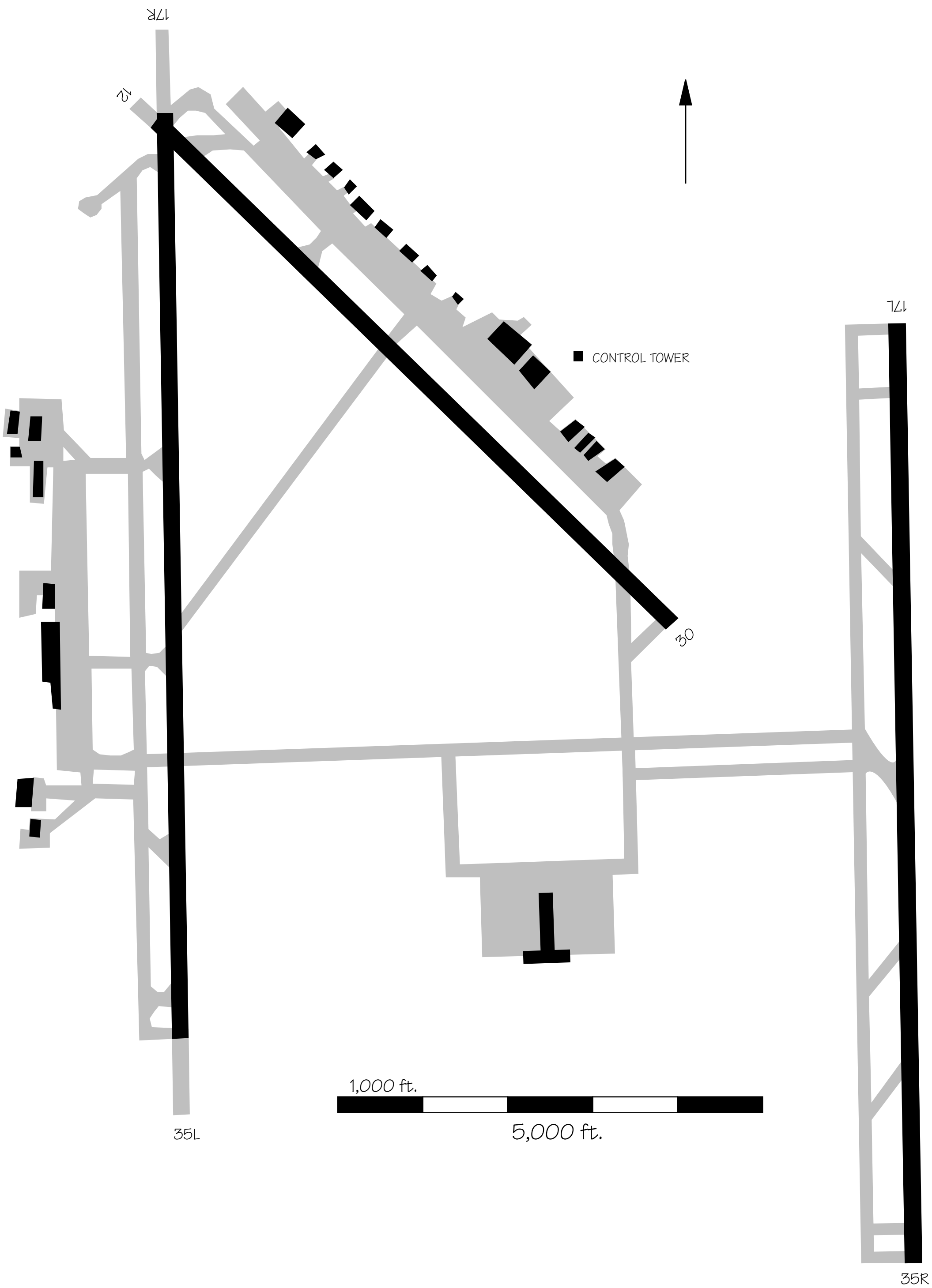
BUR — Burbank-Glendale-Pasadena Airport



CAE — Columbia Metropolitan Airport

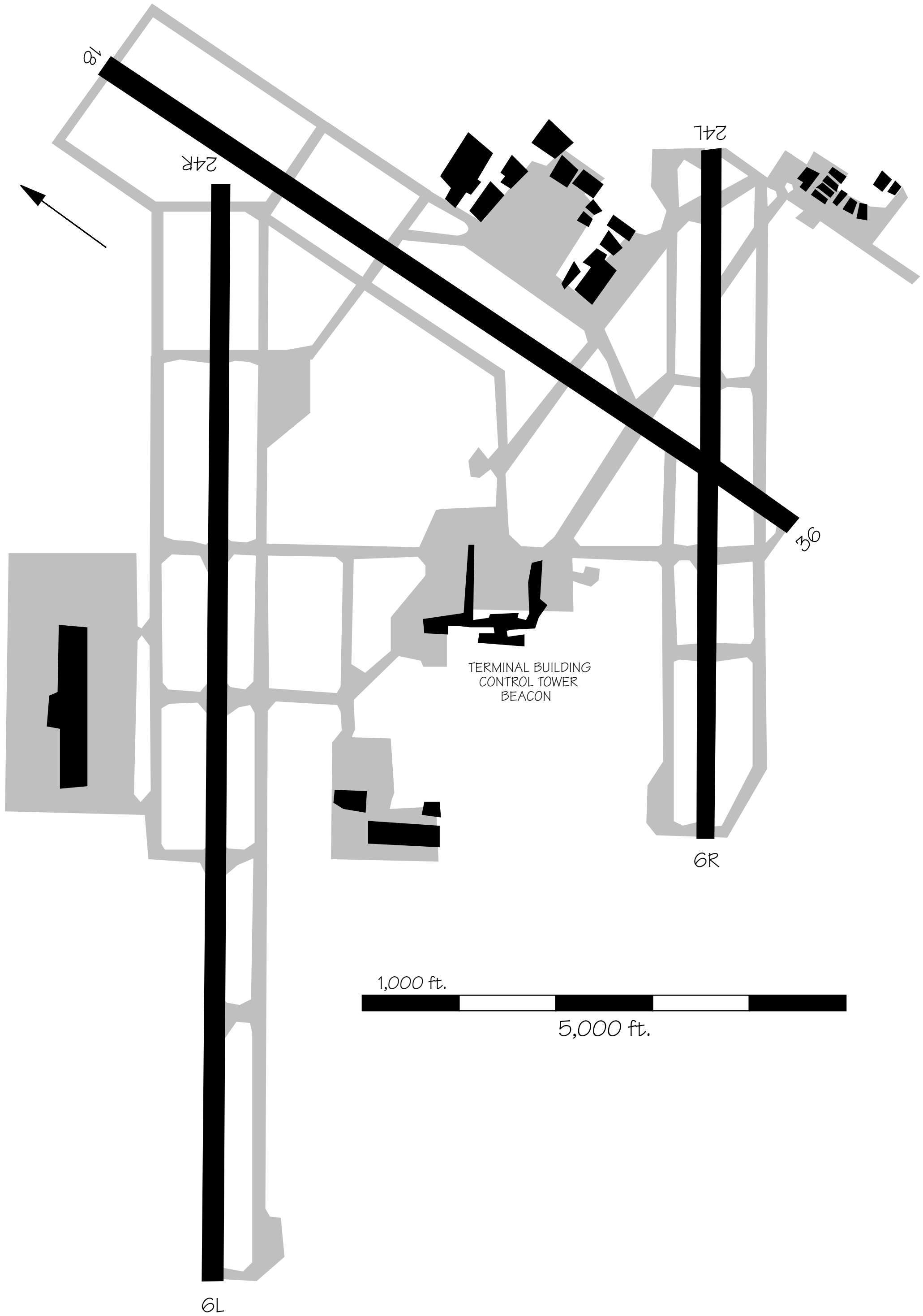


CHS — Charleston AFB International Airport

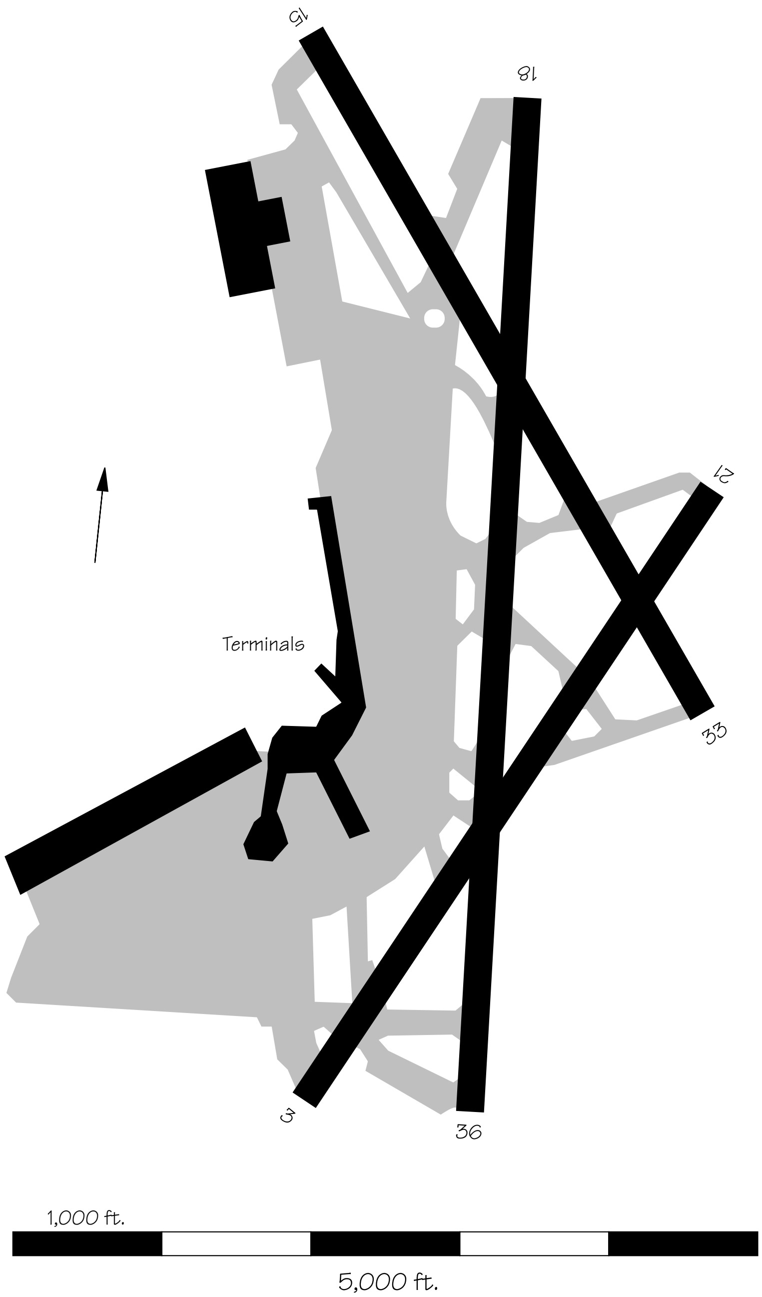


COS — Colorado Springs Municipal Airport

