1998 ACE PLAN

AVIATION CAPACITY ENHANCEMENT

U.S. Department of Transportation

Federal Aviation Administration

1998
Aviation Capacity Enhancement Plan

Federal Aviation Administration
Office of System Capacity

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EXECUTIVE SUMMARY

Aviation activity is predicted to rise steadily over the next ten years, increasing the demand on already congested airports and terminal areas. The U.S. aviation infrastructure handled 63.4 million aircraft operations in 1997, an increase of 1.4 million operations over the previous year. The 1998 Aviation Capacity Enhancement (ACE) Plan describes FAA initiatives aimed at enhancing the capacity and performance of the National Airspace System (NAS) to accommodate this growing demand, and explores issues that could inhibit the future efficiency of the NAS. The ACE Plan is produced by the FAA Office of System Capacity (ASC).

The National Airspace System

Delay is the traditional measure of NAS performance. The primary causes of delay are weather and terminal volume. In 1997, approximately 245,000 flights were delayed 15 minutes or more, a decrease of 9.6 percent from 1996. The overall decrease in delay was primarily a result of fewer weather-related delays. Twenty-seven airports in the U.S. had more than 20,000 hours of annual delay in 1997, and if no significant capacity enhancements are made this number will increase to 31 airports by 2007. Of the 29 large hub airports, Newark International Airport had the highest average delay per operation in 1997. New airport development, weather detection and forecasting tools, and new decision support technology such as the Standard Terminal Automation Replacement System (STARS) are just a few of the FAA initiatives that will help to reduce delays.

Other measures of NAS system performance are the flexibility and predictability of the air traffic control system, and user access to aviation services and facilities. FAA initiatives focused on increasing flexibility are the elimination of unnecessary ATC-preferred routes, expansion of the National Route Program (NRP), and the development of enhanced area navigation (RNAV) procedures. Key strategies for increasing system predictability are improving the quality and quantity of information available to system users and involving them in interactive operational decision making. FAA initiatives to improve access include increasing civilian access to Special Use Airspace (SUA) and supplementing GPS navigation through the development of the wide area augmentation system (WAAS) and the local area augmentation system (LAAS).

Free Flight and NAS Modernization

The FAA's two major interdependent capacity enhancement initiatives — Free Flight and NAS modernization — are providing new technologies and procedures to increase NAS efficiency. The main objective of free flight is to remove restrictions that hinder the efficient flow of traffic while maintaining or improving the current high level of safety. The transition to free flight requires both procedural and technological advances. The FAA is currently implementing many of the procedural changes required for free flight. Six new technologies will be implemented at select locations in the near future under a NAS modernization initiative referred to as Free Flight Phase 1. A full-scale testing of free flight technologies is planned in the Safe Flight 21 initiative.

Airport Development

The construction of new runways and the extension of existing runways are the most significant and direct ways to improve capacity at existing airports. Of the top 100 U.S. airports, 18 completed runway construction projects from 1995 to 1998; eight airports are currently constructing new runways or runway extensions, and 59 airports have proposed runway construction projects. ASC works with airports to study ways to redevelop and expand existing airport facilities. These studies focus on maximizing capacity at existing airports through improvements in runways and taxiways, navigational and guidance aids, and operational procedures. Increasingly, environmental issues such as noise in the airport environment are restricting airport expansion options in major metropolitan areas.

Airspace Development

Airspace development studies strive to reduce delays by determining how to restructure airspace and modify arrival, departure, en route and terminal flow patterns. In mid-1998 the FAA initiated the National Airspace Redesign, a large-scale analysis of the national airspace structure that will begin by identifying problems in the congested airspace of New York and New Jersey. Additional FAA airspace studies are ongoing in Chicago, northern and southern California, Salt Lake City, the Southern Region (from Florida to Atlanta), and the Caribbean. The FAA has also initiated a terminal airspace study at Phoenix International Airport. The efficiency benefits of airspace redesign have been demonstrated in the Dallas/Fort Worth area, where a new runway, rerouting of traffic, and expanding the TRACON airspace resulted in an increase of visual flight rules (VFR) arrival rates by more than 40 percent and annual flight time savings of $92 million in 1997.

Operational Procedures

A cost-efficient alternative to airport and airspace development is modifying air traffic control procedures to improve the flow of aircraft in the en route and terminal area. Examples of initiatives in the en route environment are the National Route Program (NRP) and the 3D User Preferred Trajectories Flight Trials Project, which are decreasing restrictions and allowing pilots to fly more direct routes. In the oceanic environment, reduced horizontal and vertical separation minima will provide pilots with more flexibility and efficient routing. Additionally, less restrictive instrument approach procedures are being developed for the terminal environment as the accuracy of landing aids improves.

Capacity Enhancing Technologies

Over the next two decades significant capacity enhancements will be gained from increased capabilities in the areas of communication, navigation, surveillance, weather, and Air Traffic Management (ATM) decision support systems. Digital communications systems, combined with augmentations to the Global Position System (GPS), Automated Dependent Surveillance (ADS), improved decision support tools for controllers, and improved weather prediction and dissemination systems will lead to the more efficient use of airspace and airports and greater operational flexibility.

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INTRODUCTION

A recent report by the National Civil Aviation Review Commission (NCARC) on aviation funding concluded that:

"…growth, without significant capacity improvements, is already posing a serious challenge to the efficiency of our air transportation system, and hence the economy at large. Continued steady growth, without adequate investment in the air traffic control and airport system, will make this challenge even more daunting with each passing day."[1]

The purpose of the Aviation Capacity Enhancement (ACE) Plan is to describe the many FAA initiatives that are addressing the challenge of keeping pace with the growing demand for aviation services. The ACE Plan provides an overview of free flight and NAS modernization — two broad programs that govern the FAA's capacity investments — as well as specific initiatives in the areas of airport development, airspace redesign, new operational procedures, and new aviation technologies. The ACE Plan is produced by the FAA Office of System Capacity (ASC).

The U.S. Department of Transportation (DOT) recently embarked on a new, intermodal approach to transportation planning called the ONE DOT management strategy. The FAA will actively participate in ONE DOT by coordinating with other transportation modes such as highways and railways in addressing transportation problems, and considering the entire transportation experience for the flying public when determining its investments in airports and other aviation infrastructure. Consistent with the ONE DOT strategy, the ACE Plan promotes an integrated approach to transportation planning by keeping officials in all transportation modes apprised of current and planned aviation capacity enhancements. As this strategy evolves, future ACE Plan publications will include highlights of intermodal capacity initiatives.

1. www.faa.gov/NCARC/reports/pepele.htm, pg 13.

CHAPTER 1: THE NATIONAL AIRSPACE SYSTEM

In the next ten years, the demand for FAA aviation services will grow steadily. This increased demand will be placed on an aviation system where key airports and terminal areas are already frequently congested.

This chapter provides information on the aviation infrastructure of the U.S., current and projected aviation activity, and changes in flight delay and other measures of system capacity and performance. The capacity of the U.S. aviation system is a direct function of the existing aviation infrastructure. Aviation activity data indicate the demand on the system; system performance measures indicate the ability of the aviation system to accommodate the demand.

Aviation Infrastructure

Airports and air traffic facilities can be viewed as static components of the aviation infrastructure that do not change significantly day to day. In comparison, the air traffic management services provided by the FAA are more dynamic, ensuring that both safety and capacity are maintained at every moment in constantly changing weather and traffic situations. The Office of System Capacity (ASC) works with other FAA organizations, airports, airlines, and other aviation system users to ensure continuous enhancement of the U.S. aviation infrastructure and air traffic services, especially in congested areas of the country.

Airport Capacity in the United States

Approximately 3,300 airports[1] in the United States are considered significant to the capacity of the national airspace system (NAS) (see Figure 1-1). These airports, by inclusion in the National Plan of Integrated Airport Systems (NPIAS), are eligible to receive grants under the Federal Airport Improvement Program (AIP).

Of the AIP-eligible airports, 413 are considered primary airports, handling the vast majority of scheduled commercial service and enplaning more than 10,000 passengers annually each. These airports, with their high level of commercial activity, form the vital network of air transportation needed to ensure the movement of people and cargo critical to interstate commerce and international competitiveness. Delay problems are most prevalent at, but not limited to, the 29 large-hub primary airports.

1. Airports include landing areas developed specifically for helicopters and seaplanes as well as conventional fixed wing aircraft landing areas.

Number of Airports	Airport Types		% of Commercial Enplanements	% of Based Aircraft*
AIP Eligible Airports				
538	**Commercial Service: Handle all regularly scheduled commercial airline traffic**			
413	Primary:	More than 10,000 annual passenger enplanements	99.9%	20.8%
29	*Large Hub*	*At least 1% of passenger enplanements*	*67.2%*	*1.3%*
42	*Medium Hub*	*0.25% to 1% of passenger enplanements*	*22.2%*	*3.8%*
70	*Small Hub*	*0.05% to 0.25% of passenger enplanements*	*7.1%*	*4.5%*
272	*Non Hub*	*Less than 0.05% of passenger enplanements; average of 135 based aircraft*	*3.4%*	*11.2%*
125	Non-Primary:	2,500 to 10,000 enplanements annually; used mainly by GA	0.1%	3.2%
2,807	**General Aviation**			
2,473	General Aviation	Have at least 10 based aircraft and fewer than 2,500 scheduled enplanements	0.0%	37.5%
334	Reliever	High-capacity GA airports to improve GA airport access in major metropolitan areas	0.0%	30.0%
3,345	**Total**		**100.0%**	**91.5%**
Non-AIP Eligible Airports				
14,961	Low Activity Landing Areas		0.0%	8.5%

* Locally-owned aircraft hangared or based at the airport

Figure 1-1. Distribution of Aviation Activity at U.S. Airports

Air Traffic Control (ATC) Facilities

Communication, navigation, surveillance, and weather resources permit air traffic controllers to view key information, such as aircraft location, aircraft flight plans, and prevailing weather conditions, and to communicate with pilots. These resources reside at, or are associated with, several aTC facilities: flight service stations (FSS), air traffic control towers (ATCT), terminal radar approach control facilities (TRACON), air route traffic control centers (ARTCC), and the Air Traffic Control System Command Center (ATCSCC) (see Figure 1-2). Controllers at these facilities work with pilots, air carriers, and each other to assure that the maximum capacity of the NAS is realized minute-to-minute and day-to-day. The functions of each of these ATC facilities are described briefly below.

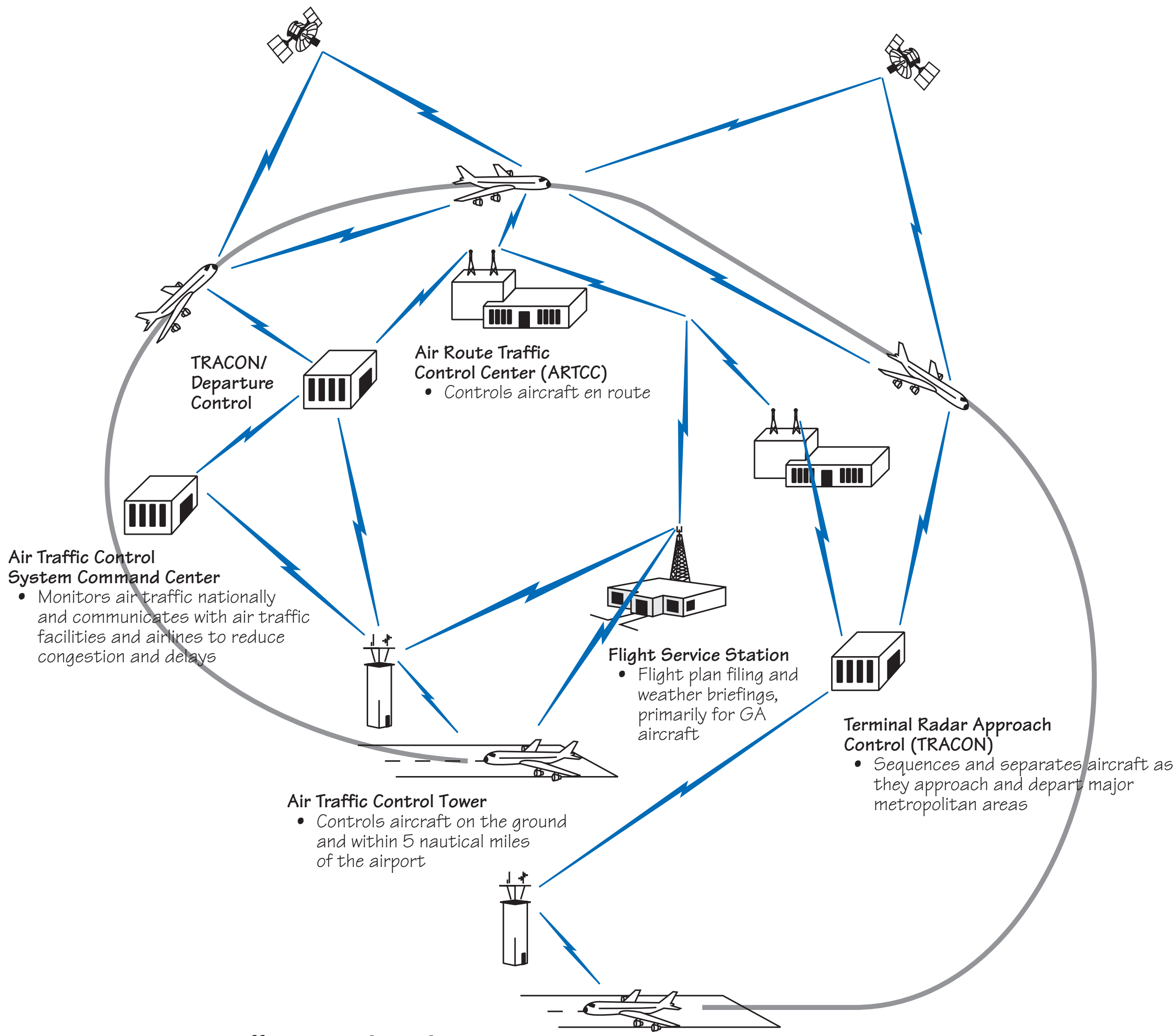

Figure 1-2. Air Traffic Control Facilities

Flight Service Stations (FSS)

Over 75 automated flight service stations (AFSS) and staffed flight service stations (FSS) provide pre-flight and in-flight services such as flight plan filing and weather report updates, primarily for general aviation aircraft. Pilots may also obtain flight services from an automated system called the Direct User Access Terminal Service (DUATS). In addition, pilots can obtain weather briefings through the Telephone Information Briefing System (TIBS) or private weather briefing vendors.

Airport Traffic Control Towers (ATCT)

Airport traffic control towers (ATCT) at more than 400 airports control aircraft on the ground, and before landing and after take-off within approximately five nautical miles of the airport and up to an altitude of 3,000 feet. Air traffic controllers rely on a combination of technology and visual surveillance to direct aircraft departures and approaches, maintain safe distances between aircraft, and communicate weather-related information, clearances, and other instructions to pilots.

Terminal Radar Approach Control Facilities (TRACON)

Over 185 Terminal Radar Approach Control facilities (TRACON) sequence and separate aircraft as they approach and depart major metropolitan areas. TRACONs typically control air traffic within a 30 mile radius and less than 15,000 feet altitude, exclusive of ATCT airspace.

A typical ARTCC has responsibility for more than 100,000 square miles of airspace extending over a number of states.

Air Route Traffic Control Centers (ARTCC)

Twenty Air Route Traffic Control Centers (ARTCC) control and monitor aircraft via radar over the continental United States in transit and during approaches to some airports. Each en route center handles a different region of airspace, passing control from one to another as respective borders are reached until the aircraft reaches TRACON airspace or leaves U.S. airspace. A typical ARTCC has responsibility for more than 100,000 square miles of airspace extending over a number of states.

Three ARTCCs —Oakland, New York, and Anchorage—also control aircraft over the ocean. Controlling aircraft over oceans is very different from controlling aircraft over land. Outside radar range, which extends only 175 to 225 miles offshore, controllers must rely on periodic radio communications of position reports to determine the aircraft's location.

Air Traffic Control System Command Center (ATCSCC)

The ATCSCC in Herndon, Virginia monitors traffic flows across the United States and communicates with ARTCCs, TRACONs, ATCTs, and Airline Operating Centers (AOC) to minimize congestion and delays due to adverse weather, equipment outages, closed runways, and other capacity-related circumstances.

ATC Services Related to Capacity

All of the services provided by the FAA concern safety, efficiency, security, or capacity. The services described below are provided by air traffic controllers to ensure that capacity is optimized in all weather and traffic conditions.

Separation Assurance

Separation assurance services ensure that aircraft maintain a safe distance from other aircraft, terrain, obstructions, and certain airspace not designated for routine air travel. While the primary function of separation services is to maintain safety, the application of separation minima also impacts capacity. Air traffic controllers apply separation standards defined for the various aircraft operating environments to guide pilots flying under instrument flight rules (IFR). Pilots flying under visual flight rules (VFR) ensure separation under a "see and avoid" policy. In the busy airspace surrounding an airport and on the airport surface, controllers in ATC towers sequence aircraft for takeoffs and landings, assign aircraft to available runways, and enforce surface movement procedures.

FAA personnel ensure the safe, orderly, and efficient movement of aircraft under conditions that vary based on a number of different factors including weather conditions, equipment availability, and runway constraints.

Traffic Management

Traffic management involves coordinating the large number of aircraft using the air traffic management (ATM) system at any given period of time, as well as coordinating the routes that these aircraft fly. FAA personnel ensure the safe, orderly, and efficient movement of aircraft under conditions that vary based on a number of different factors including weather conditions, equipment availability, and runway constraints.

The current traffic management service is a procedure-based, manual interaction between ATM specialists and aviation customers, such as airlines, to ensure that demand is balanced with available capacity. Traffic management specialists in FAA air traffic control facilities perform a wide range of traffic management activities:

- Managing ground stop and ground delay programs
- Formulating national flow management plans in coordination with AOCs
- Balancing air traffic flow within an ARTCC's airspace
- Sequencing and spacing aircraft on final approach
- Coordinating arrival and departure flows with adjacent facilities
- Formulating taxi sequences and communicating instructions to pilots for the safe and efficient flow of traffic on the airport surface

Aviation Information

The FAA gathers, processes, and disseminates aeronautical information such as weather data, aeronautical charts, and notices to airmen in support of the safe and efficient operation of aircraft. Recent enhancements to information exchange enable real-time data link communications between ATC and the cockpit for flight information and planning.

Navigation and Landing Services

The FAA establishes, operates, and maintains a majority of the terrestrial navigational and landing aids used by aircraft to determine their position en route and to/from the runway. The FAA also designs, flight checks, and publishes instrument approach procedures which determine the routes and altitudes that aircraft will fly when approaching a specific airport under marginal weather conditions.

Aviation Activity

Aircraft operations, passenger enplanements, air cargo tonnage, ARTCC traffic volume, and the number of active aircraft are all indicators of aviation activity and demand for FAA services. This section describes trends in these indicators.

U.S. Aircraft Operations and Passenger Enplanements

Over the past five years, the number of passenger enplanements has been increasing at a higher rate than aircraft operations, primarily due to increasing load factors. From 1992 to 1996 the number of aircraft operations in the U.S. remained stable at approximately 62 million, then increased to an estimated 63.4 million in 1997, a 6.3 percent increase. Air carrier and regional/commuter enplanements on the other hand, increased steadily from 507 million in 1992 to an estimated 630 million in 1997, a 24 percent increase. By 2009, aircraft operations are expected to increase to 75.4 million (a 19 percent increase over 1997), and enplanements to 986 million (a 57 percent increase over 1997). The higher growth predicted for passenger enplanements relative to aircraft operations is primarily due to a projected increase in seating capacity for air carrier aircraft. Figure 1-3 illustrates the trend in aircraft operations and passenger enplanements nationwide and at the top 100 U.S. airports.[2]

2. Based on 1997 passenger enplanements in the FAA's *Terminal Area Forecasts.*

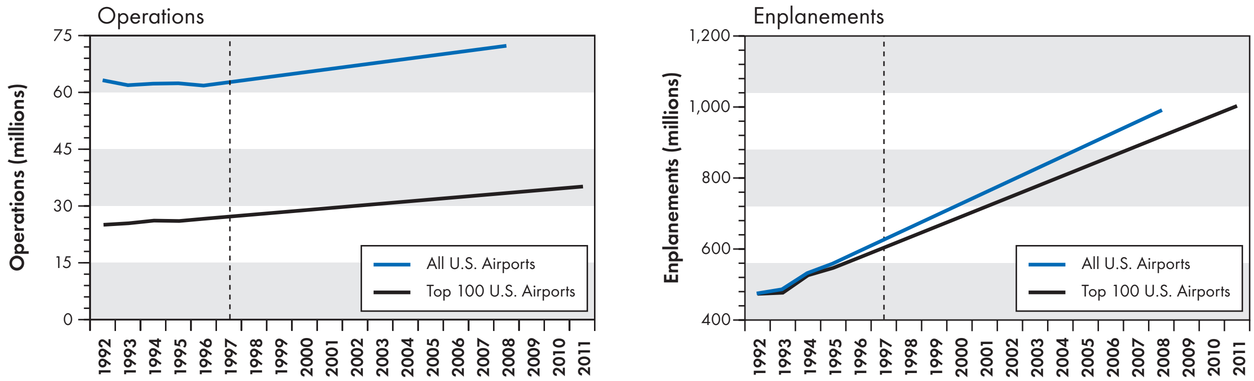

Figure 1-3. Trends in Operations and Enplanements

Aircraft Operations and Passenger Enplanements at the Top 100 Airports

The top 100 airports in the U.S., as measured by 1997 passenger enplanements, are shown in Figure 1-4. These 100 airports accounted for more than 95 percent of the passenger enplanements in the U.S. in 1997, but only 43 percent of operations. The top 100 airports were busier in 1997 than they were in 1996. From 1996 to 1997, the number of aircraft operations at the top 100 airports increased more than two percent, while the number of air carrier and regional/commuter enplanements increased 4.5 percent.

The number of aircraft operations at the top 100 airports increased from 25.3 million in 1992 to 27.2 million in 1997, a 7.5 percent increase.

The number of aircraft operations at the top 100 airports increased from 25.3 million in 1992 to 27.2 million in 1997, a 7.5 percent increase. Over the same period, the number of air carrier and regional/commuter enplanements increased from 474 million to 600 million, a 27 percent increase. By 2012, aircraft operations at the top 100 airports are projected to increase to 35.4 million (a 30 percent increase over 1997), and enplanements to 1 billion (a 67 percent increase over 1997). Operations and enplanement data for 1995, 1996, and 1997 and forecasts of operations and enplanements for the top 100 airports in 2012 are included in Appendix A.

Traffic Volume in Air Route Traffic Control Centers (ARTCCs)

The number of aircraft flying under instrument flight rules (IFR) handled by ARTCCs totaled 41.4 million in 1997, an increase of 2.4 percent over 1996. The five busiest ARTCCs in 1997 were: Cleveland, Chicago, Atlanta, Washington, D.C., and Indianapolis. By 2009, the Chicago ARTCC is projected to be the busiest in the U.S. Figure 1-5 is a map of the 20 ARTCCs in the Continental United States, with the busiest ARTCCs highlighted in blue. Figure 1-6 shows the number of operations by ARTCC for 1997, and forecast operations for 1998 and 2009.

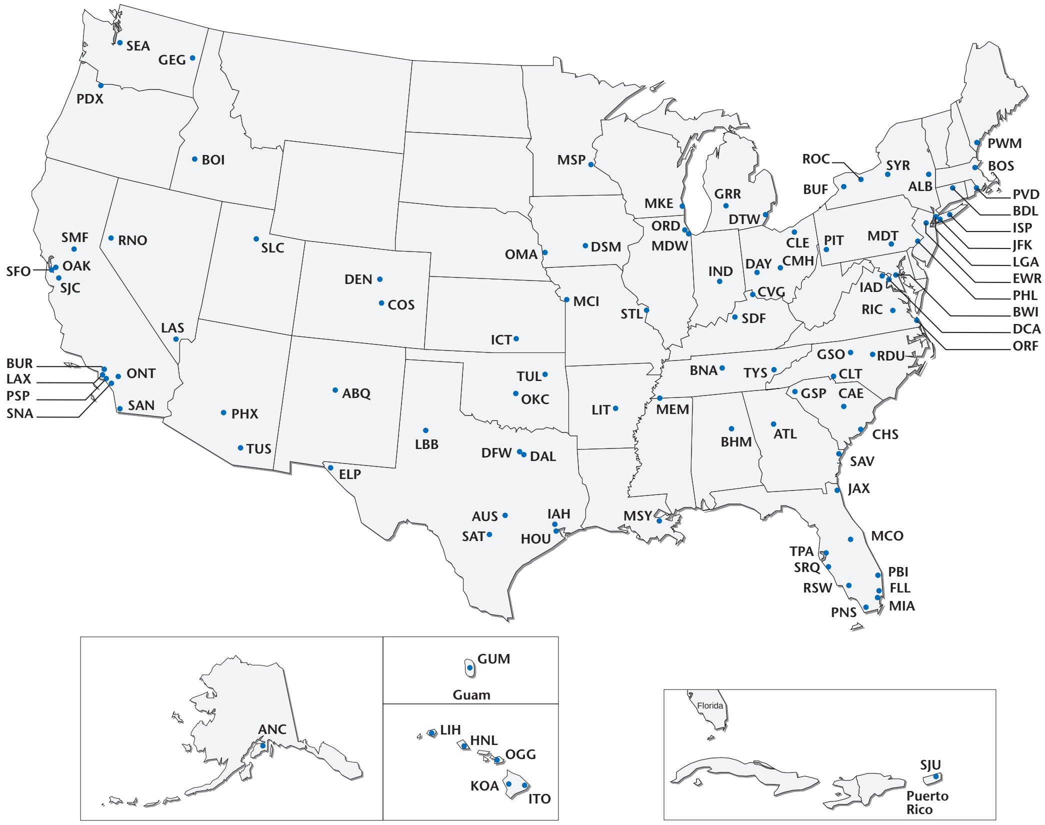

Figure 1-4. Top 100 Airports by 1997 Enplanements

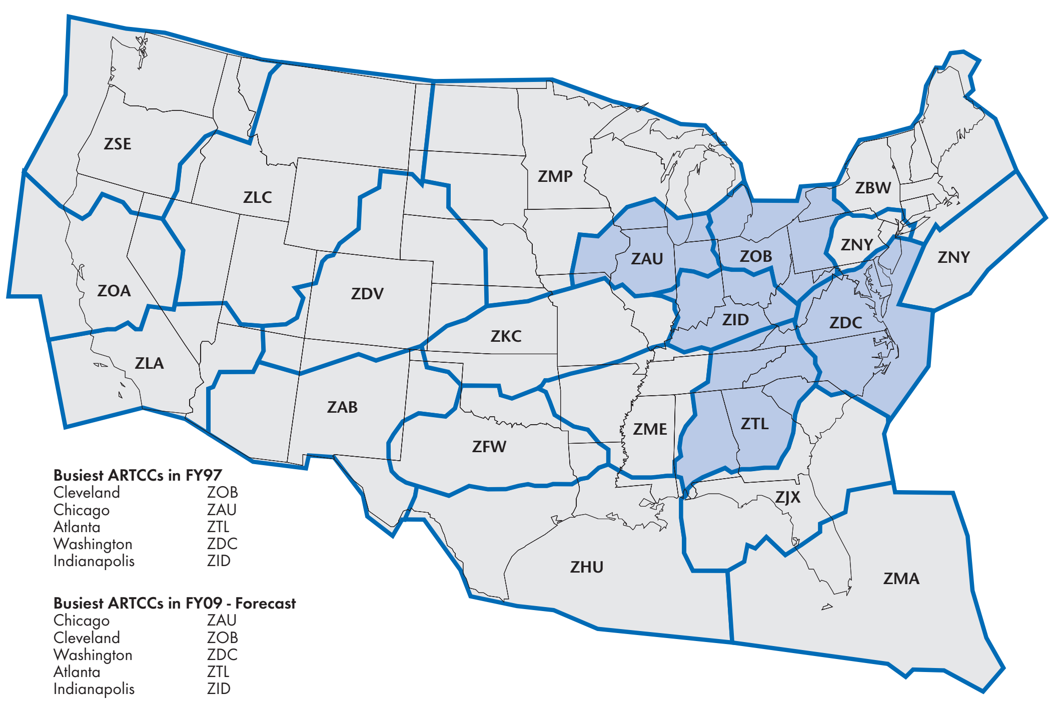

Figure 1-5. Continental Air Route Traffic Control Centers

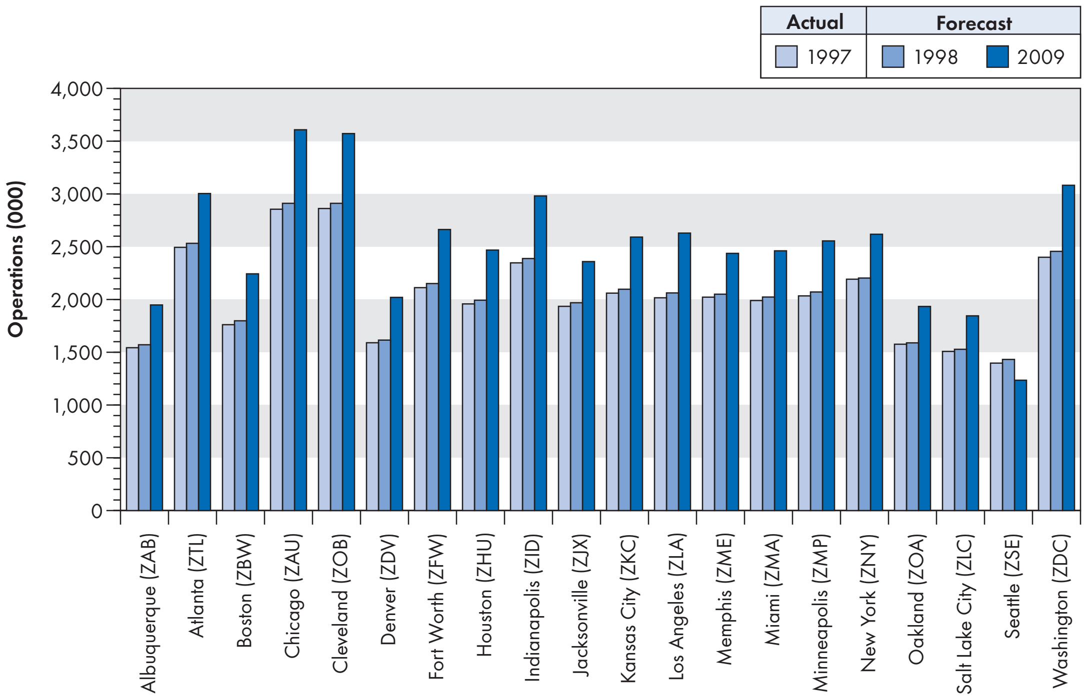

Figure 1-6. ARTCC Operations

Air Cargo

Air transportation, a preferred mode of shipment for high-value, lightweight, perishable, and time-sensitive goods, is increasingly important to the economy of the U.S. From 1990 to 1997, the share of U.S. imports shipped by air increased from 18 percent to 24 percent by dollar value. Over the same time period the share of U.S. exports shipped by air increased from 28 percent to 32 percent by dollar value (see Figure 1-7).[3] During the next 20 years, worldwide air cargo traffic is expected to more than triple, outpacing passenger growth.[4]

Air cargo is transported in the baggage compartments of scheduled passenger aircraft and by all-cargo aircraft. In 1995 there were approximately 1,200 all-cargo aircraft worldwide. The world freighter fleet is projected to nearly double by 2015, with a net addition of more than 1,000 jet freighter aircraft; 70 percent of the dedicated cargo fleet will be converted passenger planes.[5] Most all-cargo flights are scheduled during off-peak periods and do not substantially contribute to airport congestion and delay problems. Figure 1-8 lists the top 25 U.S. airports by tonnage of cargo loaded and unloaded for 1996 and 1997 and the

3. U.S. Department of Commerce, Bureau of the Census, Report FT920.
4. Boeing, www.boeing.com/commercial/value/8_cg_a.html.
5. Boeing, www.boeing.com/commercial/value/8_cg_a.html.

percentage change in tonnage. The tonnage shipped at these 25 airports increased ten percent from 1996 to 1997. The top five U.S. airports by cargo tonnage are Memphis, Los Angeles, Miami, John F. Kennedy (New York), and O'Hare (Chicago).

	1990		1996		1997	
Imports	18%	$89B	23%	$186B	23%	$213B
Exports	28%	$110B	31%	$196B	32%	$220B

Figure 1-7. Share and Value of U.S. Imports and Exports Shipped by Air (Percent and Billions of Dollars)

City	Airport	ID	Thousands of Metric Tons		% Change
			1996	1997	
Memphis, TN	Memphis International	MEM	1,934	2,233	16%
Los Angeles, CA	Los Angeles International	LAX	1,719	1,873	9%
Miami, FL	Miami International	MIA	1,710	1,766	3%
New York, NY	John F. Kennedy International	JFK	1,636	1,668	2%
Chicago, IL	O'Hare International	ORD	1,260	1,407	12%
Louisville, KY	Louisville Standiford Field	SDF	1,369	1,346	-2%
Anchorage, AK	Anchorage International	ANC	1,269	1,260	-1%
Newark, NJ	Newark International	EWR	958	1,043	9%
Atlanta, GA	Hartsfield Atlanta International	ATL	800	865	8%
Dayton, OH	Dayton International	DAY	767	813	6%
Dallas/Ft. Worth, TX	Dallas-Ft. Worth International	DFW	775	811	5%
San Francisco, CA	San Francisco International	SFO	712	780	10%
Oakland, CA	Metropolitan Oakland International	OAK	615	678	10%
Indianapolis, IN	Indianapolis International	IND	609	663	9%
Toledo, OH	Toledo Express	TOL	345	521	51%
Honolulu, HI	Honolulu International	HNL	436	501	15%
Philadelphia, PA	Philadelphia International	PHL	494	486	-2%
Boston, MA	Boston Logan International	BOS	406	442	9%
Denver, CO	Denver International	DEN	390	437	12%
Ontario, CA	Ontario International	ONT	396	419	6%
Seattle-Tacoma, WA	Seattle-Tacoma International	SEA	388	394	1%
Minneapolis-St. Paul, MN	Minneapolis-St. Paul International	MSP	361	379	5%
Cincinnati, OH	Greater Cincinnati International	CVG	289	363	26%
Washington, DC	Washington Dulles International	IAD	309	350	13%
Houston, TX	George Bush International	IAH	310	328	6%
Total			20,257	21,826	8%

* Loaded and unloaded freight and mail in thousands of metric tons.

Figure 1-8. Top 25 U.S. Airports by Total Cargo*

U.S. Commercial Air Carrier Aircraft

In 1997, there were 85 U.S. commercial airlines, of which 62 were passenger airlines and 23 were all-cargo carriers. The estimated total number of jet aircraft in this category was 4,953. By 2009, the number of air carrier jet aircraft is expected to increase by almost 50 percent to 7,419. New commercial aircraft orders totaled 1,181 in fiscal year 1997, an increase of 11.6 percent over 1996. The demand for narrowbody (single aisle) aircraft has continually outpaced the demand for widebody (more than one aisle) aircraft. Widebody aircraft are expected to account for 20.6 percent of the fleet by 2009, up from 17.6 percent in 1997.[6] See Figure 1-9.

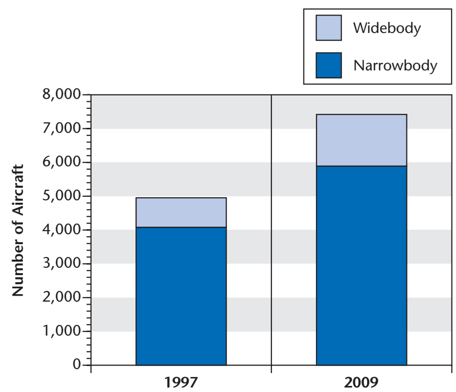

Figure 1-9. U.S. Air Carrier Large Jet Aircraft by Type

Regional/Commuter Aircraft

The regional/commuter airline industry is defined as air carriers that provide regularly scheduled passenger service with fleets that are primarily composed of aircraft with 60 seats or fewer. Its main role is to provide feeder service to large hubs served by the major commercial air carriers. In 1997, the regional/commuter traffic grew at almost the same rate as that of larger commercial air carriers. Regional/commuter enplanements increased 3.0 percent from 1996 levels, compared to a 3.5 percent increase in commercial enplanements.

The regional/commuter aircraft fleet is projected to increase 2.9 percent annually, from 2,121 aircraft in 1997 to 2,996 in 2009, a total predicted increase of 41 percent. The composition of the fleet will also be changing with significant increases in aircraft with 40 or more seats. This change in fleet composition will enable an 89 percent increase in regional/commuter enplanements by 2009.[7] Figure 1-10 illustrates the distribution of aircraft by number of seats in 1997 and 2009 projections.

6. FAA Aviation Forecasts Fiscal Years 1998-2009.

7. FAA Aviation Forecasts Fiscal Years 1998-2009.

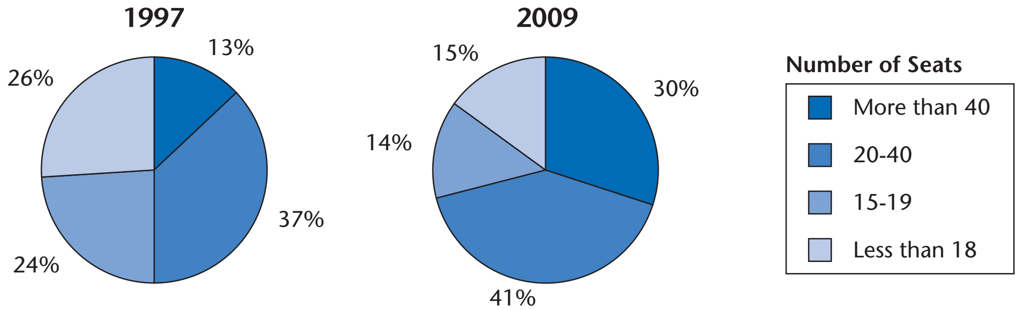

Figure 1-10. Regional/Commuter Aircraft Percent

General Aviation (GA) Aircraft

General aviation encompasses all segments of the aviation industry except commercial air carriers (including commuter/regional aircraft) and military. There were approximately 189,000 active general aviation and air taxi aircraft in the U.S. in 1997. The FAA projects that the number of active aircraft will increase 12 percent by 2009, with business use of GA expanding more rapidly than personal use of GA. This projection assumes production of about 4,000 new GA aircraft annually, and the retirement of approximately 2,000 older aircraft annually.[8] The National Aeronautics and Space Administration (NASA) and the FAA are currently developing a strategic plan called the *GA Roadmap* to stimulate the production and availability of safe, affordable, fast GA aircraft over the next 25 years. The ultimate goal of the *GA Roadmap* is to expand GA accessibility to more communities and provide enhanced personal mobility for U.S. travelers.[9] See Chapter 3 for a discussion of the projected impacts of the next generation of GA aircraft on airport utilization.

> The FAA projects the number of active aircraft will increase 12 percent by 2009, with business use of GA expanding more rapidly than personal use of GA.

System Performance Measures

Capacity-enhancing programs such as airport expansion, the modernization of air traffic control equipment, and the development of more efficient air traffic control procedures are targeted at improving NAS performance. ASC is monitoring the following four aspects of NAS performance:

- Delay: the difference between actual travel time and unimpeded travel time
- Flexibility: the extent to which the air traffic control system allows users to optimize their operations based on their own objectives and constraints

8. FAA Aviation Forecasts Fiscal Years 1998-2009.
9. *General Aviation Roadmap*: Investment Strategy Development for NASA Aeronautics Enterprise Strategy, Briefing to the NASA Office of Aeronautics and Space Transportation Technologies Executive Board, June 22-23 1998.

- Predictability: the variation in the air traffic management system as experienced by the user
- Access: the ability of users to access airports, airspace, and services

Figure 1-11 lists FAA capacity goals addressing these four aspects of system performance.

Delay

Delay is the traditional measure of NAS performance. Recent studies suggest that significant aviation capacity enhancements will be required in the next decade to prevent dramatic and unacceptable increases in flight delays.[10]

There were fewer weather-related delays in 1997 than the four previous years, and 16.9 percent fewer than in 1996.

Delay by Cause: Weather, Equipment, and Volume

Approximately 245,000 flights were delayed 15 or more minutes in 1997, a decrease of 9.6 percent from 1996. Sixty-eight percent of the delays were due to weather and 22 percent were due to terminal volume.[11]

There were fewer weather-related delays in 1997 than the four previous years, and 16.9 percent fewer than in 1996. The number of flights delayed due to terminal volume, however, increased nine percent from 1996 to 1997, indicating that airport development and the adoption of streamlined terminal area procedures did not keep pace with increasing traffic.

Figure 1-12 illustrates trends in the distribution of flights delayed 15 minutes or more by primary cause.

10. Free Flight: Preserving Airline Opportunity, Captain Russell G. Chew, American Airlines, September 22, 1997. The Economic Impacts of Air Traffic Congestion, April 1998, Peter F. Kostiuk, Eric Gaier, Doug Lou, Logistics Management Institute, study funded by NASA.
11. The data source is the Air Traffic Operations Management System (ATOMS). ATOMS is a record of aircraft delayed in excess of 15 minutes by cause during any phase of flight. A delay is recorded if an aircraft is delayed during taxi out or in any en route center. Aircraft delayed by less than 15 minutes are not included in ATOMS. Thus, an aircraft could be delayed 14 minutes during taxi out and 14 minutes in each ARTCC it passes through and not be recorded. Taxi-in delays are not counted.

Decrease System Delays

Air Traffic Volume

- Reduce delays due to volume

Equipment

- Reduce delays due to equipment outages
- Accelerate NAS modernization by reducing the time it takes to acquire and field systems
- Put into operation all systems necessary to deliver modernized NAS capabilities as documented in the NAS architecture

Weather

- Develop and demonstrate the capability of new systems to reduce weather-related delays
- Reduce weather-related delays due to restrictive instrument approach procedures

Airports

- Increase system capacity attributable to airport infrastructure at the 50 busiest airports
- Maintain 93 percent of runway pavement in good or fair condition at all NPIAS airports

Increase System Flexibility

Decision Making

- Involve system users more frequently in operational decision making

Routing

- Reduce the amount of extra flight miles associated with ATC-preferred routes
- Increase the percentage of flight segments flown off the ATC-preferred routes

Increase Predictability

Flight Time

- Improve en route and ground movement time predictability

Increase User Access

Airspace

- Improve civilian access to special use airspace (SUA) when not in use by military

Flight Services

- Reduce the average flight service call waiting time

Airports

- Publish a minimum of 500 non-precision Global Positioning System (GPS) approaches per year over the next three years
- Increase access to airports in IFR weather conditions
- Provide for and maintain public-use airports that are accessible to 98 percent of U.S. residents

Figure 1-11. FAA Capacity Goals

Distribution of Flights Delayed Greater than 15 Minutes by Cause*					
Cause	1993	1994	1995	1996	1997
Weather	72% 197.9	75% 184.6	72% 171.5	75% 201.0	68% 167.0
Terminal Volume	22% 59.4	19% 47.5	18% 43.6	18% 49.8	22% 54.3
Center Volume	0% 0.2	0% 0.2	0% 0.1	0% 0.3	0% 0.1
Closed Runways/Taxiways	3% 8.0	2% 5.7	3% 6.7	3% 7.9	3% 8.1
NAS Equipment	2% 4.7	2% 4.0	3% 6.3	2% 5.9	3% 6.4
Other	2% 5.5	2% 5.8	4% 8.5	2% 6.6	4% 9.6
Total Operations Delayed (000s)	**276**	**248**	**237**	**272**	**245**

* Listed in percentages of delay and thousands of operations delayed

Figure 1-12. Delay by Cause

Identification of Delay-Problem Airports

From 1996 to 1997, the proportion of air carrier flights delayed 15 minutes or more decreased at 29 of the 51 airports at which the FAA collects air traffic delay statistics. Figure 1-13 lists the number of operations delayed 15 minutes or more per 1,000 operations from 1992 to 1996 at these 51 airports. Newark International and LaGuardia airports, both in the New York area, have the highest delay rates in the country (58 and 49 delays per 1,000 operations, respectively). Honolulu International and Kahului airports, both in Hawaii, have the lowest delay rates in the country (0.25 and 0.10 delays per 1000 operations, respectively).

Figure 1-14 illustrates trends in operations and delays at ten of the busiest airports in the United States from 1992 to 1997. At Dallas/Fort Worth (DFW), Newark (EWR), and Chicago O'Hare (ORD) a smaller proportion of flights were delayed 15 minutes or more in 1997 than in 1993, while the number of operations increased (see Chapter 4 for a discussion of the contribution of airspace redesign to reducing delays at DFW). Delay rates at EWR, however, remain the highest in the country. The only construction planned at EWR is a runway extension, with an estimated operational date of 2000. An ongoing airport capacity study at EWR is assessing ways of increasing capacity given the current available infrastructure. In addition, the Eastern Triangle portion of the National Airspace Redesign (see Chapter 4) will assess ways of addressing delays in the Northeast, including EWR, by reconfiguring the airspace.

At Atlanta (ATL), Cincinnati (CVG), Los Angeles (LAX), and St. Louis (STL) airports, operations and delays were higher in 1997 than they were in 1993. New runways planned for ATL, CVG, and STL (scheduled to open in 2002, 2004, and 2003, respectively), will increase capacity at those airports. At LAX, a master plan study, which will address capacity and growth issues, is currently underway.

Airport	ID	1993	1994	1995	1996	1997
Newark International Airport	EWR	87.88	74.29	33.81	65.25	57.89
New York LaGuardia Airport	LGA	38.32	47.37	33.65	46.22	49.03
San Francisco International Airport	SFO	23.79	28.46	54.71	56.57	43.02
Hartsfield Atlanta International Airport	ATL	23.28	19.98	24.26	23.88	31.80
Lambert St. Louis International Airport	STL	19.54	22.72	33.87	34.04	30.48
Boston Logan International Airport	BOS	39.23	29.79	22.15	26.37	25.19
Chicago O'Hare International Airport	ORD	47.49	26.83	30.93	34.46	23.52
New York John F. Kennedy International Airport	JFK	35.68	35.79	17.38	29.53	18.32
Los Angeles International Airport	LAX	9.15	10.96	27.03	24.13	17.69
Philadelphia International Airport	PHL	18.75	20.85	6.89	17.95	16.23
Dallas-Fort Worth International Airport	DFW	33.71	37.65	26.80	19.59	14.61
George Bush International Airport	IAH	8.06	5.52	10.79	11.45	12.93
Greater Cincinnati International Airport	CVG	6.38	6.40	4.88	10.38	11.86
Phoenix Sky Harbor International Airport	PHX	2.86	3.48	4.97	7.25	9.15
Detroit Metropolitan Wayne County Airport	DTW	9.05	6.95	10.52	9.10	8.28
Seattle-Tacoma International Airport	SEA	6.78	6.09	4.77	6.37	7.07
Miami International Airport	MIA	10.48	10.47	11.00	6.79	6.84
Minneapolis-St. Paul International Airport	MSP	7.16	3.52	9.23	9.29	6.66
Washington Dulles International Airport	IAD	6.86	8.43	4.54	6.81	5.90
Cleveland Hopkins International Airport	CLE	2.37	1.62	3.74	4.68	5.76
Charlotte/Douglas International Airport	CLT	3.79	4.90	4.75	6.55	5.73
Washington Ronald Regan National Airport	DCA	9.34	10.44	5.61	6.53	4.34
Orlando International Airport	MCO	4.72	5.37	3.61	4.59	4.25
Las Vegas McCarran International Airport	LAS	0.46	0.78	1.62	3.68	4.13
Chicago Midway Airport	MDW	2.98	3.10	4.03	6.70	3.45
Houston William P. Hobby Airport	HOU	3.49	2.96	3.36	2.57	3.27
San Juan Luis Muñoz Marín International Airport	SJU	0.30	0.71	5.29	2.92	3.04
Tampa International Airport	TPA	3.88	3.22	1.62	4.43	3.02
Portland International Airport	PDX	1.94	2.41	1.47	2.41	3.01
Denver International Airport *	DEN	37.92	18.14	4.01	1.90	2.94
Greater Pittsburgh International Airport	PIT	6.86	4.20	2.99	6.60	2.84
Salt Lake City International Airport	SLC	3.86	2.79	3.16	3.53	2.65
San Diego International Lindberg Field	SAN	3.91	2.51	4.41	3.31	2.20
Fort Lauderdale-Hollywood International Airport	FLL	3.77	2.92	3.98	1.53	1.95
Indianapolis International Airport	IND	0.57	0.45	0.40	0.58	1.88
Baltimore-Washington International Airport	BWI	3.94	5.15	2.68	3.67	1.83
Ontario International Airport	ONT	1.24	0.96	1.96	1.06	1.76
Kansas City International Airport	MCI	1.26	1.82	2.22	0.98	1.43
Memphis International Airport	MEM	1.03	0.79	0.86	0.88	1.36
Bradley International Airport	BDL	0.95	1.15	1.29	1.36	1.25
Raleigh-Durham International Airport	RDU	1.99	1.25	0.50	1.59	0.75
San Antonio International Airport	SAT	0.10	0.35	0.87	0.99	0.68
Palm Beach International Airport	PBI	0.81	0.39	0.57	0.46	0.65
New Orleans International Airport	MSY	0.33	0.21	0.60	0.83	0.58
San Jose International Airport	SJC	0.38	0.72	1.03	1.39	0.52
Albuquerque International Airport	ABQ	0.27	0.21	0.09	0.14	0.47
Nashville International Airport	BNA	2.72	1.55	1.46	0.73	0.37
Dayton International Airport	DAY	0.29	0.76	0.24	0.60	0.35
Anchorage International Airport	ANC	0.74	0.29	0.51	0.33	0.32
Honolulu International Airport	HNL	0.19	0.08	0.17	0.19	0.25
Kahului Airport	OGG	0.05	0.03	0.20	0.08	0.10

* 1993 and 1994 data is for Denver Stapleton Airport, which closed in 1995. This accounts for the significant reduction in delay for the 1995 data.

Figure 1-13. Operations Delayed 15 Minutes or More Per 1,000 Operations

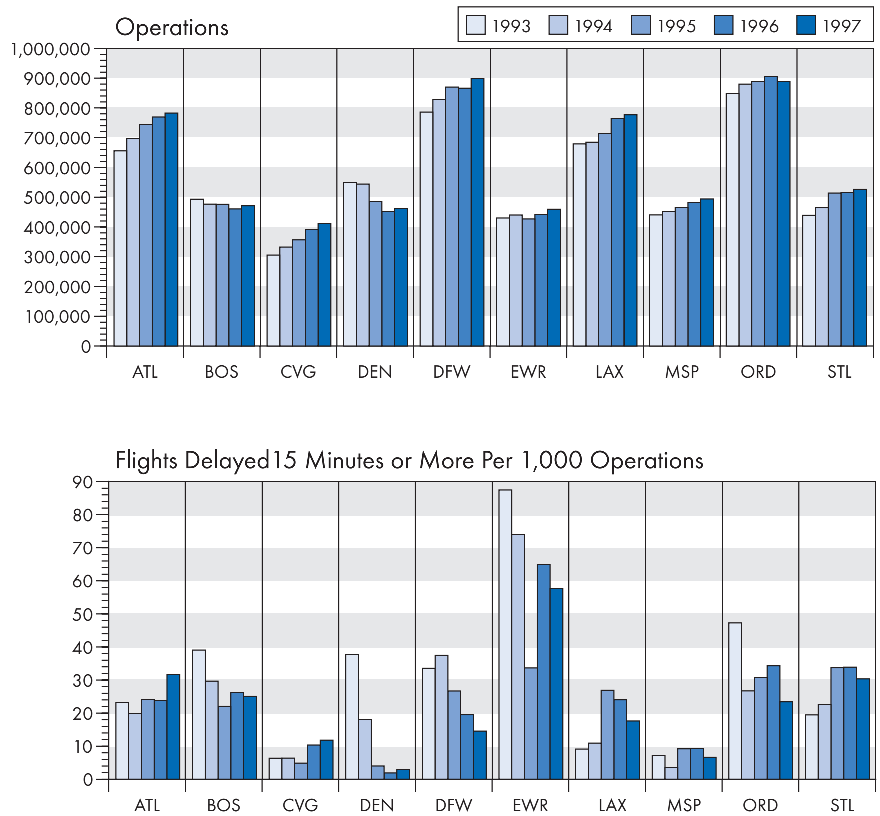

Figure 1-14. Operations and Delays at Ten of the Busiest U.S. Airports

Consolidated Operations and Delay Analysis System (CODAS)

CODAS is a new FAA database and reporting system containing delay information by phase of flight for U.S. domestic flights. CODAS is developed by merging the Airline Service Quality Performance (ASQP) database with the FAA's Enhanced Traffic Management System (ETMS). In addition, CODAS contains flight schedule information from the *Official Airline Guide* (OAG) and weather data from the National Oceanic and Atmospheric Administration (NOAA). CODAS contains actual times for gate out, wheels off, wheels on, and gate in. From this information gate delays, taxi out delays, airborne delays, and taxi in delays as small as one minute are computed.[12] CODAS measures delay where it occurs, not where it is caused. The principal purpose of CODAS is to support analytical studies and not the day-to-day management of the ATC system.

Figure 1-15 ranks the 29 large-hub airports by average minutes of delay by phase of flight and overall based on CODAS data. Newark International Airport (EWR) has the highest average delay, nearly ten minutes per operation, of all the large hub airports in the country.

12. For a complete description of the methodology used to develop CODAS, please visit the web site: www.apo.data.faa.gov and select the Information button.

	TAXI-OUT		AIRBORNE		TAXI-IN		ALL PHASES	
Rank	Airport	Minutes Per Departure	Airport	Minutes Per Arrival	Airport	Minutes Per Arrival	Airport	Minutes Per Operation
1	EWR	11.29	ATL	6.67	DFW	3.66	EWR	9.94
2	LGA	8.59	EWR	6.45	DTW	3.32	ATL	7.64
3	STL	6.94	PHL	5.57	LAX	2.40	LGA	7.63
4	ATL	6.28	LGA	4.69	ORD	2.08	PHL	6.95
5	MSP	6.27	CVG	4.58	JFK	1.98	DFW	6.42
6	DFW	6.16	BOS	4.42	ATL	1.92	DTW	6.20
7	PHL	5.99	CLT	4.29	MIA	1.76	STL	6.05
8	DTW	5.87	PIT	4.15	STL	1.74	MSP	6.00
9	SFO	5.56	SLC	4.10	MSP	1.63	JFK	5.38
10	JFK	5.26	MSP	3.74	EWR	1.59	BOS	5.37
11	ORD	4.96	SEA	3.29	PHL	1.52	CVG	5.20
12	MIA	4.66	JFK	3.00	IAH	1.52	ORD	5.14
13	CVG	4.62	STL	2.98	HNL	1.51	SFO	5.04
14	IAH	4.48	ORD	2.94	LGA	1.43	CLT	4.91
15	BOS	4.24	DTW	2.83	SFO	1.37	SLC	4.90
16	LAX	4.16	MIA	2.80	BOS	1.36	MIA	4.86
17	DCA	4.09	DFW	2.69	DEN	1.34	IAH	4.61
18	SLC	4.05	IAH	2.67	DCA	1.31	LAX	4.61
19	CLT	3.97	SFO	2.55	LAS	1.26	PIT	4.29
20	HNL	3.71	MCO	2.20	PHX	1.10	DCA	4.02
21	PHX	3.64	DCA	2.09	SLC	1.04	DEN	3.71
22	DEN	3.56	TPA	1.98	CLT	1.03	SEA	3.64
23	LAS	3.45	DEN	1.96	SEA	0.84	PHX	3.53
24	PIT	3.31	LAX	1.88	TPA	0.70	LAS	3.25
25	SEA	2.59	BWI	1.61	CVG	0.68	HNL	3.24
26	SAN	2.29	PHX	1.48	PIT	0.68	MCO	2.77
27	MCO	2.18	HNL	1.17	BWI	0.67	TPA	2.68
28	TPA	2.08	SAN	1.00	MCO	0.55	BWI	2.48
29	BWI	1.93	LAS	0.93	SAN	0.50	SAN	2.34

Data Source: Consolidated Operations and Delay Analysis System (CODAS)
Office of Aviation Policy and Plans (APO)

Figure 1-15. Average Delay by Phase of Flight at the 29 Large Hub Airports

Identification of Airports with More than 20,000 Hours of Delay

Despite ongoing capacity improvements and reduced delay system-wide, certain airports continue to account for significant delay. In 1996, 26 airports each exceeded 20,000 hours of annual flight delay. In 1997, with the addition of Memphis International (MEM), the number increased to 27 airports. Assuming airport capacity is not improved, 31 airports are forecast to exceed 20,000 hours of annual aircraft flight delay each by the year 2007. All but three of the large hub airports in the U.S. exceeded 20,000 hours of delay in 1997, and all but one are projected to exceed 20,000 hours of delay by 2007. Figure 1-16 lists airports exceeding 20,000 hours of annual delay in 1997 and in 2007, assuming no capacity improvements.

Annual Aircraft Delay in Excess of 20,000 Hours			
1997		2007	
Atlanta Hartsfield	ATL	Atlanta Hartsfield	ATL
Boston Logan	BOS	Boston Logan	BOS
		Baltimore-Washington	BWI
Charlotte/Douglas	CLT	Charlotte/Douglas	CLT
Cincinnati	CVG	Cincinnati	CVG
		Cleveland	CLE
Washington Reagan National	DCA	Washington Reagan National	DCA
Denver International	DEN	Denver International	DEN
Dallas-Ft. Worth	DFW	Dallas-Ft. Worth	DFW
Detroit	DTW	Detroit	DTW
Newark	EWR	Newark	EWR
Honolulu	HNL	Honolulu	HNL
George Bush Intercont’l	IAH	George Bush Intercont’l	IAH
New York John F. Kennedy	JFK	New York John F. Kennedy	JFK
Las Vegas	LAS	Las Vegas	LAS
Los Angeles	LAX	Los Angeles	LAX
New York La Guardia	LGA	New York La Guardia	LGA
Orlando	MCO	Orlando	MCO
		Chicago Midway	MDW
Memphis	MEM	Memphis	MEM
Miami	MIA	Miami	MIA
Minneapolis-Saint Paul	MSP	Minneapolis-Saint Paul	MSP
Chicago O’Hare	ORD	Chicago O’Hare	ORD
Philadelphia	PHL	Philadelphia	PHL
Phoenix	PHX	Phoenix	PHX
Pittsburgh	PIT	Pittsburgh	PIT
		San Diego	SAN
Seattle-Tacoma	SEA	Seattle-Tacoma	SEA
San Francisco	SFO	San Francisco	SFO
Salt Lake City	SLC	Salt Lake City	SLC
St. Louis	STL	St. Louis	STL

Figure 1-16. Airports Exceeding 20,000 Hours of Annual Delay in 1997 and 2007

Hours of delay is a function of both the number of operations and the average delay per operation. In other words, hours of delay is driven by both the demand on the system and the ability of the system to accommodate the demand. Therefore, if the delay per operation falls (due to expanded airport capacity or more efficient air traffic procedures) but the number of operations increases, an airport may continue to experience more than 20,000 hours of delay.

The Costs of Delay

The cost of delay to air carriers is significant, and growing. For example, with an average aircraft operating cost of about $1,600 per hour of delay, each of the 27 airports that exceeded 20,000 hours of delay in 1997 contributed at least $32 million dollars in annual delay costs. The Air Transport Association (ATA) estimated that the total aviation delay costs to air carriers exceeded 2.4 billion dollars in 1997 (see Figure 1-17).

Year	1993	1994	1995	1996	1997
Aircraft Operating Costs[a]	$1,502	$1,427	$1,380	$1,571	$1,557
Ground Costs[b]	$800	$810	$825	$840	$860
Total Cost	$2,302	$2,237	$2,205	$2,411	$2,417

a. Flight deck crew, fuel, maintenance, equipment charges, cabin crew, etc.
b. Facilities such as gates, holding areas and ramp space, and personnel costs for handling aircraft and passengers.

Figure 1-17. Total Aviation Delay Costs to Air Carriers, 1993-1996 (millions of dollars)[13]

Strategies to Reduce Delay

Adverse weather is the most common cause of delay. Although delays due to weather are difficult to influence, the FAA is developing several automated weather detection and forecasting tools to mitigate the negative effects of adverse weather conditions on aircraft operations. The FAA is also developing location-specific programs to address delays due to terminal area traffic volume, the second most prevalent type of delay. For example, local procedures were developed at Chicago O'Hare (ORD) that resulted in ten-minute savings in average taxi times according to the figures of one airline. Minneapolis Tower and its major carrier have collaboratively developed procedures for schedule changes to relieve congestion at the busiest times, and Detroit's new standard taxi plan and use of converging runways has reduced taxi times. Preliminary 1998 data indicate that these programs are having a positive impact on delays due to volume.[14] Service improvements in traffic management and aviation information and the addition of airport capacity will also reduce delays. Delays created by equipment outages will be reduced as components of the National Airspace System (NAS) infrastructure are replaced.

13. Air Transport Association.
14. Air Traffic Services Performance Report, Second Quarter FY98

Strategies to reduce delays in the 1998-2000 timeframe include the following:

- As part of the National Airspace Redesign, begin targeting airspace redesign to reduce volume-related delays (see Chapter 4)
- Implement new procedures that take advantage of additional runway and airport capacity increases at various locations (see Chapter 5)
- Field infrastructure replacement programs that will reduce equipment-related delay. Display System Replacement (DSR) and the Standard Terminal Automation Replacement System (STARS) will replace an aging display and computing infrastructure that have caused several high-visibility delays (see Chapter 6)
- Continue development of the Center-TRACON Automation System's (CTAS) Passive Final Approach Spacing Tool (pFAST) and single-center Traffic Management Advisor (TMA). TMA and pFAST will aid in evaluating and managing the final approach environment, providing sequencing for departures, and increasing airport acceptance rates (see Chapter 6)
- Implement the Weather and Radar Processor (WARP) and begin testing the Integrated Terminal Weather System (ITWS) (see Chapter 6)

Flexibility

Airlines, GA pilots, and other aviation system users expect more from the air traffic management system than the minimization of delay. They desire the capability to optimize their operations based on their own objectives and constraints, which vary by flight and user. Measuring the flexibility of the air traffic control system allows the FAA to evaluate its ability to permit users to adapt their operations to changing conditions. One measure of flexibility is the proportion of flights that are permitted to operate off ATC-preferred routes.

ATC-preferred routes are important tools that help air traffic controllers organize traffic flows around major airports. They are generally not the most direct routes, so any flight activity off the ATC-preferred route is an indication that the ATC system was flexible enough to grant users their route preferences. Approximately 28 percent of flights cruising above 18,000 feet are subject to ATC-preferred routes. In 1997, approximately 68 percent of the route segments between cities with published ATC-preferred routes were actually flown off of the ATC-preferred routes. This ability to deviate from the ATC-preferred route structure represents a significant portion of the flexibility allowed to users in the air traffic management system.

Measuring the flexibility of the air traffic control system allows the FAA to evaluate its ability to permit users to adapt their operations to changing conditions.

Strategies to Increase System Flexibility

To increase system flexibility, the FAA is evolving air traffic services in the direction of the free flight concept (see Chapter 2). To that end, the FAA will introduce new procedures and ATM infrastructure in the 1998-2000 timeframe that will dramatically change the way services are provided to system users. Examples of these initiatives include the following:

- Continue the National Airspace Redesign to ensure efficient and flexible use of airspace and air traffic facilities for aircraft routing (see Chapter 4)
- Develop and implement enhanced area navigation procedures (see Chapter 5)
- Continue to expand the National Route Program (NRP) by using Departure Procedures/Standard Terminal Arrival Routes (DP/STAR) as ingress/egress points to the NRP (see Chapter 5)
- Evaluate existing ATC-preferred routes and eliminate those that are unnecessary (see Chapter 5)
- Improve flexibility in trans-oceanic flights by implementing Reduced Vertical Separation Minima (RVSM) and Reduced Horizontal Separation Minima (RHSM) (see Chapter 5)
- Continue to evaluate the impacts of relaxing the 250 knot speed limit below 10,000 feet in Class B airspace (see Chapter 5)
- Continue fielding the Initial Conflict Probe (ICP). This system will help to identify potential conflicts with more certainty, thereby avoiding unnecessary aircraft maneuvers and improving user flexibility (see Chapter 6)

Predictability

Predictability is defined by the variation in the ATM system experienced by the user. The majority of system users rely on schedules that determine when aircraft should take off and land. These schedules are central to the operations of almost all commercial flights, driving crew scheduling, ground-service operations, and other operational components. Even the smallest deviation from the planned schedule can cause drastic impacts. One of the most unpredictable portions of a flight is the time the aircraft spends on the ground prior to takeoff. There are many factors that affect ground movement times, including level of demand, weather, and airport runway configuration. The FAA has begun to collect and analyze data on the predictability of ground movement times at 25 of the busiest airports in the U.S.

Strategies to Increase Predictability

A key strategy for increasing user predictability is improving the quality and quantity of information available to system users and involving them in interactive operational decision making. Collaborative decision making between the airline operations centers and the ATCSCC will be enhanced by capabilities to exchange data. These capabilities will provide the most current schedules to traffic planners, resulting in better projections of demand and less disruptive flow management strategies (see Chapter 6). Additionally, the FAA will improve the technologies available for disseminating consistent weather data to controllers and pilots, as weather is a significant contributor to the uncertainty in the ATM system. See Chapter 6 for more detailed information on technological enhancements related to weather and predictability, such as WARP and ITWS.

Collaborative decision making between the airline operations centers and the ATCSCC will be enhanced by capabilities to exchange data.

Access

Access to the ATM system, airports, airspace, and other FAA services is a basic need of all airspace users. The fundamental point of access to the ATM system for most users is the airport. In 1990, 70 percent of the U.S. population lived within 20 miles of a commercial service airport, 79 percent lived within 20 miles of a commercial service or reliever airport, and 98 percent lived within 20 miles of a commercial service, reliever, or GA NPIAS airport (see Figure 1-18).

Airport Categories	Percentage of U.S. Population
Primary and Other Commercial Service	70%
Primary, Other Commercial Service, and Reliever	79%
All NPIAS Airports	98%

Source: NPIAS

Figure 1-18. Percentage of U.S. Population within 20 miles of an Airport

An indicator of GA access to the ATM system is the timeliness and quality of flight services such as pre-flight briefings on weather conditions, flight plan filing, and en route weather updates. While it is possible to count the number of flight services provided, it is difficult to assess the quality of those services, the number of visual flight rules (VFR) users who were denied service, or the number of VFR users who chose not to request services even though they desired them. The FAA is trying to gauge the quality of its flight services through a GA pilot survey. The survey has been administered but the results have not yet been analyzed.

Another critical access issue is the utilization of special use airspace (SUA) by civilian aircraft. The FAA has been working closely with the Department of Defense (DOD) to improve civilian access to SUA when the military is not utilizing the airspace for its critical mission. The FAA has begun operational trials of improved notification procedures and information transfer with respect to selected sections of SUA (see Chapter 5).

The FAA will increase aircraft access to the Nation's airports during IFR weather conditions by accelerating the publication of area navigation (RNAV) approach procedures to provide more accurate course guidance and increase access to airports in adverse weather conditions. The FAA plans to publish a minimum of 500 RNAV approaches a year for the next several years. Before an approach procedure is published, it must first be developed by a flight procedures specialist. Then the procedure must be flight-checked and certified, and transferred to the National Flight Data Center (NFDC) for publication. The NFDC published a total of 352 non-precision RNAV approaches from 1994 through 1996, and 573 approaches in 1997.

Finally, user access will also be enhanced by supplementing GPS navigation through the development of the Wide Area Augmentation System (WAAS) and the Local Area Augmentation System (LAAS) (see Chapter 6).

Chapter 2: Major Capacity Initiatives

The capacity of today's National Airspace System (NAS) is constrained by rules, procedures, and technologies that require pilots and air traffic controllers to conduct operations within narrow, often inefficient guidelines. As air traffic continues to grow, these inefficiencies and their associated costs are compounded. Responding to these limitations, the FAA and the aviation industry are working together on two major, interdependent capacity initiatives — free flight and NAS modernization. A discussion of Safe Flight 21, a demonstration project to test and validate the free flight concept on a limited scale, follows the overview of free flight and NAS Modernization.

Free Flight

Free flight is "a concept for safe and efficient flight operating capability under instrument flight rules (IFR) in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are imposed only to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through special use airspace (SUA), and to ensure the safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a move towards free flight."[1] The transition to free flight requires changes in air traffic philosophies, procedures, and technologies.

The principal philosophical change required for free flight is a shift from the concept of air traffic control (ATC) to air traffic management (ATM). ATM differs from ATC in several ways: the increased extent of collaboration between users and air traffic managers, greater flexibility for users to make decisions to meet their unique operational goals, and the replacement of broad restrictions with user-determined limits and targeted restrictions only when required.

The procedural changes required for free flight correspond directly to the change in philosophy from ATC to ATM. Under the current air traffic system, aircraft are frequently restricted to ATC-preferred routes, which may not be the routes preferred by the pilot or airline. Air traffic controllers direct pilots to change their direction, speed, or altitude to avoid adverse weather or traffic congestion. In contrast, free flight will grant pilots substantial discretion in determining their routes. Many decisions will be collaborative, taking advantage of the best information available to the pilot and air traffic manager to ensure safe, efficient flights.

RTCA Task Force 3, a joint government/industry workgroup on free flight, identified 46 procedural and technological recommendations for moving towards free flight. Several free flight procedural initiatives that are currently being tested or implemented are described in Chapter 5. Six free flight-enabling technologies will be implemented at select locations by the end of 2002 under a NAS modernization program

1. Final Report of RTCA Task Force 3, Free Flight Implementation, October 26, 1995.

referred to as Free Flight Phase 1 (FFP1). FFP1 and other technological changes required for free flight are described below under NAS Modernization, and more extensively in Chapter 6.

NAS Modernization

Modernization of the NAS will give users new abilities such as flexible departure and arrival routes and increased usage of preferred flight trajectories.

To achieve the free flight concept and accommodate projected increases in air traffic, the FAA is modernizing and replacing much of the equipment, computers, and software used to manage air traffic and assure safe operations. Modernization of the NAS will give users new abilities such as flexible departure and arrival routes and increased usage of preferred flight trajectories. Ultimately, NAS modernization will increase the flexibility and efficiency of the NAS, improve traffic flow and weather predictability, and reduce user operating costs. The schedule and interdependencies of the many technological advances required for NAS modernization and free flight are outlined in the NAS Architecture. The FAA must balance the need to sustain and replace critical ATC infrastructure with the desire to provide new capabilities to NAS users. The NAS Architecture provides an integrated approach to modernization that matches expected FAA funding levels.

The principle NAS modernization changes affecting capacity are categorized into five functional areas: communications, navigation, surveillance, weather, and air traffic management. The transition between the current and future NAS and the new capabilities created by this change are described below.

Communications

In the future, communication between aircraft and ground facilities will require less radio voice communication and greater use of electronic data transmitted to and from the flight deck via digital data link technology. Changes in the communication system will create the following capabilities:

- Integration of voice and data communications
- More efficient use of the frequency spectrum
- Improved quality and clarity of ATC messages to aircraft
- Better flight and traffic information services, such as weather graphics and proximity traffic data
- Seamless communications across all operational domains (airport, terminal, en route, and oceanic)
- Information sharing with all NAS users
- An effective interchange network to support dynamic airspace usage

Navigation

Navigation will become increasingly reliant on the satellite-based Global Positioning System (GPS). Existing ground-based stations will be decommissioned as new ground-based systems designed to augment the accuracy of GPS are deployed. An augmented GPS system will create the following capabilities:

- Increased prevalence of user-preferred routing
- Increased access to airports under Instrument Meteorological Conditions (IMC) through more precision approaches
- Reduced separation standards
- Decommissioning of some costly ground-based navigation and landing systems

Surveillance

In the future, replacing verbal aircraft position reports with an onboard system known as Automated Dependent Surveillance (ADS) will enhance surveillance coverage and accuracy. ADS transmits position information that will be combined with radar images to ensure the system's accuracy. Analog radar will be replaced by digital radar. The implementation of ADS and digital radar will create the following capabilities:

- Continuous surveillance of all positively controlled aircraft
- More precise monitoring of aircraft separation and flight progression in oceanic airspace
- Enhanced airport surface surveillance

Weather

Today's fragmented weather gathering, analysis, and distributions systems will be enhanced by a more harmonized, integrated system. Incremental improvements in weather detection sensors, processors, dissemination systems, and displays will also occur. Improved weather technologies will allow the following advancements:

- Common situational awareness among service providers and users through the use of integrated weather products
- NAS-wide availability of distributed weather forecast data
- Improved accuracy, display and timeliness of weather information to service providers and users
- Better separation of aircraft from convective weather
- Integrated weather information into associated air traffic automation systems

Air Traffic Decision Support

Managing air traffic and airspace utilization will be increasingly augmented with computer-based decision support systems. These systems will improve the efficiency and effectiveness of NAS-wide information, enhancing all phases of surface and flight operations. The use of advanced automation and decision support systems will enable the following capabilities:

- Greater collaboration on problem resolution through dynamic airspace management
- More efficient use of airports through improved sequencing and spacing of arrival traffic and assigning aircraft to runways
- Improved acquisition and distribution of flight-specific data
- More information from static and dynamic data (e.g., route structures, NAS infrastructure status, special use airspace restrictions, aircraft position and trajectories)
- Improved accommodation of user preferences through improved traffic flow management, conflict detection and resolution, sequencing, and optimal trajectories
- More flexible airspace structure by reducing boundary restrictions and creating dynamic sectors

Free Flight Phase 1 (FFP1)

To reach consensus among the many parties affected by NAS modernization, in January 1998 the FAA Administrator established the NAS Modernization Task Force consisting of representatives from industry groups, airlines, unions, and the Federal Government. The Task Force modified the NAS Architecture with the goal of expediting the evolutionary deployment of new operational capabilities in time to meet growing needs of the aviation community. The FFP1 initiative, set to begin in 1998 and to end in 2002, is a result of Task Force recommendations directed at mitigating short-term risks associated with modernization efforts. This initiative focuses on implementing six low-risk NAS technologies at select sites. The primary objective of FFP1 is to demonstrate and measure the immediate benefits of NAS modernization to users. Results of FFP1 will be important in expediting and validating further NAS modernization planning and funding activities. The capabilities and the impacts of the six technologies to be demonstrated during FFP1 are described briefly in Figure 2-1.

The FFP1 initiative, set to begin in 1998 and to end in 2002, is a result of Task Force recommendations directed at mitigating short-term risks associated with modernization efforts.

FFP1 technologies and other capacity-enhancing technologies associated with NAS modernization are described in greater detail in Chapter 6.

Program/System	Capability	Capacity/Efficiency Benefits	Environment
Collaborative Decision Making (CDM) and NAS Information	• NAS Status Information • Enhanced Graphical Plan Display • Collaborative Routing	• Better planning by all NAS participants • User control of departure times • Collaboratively planned solutions when excess demand in system	Pre-Flight Planning En Route
Traffic Management Advisor (TMA)	• Miles-in-Trail • Meter-Fix List Schedules	• Load ballancing between feeder fixes • Optimize runway usage	En Route Terminal
Passive Final Approach Spacing Tool (pFAST)	• Runway Assignment • Arrival Sequencing	• Efficient use of runway capacity • Improved safety through better situational awareness	Terminal
Intital Conflict Probe (ICP)	• Aircraft-to-Airctaft Conflict Probe • Aircraft-to-Airspace Conflict Probe	• Controller decision aid • Reduce altitide and speed restrictions	En Route
Surface Movement Advisor (SMA)	• Aircraft Surveillance Information	• Optimize ground and ramp resources	Terminal
Controller to Pilot Data Link Communication (CPDLC)	• Initial Contact • Altimeter Setting Message • Pre-Defined Controller Messages	• Reduce communication errors • Reduce frequency congestion • Improved communications efficiency	En Route

Figure 2-1. Free Flight Phase 1 Capabilities Summary

Operational Enhancement	Capacity/Efficiency Benefits	Environment
Use of FIS to receive current and forecasted weather information and SUA status	• Increased availability of flight services • Increased timeliness and quality of weather information • Increased access to airspace • Reduced flight times and distance	En Route
Use of ADS-B and CDTI to improve approaches in low visibility conditions	• Increased access to airports • Increased arrival rates • Reduced arrival and departure delays • Increased predictability of arrival times • Increased flexibility of arrival scheduling	Terminal
Provide traffic information electronically to the cockpit to improve pilot situational awareness	• Increased pilot access to traffic information for situational awareness	Terminal
Use of CDTI and ADS-B to allow delegation of separation authority to the cockpit	• Increased access to airspace • Reduced flight delays and distances flowwn • Increased predictability of flight times and distances flown • Increased flexibility in routes flown	En Route
Use of a moving map and augmented GPS to improve the efficiency of surface operations	• Reduced taxi delays • Increased predictability of taxi times	Terminal
Use of ADS-B to improve surveillance capabilities in non-radar airspace	• Increased access to airspace • Increased arrival and departure rates • Reduced flight delays and distances flown • Increased predictability of flight times and distances flown • Reduced deviations from the intended route • Increased flexibility in the routes flown	Terminal/ En Route
Integration of ADS-B and radar data and conflict alert to determine if separation standards can be reduced.	• Increased flexibility in routing into terminal airspace • Increased access to airspace	Terminal

Figure 2-2. Expected Capacity/Efficiency Benefits of Safe Flight 21 Operational Enhancements

Safe Flight 21

Safe Flight 21 is a five-year government/industry initiative to demonstrate and validate, in a real-world environment, the capabilities of advanced communication, navigation, surveillance (CNS) and air traffic procedures associated with free flight. Safe Flight 21 is the new name for the restructured Flight 2000 program. The changes to Flight 2000 resulted from input provided by RTCA at the request of the FAA Administrator.

The objective of Safe Flight 21 is to show that integrated CNS technological capabilities provide sufficient operational benefits to justify the costs of implementation. Safe Flight 21 will also accelerate implementation of technologies and approval of procedures required to achieve free flight efficiencies, while minimizing the long-term risk and cost of transition to the remainder of the NAS.

The objective of Safe Flight 21 is to show that integrated CNS technological capabilities provide sufficient operational benefits to justify the costs of implementation.

The FAA and participants from the user community will work together to address the risks and challenges of fielding advanced CNS systems such as ADS-B, cockpit display of traffic information (CDTI), and Flight Information Services (FIS). FAA policies and decisions regarding future utilization of these technologies and associated procedures will be based upon the ongoing results of this program.

Operational Enhancements Affecting System Capacity and Efficiency

Most of the operational enhancements to be demonstrated by Safe Flight 21 will result in system capacity and efficiency benefits as well as safety benefits. Figure 2-2 lists seven operational enhancements to be demonstrated by Safe Flight 21, their expected capacity benefits, and the operating environment where the benefits will be realized.

Program Execution

The operational enhancements to be demonstrated by Safe Flight 21 will evolve incrementally. In 1999, Safe Flight 21 will build on a Cargo Airline Association (CAA) evaluation of ADS-B to address ADS-B technology issues, cockpit human factors issues, and CDTI procedures. Work will also begin in Alaska to develop initial procedures, test avionics, and deploy ground systems supporting the technologies to be tested. In 2000, testing will continue with increased equipage of CAA and Alaska participants. Demonstration and validation of the operational enhancements will continue from 2001 through 2003, prior to transition to the rest of the NAS.

CHAPTER 3: AIRPORT DEVELOPMENT

Airports are visible symbols of the economic well-being of the United States. To meet the capacity demands generated by a prosperous economy, it is essential to expand the Nation's airport infrastructure. Discussed in this chapter are the airport improvements and expansions required to meet increasing aviation capacity demands.

Financing of Airport Capital Development

Airport capital development is funded by a combination of public and private sources: airport revenue from airline terminal leases, landing fees, concessions, and other fees; tax-exempt bonds; airport improvement program (AIP) grants; passenger facility charges (PFCs), and state and local grants. In 1996, the 3,345 National Plan of Integrated Airport Systems (NPIAS) airports obtained approximately $7 billion for capital development. Fifty-eight percent of this funding came from tax-exempt bonds, 20 percent from AIP grants, and 16 percent from PFCs (see Figure 3-1).[1]

Airport Improvement Program (AIP) Grants

AIP grants are administered by the FAA. They are intended primarily to: promote safety and security; stimulate capacity-enhancement projects such as the construction of runways, taxiways, and aprons; help finance small and general aviation airports; and pay a significant part of noise and environmental mitigation cost. Terminal development projects, such as expanding commercial space and parking garages are typically not eligible for AIP grants. AIP grants also cannot be used to pay interest on debt.

From 1985 to 1993, AIP grants financed 14 percent of all capital spending at large commercial airports, 28 percent at medium-sized commercial airports, and 41 percent at small airports (small commercial airports as well as reliever and GA facilities).[2] In 1997, the FAA funded 1,066 AIP grants for a total of $1.47 billion dollars. Primary airports received 73.3 percent of the AIP funds (see Figure 3-2).[3]

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1. Airport Financing: Comparing Funding Sources with Planned Development. GAO/T-RCED-98-129.
2. The Securities Data Company, Database of Municipal Bond Issues, 1995; FAA, AIP Program, Twelfth Annual Report, FY93.
3. www.faa.gov/arphome.htm. FY97 Airport Improvement Program: Number of Grants Awarded.

Funding Source	1996 Amount (in billions)
Tax-Exempt Bonds	$4.1
Airport Improvement Program Grants (AIP)	$1.4
Passenger Facility Charges (PFC)	$1.1
State and Local Contributions	$0.28
Airport Revenue	$0.15
Total	**$7.03**

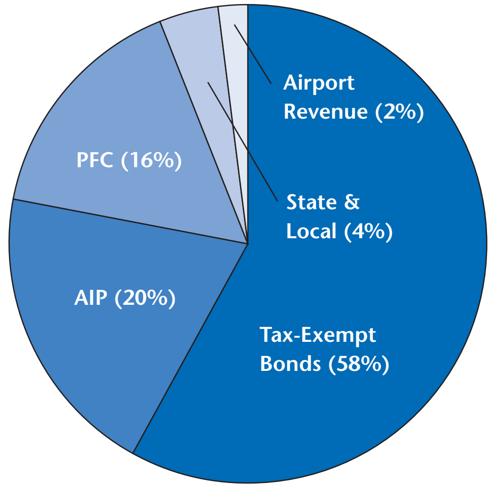


Figure 3-1. Sources of Airport Funding

Airport Type	Number of Grants	Grant Amount	Percent of Grants
Primary	561	$1,083.0 M	73.3%
Other Commercial	66	$71.0 M	4.8%
Reliever	124	$101.0 M	6.8%
General Aviation	251	$140.0 M	9.5%
Other (State block grants and system plans)	64	$82.0 M	5.5%
Total	1,066	$1,477.0 M	100%

Figure 3-2. Distribution of AIP Grants by Airport Type, 1997

Passenger Facility Charges (PFC)

Public agencies controlling commercial service airports, after receiving approval from the FAA, can charge enplaning passengers a $1, $2, or $3 PFC. PFC revenues are used primarily for terminal and airport access projects and paying the interest on debt; they are also used for developing airport runway, taxiway and apron infrastructure. The PFC program currently generates approximately $1.2 billion annually from approximately 130 airports. As of January 1998, 75 percent of large-, medium-, and small-hub airports imposed a PFC, while only 45 percent of non-hub and fewer than ten percent of other commercial service airports imposed a PFC.[4]

4. Airport Financing: Funding Sources for Airport Development, March 1998, GAO/RECD-98-71, pg 20.

Capacity Enhancements Funded by FAA Facilities and Equipment (F&E) and Research Engineering and Development (RE&D) Funds

Full realization of the capacity benefits of new and extended runways and other airport improvements frequently requires the installation of an air traffic control tower and equipment such as Instrument Landing Systems (ILS), Runway Visual Ranges (RVR), VHF Omnidirectional Ranges (VOR), approach lighting, and Precision Runway Monitors (PRM). FAA F&E and RE&D funds are used to finance the development, installation, and maintenance of these and other air traffic management facilities and systems on the airport grounds. Due to funding limitations, installation of equipment must be staggered to give priority to the needs of the most capacity-constrained airports.

Operational improvements to expand airport capacity, such as improved Instrument Flight Rules (IFR) approach procedures and reduced separation standards for arrivals, are primarily funded by the FAA's R,E&D budget. See Chapter 5 for information on several operational improvements under development.

Airport Construction and Expansion

Airport development frequently entails the construction of new terminals, new and extended runways, and improved taxiway systems. In large metropolitan areas with frequent flight delays and limited airport expansion possibilities, 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 of the additional options available for meeting expanding aviation needs.

Construction of New Airports

The largest NAS capacity gains result from the construction of new airports. However, given the high cost of airport construction (e.g., more than $4 billion for the new Denver International Airport, which opened in 1995), building a new airport is not a common capacity-enhancement technique.

Currently, the only significant new airport development is the conversion of Bergstrom Air Force Base in Austin, Texas into a civilian airport to replace Robert Mueller Airport, which can no longer meet growing demand (also see Conversion of Military Airfields, below). The new airport is called Austin-Bergstrom International Airport. Its terminal and air cargo facilities are three times as large as those at Robert Mueller Airport, and it has two runways spaced one mile apart which will allow independent parallel approaches in IFR conditions. The 12,250 foot east runway, which includes the existing main runway from the Air Force Base, has been in use by cargo operations since June 1997. The new 9,000 foot west runway was recently completed. The

Currently, the only significant new airport development is the conversion of Bergstrom Air Force Base in Austin, Texas into a civilian airport to replace Robert Mueller Airport, which can no longer meet growing demand.

airport will be opened for passenger and GA operations on May 1, 1999. The total estimated project cost is currently $585 million. Robert Mueller Airport will close upon completion of the new airport.

Conversion of Military Airfields to Civilian Airport Facilities

To date, 19 military airfields have been converted to civil use airports under the DOD Base Realignment and Closure program (BRAC). This has resulted in the addition of 27 runways of lengths ranging from 8,000 feet to 12,000 feet to the national civil airport system. Eleven BRAC airports have participated in the Military Airport Program (MAP). The MAP, funded by an AIP set-aside, provides grants to current or former military airports with the potential to improve the capacity of the NAS. Airports remain eligible to participate in the MAP for five fiscal years following their initial designation as participants. There were twelve MAP participants in 1997, six reliever airports, five primary commercial service airports, and one other commercial service airport. Figure 3-3 lists current MAP participants. Several MAP projects are described below:

- As described previously, in Austin, Texas Bergstrom Air Force Base is being converted to a civilian airport to replace Robert Mueller Airport.
- The former Williams Air Force Base has been converted to a civil use reliever airport for Phoenix Sky Harbor International Airport. The airport was renamed Williams Gateway Airport. It will serve most categories of civil aircraft with its three runways ranging from 9,300 to 10,400 feet long. The additional airport will add capacity for over 290,000 potential annual aircraft operations to the Phoenix airport system.
- The former Memphis Naval Air Station has been converted to a civil use reliever airport for Memphis International Airport. The airport was renamed Millington Municipal Airport. It will serve most categories of aircraft with its runway of 8,000 feet. The airport has a potential capacity of 205,000 annual operations.

Other MAP participants include: San Bernardino International Airport, California (a reliever for Los Angeles and Ontario), and Dade County-Homestead Regional, Florida (a reliever for Miami Airport).

Thirty-six additional military airfields are potential candidates for conversion to civil airports. If most of these conversions are accomplished, 60,000 acres of airport property will be added to the National airport system, including over 50 runways, and 7 million potential aircraft operations, of which about 2 million would be in congested metropolitan areas.

Civilian Name	Military Name	Location	Airport Type	Remarks
Myrtle Beach International	Myrtle Beach AFB	Myrtle Beach, SC	Primary	1991 BRAC Closure
Laredo International Airport	Laredo AFB	Laredo, TX	Primary	Former Military Airfield
Smyrna Airport	Smyrna AFB	Smyrna, TN	Reliever	Former Military Airfield
Pease International Airport	Pease AFB	Portsmouth, NH	Primary	1988 BRAC Closure
San Bernardino	Norton AFB	San Bernardino, CA	Reliever	1988 BRAC Closure
Austin-Bergstrom	Bergstrom AFB	Austin, TX	Primary	1991 BRAC Replaces Mueller Field
Homestead Regional	Homestead AFB	Homestead, FL	Reliever	1993 BRAC Closure
Millington Municipal	Memphis NAS	Memphis, TN	Reliever	1993 BRAC Closure
Williams Gateway	Williams AFB	Williams, AZ	Reliever	1991 BRAC Closure
Alexandria International Airport	England AFB	Alexandria, LA	Primary	1991 BRAC Replaces Esler
Rickenbacker International Airport	Rickenbacker AFB	Columbus, OH	Reliever	1991 BRAC Closure
Sawyer Airport	K.I. Sawyer AFB	Gwinn, MI	Commercial Service	1993 BRAC Replaces Marquette Co.

Figure 3-3. 1997 Participants In The Military Airport Program

Construction of New Runways and Runway Extensions

Of the top 100 airports (based on 1997 passenger enplanements), 18 completed runway construction projects from 1995 to 1998. Eight additional airports are presently constructing new runways or runway extensions, and 59 airports have proposed or planned new runways or runway extensions.

The construction of new runways and extension of existing runways is the most direct and significant action to improve capacity at existing airports. Large capacity increases, under both visual flight rules (VFR) and instrument flight rules (IFR), result from the addition of new runways that are properly placed to allow additional independent arrival/departure streams. For example, in October 1996, a new $300 million north/south runway 17L/35R opened at Dallas/Fort Worth International Airport (DFW). The additional runway increased the total number of available runways to seven, and allowed the airport to accommodate four simultaneous precision instrument approaches. The new runway also gave the airport nearly equal capacity during IFR and VFR operations, thereby reducing delays during low-visibility weather at DFW, as well as throughout the NAS.

The construction of new runways and extension of existing runways is the most direct and significant action to improve capacity at existing airports.

Figure 3-4 lists new runways and runway extensions that were completed from 1995 to1998. Figure 3-5 lists runways that are planned, proposed, or currently under construction at the top 100 airports.

Airport	Runway	Operational Date
Anchorage (ANC)	Runway 32 extension	1996
Bergstrom (new Austin) (BSM)	17L/35R renovation	1997
Boise (BOI)	10L/28R extension	1997
Chicago Midway (MDW)	4R/22L reconstruction	1997
Cincinnati (CVG)	18R/36L extension	1995
Dallas-Ft. Worth (DFW)	17L/35R new parallel	1996
Grand Rapids (GRR)	18/36 extension	1997
Indianapolis (IND)	5L/23R parallel	1997
Las Vegas (LAS)	1L/19R reconstruction	1997
Louisville (SDF)	17R/35L Parallel	1997
Memphis (MEM)	18L/36R new parallel	1998
Milwaukee (MKE)	7L/25R realignment	1996
Minneapolis-St. Paul (MSP)	4/22 extension	1996
Omaha Eppley Field (OMA)	14R/32L extension	1996
Palm Springs Regional (PSP)	31L/13R extension	1998
Port Columbus (CMH)	10L extension	1997
	28R extension	1996
Portland (PDX)	28L extension	1998
Richmond (RIC)	16/34 extension	1997

Figure 3-4. Runways and Runway Extensions Completed from 1995 to 1998 at the Top 100 Airports

Of the 27 airports exceeding 20,000 hours of air carrier flight delay in 1997 (see Figure 1-16), 17 are planning or constructing new runways or runway extensions. Of the 31 airports forecasted to exceed 20,000 hours of annual air carrier delay in 2007, 19 are planning or constructing new runways or runway extensions.

Airport Development Implications of Next-Generation Aircraft

As new types and sizes of aircraft are produced, ASC is evaluating their operational impacts on the U.S. airports system.

Airport Enhancements for New Large Airplanes (NLA)

New Large Airplanes (NLA) — also referred to as very large civil transport and very large aircraft — offer the potential of meeting the expected increase in passenger volume in the foreseeable future with a minimal increase in aircraft operations. NLA seating capacities are expected to be in the 600-800 passenger range and will provide added cargo capacity. In response to announced plans to build NLA by the year 2004, the FAA has formed an NLA Facilitation Group, which will draw on internal and external expertise in airports, air traffic control, aircraft rescue and fire fighting, manufacturing, operations, security, and other relevant areas. This group will address the criteria and conditions under which NLA will operate in the United States, including required infrastructure alterations.

To make use of existing airport runways, taxiways, ramp, and parking areas with minimal modifications, the maximum fuselage length and wingspan of the NLA must be limited to 80 meters, a figure already exceeded by some NLA proposals. Other issues include aircraft turning radius, the effects of the landing gear on pavement, and the effects of engine thrust on other operations and the airport environment.

The operation of NLA may affect departure and landing separation, as well as ground handling procedures. Such issues as wake vortices and obstacle clearance must be reviewed and special handling procedures may need to be developed. These could include mandatory taxi routes, remote holding or remote gates during infrequent CAT II/III operations, and special accommodations for terminal use.

Derivative aircraft, such as the B777-300, which in May 1998 became the longest commercial airplane ever certified, indicate the need for near-term attention to these issues. At 242.3 feet, the fuselage length of the B777-300 exceeds that of the B747-400 by more than ten feet. It began passenger service in mid-1998.

The Impacts of Next-Generation GA Aircraft on Airport Utilization

NASA, in conjunction with the FAA, is investing in the development of an advanced small aircraft transportation system (SATS). This new generation of GA aircraft will be faster, quieter, and more affordable then the GA aircraft currently in operation. As envisioned by NASA, the new aircraft will use digital datalink radios to bring real-time graphical weather and traffic information into the cockpit for display on satellite navigation moving maps. Coupled with wide availability of GPS-based instrument approaches that provide access for landings in all but the most severe weather conditions, and the use of Automated Dependent Surveillance — Broadcast (ADS-B) systems for air traffic separation and sequencing, these new aircraft will allow more people to fly directly to their destinations.

This new generation of GA aircraft will be faster, quieter, and more affordable then the GA aircraft currently in operation.

Currently, approximately 22 percent of the public use airports in the U.S. are equipped for precision instrument approaches. When precision approaches are possible at most public-use airports due to the availability of differential GPS, the new GA aircraft will increase access to suburban and rural communities that are currently not well served by hub-and-spoke facilities. Direct flights from any airport to suburbs and rural areas without passing through a hub airport will be commonplace, thus freeing up capacity at larger, capacity-constrained airports. In this way, the proposed SATS is projected to increase capacity at small, underutilized airports, and relieve congestion at overutilized airports, thus helping to reduce delays.

Airport	Runway	Est Cost ($M)	Operational Date	Under Construction
Albany (ALB)	10/28 extension	5.8	2000	
	1R/19L parallel	7.5	2010	
Albuquerque (ABQ)	12/30 extension	14.0	2000	
Atlanta (ATL)	5th E/W parallel	440.0	2002	
Austin Bergstrom (BSM)	17L/35R parallel	46.0	1999	X
Baltimore (BWI)	10R/28L parallel	TBD	2003	
Birmingham (BHM)	5/23 extension	27.0	TBD	
Boise(BOI)	10R/28L third parallel	TBD	2015+	
Boston (BOS)	14/32	20.0	TBD	
Charlotte (CLT)	18W/36W third parallel	140.0	2001	
	18R/36L extension	20.0	2006	
Cincinnati (CVG)	18R/36L third parallel	233.0	2004	
	9/27 extension	12.0	2003	
Cleveland-Hopkins (CLE)	5L/23R replacement	180.0	2000	
	5R/23L extension	40.0	2005	
Dallas-Fort Worth (DFW)	18L/36R extension	25.0	2000	
	18R/36L extension	25.0	2001	
	18R/36L parallel	268.0	2003	
	17C/35C extension	15.0	2000	
Denver Intl (DEN)	16R/34L parallel	103.0	2002	
Des Moines (DSM)	5/23 extension	31.0	2001	X
Detroit (DTW)	4/22 parallel	116.5	2001	
El Paso (ELP)	22 extension	8.0	2000	
Fort Lauderdale (FLL)	9R/27L extension	300.0	2005	
Fort Myers (RSW)	6R/24L parallel	80.0	2004	
Greensboro (GSO)	5L/23R parallel	150.0	2003	
	14/32 extension	27.0	2002	
Greer (GSP)	3R/21L parallel	65.0	2010	
	3L/21R extension	34.1	1999	
George Bush Intl (IAH)	14R/32L extension	8.0	2000	
	8L/26R parallel	95.0	2002	
	9R/27L parallel	TBD	TBD	
Guam (GUM)	6L/24R extension	30.0	2004	
	6R/24L extension	30.0	2010	
Hilo (ITO)	8/26 east extension	25.0	2010	
Indianapolis (IND)	5R/23L parallel	80.0	2008	
Jacksonville (JAX)	7R/25L parallel	50.0	2011	
John Wayne (SNA)	1L/19R extension	TBD	TBD	
Kahului (OGG)	2/20 extension	47.0	2001	
Kansas City (MCI)	1L/19R extension	12.0	TBD	
Lihue (LIH)	17/35 extension	30.0	2003	
Lambert-St.Louis (STL)	12R/30L parallel	850.0	2003	
	12R/30L extension	50.0	TBD	
Little Rock (LIT)	4L/22R extension	31.0	1998	X
Lubbock (LBB)	8/26 extension	5.0	2005	
Memphis (MEM)	18C/36C extension & reconst	103.0	2000	
Miami (MIA)	8/26 parallel	180.0	2002	
Milwaukee (MKE)	7R/25L parallel	160.0	TBD	
	7L/25R extension	1.9	1999	X

Figure 3-5. Runways and Runway Extensions Planned, Proposed, or Currently Under Construction at the Top 100 Airports.

Airport	Runway	Est Cost ($M)	Operational Date	Under Construction
Minneapolis (MSP)	17/35 air carrier	175.0	2003	
	4/22 extension	10.0	2000	
Nashville (BNA)	2E/20E parallel	TBD	TBD	
	2R/20L extension	TBD	TBD	
New Orleans (MSY)	18/36 near parallel	400.0	2010	
Newark (EWR)	4L/22R extension	55.0	2000	X
Norfolk (ORF)	5R/23L parallel	75.0	2005	
Oklahoma City (OKC)	17R/35L extension	8.0	2014	
	17L/35R extension	8.0	2014	
	17R/35L parallel	13.0	2012	
	13/31 extension	5.0	2005	
Omaha Eppley (OMA)	14L/32R extension	TBD	TBD	
Orlando (MCO)	17L/35R 4th parallel	137.0	2002	
	17R/35L extension	TBD	TBD	
Palm Beach (PBI)	9L/27R extension	12.9	2000	
Philadelphia (PHL)	8/26 parallel-commuter	220.0	1999	X
	9L/27R relocation	TBD	TBD	
Phoenix (PHX)	7/25 3rd parallel	180.4	1999	X
	8L/26R extension	7.0	2000	
Pittsburgh (PIT)	4th parallel 10/28	150.0	TBD	
	5th parallel 10/28	TBD	TBD	
Port Columbus (CMH)	10S/28S parallel	100.0	2020	
Raleigh-Durham (RDU)	5R/23L extension	TBD	2005	
	3rd parallel	TBD	TBD	
Richmond (RIC)	16/34 extension	45.0	2001+	
Rochester (ROC)	4R/22L parallel	10.0	2010	
	4/22 extension	4.0	2000+	
	10/28 extension	3.2	2000+	
Sacramento (SMF)	34L/16R north extension	TBD	TBD	
	34R/16L north extension	TBD	TBD	
San Antonio (SAT)	12L/30R reconstruction	20.0	2010	
	12N/30N parallel	400.0	TBD	
San Jose (SJC)	12L/30R extension	54.3	2000	
Sarasota-Bradenton (SRQ)	14L/32R parallel	10.0	2002+	
	14/32 extension	5.1	2002+	
Savannah (SAV)	9L/27R parallel	20.0	2020	
Seattle-Tacoma (SEA)	16W/34W parallel	585.0	2004	X
Spokane (GEG)	3L/21R	11.0	TDB	
Syracuse (SYR)	10L/28R parallel	55.0	TBD	
	10R/28L extension	TBD	TBD	
Tampa (TPA)	17/35 3rd parallel	TBD	TBD	
	9/27 extension	TBD	2010+	
	18L/36R extension	TBD	2005+	
Tucson (TUS)	11R/29L parallel	30.0	2005	
Tulsa (TUL)	18L/36R parallel	115.0	2010	
Washington Dulles (IAD)	1W/19W parallel	TBD	2009	
	12R/30L parallel	TBD	2010	
Wichita (ICT)	1R/19L extension	TBD	TBD	
Total of Available estimated costs:		$7,114.7M		

TBD = no data available at press time

Figure 3-5. Runways and Runway Extensions Planned, Proposed, or Currently Under Construction at the Top 100 Airports.

Potential Capacity Benefits of Civil Tiltrotor (CTR) Aircraft to Airport Capacity

> These aircraft have tremendous potential to contribute to capacity by operating from vertiports in urban areas, freeing up slots at congested airports.

The FAA is conducting a multi-year program to identify the ATM and operational procedures that will permit the safe operation of civil tiltrotor (CTR) aircraft and advanced helicopters in the modernized NAS. Major aircraft manufacturers are planning to build large passenger CTRs that will be flying by the second decade of the 21st century. These aircraft have tremendous potential to contribute to capacity by operating from vertiports in urban areas, freeing up slots at congested airports that are now taken by short-haul airplanes carrying forty passengers or fewer. In addition, the development of CTR terminal operational procedures will ensure that these aircraft will be able to operate in busy terminal areas with no impact on existing traffic.

Airport Capacity Studies

As environmental, financial, and other constraints continue to restrict the development of new airports in the United States, increased emphasis has been placed on the redevelopment and expansion of existing airport facilities. The FAA's Office of System Capacity (ASC) forms Airport Capacity Design, Tactical Initiative, and Regional Design Teams to focus on maximizing the capacity at existing airports through improvements in runways and taxiways, navigational and guidance aids, and operational procedures. In addition to forming these teams, ASC participates as a team member on additional airport development projects and works with regional and local Air Traffic offices and facilities to assist in the development of initiatives to improve operational efficiencies. Figure 3-6 lists the completed airport capacity, tactical initiative, and regional studies and the year in which they were published.

Airport Capacity Design Teams

Airport Capacity Design Teams address capacity problems at airports with significant flight delays. The teams are composed of: FAA representatives from ASC, the Technical Center, Air Traffic, and the appropriate FAA Region; airport operators; airlines; general aviation; and other aviation industry representatives.

Airport Capacity Design Teams consider capacity improvement alternatives. Alternatives that are considered technically feasible are evaluated by computer simulation modeling conducted by the FAA Technical Center's Aviation Systems Analysis and Modeling Branch. The product of the study is a capacity enhancement plan containing a set of capacity-enhancing recommendations and their annual delay savings. The presence of a recommended improvement in a capacity enhancement plan does not obligate the FAA to provide F&E or AIP funds.

Environmental, socioeconomic, and political implications, while not evaluated by the design teams, are addressed by the FAA and local authorities if and when the airport authority chooses to pursue one or

Study	Date
Capacity Enhancement Plans	
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
Norfolk Int'l	
Righmond Int'l	
Newport News Int'l	
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
Memphis Int'l Update	1997
Miami Int'l	1989
Miami Int'l Update	1997
Minneapolis-Saint Paul Int'l	1993
Nashville Int'l	1991
New Orleans Int'l	1992
Oakland Int'l	1987
Orlando Int'l	1990
Philadelphia Int'l	1991
Phoenix Sky Harbor Int'l	1989
Port Columbus Int'l	1993
Portland Int'l	1996
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 Update	1995
Washington Dulles Int'l	1990
Tactical Initiatives	
Charlotte Douglas Int'l	1995
Los Angeles Int'l (Commuter Gates)	1996
Los Angeles Int'l (TBIT Expansion)	1993
New York La Guardia Airport	1994
Orlando Int'l	1995

Figure 3-6. Completed Airport Capacity Studies

more of the capacity enhancement alternatives. See Environmental Constraints on Airport Capacity, below, for a description of environmental issues.

Recommendations from Previous Airport Capacity Studies

Since 1985, more than 40 Airport Capacity Design Team studies have been conducted. The typical Airport Capacity Design Team considers 20 to 30 alternatives for increasing capacity. Figure 3-7 lists completed airport capacity studies and their recommendations according to generalized categories of improvements, and indicates those recommendations that have been implemented, completed, or are no longer under consideration.

Airfield improvements such as construction of new runways and runway extensions may take more than ten years from proposal to completion due to financing constraints and the need to study and address environmental concerns.

Airfield improvements were recommended for all of the airports studied. Common airfield recommendations include building or extending runways and taxiways and improving exits and staging areas to increase the efficiency of existing runways. More than two-thirds of the airports studied implemented at least one of the recommended airfield improvements. Airfield improvements such as construction of new runways and runway extensions may take more than ten years from proposal to completion due to financing constraints and the need to study and address environmental concerns.

Common recommendations for improving capacity through investments in aviation facilities and equipment at an airport are the installation or upgrade of Instrument Landing Systems (ILS) to improve runway capacity during IFR operations, and the installation of Runway Visual Range (RVR) and approach lighting systems. Improvements to facilities and equipment are generally less expensive and time consuming to implement than airfield improvements. However, like airfield improvements, the ability to obtain and install new equipment is contingent upon available financing. Improvements such as the installation of RVRs and approach lights generally coincide with the completion of a new runway or runway extension.

Common procedural recommendations include improved IFR approach procedures and reduced separation standards for arrivals. Enhancement of the reliever and general aviation airport system is also a frequent recommendation for moderating the demand on a given airport. Improved IFR approach procedures and reduced separations between arrivals have been implemented at several of the airports studied by the Capacity Design Teams.

√ Recommended
C Completed
⊗ No Longer Under Consideration

Airports / Recommended Improvements [1]	Airfield Improvements	Construct third parallel runway	Construct fourth parallel runway [2]	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
Albuquerque					C	C	C	C	√	√		C			√								√		√					√
Atlanta (original study)					C			C	C	C		C	C	C		C	C	√		√					C				⊗	
Atlanta (update study)			√					√	√	√		√						√		√					√					√
Boston					⊗	⊗	⊗	√	C			√								√			C			√				
Charlotte-Douglas						C	√	C	√			√		√			√	√								√	C			√
Chicago Midway					√	C			C	√													√		√					
Chicago O'Hare				√	⊗	√		C	C			C	√													C				
Cleveland		⊗		√	√	√	√	√		√		√			√			√					√	√	√					√
Dallas-Ft. Worth					C	√		C															C	C	C					C
Port Columbus		√	⊗	√	√	C		√	√	√		√		√			√	√	√			√	√		√				√	√
Fort Lauderdale					√	√		√	√	√		√			√	C		√		√		√	√		√				√	√
Honolulu		√				√		√	√	√		√																	√	C
Houston Intercontinental		√	√		√	√		√	√	√		√											√						√	√
Indianapolis		√	√	C	√		√	√	C			√	√	√			√						C	√	√					√
Kansas City		√	⊗				C	√	√	√		√	√				C						√		√				√	
Las Vegas					√	C	C		C	√		√											√			√				C
Los Angeles					C	√	C	√	C	√		C							C			√								
Memphis (original study)		C			√	√	C	√				C											C		⊗				⊗	
Memphis (update study)					√	√	√	√	√			√						√		√			C		√					√
Miami (original study)					C		√	C	C			C	C	C			C						C							C
Miami (update study)		√								√		√								√		√			√				C	
Minneapolis-Saint Paul		√			√	C		√	√	√		√	C	√	√			C				C			C					√
Nashville			√	C	C	√	√		√			C								√		C	√				√		⊗	√
New Orleans					C										√				C			√	C		C					C
Newport News						√		√															√		√					
Norfolk						√						√	√	√											√					
Oakland					√			√	√																					
Orlando			√		√		C		√			√			√		√	√				C	√					√		√
Philadelphia		√		⊗		⊗												√				√	√	√						
Phoenix		√			√		C	√	C	C		C		√	C								√	√	√			√	√	C
Pittsburgh			√			C				C		C						√				√								
Portland					√		√	√				√											√	√	C			√		
Raleigh-Durham		√	⊗	⊗	√			√	√			√	√				√			√		√	√		√		√			
Richmond						√		√				√	√	√									√		√					
St. Louis		√					C	√	√			√		√			C			√			C		C				⊗	
Salt Lake City		C					C	C	√	√		C	C	C			C	√					C		C					√
San Antonio		√			√	√	√		C			C	C	√				√		√		√	√		√					√
San Fransisco		⊗	⊗			√	C	√	√															C					√	C
San Jose						C		C	C															C						
San Juan, Puerto Rico					√		√	C	√	C				√	C				C	√					√					√
Seattle-Tacoma		√						C				√								√			√		C				⊗	
Washington-Dulles		√			C	C	C		C	√			C	C									C		C				⊗	⊗

1. Recommendations summarized and grouped in generalized improvement categories.
2. Construct fifth parallel runway in the case of Atlanta.

Figure 3-7. Completed Airport Capacity Studies and their Recommendations

1998 Airport Capacity Design Team Studies

Ongoing and recently published Airport Capacity Design Team studies and updates of previous studies are summarized below.

Reno/Tahoe International Airport (RNO)

Growth at Reno/Tahoe International Airport (RNO) has been steady over the last decade. This growth is exhibited in the doubling of passenger enplanements from 1.4 million in 1983 to 3.2 million in 1997. As a result, an Airport Capacity Design Team for RNO is continuing to study capacity-enhancing alternatives including the construction of a new apron, a new concourse, de-icing facilities, and runway and taxiway extensions. Possible F&E improvements under consideration include development of precision approaches and the installation of Doppler radar and RVR systems. Procedural improvements include adoption of land-and-hold-short procedures (LAHSO).

Miami International Airport Update (MIA)

Miami International Airport (MIA) was ranked the seventh-busiest airport in total operations for 1997. Aircraft operations have been on the rise, increasing more than 69 percent between 1983 and 1995. Passenger enplanements at MIA have increased more than 61 percent during this same time period. According to FAA projections, this growth at MIA will keep it on the list of airports experiencing over 20,000 hours of annual delay through the year 2007, if no capacity improvements are made.

In 1986, an Airport Capacity Design Team for Miami International Airport was formed and in 1989 published recommendations for increasing capacity and reducing delays. Changes in computer simulation model inputs, growth in traffic at MIA, and the need to reassess and further analyze capacity enhancement alternatives resulted in a second Airport Capacity Design Team in September 1995.

The Design Team's analysis showed that delay costs and annual delays will continue to grow at a substantial rate as demand increases if no improvements in airfield capacity are made. The recommendations that will reduce delays the most are a new non-precision air carrier runway (parallel to and 800 feet north of existing Runway 9L/27R), establishment of a third departure heading for jets (day-only operations), and the use of intersection departures for cargo aircraft on runway 27L. Currently, an environmental impact study of the new runway is being prepared. The update of the MIA plan was published in December 1997.

Newark International Airport (EWR)

The Airport Capacity Design Team study of Newark International Airport (EWR) is still in progress. At this point, the study is examining new approach procedures to the converging runway and innovative dual approach procedures to the closely spaced parallel runways. In support of the study of these new approach procedures the following simulations have been completed at EWR: parallel dual visual approaches, reduced in-trail separation, and localizer directional aid (LDA) offset approaches for north flow traffic. The expected completion date of the EWR study is 1999.

Tampa International Airport (TPA)

The Airport Capacity Design Team study of Tampa International Airport (TPA) is currently underway. The study is analyzing airfield improvements including taxiway and runway extensions, a proposed new runway, and holding pads. Operational improvements such as dependent converging instrument approaches to Runways 27 and 36L, utilization of Runway 18L/36R, and independent precision instrument approaches to the parallel runways are being investigated. The study is being conducted in conjunction with a master plan update for Tampa. Completion of the study is expected in 1999.

Additional Airport Capacity Activities

ASC also acts as a team member in other airport capacity projects. ASC is currently a participant with projects involving Los Angeles, Dallas Fort Worth, and Hartsfield Atlanta International Airports.

Los Angeles International Airport (LAX)

Los Angeles International Airport (LAX) is ranked fourth in the U.S. for number of operations for 1997, is a leader in air cargo, handling approximately 1.87 million tons of goods in 1997, and currently is one of 27 U.S. airports with over 20,000 hours of annual delay. LAX has experienced steady growth over the past five years in both passenger enplanements and airport operations. This growth at LAX is predicted to continue, and if no improvements are made the excessive delays are predicted to continue as well.

LAX is currently in the process of addressing the need for growth through an Airport Master Planning effort that is underway. Thirty proposals for modernization were initially evaluated and the field has been narrowed to three. ASC has been asked to assist the LAX Master Plan review team in the evaluation of those proposals. The common elements in each of the proposals are:

- Center parallel taxiways in between both sets of parallel runways
- Extension of the north-side inner parallel runway to 12,000 feet
- A fifth runway that is between 6,000 and 7,000 feet in length
- A new west terminal

Dallas-Fort Worth International Airport (DFW)

Dallas Fort Worth (DFW) ranked first in U.S. airport operations in 1997, with 903,006 operations. Operations at DFW are expected to increase by 55.4 percent by 2012. DFW is also one of the airports expected to have over 20,000 hours of annual delays through 2007, if no additional capacity improvements are made.

Runway and taxiway plans are being explored at DFW to compensate for predicted increases in aircraft traffic. A new west runway is scheduled for commissioning in 2003, which will allow the airport to support simultaneous quadruple parallel arrival streams. An extension of Runway 18R/36L to 16,000 feet is being considered to accommodate extended range B777 for non-stop service to the Far East. Also being looked at is the placement of perimeter taxiways around the ends of the runways to alleviate departure delays due to runway crossings.

Hartsfield Atlanta International Airport (ATL)

The Hartsfield Atlanta International Airport (ATL) Capacity Design Team recommended a commuter/general aviation (GA) runway complex in its March 1987 Airport Capacity Enhancement Plan. This concept was later modified to a 6,000 foot long fifth parallel commuter runway, 4,200 feet south of existing Runway 9R/27L. A December 1995 update of the Airport Capacity Enhancement Plan showed this runway would provide significant delay savings benefits at ATL. Construction of the new runway is expected to begin in early 1999 and be completed in March 2002. This runway will allow triple simultaneous arrivals to ATL in instrument conditions using the new Precision Runway Monitor (PRM) technology. A runway dedicated to commuter aircraft arrivals will reduce airborne delay for these aircraft and air carrier aircraft operating on the four existing runways. A reduction in delays at a major hub airport such as ATL will reduce delays in the entire NAS.

1998 Tactical Initiative Teams

Tactical Initiative Teams focus on providing immediate relief to airports with chronic delay. The recommendations of Tactical Initiative Teams generally focus on procedural changes that can be implemented quickly with little financial investment. Ongoing Tactical Initiative projects in 1998 are summarized below.

La Guardia Airport (LGA)

The FAA Office of System Capacity (ASC) and the FAA's William J. Hughes Technical Center conducted a study of the capacity and delay implications of introducing the Boeing 767-400 into the aircraft fleet at La Guardia Airport (LGA). An analysis was conducted based on five runway configurations. The analysis focused on determining any special operating procedures that would be required for the B767-400. The study determined that no additional runway considerations were necessary, but found two potential taxiway clearance problems. The final conclusion reached was that the introduction of the B767-400 does not appear to have any significant capacity or delay impact on taxiway operations at LGA. The report *The Capacity/Delay Impacts of 767-400 at LGA* was issued in April 1998.

San Diego International Airport (SAN)

The San Diego study continues and the expected completion date is late 1998. The Tactical Initiative Team has been investigating the effect of another terminal, ground flow, and other short-term improvements such as an additional terminal concourse, taxiway development, and remote aircraft parking areas already approved in the Immediate Action Plan. A Master Plan study, which will address capacity and growth issues of San Diego International-Linbergh Field is currently underway. Completion of the Master Plan study is expected early 1999.

Air Traffic Control (ATC) Ground Simulations

At the request of regional Air Traffic offices and local Air Traffic facilities, ASC has initiated ATC ground simulations at Las Vegas McCarran International Airport (LAS), Salt Lake City Airport, and Phoenix Sky Harbor International Airport (PHX). The goal of the ground simulation initiatives is to improve the operational efficiencies at these airports.

Las Vegas McCarran International Airport (LAS)

A ground simulation initiative is being conducted in support of an effort with Air Traffic to improve ground operations at Las Vegas McCarran International Airport (LAS). LAS recently added an additional gate complex, Terminal D, to the airport. The FAA is examining the impacts of an increase in traffic on existing taxiways and gates and ways to increase the tower efficiency of ground operations. In addition, the ability of the new terminal complex to accommodate future traffic levels is being tested. Also being studied are different runway scenarios and their impact on noise abatement efforts. Expected completion of the initiative is 1999.

Salt Lake City Airport (SLC)

An initiative instituted at Salt Lake City Airport (SLC) will assist Air Traffic in finding ways to improve ground operations. This study is examining the effect of additional taxiways on ground operations efficiency. The impact of new terminals and the relocation of existing terminals on ground operations is also being studied. In addition, initiatives to improve operational efficiency during times of reduced visibility are to be examined. The planned conclusion of this initiative is 1999.