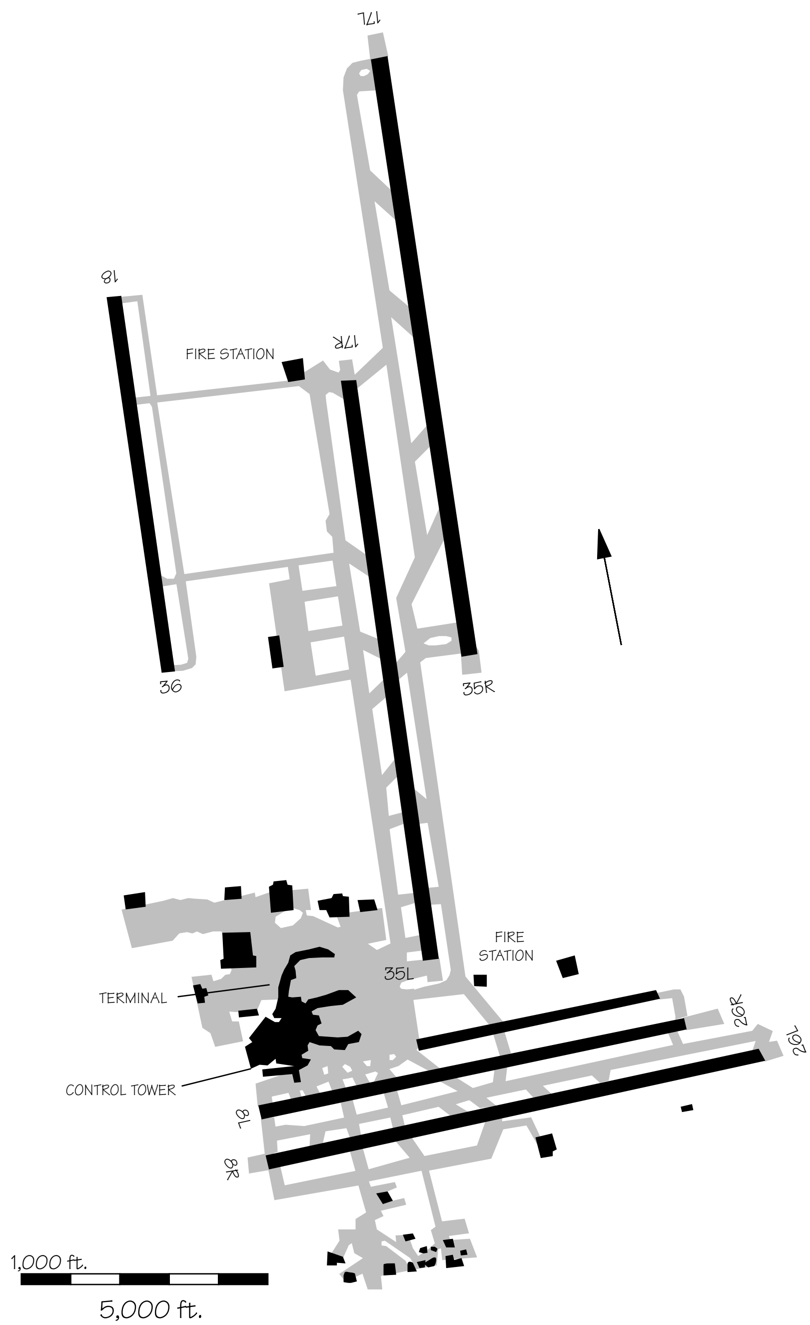
DAL — Dallas-Love Field



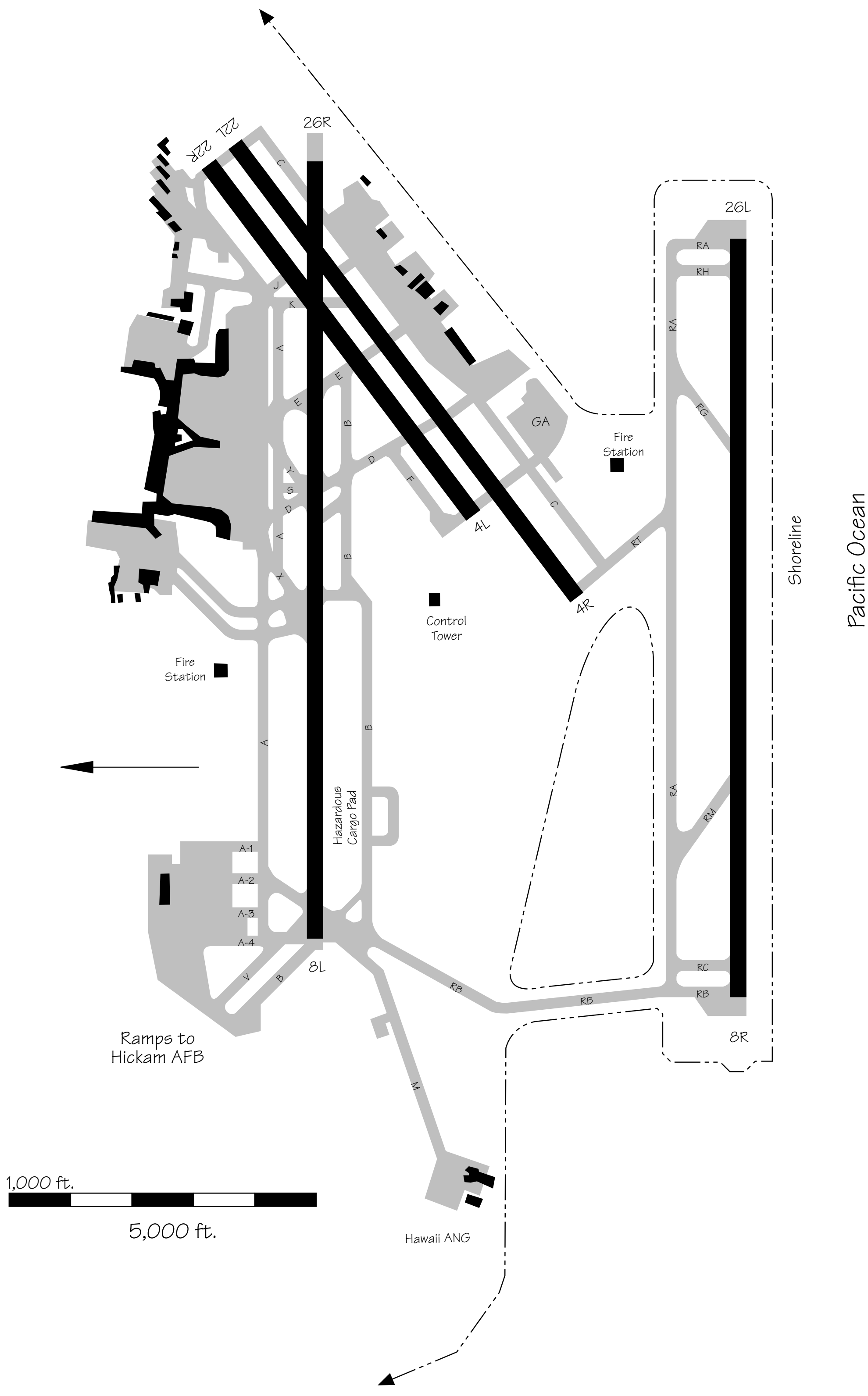
DAY — Dayton International Airport



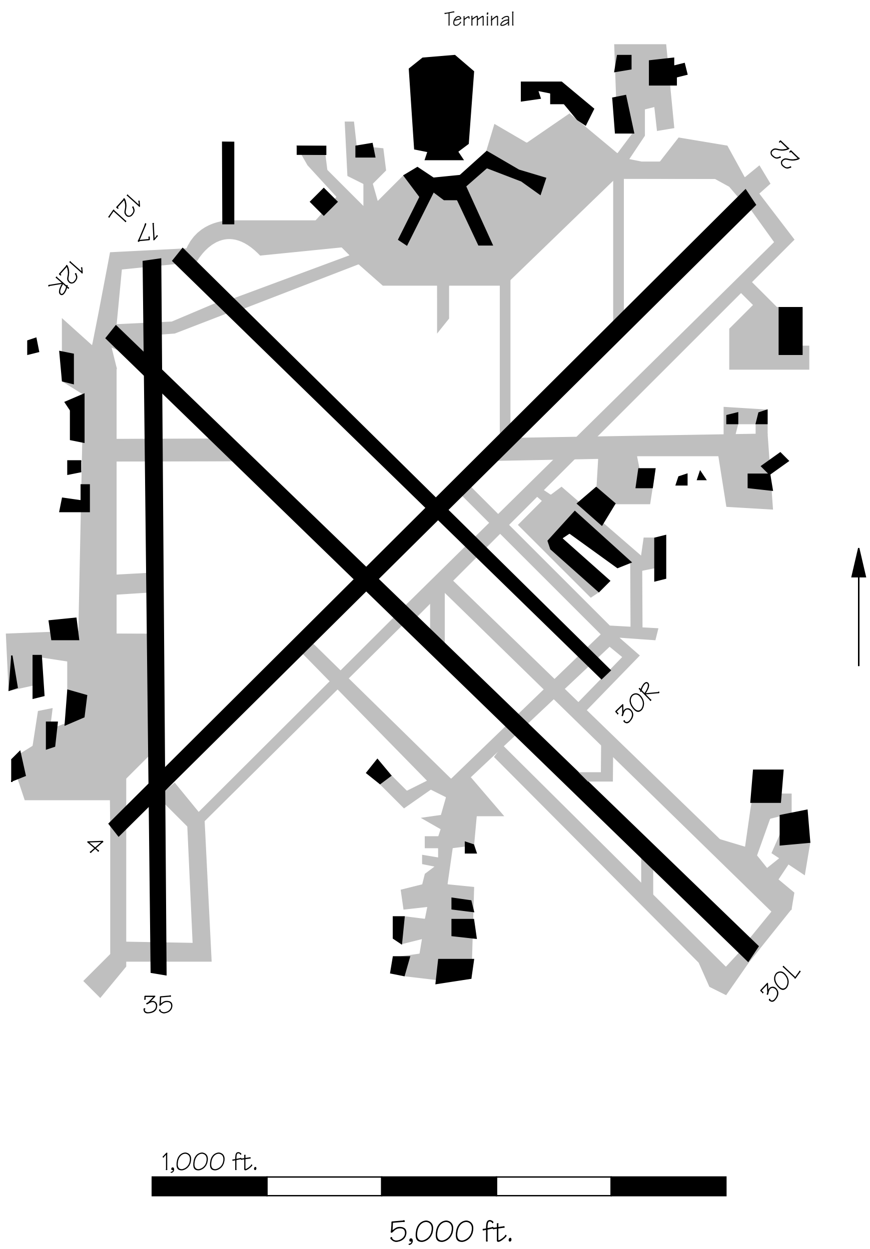
DCA — Washington National Airport



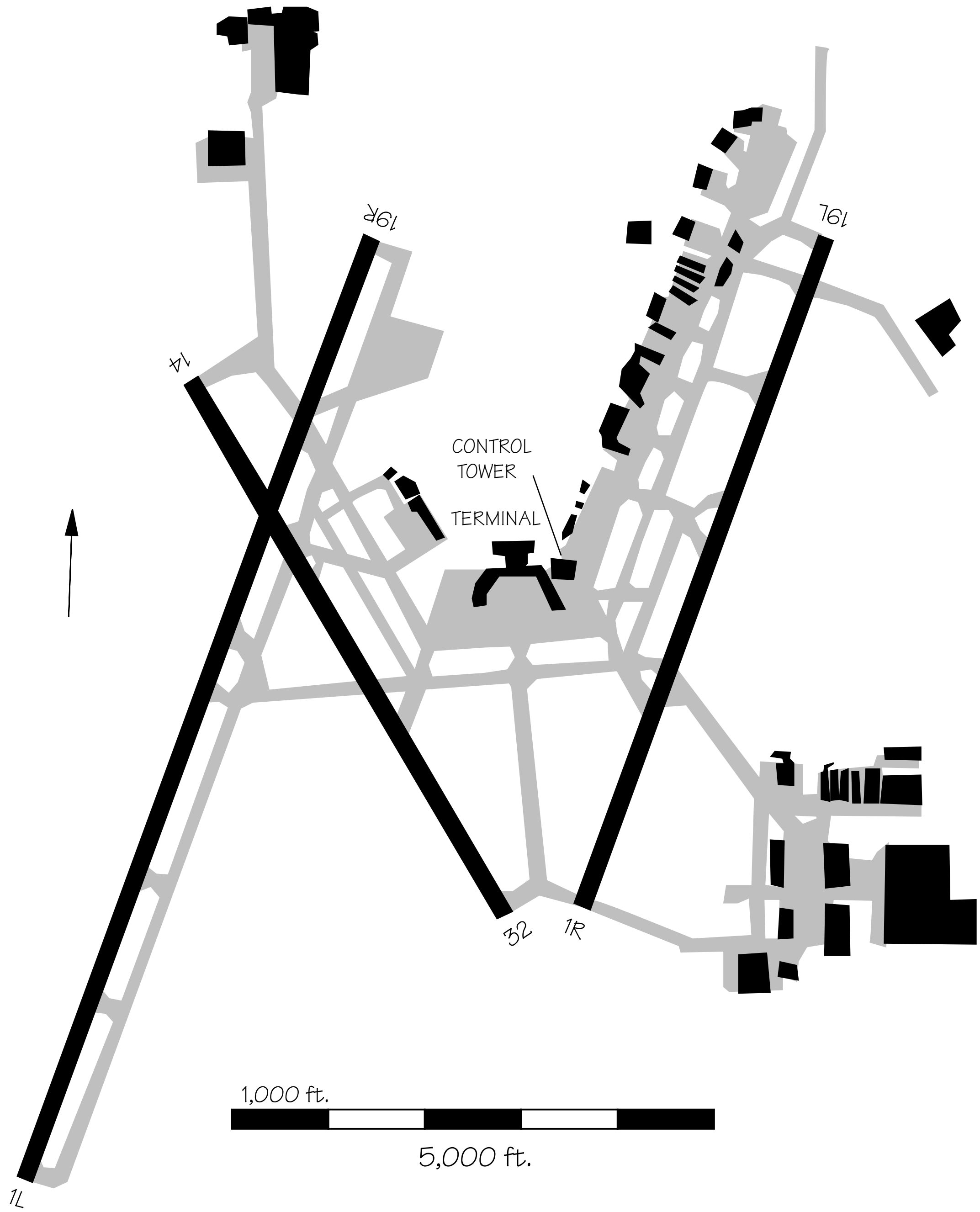
DEN — Denver Stapleton International Airport (closed)



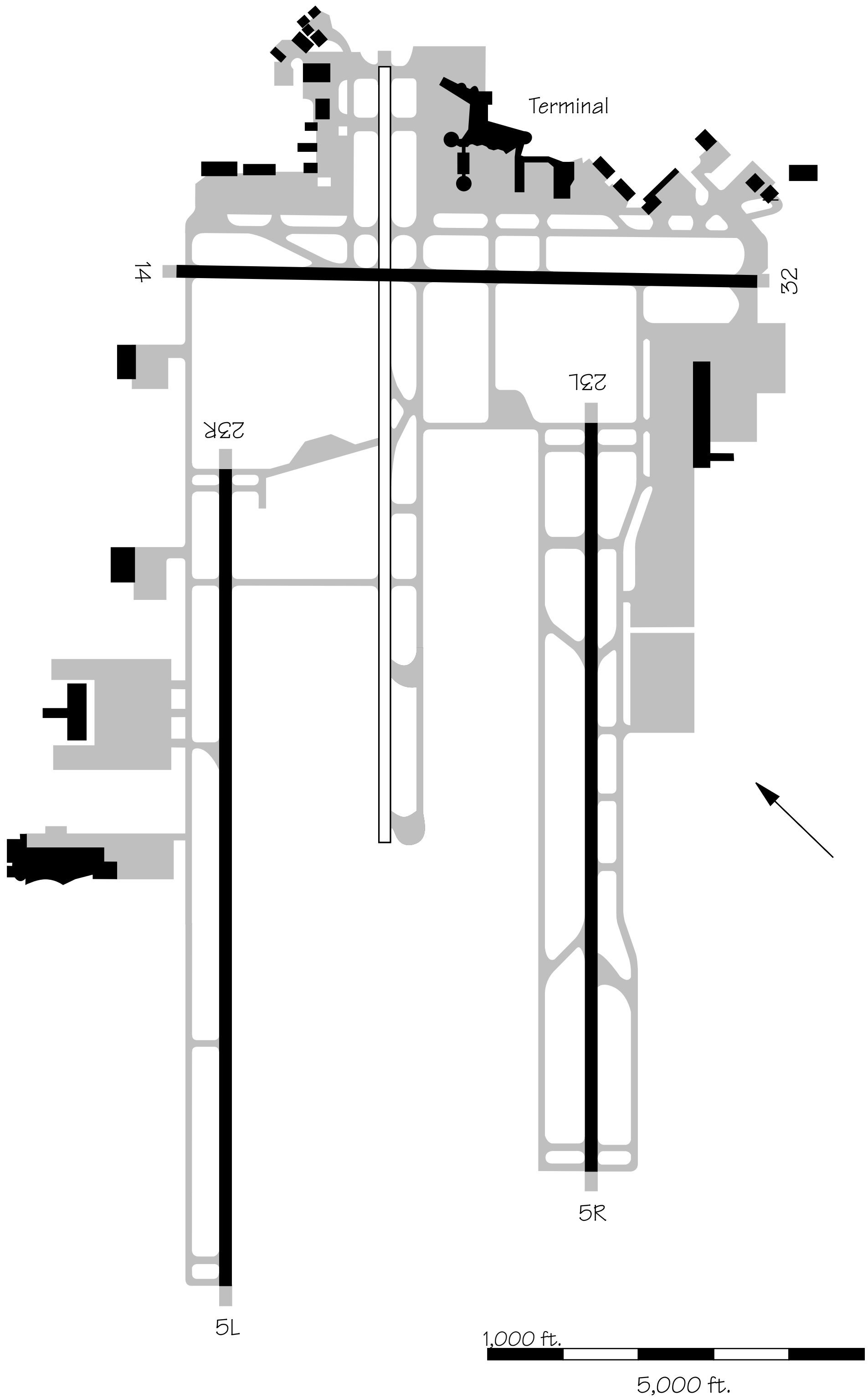
HNL — Honolulu International Airport



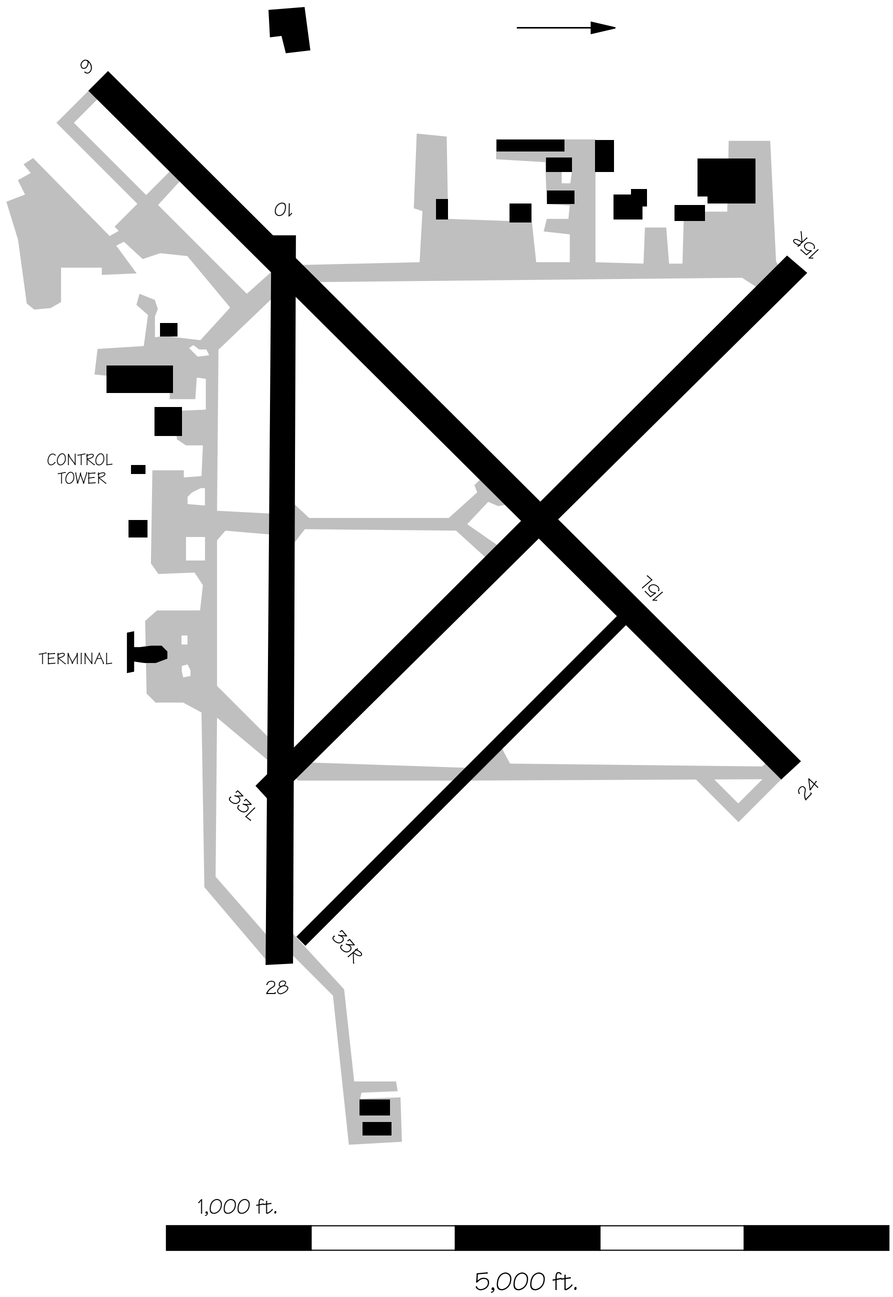
HOU — Houston William P. Hobby Airport



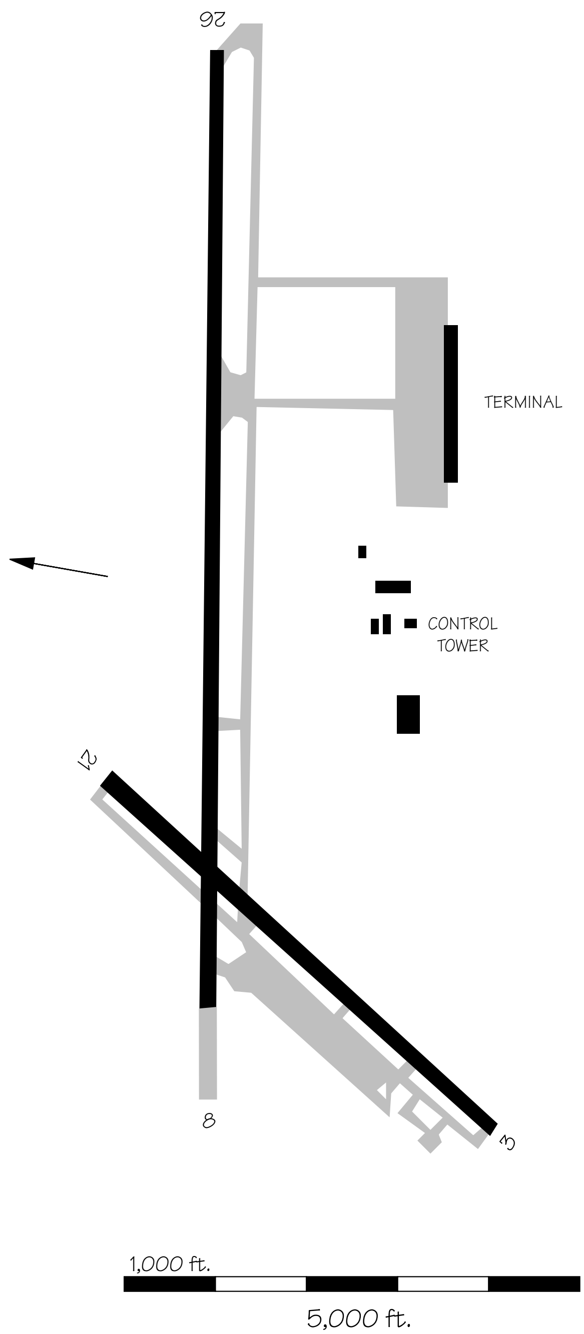
ICT — Wichita Mid-Continent Airport



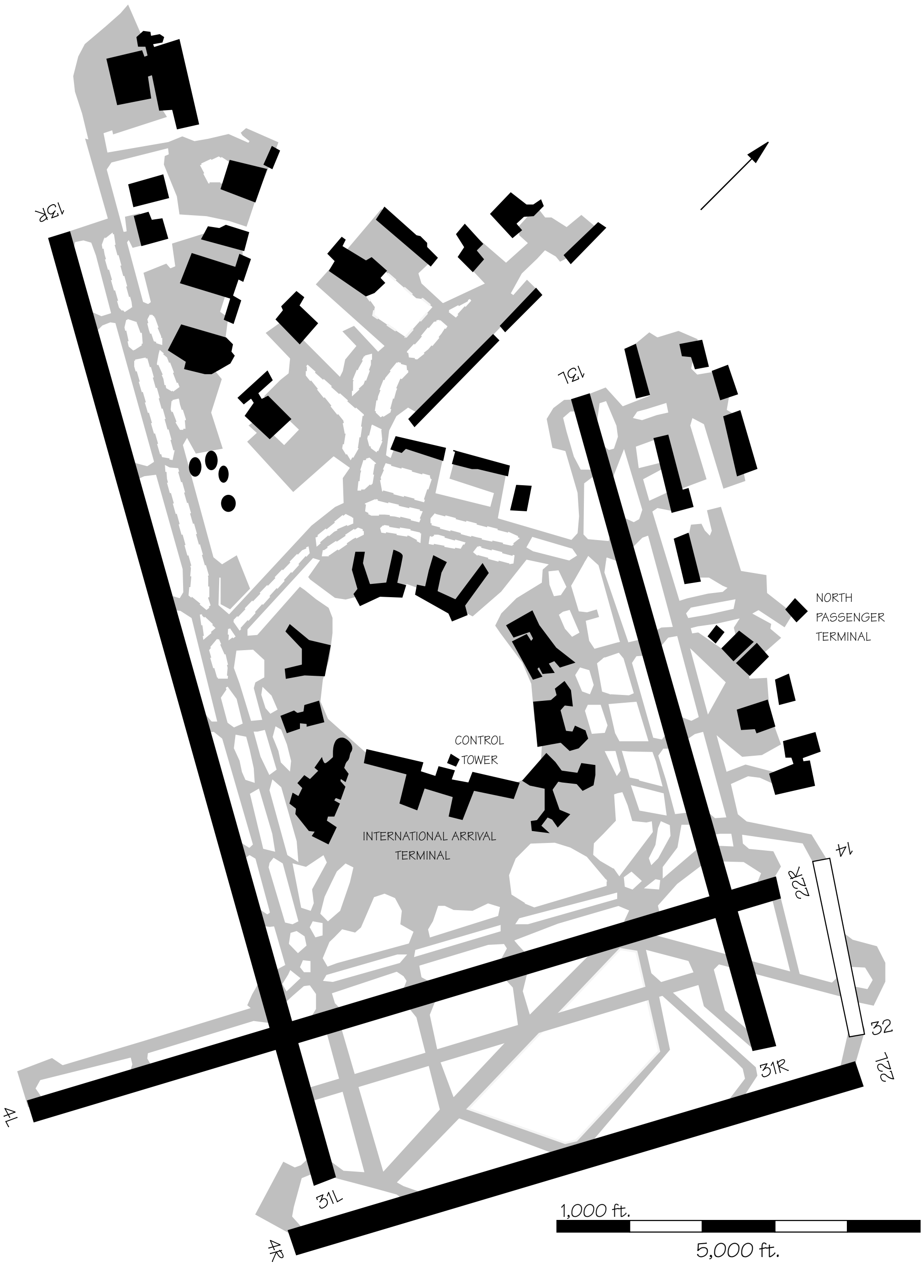
IND — Indianapolis International Airport



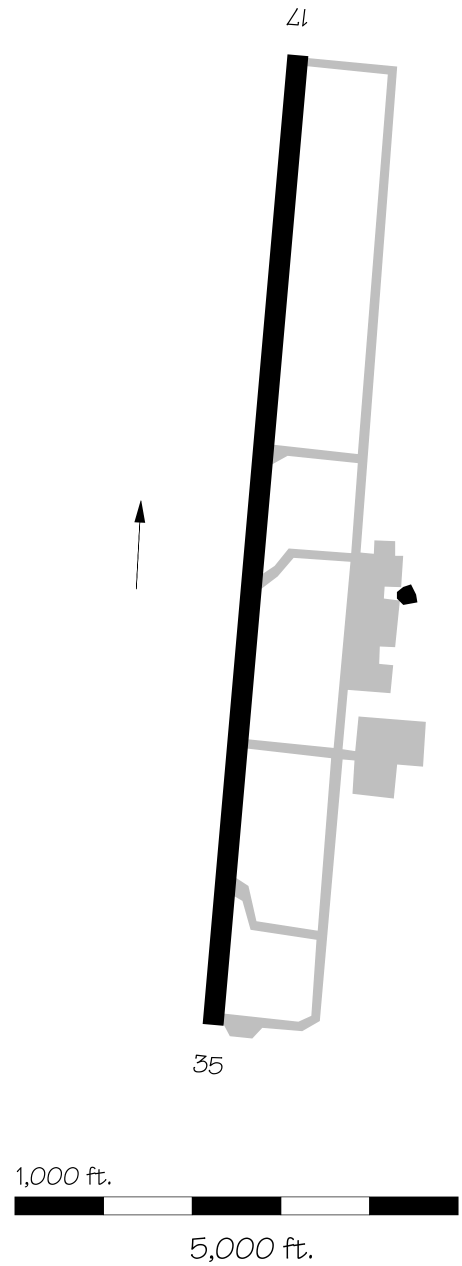
ISP — Islip Long Island Mac Arthur Airport