Phoenix Sky Harbor International Airport (PHX)

An initiative to assist Air Traffic with ground operations efficiency, similar to airport initiatives at LAS and SLC, is being conducted at Phoenix Sky Harbor International Airport (PHX). The goal is to determine a more efficient use of runways for arrival and departure operations, based on both the present runway configuration and also during construction of a new runway and the repair of existing runways. Several runway configuration scenarios are being considered during the construction of a third runway and the subsequent reconstruction of the existing runways. The third runway is being constructed to prevent additional delays, reduce aircraft operating costs and passenger travel times, and provide the capability to perform simultaneous instrument operations. One of the most challenging aspects involved in the construction of the third runway is the relocation of facilities that lie in its path. This initiative is expected to be complete in 1999.

1998 Regional Capacity Design Teams

Looking beyond the individual airport and its immediate airspace, the Office of System Capacity conducts regional studies. Regional Capacity Design Teams analyze all the major airports in a metropolitan or regional system and model them in the same terminal airspace environment. This regional perspective explores how capacity-producing improvements at one airport will affect air traffic operations at other airports and within associated airspace.

Northeast Region Capacity Design Study

Phase One of the Northeast Region Study examined the capacity impacts of passengers migration from the primary airports (BOS, EWR, JFK, and LGA) to surrounding commercial passenger service airports. Phase Two is a planned expansion of the study to the major Washington area airports (DCA, BWI, and IAD) and Philadelphia (PHL). The Design Team is working with the Volpe National Transportation Systems Center on this effort. Phase One was completed in September 1998 and completion of Phase Two is expected in September 1999.

Anchorage Area Airspace Design Team Study

The Anchorage Area Airspace Design Team Study started in April 1997 and expected completion is March 1999. The focus of the study is to identify the best ways of accommodating existing and future aircraft operations in the Anchorage area. Anchorage International (ANC), Lake Hood, Merrill Field, and Elmendorf airports, as well as private-use airports and heliports in the Anchorage area, are included in the study. The study is focused on the following considerations: the impact on operations in the Anchorage area of constructing a new runway and runway extension; innovative approach procedures to the converging runway at ANC and to the closely spaced parallel runways; and a means of addressing congestion problems caused by more than one million annual operations transiting over Point McKenzie, a single fix.

Environmental Constraints on Capacity

Environmental constraints on aviation system capacity can occur based on a number of categories of concerns. Currently, noise in the airport environment is the greatest environmental issue affecting aviation capacity, while the focus on emissions is expected to increase in the future. Other categories of environmental issues include community disruption, relocation, surface and air traffic changes, changes to sensitive cultural and natural resources (e.g., preservation of wildlife refuges, national parks and bird sanctuaries), air and water quality, water and sewer demand, energy demand, aesthetics, site clean up, and concerns about electromagnetic fields. Collectively, these constraints affect where and how aircraft are allowed to fly, the airports they can use, and the available airport capacity enhancement options.

Noise in the airport environment is the greatest environmental issue affecting aviation capacity, while the focus on emissions is expected to increase in the future.

The effort to reduce noise is concentrated in three areas: reducing noise at the source, through operational procedures, and through land-use planning. The major initiative to reduce noise at the source is the phase out of Stage 2 aircraft (noisier aircraft) by December 31, 1999. This deadline requires airlines to replace their Stage 2 aircraft or retrofit their older aircraft with "hushkits" or new engines that meet Stage 3 noise standards (quieter aircraft). Noise mitigation also occurs through implementation of certain operational procedures. Airlines, airports, and the FAA work together to route traffic away from residential areas. Examples of procedural steps taken are takeoffs and landings routed over large bodies of water or industrial areas and pilots adjusting power settings on take-off — applying maximum power while climbing and then reducing power when flying over residential areas. Land-use planning is another way the FAA is working to reduce noise effects on communities. The FAA, through Airport Improvement Program (AIP) funding, provides grants to airport proprietors for soundproofing homes, schools, churches, and other structures near airports. Airport proprietors also can use AIP grant funding to buy homes outright and resell them for commercial development that is more compatible with the airport.

The push for aircraft emissions reduction is coming from three primary sources: the International Civil Aviation Organization Committee on Aviation Environmental Protection (ICAO/CAEP), the Kyoto Protocol (an agreement for industrialized countries to reduce greenhouse gas emissions over the next 10-14 years), and the U.S. Environmental Protection Agency (EPA). In 1993, ICAO/CAEP mandated a 20 percent decrease in the allowable emissions levels of oxides of nitrogen (NOx) from aircraft engines. A future recommendation is likely to be a reduction of NOx emissions by an additional 16 percent. The Kyoto Protocol is a driving force in the reduction of emissions into the upper atmosphere in the effort to protect the planet from global warming.

The Protocol sets varying targets for individual countries; the U.S. has agreed to a 7 percent reduction from 1990 greenhouse gas emission levels. The EPA focus is on reducing emissions of particulates, thereby improving public health.

Federal actions with environmental impacts are subject to the provisions of the National Environmental Policy Act (NEPA). Preparation of environmental assessments (EA) and/or mitigation measures by or for the FAA is usually required for major airport changes requiring FAA approval and for significant airspace changes. Examples of situations in which an EA is required are when a new runway is proposed, when major runway extension or strengthening is proposed, prior to installing an instrument landing system, or when altering an airport's arrival or departure tracks. If significant environmental impacts are determined from the assessment, then FAA must prepare an environmental impact statement (EIS). The environmental process, from an EA through an EIS, can consist of up to 44 different steps and can take a number of years to complete. Although frequently prepared by the airport operator, the resulting EIS is adopted by the FAA and is the FAA's environmental commitment and responsibility.

CHAPTER 4: AIRSPACE DEVELOPMENT

The FAA Office of System Capacity (ASC) has a long-established airspace capacity program which has sponsored more than twenty projects over the past nine years aimed at increasing capacity and decreasing delay in the National Airspace System (NAS). Airspace development studies strive to relieve congestion and reduce delays by determining how to restructure airspace and modify arrival, departure, en route, and terminal flow patterns. En route airspace studies may extend to one or more Air Route Traffic Control Centers (ARTCCs), encompassing traffic flowing into and out of several airports. In contrast, terminal airspace studies, undertaken to ensure that traffic patterns resulting from new runways, runway extensions, and traffic increases can be accommodated efficiently, usually encompass only about a 40 mile radius around the airport.

This chapter begins by describing the role of several new airspace planning organizations. It continues with a summary of the capacity benefits that resulted from the implementation of airport and airspace enhancements in the Dallas/Fort Worth Metroplex, and descriptions of ongoing and recently completed en route and terminal airspace studies. It concludes with a short description of the FAA's involvement in a relatively new airspace frontier, commercial space transportation.

New FAA Airspace Management and Development Organizations

In 1996 the FAA established the Airspace Management Program Office (ATA). The purpose of this division is to develop, test, and analyze current airspace design using modeling and simulation and to manage changes to airspace design, efficiency, and utilization. Any significant proposed airspace changes are evaluated by ATA, which assesses the impacts of the changes from a national perspective.

The Airspace Liaison Team (ALT) provides a forum within the FAA for airspace management issues and activities. The ALT includes representatives from ATA, other FAA headquarters offices (such as the offices of System Capacity, Air Traffic Operations, and Commercial Space Transport), and airspace managers from all nine FAA Regional Offices. Input from air carriers and other airspace users are communicated to the ALT through the Regional airspace managers.

RTCA *Special Committee 192, National Airspace Review Planning and Analysis*, is providing guidance to the FAA for the review and management of national airspace redesign. The committee represents the views and perspectives of all airspace users and stakeholders, and addresses issues associated with all types of domestic and oceanic airspace.

Efficiency Benefits of Airspace and Airport Enhancements in the Dallas/Fort Worth Metroplex

Implementation of the study's recommendations has begun and the results are even better than the simulations predicted.

In 1987, an ambitious study was developed by the Dallas/Fort Worth (DFW) airport board in conjunction with the FAA that addressed navigation and communication facilities and equipment, airspace realignment, and procedural development in the Dallas/Fort Worth Metroplex. The study focused on both the need for additional runways to accommodate increased operations and the redesign of approach streams for arrivals and departures. The study's goals were to ensure that the airspace and airport capacities in the Dallas/Ft. Worth areas kept pace with the predicted increases in demand. Specific recommendations included modifications for DFW traffic flows to establish demand-responsive dual jet arrival routings over each cornerpost, establishing additional terminal departure routings, and segregating DFW arrival traffic from satellite operations in the terminal area. The new airspace design included an expansion of TRACON airspace 15 NM into the existing en route system to incorporate moving the cornerpost navigational aids. Implementation of the study's recommendations has begun and the results are even better than the simulations predicted.

In the first year after implementation of the new airspace design for the DFW Metroplex area, VFR arrival rates reached as high as 156 planes per hour, an increase of more than 40 percent over previous rates, and much higher than the airspace analysts had predicted. The flight-time savings in 1997 compared to 1996 totaled 57,634 hours, equating to an estimated savings of $92 million in aircraft operating costs. Cumulative savings over the next 20 years due to reduced flight-time are estimated to exceed $12 billion. Figures 4-1 illustrates DFW arrival traffic before airspace and runway changes. The wavering flight paths are evidence of path stretching required to moderate the traffic coming into the terminal area over a single fix. Figure 4-2 illustrates the flight tracks of DFW arrival traffic after airspace and runway changes. The prevalence of straight flight paths is evidence of the operational benefits of the new dual arrival fix and runway.

The Metroplex plan is currently entering its final phase with the addition of a new north/south runway at DFW International Airport. This runway will provide additional capacity and include a new air traffic procedure: quadruple simultaneous instrument landing system (ILS) approaches.

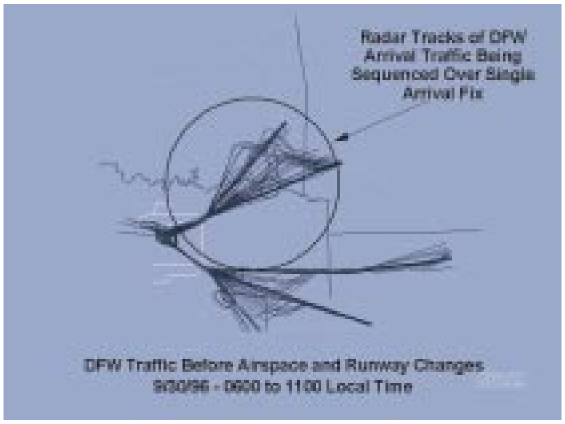


Figure 4-1. DFW Arrival Traffic Before Airport and Airspace Enhancements

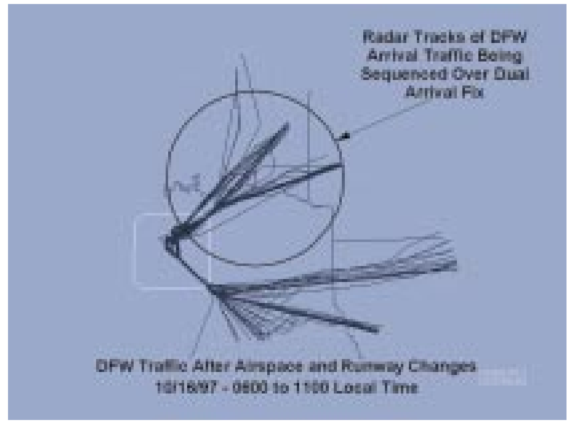


Figure 4-2. DFW Arrival Traffic After Airport and Airspace Enhancements

Ongoing Airspace Studies

In mid-1998 the FAA initiated a large-scale analysis of the national airspace structure, referred to as the National Airspace Redesign. The FAA is also currently involved in en route airspace studies in Chicago; the West Coast, including Northern California, Southern California and Las Vegas; Salt Lake City; Cincinnati; the Southern Region, including Atlanta, central Florida and Miami; and the Caribbean. In addition, the FAA has recently initiated a terminal airspace study at Phoenix International Airport.

National Airspace Redesign

The goal of the National Airspace Redesign is to ensure that the design and management of our national airspace is consistent with new requirements as the NAS evolves towards free flight. The National Airspace Redesign will consist of incremental changes to the national airspace structure consistent with evolving air traffic technologies and avionics and NAS operational concepts. Environmental issues will be addressed in parallel with capacity and efficiency analyses.

In July 1998, the first phase of the National Airspace Redesign was initiated in the Eastern Triangle. The Eastern Triangle is associated with the ARTCCs and TRACONs serving Boston, New York, Philadelphia, Washington DC, Atlanta, Orlando, Miami, Cincinnati, Cleveland, and Chicago. Initial efforts for 1998 and 1999 will focus on problem identification in the airspace of New York and New Jersey. That region is a priority because its airspace is the most congested in the nation. By the year 2000, the FAA expects to have completed problem identification and alternative evaluations, and begun environmental evaluations for the Eastern Triangle.

The National Airspace Redesign will consist of incremental changes to the national airspace structure consistent with evolving air traffic technologies and avionics and NAS operational concepts.

Chicago Terminal Airspace Project (CTAP)

The Chicago Terminal Airspace Project (CTAP) is an outgrowth of efforts that began ten years ago to efficiently service aircraft demand within the region. In 1988, the FAA conducted a Chicago System Safety & Efficiency Review because of concerns over operational errors, continued regional growth, and increased delays to the users. In 1989, the Chicago Delay Task Force was established to identify initiatives to enhance safety, improve efficiency, and reduce controller workload. In 1991, the FAA initiated a three-phase program of improvements for NAS users in the Chicago metropolitan area. Phase II CTAP includes proposed modification of the existing airspace design and procedures, quantification of user benefits, and preparation of an Environmental Impact Statement.

The basic structure of the Chicago regional airspace has not changed in over 20 years, but the number, performance, and mix of aircraft using the airspace has changed. The existing airspace limits flexibility for controllers operating in an extremely complex environment. For aircraft destined to the region, en route in-trail spacing is conservative to avoid saturation of arrival streams. Arriving aircraft are sequenced into a single stream at each cornerpost. En route and terminal arrival spacing and sequencing are achieved through ground holds, speed control, and delay vectors (S-Turns).

A significant modification proposed by the CTAP program is transfer of portions of the Chicago ARTCC airspace to Chicago TRACON airspace along the existing high-altitude arrival gateways, thus expanding TRACON airspace from today's 40 miles to between 50 and 60 miles. Other components of the CTAP proposal include:

- One additional high-altitude arrival route, two modified arrival routes, and more flexible use of existing departure corridors for Chicago O'Hare International Airport
- A more direct route for aircraft arriving from the northwest and northeast destined for Chicago Midway Airport, Chicago Meigs Airport, Gary Airport, and other general aviation/reliever airports
- One new high-altitude arrival route separating Milwaukee General Mitchell Airport and reliever/satellite airport traffic

The expected benefits of the proposed CTAP modifications include:

- Enhanced safety by reducing complexity of arrival procedures
- Improved on-time service for the flying public
- Fewer miles flown en-route — offering potential fuel savings
- Reduced ground-hold delays
- More flexible use of existing departure corridors
- Redundant back-up during radar outages

Figure 4-3 illustrates the proposed CTAP airspace modifications.

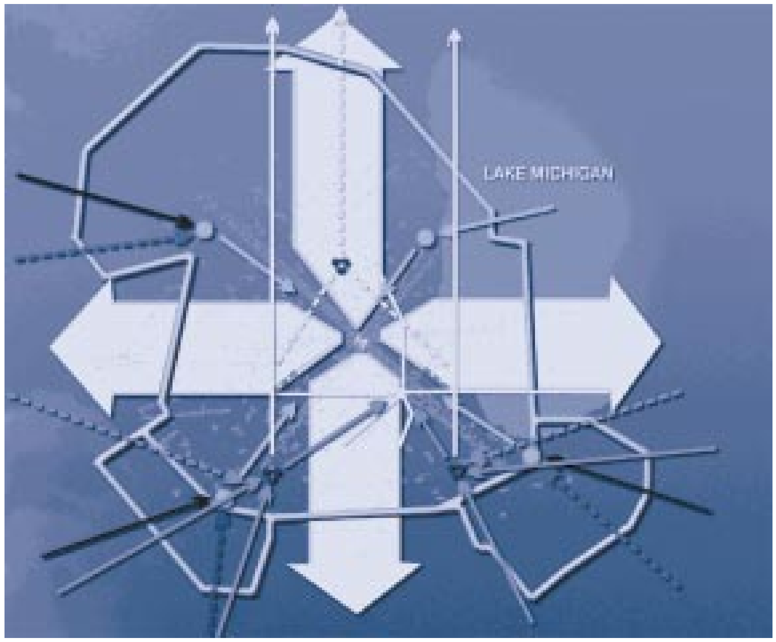


Figure 4-3. Proposed Airspace Design for Chicago

West Coast Airspace Analysis

ASC is involved in a large-scale analysis of the airspace on the west coast of the United States, ranging from San Francisco/Oakland in the north, to Los Angeles in the south, and extending to Las Vegas to the east. Arrival procedures to Los Angeles International Airport (LAX) were recently modified to take advantage of the air traffic management capabilities made possible by the new Southern California TRACON (SCT). ASC analyzed the airspace of the Northern California TRACON (NCT) (under construction) to capitalize on potential efficiency and capacity gains in that region.

Southern California TRACON (SCT) Airspace Analysis

The SCT controls airspace in the Los Angeles-San Diego area. By consolidating the operations of five TRACONs into a single facility, the SCT enhanced controller flexibility for merging and sequencing aircraft. In addition, the LAX approach control area was expanded, allowing earlier use of airborne precision navigation and terminal separation criteria (three miles in trail), providing additional flexibility in maneuvering aircraft and making runway assignments.

Prior to construction of the SCT, LAX arrivals from the east were funneled into the Los Angeles Basin via an arrival procedure which merged various airways into a single arrival stream over CIVET intersection. During peak arrival rushes, the single arrival stream over CIVET did not have the capacity to support the heavy traffic from the east. The traffic bottleneck caused by the single arrival stream frequently required the use of ground stops and en route flow restrictions, resulting in flight delays and underutilization of available runway capacity at LAX.

In February 1998, an arrival enhancement procedure (AEP) for LAX was implemented, providing dual arrival streams for flights landing at LAX from the east. Figures 4-4 and 4-5 show a comparison of flight tracks for the old arrival procedures and traffic flows under the AEP, respectively. Annualized cost savings due to reduced flight times as a result of the AEP are projected to be $13 million at baseline traffic levels. By 2005, savings are expected to increase to $65 million annually. ASC is currently conducting a post-implementation analysis of the airspace changes to assess the actual flight time and delay savings.

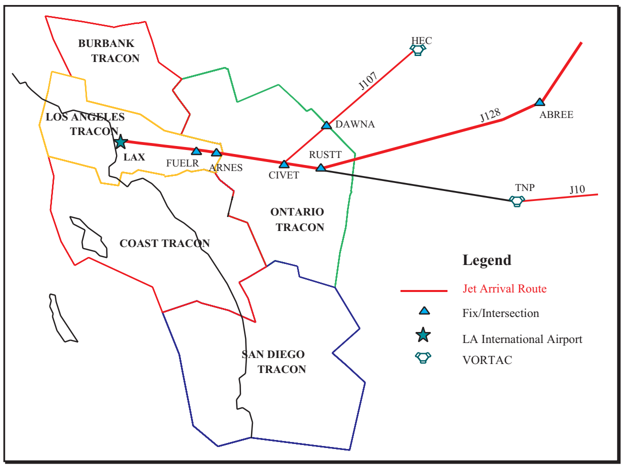


Figure 4-4. Old TRACON Boundaries and Arrival Routes to Los Angeles International Airport

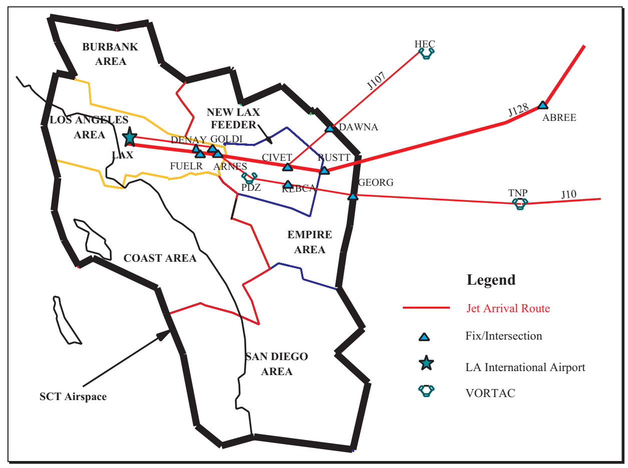


Figure 4-5. New SCT Boundary and Arrival Enhancement Procedure to Los Angeles International Airport

Northern California TRACON (NCT) Airspace Analysis

The proposed NCT will consolidate four existing northern California TRACONs into a new facility. This restructuring and expansion of terminal airspace will provide an opportunity for implementing airspace changes with the specific goal of improving efficiency of airspace usage by enhancing controller flexibility for merging and sequencing aircraft.

ASC investigated two proposals for using the NCT to enhance airspace efficiency in northern California when the Southeast Plan configuration is in effect in instrument meteorological conditions. The Southeast Plan, used approximately ten percent of the time under certain wind and weather conditions, limits arrivals and takeoffs at San Francisco International Airport (SFO) to one runway. The first proposal would reduce congestion in northbound traffic by establishing an offshore arrival route for Oakland Airport (OAK) to remove

Oakland-bound traffic from the San Francisco arrival stream. The second proposal is a straight-in arrival route for flights from the north, northwest, and northeast to reduce controller workload and eliminate the need for path-stretching during heavy traffic.

Figures 4-6 and 4-7 show a comparison of existing SFO arrival routes from the north and the proposed straight-in arrival route, respectively. Annual aircraft operating cost savings resulting from the SFO straight-in and OAK offshore arrival routes are estimated at $6.6 million at baseline traffic levels.

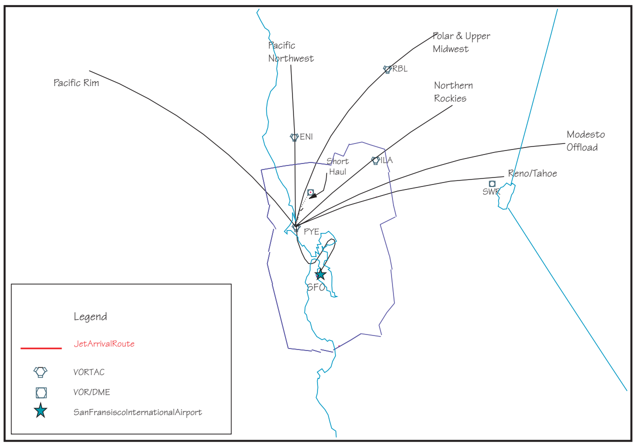


Figure 4-6. Existing SFO North Arrival Routes

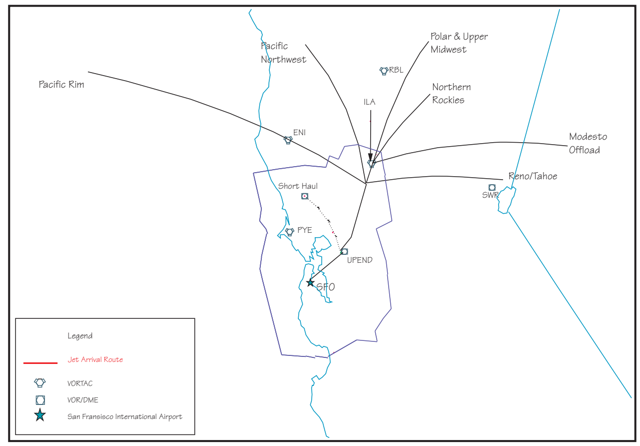


Figure 4-7. Proposed Straight-In Arrival Routes for SFO

Las Vegas Airspace Analysis

In 1995, Las Vegas had 29 million tourists. Of these, over 14 million traveled by air. By 1997, the number of tourists increased to more than 34 million, with more expected as new hotel rooms continue to be built. The consistent increase in visitors to Las Vegas has strained the operations at McCarren International Airport (LAS), which experienced more than 20,000 hours of delay in 1997, and for which continued delays are projected if no capacity improvements are made. Twenty-six new gates opened in 1998, and an additional twelve gates are under construction. Although one runway was recently upgraded to accommodate air carrier aircraft, this improvement will probably not be sufficient to accommodate projected demand. Airspace north of McCarren is constrained by the significant airspace reserve of Nellis Air Force Base, which limits the maneuvering room of flights in that region.

Most GA flights, primarily VFR sightseeing tours, now operate out of North Las Vegas Airport (VGT), which has relieved capacity pressures on LAS. In addition, Clark County, which owns and operates LAS, recently purchased Henderson Airport for the purpose of developing it into a reliever airport for LAS to accommodate the significant residential growth south of Las Vegas.

The Las Vegas airspace analysis encompassed the airspace of the Los Angeles ARTCC, including LAS and VGT. The study assessed modifications to arrival and departure routings and runway use to enable the FAA to better service the dramatic growth in air traffic demand in the Las Vegas area. As a result of the analysis, a new cornerpost structure for LAS arrivals and dedicated arrival and departure runways are being implemented in phases. These modifications are expected to reduce flight times by more than 65 hours daily, and delays greater than fifteen minutes by more than 82 percent.

The use of VGT instead of LAS by GA operations relieved capacity pressures on LAS, but not on the surrounding airspace, because tour operations are still required to traverse the McCarren approach to do their business. Therefore, the FAA is also analyzing the effect on controller workload of GA flights using the McCarren approach, and assessing how to best route GA operations so that they are compatible with other flights within the Las Vegas TRACON.

Cincinnati Airspace Analysis

Air traffic has grown significantly at Cincinnati (CVG) in recent years due to increases in Delta Airlines and Comair hub operations. Traffic growth exceeded seven percent annually from 1994 to 1997, well above the national average. Two factors complicate Cincinnati's airspace: a parachute jump area to the northeast and a military operations area (MOA) 35 miles east of the airport. Under the current route structure, if arrivals from the northeast are required to hold in the air, the only airspace available for the holding pattern is between the arrival route and the MOA, airspace usually used by eastbound departures. Thus, if airborne holding is required by northeast arrivals, at least some eastbound departures are forced to hold on the ground. Air traffic controllers have been forced to use traffic-management initiatives, including ground-delay programs (GDPs), to avoid excessive airborne holding. This increases both departure delays and airport surface congestion.

An FAA taskforce is now addressing airspace issues at Cincinnati by developing new routes and procedures that will eliminate the need for regular GDPs. The taskforce is also working with Department of Defense representatives to improve the real-time communication of MOA activation times. Better knowledge of MOA activation times should allow greater civilian use of the airspace. Increasing the ceiling height of the terminal airspace, adding new FMS-based arrival routes, and adding parallel routes through each departure gate are other possibilities for increasing airspace utilization and reducing delays.

Salt Lake City En Route and Terminal Airspace Analyses

Air traffic activity at the Salt Lake City Airport (SLC) has increased significantly in the past few years, from 317,000 operations in 1992 to 385,000 operations in 1997. SLC is a hub for Delta and SkyWest Airlines, and Federal Express is in the process of building a cargo hub operation there. SLC experienced more than 20,000 hours of delay in FY97, and if no further capacity enhancements are made it will continue to exceed 20,000 hours of delay annually. Routing options for SLC are limited by the Utah Test and Training Range (UTT) special use airspace west of the airport, and limited radar coverage and maneuvering room to the east due to mountainous terrain. The Salt Lake City airspace analysis began in April 1997. The purpose of the study is to reduce traffic flow complexity en route and in the terminal area to accommodate expected traffic growth, including traffic growth projections for the upcoming 2002 Winter Olympic games.

Under the existing en route air traffic structure, certain sectors handle both arrivals and departures, which is not ideal from a workload and efficiency standpoint. To address these shortcomings, ASC developed a proposed cornerpost structure for arrivals with redefined sector boundaries. ASC then developed four routing alternatives for the terminal area in conjunction with the en route modifications. Of the four terminal area options evaluated, the largest flight time savings are projected for the east and west downwind terminal option. Specifically, this terminal option would result in $2.7 million of annual operating savings today and $7.7 million by the year 2010. Figures 4-8 and 4-9 compare routing under the current structure to routing under the east and west downwind terminal option with a four-cornerpost en route structure, for the north and south flow operations, respectively.

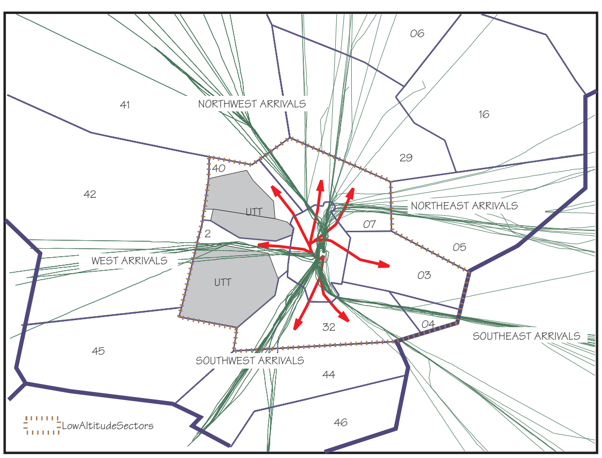


Figure 4-8. SLC Current Routes

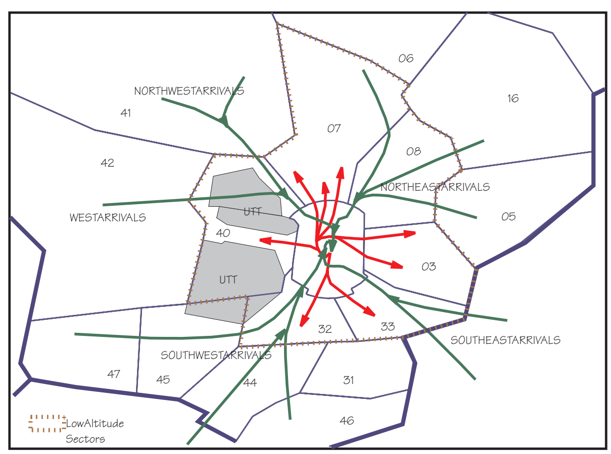


Figure 4-9. SLC Proposed Routes

Southern Region Multi-Center Study

A multiple-ARTCC (Multi-Center) study is being performed in FAA's Southern Region with the objective of creating GPS-based user-preferred trajectories (UPTs) between Atlanta, the central-Florida complex of airports (Tampa, Orlando, Daytona Beach, and Jacksonville), and Miami. In the study, airspace in the Miami, Jacksonville, and Atlanta ARTCCs airspace is being redesigned for use by aircraft equipped with advanced navigation systems. Ultimately, UPTs will connect the departure-runway end to the arrival-runway end via a series of waypoints. The portion of the trajectory in the en-route airspace will allow direct flight to the maximum extent possible, given the origin and destination airport configurations, active special-use airspace, complex traffic areas, and weather conditions.

Both departure and arrival routes will be modified for the new UPTs. Multiple UPTs will be created in each departure sector and the extension of these trajectories to variable points with the adjacent ARTCC's airspace will create Free Flight opportunities. New waypoints will be established that will allow GPS-equipped aircraft to fly new, published transitions to arrival routes. In effect, GPS departure/arrival corridors will be created to integrate transitioning aircraft to and from the en-route airspace.

In the en-route airspace, GPS-based "flyways" will be designed by a group of FAA representatives with inputs from system users. Initially, flyways will be developed and tested between the Atlanta and Miami airports. With successful implementation of these flyways, others will be designed for use within Southern-Region airspace and, ultimately, to airports outside of Southern Region.

RNAV Route Development in the Bahamas and Caribbean

Over the past few years, numerous hurricanes and tropical storms have reduced ATC equipment in the Caribbean area to two beacon-only radars and five navigational aids. Establishing and maintaining ATC equipment in the Caribbean is expensive and difficult; on many islands, reliable commercial power and transmission media are not available, and maintenance personnel must be flown in at significant cost. At the same time, Caribbean air traffic continues to increase at approximately eight percent per year.

These difficulties make the Caribbean an ideal place for early development of advanced-navigation, non-ground-based routes. These routes are expected to be eight nautical miles wide with at least two nautical miles between parallel routes. The maximum flight time on a given route would be two hours. The routes would be usable by aircraft equipped with GPS and other RNAV systems. Although the ultimate goal is to design routes for aircraft in a non-radar environment, the routes will be tested on traffic collision avoidance system (TCAS) equipped aircraft in a radar environment for 90 days, evaluated, and then tested again in a radar environment for another 90 days. If the test results are favorable and all participants agree, the project will be expanded to a non-radar environment.

FAA Flight Standards specialists are presently evaluating the new routes. The short-term goal is to implement the new routes by the third quarter of 1999. See Chapter 5 for more information on the development of RNAV routes.

Phoenix Terminal Airspace Analysis

Due to a significant increase in operations, a terminal airspace study has been initiated in Phoenix. The study, which also involves the Albuquerque Center, began in the fall of 1997. This team is addressing the expected increase of arrival and departures in the Phoenix area.

Commercial Space Transportation

The FAA, through the Associate Administrator for Commercial Space Transportation (AST), regulates the U.S. commercial space transportation industry, licenses commercial launches and launch sites, and manages the airspace required for commercial launches to assure safety. Most commercial space launches contain communications, scientific, weather, or remote-sensing satellites. Launches are financed by private corporations, states, the Air Force, and NASA. Unlike airports, where the FAA builds and maintains air traffic control facilities, the FAA has no infrastructure at launch sites.

In January 1998, the first launch from a non-Federal space launch site took place from Spaceport Florida, located at Cape Canaveral.

As of April 1998, there had been 94 licensed launches; all but two launched from one of the following Federal launch sites: Cape Canaveral, White Sands Missile Range, Vandenberg, Wallops Island, and Barking Sands, Hawaii.

In January 1998, the first launch from a non-Federal space launch site took place from Spaceport Florida, located at Cape Canaveral, which was licensed to operate by the FAA in 1997. The FAA has licensed two other commercial spaceports — the California Spaceport at Vandenberg and the Virginia Space Flight Center at Wallops Island. The FAA is currently working with Alaska, Nevada, and New Mexico on other proposed commercial launch sites. The FAA is preparing regulations for licensing commercial launches and launch sites.

AST is currently developing a concept of operations that will address the challenge of integrating new and existing commercial space operations with current air traffic operations in a manner that best promotes system efficiency and safety. The concept of operations will examine Reusable Launch Vehicle (RLV) operational characteristics and airspace requirements, as well as operational and economic impacts of commercial space transportation vehicle operations on other NAS users, from 2005 through 2015.

Chapter 5: New Operational Procedures

This chapter describes recent and developing air traffic control procedures that require little or no investment in new technology. The procedures described in this chapter are grouped by operating environment: en route, oceanic, and terminal/approach procedures. These programs will increase capacity by giving pilots more flexibility in determining their routes, altitude, speed, and departure and landing times. Modernization of the National Airspace System (NAS) equipment over the next decade will provide additional opportunities to develop procedures that take advantage of new technological capabilities.

En Route Procedures

Several procedural initiatives will improve pilots' ability to plan and fly direct routes. These direct routing procedures allow increased system capacity, efficiency, and economy. A few of these procedures, as well as other en route procedures, are described below.

Area Navigation (RNAV)

RNAV is a generic term that refers to any instrument navigation performed outside of conventional routes defined by the ground-based navigational aids or by intersections formed by two navigational aids. Technologies such as Flight Management Systems (FMS), LORAN-C, and inertial guidance systems have offered RNAV capability to aircraft, especially commercial carriers, for nearly two decades. With the introduction and widespread acceptance of Global Positioning System (GPS) to civilian aviation in the 1990s, even more aircraft have acquired this capability.

While RNAV offers the potential for more flexibility and greater airspace efficiency, its use is often restricted by air traffic control procedures that are based on established route structures. This is the case in high-density terminal airspace where air traffic controllers rely on the use of departure procedures (DP) and standard terminal arrival routes (STAR) to align and sequence traffic. It is often difficult for controllers to simultaneously accommodate non-standard RNAV arrival and departure procedures with traditional DP and STAR procedures. For this reason, RNAV arrival and departure routes are typically restricted to periods of low traffic.

To make greater use of RNAV capabilities in terminal airspace, the FAA has begun to develop RNAV arrival and departure procedures for the top 50 airports. Four airports currently have published RNAV procedures: Seattle-Tacoma, Milwaukee, Boston, and Houston George Bush. The FAA is currently developing an RNAV departure procedure out of Los Angeles.

For major airports within 500 NM of each other (e.g., Phoenix and Las Vegas), the FAA is exploring the concept of city pair DP/STAR routes whereby the STAR would begin where the DP ends, and en route air traffic control services would not be required. Six RNAV routes have already been implemented in the Caribbean between Florida and the Dominican Republic, San Juan, and Puerto Rico.

Approximately 70 additional RNAV procedures are in various stages of development and the FAA is awaiting commitment from industry carriers to move forward with more RNAV procedures. The FAA is also working on making RNAV routes eligible in non-radar environments, since many flights occur outside of radar range.

The National Route Program (NRP)

NRP flights are only subject to route limitations within a 200 NM radius of take-off or landing.

The NRP gives airlines and pilots increased flexibility in choosing their routes. Aircraft operating under the NRP are not subject to route restrictions such as published preferred IFR routes, letter of agreement requirements, and standard operating procedures. NRP flights are only subject to route limitations within a 200 NM radius of take-off or landing. This flexibility allows airlines to plan and fly the most cost-effective routes and increases the efficiency of the aviation system. NRP operations are currently authorized at or above FL290 across the contiguous United States. The FAA accommodates all flights that want to take advantage of the NRP.

The FAA estimates that approximately 1,200 flights per day participated in the NRP in 1997, saving the aviation industry as much as $65 million, or about $150 per flight. As of February 1998, an average of 1,500 flights a day (more than seven percent of eligible flights) participated in the NRP, with a peak day numbering 1,967. Participation rates are higher on longer flights.

In an effort to expand the NRP and increase participation rates, the FAA has begun to eliminate the 200 NM requirement by developing DP/NRP/STAR procedures. DP/NRP/STAR procedures allow a pilot to enter the NRP using a DP and to exit the NRP using a STAR. DP/NRP/STAR procedures at Denver, Salt Lake City, Minneapolis, and Albuquerque were implemented in May 1998. Procedures are being developed for a number of airports including Seattle, Portland, Atlanta, Kansas City, St.Louis, Dallas/Ft. Worth, Houston, San Antonio, Austin, Atlanta, Nashville, and Memphis, with implementation planned for fall of 1998. The FAA plans to develop and publish additional DP/NRP/STAR procedures every four months, thereby continually improving availability of NRP procedures.

Three-Dimension User Preferred Trajectories (3D UPT) Flight Trials Project

The purpose of the 3D UPT Flight Trials Project is to quantify the savings associated with unrestricted flight. The 3D UPT project differs from the NRP in that it allows unrestricted climb and descent. Under the 3D UPT procedures, the airline operations center plans the route for each phase of flight to maximize efficiency and cost savings. The 3D UPT route includes priority initial departure, unrestricted climb to cruise altitude, and priority descent. After reaching an initial cruise altitude, the pilots fly within a block altitude of 2,000 feet and are free to fly at optimal altitudes based on favorable winds and aircraft performance information.

Five air carriers are taking part in the trials and a sixth may participate in the future. The first trial between Seattle and Minneapolis occurred in February 1998. The trials will continue to run through December 1998 during periods of low traffic (primarily on "red-eye" flights) between three departure airports (Seattle, San Francisco, and Los Angeles) and fourteen arrival airports.

Currently 25 3D UPT flights occur each day. Preliminary time savings estimates range from 10 to 22 minutes per flight compared with non-UPT flights during periods of low traffic. The final results of the trials will be used to quantify the time and money savings that are possible using 3D UPT and to identify those tools needed to allow 3D UPT during periods of moderate to high traffic density.

Increasing Civilian Access to Special Use Airspace (SUA)

Commercial and general aviation (GA) users seek access to Special Use Airspace (SUA) in order to fly more fuel-efficient routes. The FAA is working with the Department of Defense (DOD) and NAS users to develop procedures which will permit greater civilian access to SUA. For these procedures to be effective, more real-time information on SUA availability is needed. Providing civilian users with this information requires the development of software for recording SUA time and altitude availability and ensuring that users have access to the data. Other initiatives to increase access to SUA include cooperative decision-making between the DOD and the FAA on which hours SUA will be active and redefining some SUA boundaries.

The FAA is working with the Department of Defense and NAS users to develop procedures which will permit greater civilian access to SUA.

An operational trial conducted within the Edwards R-2508 airspace complex demonstrated that improved information exchange on the status of SUA can increase civil aircraft use of these military areas. Users also reported fuel savings from these procedures. Due to the success of this trial, the FAA continues to disseminate SUA information on a real-time basis and to allow flights to file flight plans that transverse the Edwards R-2508 airspace complex when not in use by the military.

In a similar effort to expand SUA access, the Denver ARTCC and the U.S. Army collaborated to subdivide a large block of Fort Carson SUA (R-2601) into four smaller blocks defined by altitude. Previously, R-2601 was designated in use by the military continuously to 35,000 feet. The revised airspace and applicable charts now indicate that the airspace from 12,500 feet upwards is now open continuously, unless a NOTAM indicates otherwise.

To maximize the efficiency of SUA usage, the FAA is developing the Special Use Airspace Management System (SAMS) to track SUA availability and to serve as the central information point for SUA schedules. Installation of SAMS began in August 1997 and should be completed by the end of 1998. A second system, the Military Airspace Management System (MAMS), will allow the military's SUA information to be automatically downloaded into SAMS. MAMS will be deployed in 1999.

These systems will allow more precise and consistent information to be available to system users and air traffic managers.

Elimination of Unnecessary ATC-Preferred Routes

While the NRP has increased flexibility for aircraft that fly at higher altitudes and longer distances, flexibility in flights that traverse lower altitudes is also critical to system capacity. ATC-preferred routes are important tools that help air traffic controllers organize traffic flows around major airports and at lower altitudes. There are currently 1,975 ATC-preferred routes. It is estimated that during a given day, pilots using the low altitude system (below 18,000 feet) add approximately 125,000 miles of extra distance to their flight plans as a result of published ATC-preferred routes. In an effort to reduce this inefficiency, the FAA plans to eliminate unnecessary routes.

The primary goal of the published preferred route reduction program (also called P2R2), is to evaluate and validate ATC-preferred routes. Routes found unnecessary will be eliminated, while necessary routes will be maintained or altered. In May 1998, the FAA began the first stage of reduction by suspending 76 ATC-preferred routes in a six-month test phase. If no traffic flow problems arise from the suspension of a particular ATC-preferred route, that ATC-preferred route will be permanently eliminated in October 1998. By early fall 1998, the FAA will begin a second six-month test phase in which 100 or more routes will be suspended.

In May 1998, the FAA began the first stage of reduction by suspending 76 ATC-preferred routes in a six-month test phase.

Using this same six month testing process, an additional 1,300 routes will be analyzed to assess whether they also can be eliminated. The FAA's goal is to eliminate seven percent of the published ATC preferred routes by December 1998.

Oceanic En Route Procedures

Oceanic separation standards are based on limits in the capability of ATC to determine the position and altitude of aircraft. Procedures implemented more than 40 years ago required 2,000 foot separation above FL290 because altimeters in use at that time were less accurate at higher altitudes. The current oceanic ATC system uses filed flight plans and position reports to track an aircraft's progress and ensure horizontal separation is maintained. Position reports, created using high frequency (HF) radio, are infrequent (approximately one report per hour) and require the use of radio operators to relay the messages between pilots and controllers. HF communication is also subject to interference. These deficiencies in communications and surveillance have necessitated horizontal separation minima of 60 to 100 NM laterally, and 15 minutes longitudinally.

The separation minima currently in effect on many oceanic routes limits the ability of controllers to grant preferred wind-efficient routes or preferred altitudes during peak traffic periods. With anticipated increases in air traffic congestion, the associated delays and unavailablity of desired routes will only escalate. As a result of improved navigational capabilities made possible by highly accurate altimeters, advanced navigation, satellite communications, and collision-avoidance systems, however, oceanic separation minima are being incrementally reduced.

Reduced Vertical Separation Minima (RVSM)

The goal of RVSM is to reduce the oceanic vertical separation between FL290 and FL410 from the current 2,000-feet minimum to 1,000-feet minimum. Operational trials of RVSM began in the North Atlantic airspace from FL330 to FL370, inclusive, in March 1997. The trials have shown that fewer flight tracks are required as users take advantage of the available flight levels on prime tracks. Further expansion of the RVSM in the North Atlantic from FL310 to FL390 is planned for Fall 1998. Full implementation for FL290 to 410 should be complete by the year 2001.

RVSM improves system efficiency by increasing the number of available altitudes, allowing aircraft to operate closer to optimum altitudes. It also allows users more flexibility in choosing their desired altitude. Fuel savings from aircraft flying more optimum routes due to RVSM in the North Atlantic are projected to range from 13 to 18 million gallons annually, depending on traffic density.

Fuel savings from aircraft flying more optimum routes due to RVSM in the North Atlantic are projected to range from 13 to 18 million gallons annually, depending on traffic density.

Based on the successful implementation of RVSM in the North Atlantic, users have requested RVSM in the Pacific and the FAA responded by forming a task force to address this user request. The first implementation of RVSM in the Pacific is expected in the Oakland-Anchorage-Tokyo airspace by February 2000.

Reduced Horizontal Separation Minima (RHSM)

In April 1998, oceanic lateral separation standards were reduced from 100 NM to 50 NM in the Anchorage airspace of the North Pacific. Longitudinal separation minima were also reduced in the North Pacific in 1998 from the time-based standard of 15 minutes to 50 NM. The FAA intends to expand the 50 NM lateral and longitudinal separation standards to the Central Pacific airspace for all qualified aircraft by December 1998.

The reduced lateral and longitudinal separation minima will provide increased opportunities for altitude changes to achieve optimum altitudes, fuel efficiency, and time savings. There are also proposed initiatives to further reduce lateral separation minima to 30 NM. However, there is currently no funding for the enhanced automation and technology required to support separation reduction initiatives beyond 50 NM lateral and 50 NM longitudinal.

Terminal Area/Approach Procedures

A number of visual and electronic landing aids at or near airports assist pilots in locating the runway, particularly during IFR weather conditions. Approach procedures have been developed based on the type and accuracy of landing aids available, geography, traffic, and may other factors. Some of these approach procedures are discussed below.

Removal of 250 Knot Speed Limit for Departing Aircraft in Class B Airspace

Aircraft are currently restricted to 250 knots below 10,000 feet mean sea level (MSL). This restriction can constrain capacity by limiting departure rates from busy terminal areas. In June 1997, the FAA began to field test removing the 250-knot speed restriction for departures from Houston Class B airspace. In that field test, controllers were given the authority to remove the speed restriction. American Airlines reviewed a month of efficiency data for 405 Houston departures that participated in the field trial. They found significant savings of approximately half a minute and 100 pounds of fuel per flight.

The evaluation also found that the vast majority of the controllers interviewed believed that it is operationally acceptable for departures to fly faster than 250 knots below 10,000 feet in Class B airspace.

The results of that test were evaluated in terms of the impacts on air traffic controllers, flight crews, and aircraft noise on the ground. The evaluation found that a substantial number of controllers removed the speed restriction for departures when authorized to do so. The evaluation also found that the vast majority of the controllers interviewed believed that it is operationally acceptable for departures to fly faster than 250 knots below 10,000 feet in Class B airspace. All of the pilots interviewed during the test also found the concept operationally acceptable. There were no noise impacts from removing the speed limit that were perceived by the community surrounding the airports within the Class B airspace.

The one concern raised by the test was an apparent increase in the number of aircraft exiting the Class B airspace below 10,000 feet at speeds greater than 250 knots. It was found that aircraft traded altitude for speed during the test and tended to exit the Class B airspace at lower altitudes. Thus aircraft exited through the side of the Class B airspace rather than the top of the Class B airspace, which had previously been the case. Procedures for ensuring that the faster aircraft exit the Class B airspace at or above 10,000 feet are now being developed.

Simultaneous Converging Instrument Approaches (SCIA)

Under existing approach procedures, converging runways can be used for independent streams of arriving aircraft only when the ceiling is at least 1,000 feet and visibility is at least three statute miles. This requirement decreases runway capacity in instrument meteorological conditions (IMC) and causes weather-related delays. Simultaneous approaches cannot be conducted under IMC if the converging runways intersect. However, a new missed-approach procedure, requiring a 95 degree turn and a Flight Management System in the cockpit, may enable SCIA at 650-foot minimums. Following validation and further flight testing, these minimums could be reduced to as little as 500 feet.

In 1997, the Converging Approach Standards Technical Work Group (CASTWG) continued to work toward increasing operational efficiency for users by refining and applying new converging approach procedures. Much of the CASTWG's efforts focused on applying SCIA at Chicago O'Hare's runways 4R and 9R. This application of SCIA would not have increased arrival capacity, but would have removed arrival traffic from the north side of airport, greatly increasing departure capacity and reducing departure delays. However, SCIA will not be applied at O'Hare until concerns about controller's visual contact with aircraft flying FMS-based missed approaches in the busy Chicago airspace are resolved. Efforts to apply SCIA are also being directed toward sites other than Chicago O'Hare; two potential candidates are New Orleans and Houston George Bush airports.

Simultaneous Offset Instrument Approaches (SOIA)

A new combination of technology and procedures called Simultaneous Offset Instrument Approaches is now under development. This combination has the potential to increase airport capacity and reduce delays at airports with closely spaced parallel runways. Using a Precision Runway Monitor, an offset ILS localizer and glide slope, and a new procedure, it may be possible to significantly reduce the minimums for simultaneous approaches to parallel runways with centerlines as close as 700 feet apart. This procedure, illustrated in Figure 5-1, could be applied at San Francisco International Airport and could reduce approach minimums to a ceiling of 1,600 feet and visibility of four miles from the current minimums of 3,000 feet and five miles.

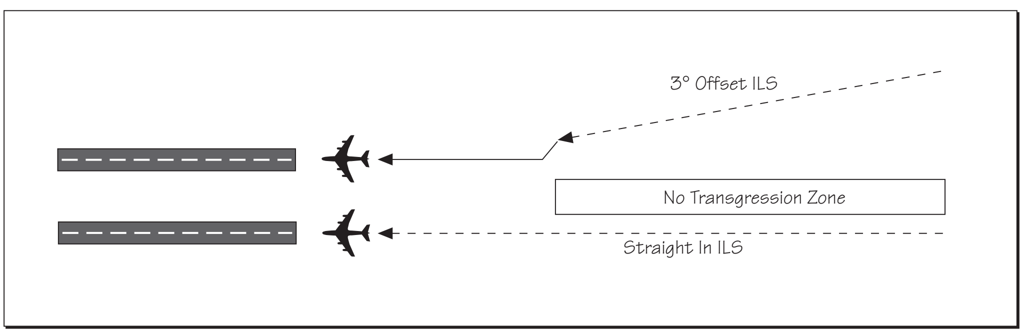


Figure 5-1. Simultaneous Offset Instrument Approach

In the SOIA procedure, pilots on the offset approach would fly a straight-but-angled instrument (and possibly autopilot) approach until descending below the cloud cover. At that point, they would have a period of time to visually acquire the traffic on the other approach until they reach the missed approach point (MAP). If, as expected, the pilots visually acquire the traffic on the other approach before the aircraft reaches the MAP, they would switch to a visual approach and hand-fly the aircraft to the runway.

Other potential candidate sites for SOIA include Newark and Cleveland.

Chapter 6: Capacity Enhancing Technologies

Over the next two decades, the FAA will introduce numerous technologies to the civil aviation system that promise to improve safety and increase the capacity and efficiency of the National Airspace System (NAS). Many of these technologies are being adopted worldwide as part of the transition from traditional air traffic control (ATC), a system based on radio communications, radar surveillance, and ground-based navigation, to a more flexible and efficient airspace management system using digital communications and satellite navigation.

The technologies discussed in this chapter, selected based on their projected benefits to airspace and airport capacity, are described in more detail in the FAA's Capital Investment Plan (CIP), Plan for Research, Engineering, and Development (R,E&D), and NAS Architecture. Several of these technologies are the result of cooperative efforts between the FAA and other governmental organizations, most notably the National Aeronautics and Space Administration (NASA), Department of Defense (DOD), National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA), and International Civil Aviation Organization (ICAO).

Two NASA programs are particularly important as they focus directly on developing technologies to improve air traffic efficiency and capacity. The Terminal Area Productivity (TAP) program seeks to increase capacity and reduce delays by decreasing air traffic spacing requirements between aircraft approaching an airport and by expediting ground operations. The objective of the TAP program is to achieve clear-weather capacity under instrument flight rules (IFR) through the application of innovative technologies. NASA's Advanced Air Transport Technologies (AATT) program is assisting the FAA in developing advanced computer-based analysis, prediction, and display technologies. These technologies are designed to increase the effectiveness of NAS operations by assisting air traffic controllers, dispatchers, and pilots in making decisions that affect the efficiency of flight and surface operations.

Chapter six is divided into five areas: Communications, Navigation, Surveillance, Weather, and Air Traffic Management. For each area, the characteristics of the current system are described, followed by a description of planned enhancements and the key technologies that will make those enhancements possible.

Communications

The exchange of information is vital to all flight operations. This is especially true for large commercial operations that require continual interaction with flight planning and ATC facilities to obtain information concerning weather forecasts, clearances, taxi instructions, expected delays, position reports, air traffic advisories, airport information, etc. Problems in the communication system, such as frequency congestion and interference, impact the overall efficiency of operations. Planned improvements to the communications systems will greatly improve the quality, clarity, and amount of information exchanged among and between aircraft and ground facilities.

Current Communication Capabilities

In domestic airspace, information is typically transmitted and received using voiced air/ground ultra high frequency (UHF) and very high frequency (VHF) radio. As the number of aircraft operations has grown and the demand for information exchange continues to rise, frequency congestion has become increasingly problematic, especially within terminal airspace. This congestion limits the effectiveness of communication, increases controller/pilot workload, creates delays, and increases the likelihood of missed or misinterpreted information. Frequency congestion is largely a result of increased demand for the spectrum available to the FAA. Los Angeles, Chicago, New York, and Atlanta airspace are already out of available channels. As early as 2004, the FAA will be unable to provide additional channel assignments.

In oceanic airspace, long-range air/ground communication is performed through third-party high-frequency (HF) radios — a communication system that is often hampered by lengthy delays and subject to atmospheric interference. The shortcomings inherent in the HF radio system make position reports and ATC approvals for routine pilot clearance requests (i.e., altitude changes for favorable winds) difficult to obtain due to communication delays and uncertainties concerning the location of nearby air traffic.

Planned Communication Enhancements

Between now and 2003, the NAS will add digital communication capabilities through the expanded use of VHF, HF, and satellite data link. As a result of this transition, the volume of information transmitted among aircraft and ground facilities will increase while frequency congestion, interference, delays, and misunderstandings are minimized. Data, especially in the form of text and graphical information, will constitute a much larger portion of all air/ground communications than today.

Aeronautical Data Link Systems

The term data link refers to the overall system for entering, processing, transmitting and displaying voice, alphanumeric, and graphic information between aircraft and ground facilities. Conceptually, data link can be thought of as an information pipeline. Many systems connect with this pipeline, including ground automation, avionics, applications, subnetworks, and transmission equipment.

Today's analog-based data link system — a technology developed over 20 years ago — remains widely in use by airlines for text messaging to aircraft. While useful, the analog system has many technical and capacity limitations due to its slow data transmission rate. To improve data link capabilities, the FAA has adopted the VHF Digital Link (VDL). VDL, being digital, can transmit data at a much higher rate, with greater frequency spectrum efficiency, and with less interference than existing analog systems. The development of VDL is vital to the free flight concept as it supports advances being made in communications, navigation, surveillance, and decision support technologies.

Technical improvements enabled by advanced data link systems and associated services will encompass all domestic operational environments, from the airport surface through all phases of flight. In the oceanic environment, a satellite data link network will be combined with a High Frequency Data Link (HFDL) to improve the exchange of voice and data messages in oceanic airspace. The satellite and HFDL technologies will vastly improve communications coverage, surveillance capabilities, and flexibility in requesting course changes over the ocean.

These new systems will allow for greater on-demand access to important aeronautical information such as airport arrival, departure, and taxi clearance schedules; airborne and surface traffic surveillance information; NAS infrastructure status; and real-time weather. Expanded use of data link technologies in the cockpit will increase the effectiveness of pilot and air traffic controller communications, situational awareness, and collaborative decision making. These changes will improve capacity by reducing congestion on the voice channels and improving airspace usage by allowing more efficient routing, spacing, and sequencing of traffic.

Controller to Pilot Data Link Communications (CPDLC)

The Controller to Pilot Data Link Communications (CPDLC) is a data link service that will improve the speed, quality, and reliability of controller/pilot communications in the terminal and en route environment. To achieve this, the CPDLC will replace sets of controller/pilot voice messages with data messages displayed in the cockpit. By permitting more timely and effective communication of ATC messages, CPDLC will improve airspace use and capacity by reducing frequency congestion and operational errors resulting from verbal miscommunication.

CPDLC will improve airspace use and capacity by reducing frequency congestion and operational errors.

The initial version of CPDLC, which uses a combination of analog and digital data link technologies and supports four uplink messages with corresponding pilot response messages, provides an incremental step for implementing en route data link. CPDLC is a Free Flight Phase 1 (FFP1) technology that will be tested in the en route airspace of the Miami ARTCC. Initial operating capability is expected at Miami by the end of 2001, and national availability by 2003.

The final version of CPDLC, expected in the year 2011, will be an all-digital system that will be fully integrated with air traffic management decision support systems.

Next Generation Air/Ground Communication System (NEXCOM)

Demand for air-to-ground communication frequency assignments is expected to increase four percent annually, a rate unsustainable under the current communications system. If the frequency spectrum is exhausted, overall NAS system expansion will be constrained. To illustrate this, an analysis by the FAA Joint Research Council indicates that of 21 airports planning new runways, 16 will have insufficient frequency spectrum to support them unless communications systems are improved.[1]

In addition to frequency shortages, other deficiencies of the current, analog-based communication system include a lack of data link capability, an inability to overcome channel blockage, and a lack of security against unauthorized users. If not resolved, these deficiencies will increase delays and prevent implementation of new services, or will lead to a curtailment of existing services. Moreover, investment in NAS modernization will not yield expected productivity and efficiency gains.

The Next Generation Air/Ground Communication (NEXCOM) is a digital radio system designed to alleviate the problems of the current system while meeting future requirements. NEXCOM radios will be compatible with existing analog radios. When fully operational, NEXCOM will:

- Increase the number of available voice circuits
- Provide for simultaneous use of frequency for both voice and data communications
- Increase capacity within the available VHF frequency spectrum
- Provide new data link communications capability to all users
- Enable new operational capabilities of advance digital technologies
- Reduce frequency change errors
- Reduce air/ground radio frequency interference
- Provide consistent voice quality over a range of operating conditions

In May 1998, the FAA Joint Resources Council approved the first implementation segment of the NEXCOM program. In this initial segment (2002-2008) ground-based analog radios currently used to transmit voice communications between pilots and controllers will be replaced with new radios installed for communication with aircraft in high and super-high en route airspace. Communications with aircraft flying in the remaining airspace will transition to the new radios in later program segments. Full operational capability is planned for 2015.