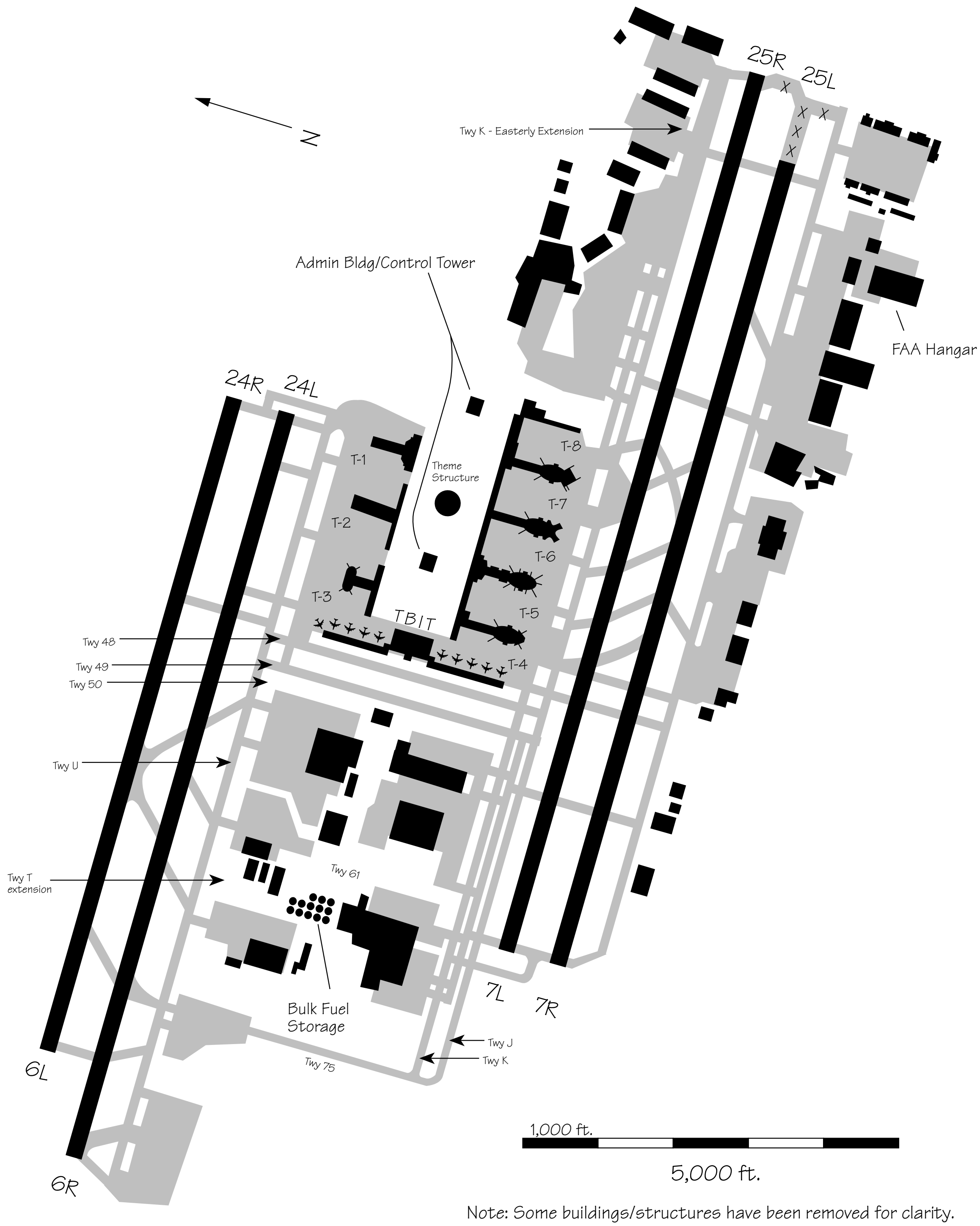
ITO — Hilo International Airport



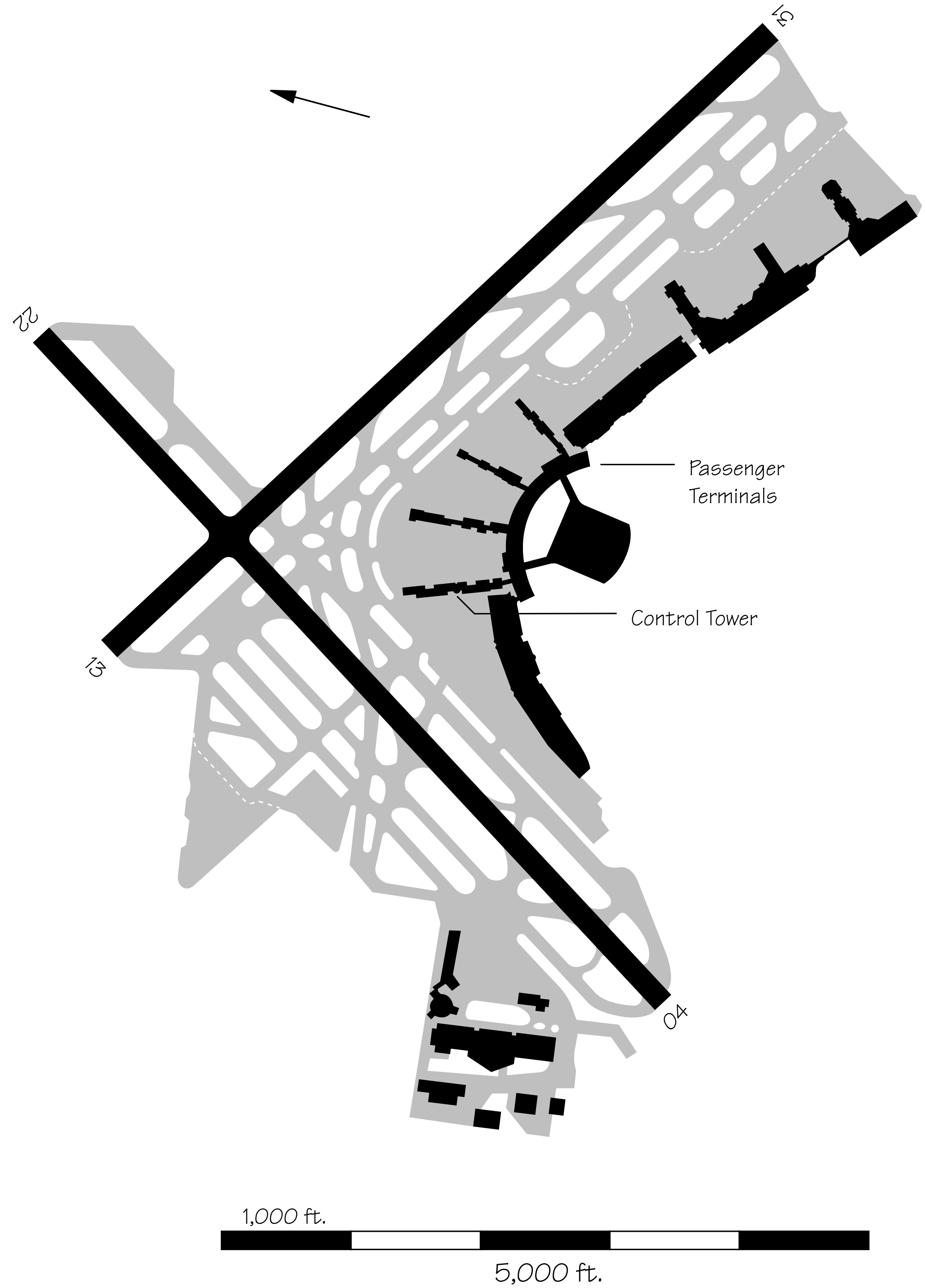
JFK — New York John F. Kennedy International Airport