1. Vincent Schultz, "Investment Decision for Next-Generation Air/Ground Communication (NEXCOM)," briefing to the FAA Joint Resource Council, May 5, 1998.

Flight Information Service (FIS) and Cockpit Information System (CIS)

The FIS will use a ground-based data server and data links to provide a variety of non-operational control information to the cockpit such as weather products, traffic information, Special Use Airspace (SUA) status, Notices to Airmen, and obstruction updates. The Cockpit Information System (CIS) will process and display FIS information and integrate it with navigation, surveillance, terrain, and other data available in the cockpit. When fully operational, the CIS will also be capable of sending and receiving route requests, via data link, to the air traffic controller. Weather information will be obtained via data link from a ground-based source or from other aircraft. SUA information may be stored prior to flight or may be updated real time while in flight. The primary capacity benefits of FIS/CIS technology are enhanced situational awareness leading to greater flexibility and predictability, and reduced delays resulting from improved planning and more direct routes made possible by current and accurate traffic, environmental, terrain, and NAS resource information. The FAA does not expect to provide significant FIS until deployment of NEXCOM.

The primary capacity benefits of FIS/CIS technology are enhanced situational awareness leading to greater flexibility and predictability, and reduced delays.

Navigation

Aviation navigation systems in use today vary considerably in terms of accuracy, coverage, reliability, and capabilities. The current navigational airways structure and most approach and landing charts are designed principally around the geographic location and technical characteristics of ground-based navigational aids. Future initiatives will enhance the current navigation system by using a more flexible satellite-based system augmented by ground-based systems.

Current Navigation Capabilities

The primary means of aircraft en route navigation in the United States today is the VHF omnidirectional range (VOR) — a system made up of a series of ground stations that broadcast directional signals. These signals are used by aircraft to determine bearings to or from VOR stations. If the VOR and aircraft are equipped with Distance Measuring Equipment (DME), the signals can also be used to determine the distance to VORs. Navigating using VORs typically consists of flying airways (specific radials connecting VOR stations). The location of VOR stations often leads to indirect, inefficient flight paths between an aircraft's origin and destination. However, some avionics are capable of interpreting VOR and/or DME signals to provide Area Navigation (RNAV), allowing for more direct routing of flights. Most new large commercial aircraft are equipped with a Flight Management System (FMS) having multiple DMEs that improve RNAV VOR accuracy.

Landing navigational systems are similar to and in some cases the same as en route systems. Landing aids are classified as precision and non-precision. Precision landing aids refer to systems that can, with a high degree of accuracy, align an aircraft's vertical and horizontal path with a runway to allow for low visibility landings. The Instrument Landing System (ILS) is the primary system used for precision navigation today. The capabilities of ILS systems are defined in three categories, with Category I being the least accurate and Category III being the most accurate.

The satellite-based U.S. Global Positioning System (GPS), managed by DOD, is an alternative to land-based navigation systems that has been steadily gaining in popularity among civil aviation users for much of the last decade. The current GPS system available to civilian users, while not as accurate as many of the ground-based navigational aids, offers several advantages such as: RNAV capability; ease of use; worldwide coverage; and horizontal and vertical position information — a capability lacking in ground-based navigational aids (with the exception of certain precision landing aids). These combined attributes offer pilots more flexibility in determining routes and provide for non-precision approach to any runway. GPS has been extensively tested and is already being used as a primary means of navigation in the oceanic environment.

Planned Navigation Enhancements

The GPS navigation system in use today will become more prevalent, accurate, available, and will have greater integrity. Current GPS capabilities will be further augmented by ground facilities that will allow for precision guidance to landing, thereby expanding the number of precision approaches available during instrument meteorological conditions. On the ground, innovative navigation technologies will assist in efficiently and safely guiding aircraft during low visibility operations. Many existing ground navigation systems will be phased out as these advanced GPS systems come on line.

GPS Wide Area Augmentation System (WAAS)

The Wide Area Augmentation System (WAAS) is an augmentation of GPS that includes integrity broadcasts, differential corrections, and additional ranging signals; its primary object is to provide the accuracy, integrity, availability, and continuity required to support all phases of flight. In doing this, the WAAS system will allow GPS to be used for en route navigation and non-precision approaches throughout the NAS, as well as for making Category (CAT) I approaches to selected airports. WAAS will allow a pilot to determine a horizontal and vertical position within six to seven meters as compared to 100 meter accuracy available from basic GPS service. The wide area of coverage for this system includes the entire United States and some outlying areas.

WAAS will allow a pilot to determine a horizontal and vertical position within six to seven meters as compared to 100 meter accuracy available from basic GPS service.

WAAS consists of a network of ground reference stations that monitor GPS signals. Data from these reference stations are data-linked to master stations, where the validity of the signals from each satellite is assessed and wide area corrections provide a direct verification of the integrity of the signal from each satellite in view. The signals broadcast from the WAAS geo-stationary satellites act as additional sources of GPS ranging signals, thereby improving the availability of the GPS WAAS system.

The last of 25 initial WAAS reference stations was installed in June 1998. Operational and testing activities in preparation for initial WAAS system commissioning will be completed in July 1999, with full-operational WAAS certification expected by December 2001. Most IFR aircraft are anticipated to equip with GPS/WAAS receivers by 2005, at which time the FAA plans to begin reducing VOR/DME, NDB, and ILS service based on the anticipated decrease in the use off these conventional ground-based navigational aids.

Until WAAS is certified as a sole-means precision approach aid, CAT I ILSs will be installed at newly qualifying runways only if there is a clear indication that the benefits exceed the costs. Once GPS/WAAS is available to support CAT I approaches, no new CAT I ILS's will be installed.

GPS Local Area Augmentation System (LAAS)

The Local Area Augmentation System (LAAS) is a differential GPS (DGPS) system which provides localized measurement correction signals to basic GPS signals to improve navigation accuracy, integrity, continuity, and availability of GPS. With these increased capabilities, LAAS will allow for stringent CAT II/III precision landing minimums. The system also provides accurate navigation signals for aircraft and vehicles on the airport surface.

The LAAS system relies on precisely surveyed ground stations, called psuedolites, which are located within the airport area and are used to calculate differential correction and integrity information. This corrected information is transmitted to aircraft within a radius 25-30 nautical miles. One LAAS system can provide service for multiple runways as long as the runway approaches are within the LAAS operational range. By making precision approach procedures available to more airport runways and by extending precision navigation to the airport surface, the LAAS will improve the safety, efficiency, and capacity of airports and surrounding airspace.

The LAAS will improve the safety, efficiency, and capacity of airports and surrounding airspace.

An FAA Joint Resources Council decision in January 1998 approved the development and acquisition of 143 LAAS systems (31 CAT I and 112 CAT III systems). In 1998, the FAA will begin performing specification validation testing of a prototype LAAS ground station located at the FAA Technical Center. Acquisition of LAAS systems is planned to begin in 2003, with full operational capability expected by 2006.

Surveillance

Knowing the position and intended path of aircraft relative to other aircraft — both on the ground and in the air — is necessary to ensure safe separation. The accuracy and certainty with which aircraft positions can be tracked determines the procedures and spacing allowed into maintaining safe operations. Enhancing surveillance improves the efficiency of airspace usage by allowing for reduced separation requirements. In order to realize reduced separation standards, the free flight concept imposes particularly high demands on the ability to accurately and reliably locate and track the movement of aircraft with greater precision and at a faster update rate than is used today.

Current Surveillance Capabilities

Separation is ensured today by visual confirmation, radar imaging, and pilot position reports. Visual separation is common in both general aviation and commercial air transport operations, though its use is limited to clear weather conditions. Radar imaging allows air traffic controllers to see a wide view of aircraft movements and makes possible the task of monitoring and sequencing large numbers of aircraft. Pilot position reports are used particularly in areas where radar coverage is poor or absent and where visual contact cannot be assured.

Planned Surveillance Enhancements

Surveillance coverage and accuracy will be enhanced by incorporating aircraft navigation information with existing radar. This information will be translated into 4-D (three dimensional position plus time) information and made available to pilots and controllers to enhance situational awareness, improve the efficiency of aircraft spacing, allow for greater route flexibility, and heighten conflict avoidance capabilities.

Automated Dependent Surveillance (ADS)

Unlike radar, which tracks aircraft using interrogating radio signals, ADS transmits position reports based on onboard navigational instruments.

To augment existing surveillance procedures and radar, a new system known as Automated Dependent Surveillance (ADS) will be used. Unlike radar, which tracks aircraft using interrogating radio signals, ADS transmits position reports based on onboard navigational instruments. ADS relies on data link technologies to transmit this information. Presently there are two forms of ADS: ADS-Address (ADS-A) and ADS-Broadcast (ADS-B). The ADS-A system exchanges point-to-point information between a specific aircraft and air traffic management facility, while the ADS-B system broadcasts information periodically to all aircraft and all air traffic management facilities within a specified area. The primary objective of ADS-A and ADS-B technology is to improve surveillance coverage, particularly in areas having poor or no radar coverage.

ADS-B will enable transmission of GPS position information, aircraft identification, altitude, velocity vector, and intent information. Airborne surveillance will be obtained using the Cockpit Display of Traffic Information (CDTI) system that will show pilots the relative position and movement of ADS-equipped aircraft in their vicinity. Air traffic controllers will verify ADS positions by superimposing them over primary radar reports. In areas not covered by radar, ADS-B will allow separation requirements for participating aircraft to be reduced from current procedural separation standards, providing greater capacity and increasing the number of approvals for user preferred routes and altitudes.

In the oceanic environment, where separation is now maintained through pilot position reports, the use of ADS-B will have a particularly beneficial impact. Optimum altitudes and speeds will be achieved through the expanded use of oceanic in-trail climb and descent procedures and aircraft will have the flexibility to change routes mid-flight if winds are not as forecast. Because separation requirements will be reduced, more efficient merging of traffic from multiple oceanic tracks onto arrival routes will be possible.

In areas not covered by radar, ADS-B will allow separation requirements for participating aircraft to be reduced from current procedural separation standards.

On the airport surface, ADS-B will be used to assist in taxi operations. ADS-B-equipped aircraft will be displayed directly to flight crews and air traffic controllers on an appropriate overlay map. This capability will give the flight crew information to better evaluate the potential for runway and taxiway incursions, especially at night or in poor visibility, than is available today. The FAA plans to add ADS-A capabilities in Oakland and New York oceanic airspace in the year 2000. With deployment of Standard Terminal Automation Replacement System (STARS) and replacement of the Host computer, the FAA can begin to initially use interrogation of aircraft to receive the ADS-B information, then add additional ground stations to increase surveillance coverage. A fully operational ground system is not scheduled until 2008.

Prior to planned FAA deployment for ADS systems, three cargo carriers will participate in a limited evaluation of the technology. The FAA will provide equipment for the ATC ground stations. Three phases of this initiative will test:

- Aircraft detection using ADS-B information verified by actual traffic information
- Conflict detection and alerting capabilities
- Resolution advisories and evasive maneuvers

This evaluation will take place prior to Safe Flight 21 demonstrations and should help to resolve issues that would otherwise slow the Safe Flight 21 schedule.

Airport Surface Detection Equipment (ASDE-3) and Airport Movement Area Safety System (AMASS)

During periods of low visibility caused by conditions such as rain, fog, and night, the surface movement of aircraft and service vehicles is drastically reduced. To improve the safety and efficiency of ground movement operations in low visibility, controllers require improved monitoring of traffic and early warnings of potential conflicts. Two systems currently being deployed have been designed to meet this objective: Airport Surface Detection Equipment (ASDE-3) and Airport Movement Area Safety System (AMASS).

ASDE-3 is a high-resolution ground mapping radar that provides surveillance of taxiing aircraft and service vehicles at high activity airports. AMASS enhances the function of the ASDE-3 radar by providing automated alerts and warnings to potential runway incursions and other hazards. AMASS can visually and aurally prompt tower controllers to respond to situations which potentially compromise safety. Combined, ASDE-3 and AMASS allow for more efficient and safer airport surface movement operations during low visibility conditions which are currently responsible for numerous airport delays. AMASS and ASDE-3 systems are scheduled for installation and commissioning at 40 airports by the year 2000.

AMASS can visually and aurally prompt tower controllers to respond to situations which potentially compromise safety.

The ADS-B system, using the navigational accuracy of GPS LAAS and combined with upgrades to AMASS, will eventually display accurate surface movement information to pilots and controllers, which may eliminate the need for ADSE-3. To further improve the efficiency of low visibility operations, NASA's Taxi Navigation and Situation Awareness (T-NASA) system combines ADS-B and GPS LAAS technology with advanced visual displays and an audible ground-collision-avoidance system. Early simulations of T-NASA technology have shown that taxi speeds can be safely increased by as much as 25 percent in low visibility operations. Eventually, T-NASA and other surface surveillance technologies being researched by NASA may replace or augment AMASS/ASDE-3 capabilities.

Weather

Weather is the single largest contributor to delay in the civil aviation system and is a major factor in aircraft safety incidents and accidents. Short-term forecasts and timely, accurate weather information on hazardous weather are critical to ensure safe flight and to plan fuel and time-efficient flight plans.

Many of the inefficiencies in today's weather system can be attributed to limitations in the accuracy, predictability, analysis, transmission, coordination, and display of weather data. To mitigate these issues, the FAA will incorporate technologies and procedures to improve the dissemination of consistent, timely, and user-friendly aviation weather information in graphical format available to all users of the aviation system, both ground and airborne. Further, weather information will be improved through the use of better sensors, sophisticated computer modeling, and new automated systems.

Current Weather Capabilities

The timeliness, reliability, and clarity of weather information available to pilots and air traffic controllers is largely determined by the degree of communication and coordination among the many organizations and technical systems that gather and disseminate that information. Weather information is not always accessible to all parties when needed, especially real-time, route-specific information. Even when weather can be predicted accurately and reliably, the air traffic system cannot operate with the same efficiency as in good weather conditions. To maintain safe separation in poor visibility, for example, procedures require that spacing between aircraft is increased due to limitations of current communication, navigation, and surveillance technologies. These procedures create delays both on the ground and in the air.

Planned Weather Enhancements

The FAA is working in conjunction with other agencies such as NASA, National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA) to improve NAS capacity though better forecasting, detection, and dissemination of adverse weather conditions. Other weather-related technology enhancements include new information systems designed to integrate a wide range of weather data into a single database where it can be analyzed using new models. The output of these analytic tools will be displayed in the form of enhanced graphics on new display systems in ATC facilities and in the aircraft cockpit. Data link will be an essential element in the timely dissemination and coordination of weather information to flight crews.

Integrated Terminal Weather System (ITWS)

The Integrated Terminal Weather System (ITWS) is a fully-automated weather-prediction system installed at ARTCCs that will give both air traffic personnel and pilots better information on near-term weather hazards in the airspace within 60 NM miles of an airport. ITWS will work by integrating data from radar, weather sensors, and automated aircraft reports and present the information in easily understood graphics and text. ITWS can generate predictions of weather phenomena such as microbursts, gust fronts, storm cell movements and runway winds up to 30 minutes in advance. ITWS can also display data on the presence of lightning, hail, and tornadoes.

ITWS will work by integrating data from radar, weather sensors, and automated aircraft reports and present the information in easily understood graphics and text.

Additionally, the system will display weather data in tower cabs, TRACONs, and ARTCCs to facilitate coordination among air traffic control personnel. ITWS will free controllers from the labor-intensive task of manually interpreting data from the various weather sensors and will allow them to concentrate on controlling air traffic. Airline dispatchers will receive ITWS data and pilots will receive a simplified version of the ITWS products via the Terminal Weather Information for Pilots program.

ITWS will improve the FAA's ability to minimize the delays caused by localized, hazardous weather, and will increase the margin of safety. Additionally, ITWS will improve traffic flow due to earlier warnings of weather impacts to an airport. By providing accurate, predictive wind information, ITWS will enhance the capabilities of decision-support tools that rely on making accurate aircraft trajectory predictions. Having better wind information will also improve the merging and sequencing of aircraft in the terminal area. In prototype testing, controllers at Dallas-Fort Worth used more accurate wind predictions from the ITWS Terminal Winds Product to pass requests for wind-specific separations to upstream controllers, enabling more accurate aircraft-to-aircraft separations throughout the terminal area.

ITWS testing will begin in 1999. Upon completion of these tests, ITWS will be installed at 34 operational sites covering 45 airports with significant weather hazards. The first system is scheduled to be operational at Memphis in November 2001, with the last installation becoming operational at Dayton, Ohio in February 2003.

Weather and Radar Processor (WARP)

WARP will assist meteorologists in analyzing rapidly changing weather conditions and ATC in managing and minimizing weather-related delays.

Meteorologists working in the weather units of ATC centers do not have an integrated system for collecting and displaying multiple weather sensor inputs, but instead rely on time consuming and inefficient human interpretation of these weather sources. The Weather and Radar Processor (WARP) will collect and process weather data from Low Level Windshear Systems (LLWAS), Next Generation Weather Radar (NEXRAD), Terminal Doppler Weather Radar (TDWR) and surveillance radar, and disseminate this data to controllers, traffic management specialists, pilots, and meteorologists. In addition to the radar information, meteorological observations, warnings, forecasts, lightning strikes, satellite data, and oceanographic information will be received by WARP. Information significant to operations will be sorted and overlaid on ATC displays as they monitor flights. By providing a mosaic of weather information to advanced display systems, WARP will assist meteorologists in analyzing rapidly changing weather conditions and ATC in managing and minimizing weather-related delays. Initial deployment of WARP is planned for 1999 and 2000.

Air Traffic Management

Air traffic management requires gathering and processing large volumes of data to make effective decisions according to ever changing conditions. The development of automated decision support systems will improve the effectiveness of air traffic information and yield more efficient use of airspace.

Current Air Traffic Management Capabilities

Air traffic controllers today use a combination of procedures and automated systems to separate traffic. The decision support systems in use today, however, provide only limited assistance to air traffic controllers. Most routine decisions are made based on the training, experience, and judgment of the individual controllers who must follow a set of narrowly defined air traffic procedures. As the volume of air traffic increases and as procedures allow greater pilot discretion, the efficient management and monitoring of air traffic will require the use of more advanced decision support systems.

Planned Air Traffic Management Enhancements

Numerous technologies are being developed to ensure the efficient and effective collection, transfer, and display of information. Decision support systems will augment these initiatives by coordinating information (e.g., flight plans, weather forecasts, infrastructure status, traffic densities, etc.) from multiple ground, air, and space-based sources and processing this information to improve, with minimum intervention, the effectiveness of flight planning, conflict checking and resolution, and traffic flow management. Graphical output from these analytic tools will assist users in decision making. Advanced decision support systems will enable controllers throughout the system to simultaneously provide greater flexibility, reduce delays in congested airspace, and enhance overall safety.

Several near-term decision support technologies, including five technologies being evaluated in conjunction with FFP1, are described in this section. Figure 6-1 shows the test sites proposed for the FFP1 decision-support technologies.

Facilities	Collaborative Decision Making	Traffic Management Advisor (TMA) – Single Center	Passive Final Approach Spacing Tool (pFAST)	Initial Conflict Probe (ICP)	Surface Movement Advisor (SMA)*
Chicago ARTCC		•	ORD	•	ORD
Fort Worth ARTCC		•	DFW		DFW
Los Angeles ARTCC		•	LAX		
Atlanta ARTCC		•	ATL	•	ATL
Indianapolis ARTCC				•	
Memphis ARTCC				•	
Washington ARTCC				•	
Cleveland ARTCC				•	DTW
Minneapolis ARTCC		•	MSP		
Kansas City ARTCC			STL	•	
New York ARTCC					EWR, PHL, TEB
Oakland ARTCC		•			
Miami ARTCC		•			
Denver ARTCC		•			
ATC System Command Center	•				
Airline Operations Centers	•				

* Full implementation at Atlanta. Limited capabilities at all other FFP1 locations.

Figure 6-1. Candidate Sites for Free Flight Phase 1 Decision Support Technologies

Standard Terminal Automation Replacement System (STARS) and Display System Replacement (DSR)

The Standard Terminal Automation Replacement System (STARS) will replace outdated air traffic control computers with 21st century systems at nine large consolidated TRACONS and approximately 173 FAA and 60 DOD terminal radar approach control sites across the country. STARS will support radar target identification and separation, traffic and weather advisory services, and navigational assistance to aircraft. STARS will also provide safety functions such as conflict alert and minimum safe altitude warning. Improvements, such as better weather displays, will be introduced on the STARS platform to support air traffic management decision support functionality. STARS will also provide the platform for data link communications and Center-TRACON Automation System (CTAS) and Final Approach Spacing Tool (FAST) (described below).

The FAA expects an early display configuration (EDC) of STARS to be operational at Reagan National Airport by March 1999, and an operational readiness demonstration is scheduled for July 1999. An EDC of STARS for Boston Logan International Airport is expected to be operational by the end of 1999. Subsequent deliveries of enhanced versions of STARS to the FAA and DOD facilities are scheduled through 2007.

The STARS' counterpart for en route airspace is the Display System Replacement (DSR). DSR will provide air traffic controllers with a modern digital display system capable of processing and providing information in a fast, reliable manner. DSR will support a conflict probe capability. Twelve DSRs will be delivered to ARTCCs in 1999; full implementation is expected by May 2000.

Collaborative Decision Making (CDM)

Collaborative Decision Making (CDM) is a joint FAA/industry initiative designed to improve traffic flow management through increased interaction and collaboration between airspace users and the FAA. Through improved communication and more efficient use of airline schedules, CDM reduces the use of Ground Delay Programs (GDP) and gives NAS users more flexibility in responding to airport arrival constraints. The FAA runs the GDP programs at major airports when weather, air traffic control (ATC), system outages, airport operational status, and other factors are affected to the point where restricting the flow of aircraft into or out of affected airports is required.

The Flight Schedule Monitor (FSM), a primary component of CDM, is a support tool which collects and displays arrival information, retrieves real-time demand and schedule information, monitors ground delay performance, and provides "what if" analyses capable of projecting arrival rates, slot availability, and departure delays. The FSM is shared among CDM participants and is updated as schedules change.

FSM works by giving participants notice of actual and potential delay issues that can be mitigated or avoided through schedule adjustments. For example, when a GDP is proposed for an airport expected to encounter bad weather, airlines using FSM can cancel a flight and move another aircraft, delayed by the GDP, to arrive at the slot opened by the cancelled flight. This process is known as slot swapping.

Another mechanism for reducing delays using FSM is schedule compression which moves participating flights into newly available slots, thereby compressing the departure schedule and reducing assigned delay. In this process, one airline cancels a flight and offers this open slot to another airline expecting or experiencing a flight delay. The slot opened by the moved flight is then offered back to the original airline for its use, and then to other airlines if it cannot be used by the original airline. Schedule compression and slot swapping activities cascade through the flight schedules and benefit all participating airlines, leading to overall reductions in GDP delays.

Another mechanism for reducing delays using FSM is schedule compression which moves participating flights into newly available slots.

When adjusting schedules using FSM, airlines can make decisions concerning individual slot assignments or they can have the FSM software perform these substitutions automatically. In either case, the FSM flight schedule and the supporting database are continually updated to reflect the results of schedule changes. Operational testing of the FSM prototype was completed in March 1997.

Another component of CDM is the Airline Operations Center Network (AOCNet). AOCNet is a private intranet that provides an enhanced capability for the FAA and airline operations control centers to rapidly exchange and share a single integrated source of CDM-related aeronautical information concerning delays and constraints in the NAS. This network allows airlines to access FAA GDP and Aircraft Situation Display-to-Industry (ASDI) data. ASDI data includes near real-time position and other relevant flight data for every IFR aircraft operating within the NAS subject to traffic flow management planning. Using information provided through the AOCNet, airlines can better manage flight delays by making informed operational decisions in real time. Implementation of AOCNet was completed in March 1997.

CDM is in use at four airports: Newark, New York La Guardia, San Francisco, and St. Louis. Participating airlines include American, Continental, Delta, Southwest, TWA, United, and USAir. Current efforts in the CDM project are being directed toward improving the database of flight information shared between the FAA and the airlines. Following the completion of those improvements, CDM will be expanded to additional airports. A decision on operational acceptability or need for continued testing of CDM is due in 1999.

Center Terminal Radar Approach Control Automation System (CTAS), Traffic Management Advisor (TMA), and Passive Final Approach Spacing Tool (pFAST)

The Center Terminal Radar Approach Control Automation System (CTAS) will provide users with airspace capacity improvement, delay reductions, and fuel savings by introducing computer automation to assist controllers in efficiently descending, sequencing, and spacing arriving aircraft within 200 nautical miles of an airport. CTAS will provide two major functional capabilities in the near term: Single Center Traffic Management Advisor (TMA) and Passive Final Approach Spacing Tool (pFAST). The TMA will provide en route controllers and traffic management coordinators with automation tools to manage the flow of traffic from a single center into selected major airports. It will result in estimated delay reductions of one to two minutes per aircraft during peak periods. The pFAST tool will help controllers select the most efficient arrival runway and arrival sequence within 60 NM of an airport, resulting in increased arrival throughput. The CTAS and FAST technologies are part of NASA's AATT program.

Long term improvements for CTAS include: multi-center TMA capability, required when multiple ARTCCs meter arrivals into a single terminal; descent advisor, which will provide optimized descent point and speed advisories to controllers based on aircraft type; and active FAST, which will help controllers determine how to vector aircraft onto final approach.

Prototype CTAS tools have been installed at Denver, Miami, Los Angeles, Atlanta, and Ft. Worth centers and the Dallas-Ft. Worth TRACON. Installations of the TMA prototypes at the Miami, Los Angeles, and Atlanta centers were operated throughout 1997 with preliminary results showing estimated delay reductions of 1 to 2 minutes per aircraft during peak periods. The FAST prototype at the Dallas-Ft. Worth TRACON has demonstrated an increase in arrival throughput ranging from 4.2 percent to 13 percent during peak periods. Between 2002 and 2004, the FAA is planning to implement TMA at 15 centers, and pFAST at 22 TRACONS between 2002 and 2006.

Initial Conflict Probe (ICP)

The Initial Conflict Probe (ICP), formerly called the User Request Evaluation Tool, provides controllers with the ability to identify potential separation conflicts up to 20 minutes in advance, and to do this with greater precision and accuracy than possible today. By estimating current position and predicted flight paths, ICP checks for potential loss of separation at current and future times. This system can be triggered automatically or manually.

The ICP display supports the strategic planning function and reduces the use by air traffic controllers of manual flight strips. Other potential benefits of ICP include conflict detection in oceanic airspace, greater route flexibility during weather changes, relaxed boundary restrictions, and more efficient routings provided well in advance of, rather than close to, the conflict. A primary capacity benefit of ICP is that it enables more efficient routings that reduce the frequency and magnitude of course changes. A prototype ICP was demonstrated in the Memphis and Indianapolis ARTCCs in 1997; evaluations of the two-way conflict probe at these locations will begin in 1999.

Surface Movement Advisor (SMA)

The Surface Movement Advisor (SMA) is a system developed collaboratively between FAA and NASA that promotes sharing of dynamic information among airlines, airport operators, and air traffic controllers in order to control the efficient flow of aircraft and vehicles on the airport surface. The system provides prediction capabilities to controllers to assist them with increased airport capacity and to help them more efficiently manage operational resources.

SMA uses a decentralized airport situational awareness tool that presents the effects that previous, current, and future arriving and departing aircraft have had and are having on the airport system. It provides help to air traffic controllers, supervisors, and coordinators in selecting optimum airport configurations and specifics on each aircraft before an aircraft leaves the gate. SMA also gives airlines and airport officials touchdown, takeoff, and taxi time predictions.

The SMA software and architecture interfaces with NAS data, airline data, electronic *Official Airlines Guide* (OAG), and airport/ramp tower "pushed-back" and/or "blocked-in" data. The real time data provided by SMA has potentially huge tactical and monetary value. Results of the SMA prototype evaluation at the Hartsfield Atlanta International airport in 1997 show a reduction in taxi times of more than one minute per operation, or over 1,000 minutes per day. These taxi time savings can be translated into commercial airline savings that could potentially be passed on to the customer. Another beneficial result from the SMA prototype was the increased sharing of information that the system facilitated among airport users. Over the next two years, a series of assessment activities and demonstration tests are scheduled for the SMA prototype at the Atlanta airport.

APPENDIX A: AVIATION STATISTICS

Denver International Airport replaced Denver Stapleton International in 1995. Therefore, the data for 1995 reflects the enplanements and operations for Denver Stapleton International.

Table A-1. Airport Operations and Enplanements, 1995, 1996, and 1997[1]

City-Airport	Airport ID	Rank	Enplanements FY95	Enplanements FY96	Enplanements FY97	Operations FY95	Operations FY96	Operations FY97
Chicago O'Hare Int'l Airport	ORD	1	31,611,635	32,174,494	32,621,596	892,330	909,186	892,665
Hartsfield Atlanta Int'l Airport	ATL	2	27,349,930	30,651,427	31,625,414	747,105	772,597	785,854
Los Angeles Int'l Airport	LAX	3	26,146,785	28,247,301	29,105,008	716,293	764,002	780,013
Dallas-Fort Worth Int'l Airport	DFW	4	26,947,281	27,361,201	28,850,595	873,510	869,831	903,006
San Francisco Int'l Airport	SFO	5	16,887,347	18,325,018	19,426,622	436,907	442,281	454,618
Miami Int'l Airport	MIA	6	15,722,329	16,077,377	16,640,458	576,609	546,487	545,883
Detroit Metropolitan Airport	DTW	7	13,990,302	14,967,807	15,856,203	498,887	531,098	547,350
Denver Int'l Airport	DEN	8	14,979,616	15,237,496	15,721,977	487,225	454,234	463,263
New York John F. Kennedy Int'l Airport	JFK	9	14,332,130	15,003,739	15,524,644	345,263	360,511	362,305
Phoenix Sky Harbor Int'l Airport	PHX	10	13,517,238	14,577,015	15,400,209	522,634	544,363	557,746
Las Vegas McCarran Int'l Airport	LAS	11	13,019,859	14,295,208	15,263,550	508,077	479,625	497,115
Newark Int'l Airport	EWR	12	13,446,484	14,204,288	14,810,492	428,703	443,431	461,500
Lambert St. Louis Int'l Airport	STL	13	12,714,579	13,496,561	14,132,514	516,021	517,352	528,746
Minneapolis-St. Paul Int'l Airport	MSP	14	12,301,110	13,382,706	14,061,054	466,916	483,570	496,091
Boston Logan Int'l Airport	BOS	15	11,954,568	12,250,552	12,745,875	478,253	462,507	473,127
Orlando Int'l Airport	MCO	16	10,584,116	11,791,816	12,710,365	343,609	341,942	348,506
George Bush Intercontinental Airport	IAH	17	11,494,226	11,912,957	12,645,469	375,246	391,939	407,844
Seattle-Tacoma Int'l Airport	SEA	18	11,188,640	11,741,706	12,261,521	382,100	397,591	407,243
Honolulu Int'l Airport	HNL	19	11,072,604	11,264,391	11,633,047	376,224	374,965	382,466
Charlotte/Douglas Int'l Airport	CLT	20	10,473,627	10,725,530	11,169,789	474,338	457,054	473,800
New York LaGuardia Airport	LGA	21	10,387,115	10,323,763	10,595,496	346,869	342,618	348,854
Greater Pittsburgh Int'l Airport	PIT	22	9,986,599	10,108,915	10,343,059	452,900	447,436	454,259
Salt Lake City Int'l Airport	SLC	23	8,662,126	9,813,187	10,332,701	349,699	373,815	384,907
Philadelphia Int'l Airport	PHL	24	8,849,175	9,073,360	10,138,019	409,148	406,121	422,493
Greater Cincinnati Int'l Airport	CVG	25	7,095,874	8,782,063	9,523,399	358,203	393,523	413,579
Ronald Reagan National Airport	DCA	26	7,380,226	7,227,361	7,231,903	316,404	309,754	311,105
San Diego Int'l Lindberg Field	SAN	27	6,626,050	6,841,862	7,228,689	228,740	243,595	249,735
Baltimore-Washington Int'l Airport	BWI	28	6,595,515	6,554,638	6,870,058	296,932	270,156	276,477
Tampa Int'l Airport	TPA	29	5,675,105	6,229,896	6,509,377	261,617	272,782	279,196
Portland Int'l Airport	PDX	30	5,454,342	6,060,665	6,420,974	301,785	305,964	316,644
Washington Dulles Int'l Airport	IAD	31	5,713,037	6,039,746	6,183,274	311,279	330,439	337,383
Cleveland Hopkins Int'l Airport	CLE	32	5,333,077	5,429,955	5,710,452	268,097	291,029	300,620
Fort Lauderdale Int'l Airport	FLL	33	4,679,592	5,191,494	5,656,758	238,108	236,342	246,257
Kansas City Int'l Airport	MCI	34	4,692,493	4,971,749	5,239,706	207,518	196,405	205,128
San Juan Int'l Airport	SJU	35	5,050,689	5,025,689	5,216,460	183,082	186,273	188,831
San Jose Int'l Airport	SJC	36	4,335,906	4,778,998	5,028,532	270,519	278,941	283,258
Metropolitan Oakland Int'l Airport	OAK	37	4,720,940	4,809,148	4,931,387	502,952	516,498	522,878
Memphis Int'l Airport	MEM	38	4,215,624	4,579,094	4,731,723	356,294	363,945	380,333
Chicago Midway Airport	MDW	39	4,278,735	4,476,761	4,386,408	268,575	254,351	261,511
New Orleans Int'l Airport	MSY	40	4,133,169	4,186,698	4,345,112	177,383	163,210	165,205
Houston William P. Hobby Airport	HOU	41	3,925,461	3,965,391	4,088,606	245,603	252,254	255,440
Santa Ana John Wayne Airport	SNA	42	3,521,360	3,577,067	3,833,147	493,391	474,976	484,038

1. At the top 100 airports, ranked by 1997 enplanements.

Table A-1. Airport Operations and Enplanements, 1995, 1996, and 1997[1]

City-Airport	Airport ID	Rank	Enplanements FY95	Enplanements FY96	Enplanements FY97	Operations FY95	Operations FY96	Operations FY97
Indianapolis Int'l Airport	IND	43	3,170,445	3,477,759	3,685,658	245,541	235,940	242,783
Sacramento Metropolitan Airport	SMF	44	3,308,376	3,460,728	3,666,453	177,010	174,117	182,496
Nashville Int'l Airport	BNA	45	3,915,839	3,433,435	3,616,408	278,957	226,274	236,235
Dallas-Love Field	DAL	46	3,418,261	3,505,076	3,522,009	208,768	220,651	224,971
San Antonio Int'l Airport	SAT	47	3,066,256	3,283,997	3,485,934	238,315	258,265	254,778
Albuquerque Int'l Airport	ABQ	48	3,079,572	3,235,874	3,412,363	199,114	202,254	205,850
Port Columbus Int'l Airport	CMH	49	2,805,286	3,133,068	3,329,803	204,100	211,434	221,852
Reno Cannon Int'l Airport	RNO	50	2,691,092	3,042,339	3,256,473	151,603	154,234	161,426
Raleigh-Durham Int'l Airport	RDU	51	3,216,256	3,096,367	3,241,335	214,011	227,816	236,057
Ontario Int'l Airport	ONT	52	3,234,261	3,188,397	3,222,359	158,302	153,924	156,500
Austin Municipal Airport	AUS	53	2,652,309	2,808,852	2,968,205	201,409	215,055	210,864
Kahului Airport	OGG	54	2,763,401	2,801,737	2,930,343	178,602	183,046	192,128
Palm Beach Int'l Airport	PBI	55	2,687,516	2,804,201	2,902,804	205,104	202,875	205,884
Milwaukee Int'l Airport	MKE	56	2,527,447	2,662,988	2,798,413	209,939	199,584	209,378
Bradley Int'l Airport	BDL	57	2,519,357	2,667,513	2,792,441	176,382	160,752	163,965
Burbank-Glendale-Pasadena Airport	BUR	58	2,471,234	2,464,662	2,619,946	184,366	184,843	187,945
Colorado Springs Municipal Airport	COS	59	1,125,562	2,316,084	2,477,560	206,192	227,201	234,002
Fort Myers Regional Airport	RSW	60	1,989,677	2,088,515	2,248,101	67,026	71,231	77,088
Anchorage Int'l Airport	ANC	61	2,104,169	1,894,953	1,993,525	217,768	283,611	289,943
Guam Int'l	GUM	62	1,407,688	1,838,771	1,945,988	59,928	61,156	62,697
Jacksonville Int'l Airport	JAX	63	1,816,518	1,823,174	1,937,631	142,786	136,725	144,150
El Paso Int'l Airport	ELP	64	1,861,059	1,808,991	1,903,492	151,905	140,226	139,375
Tucson Int'l Airport	TUS	65	1,713,680	1,753,331	1,875,054	238,024	245,929	249,803
Louisville Standiford Field	SDF	66	1,787,115	1,764,275	1,864,416	178,646	173,152	181,472
Omaha Eppley Airfield	OMA	67	1,462,172	1,710,151	1,838,820	160,039	159,974	167,412
Oklahoma City World Airport	OKC	68	1,680,562	1,733,087	1,809,176	149,275	151,828	154,099
Spokane Int'l Airport	GEG	69	1,494,645	1,631,997	1,748,614	119,701	114,767	121,613
Tulsa Int'l Airport	TUL	70	1,576,745	1,647,923	1,723,077	186,512	199,383	202,888
Greater Buffalo Int'l Airport	BUF	71	1,628,842	1,551,792	1,581,837	153,646	148,404	152,436
Greensboro Int'l Airport	GSO	72	1,846,943	1,448,177	1,542,486	173,259	143,661	150,135
Norfolk Int'l Airport	ORF	73	1,423,899	1,372,199	1,438,941	135,793	139,079	142,930
Birmingham Airport	BHM	74	1,229,411	1,351,333	1,428,405	165,295	160,728	165,140
Little Rock Adams Field	LIT	75	1,273,827	1,269,245	1,355,096	169,312	163,341	167,845
Boise Air Terminal	BOI	76	1,063,795	1,253,019	1,334,821	166,499	179,843	185,650
Lihue Airport	LIH	77	1,160,951	1,233,555	1,304,304	94,439	104,782	110,328
Greater Rochester Int'l Airport	ROC	78	1,249,038	1,213,888	1,293,084	190,053	177,267	183,059
Kailua-Kona Keahole	KOA	79	1,146,240	1,203,305	1,247,768	72,057	73,110	75,520
Providence Green State Airport	PVD	80	1,122,944	1,078,836	1,155,958	133,679	119,355	124,284
Richmond Int'l Airport	RIC	81	1,096,129	1,078,592	1,137,696	153,119	146,105	150,157
Albany County Airport	ALB	82	1,055,983	1,003,412	1,053,131	150,986	132,928	138,122
Syracuse Hancock Int'l Airport	SYR	83	1,026,957	994,271	1,018,227	153,066	145,512	157,544
Dayton Int'l Airport	DAY	84	1,174,318	991,908	996,824	151,248	148,343	150,074

1. At the top 100 airports, ranked by 1997 enplanements.

Table A-1. Airport Operations and Enplanements, 1995, 1996, and 1997[1]

City-Airport	Airport ID	Rank	Enplanements FY95	Enplanements FY96	Enplanements FY97	Operations FY95	Operations FY96	Operations FY97
Des Moines Int'l Airport	DSM	85	740,458	917,160	972,916	137,043	137,698	139,857
Grand Rapids Int'l Airport	GRR	86	801,531	837,568	887,842	151,742	138,020	142,457
Sarasota Bradenton Airport	SRQ	87	783,290	791,734	843,731	145,886	154,833	157,759
Hilo Int'l Airport	ITO	88	717,226	760,001	802,471	81,497	90,024	92,064
Wichita Mid-Continent Airport	ICT	89	613,569	734,820	750,701	177,982	182,186	185,233
Charleston AFB Int'l Airport	CHS	90	750,803	706,168	740,814	137,517	145,025	146,451
Greer Greenville-Spartanburg Airport	GSP	91	704,493	691,467	731,128	58,978	59,371	62,210
Knoxville McGhee-Tyson Airport	TYS	92	663,253	689,864	720,888	136,507	131,598	134,209
Savannah Int'l Airport	SAV	93	567,705	599,210	625,392	95,060	95,472	96,044
Lubbock Int'l Airport	LBB	94	594,641	605,724	620,240	101,944	95,150	89,279
Harrisburg Int'l Airport	MDT	95	658,083	595,720	611,688	83,447	78,161	78,903
Islip Long Island Mac Arthur Airport	ISP	96	565,521	560,144	590,403	188,314	175,750	177,397
Palm Springs Regional Airport	PSP	97	457,423	549,218	582,076	102,072	93,584	96,423
Columbia Metropolitan Airport	CAE	98	596,761	568,892	580,899	106,544	107,107	107,953
Portland Int'l Jetport	PWM	99	562,556	564,580	576,880	120,234	115,032	117,070
Pensacola Regional	PNS	100	563,788	541,690	571,390	119,795	121,576	122,612

Totals:
1995 Enplanements 546,433,494
1996 Enplanements 574,571,82
1997 Enplanements 600,666,080
1995 Operations 26,407,686
1996 Operations 26,534,285
1997 Operations 27,174,071

1. At the top 100 airports, ranked by 1997 enplanements.

Table A-2. Airport Enplanements, 1997 and Forecast 2012[2]

City-Airport	Airport ID	Rank	Enplanements FY97	Enplanements FY2012	% Growth
Chicago O'Hare Int'l Airport	ORD	1	32,621,596	48,498,000	48.7
Hartsfield Atlanta Int'l Airport	ATL	2	31,625,414	46,301,000	46.4
Los Angeles Int'l Airport	LAX	3	29,105,008	48,433,000	66.4
Dallas-Fort Worth Int'l Airport	DFW	4	28,850,595	51,335,000	77.9
San Francisco Int'l Airport	SFO	5	19,426,622	32,664,000	68.1
Miami Int'l Airport	MIA	6	16,640,458	32,826,000	97.3
Detroit Metropolitan Airport	DTW	7	15,856,203	29,272,000	84.6
Denver Int'l Airport	DEN	8	15,721,977	23,022,000	46.4
New York John F. Kennedy Int'l Airport	JFK	9	15,524,644	23,379,000	50.6
Phoenix Sky Harbor Int'l Airport	PHX	10	15,400,209	28,755,000	86.7
Las Vegas McCarran Int'l Airport	LAS	11	15,263,550	31,683,000	107.6
Newark Int'l Airport	EWR	12	14,810,492	23,711,000	60.1
Lambert St. Louis Int'l Airport	STL	13	14,132,514	23,728,000	67.9
Minneapolis-St. Paul Int'l Airport	MSP	14	14,061,054	24,299,000	72.8
Boston Logan Int'l Airport	BOS	15	12,745,875	17,474,000	37.1
Orlando Int'l Airport	MCO	16	12,710,365	27,680,000	117.8
George Bush Intercontinental Airport	IAH	17	12,645,469	23,709,000	87.5
Seattle-Tacoma Int'l Airport	SEA	18	12,261,521	20,103,000	64.0
Honolulu Int'l Airport	HNL	19	11,633,047	18,770,000	61.4
Charlotte/Douglas Int'l Airport	CLT	20	11,169,789	17,870,000	60.0
New York LaGuardia Airport	LGA	21	10,595,496	15,414,000	45.5
Greater Pittsburgh Int'l Airport	PIT	22	10,343,059	16,419,000	58.7
Salt Lake City Int'l Airport	SLC	23	10,332,701	18,175,000	75.9
Philadelphia Int'l Airport	PHL	24	10,138,019	17,269,000	70.3
Greater Cincinnati Int'l Airport	CVG	25	9,523,399	20,734,000	117.7
Ronal Reagan National Airport	DCA	26	7,231,903	9,354,000	29.3
San Diego Int'l Lindberg Field	SAN	27	7,228,689	12,069,000	67.0
Baltimore-Washington Int'l Airport	BWI	28	6,870,058	12,064,000	75.6
Tampa Int'l Airport	TPA	29	6,509,377	10,604,000	62.9
Portland Int'l Airport	PDX	30	6,420,974	12,135,000	89.0
Washington Dulles Int'l Airport	IAD	31	6,183,274	11,461,000	85.4
Cleveland Hopkins Int'l Airport	CLE	32	5,710,452	10,062,000	76.2
Fort Lauderdale Int'l Airport	FLL	33	5,656,758	11,266,000	99.2
Kansas City Int'l Airport	MCI	34	5,239,706	8,042,000	53.5
San Juan Int'l Airport	SJU	35	5,216,460	8,300,000	59.1
San Jose Int'l Airport	SJC	36	5,028,532	9,482,000	88.6
Metropolitan Oakland Int'l Airport	OAK	37	4,931,387	9,205,000	86.7
Memphis Int'l Airport	MEM	38	4,731,723	6,950,000	46.9
Chicago Midway Airport	MDW	39	4,386,408	7,375,000	68.1
New Orleans Int'l Airport	MSY	40	4,345,112	6,734,000	55.0
Houston William P. Hobby Airport	HOU	41	4,088,606	5,945,000	45.4
Santa Ana John Wayne Airport	SNA	42	3,833,147	7,703,000	101.0

2. At the top 100 airports, ranked by 1997 enplanements.

Table A-2. Airport Enplanements, 1997 and Forecast 2012[2]

City-Airport	Airport ID	Rank	Enplanements FY97	Enplanements FY2012	% Growth
Indianapolis Int'l Airport	IND	43	3,685,658	6,844,000	85.7
Sacramento Metropolitan Airport	SMF	44	3,666,453	6,773,000	84.7
Nashville Int'l Airport	BNA	45	3,616,408	6,334,000	75.1
Dallas-Love Field	DAL	46	3,522,009	6,090,000	72.9
San Antonio Int'l Airport	SAT	47	3,485,934	6,571,000	88.5
Albuquerque Int'l Airport	ABQ	48	3,412,363	6,034,000	76.8
Port Columbus Int'l Airport	CMH	49	3,329,803	6,305,000	89.4
Reno Cannon Int'l Airport	RNO	50	3,256,473	6,526,000	100.4
Raleigh-Durham Int'l Airport	RDU	51	3,241,335	5,851,000	80.5
Ontario Int'l Airport	ONT	52	3,222,359	5,328,000	65.3
Austin Municipal Airport	AUS	53	2,968,205	5,374,000	81.1
Kahului Airport	OGG	54	2,930,343	5,249,000	79.1
Palm Beach Int'l Airport	PBI	55	2,902,804	4,392,000	51.3
Milwaukee Int'l Airport	MKE	56	2,798,413	5,176,000	85.0
Bradley Int'l Airport	BDL	57	2,792,441	4,986,000	78.6
Burbank-Glendale-Pasadena Airport	BUR	58	2,619,946	5,179,000	97.7
Colorado Springs Municipal Airport	COS	59	2,477,560	4,429,000	78.8
Fort Myers Regional Airport	RSW	60	2,248,101	4,937,000	119.6
Anchorage Int'l Airport	ANC	61	1,993,525	3,298,000	65.4
Guam Int'l	GUM	62	1,945,988	3,864,000	98.6
Jacksonville Int'l Airport	JAX	63	1,937,631	3,667,000	89.3
El Paso Int'l Airport	ELP	64	1,903,492	3,330,000	74.9
Tucson Int'l Airport	TUS	65	1,875,054	3,714,000	98.1
Louisville Standiford Field	SDF	66	1,864,416	3,376,000	81.1
Omaha Eppley Airfield	OMA	67	1,838,820	3,784,000	105.8
Oklahoma City World Airport	OKC	68	1,809,176	3,089,000	70.7
Spokane Int'l Airport	GEG	69	1,748,614	3,513,000	100.9
Tulsa Int'l Airport	TUL	70	1,723,077	2,857,000	65.8
Greater Buffalo Int'l Airport	BUF	71	1,581,837	2,332,000	47.4
Greensboro Int'l Airport	GSO	72	1,542,486	2,967,000	92.4
Norfolk Int'l Airport	ORF	73	1,438,941	2,632,000	82.9
Birmingham Airport	BHM	74	1,428,405	2,592,000	81.5
Little Rock Adams Field	LIT	75	1,355,096	2,652,000	95.7
Boise Air Terminal	BOI	76	1,334,821	2,448,000	83.4
Lihue Airport	LIH	77	1,304,304	2,182,000	67.3
Greater Rochester Int'l Airport	ROC	78	1,293,084	2,364,000	82.8
Kailua-Kona Keahole	KOA	79	1,247,768	1,918,000	53.7
Providence Green State Airport	PVD	80	1,155,958	2,321,000	100.8
Richmond Int'l Airport	RIC	81	1,137,696	1,941,000	70.6
Albany County Airport	ALB	82	1,053,131	1,850,000	75.7
Syracuse Hancock Int'l Airport	SYR	83	1,018,227	1,379,000	35.4

2. At the top 100 airports, ranked by 1997 enplanements.

Table A-2. Airport Enplanements, 1997 and Forecast 2012[2]

City-Airport	Airport ID	Rank	Enplanements FY97	Enplanements FY2012	% Growth
Dayton Int'l Airport	DAY	84	996,824	1,071,000	7.4
Des Moines Int'l Airport	DSM	85	972,916	1,734,000	78.2
Grand Rapids Int'l Airport	GRR	86	887,842	1,589,000	79.0
Sarasota Bradenton Airport	SRQ	87	843,731	1,629,000	93.1
Hilo Int'l Airport	ITO	88	802,471	1,348,000	68.0
Wichita Mid-Continent Airport	ICT	89	750,701	990,000	31.9
Charleston AFB Int'l Airport	CHS	90	740,814	1,352,000	82.5
Greer Greenville-Spartanburg Airport	GSP	91	731,128	1,330,000	81.9
Knoxville McGhee-Tyson Airport	TYS	92	720,888	1,269,000	76.0
Savannah Int'l Airport	SAV	93	625,392	1,100,000	75.9
Lubbock Int'l Airport	LBB	94	620,240	839,000	35.3
Harrisburg Int'l Airport	MDT	95	611,688	881,000	44.0
Islip Long Island Mac Arthur Airport	ISP	96	590,403	1,106,000	87.3
Palm Springs Regional Airport	PSP	97	582,076	1,134,000	94.8
Columbia Metropolitan Airport	CAE	98	580,899	762,000	31.2
Portland Int'l Jetport	PWM	99	576,880	762,000	32.1
Pensacola Regional	PNS	100	571,390	1,046,000	83.1

Totals:

1997 Enplanements 600,666,080

2012 Enplanements 1,026,664,000

2. At the top 100 airports, ranked by 1997 enplanements.

Table A-3. Total Airport Operations, 1997 and Forecast 2012[3]

City-Airport	Airport ID	Rank	Operations FY97	Operations FY2012	% Growth
Dallas-Fort Worth Int'l Airport	DFW	1	903,006	1,403,000	55.4
Chicago O'Hare Int'l Airport	ORD	2	892,665	1,110,000	24.3
Hartsfield Atlanta Int'l Airport	ATL	3	785,854	985,000	25.3
Los Angeles Int'l Airport	LAX	4	780,013	1,037,000	32.9
Phoenix Sky Harbor Int'l Airport	PHX	5	557,746	789,000	41.5
Detroit Metropolitan Airport	DTW	6	547,350	792,000	44.7
Miami Int'l Airport	MIA	7	545,883	778,000	42.5
Lambert St. Louis Int'l Airport	STL	8	528,746	700,000	32.4
Metropolitan Oakland Int'l Airport	OAK	9	522,878	619,000	18.4
Las Vegas McCarran Int'l Airport	LAS	10	497,115	761,000	53.1
Minneapolis-St. Paul Int'l Airport	MSP	11	496,091	685,000	38.1
Santa Ana John Wayne Airport	SNA	12	484,038	625,000	29.1
Charlotte/Douglas Int'l Airport	CLT	13	473,800	613,000	29.4
Boston Logan Int'l Airport	BOS	14	473,127	527,000	11.4
Denver Int'l Airport	DEN	15	463,263	599,000	29.3
Newark Int'l Airport	EWR	16	461,500	611,000	32.4
San Francisco Int'l Airport	SFO	17	454,618	640,000	40.8
Greater Pittsburgh Int'l Airport	PIT	18	454,259	590,000	29.9
Philadelphia Int'l Airport	PHL	19	422,493	551,000	30.4
Greater Cincinnati Int'l Airport	CVG	20	413,579	716,000	73.1
George Bush Intercontinental Airport	IAH	21	407,844	648,000	58.9
Seattle-Tacoma Int'l Airport	SEA	22	407,243	553,000	35.8
Salt Lake City Int'l Airport	SLC	23	384,907	552,000	43.4
Honolulu Int'l Airport	HNL	24	382,466	510,000	33.3
Memphis Int'l Airport	MEM	25	380,333	530,000	39.4
New York John F. Kennedy Int'l Airport	JFK	26	362,305	415,000	14.5
New York LaGuardia Airport	LGA	27	348,854	397,000	13.8
Orlando Int'l Airport	MCO	28	348,506	588,000	68.7
Washington Dulles Int'l Airport	IAD	29	337,383	437,000	29.5
Portland Int'l Airport	PDX	30	316,644	443,000	39.9
Ronal Reagan National Airport	DCA	31	311,105	329,000	5.8
Cleveland Hopkins Int'l Airport	CLE	32	300,620	415,000	38.0
Anchorage Int'l Airport	ANC	33	289,943	333,000	14.9
San Jose Int'l Airport	SJC	34	283,258	348,000	22.9
Tampa Int'l Airport	TPA	35	279,196	367,000	31.4
Baltimore-Washington Int'l Airport	BWI	36	276,477	384,000	38.9
Chicago Midway Airport	MDW	37	261,511	318,000	21.6
Houston William P. Hobby Airport	HOU	38	255,440	303,000	18.6
San Antonio Int'l Airport	SAT	39	254,778	342,000	34.2
Tucson Int'l Airport	TUS	40	249,803	272,000	8.9
San Diego Int'l Lindberg Field	SAN	41	249,735	348,000	39.3
Fort Lauderdale Int'l Airport	FLL	42	246,257	337,000	36.8

3. At the top 100 airports, ranked by 1997 operations.

Table A-3. Total Airport Operations, 1997 and Forecast 2012[3]

City-Airport	Airport ID	Rank	Operations FY97	Operations FY2012	% Growth
Indianapolis Int'l Airport	IND	43	242,783	346,000	42.5
Nashville Int'l Airport	BNA	44	236,235	276,000	16.8
Raleigh-Durham Int'l Airport	RDU	45	236,057	282,000	19.5
Colorado Springs Municipal Airport	COS	46	234,002	300,000	28.2
Dallas-Love Field	DAL	47	224,971	286,000	27.1
Port Columbus Int'l Airport	CMH	48	221,852	280,000	26.2
Austin Municipal Airport	AUS	49	210,864	282,000	33.7
Milwaukee Int'l Airport	MKE	50	209,378	270,000	29.0
Palm Beach Int'l Airport	PBI	51	205,884	222,000	7.8
Albuquerque Int'l Airport	ABQ	52	205,850	266,000	29.2
Kansas City Int'l Airport	MCI	53	205,128	266,000	29.7
Tulsa Int'l Airport	TUL	54	202,888	222,000	9.4
Kahului Airport	OGG	55	192,128	237,000	23.4
San Juan Int'l Airport	SJU	56	188,831	235,000	24.4
Burbank-Glendale-Pasadena Airport	BUR	57	187,945	247,000	31.4
Boise Air Terminal	BOI	58	185,650	237,000	27.7
Wichita Mid-Continent Airport	ICT	59	185,233	209,000	12.8
Greater Rochester Int'l Airport	ROC	60	183,059	222,000	21.3
Sacramento Metropolitan Airport	SMF	61	182,496	251,000	37.5
Louisville Standiford Field	SDF	62	181,472	234,000	28.9
Islip Long Island Mac Arthur Airport	ISP	63	177,397	177,000	-0.2
Little Rock Adams Field	LIT	64	167,845	192,000	14.4
Omaha Eppley Airfield	OMA	65	167,412	219,000	30.8
New Orleans Int'l Airport	MSY	66	165,205	204,000	23.5
Birmingham Airport	BHM	67	165,140	187,000	13.2
Bradley Int'l Airport	BDL	68	163,965	207,000	26.2
Reno Cannon Int'l Airport	RNO	69	161,426	213,000	31.9
Sarasota Bradenton Airport	SRQ	70	157,759	186,000	17.9
Syracuse Hancock Int'l Airport	SYR	71	157,544	190,000	20.6
Ontario Int'l Airport	ONT	72	156,500	195,000	24.6
Oklahoma City World Airport	OKC	73	154,099	168,000	9.0
Greater Buffalo Int'l Airport	BUF	74	152,436	182,000	19.4
Richmond Int'l Airport	RIC	75	150,157	179,000	19.2
Greensboro Int'l Airport	GSO	76	150,135	184,000	22.6
Dayton Int'l Airport	DAY	77	150,074	176,000	17.3
Charleston AFB Int'l Airport	CHS	78	146,451	155,000	5.8
Jacksonville Int'l Airport	JAX	79	144,150	183,000	27.0
Norfolk Int'l Airport	ORF	80	142,930	165,000	15.4
Grand Rapids Int'l Airport	GRR	81	142,457	178,000	24.9
Des Moines Int'l Airport	DSM	82	139,857	158,000	13.0
El Paso Int'l Airport	ELP	83	139,375	144,000	3.3
Albany County Airport	ALB	84	138,122	180,000	30.3

3. At the top 100 airports, ranked by 1997 operations.

Table A-3. Total Airport Operations, 1997 and Forecast 2012[3]

City-Airport	Airport ID	Rank	Operations FY97	Operations FY2012	% Growth
Knoxville McGhee-Tyson Airport	TYS	85	134,209	149,000	11.0
Providence Green State Airport	PVD	86	124,284	158,000	27.1
Pensacola Regional	PNS	87	122,612	136,000	10.9
Spokane Int'l Airport	GEG	88	121,613	165,000	35.7
Portland Int'l Jetport	PWM	89	117,070	131,000	11.9
Lihue Airport	LIH	90	110,328	156,000	41.4
Columbia Metropolitan Airport	CAE	91	107,953	113,000	4.7
Palm Springs Regional Airport	PSP	92	96,423	107,000	11.0
Savannah Int'l Airport	SAV	93	96,044	104,000	8.3
Hilo Int'l Airport	ITO	94	92,064	112,000	21.7
Lubbock Int'l Airport	LBB	95	89,279	92,000	3.0
Harrisburg Int'l Airport	MDT	96	78,903	81,000	2.7
Fort Myers Regional Airport	RSW	97	77,088	137,000	77.7
Kailua-Kona Keahole	KOA	98	75,520	87,000	15.2
Guam Int'l	GUM	99	62,697	74,000	18.0
Greer Greenville-Spartanburg Airport	GSP	100	62,210	75,000	20.6