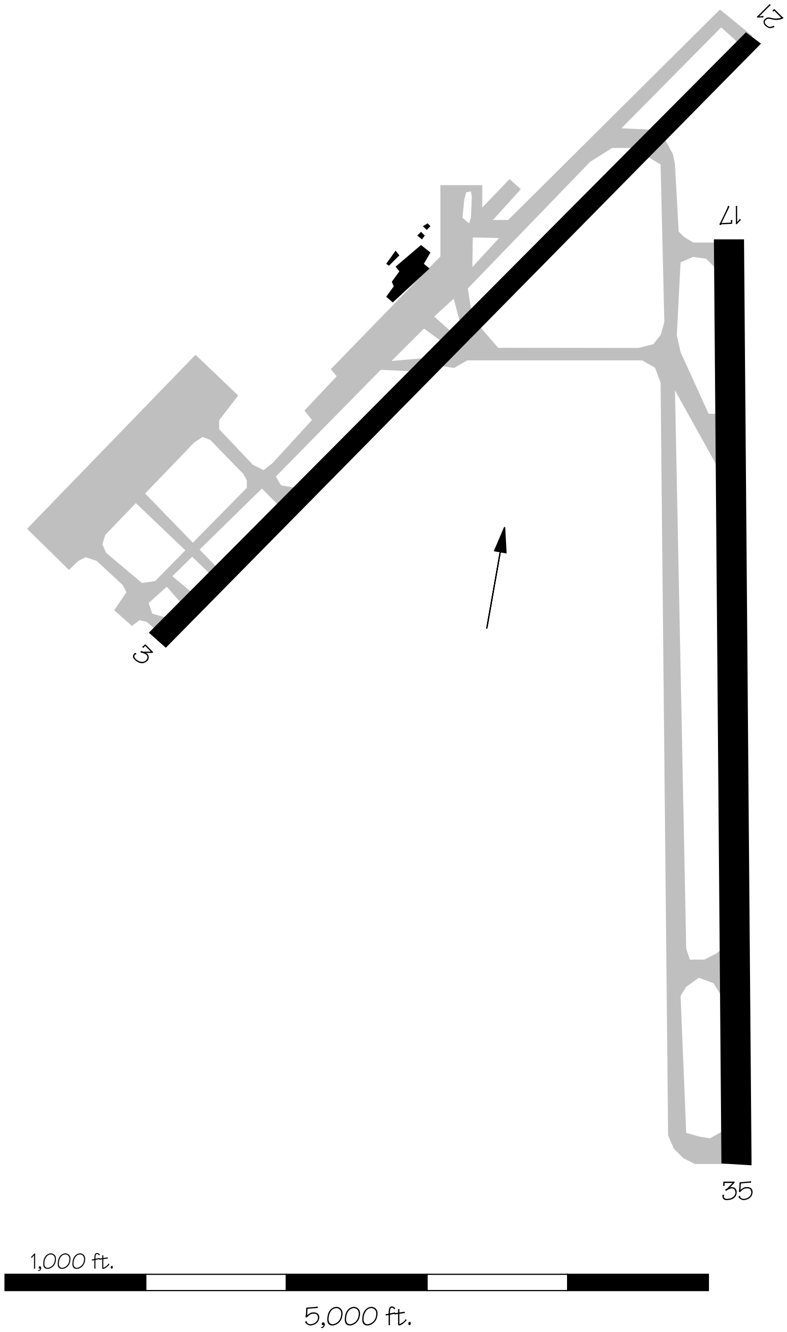
KOA — Kailua-Kona Keahole



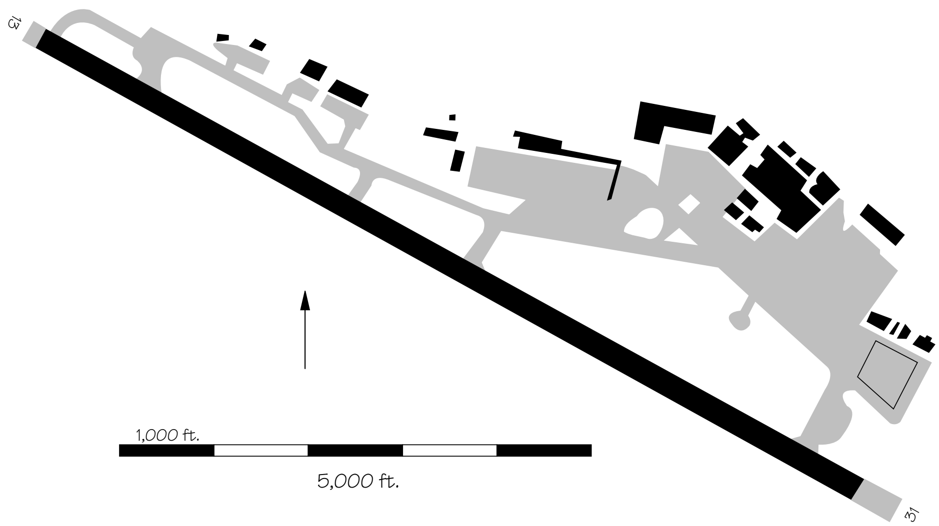
LAX — Los Angeles International Airport



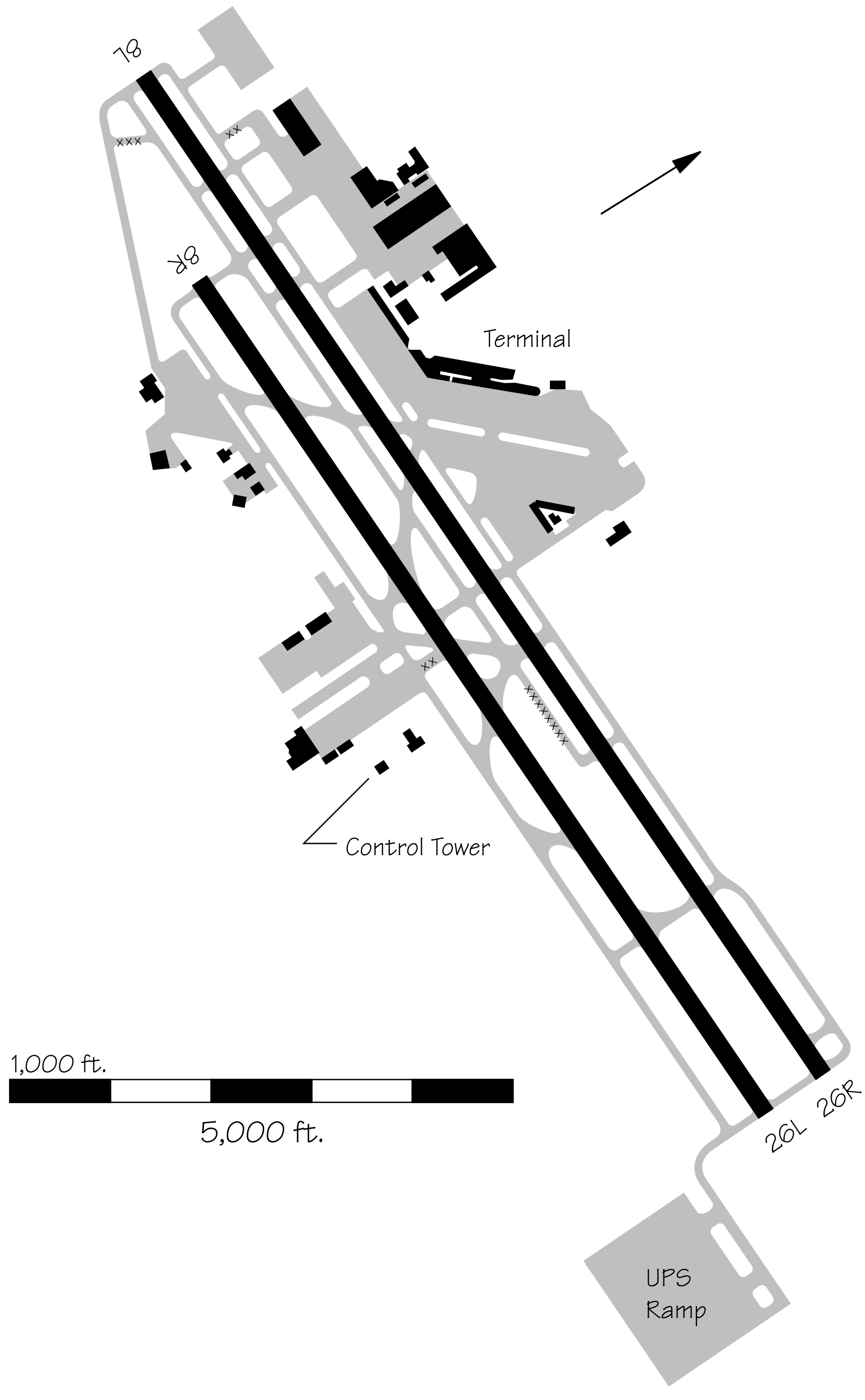
LGA — New York LaGuardia Airport



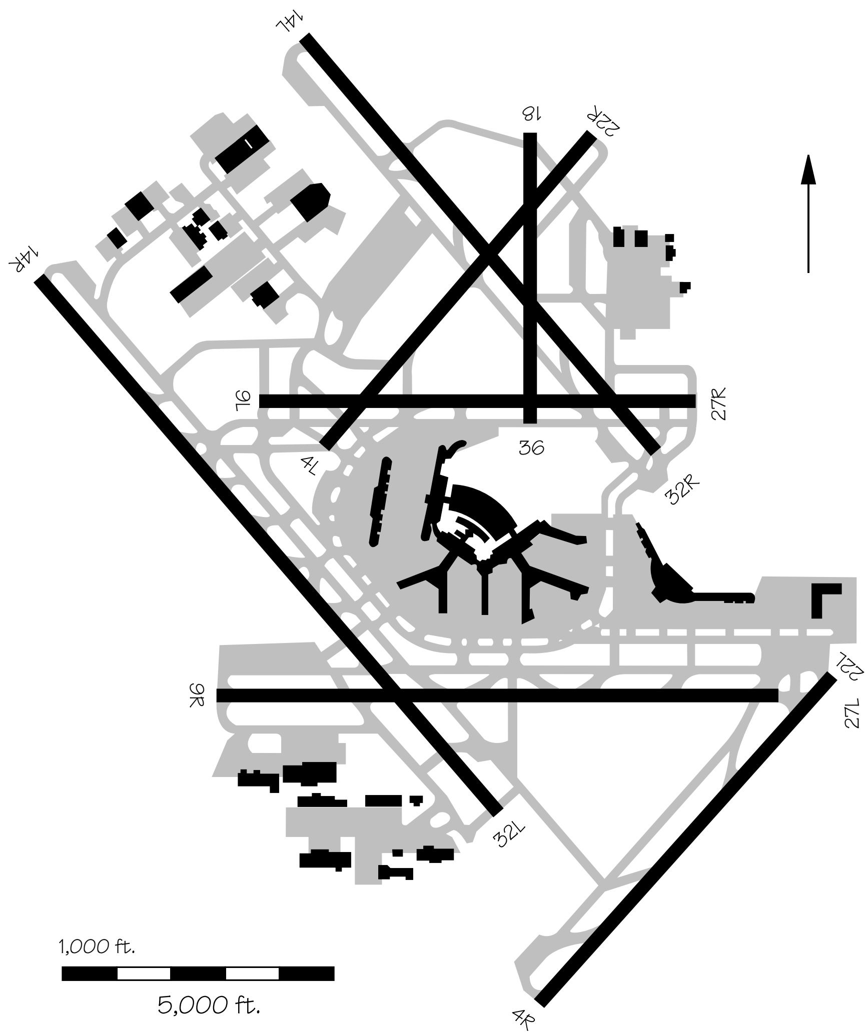
LIH — Lihue Airport



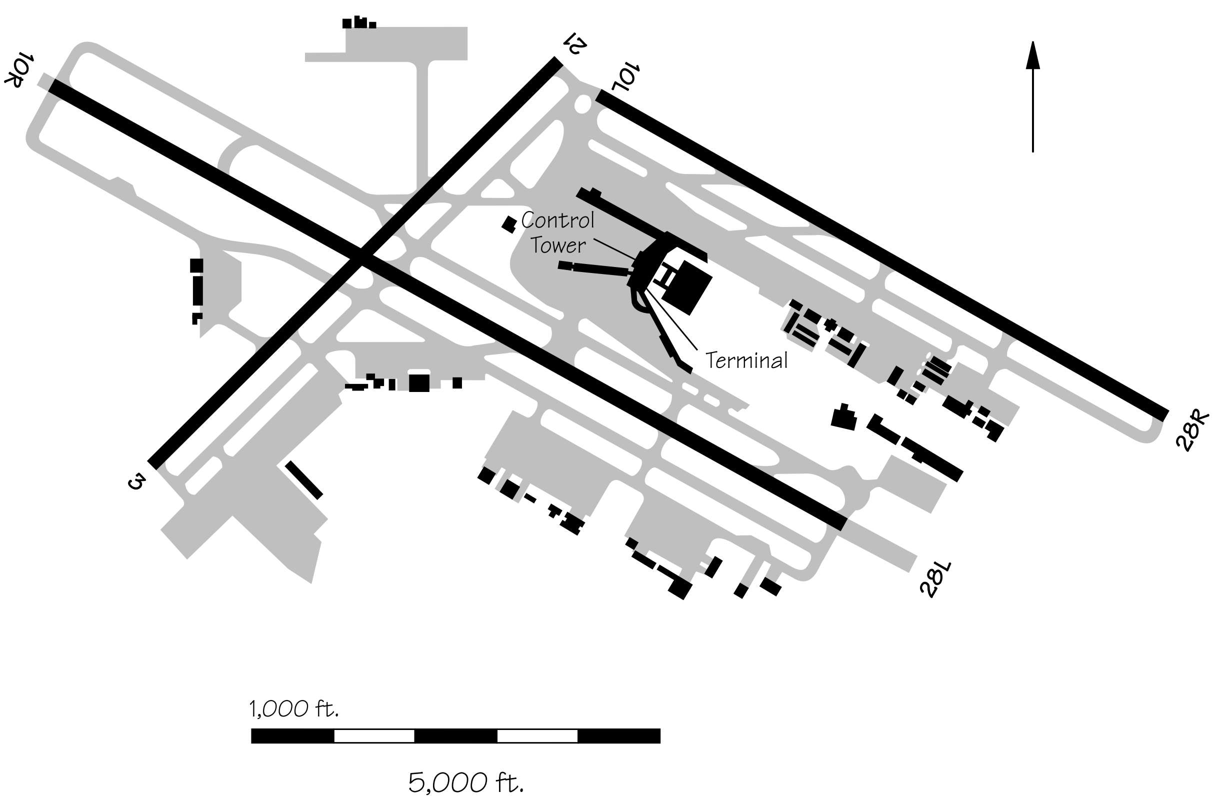
MDT — Harrisburg International Airport



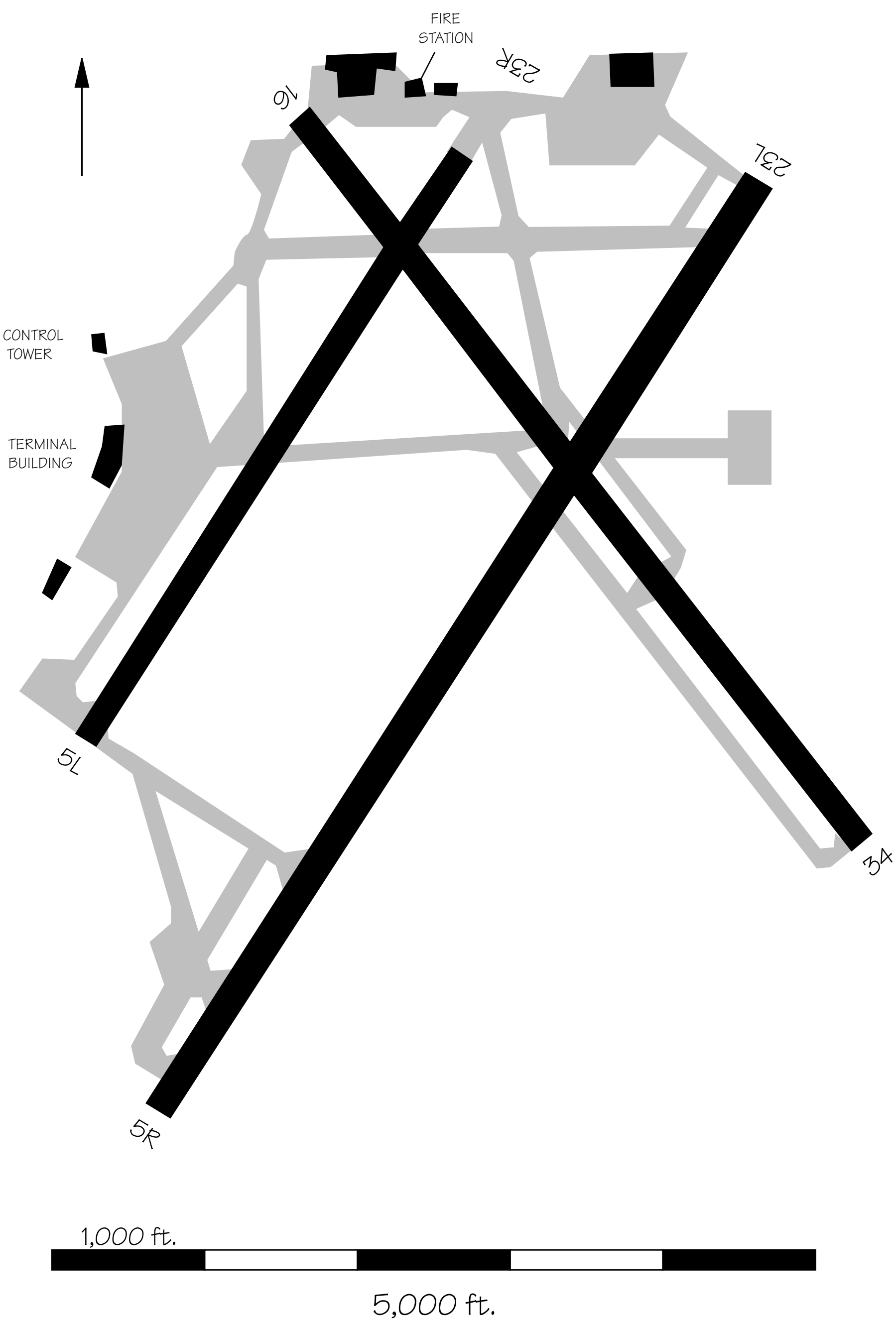
ONT — Ontario International Airport



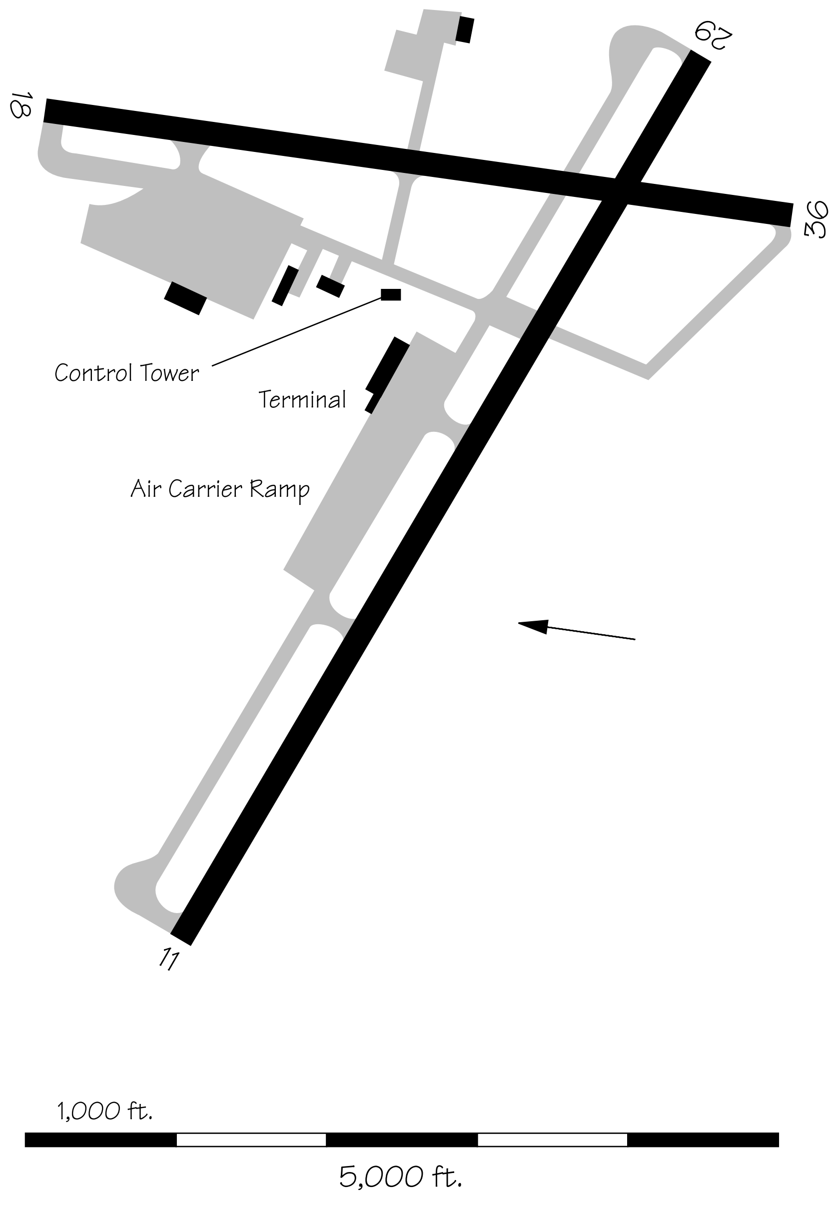
ORD — Chicago O'Hare International Airport