Totals:

1996 Operations 27,174,071

2011 Operations 35,369,000

3. At the top 100 airports, ranked by 1997 operations.

Table A-4. Growth in Enplanements From 1996 to 1997[4]

City-Airport	Airport ID	Rank	Enplanements FY96	Enplanements FY97	% Growth
Philadelphia Int'l Airport	PHL	1	9,073,360	10,138,019	11.7
Fort Lauderdale Int'l Airport	FLL	2	5,191,494	5,656,758	9.0
Greater Cincinnati Int'l Airport	CVG	3	8,782,063	9,523,399	8.4
Orlando Int'l Airport	MCO	4	11,791,816	12,710,365	7.8
Fort Myers Regional Airport	RSW	5	2,088,515	2,248,101	7.6
Omaha Eppley Airfield	OMA	6	1,710,151	1,838,820	7.5
Santa Ana John Wayne Airport	SNA	7	3,577,067	3,833,147	7.2
Providence Green State Airport	PVD	8	1,078,836	1,155,958	7.1
Spokane Int'l Airport	GEG	9	1,631,997	1,748,614	7.1
Reno Cannon Int'l Airport	RNO	10	3,042,339	3,256,473	7.0
Colorado Springs Municipal Airport	COS	11	2,316,084	2,477,560	7.0
Tucson Int'l Airport	TUS	12	1,753,331	1,875,054	6.9
Las Vegas McCarran Int'l Airport	LAS	13	14,295,208	15,263,550	6.8
Little Rock Adams Field	LIT	14	1,269,245	1,355,096	6.8
Sarasota Bradenton Airport	SRQ	15	791,734	843,731	6.6
Boise Air Terminal	BOI	16	1,253,019	1,334,821	6.5
Greater Rochester Int'l Airport	ROC	17	1,213,888	1,293,084	6.5
Greensboro Int'l Airport	GSO	18	1,448,177	1,542,486	6.5
Burbank-Glendale-Pasadena Airport	BUR	19	2,464,662	2,619,946	6.3
Port Columbus Int'l Airport	CMH	20	3,133,068	3,329,803	6.3
Jacksonville Int'l Airport	JAX	21	1,823,174	1,937,631	6.3
San Antonio Int'l Airport	SAT	22	3,283,997	3,485,934	6.1
George Bush Intercontinental Airport	IAH	23	11,912,957	12,645,469	6.1
Des Moines Int'l Airport	DSM	24	917,160	972,916	6.1
San Francisco Int'l Airport	SFO	25	18,325,018	19,426,622	6.0
Grand Rapids Int'l Airport	GRR	26	837,568	887,842	6.0
Palm Springs Regional Airport	PSP	27	549,218	582,076	6.0
Indianapolis Int'l Airport	IND	28	3,477,759	3,685,658	6.0
Portland Int'l Airport	PDX	29	6,060,665	6,420,974	5.9
Sacramento Metropolitan Airport	SMF	30	3,460,728	3,666,453	5.9
Detroit Metropolitan Airport	DTW	31	14,967,807	15,856,203	5.9
Guam Int'l	GUM	32	1,838,771	1,945,988	5.8
Greer Greenville-Spartanburg Airport	GSP	33	691,467	731,128	5.7
Lihue Airport	LIH	34	1,233,555	1,304,304	5.7
Birmingham Airport	BHM	35	1,351,333	1,428,405	5.7
Louisville Standiford Field	SDF	36	1,764,275	1,864,416	5.7
Austin Municipal Airport	AUS	37	2,808,852	2,968,205	5.7
San Diego Int'l Lindberg Field	SAN	38	6,841,862	7,228,689	5.7
Phoenix Sky Harbor Int'l Airport	PHX	39	14,577,015	15,400,209	5.6
Hilo Int'l Airport	ITO	40	760,001	802,471	5.6
Pensacola Regional	PNS	41	541,690	571,390	5.5
Richmond Int'l Airport	RIC	42	1,078,592	1,137,696	5.5

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

Table A-4. Growth in Enplanements From 1996 to 1997[4]

City-Airport	Airport ID	Rank	Enplanements FY96	FY97	% Growth
Albuquerque Int'l Airport	ABQ	43	3,235,874	3,412,363	5.5
Dallas-Fort Worth Int'l Airport	DFW	44	27,361,201	28,850,595	5.4
Islip Long Island Mac Arthur Airport	ISP	45	560,144	590,403	5.4
Kansas City Int'l Airport	MCI	46	4,971,749	5,239,706	5.4
Nashville Int'l Airport	BNA	47	3,433,435	3,616,408	5.3
Salt Lake City Int'l Airport	SLC	48	9,813,187	10,332,701	5.3
El Paso Int'l Airport	ELP	49	1,808,991	1,903,492	5.2
San Jose Int'l Airport	SJC	50	4,778,998	5,028,532	5.2
Anchorage Int'l Airport	ANC	51	1,894,953	1,993,525	5.2
Cleveland Hopkins Int'l Airport	CLE	52	5,429,955	5,710,452	5.2
Milwaukee Int'l Airport	MKE	53	2,662,988	2,798,413	5.1
Minneapolis-St. Paul Int'l Airport	MSP	54	13,382,706	14,061,054	5.1
Albany County Airport	ALB	55	1,003,412	1,053,131	5.0
Charleston AFB Int'l Airport	CHS	56	706,168	740,814	4.9
Norfolk Int'l Airport	ORF	57	1,372,199	1,438,941	4.9
Baltimore-Washington Int'l Airport	BWI	58	6,554,638	6,870,058	4.8
Lambert St. Louis Int'l Airport	STL	59	13,496,561	14,132,514	4.7
Bradley Int'l Airport	BDL	60	2,667,513	2,792,441	4.7
Raleigh-Durham Int'l Airport	RDU	61	3,096,367	3,241,335	4.7
Kahului Airport	OGG	62	2,801,737	2,930,343	4.6
Tulsa Int'l Airport	TUL	63	1,647,923	1,723,077	4.6
Knoxville McGhee-Tyson Airport	TYS	64	689,864	720,888	4.5
Tampa Int'l Airport	TPA	65	6,229,896	6,509,377	4.5
Seattle-Tacoma Int'l Airport	SEA	66	11,741,706	12,261,521	4.4
Oklahoma City World Airport	OKC	67	1,733,087	1,809,176	4.4
Savannah Int'l Airport	SAV	68	599,210	625,392	4.4
Newark Int'l Airport	EWR	69	14,204,288	14,810,492	4.3
Charlotte/Douglas Int'l Airport	CLT	70	10,725,530	11,169,789	4.1
Boston Logan Int'l Airport	BOS	71	12,250,552	12,745,875	4.0
San Juan Int'l Airport	SJU	72	5,025,689	5,216,460	3.8
New Orleans Int'l Airport	MSY	73	4,186,698	4,345,112	3.8
Kailua-Kona Keahole	KOA	74	1,203,305	1,247,768	3.7
Palm Beach Int'l Airport	PBI	75	2,804,201	2,902,804	3.5
Miami Int'l Airport	MIA	76	16,077,377	16,640,458	3.5
New York John F. Kennedy Int'l Airport	JFK	77	15,003,739	15,524,644	3.5
Memphis Int'l Airport	MEM	78	4,579,094	4,731,723	3.3
Honolulu Int'l Airport	HNL	79	11,264,391	11,633,047	3.3
Denver Int'l Airport	DEN	80	15,237,496	15,721,977	3.2
Hartsfield Atlanta Int'l Airport	ATL	81	30,651,427	31,625,414	3.2
Houston William P. Hobby Airport	HOU	82	3,965,391	4,088,606	3.1
Los Angeles Int'l Airport	LAX	83	28,247,301	29,105,008	3.0
Harrisburg Int'l Airport	MDT	84	595,720	611,688	2.7

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

Table A-4. Growth in Enplanements From 1996 to 1997[4]

City-Airport	Airport ID	Rank	Enplanements FY96	Enplanements FY97	% Growth
New York LaGuardia Airport	LGA	85	10,323,763	10,595,496	2.6
Metropolitan Oakland Int'l Airport	OAK	86	4,809,148	4,931,387	2.5
Syracuse Hancock Int'l Airport	SYR	87	994,271	1,018,227	2.4
Lubbock Int'l Airport	LBB	88	605,724	620,240	2.4
Washington Dulles Int'l Airport	IAD	89	6,039,746	6,183,274	2.4
Greater Pittsburgh Int'l Airport	PIT	90	10,108,915	10,343,059	2.3
Portland Int'l Jetport	PWM	91	564,580	576,880	2.2
Wichita Mid-Continent Airport	ICT	92	734,820	750,701	2.2
Columbia Metropolitan Airport	CAE	93	568,892	580,899	2.1
Greater Buffalo Int'l Airport	BUF	94	1,551,792	1,581,837	1.9
Chicago O'Hare Int'l Airport	ORD	95	32,174,494	32,621,596	1.4
Ontario Int'l Airport	ONT	96	3,188,397	3,222,359	1.1
Dayton Int'l Airport	DAY	97	991,908	996,824	0.5
Dallas-Love Field	DAL	98	3,505,076	3,522,009	0.5
Ronal Reagan National Airport	DCA	99	7,227,361	7,231,903	0.1
Chicago Midway Airport	MDW	100	4,476,761	4,386,408	-2.0

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

Table A-5. Growth in Operations From 1996 to 1997[5]

City-Airport	Airport ID	Rank	Operations FY96	Operations FY97	% Growth
Syracuse Hancock Int'l Airport	SYR	1	145,512	157,544	8.3
Fort Myers Regional Airport	RSW	2	71,231	77,088	8.2
Spokane Int'l Airport	GEG	3	114,767	121,613	6.0
Jacksonville Int'l Airport	JAX	4	136,725	144,150	5.4
Lihue Airport	LIH	5	104,782	110,328	5.3
Greater Cincinnati Int'l Airport	CVG	6	393,523	413,579	5.1
Kahului Airport	OGG	7	183,046	192,128	5.0
Port Columbus Int'l Airport	CMH	8	211,434	221,852	4.9
Milwaukee Int'l Airport	MKE	9	199,584	209,378	4.9
Sacramento Metropolitan Airport	SMF	10	174,117	182,496	4.8
Louisville Standiford Field	SDF	11	173,152	181,472	4.8
Greer Greenville-Spartanburg Airport	GSP	12	59,371	62,210	4.8
Reno Cannon Int'l Airport	RNO	13	154,234	161,426	4.7
Omaha Eppley Airfield	OMA	14	159,974	167,412	4.6
Greensboro Int'l Airport	GSO	15	143,661	150,135	4.5
Memphis Int'l Airport	MEM	16	363,945	380,333	4.5
Kansas City Int'l Airport	MCI	17	196,405	205,128	4.4
Nashville Int'l Airport	BNA	18	226,274	236,235	4.4
Fort Lauderdale Int'l Airport	FLL	19	236,342	246,257	4.2
Providence Green State Airport	PVD	20	119,355	124,284	4.1
Newark Int'l Airport	EWR	21	443,431	461,500	4.1
George Bush Intercontinental Airport	IAH	22	391,939	407,844	4.1
Philadelphia Int'l Airport	PHL	23	406,121	422,493	4.0
Albany County Airport	ALB	24	132,928	138,122	3.9
Dallas-Fort Worth Int'l Airport	DFW	25	869,831	903,006	3.8
Charlotte/Douglas Int'l Airport	CLT	26	457,054	473,800	3.7
Las Vegas McCarran Int'l Airport	LAS	27	479,625	497,115	3.6
Raleigh-Durham Int'l Airport	RDU	28	227,816	236,057	3.6
Portland Int'l Airport	PDX	29	305,964	316,644	3.5
Kailua-Kona Keahole	KOA	30	73,110	75,520	3.3
Cleveland Hopkins Int'l Airport	CLE	31	291,029	300,620	3.3
Greater Rochester Int'l Airport	ROC	32	177,267	183,059	3.3
Boise Air Terminal	BOI	33	179,843	185,650	3.2
Grand Rapids Int'l Airport	GRR	34	138,020	142,457	3.2
Detroit Metropolitan Airport	DTW	35	531,098	547,350	3.1
Palm Springs Regional Airport	PSP	36	93,584	96,423	3.0
Colorado Springs Municipal Airport	COS	37	227,201	234,002	3.0
Salt Lake City Int'l Airport	SLC	38	373,815	384,907	3.0
Indianapolis Int'l Airport	IND	39	235,940	242,783	2.9
Chicago Midway Airport	MDW	40	254,351	261,511	2.8
San Francisco Int'l Airport	SFO	41	442,281	454,618	2.8
Richmond Int'l Airport	RIC	42	146,105	150,157	2.8

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

Table A-5. Growth in Operations From 1996 to 1997[5]

City-Airport	Airport ID	Rank	Operations FY96	Operations FY97	% Growth
Norfolk Int'l Airport	ORF	43	139,079	142,930	2.8
Little Rock Adams Field	LIT	44	163,341	167,845	2.8
Birmingham Airport	BHM	45	160,728	165,140	2.7
Greater Buffalo Int'l Airport	BUF	46	148,404	152,436	2.7
Minneapolis-St. Paul Int'l Airport	MSP	47	483,570	496,091	2.6
San Diego Int'l Lindberg Field	SAN	48	243,595	249,735	2.5
Guam Int'l	GUM	49	61,156	62,697	2.5
Phoenix Sky Harbor Int'l Airport	PHX	50	544,363	557,746	2.5
Seattle-Tacoma Int'l Airport	SEA	51	397,591	407,243	2.4
Tampa Int'l Airport	TPA	52	272,782	279,196	2.4
Baltimore-Washington Int'l Airport	BWI	53	270,156	276,477	2.3
Boston Logan Int'l Airport	BOS	54	462,507	473,127	2.3
Hilo Int'l Airport	ITO	55	90,024	92,064	2.3
Anchorage Int'l Airport	ANC	56	283,611	289,943	2.2
Lambert St. Louis Int'l Airport	STL	57	517,352	528,746	2.2
Washington Dulles Int'l Airport	IAD	58	330,439	337,383	2.1
Los Angeles Int'l Airport	LAX	59	764,002	780,013	2.1
Honolulu Int'l Airport	HNL	60	374,965	382,466	2.0
Bradley Int'l Airport	BDL	61	160,752	163,965	2.0
Denver Int'l Airport	DEN	62	454,234	463,263	2.0
Knoxville McGhee-Tyson Airport	TYS	63	131,598	134,209	2.0
Dallas-Love Field	DAL	64	220,651	224,971	2.0
Orlando Int'l Airport	MCO	65	341,942	348,506	1.9
Santa Ana John Wayne Airport	SNA	66	474,976	484,038	1.9
Sarasota Bradenton Airport	SRQ	67	154,833	157,759	1.9
New York LaGuardia Airport	LGA	68	342,618	348,854	1.8
Albuquerque Int'l Airport	ABQ	69	202,254	205,850	1.8
Portland Int'l Jetport	PWM	70	115,032	117,070	1.8
Tulsa Int'l Airport	TUL	71	199,383	202,888	1.8
Hartsfield Atlanta Int'l Airport	ATL	72	772,597	785,854	1.7
Burbank-Glendale-Pasadena Airport	BUR	73	184,843	187,945	1.7
Ontario Int'l Airport	ONT	74	153,924	156,500	1.7
Wichita Mid-Continent Airport	ICT	75	182,186	185,233	1.7
Tucson Int'l Airport	TUS	76	245,929	249,803	1.6
Des Moines Int'l Airport	DSM	77	137,698	139,857	1.6
San Jose Int'l Airport	SJC	78	278,941	283,258	1.5
Greater Pittsburgh Int'l Airport	PIT	79	447,436	454,259	1.5
Oklahoma City World Airport	OKC	80	151,828	154,099	1.5
Palm Beach Int'l Airport	PBI	81	202,875	205,884	1.5
San Juan Int'l Airport	SJU	82	186,273	188,831	1.4
Houston William P. Hobby Airport	HOU	83	252,254	255,440	1.3
Metropolitan Oakland Int'l Airport	OAK	84	516,498	522,878	1.2

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

Table A-5. Growth in Operations From 1996 to 1997[5]

City-Airport	Airport ID	Rank	Operations FY96	FY97	% Growth
New Orleans Int'l Airport	MSY	85	163,210	165,205	1.2
Dayton Int'l Airport	DAY	86	148,343	150,074	1.2
Charleston AFB Int'l Airport	CHS	87	145,025	146,451	1.0
Harrisburg Int'l Airport	MDT	88	78,161	78,903	0.9
Islip Long Island Mac Arthur Airport	ISP	89	175,750	177,397	0.9
Pensacola Regional	PNS	90	121,576	122,612	0.9
Columbia Metropolitan Airport	CAE	91	107,107	107,953	0.8
Savannah Int'l Airport	SAV	92	95,472	96,044	0.6
New York John F. Kennedy Int'l Airport	JFK	93	360,511	362,305	0.5
Ronal Reagan National Airport	DCA	94	309,754	311,105	0.4
Miami Int'l Airport	MIA	95	546,487	545,883	-0.1
El Paso Int'l Airport	ELP	96	140,226	139,375	-0.6
San Antonio Int'l Airport	SAT	97	258,265	254,778	-1.4
Chicago O'Hare Int'l Airport	ORD	98	909,186	892,665	-1.8
Austin Municipal Airport	AUS	99	215,055	210,864	-1.9
Lubbock Int'l Airport	LBB	100	95,150	89,279	-6.2

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

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

City-Airport	Airport ID	% Growth in Enplanements FY96-FY97	FY97-FY2012	% Growth in Operations FY96-FY97	FY97-FY2012
Albuquerque Int'l Airport	ABQ	5.5	76.8	1.8	29.2
Albany County Airport	ALB	5	75.7	3.9	30.3
Anchorage Int'l Airport	ANC	5.2	65.4	2.2	14.9
Hartsfield Atlanta Int'l Airport	ATL	3.2	46.4	1.7	25.3
Austin Municipal Airport	AUS	5.7	81.1	-1.9	33.7
Bradley Int'l Airport	BDL	4.7	78.6	2	26.2
Birmingham Airport	BHM	5.7	81.5	2.7	13.2
Nashville Int'l Airport	BNA	5.3	75.1	4.4	16.8
Boise Air Terminal	BOI	6.5	83.4	3.2	27.7
Boston Logan Int'l Airport	BOS	4	37.1	2.3	11.4
Greater Buffalo Int'l Airport	BUF	1.9	47.4	2.7	19.4
Burbank-Glendale-Pasadena Airport	BUR	6.3	97.7	1.7	31.4
Baltimore-Washington Int'l Airport	BWI	4.8	75.6	2.3	38.9
Columbia Metropolitan Airport	CAE	2.1	31.2	0.8	4.7
Charleston AFB Int'l Airport	CHS	4.9	82.5	1	5.8
Cleveland Hopkins Int'l Airport	CLE	5.2	76.2	3.3	38
Charlotte/Douglas Int'l Airport	CLT	4.1	60	3.7	29.4
Port Columbus Int'l Airport	CMH	6.3	89.4	4.9	26.2
Colorado Springs Municipal Airport	COS	7	78.8	3	28.2
Greater Cincinnati Int'l Airport	CVG	8.4	117.7	5.1	73.1
Dallas-Love Field	DAL	0.5	72.9	2	27.1
Dayton Int'l Airport	DAY	0.5	7.4	1.2	17.3
Ronal Reagan National Airport	DCA	0.1	29.3	0.4	5.8
Denver Int'l Airport	DEN	3.2	46.4	2	29.3
Dallas-Fort Worth Int'l Airport	DFW	5.4	77.9	3.8	55.4
Des Moines Int'l Airport	DSM	6.1	78.2	1.6	13
Detroit Metropolitan Airport	DTW	5.9	84.6	3.1	44.7
El Paso Int'l Airport	ELP	5.2	74.9	-0.6	3.3
Newark Int'l Airport	EWR	4.3	60.1	4.1	32.4
Fort Lauderdale Int'l Airport	FLL	9	99.2	4.2	36.8
Spokane Int'l Airport	GEG	7.1	100.9	6	35.7
Grand Rapids Int'l Airport	GRR	6	79	3.2	24.9
Greensboro Int'l Airport	GSO	6.5	92.4	4.5	22.6
Greer Greenville-Spartanburg Airport	GSP	5.7	81.9	4.8	20.6
Guam Int'l	GUM	5.8	98.6	2.5	18
Honolulu Int'l Airport	HNL	3.3	61.4	2	33.3
Houston William P. Hobby Airport	HOU	3.1	45.4	1.3	18.6
Washington Dulles Int'l Airport	IAD	2.4	85.4	2.1	29.5
George Bush Intercontinental Airport	IAH	6.1	87.5	4.1	58.9
Wichita Mid-Continent Airport	ICT	2.2	31.9	1.7	12.8
Indianapolis Int'l Airport	IND	6	85.7	2.9	42.5
Islip Long Island Mac Arthur Airport	ISP	5.4	87.3	0.9	-0.2

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

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

City-Airport	Airport ID	% Growth in Enplanements FY96-FY97	% Growth in Enplanements FY97-FY2012	% Growth in Operations FY96-FY97	% Growth in Operations FY97-FY2012
Hilo Int'l Airport	ITO	5.6	68	2.3	21.7
Jacksonville Int'l Airport	JAX	6.3	89.3	5.4	27
New York John F. Kennedy Int'l Airport	JFK	3.5	50.6	0.5	14.5
Kailua-Kona Keahole	KOA	3.7	53.7	3.3	15.2
Las Vegas McCarran Int'l Airport	LAS	6.8	107.6	3.6	53.1
Los Angeles Int'l Airport	LAX	3	66.4	2.1	32.9
Lubbock Int'l Airport	LBB	2.4	35.3	-6.2	3
New York LaGuardia Airport	LGA	2.6	45.5	1.8	13.8
Lihue Airport	LIH	5.7	67.3	5.3	41.4
Little Rock Adams Field	LIT	6.8	95.7	2.8	14.4
Kansas City Int'l Airport	MCI	5.4	53.5	4.4	29.7
Orlando Int'l Airport	MCO	7.8	117.8	1.9	68.7
Harrisburg Int'l Airport	MDT	2.7	44	0.9	2.7
Chicago Midway Airport	MDW	-2	68.1	2.8	21.6
Memphis Int'l Airport	MEM	3.3	46.9	4.5	39.4
Miami Int'l Airport	MIA	3.5	97.3	-0.1	42.5
Milwaukee Int'l Airport	MKE	5.1	85	4.9	29
Minneapolis-St. Paul Int'l Airport	MSP	5.1	72.8	2.6	38.1
New Orleans Int'l Airport	MSY	3.8	55	1.2	23.5
Metropolitan Oakland Int'l Airport	OAK	2.5	86.7	1.2	18.4
Kahului Airport	OGG	4.6	79.1	5	23.4
Oklahoma City World Airport	OKC	4.4	70.7	1.5	9
Omaha Eppley Airfield	OMA	7.5	105.8	4.6	30.8
Ontario Int'l Airport	ONT	1.1	65.3	1.7	24.6
Chicago O'Hare Int'l Airport	ORD	1.4	48.7	-1.8	24.3
Norfolk Int'l Airport	ORF	4.9	82.9	2.8	15.4
Palm Beach Int'l Airport	PBI	3.5	51.3	1.5	7.8
Portland Int'l Airport	PDX	5.9	89	3.5	39.9
Philadelphia Int'l Airport	PHL	11.7	70.3	4	30.4
Phoenix Sky Harbor Int'l Airport	PHX	5.6	86.7	2.5	41.5
Greater Pittsburgh Int'l Airport	PIT	2.3	58.7	1.5	29.9
Pensacola Regional	PNS	5.5	83.1	0.9	10.9
Palm Springs Regional Airport	PSP	6	94.8	3	11
Providence Green State Airport	PVD	7.1	100.8	4.1	27.1
Portland Int'l Jetport	PWM	2.2	32.1	1.8	11.9
Raleigh-Durham Int'l Airport	RDU	4.7	80.5	3.6	19.5
Richmond Int'l Airport	RIC	5.5	70.6	2.8	19.2
Reno Cannon Int'l Airport	RNO	7	100.4	4.7	31.9
Greater Rochester Int'l Airport	ROC	6.5	82.8	3.3	21.3
Fort Myers Regional Airport	RSW	7.6	119.6	8.2	77.7
San Diego Int'l Lindberg Field	SAN	5.7	67	2.5	39.3
San Antonio Int'l Airport	SAT	6.1	88.5	-1.4	34.2

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

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

City-Airport	Airport ID	% Growth in Enplanements FY96-FY97	% Growth in Enplanements FY97-FY2012	% Growth in Operations FY96-FY97	% Growth in Operations FY97-FY2012
Savannah Int'l Airport	SAV	4.4	75.9	0.6	8.3
Louisville Standiford Field	SDF	5.7	81.1	4.8	28.9
Seattle-Tacoma Int'l Airport	SEA	4.4	64	2.4	35.8
San Francisco Int'l Airport	SFO	6	68.1	2.8	40.8
San Jose Int'l Airport	SJC	5.2	88.6	1.5	22.9
San Juan Int'l Airport	SJU	3.8	59.1	1.4	24.4
Salt Lake City Int'l Airport	SLC	5.3	75.9	3	43.4
Sacramento Metropolitan Airport	SMF	5.9	84.7	4.8	37.5
Santa Ana John Wayne Airport	SNA	7.2	101	1.9	29.1
Sarasota Bradenton Airport	SRQ	6.6	93.1	1.9	17.9
Lambert St. Louis Int'l Airport	STL	4.7	67.9	2.2	32.4
Syracuse Hancock Int'l Airport	SYR	2.4	35.4	8.3	20.6
Tampa Int'l Airport	TPA	4.5	62.9	2.4	31.4
Tulsa Int'l Airport	TUL	4.6	65.8	1.8	9.4
Tucson Int'l Airport	TUS	6.9	98.1	1.6	8.9
Knoxville McGhee-Tyson Airport	TYS	4.5	76	2	11

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

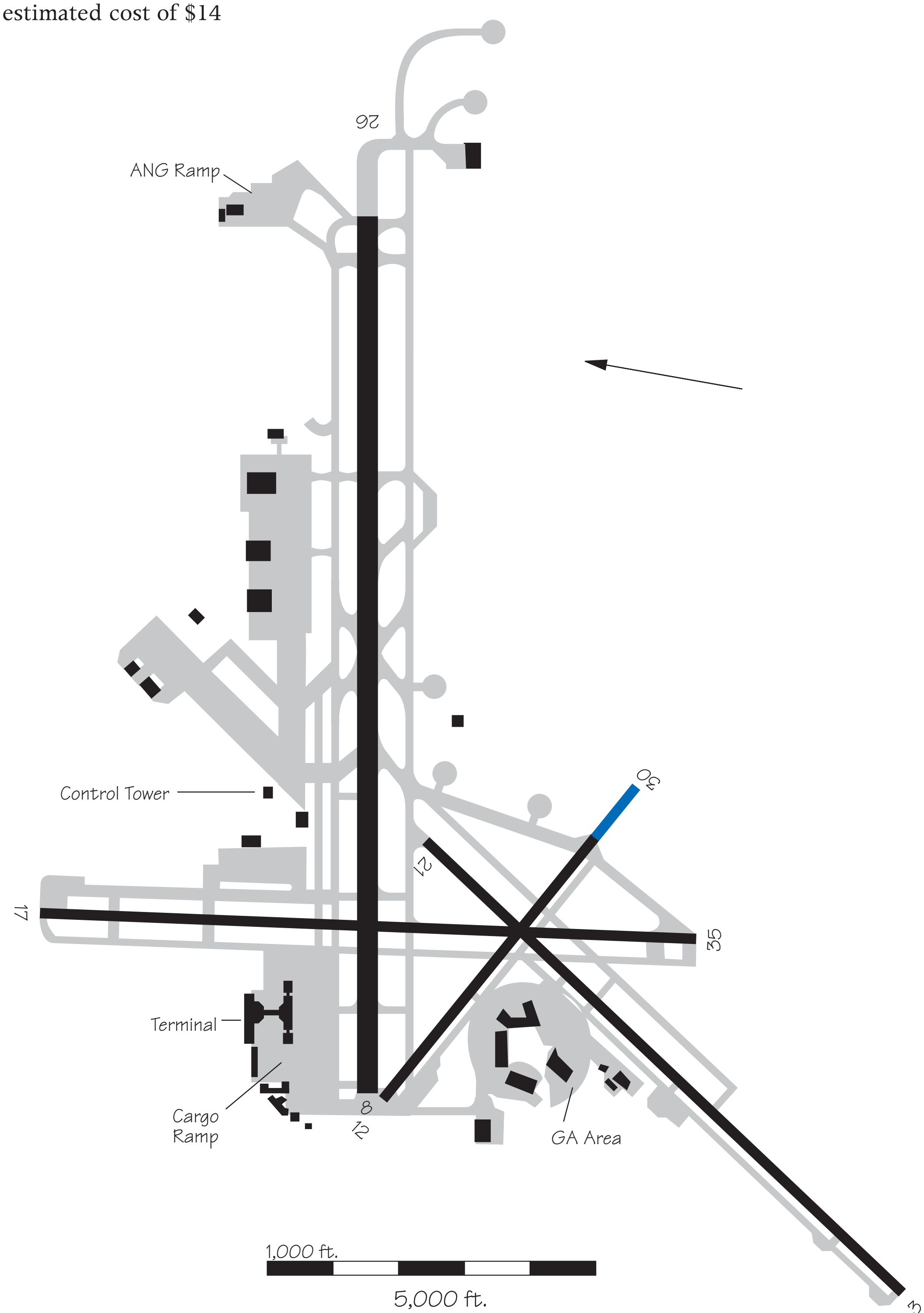
APPENDIX B: TOP 100 AIRPORTS

This appendix contains current airport diagrams for the top 100 airports.[1] For those airports that are considering or have plans for the construction of new runways or extensions to existing runways, the diagrams show the proposed runway and runway extension projects indicated in blue. These diagrams are for illustration only, and should not be used in any way for airport planning purposes. Accompanying the diagrams is a brief narrative of construction projects being planned or considered.

1. Based on 1997 passenger enplanements (see Appendix A, Table A-1).

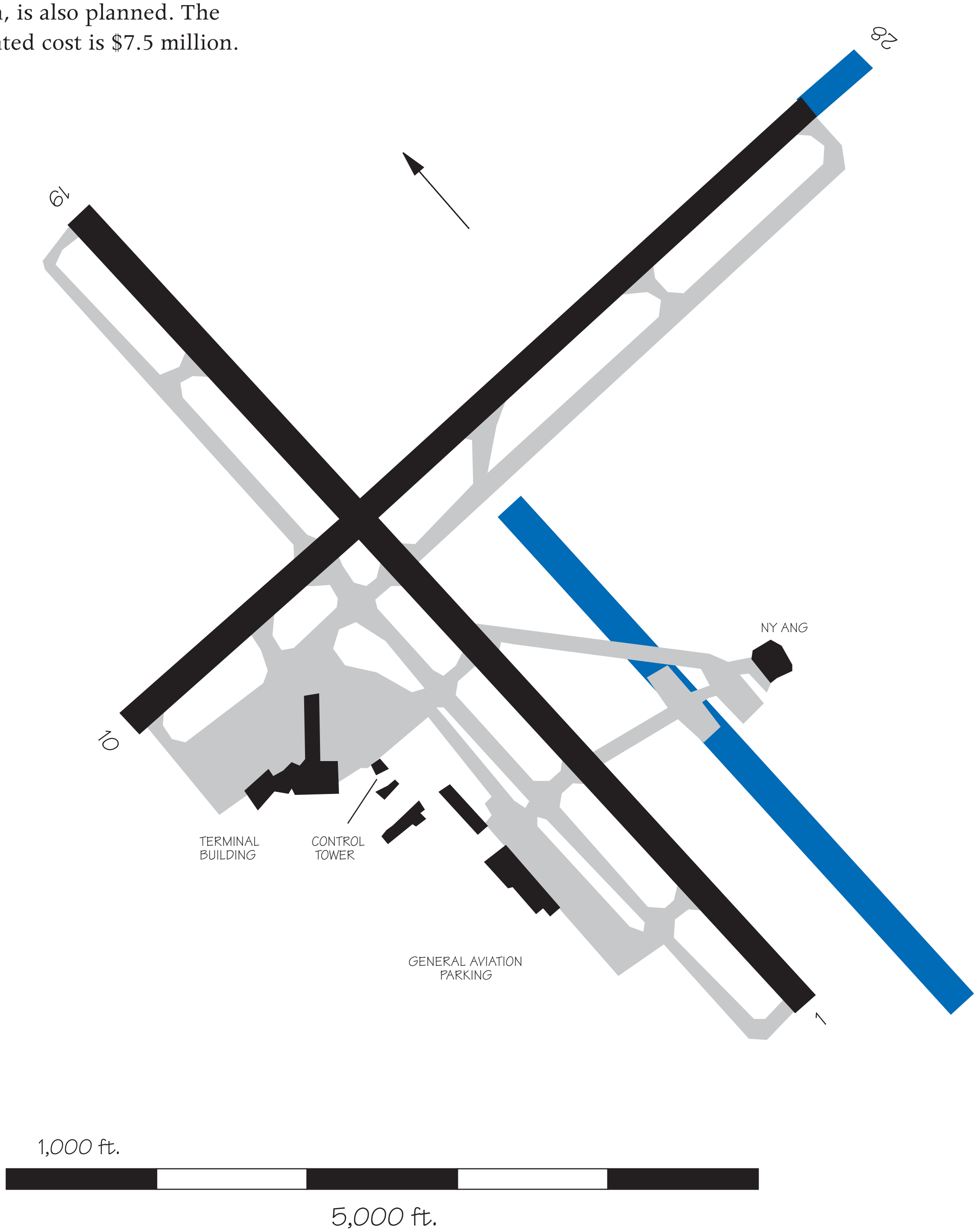
ABQ — Albuquerque International Airport

A 1,000 ft. extension to Runway 12/30 is proposed. It is expected to be operational by 2000, at an estimated cost of $14 million.

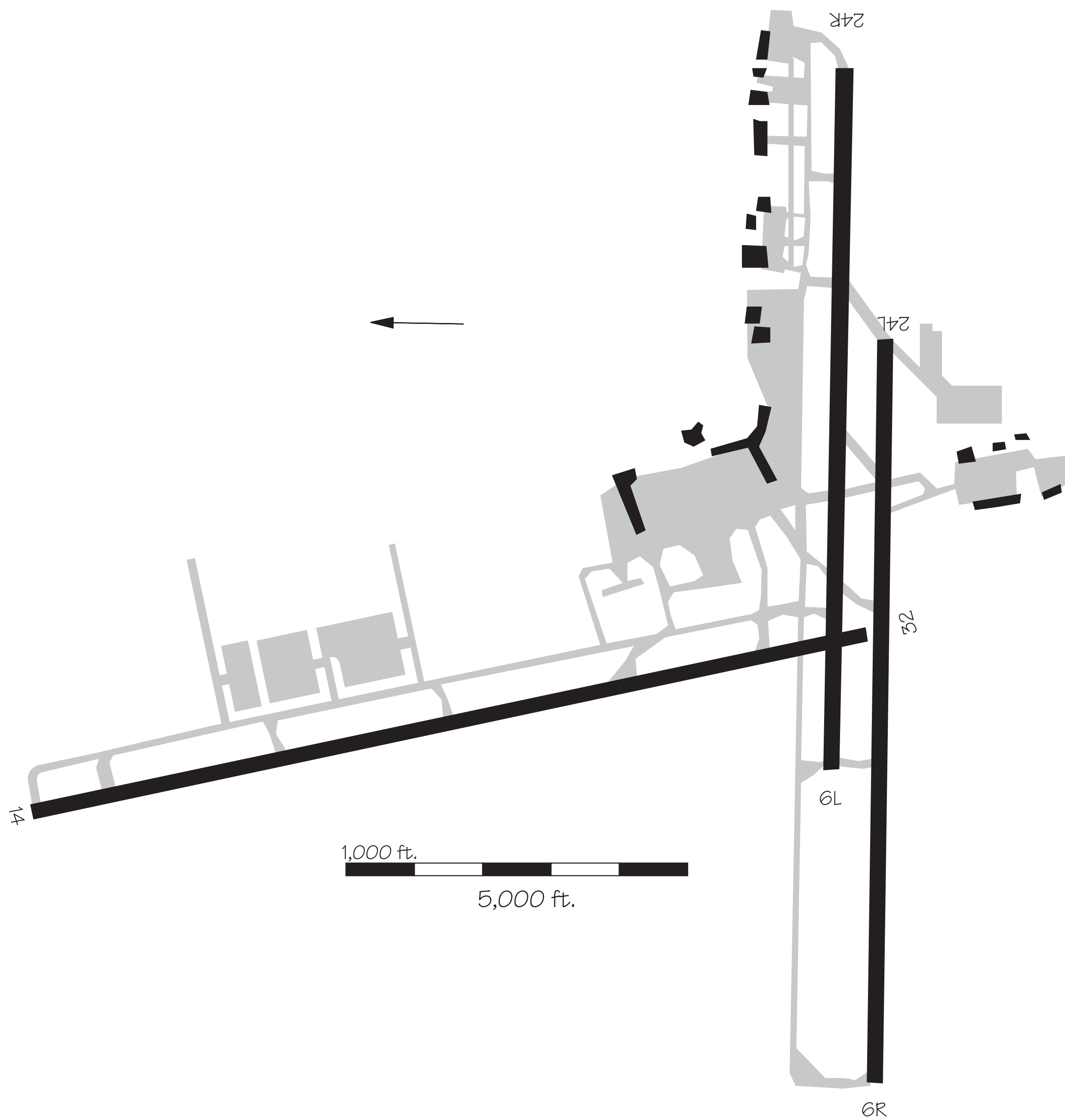


ALB — Albany County Airport

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, 4,850 ft. in length, is also planned. The estimated cost is $7.5 million.

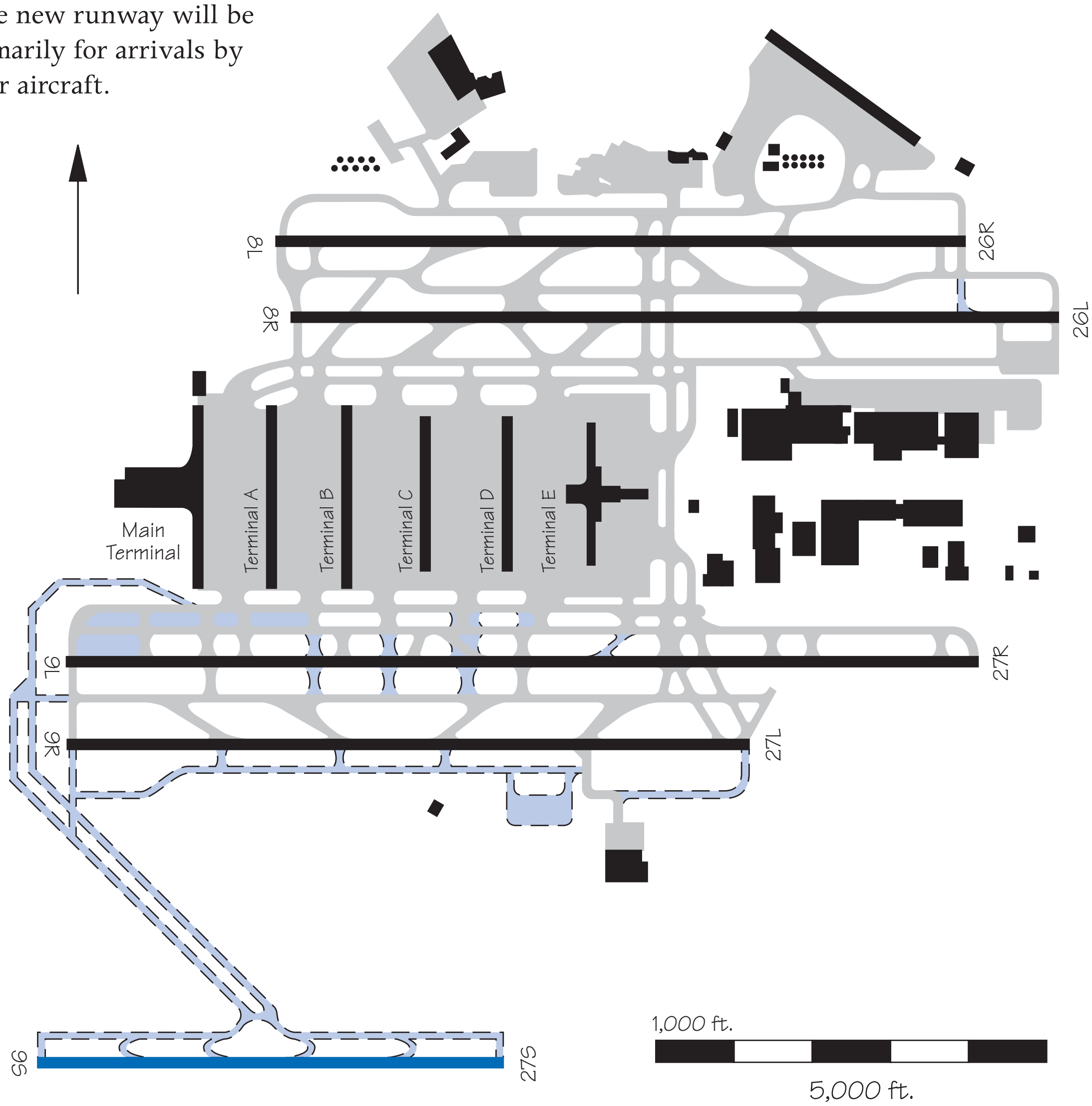


ANC — Anchorage International Airport



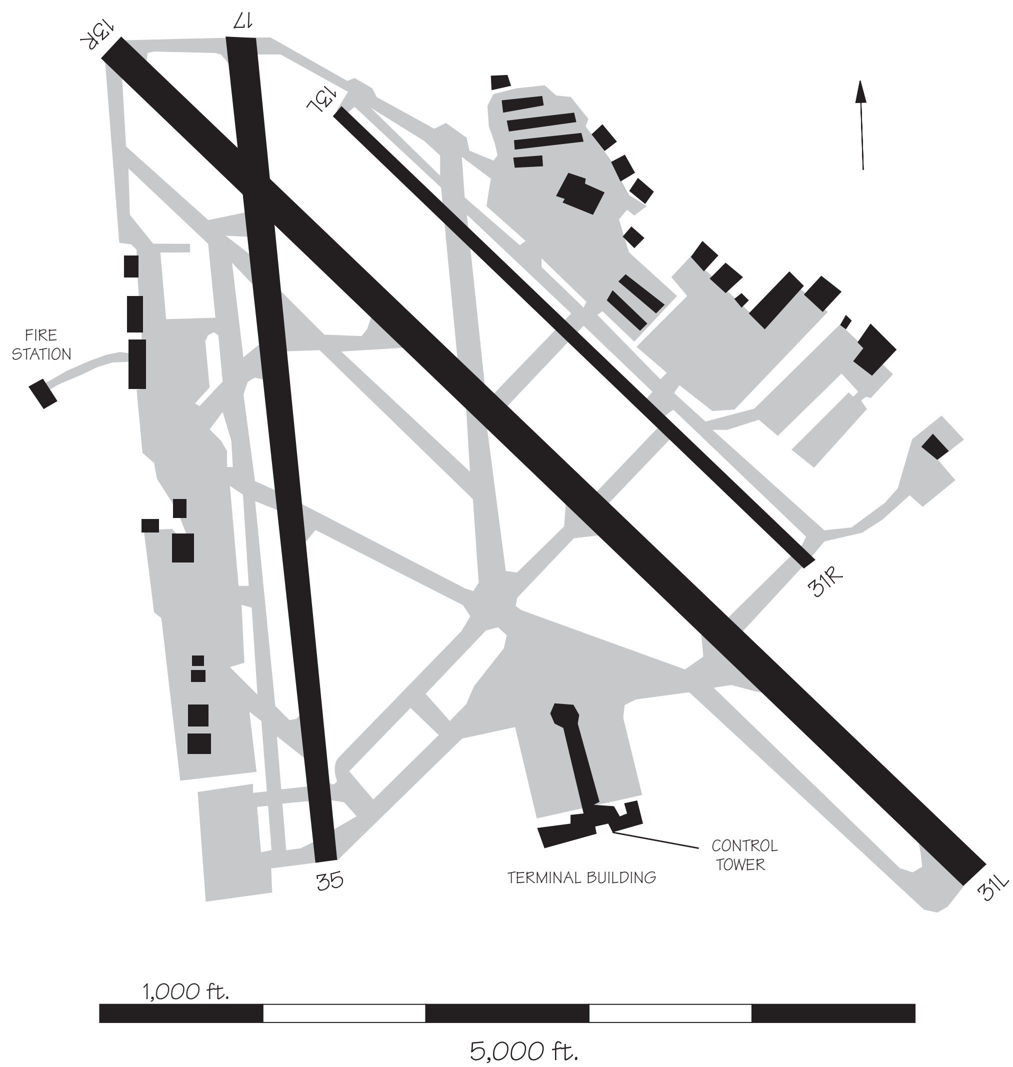
ATL — Hartsfield Atlanta International Airport

A fifth parallel commuter runway, 6,000 ft. long and approximately 4,200 ft. south of Runway 9R/27L, is under design. Land acquisition is ongoing. The runway will permit triple independent IFR approaches using the PRM. The total estimated cost is $440 million. Construction is expected to begin in early 1999. The estimated operational date is early 2002. The new runway will be used primarily for arrivals by commuter aircraft.



AUS — Austin Robert Mueller Municipal Airport

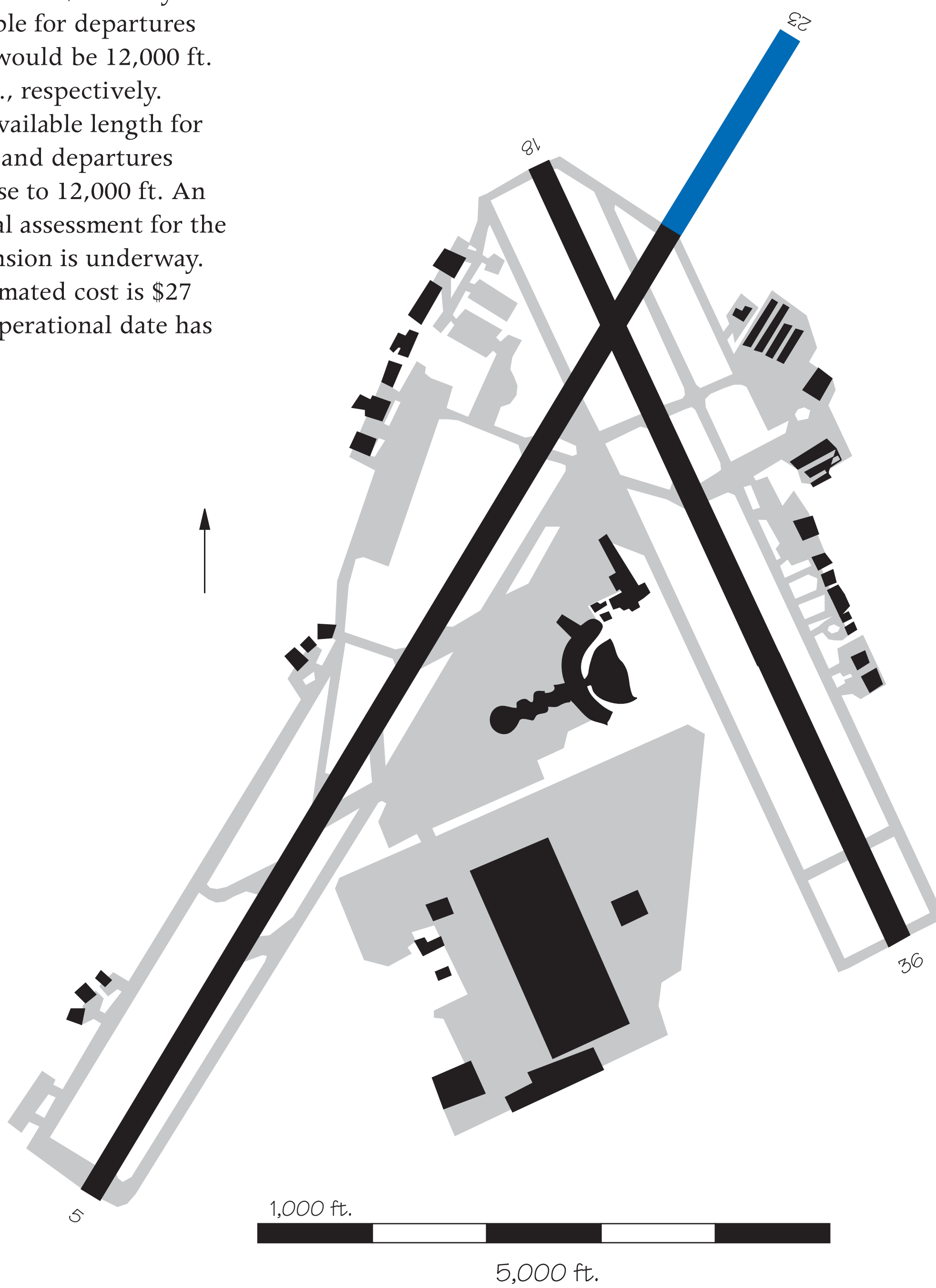
The airport is being replaced by the redeveloped Bergstrom Air Force Base (BSM). See Austin-Bergstrom International Airport (BSM) for details.



BDL — Bradley International Airport

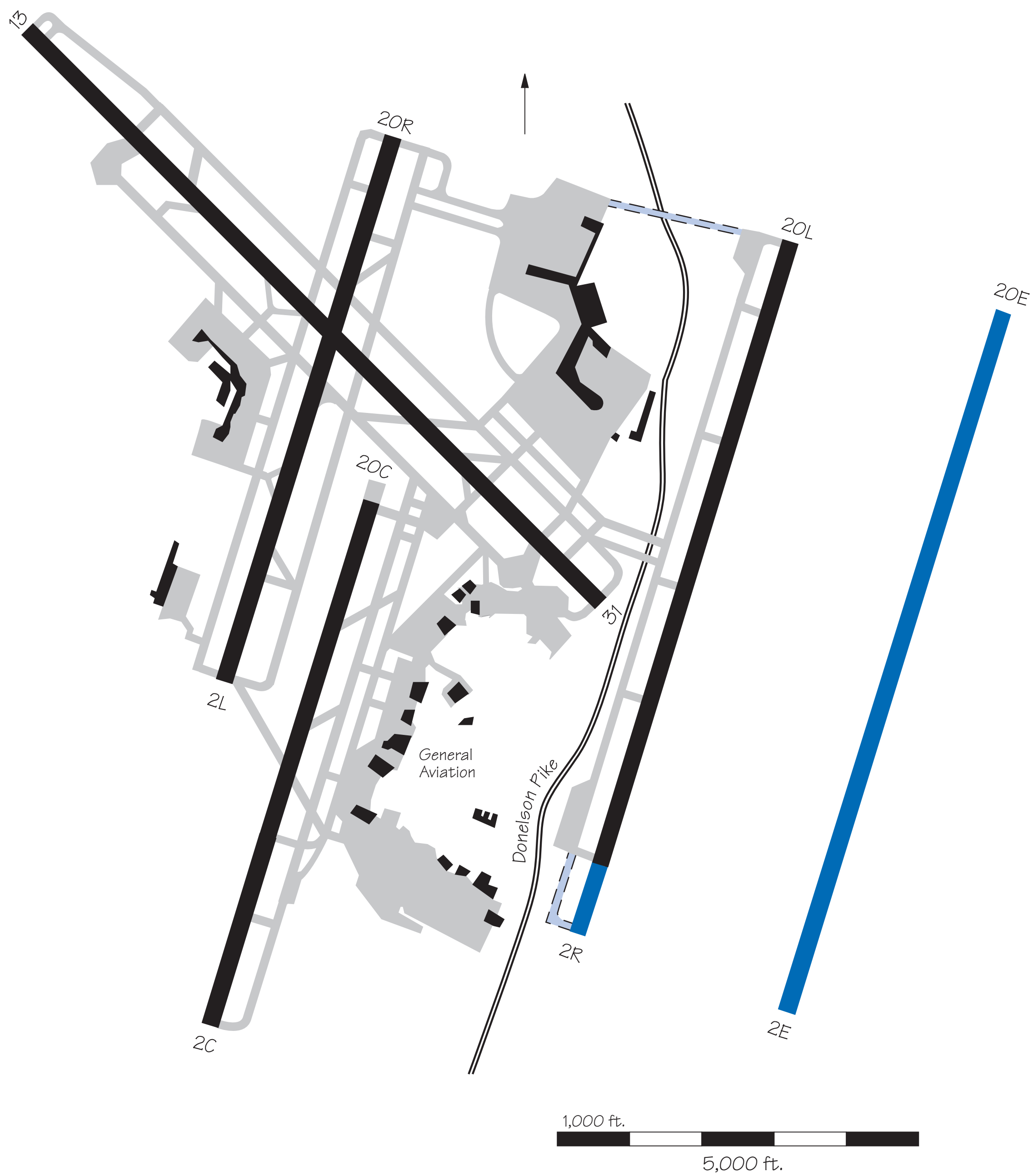
BHM — Birmingham Airport

A 2,000 ft. extension of Runway 5/23 is currently proposed in the Airport's Master Plan. As proposed, the Runway 23 threshold would be displaced 2,000 ft.. Therefore, Runway 23's length available for departures and arrivals would be 12,000 ft. and 10,000 ft., respectively. Runway 5's available length for both arrivals and departures would increase to 12,000 ft. An environmental assessment for the runway extension is underway. The total estimated cost is $27 million. No operational date has been set.



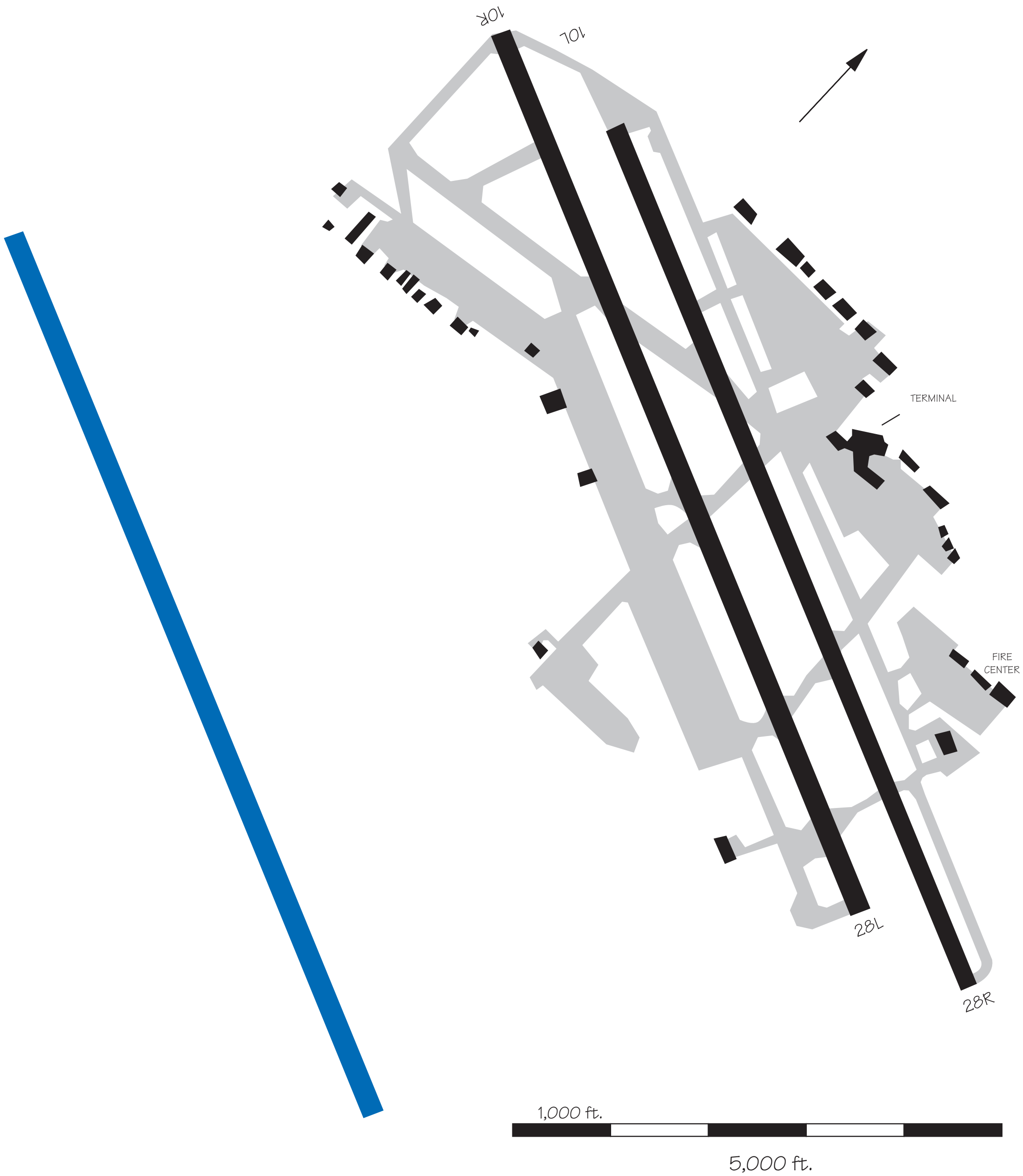
BNA — Nashville International Airport

A new Runway 2E/20E is planned for the future between 1,500 and 3,500 ft. from Runway 2R/20L. In addition, an extension to Runway 2R/20L is planned.



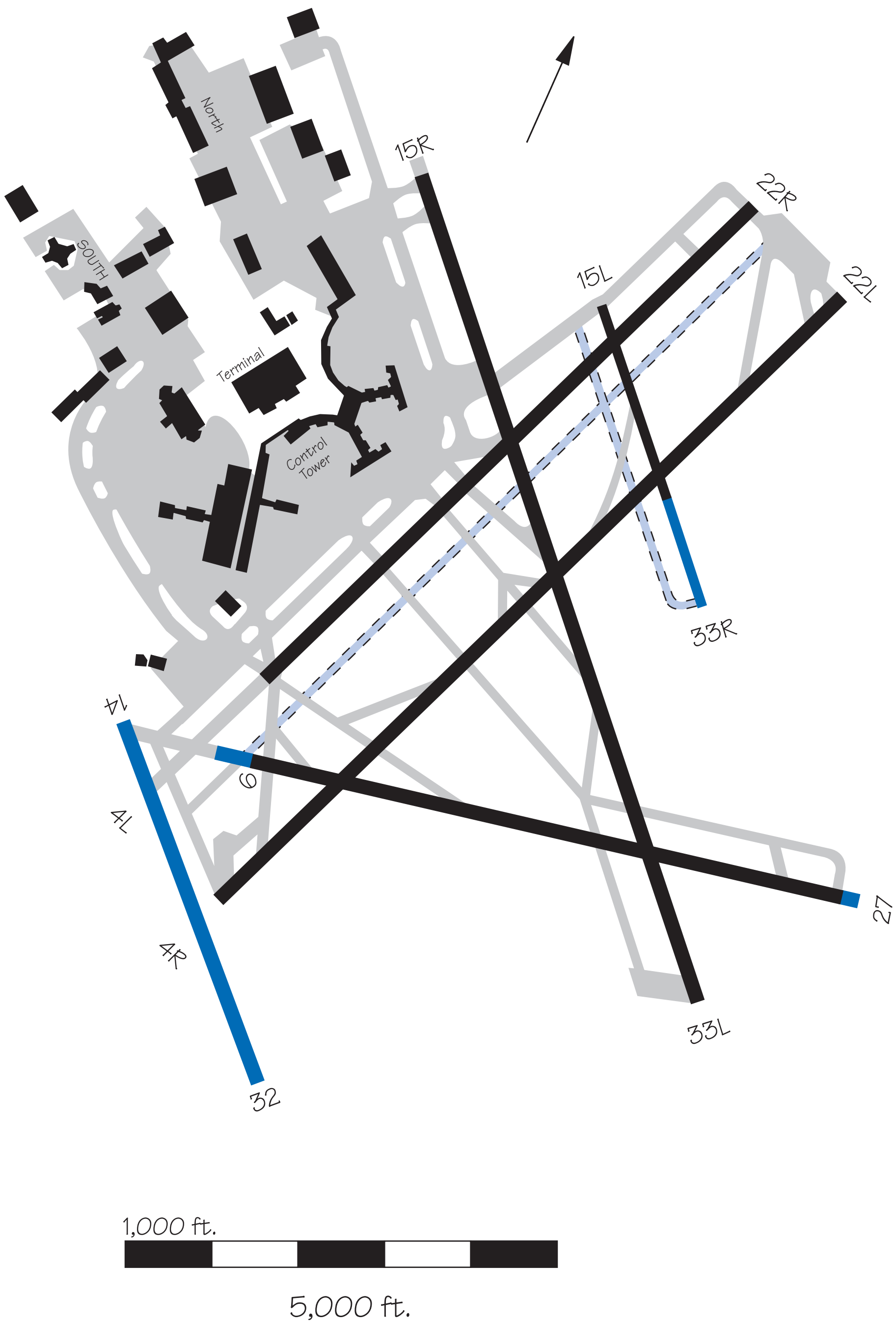
BOI — Boise Air Terminal

A third parallel runway is planned for the long-term future. It is planned 5,400 ft. south of 10R/28L.



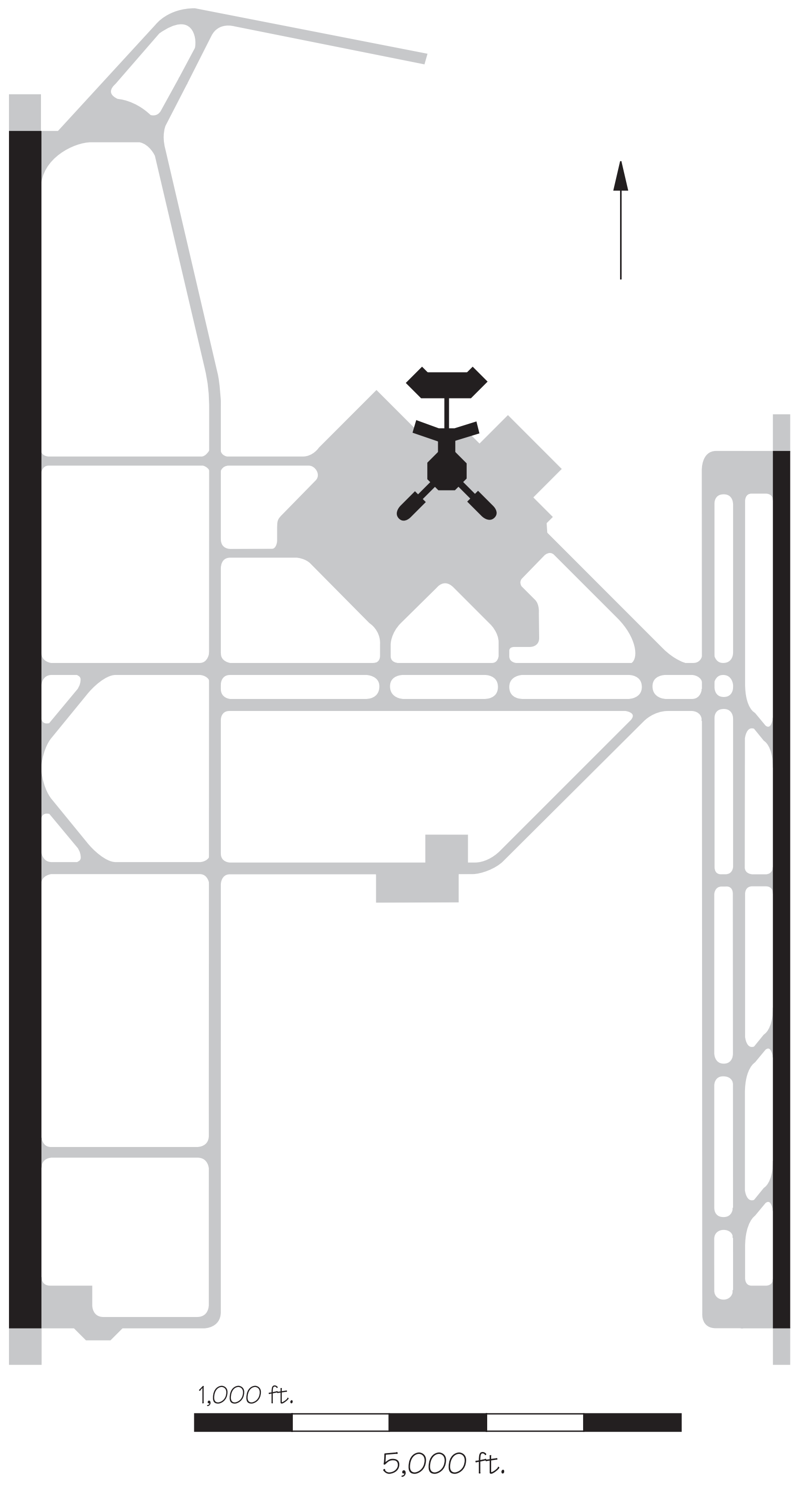
BOS — Boston Logan International Airport

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



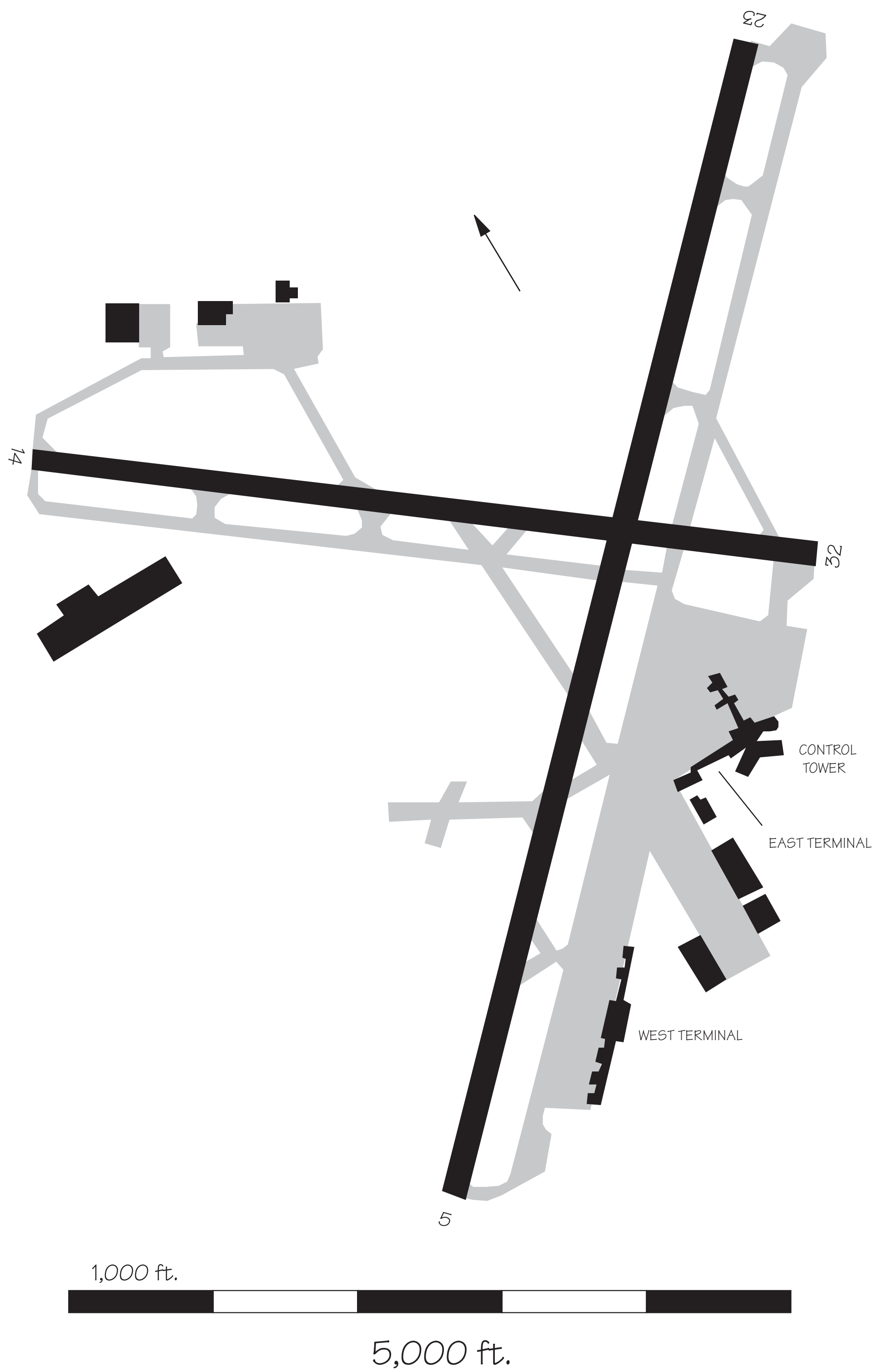
BSM — Austin-Bergstrom International Airport

The community approved and sold approximately $400 million of revenue bonds supporting the redevelopment of the former Bergstrom Air Force base into Austin-Bergstrom International Airport; a replacement airport for the current Robert Mueller Municipal Airport. Austin-Bergstrom International Airport opened for air cargo operations on June 28, 1997. The airport will be opened for air passenger and general aviation operations on May 1, 1999. The new facilities include a recently completed new 9,000 ft. x 150 ft. Runway 17R/35L, as well as associated taxiways, crossfield taxiways, as well as air cargo, air passenger, and general aviation aprons. The airport will also have a new 26 gate air passenger terminal and support facilities. Robert Mueller Municipal will close upon completion of the new airport. The total estimated project cost is currently $585 million. The airport is expected to open on time and under budget.



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

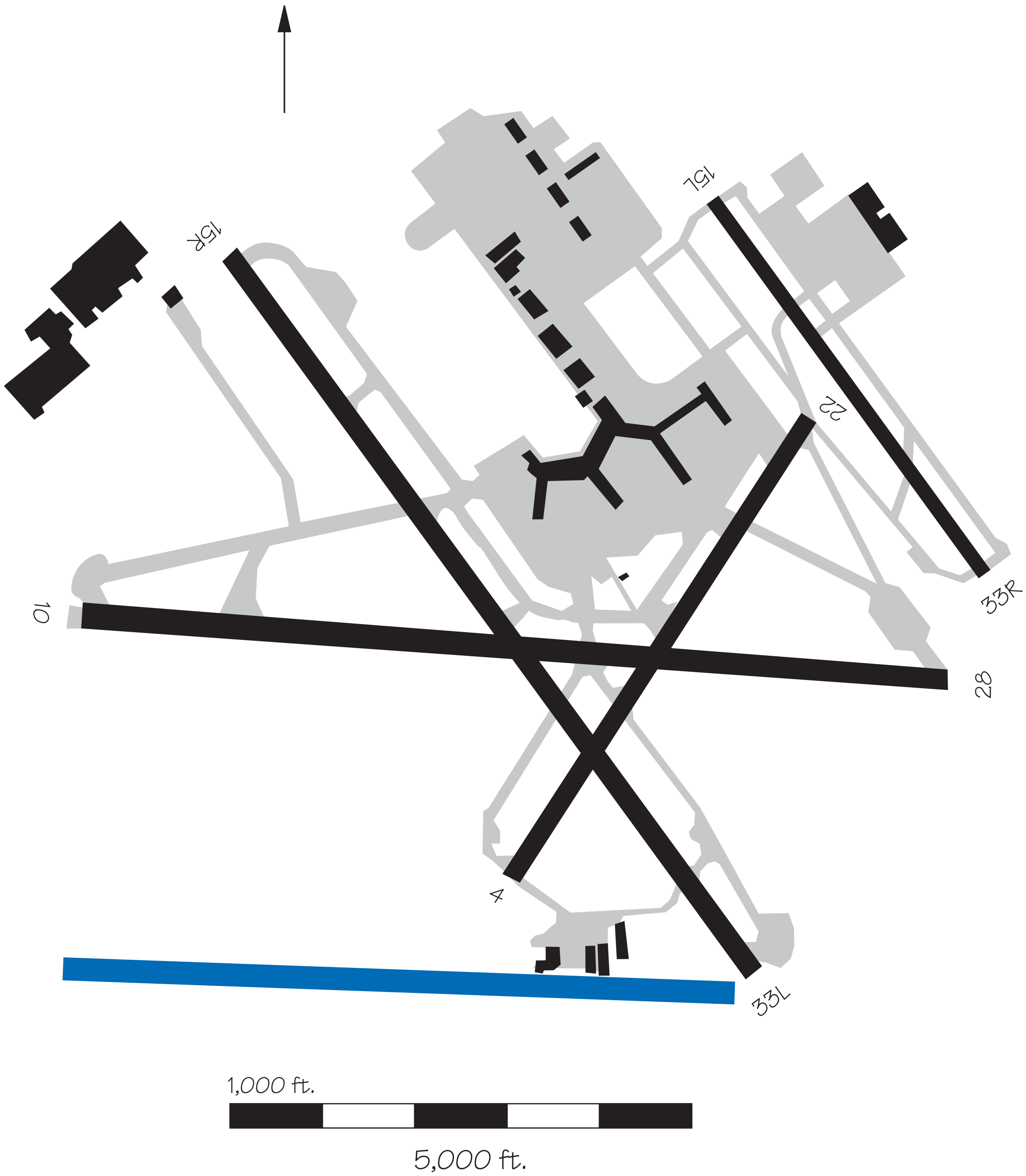
BUF — Greater Buffalo International Airport



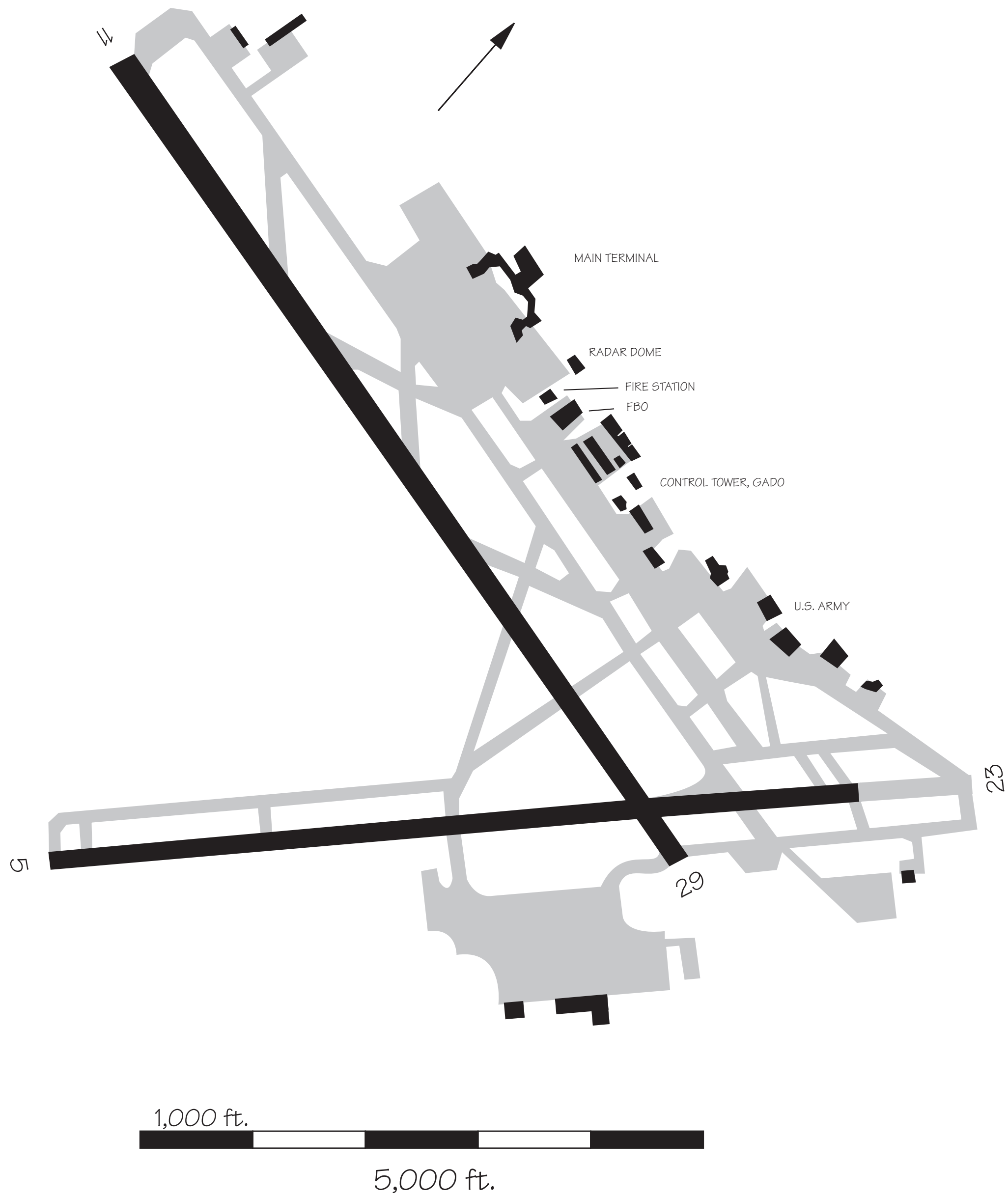
BUR — Burbank-Glendale-Pasadena Airport

BWI — Baltimore-Washington International Airport

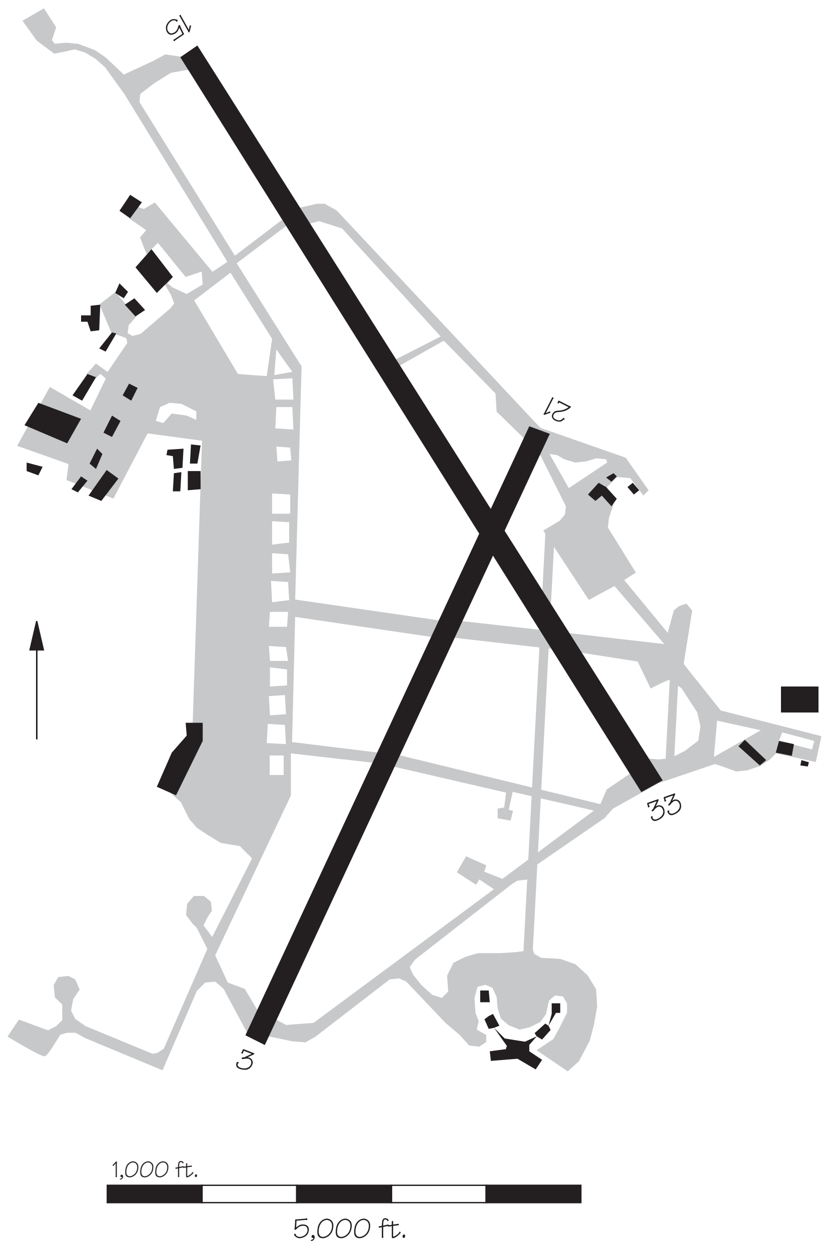
A new 7,800 ft. runway, Runway 10R/28L, is planned to be constructed by 2003, 3,500 ft. south of Runway 10/28. When Runway 10R/28L is constructed, Runway 4/22 will be converted to a taxiway.



CAE — Columbia Metropolitan Airport

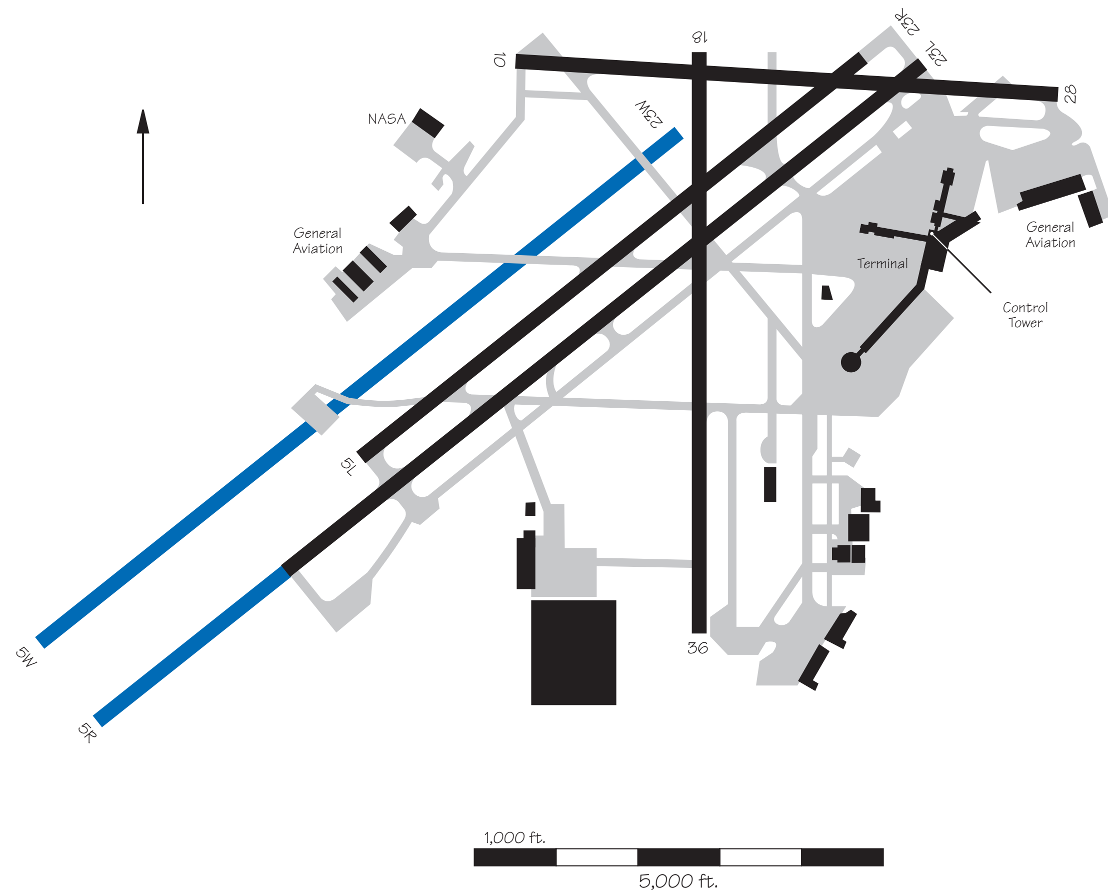


CHS — Charleston AFB International Airport



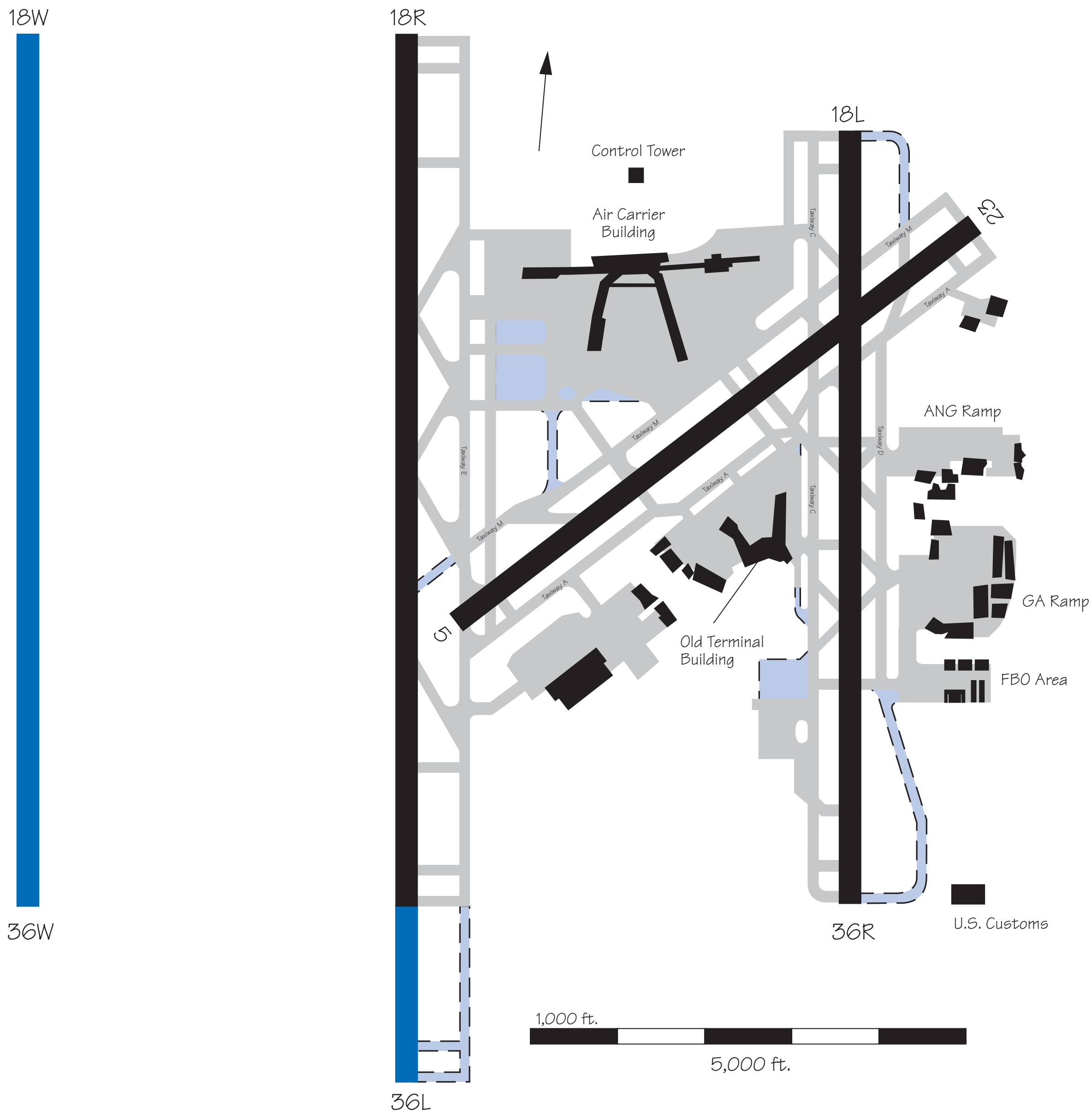
CLE — Cleveland Hopkins International Airport

The Master Plan Update, Phase 1, is conditionally approved. The Airport Layout Plan shows construction of a new Runway 5W/23W that would be 9,000 ft. long and 150 ft. wide. Construction is expected to be completed in 2000 at a cost of $180 million. Also included in the development plan is an extension of the existing Runway 5R/23L from 9,000 ft. to 11,250 ft. at an estimated cost of $40 million and conversion of the existing Runway 5L/23R to a parallel taxiway at a cost of $3 million. All of this work is scheduled for completion by 2005.



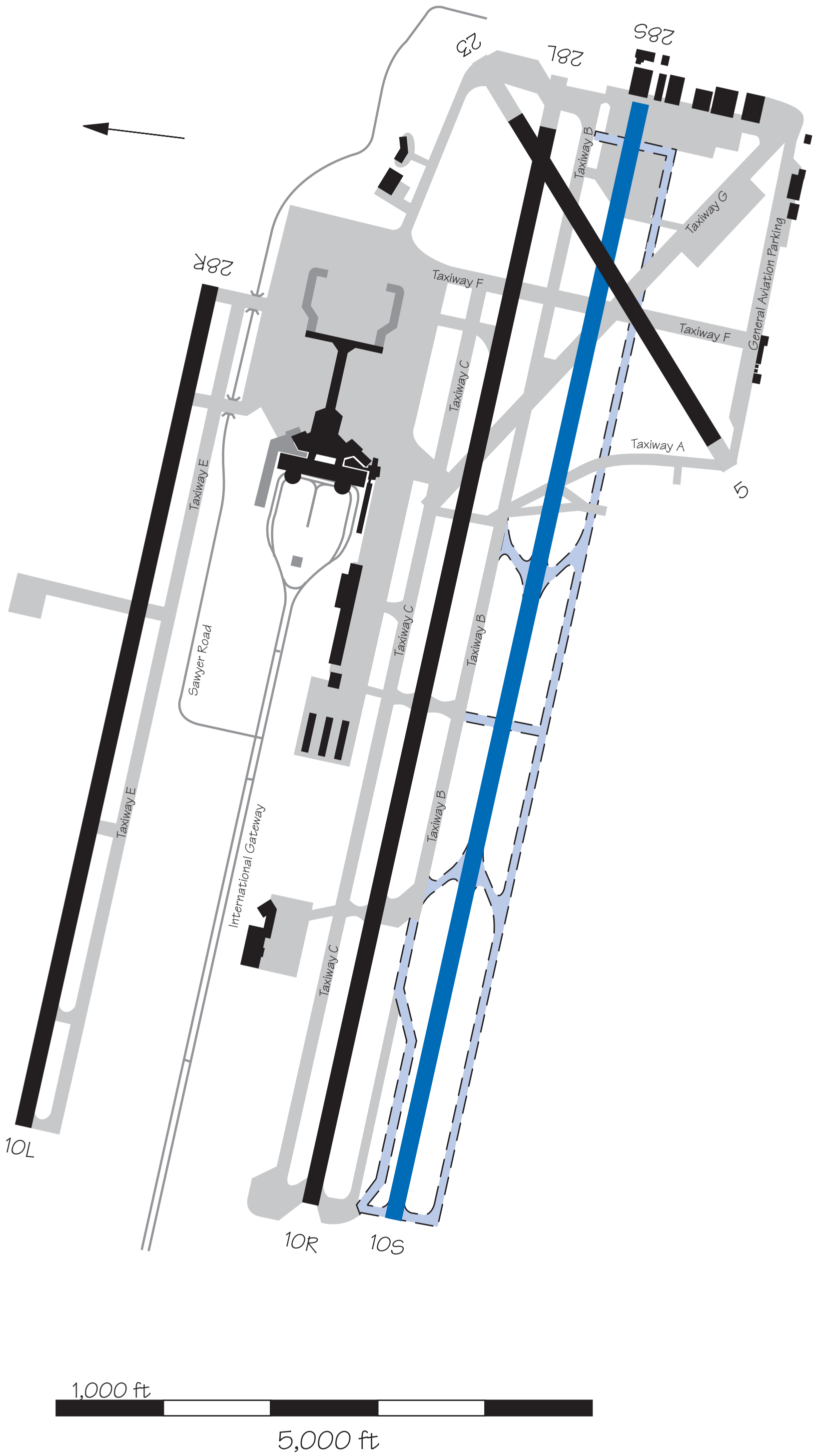
CLT — Charlotte/Douglas International Airport

A third parallel 9,000 ft. runway, 3,700 ft. west of Runway 18R/36L, is being planned. It would permit triple dependent IFR approaches. An Environmental Impact Statement is underway and is expected to be completed by early 1999. Construction is expected to start in late 1999 and be completed in 2001, at an estimated cost of $140 million. A 2,000 ft. extension of Runway 18R/36L is also planned. The estimated cost is $20 million, and it is expected to be operational by 2006. The extension is primarily for departures.

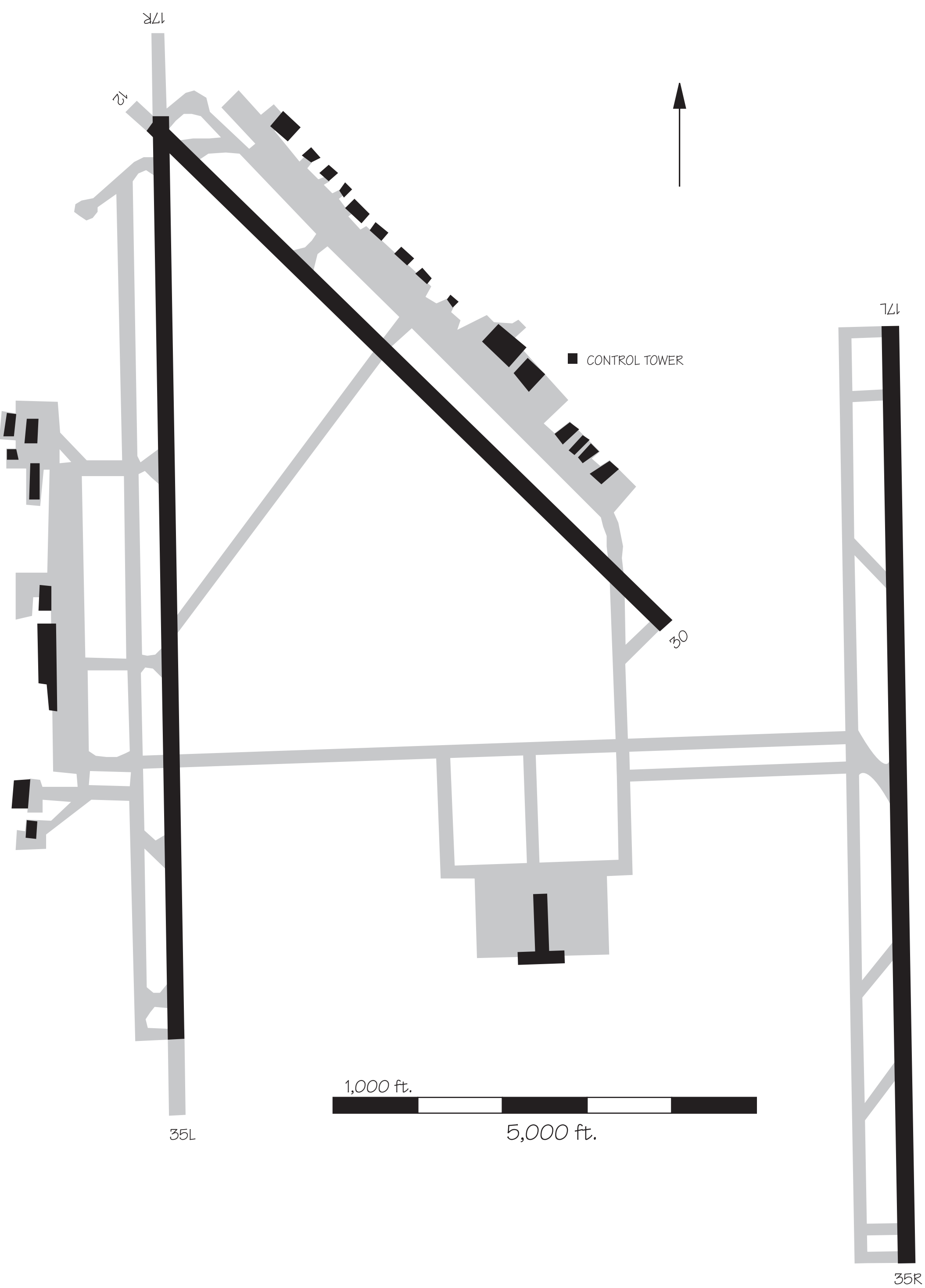


CMH — Port Columbus International Airport

The Airport Layout Plan has been coordinated to show a third parallel Runway 10S/28S constructed 800 ft. south of the existing Runway 10R/28L. This runway will be 10,250 ft. long and 150 ft. 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 ft. 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. Expected operational date is 2020, with project costs estimated at $100 million.

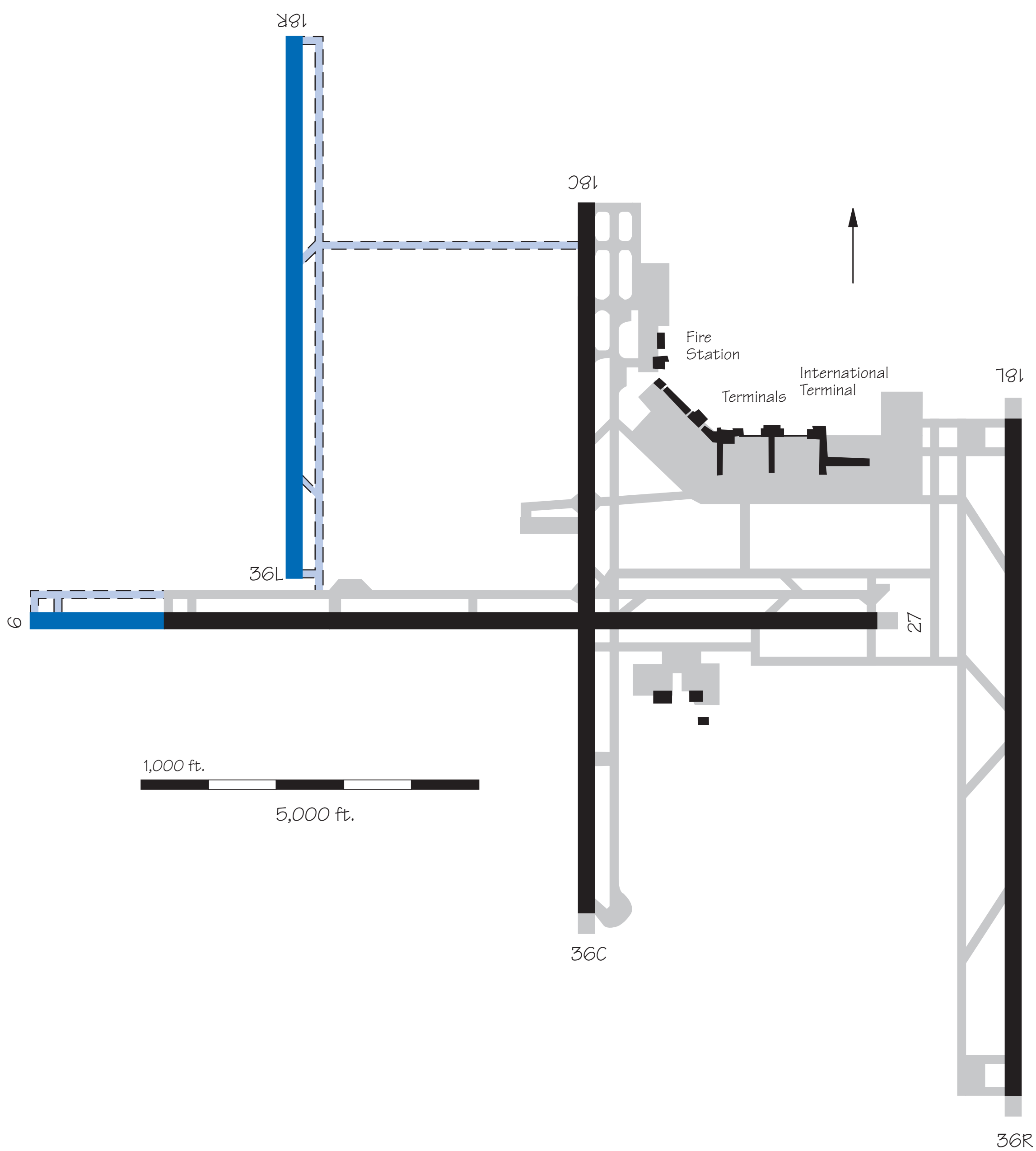


COS — Colorado Springs Municipal Airport



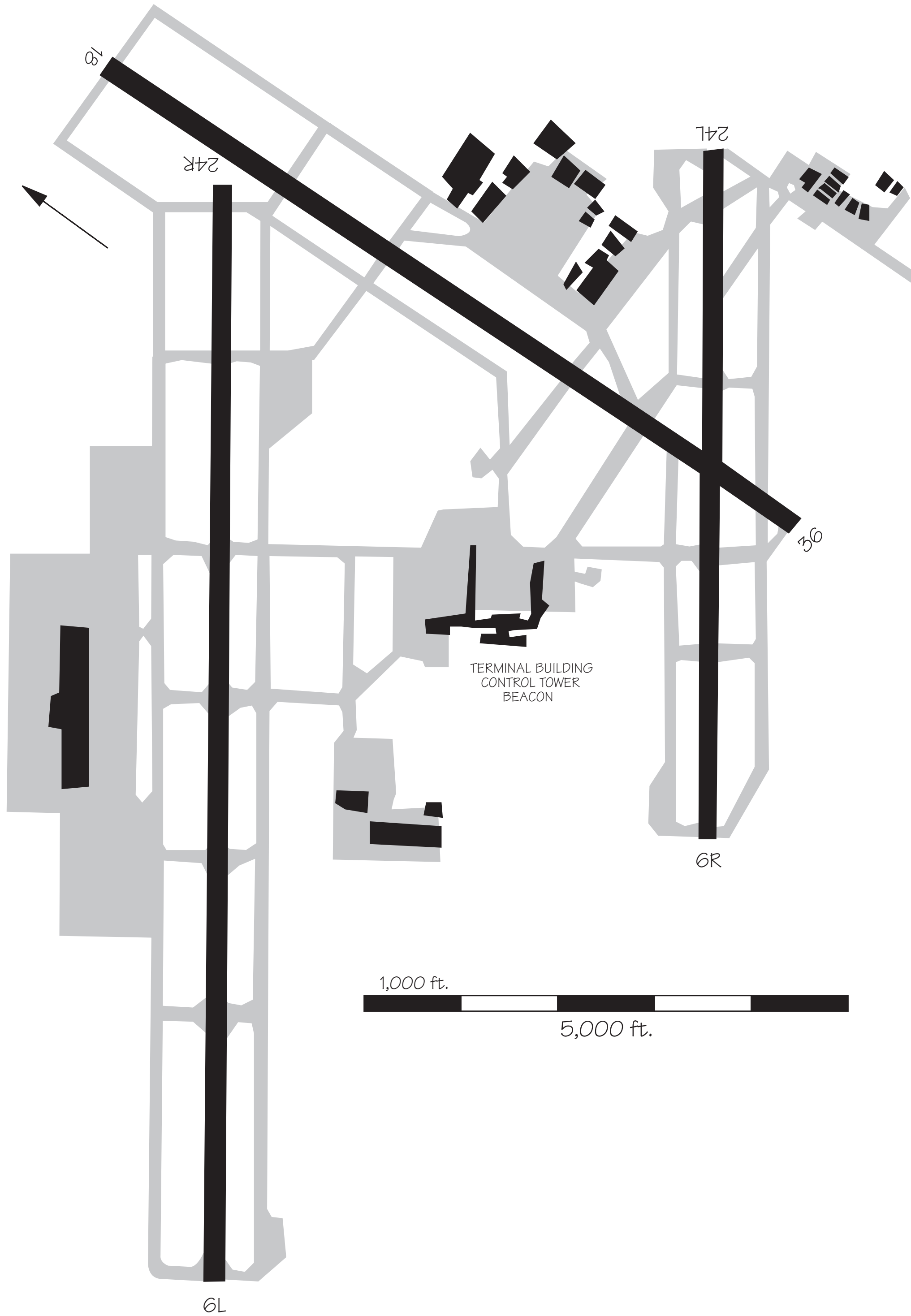
CVG — Greater Cincinnati International Airport

A new 8,000 ft. third parallel Runway 18R/36L is planned to be located 4,300 ft. west of the existing Runway 18R/36L. The estimated cost is $233 million. The expected operational date is 2004. The new runway may allow triple independent IFR approaches. A 2,000 ft. extension of Runway 9/27 is also planned. It is expected to be completed by 2003, at an estimated cost of $12 million. The extension would allow departures of aircraft with heavier payloads and/or longer haul-lengths. An EIS is currently underway for both projects, and is expected to be completed by 2000.

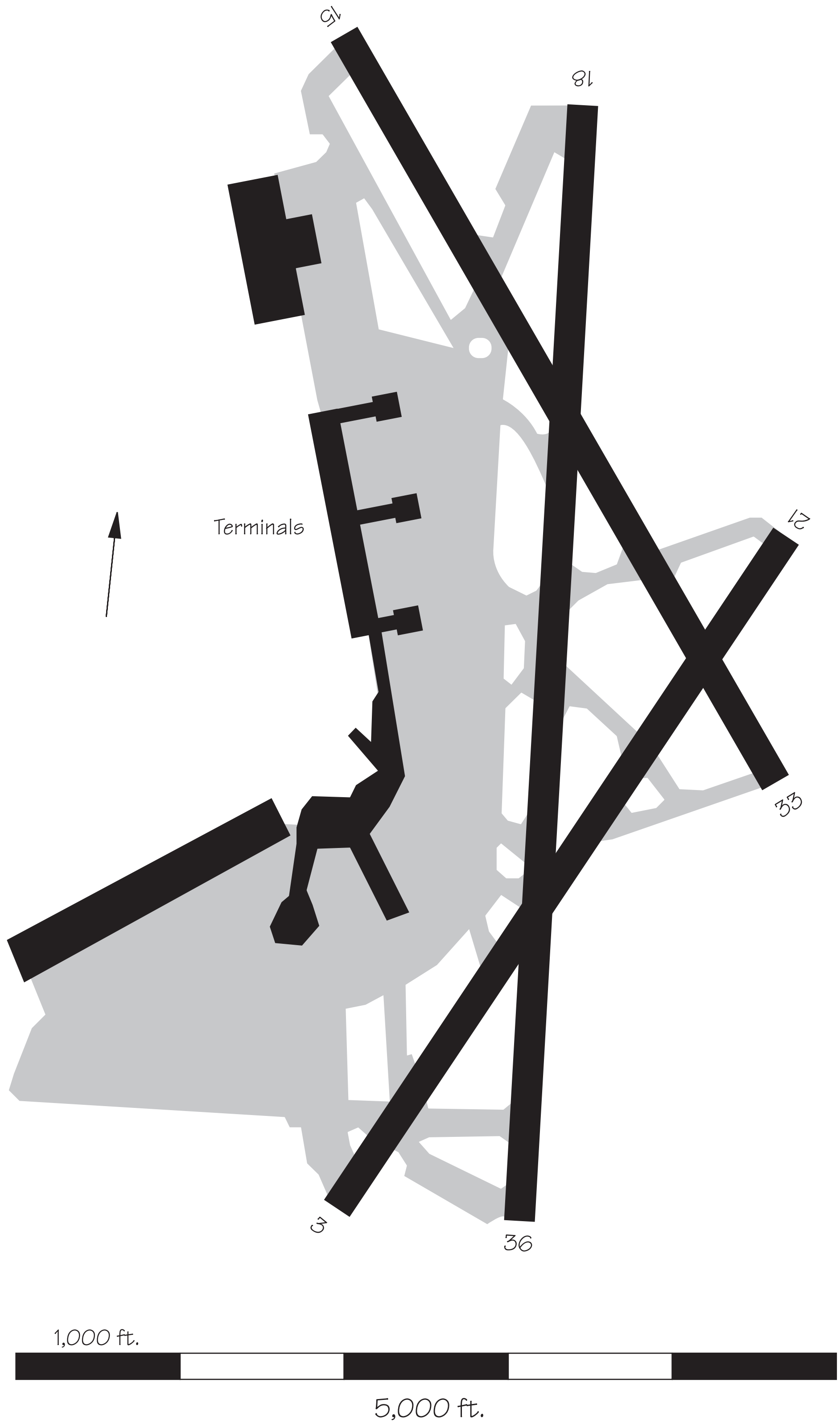


DAL — Dallas-Love Field

DAY — Dayton International Airport

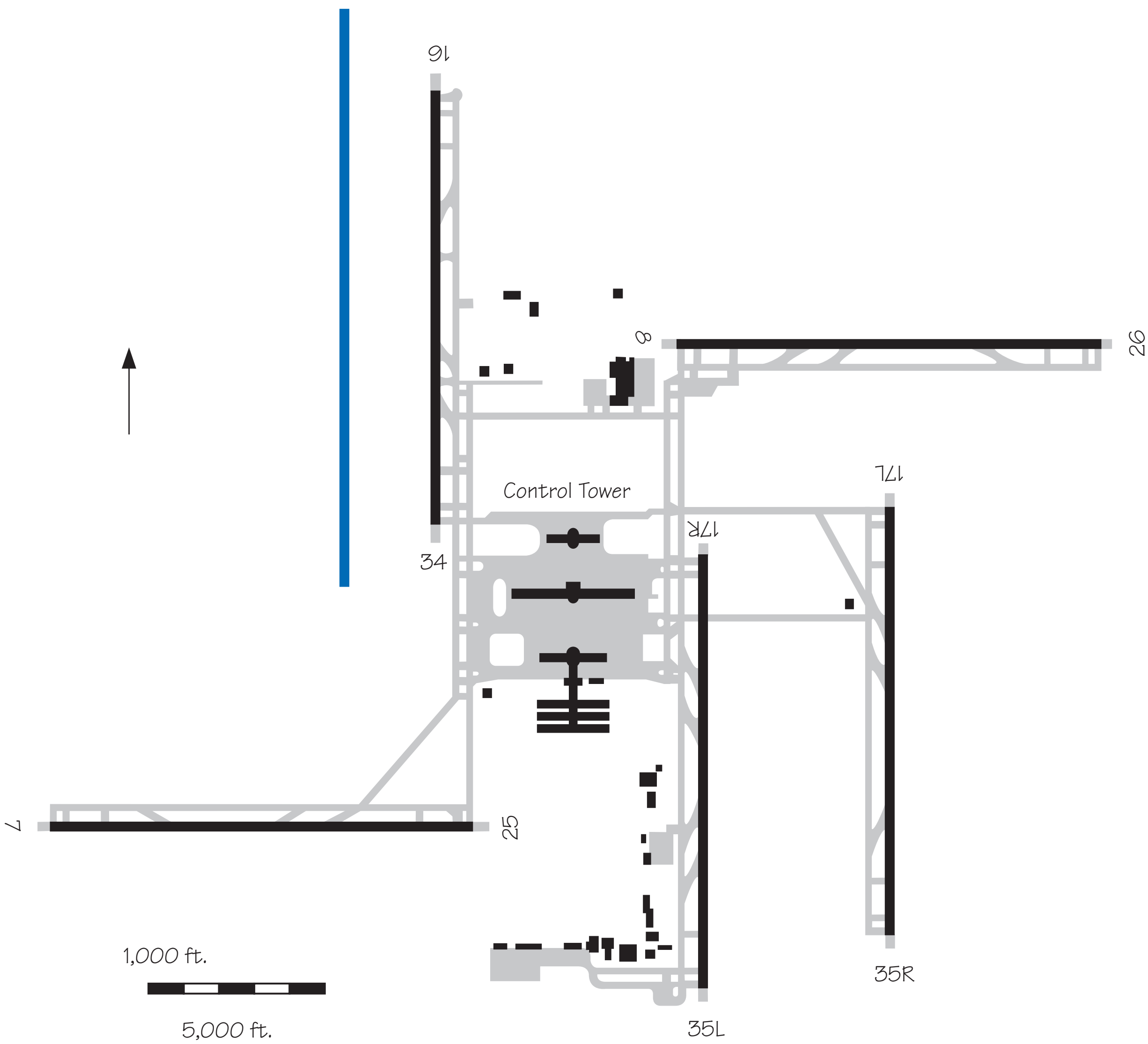


DCA — Ronald Reagan National Airport



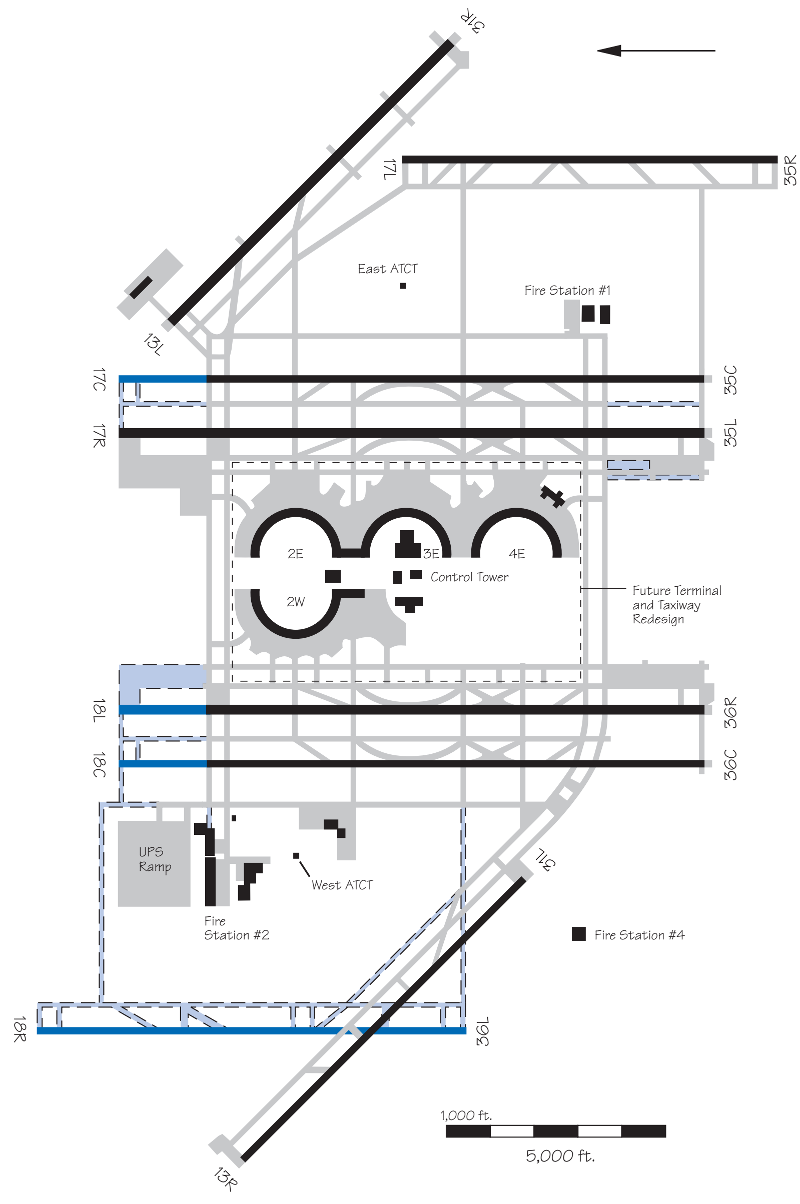
DEN — Denver International Airport

Runway 16R/34L is the last of the six original runways to be built at the new airport. It will be separated 2,600 ft. from Runway 16L/34R, and be 16,000 ft. in length. The runway is expected to be completed in 2002, at an estimated cost of $103 million.