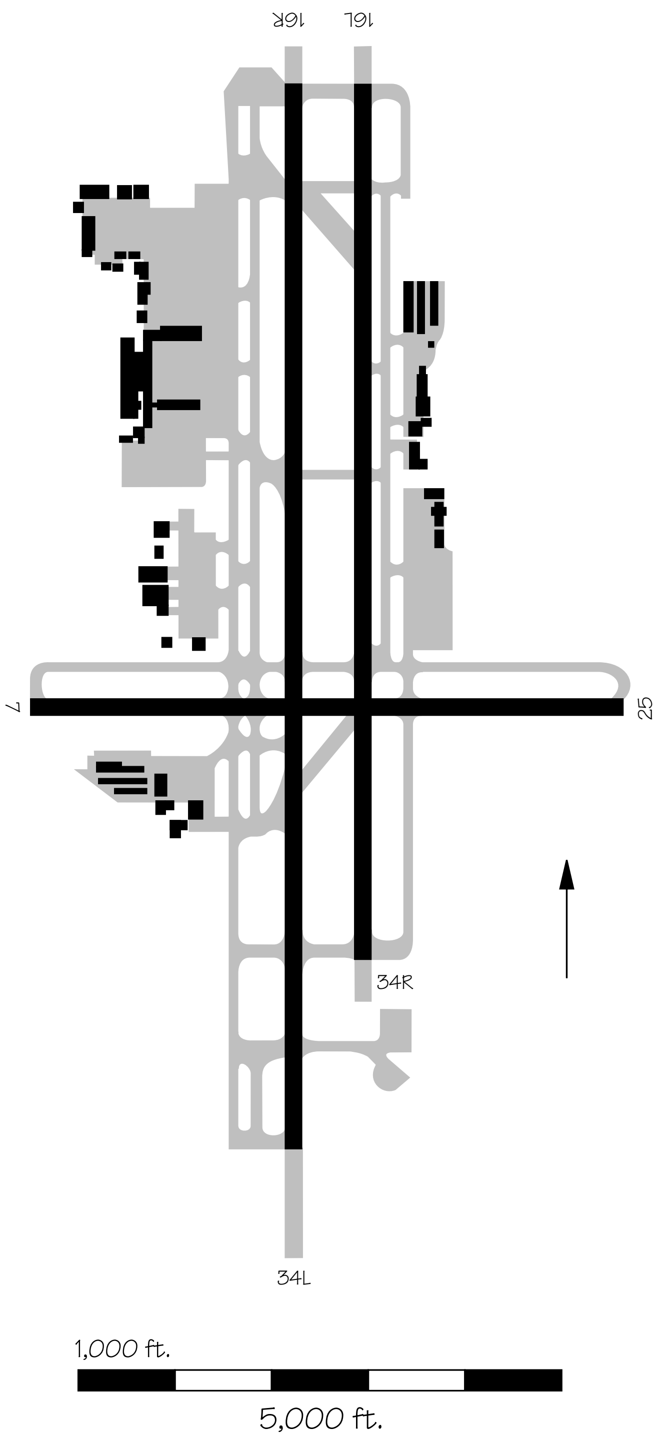
PDX — Portland International Airport



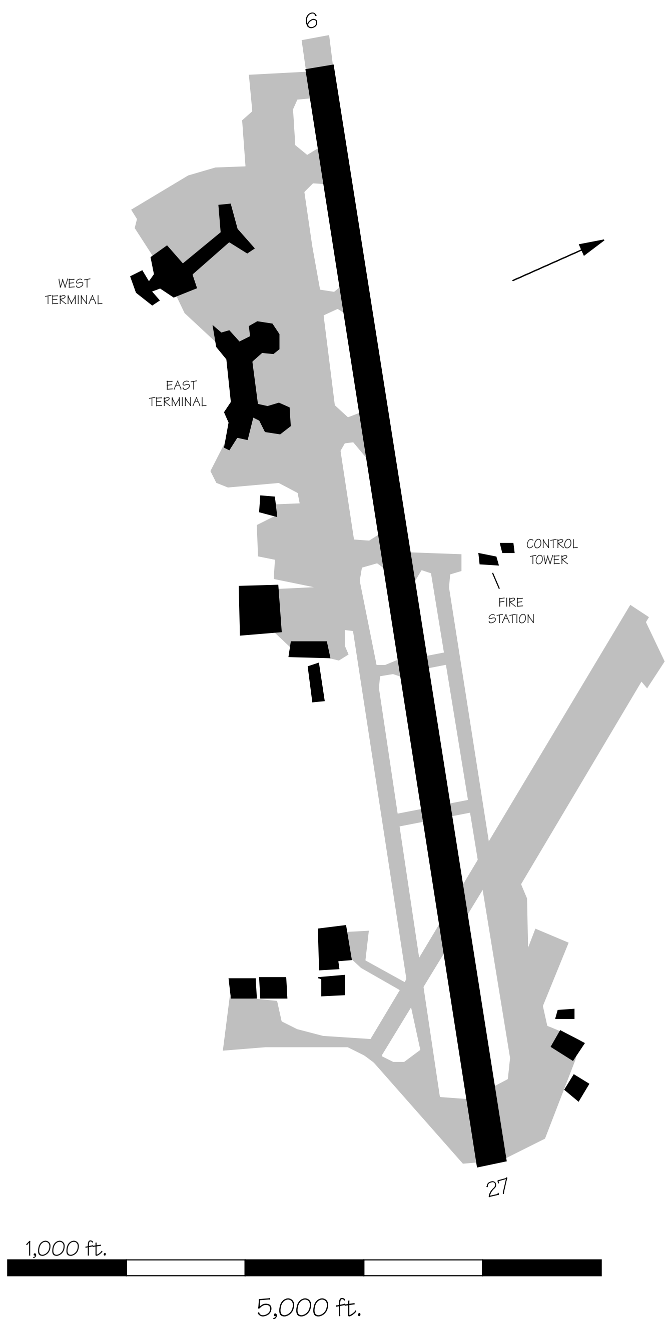
PVD — Providence Theodore Francis Green State Airport



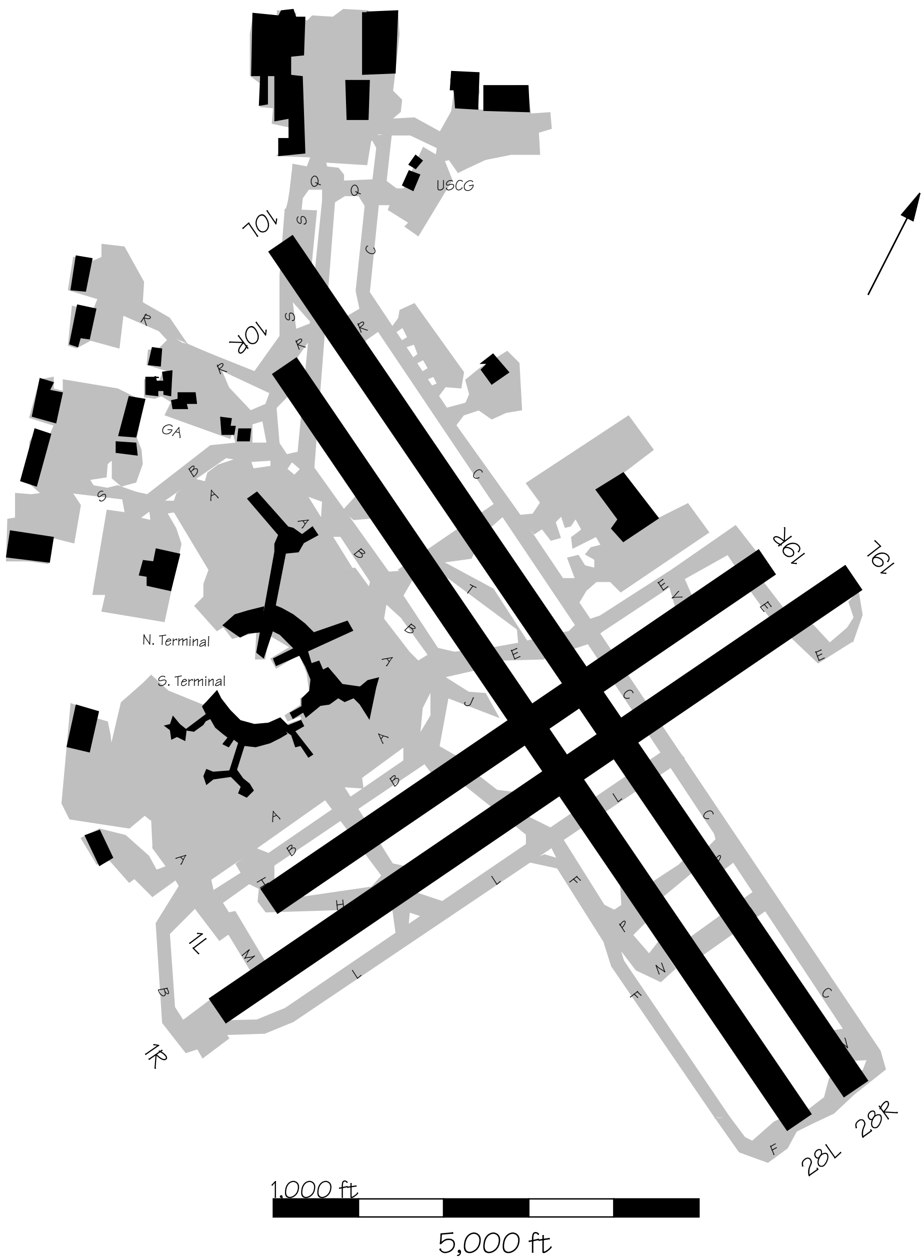
PWM — Portland International Jetport



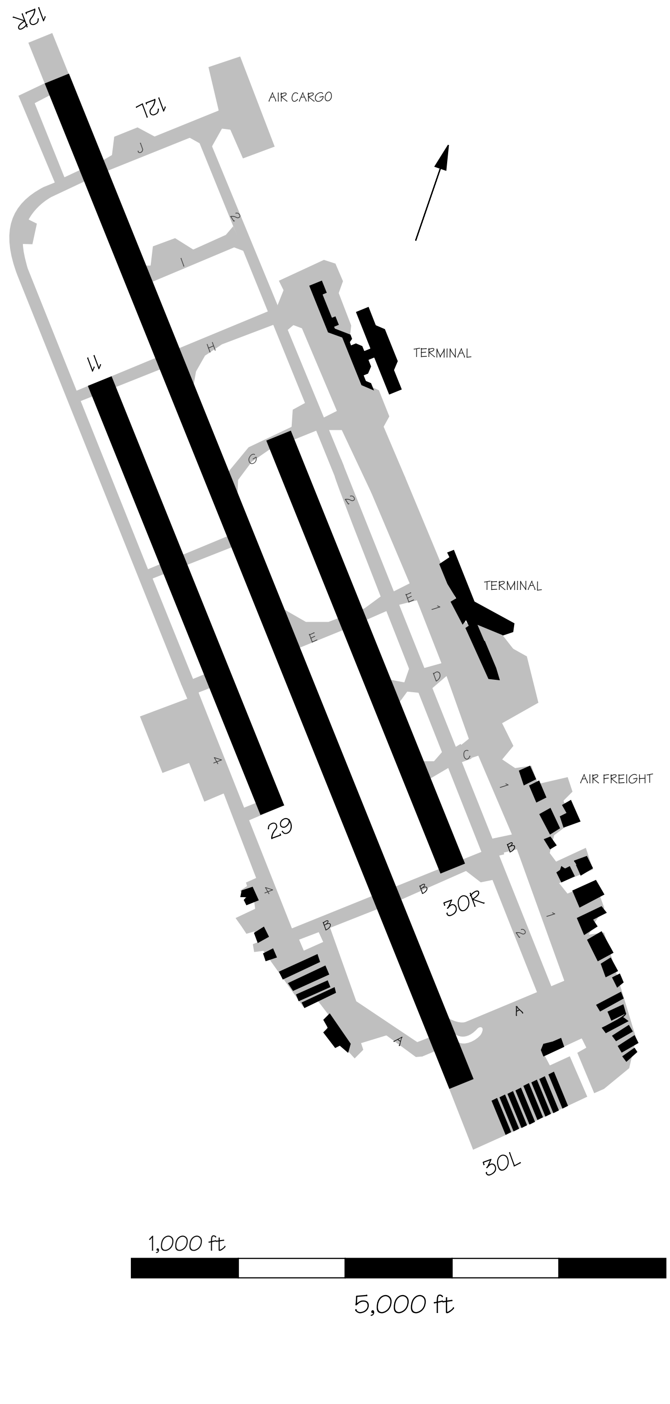
RNO — Reno Tahoe International Airport



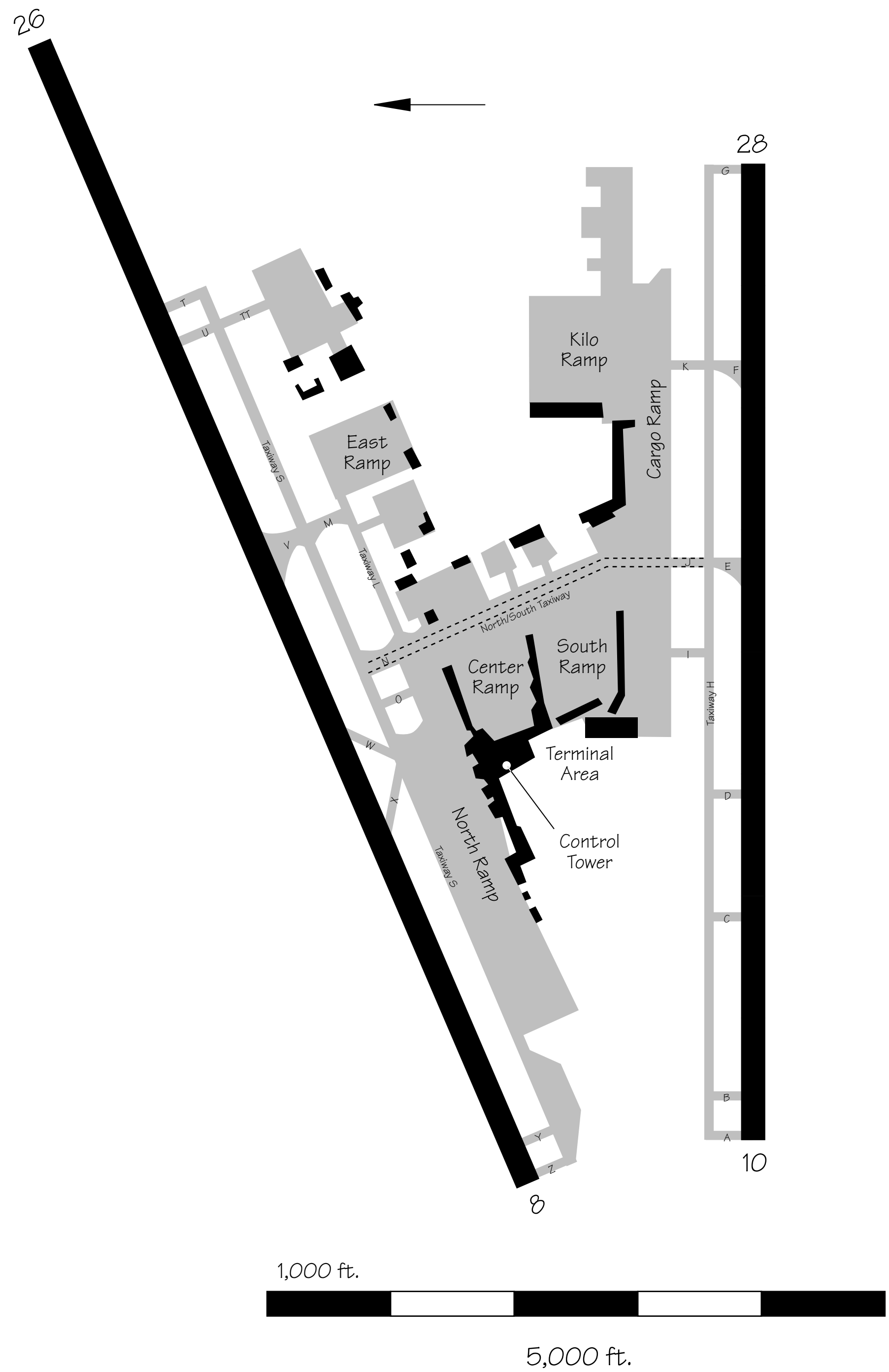
SAN — San Diego International Lindberg Field



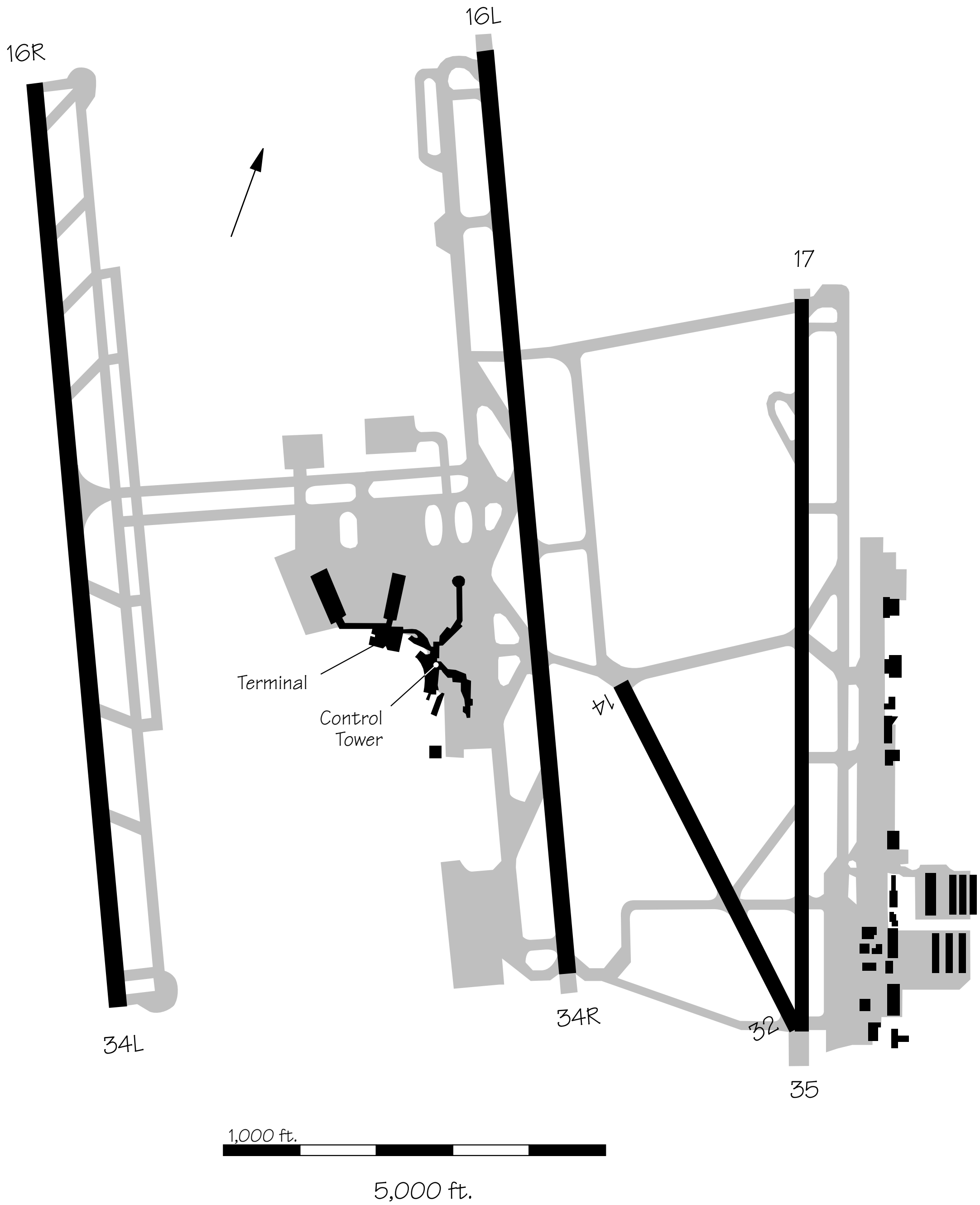
SFO — San Francisco International Airport



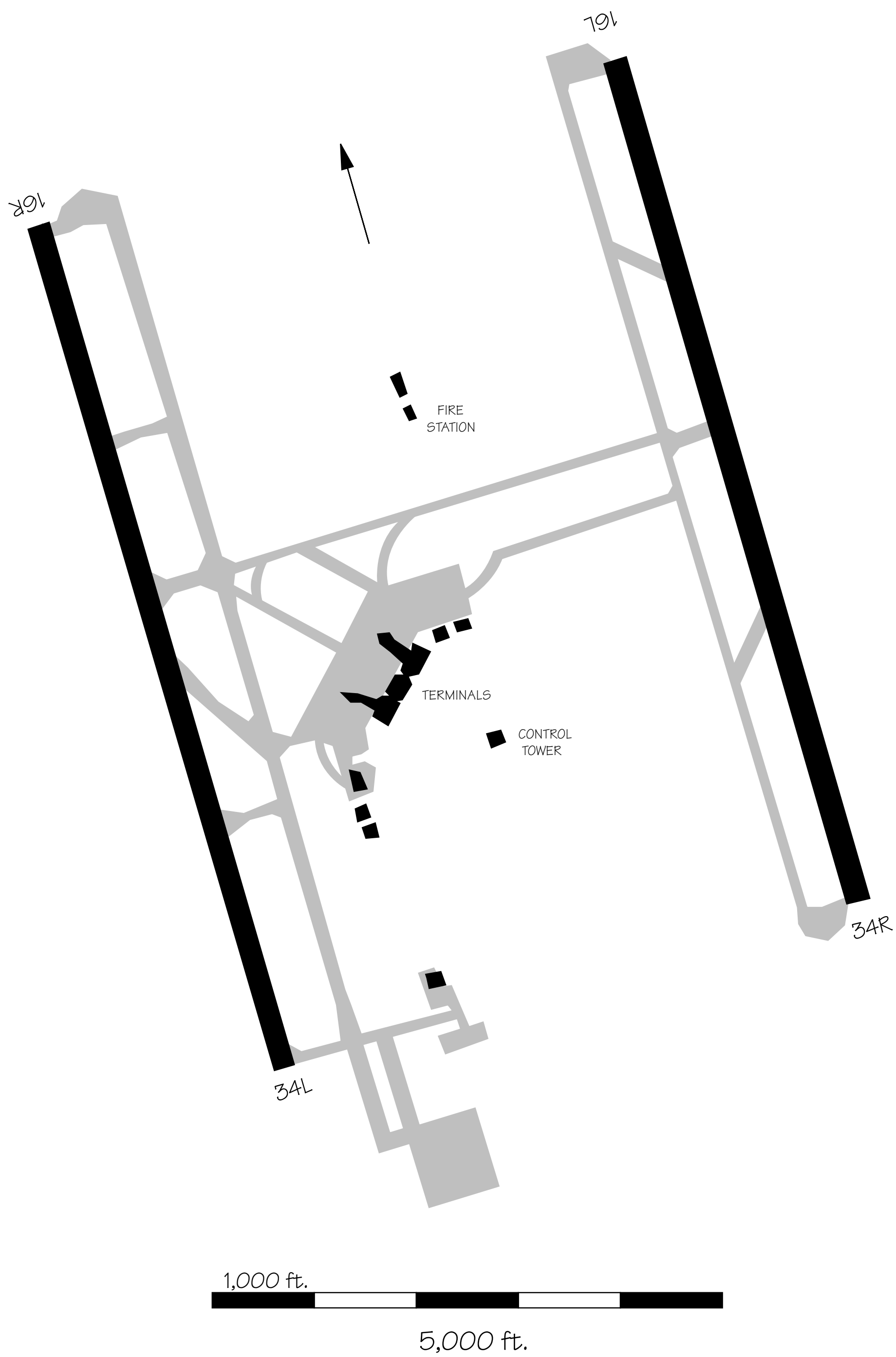
SJC — San Jose International Airport



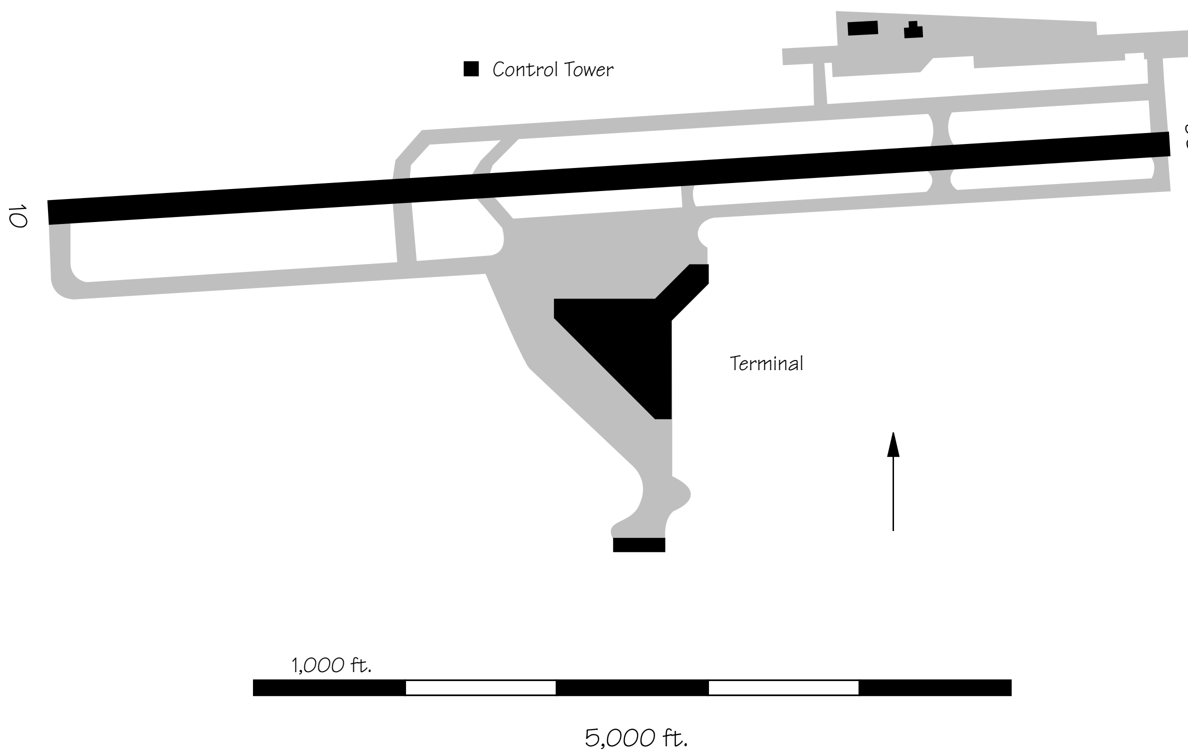
SJU — San Juan Luis Muñoz Marín International Airport