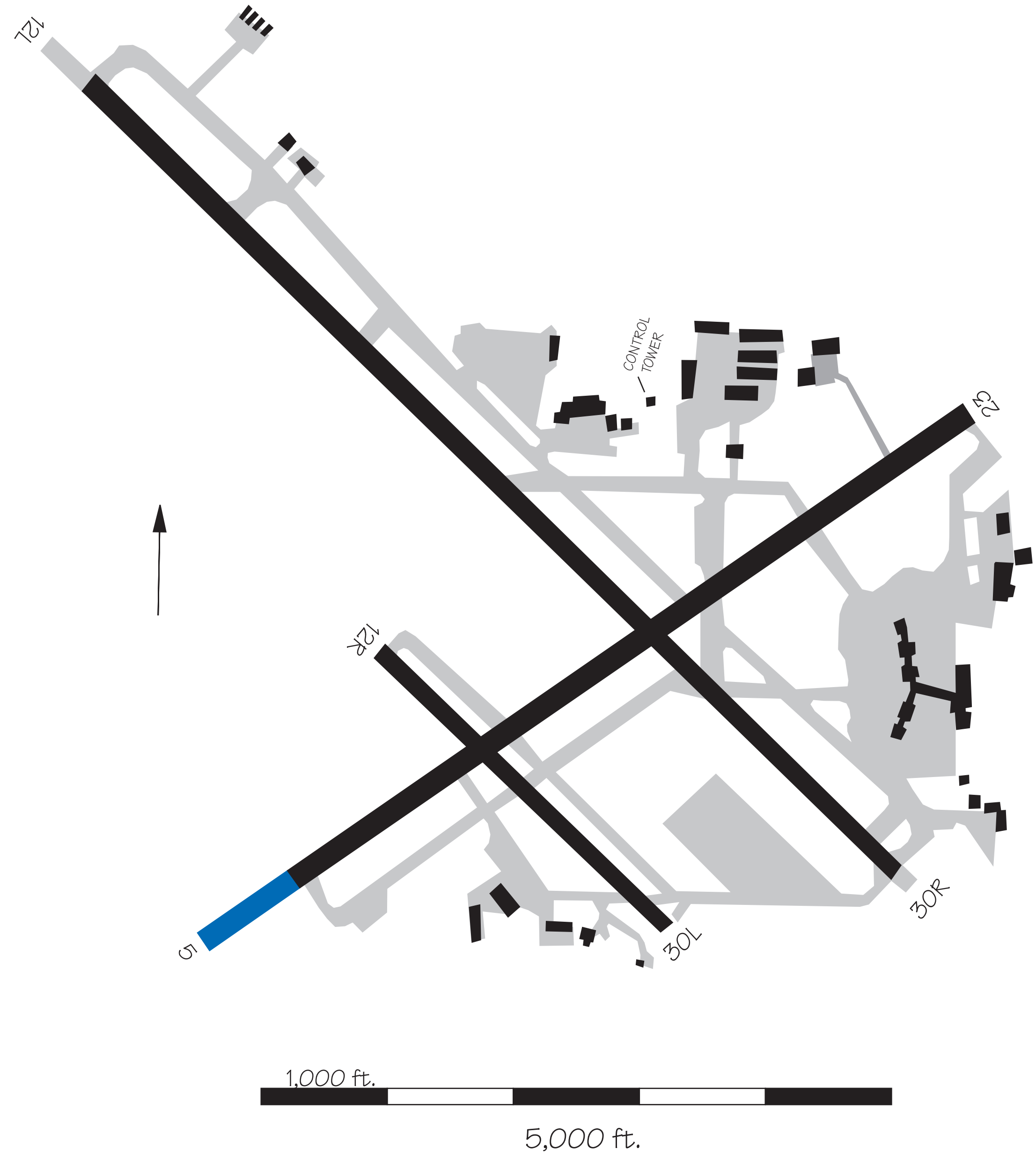
DFW — Dallas-Fort Worth International Airport

Proposed 2,000 ft. extensions to all of the north/south parallel runways will provide an overall length of 13,400 ft. for each. Environmental assessment for the extension to Runway 17C/35C, Runway 18L/36R, and Runway 18R/36L were completed in 1998. The estimated cost of each extension is $25 million. A terminal expansion program is underway that will add five new jet departure gates to the south side of Terminal 2W; provide baggage and passenger connections to Terminal 2E; and renovate a portion of Terminal 2W. The total cost of this program is approximately $100 million and is scheduled for completion in 1999. Construction on the west runway, Runway 18R/36L, will begin when warranted by aviation demand. It could be available as early as 2003. The estimated cost is $268 million. It will be located 5,800 ft. west of Runway 18R/36L (to be renamed 18C/36C). The runway will be used primarily for arrivals. The addition of Runway 18R/36L will allow DFW to accommodate quadruple simultaneous precision instrument approaches.



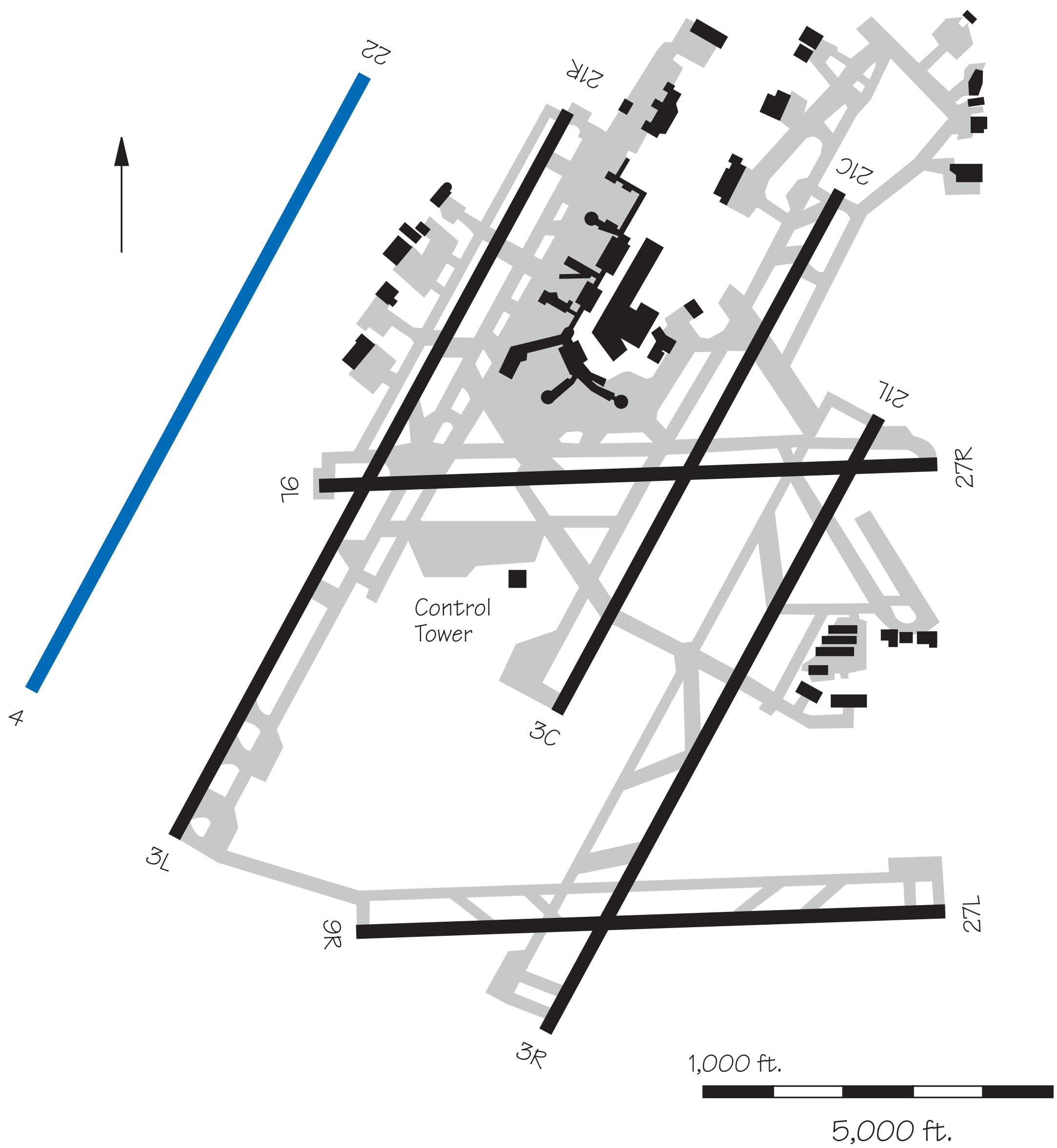
DSM — Des Moines International Airport

A Finding of No Significant Impact (FONSI) was approved in August, 1995, for a southwest extension of Runway 5/23. Construction began in 1997, and is expected to be completed in 2001. Cost for construction is estimated at $31 million, with an additional estimated $23 million for road relocation.



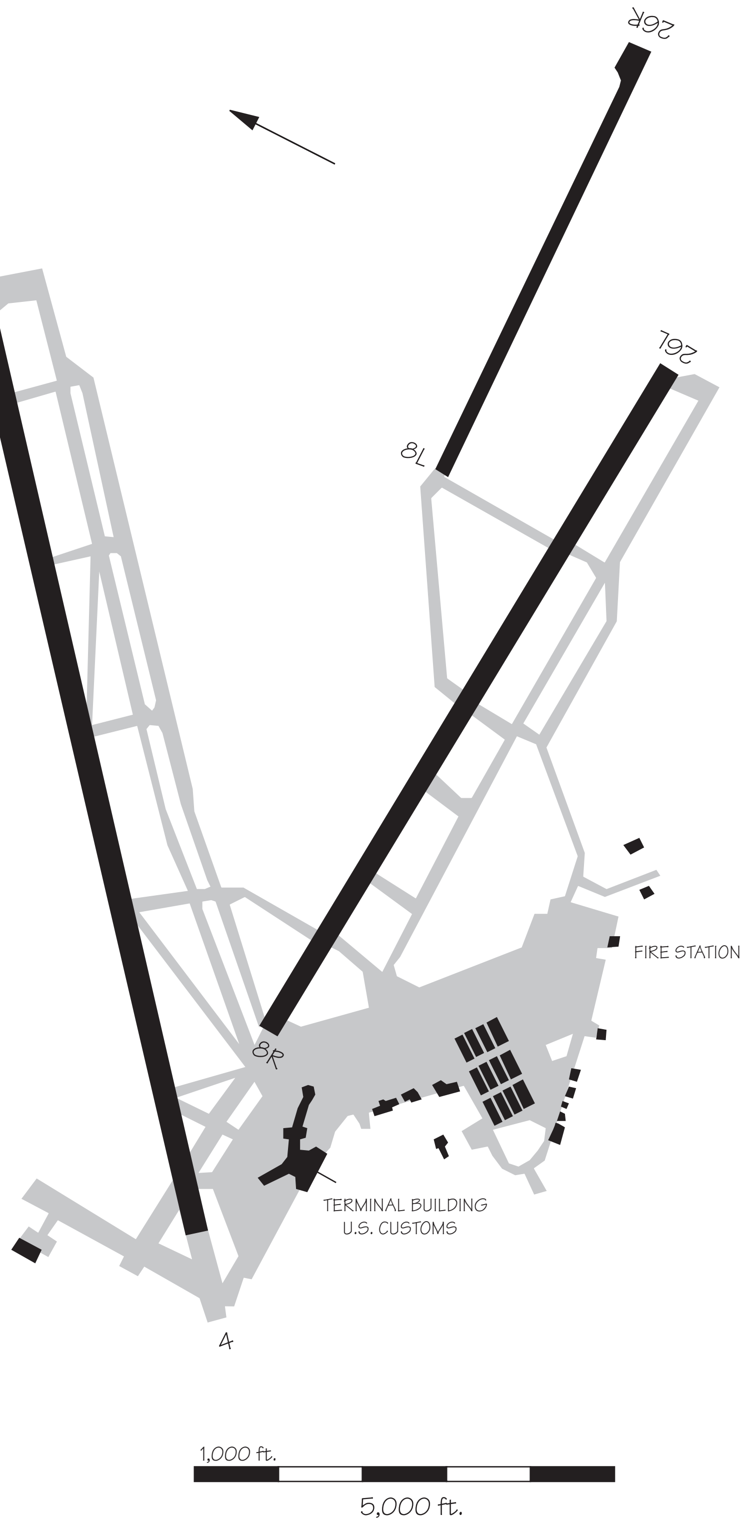
DTW — Detroit Metropolitan Wayne County Airport

A fourth north-south parallel, Runway 4/22 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 will be completed by early 1999. Relocation of roads, utilities, and drainage is underway.



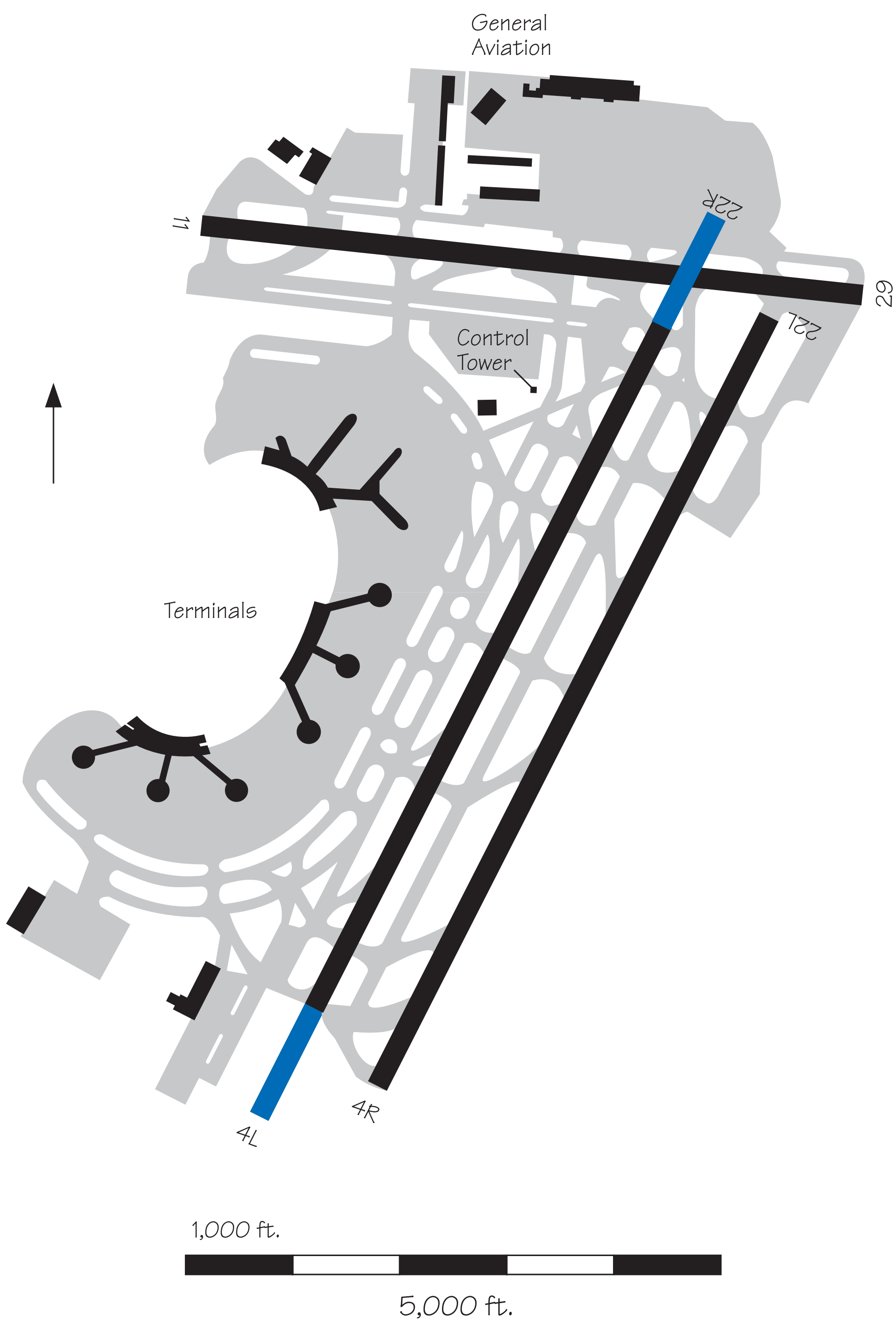
ELP — El Paso International Airport

A 1,000 ft. extension to Runway 22 is included in the currently approved Passenger Facility Charge for the year 2000. Estimated cost would be $8 million.



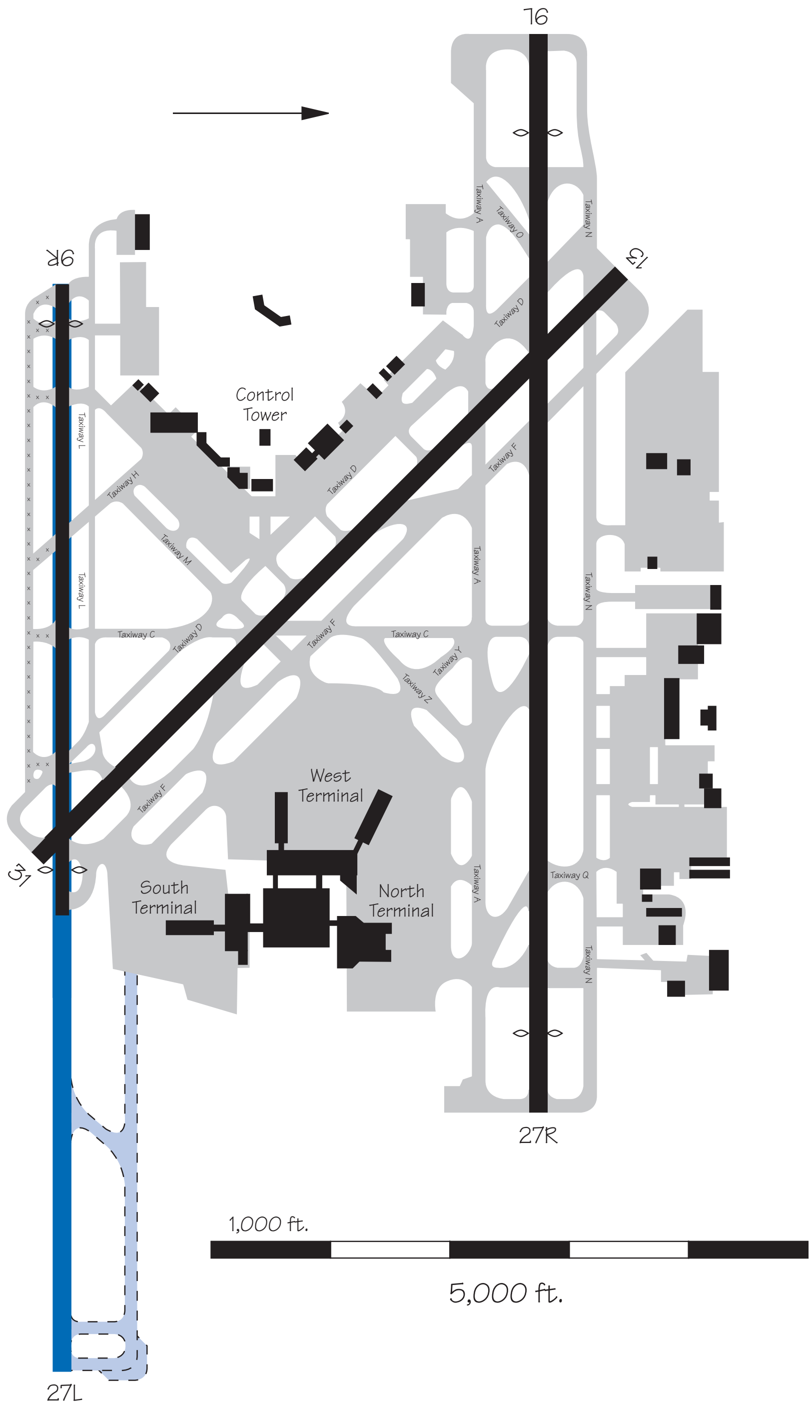
EWR — Newark International Airport

An extension to Runway 4L/22R is currently under construction. The estimated operational date is 2000.



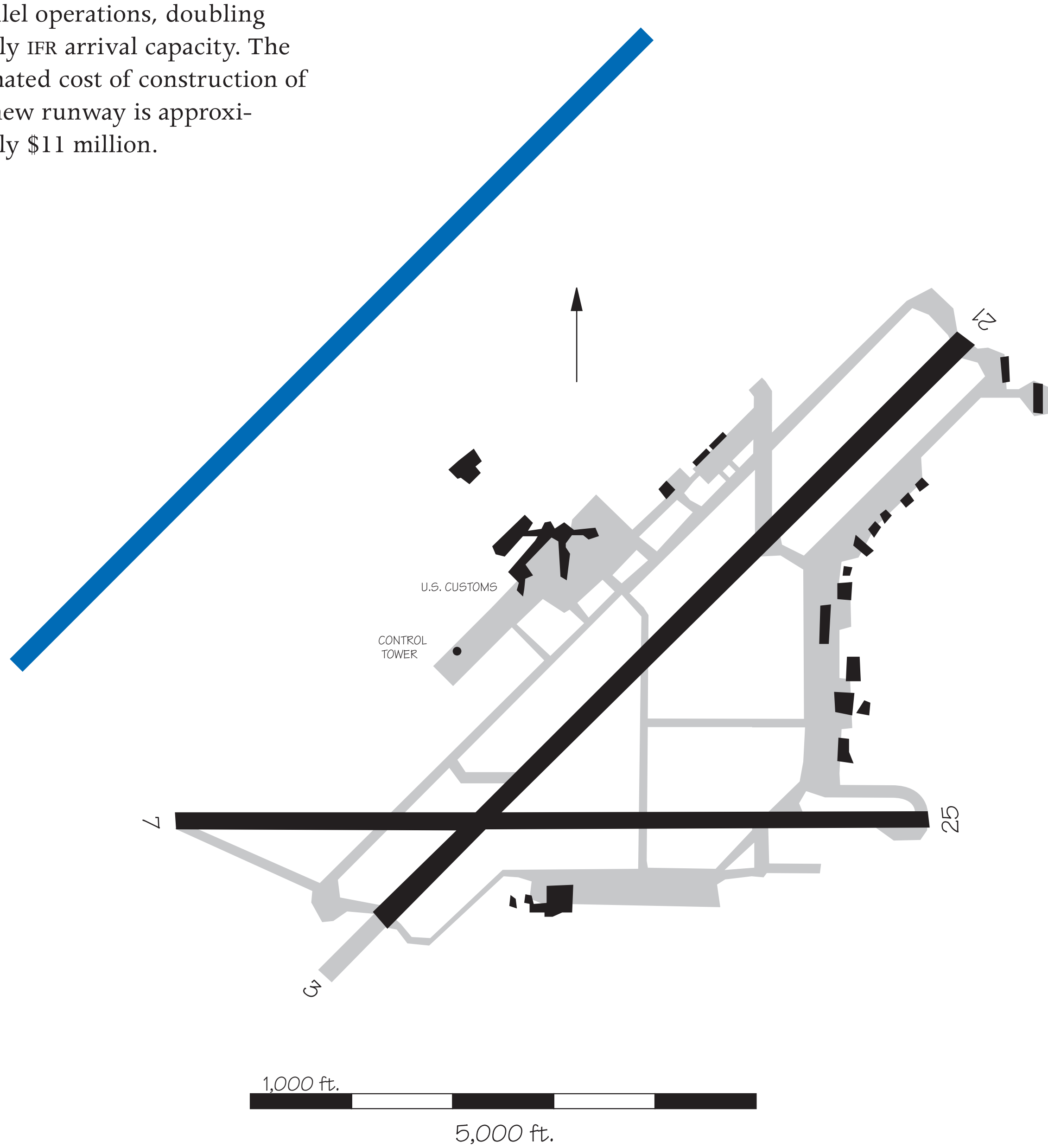
FLL — Fort Lauderdale-Hollywood International Airport

An extension of the short parallel Runway 9R/27L to 9,000 ft. is planned to provide the airport with a second parallel air carrier runway. Construction is expected to begin in 2002. The estimated cost of construction is $300 million. The anticipated operational date is 2005. An EIS is underway and expected to be completed in 2000. The extended runway would be used for arrivals and departures and would allow dual dependent IFR arrivals of all types of aircraft.



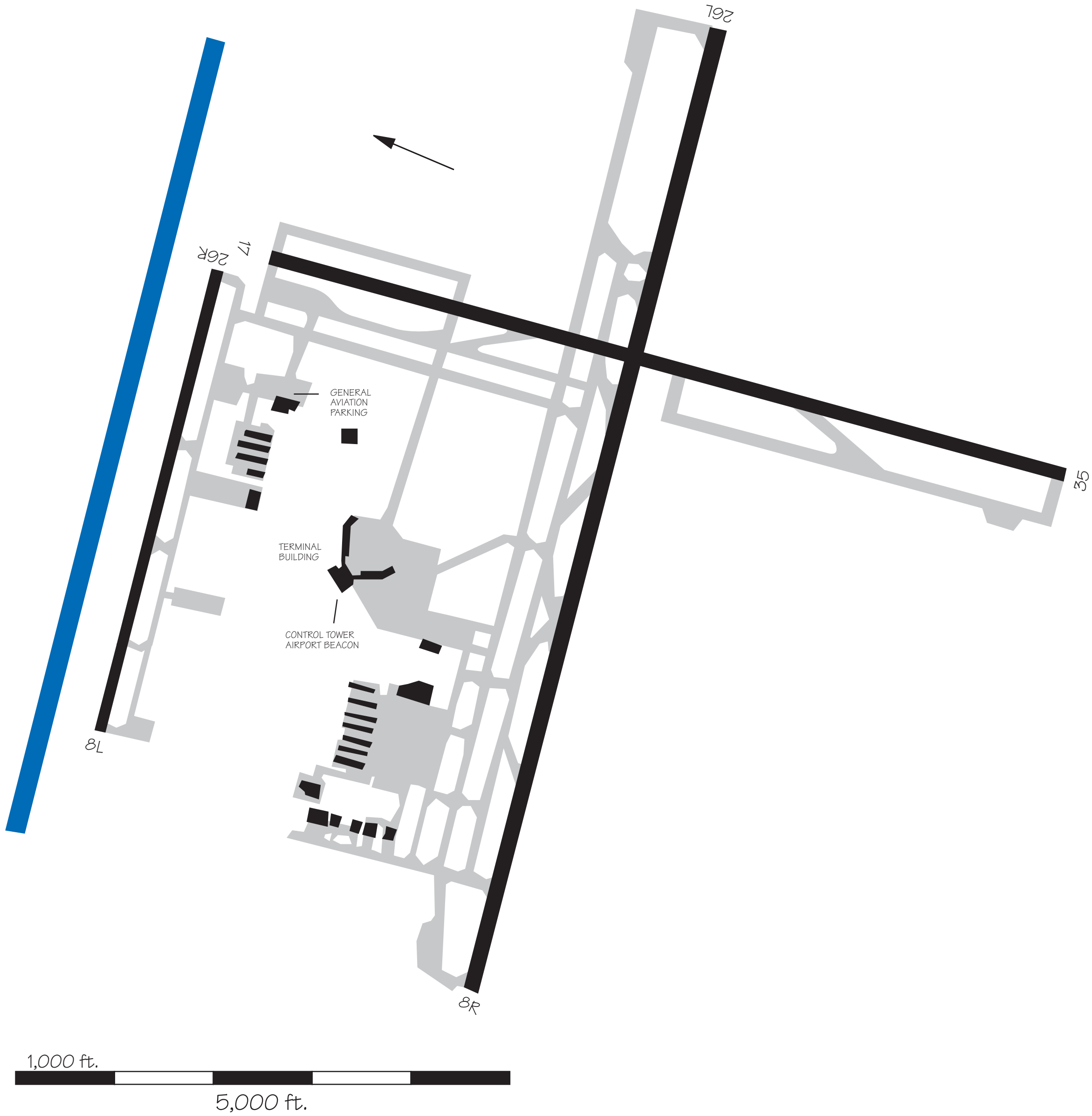
GEG — Spokane International Airport

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



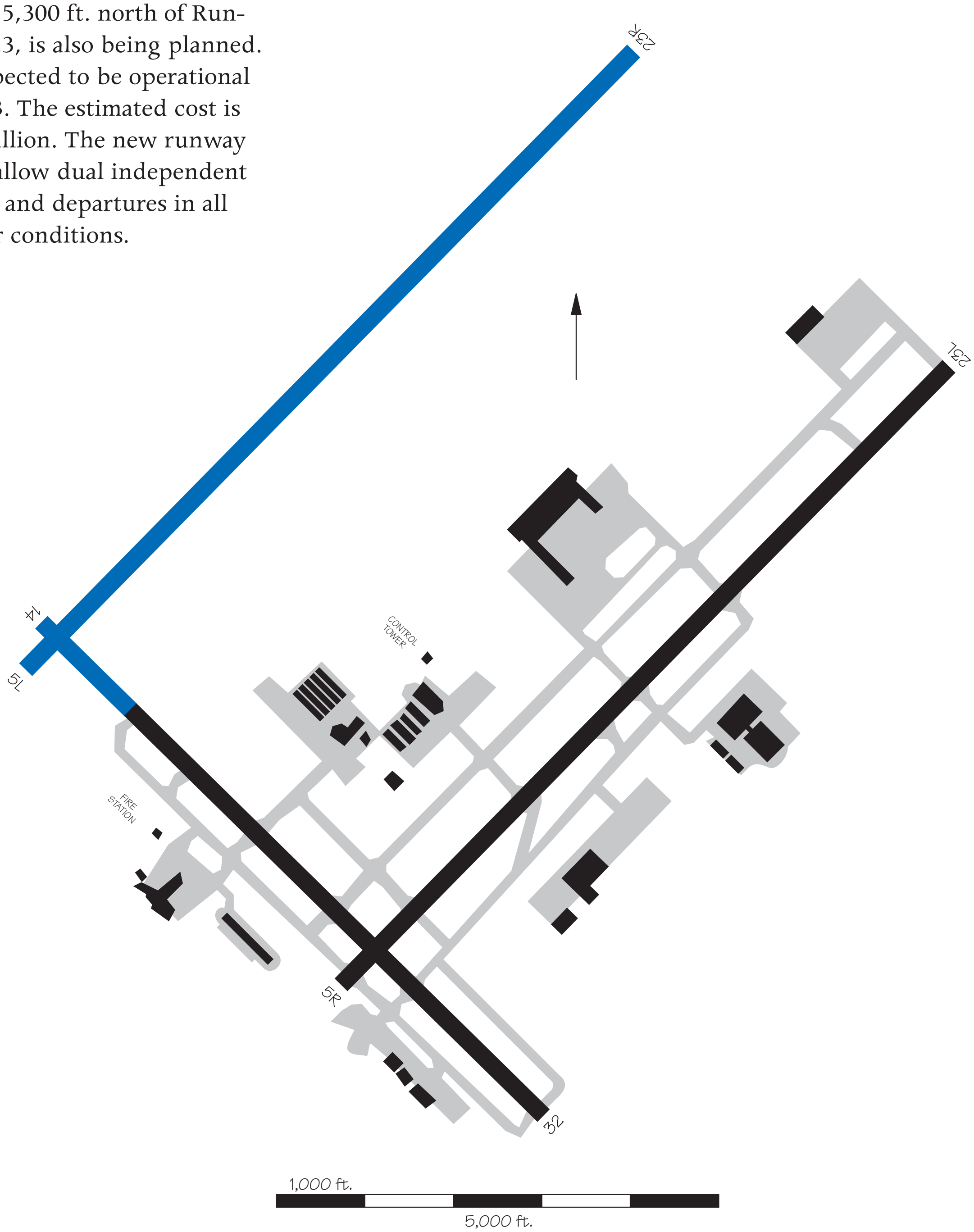
GRR — Grand Rapids Kent County International Airport

A new 7,000 ft. parallel Runway 8L/26R is planned for future development. The current 8L/26R would be converted into a taxiway at that time.



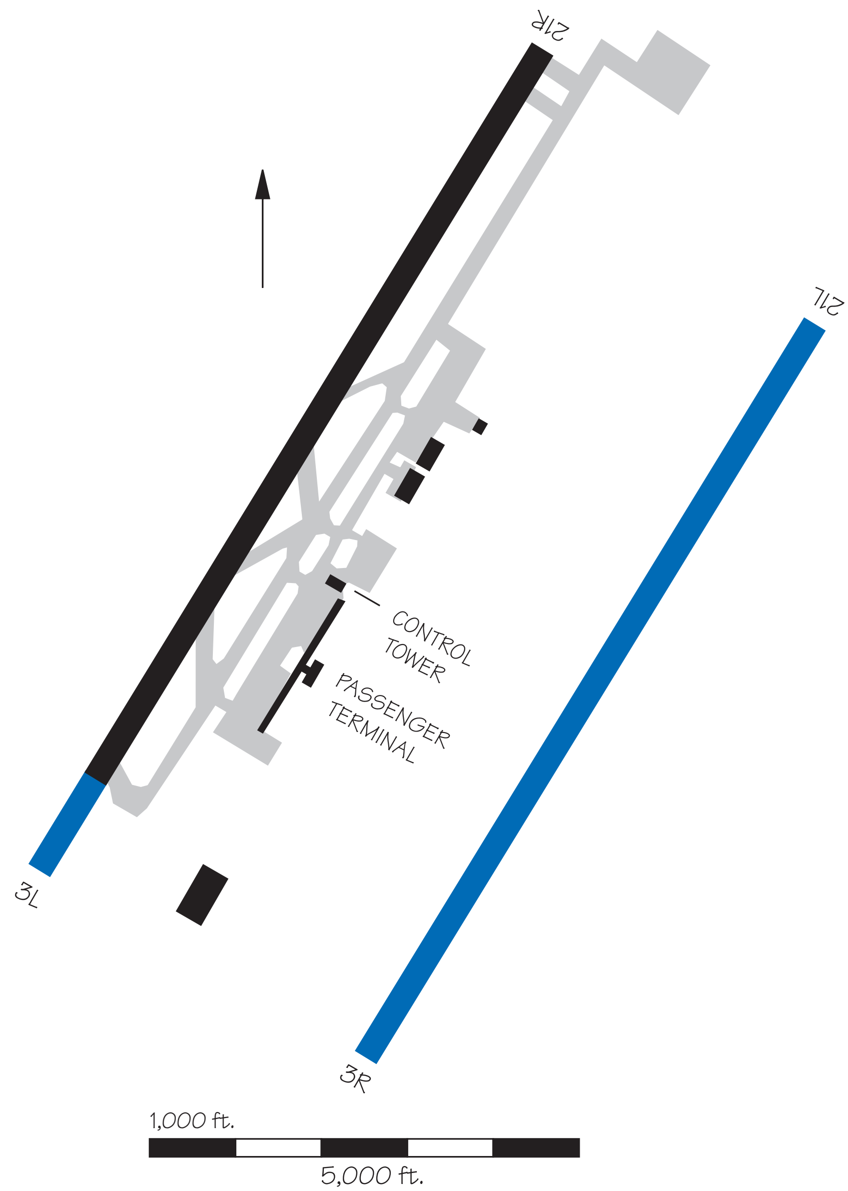
GSO — Greensboro Piedmont Triad International Airport

An extension of Runway 14/32 is planned. It is expected to be operational by 2002, at a cost of $27 million. Construction of a new 10,000 ft. parallel Runway 5L/23R, 5,300 ft. north of Runway 5/23, is also being planned. It is expected to be operational by 2003. The estimated cost is $150 million. The new runway would allow dual independent arrivals and departures in all weather conditions.



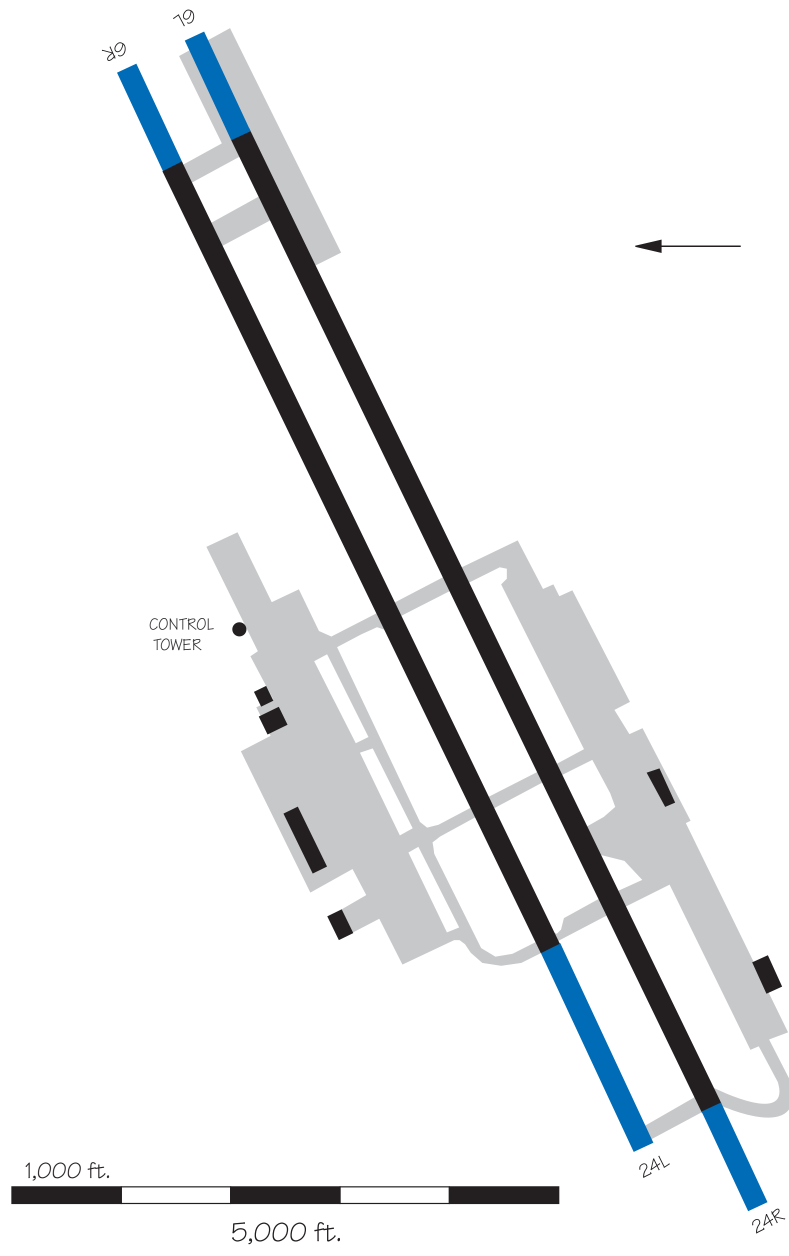
GSP — Greer Greenville-Spartanburg Airport

A new 8,200 ft. parallel Runway 3R/21L is anticipated in 2010 at an estimated cost of $65 million. Presently, it is planned to have a 4,300 ft. separation from Runway 3L/21R. This would allow dual independent IFR arrivals, potentially doubling hourly IFR arrival capacity. Also, an extension of Runway 3L/21R to 11,000 ft. is expected to be completed by 1999 at a cost of $34.1 million. The extension would allow departures of aircraft with larger payloads and/or greater haul-lengths.

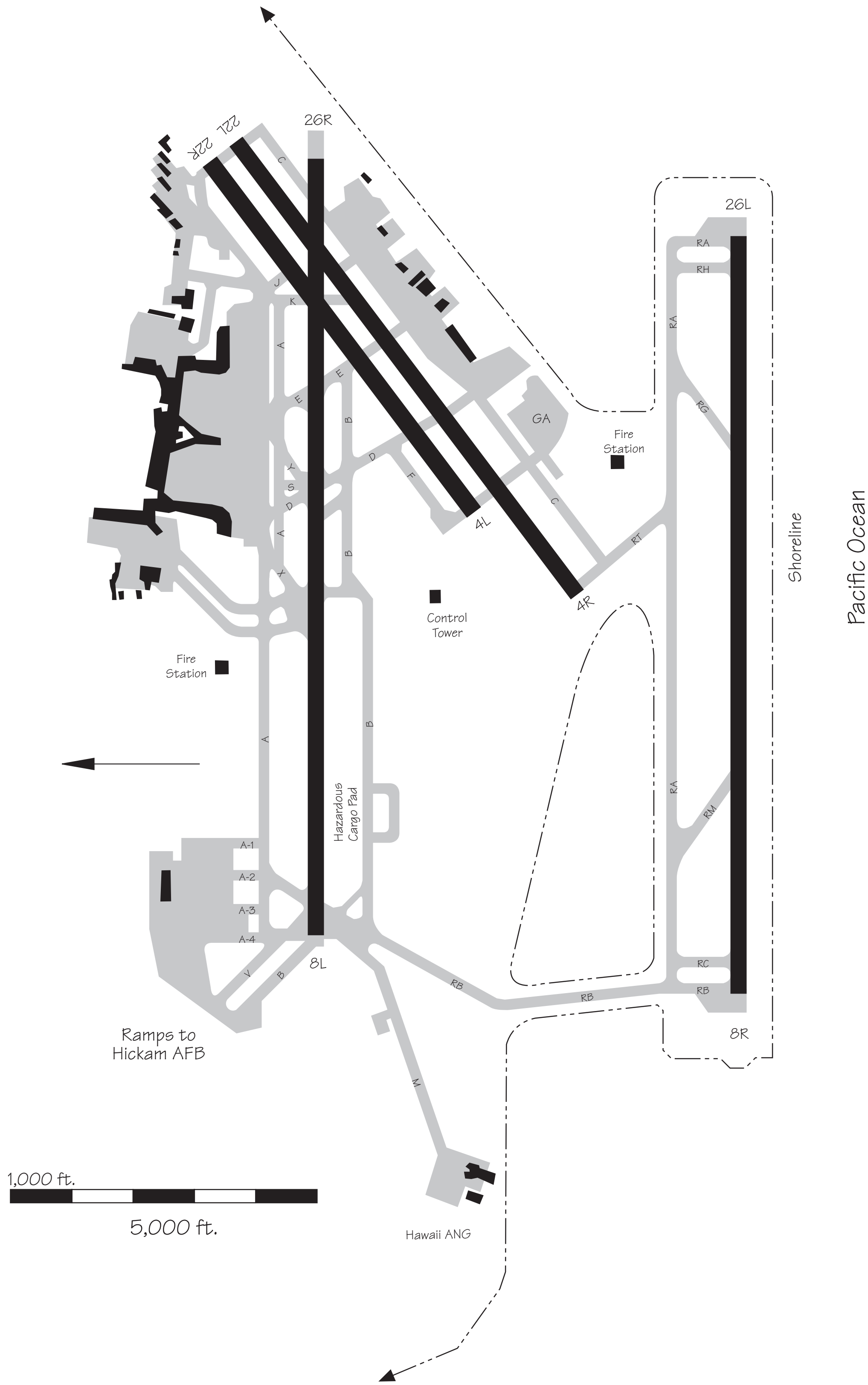


GUM — Guam International Airport

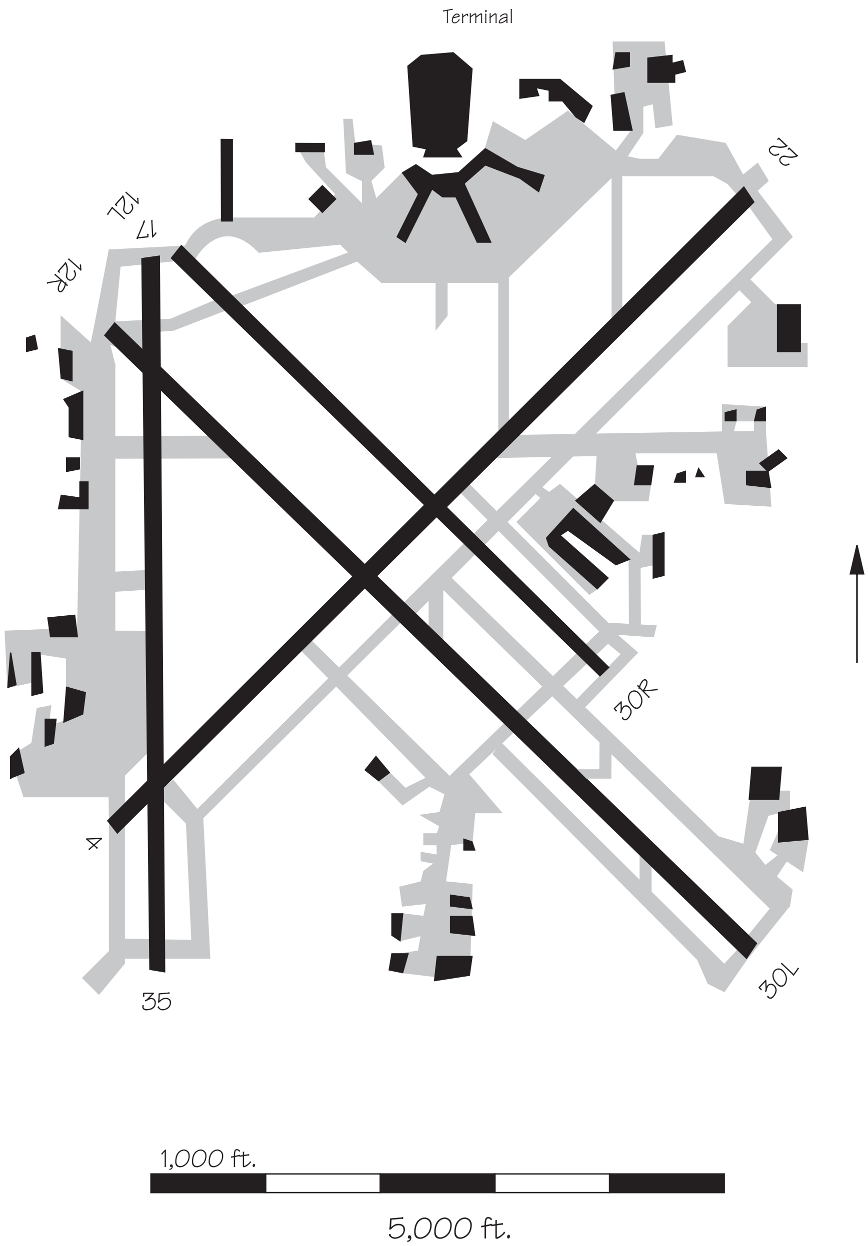
Extensions to both Runway 6L/24R and Runway 6R/24L are proposed. The 2,000 ft. extension to Runway 6L/24R has a proposed operational date of 2004. The 3,000 ft. extension to Runway 6R/24L has a proposed operational date of 2010. Both runway extensions are expected to cost $30 million each.



HNL — Honolulu International Airport

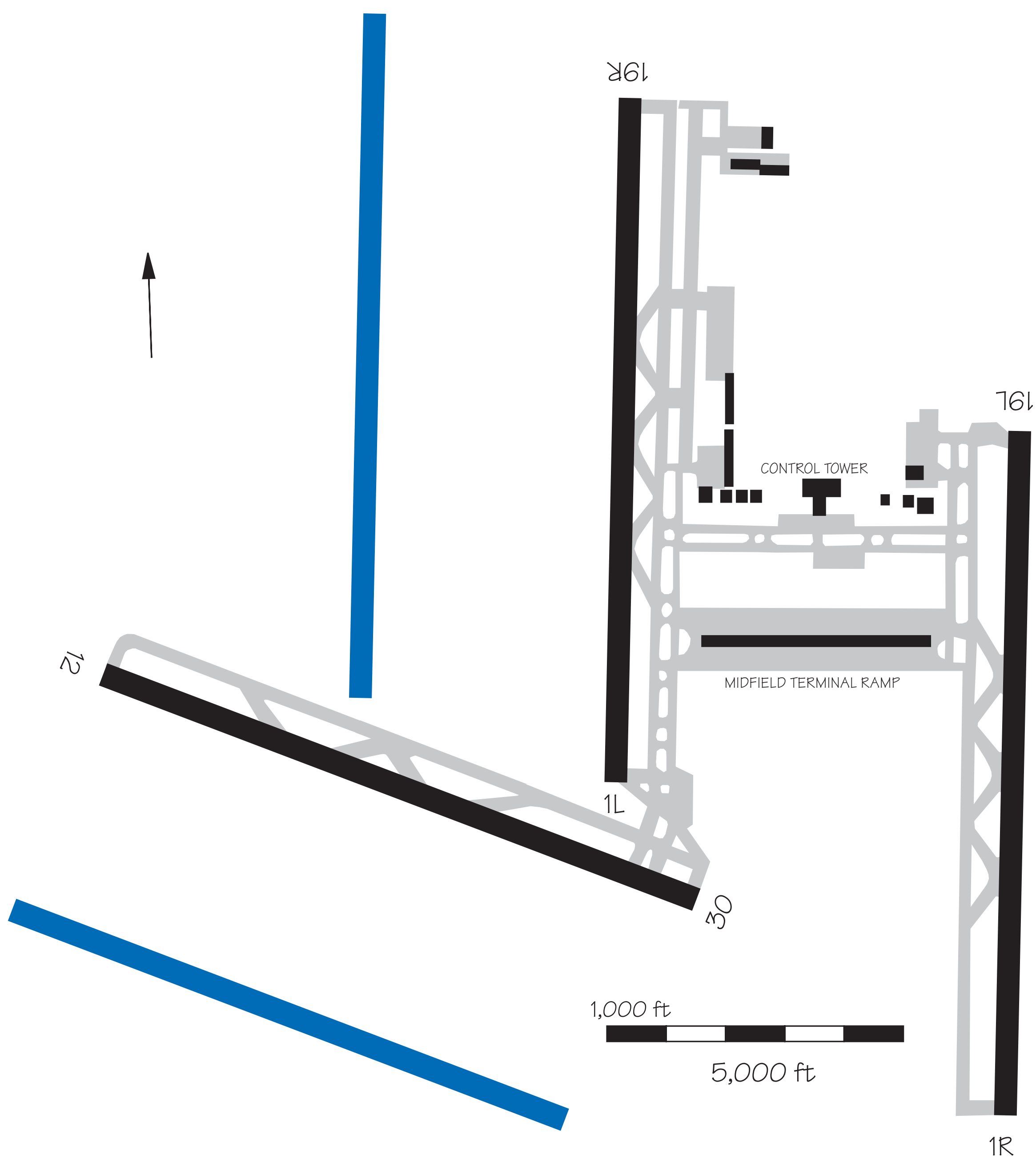


HOU — Houston William P. Hobby Airport



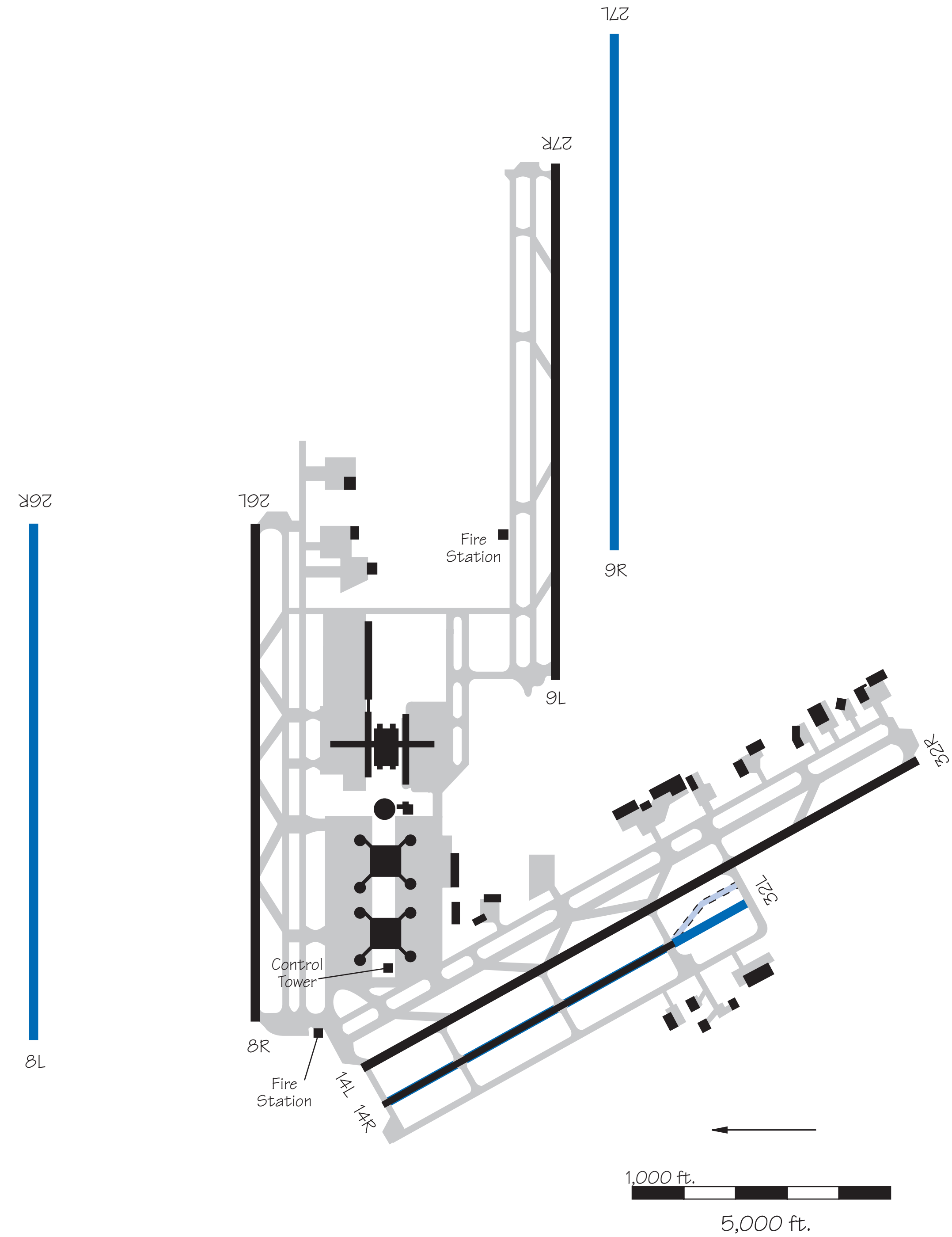
IAD — Washington Dulles International Airport

Two new parallel runways are under consideration. A north-south parallel, Runway 1W/19W, would be located 4,300 ft. west of the existing parallels and north of Runway 12/30. Estimated opening date 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 ft. southwest of Runway 12/30. The runway is expected to be completed by 2010.



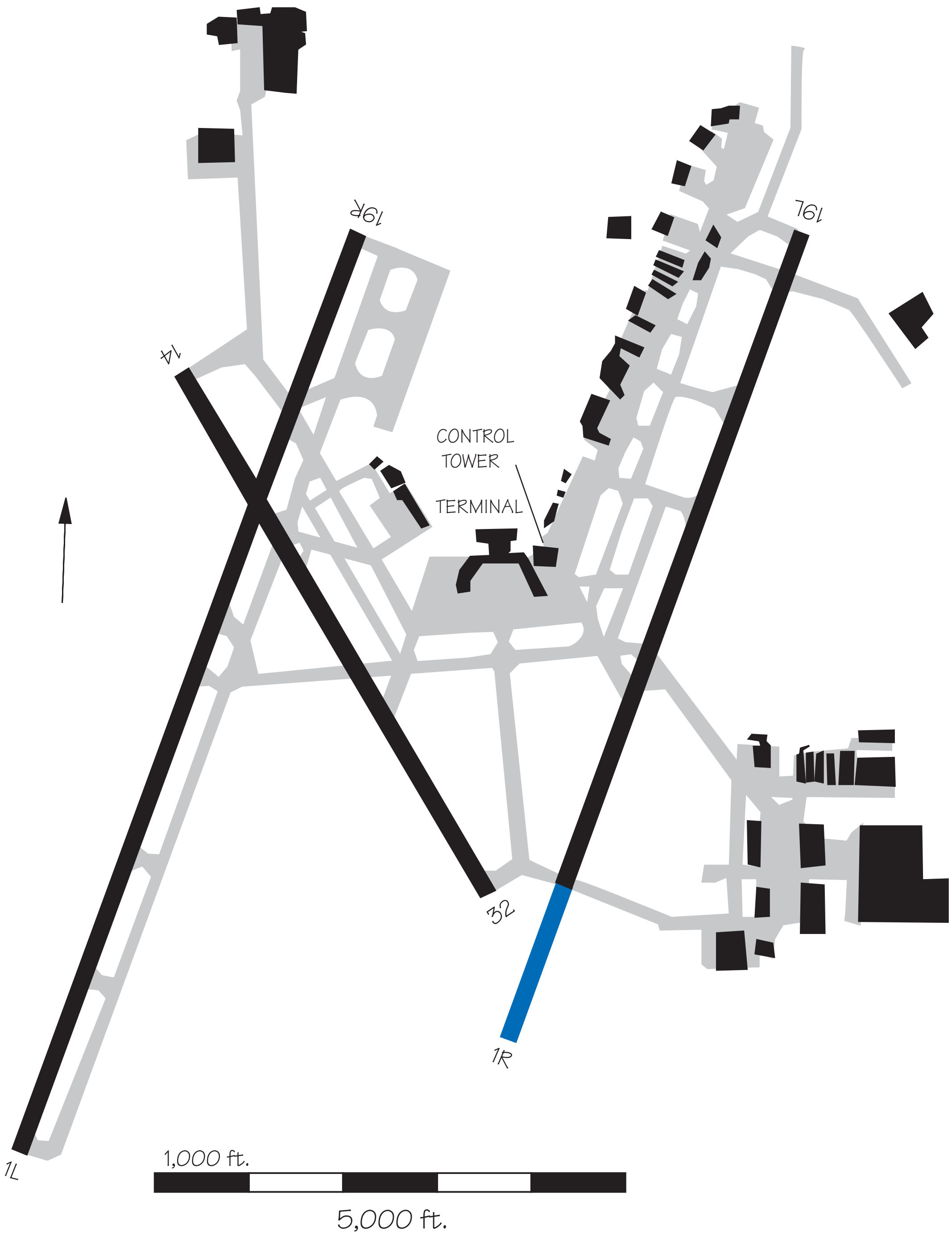
IAH — George Bush International Airport

An $8 million 2,000 ft. extension to Runway 14R/32L is planned for the year 2000. A new Runway 8L/26R is planned to be parallel to, and north of, the existing Runway 8/26. Commissioning is tentatively scheduled for the year 2002. 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 in the distant future. Construction is expected to cost $95 million for Runway 8L/26R.



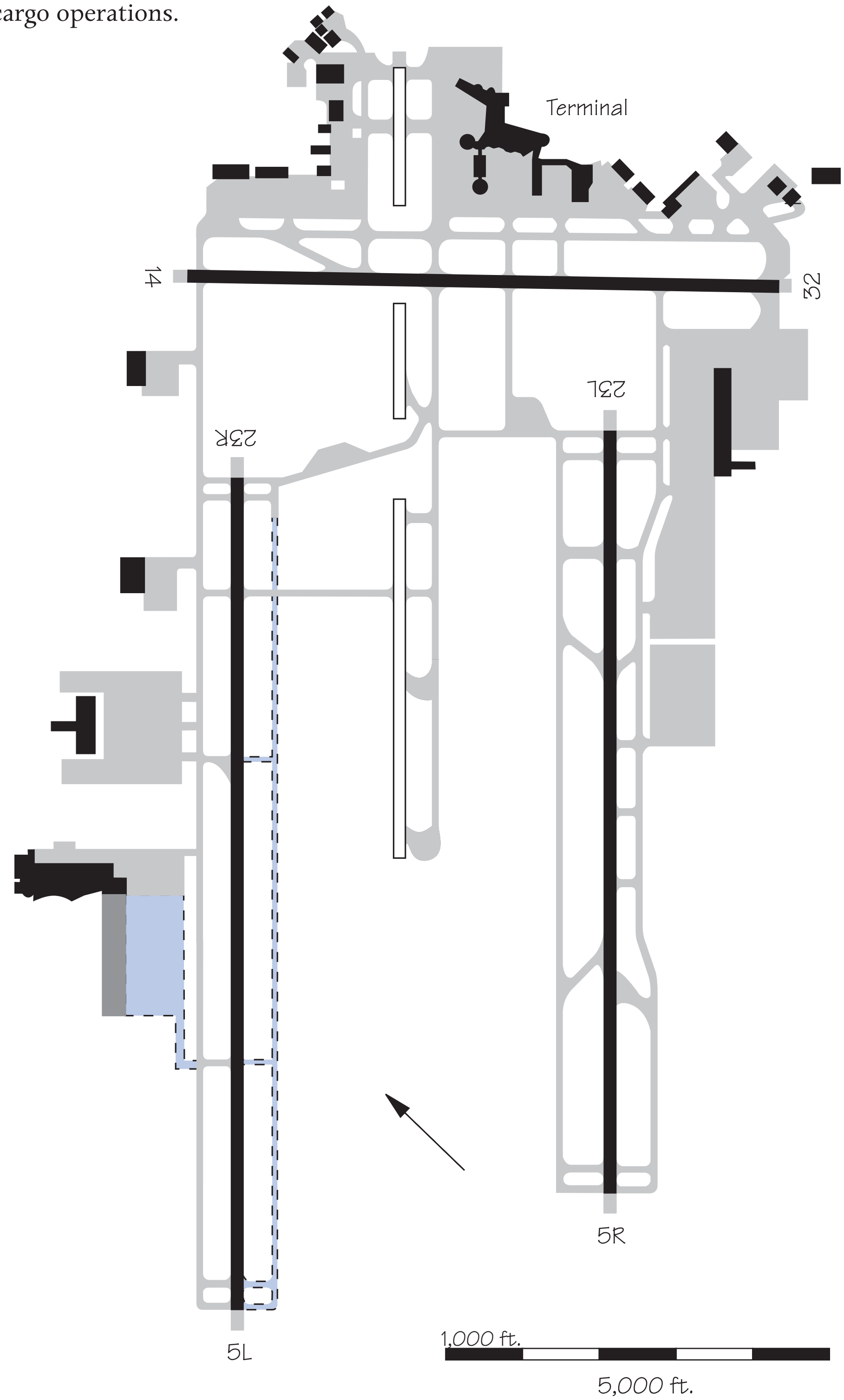
ICT — Wichita Mid-Continent Airport

A 1,700 ft. extension to Runway 1R/19L is proposed for possible expansion of cargo operations. This is not considered as a potential development through 2015.