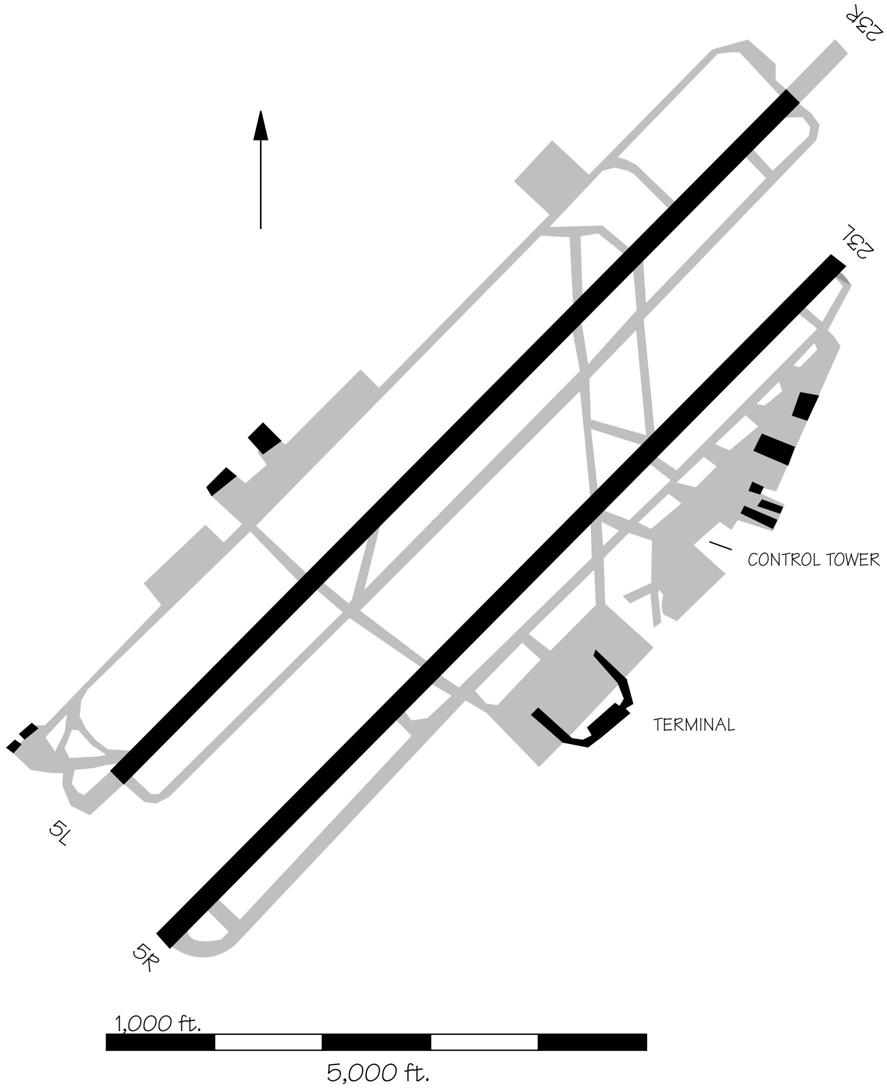
SLC — Salt Lake City International Airport



SMF — Sacramento Metropolitan Airport



STT — Charlotte Amalie St. Thomas, Virgin Islands



TYS — Knoxville McGhee-Tyson Airport

Appendix F

Glossary

AAC .... Advanced AERA Concepts
AAF .... Army Airfield
AAP .... Advanced Automation, FAA
AAS .... Advanced Automation System
ACARS .... ARINC Communications Addressing and Reporting System
ACCC .... Area Control Computer Complex
ACD .... Engineering, Research and Development Service, FAA
ACE .... Airport Capacity Enhancement
ACF .... Area Control Facility
ADR .... Automated Demand Resolution
ADS .... Automatic Dependent Surveillance
ADSIM .... Airfield Delay Simulation Model
AERA .... Automated En Route Air Traffic Control
AEX .... Automated Execution
AF .... Airway Facilities
AFB .... Air Force Base
AGFS .... Aviation Gridded Forecast System
AGL .... Above Ground Level
AIP .... Airport Improvement Program
AIRNET .... Airport Network Simulation Model
AIV .... Aviation Impact Variable
ALP .... Airport Layout Plan
ALS .... Approach Lighting System
ALSF-II .... Approach Light System with Sequenced Flashers and CAT II modification
AMASS .... Airport Movement Area Safety System
AMSS .... Aeronautical Mobile Satellite Service
ANA .... Program Director for Automation, FAA
AND .... Associate Administrator for NAS Development, FAA
ANG .... Air National Guard
ANN .... Program Director for Navigation and Landing, FAA
ANR .... Program Director for Surveillance, FAA
ANS .... NAS Transition Implementation Service, FAA
ANW .... Program Director for Weather and Flight Service Stations, FAA
AOC .... Aeronautical Operational Control
AOR .... Operations Research Service, FAA
APO .... Office of Aviation Policy and Plans, FAA
APP .... Office of Airport Planning and Programming, FAA
ARD .... Research and Development Service, FAA
ARF .... Airport Reservation Function
ARINC .... Aeronautical Radio Incorporated
ARSA .... Airport Radar Surface Area
ARTCC .... Air Route Traffic Control Center
ARTS .... Automated Radar Terminal System
ASC .... Office of System Capacity and Requirements, FAA
ASCP .... Aviation System Capacity Plan
ASD .... Aircraft Situation Display
ASDE .... Airport Surface Detection Equipment
ASE .... NAS System Engineering Service, FAA
ASOS .... Automated Surface Observation System
ASP .... Arrival Sequencing Program
ASQP .... Airline Service Quality Performance
ASR .... Airport Surveillance Radar
ASTA .... Airport Surface Traffic Automation
ATC .... Air Traffic Control
ATCAA .... Air Traffic Control Assigned Airspace
ATCSCC .... Air Traffic Control System Command Center
ATIS .... Automated Terminal Information Service
ATN .... Aeronautical Telecommunications Network
ATMS .... Advanced Traffic Management System
ATO .... Air Traffic Operations Service, FAA
ATOMS .... Air Traffic Operations Management System
AWDL .... Aviation Weather Development Laboratory
AWOS .... Automated Weather Observing System
AWPG .... Aviation Weather Products Generator
CAA .... Civil Aviation Authority
CAEG .... Computer Aided Engineering Graphics
CARF .... Central Altitude Reservation Function

CASA .... Controller Automated Spacing Aid
CASTWG......... Converging Approach Standards Technical Working Group
CAT................ Category
CDTI............... Cockpit Display of Traffic Information
CFWSU .... Central Flow Weather Service Unit
CIP.................. Capital Investment Plan
CNS .... Communication, Navigation, and Surveillance
CODAS............ Consolidated Operations and Delay Analysis System
CONDAT .... CONUS National Airspace Data Access Tool
CONUS............ Continental United States
CRDA.............. Converging Runway Display Aid
CRS................. Computer Reservation System
CSD .... Critical Sector Detector
CTAS............... Center–TRACON Automation System
CTMA .... Center Traffic Management Advisor
CTR .... Civil Tilt Rotor
CVFP............... Charted Visual Flight Procedures
CW .... Continous Wave
CWSU .... Center Weather Service Unit
CY................... Calendar Year
DA .... Descent Advisor
DDAS .... Daily Decision Analysis System
DEMVAL .... Demonstration/Validation
DGPS .... Differential GPS
DH.................. Decision Height
DLP................. Data Link Processor
DME .... Distance Measuring Equipment
DME/P .... Precision Distance Measuring Equipment
DOD .... Department of Defense
DOT................ Department of Transportation
DOTS .... Dynamic Ocean Tracking System
DSB................. Double Sideband
DSP................. Departure Sequencing Program
DSUA .... Dynamic Special-Use Airspace
DVOR.............. Doppler VOR
ECVFP .... Expanded Charted Visual Flight Procedures
EDP .... Expedite Departure Path
EDPRT .... Expert Diagnostic, Predictive, and Resolution Tool
EFF .... Experimental Forecast Facility
EIS .... Environmental Impact Statement
EOF .... Emergency Operations Facility
ESP .... En Route Spacing Program
ETMS .... Enhanced Traffic Management System
EVAS .... Enhanced Vortex Advisory System
F&E .... Facilities and Equipment
FAA................. Federal Aviation Administration
FAATC .... Federal Aviation Administration Technical Center
FADE .... FAA-Airline Data Exchange
FAF .... Final Approach Fix
FANS .... Future Air Navigation System
FAST .... Final Approach Spacing Tool
FBO................. Fixed Base Operator
FDAD .... Full Digital ARTS Display
FL .... Flight Level
FLOWALTS...... Flow Generation Function
FLOWSIM .... Traffic Flow Planning Simulation
FMA .... Final Monitor Aid
FMS .... Flight Management System
FSD .... Full-Scale Development
FSM .... Flight Simulation Monitor
FT .... Feet
FTMI .... Flight Operations and Air Traffic Management Integration
FY .... Fiscal Year
GA .... General Aviation
GAO .... General Accounting Office
GDP .... Gross Domestic Product
GLONASS........ Global Orbiting Navigational Satellite System
GNSS............... Global Navigation Satellite System
GPS .... Global Positioning System
GRADE .... Graphical Airspace Design Environment
HARS .... High Altitude Route System
HIRL .... High Intensity Runway Lights
HUD .... Heads-Up Display
HF................... High Frequency
ICAO .... International Civil Aviation Organization
IFCN .... Inter-Facility Flow Control Network
IFR.................. Instrument Flight Rules
I-LAB .... Integration and Interaction Laboratory
ILS .... Instrument Landing System
IMC .... Instrument Meteorological Conditions

INMARSAT ...... International Maritime Satellite
IOC .... Initial Operational Capability
ISSS .... Initial Sector Suite System
ITS .... Intelligent Tutoring System
ITWS .... Integrated Terminal Weather System
LDA .... Localizer Directional Aid
LIP .... Limited Implementation Program
LLWAS .... Low Level Wind Shear Alert System
LORAN .... Long Range Navigation
MA .... Monitor Alert
MALSR .... Medium Intensity Approach Lighting System with RAIL
MAP .... Military Airport Program
MAP .... Missed Approach Point
MASPS .... Minimum Aviation System Performance Standards
MCAS .... Marine Corps Air Station
MCF .... Metroplex Control Facility
MDCRS .... Meteorological Data Collection and Reporting System
MIT .... Miles In Trail
MLS .... Microwave Landing System
MNPS .... Minimum Navigation Performance Specifications
MOA .... Military Operations Area
MOPS .... Minimum Operations Performance Standards
MRAD .... Milli-Radian
MWP .... Meteorologist Weather Processor
NAS .... Naval Air Station
NAS .... National Airspace System
NASP .... NAS Plan
NASPAC .... NAS Performance Analysis Capability
NASPALS .... NAS Precision Approach and Landing System
NASSIM .... NAS Simulation Model
NATSPG .... North Atlantic Special Planning Group
NAVAID .... Navigational Aid
NCF .... National Control Facility
NCP .... NAS Change Proposal
NEXRAD .... Next Generation Weather Radar
NFDC .... National Flight Data Center
NMC .... National Meteorological Center
NMCC .... National Maintenance Coordination Complex
NM .... Nautical Mile
NOAA .... National Oceanic and Atmospheric Administration
NPIAS .... National Plan of Integrated Airport Systems
NSC .... National Simulation Capability
NTP .... National Transportation Policy
NTZ .... No Transgression Zone
NWS .... National Weather Service
OAG .... *Official Airline Guide*
ODALS .... Omni-Directional Approach Lighting System
ODAPS .... Oceanic Display and Planning System
ODF .... Oceanic Development Facility
ODL .... Oceanic Data Link
OMB .... Office of Management and Budget
OPTIFLOW ..... Optimized Flow Planning
ORD .... Operational Readiness Date
ORD .... Operational Readiness Demonstration
OST .... Office of the Secretary of Transportation
OTFP .... Operational Traffic Flow Planning
OTPS .... Oceanic Traffic Planning System
PADS .... Planned Arrival and Departure System
PAPI .... Precision Approach Path Indicator
PCA .... Positive Control Airspace
PDC .... Pre-Departure Clearance
PRM .... Precision Runway Monitor
R&D .... Research and Development
RE&D .... Research, Engineering, and Development
RAIL .... Runway Alignment Indicator Lights
RDSIM .... Runway Delay Simulation Model
REIL .... Runway End Identifier Lights
RFP .... Request for Proposal
RGCSP .... Review of General Concepts of Separation Panel
RMM .... Remote Maintenance Monitoring
RMP .... Rotorcraft Master Plan
RNAV .... Remote Area Navigation
RNP .... Required Navigation Performance
RNPC .... Required Navigation Performance Capability
ROT .... Runway Occupancy Time
RSLS .... Runway Status Light System
RTCA .... Radio Technical Commission for Aeronautics

RVR .... Runway Visual Range
SAR .... System Analysis Recording
SARPS .... Standards and Recommended Practices
SATCOM .... Satellite Communications
SCIA .... Simultaneous Converging Instrument Approaches
SDAT .... Sector Design Analysis Tool
SDRS .... Standardized Delay Reporting System
SE .... Strategy Evaluation
SID .... Standard Instrument Departure
SIMMOD .... Airport and Airspace Simulation Model
SM .... Statute Mile
SMARTFLOW .. Knowledge-Based Flow Planning
SMGC .... Surface Movement Guidance and Control
SMS .... Simulation Modeling System
SOIR .... Simultaneous Operations on Intersecting Runways
SOIWR .... Simultaneous Operations on Intersecting Wet Runways
STAR .... Standard Terminal Arrival Route
SUA .... Special Use Airspace
TACAN .... Tactical Air Navigation — UHF omnidirectional course and distance information
TASS .... Terminal Area Surveillance System
TATCA .... Terminal ATC Automation
TAVT .... Terminal Airspace Visualization Tool
TCA .... Terminal Control Area
TCAS .... Traffic Alert and Collision Avoidance System
TCCC .... Tower Control Computer Complex
TDP .... Technical Data Package
TERPS .... Terminal Instrument Procedures
TFM .... Traffic Flow Management
TIDS .... Tower Integrated Display System
TMA .... Traffic Management Advisor
TMCC .... Traffic Management Computer Complex
TMS .... Traffic Management System
TMU .... Traffic Management Unit
TRACON .... Terminal Radar Approach Control
TSC .... Volpe Transportation Systems Center
TSO .... Technical Standard Order
TTMA .... TRACON Traffic Management Advisor
TVOR .... Terminal VOR
TWDR .... Terminal Weather Doppler Radar
USWRP .... U.S. Weather Research Program
VASI .... Visual Approach Slope Indicators
VF .... Vertical Flight
VFR .... Visual Flight Rules
VHF .... Very High Frequency
VMC .... Visual Meteorological Conditions
VOR .... VHF Omnidirectional Range — course information only
VORTAC .... Combined VOR and TACAN Navigational Facility
VOT .... VOR Test
WAAS .... Wide Area Augmentation System

Appendix G

Index*

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C

* A note concerning airport names and locations:

This index does not reference the occurrences of airports that appear in any Tables or Figures. For a listing of Tables and Figures, please see the Table of Contents. For a listing of airport layouts and their locations, please refer to Appendix B.

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