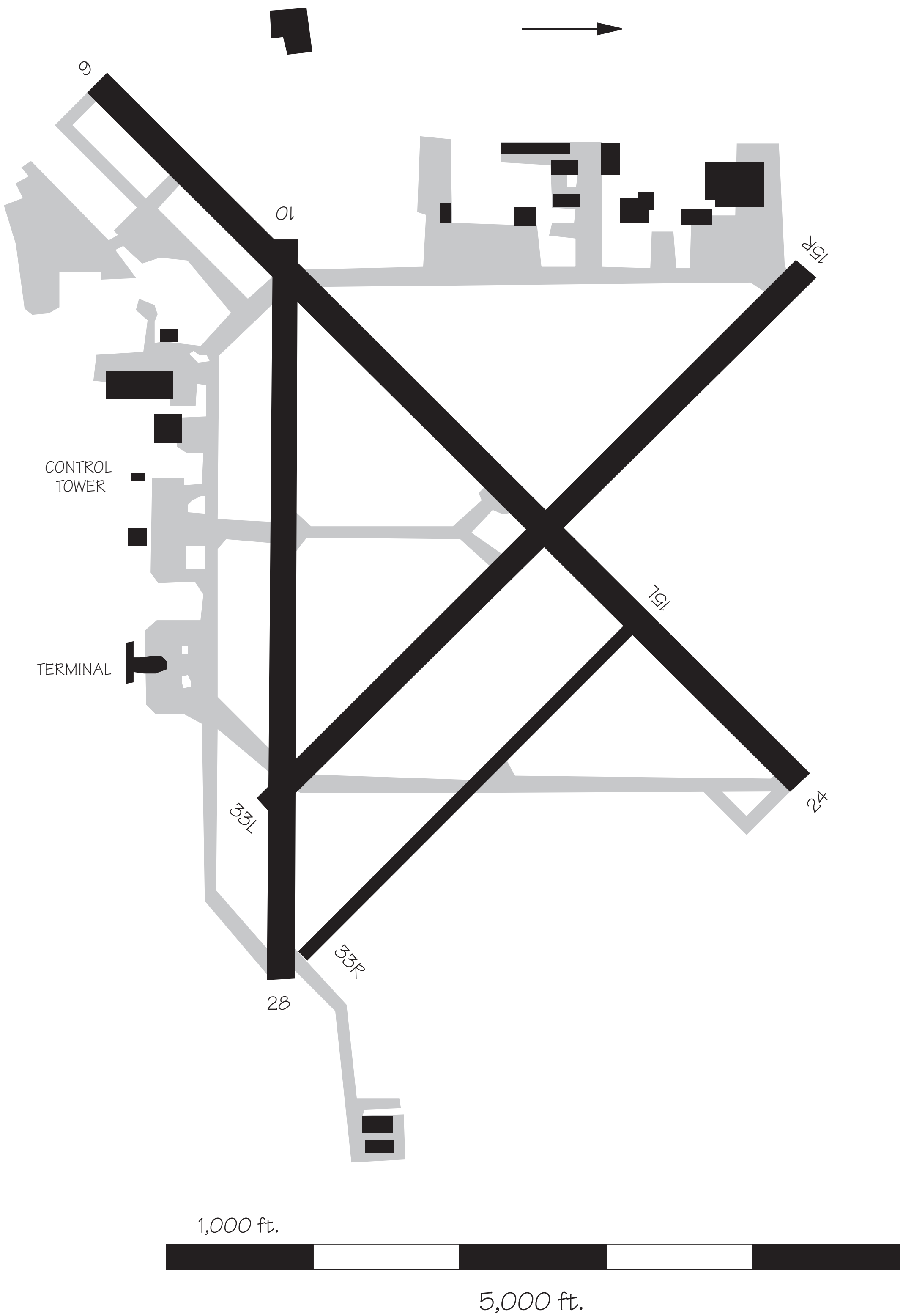


IND — Indianapolis International Airport

Construction of new Runway 5R/23L in 2008 will increase needed capacity and reduce anticipated air traffic delays. The runway will also facilitate increased air cargo operations.

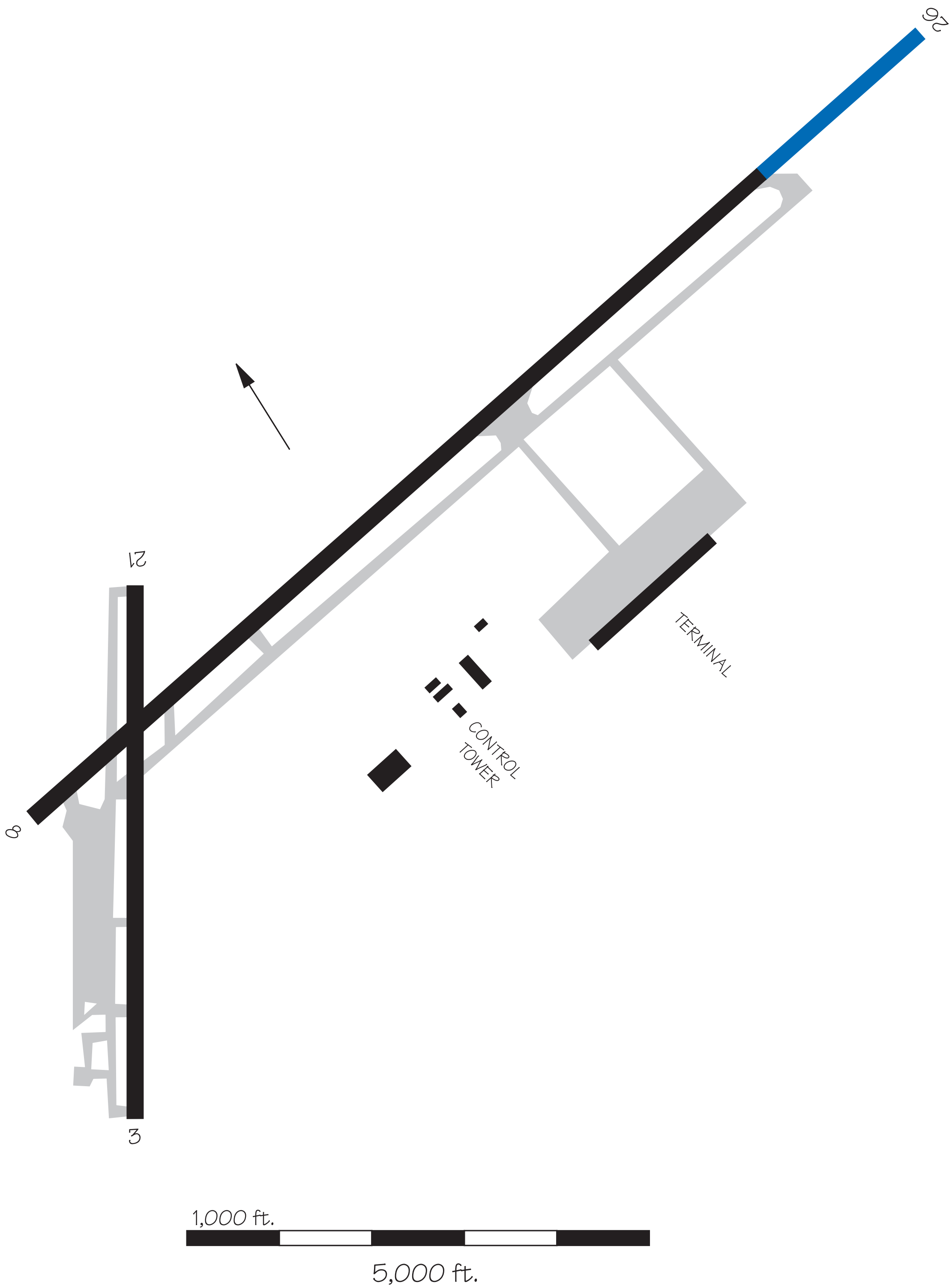


ISP — Islip Long Island Mac Arthur Airport



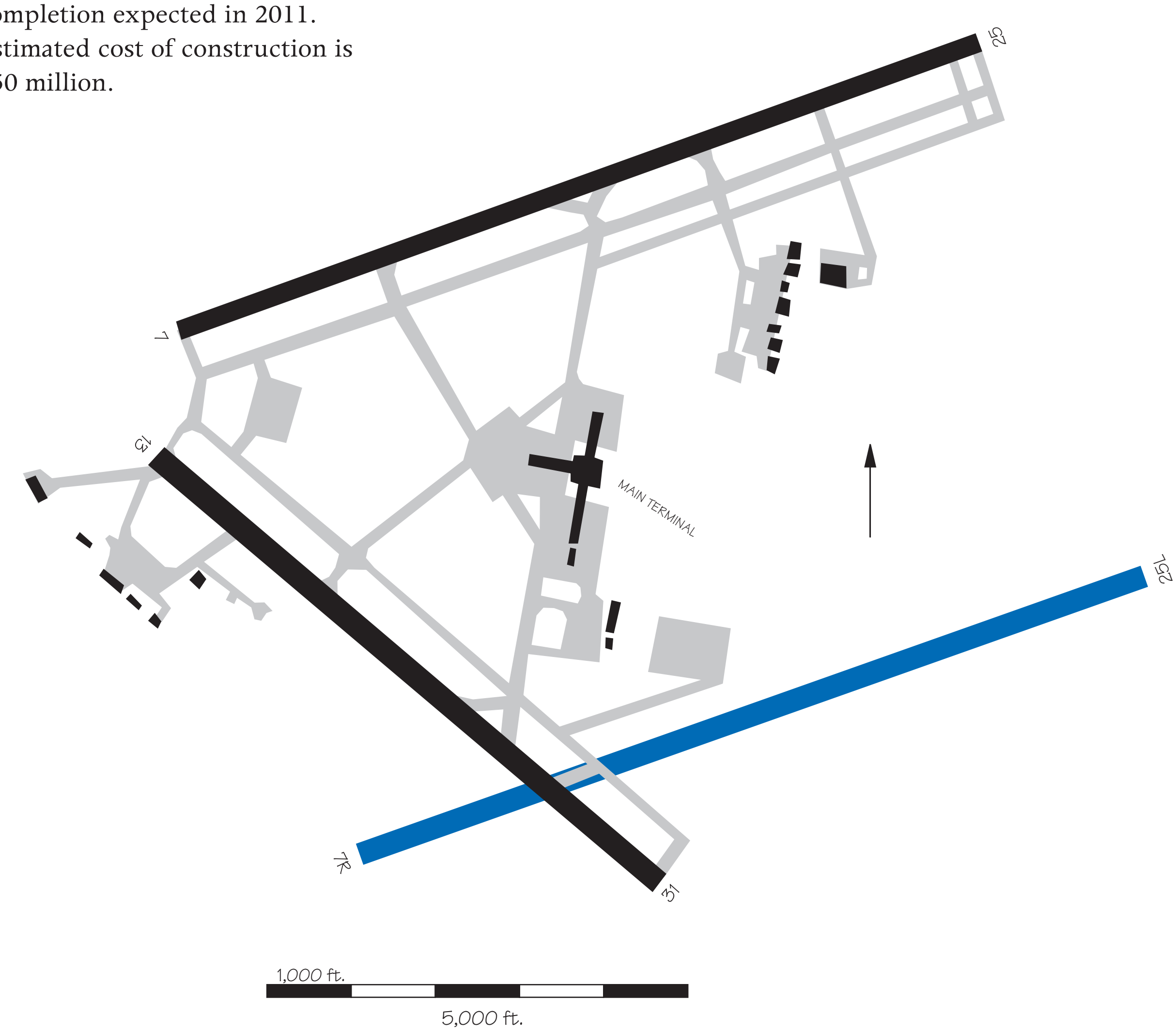
ITO — Hilo International Airport

A 2,200 ft. east extension of Runway 8/26 is proposed for development by 2010.

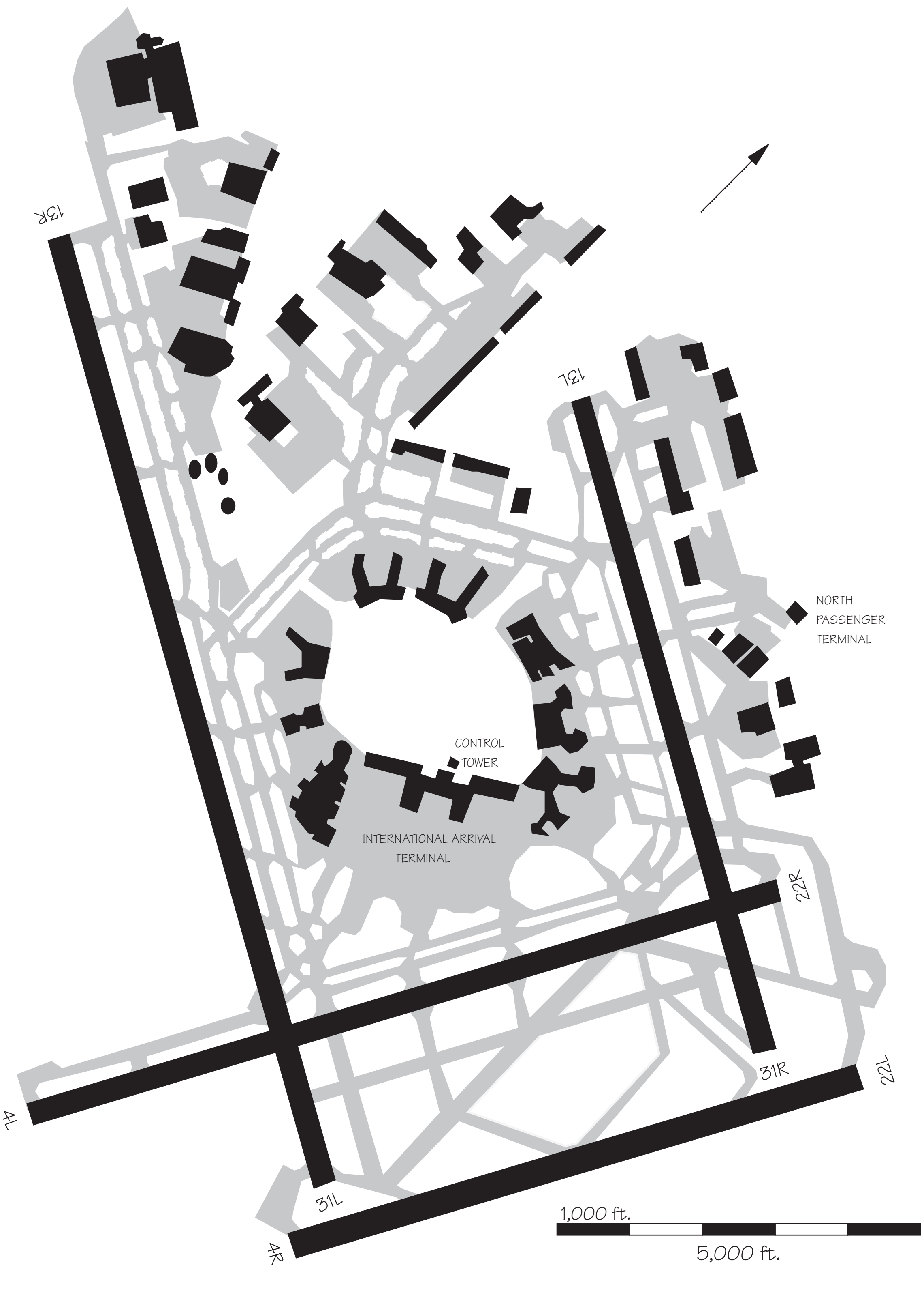


JAX — Jacksonville International Airport

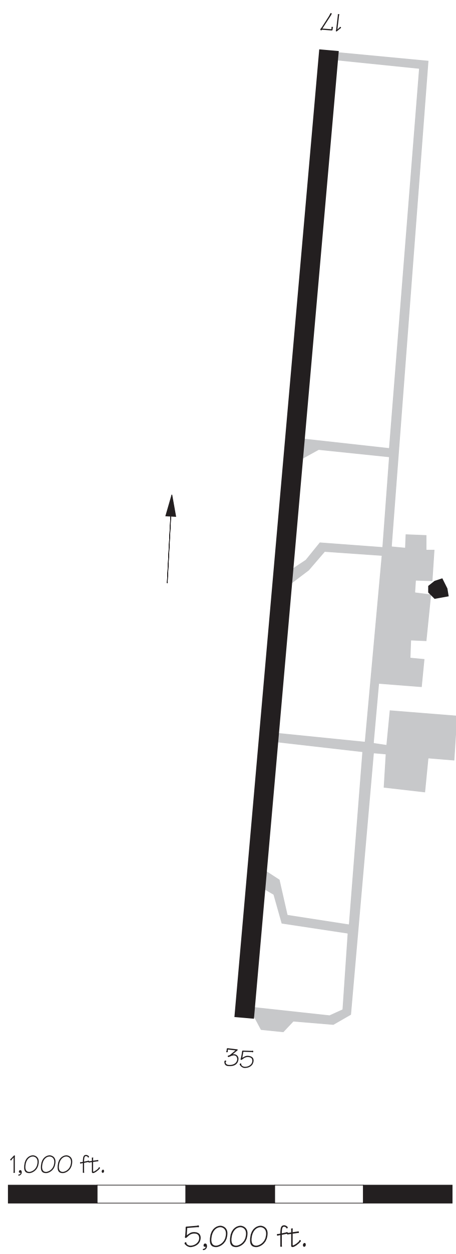
A new parallel Runway 7R/25L is being planned. It will be 6,500 ft. south of the existing Runway 7/25, permitting independent parallel IFR operations and potentially doubling Jacksonville's hourly IFR arrival capacity. Construction is scheduled to begin in 2010, with completion expected in 2011. Estimated cost of construction is $50 million.



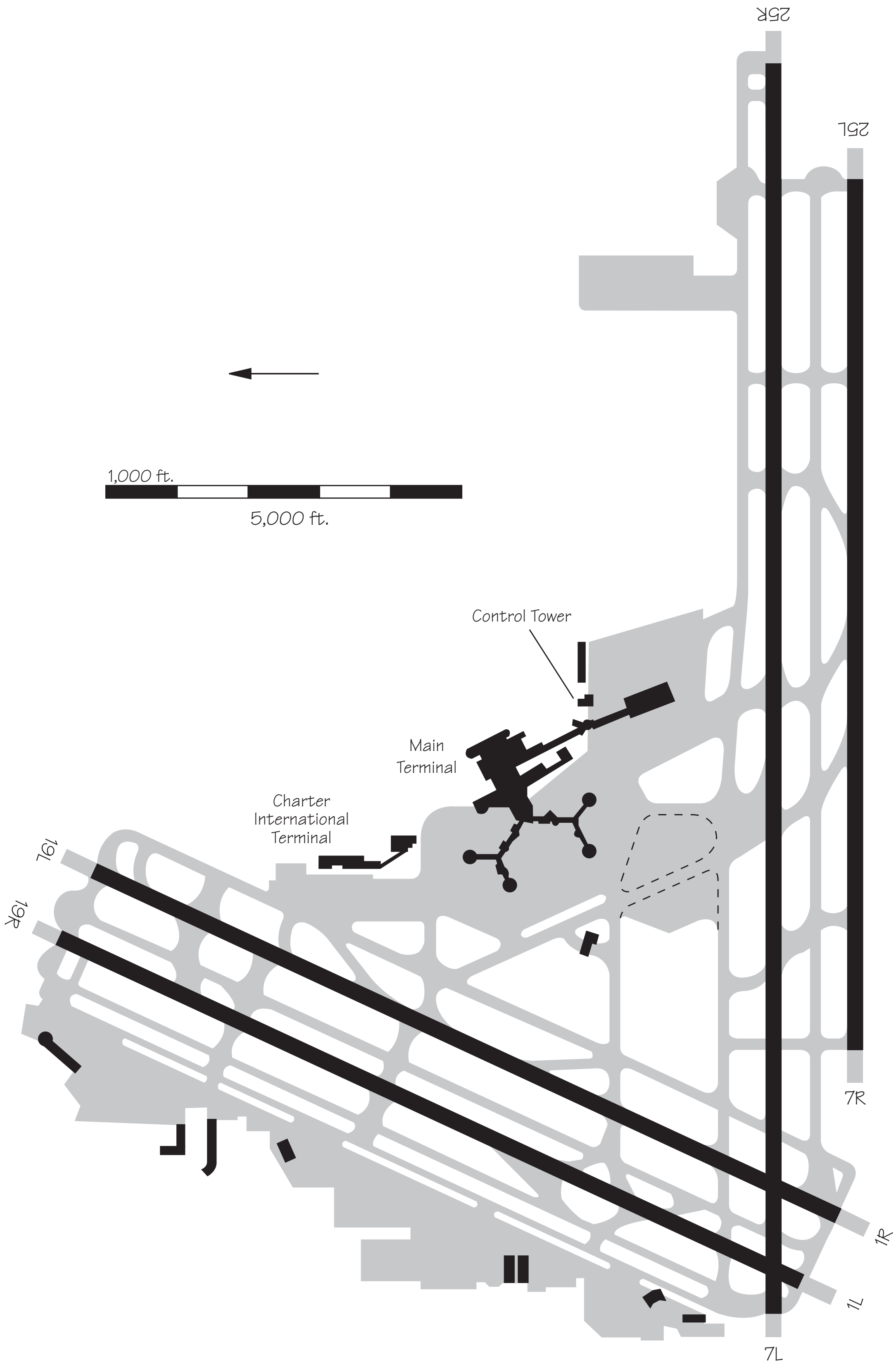
JFK — New York John F. Kennedy International Airport



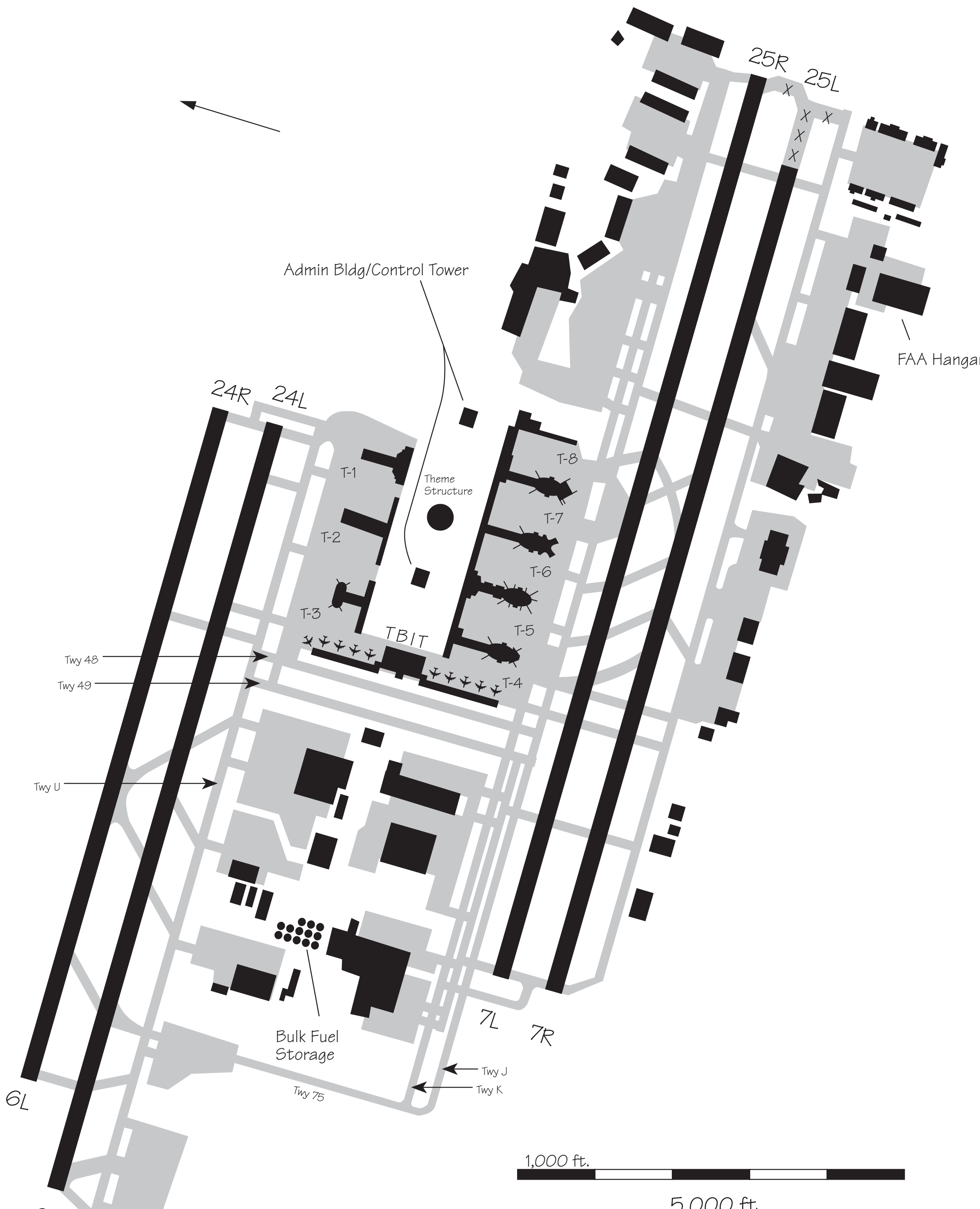
KOA — Kona International at Keahole



LAS — Las Vegas McCarran International Airport



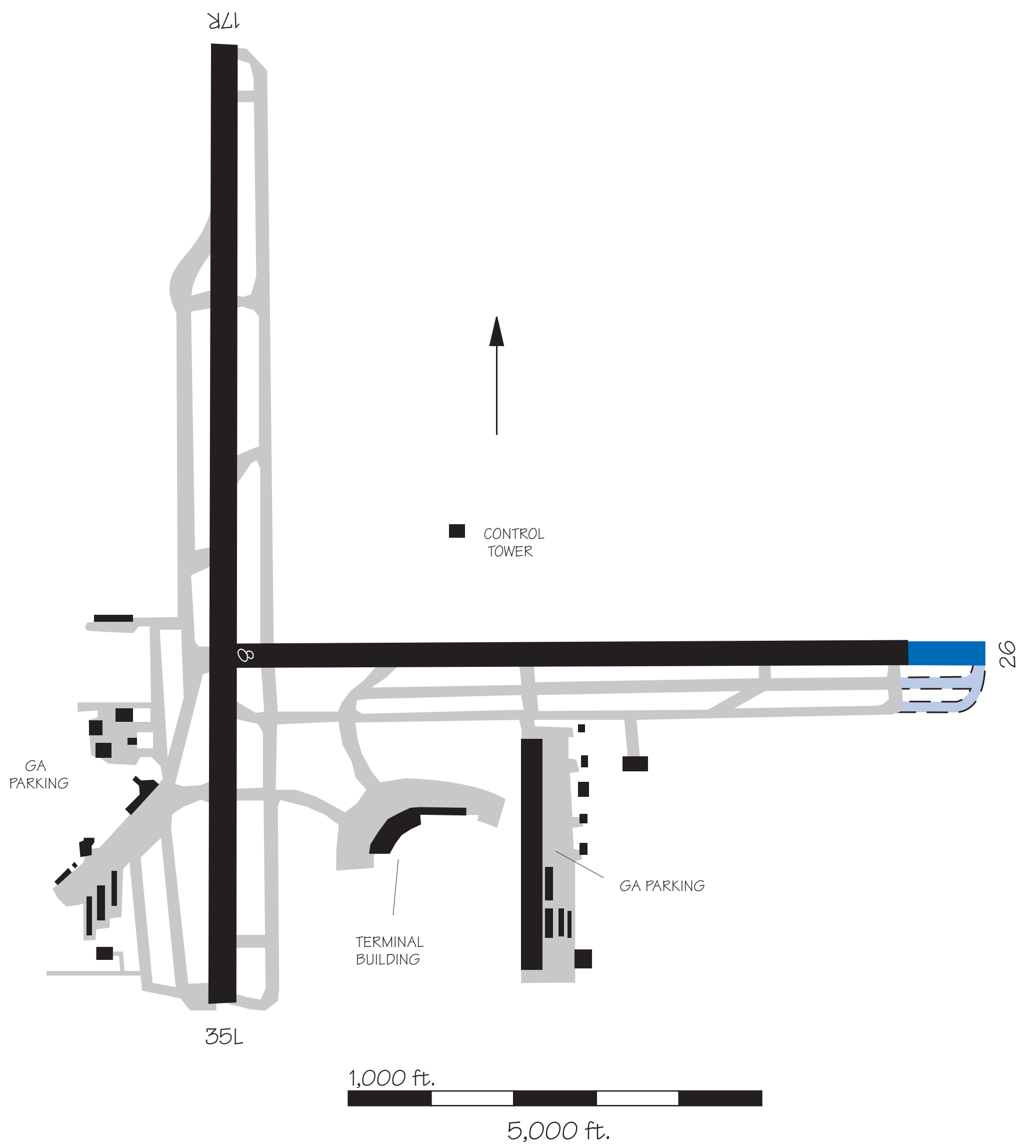
LAX — Los Angeles International Airport



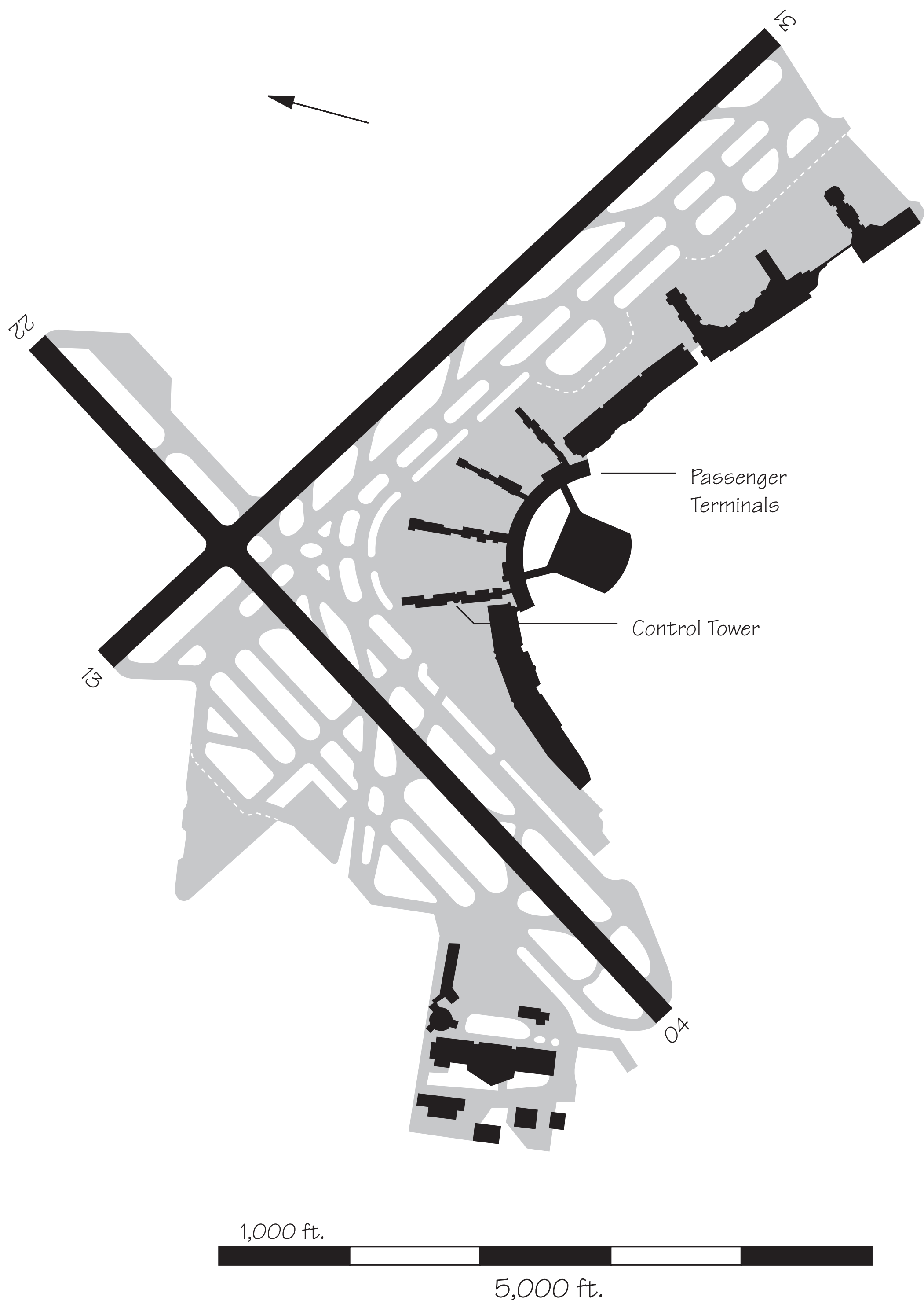
Note: Some buildings/structures have been removed for clarity.

LBB — Lubbock International Airport

An extension to Runway 8/26 is planned. The start of construction is scheduled for 2004 and the estimated cost is $5 million. It is anticipated that the extension will be operational in 2005.

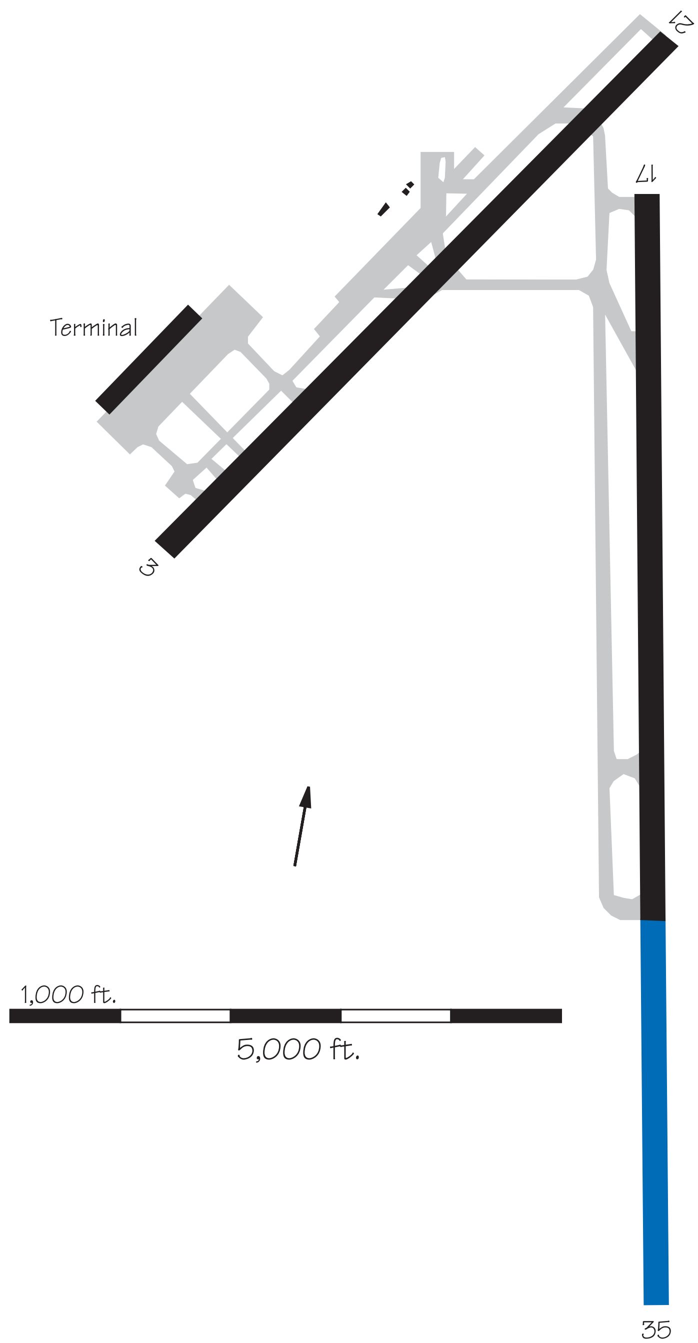


LGA — New York LaGuardia Airport



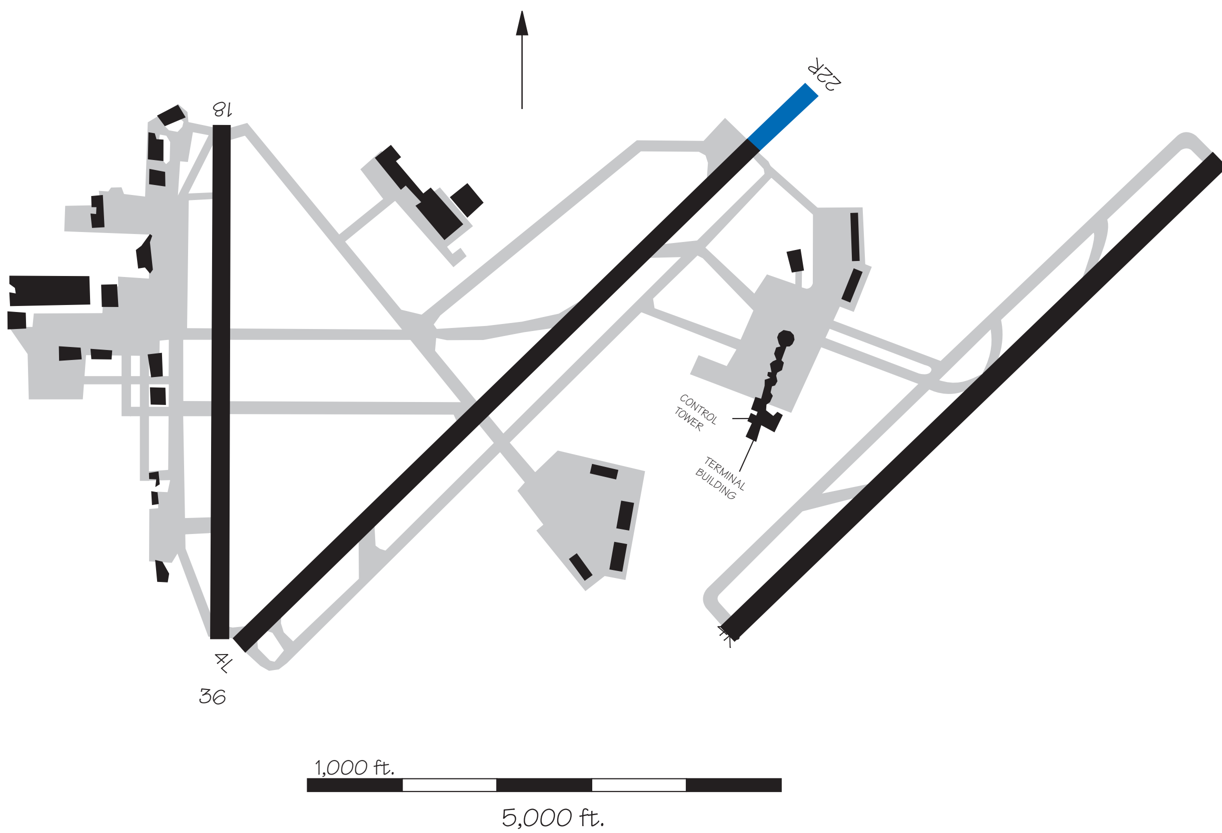
LIH — Lihue Airport

A 3,500 ft. extension of Runway 17/35 is proposed. Expected operational date is 2003, with an estimated project cost of $30 million.



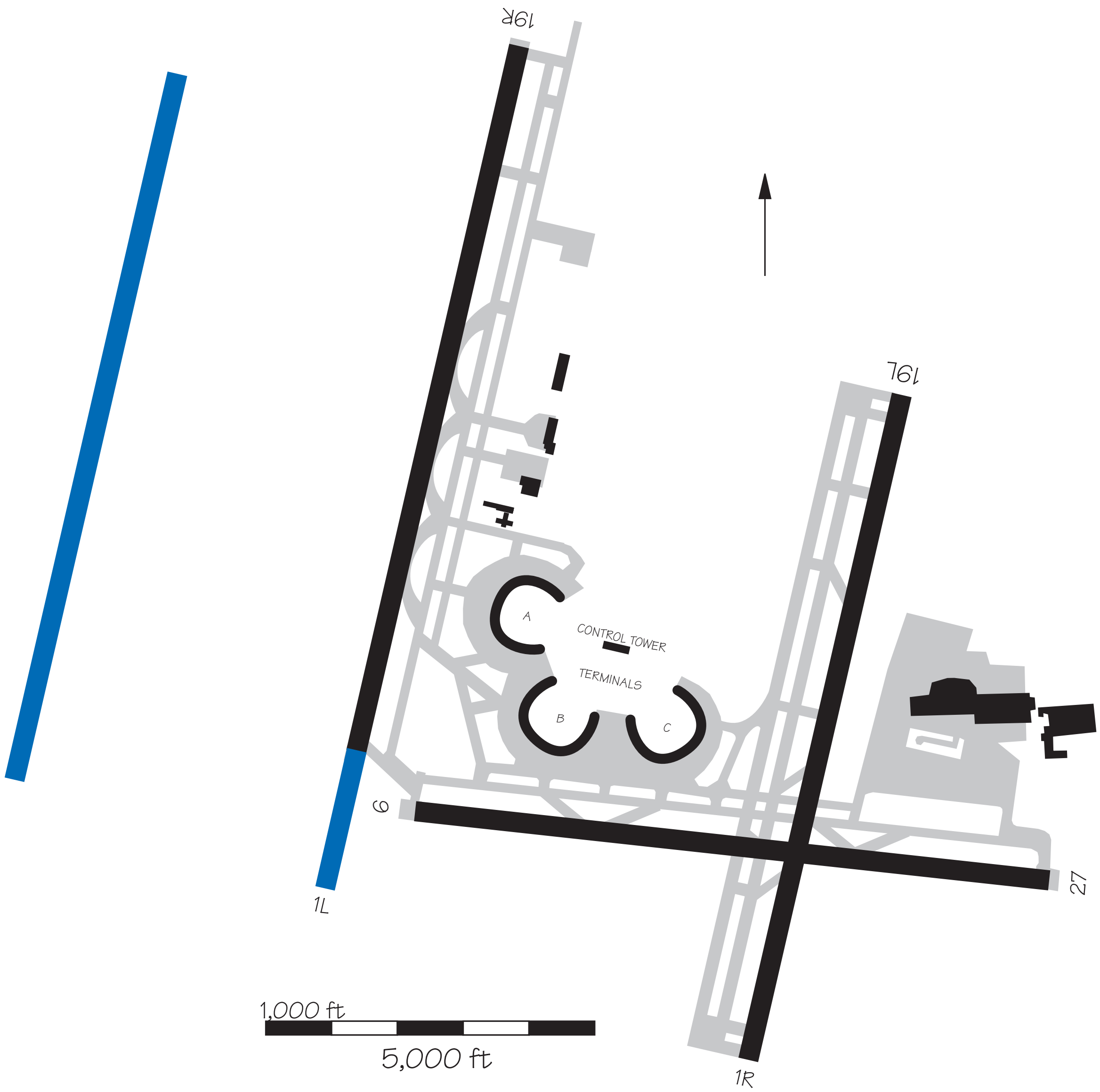
LIT — Little Rock Adams Field

An extension of Runway 4L/22R is underway, and should be operational in late 1998. The estimated cost of construction is $31 million.



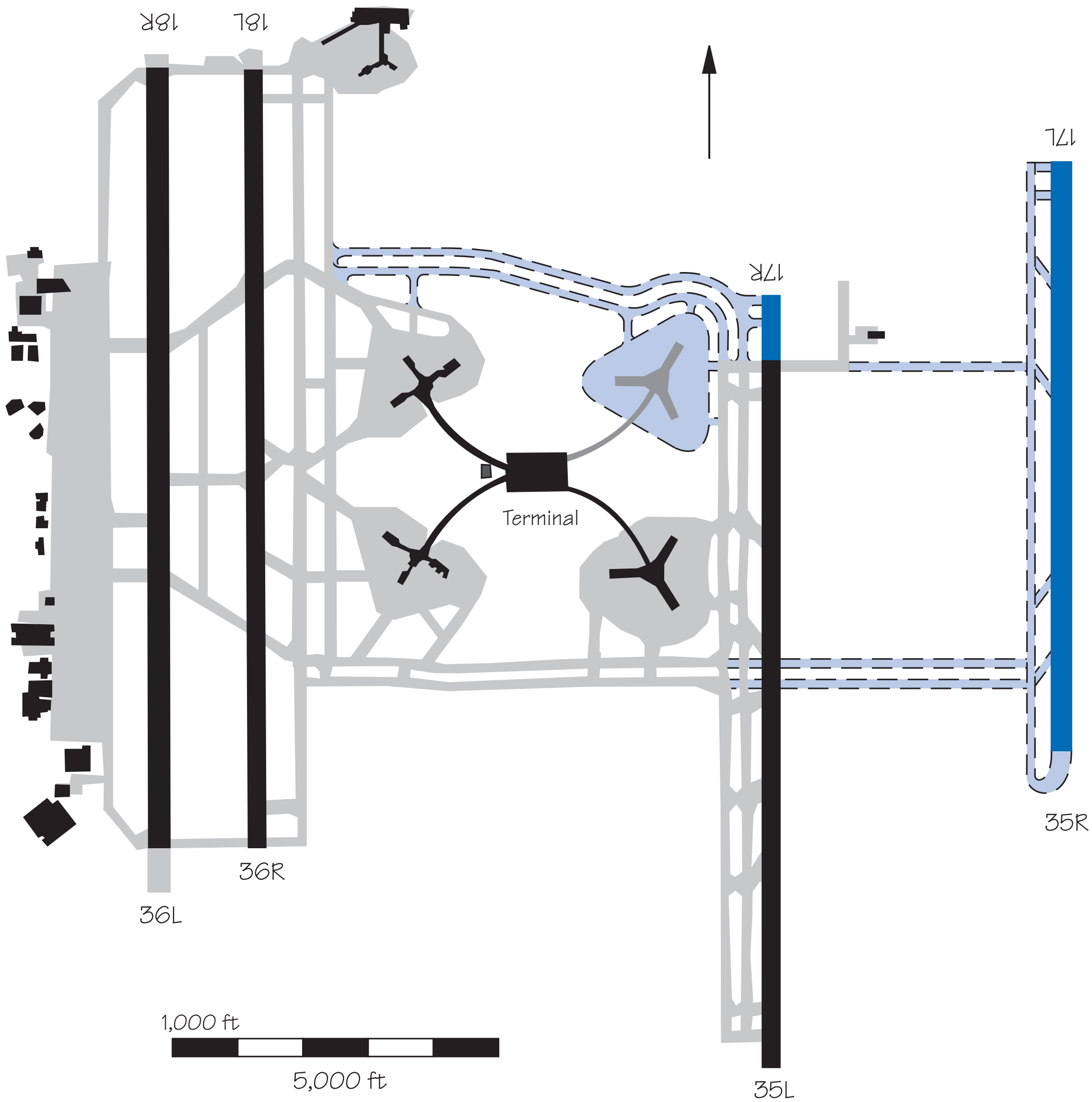
MCI — Kansas City International Airport

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

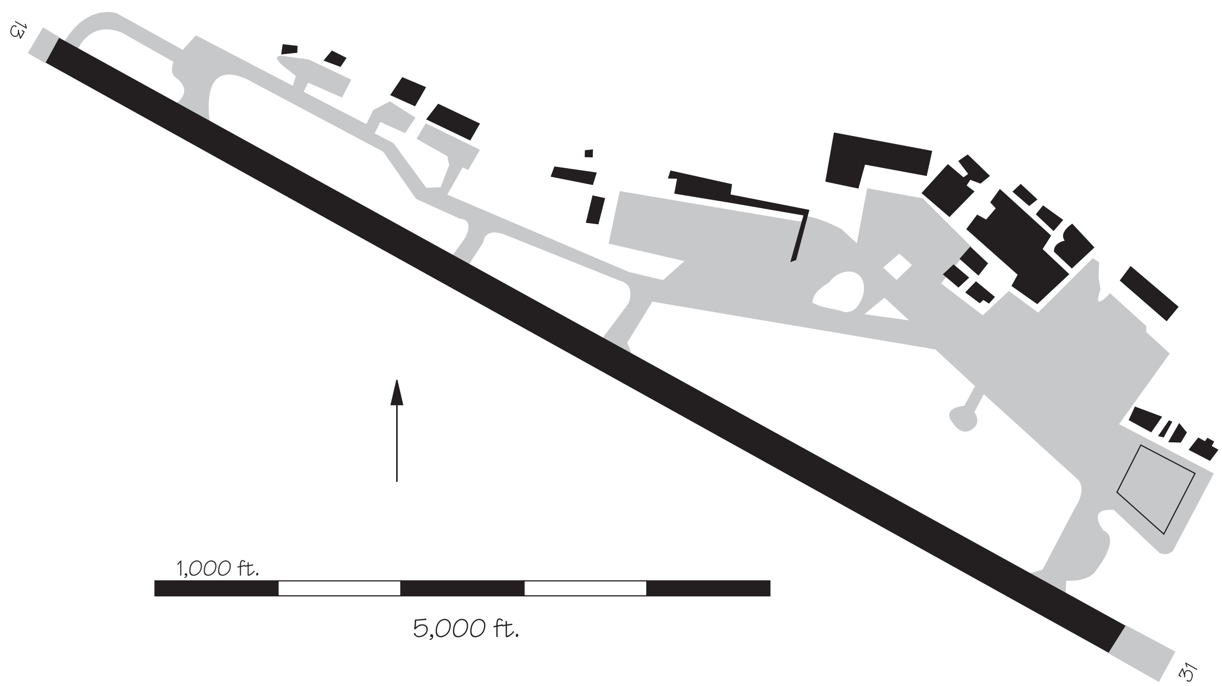


MCO — Orlando International Airport

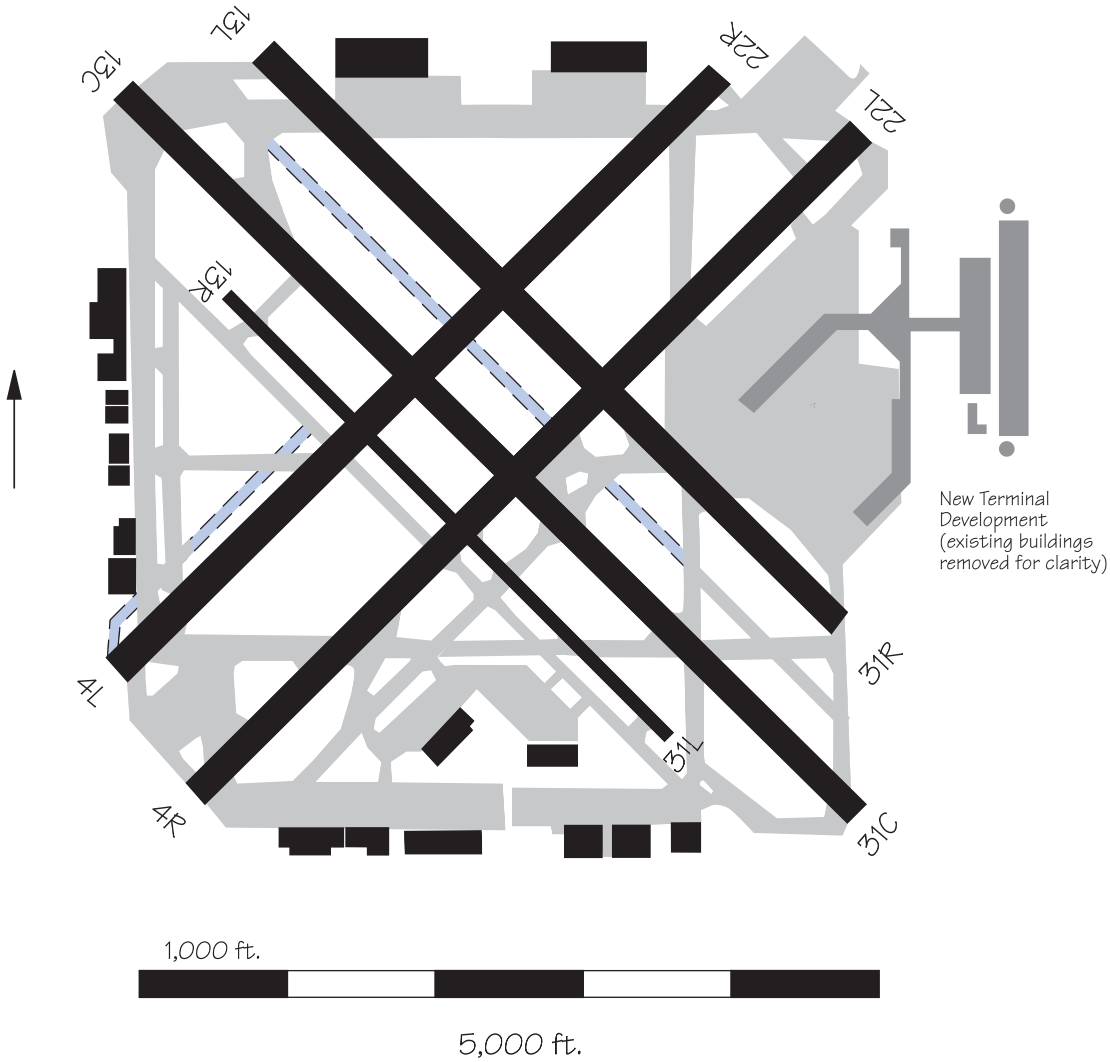
Environmental mitigation for a fourth north-south parallel runway, Runway 17L/35R, began October 10, 1990 and is ongoing. The runway is expected to be operational in 2002. It will be located 4,300 ft. east of Runway 17R/35L. This may permit triple independent IFR operations. The estimated cost of construction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



MDT — Harrisburg International Airport

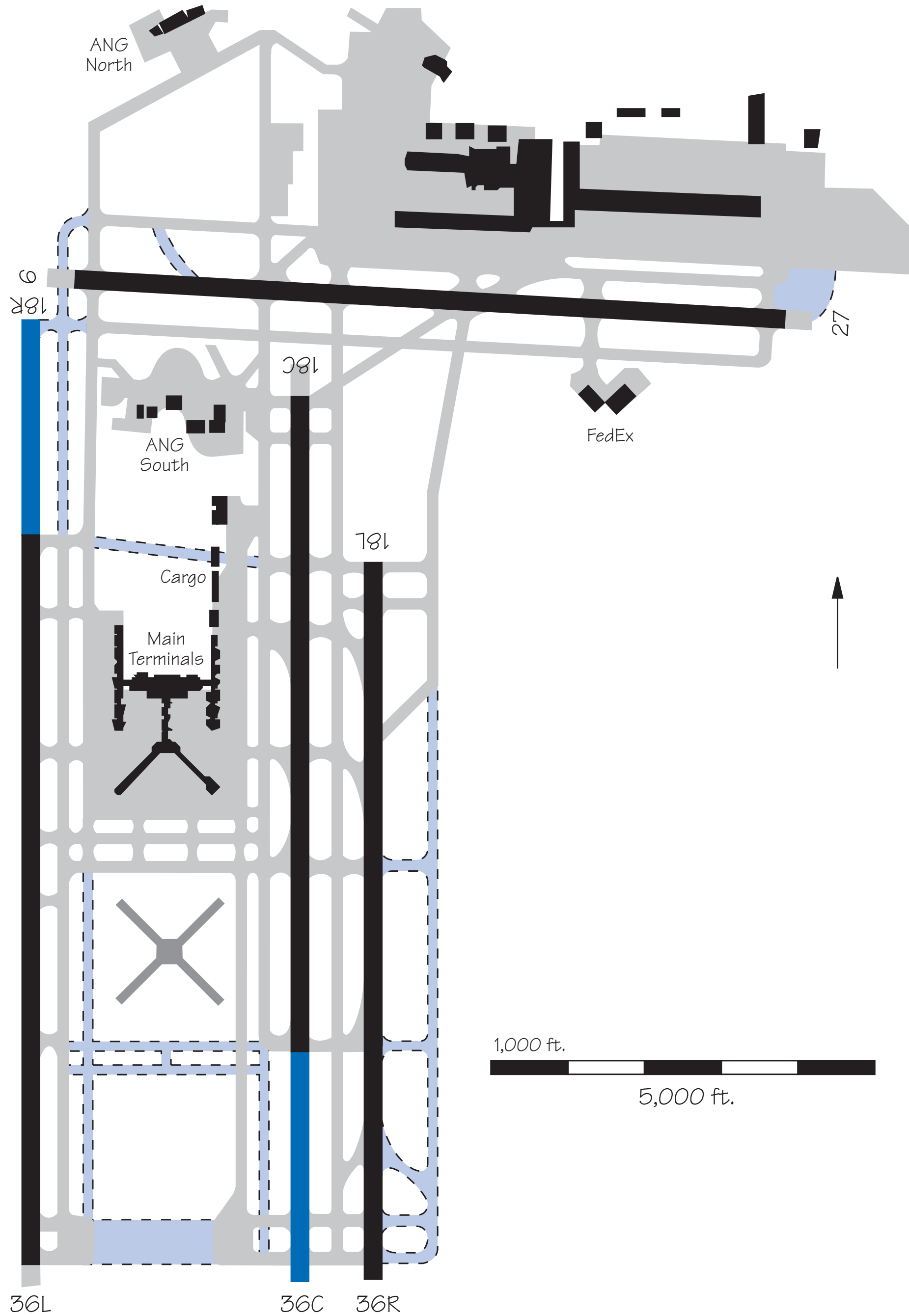


MDW — Chicago Midway Airport



MEM — Memphis International Airport

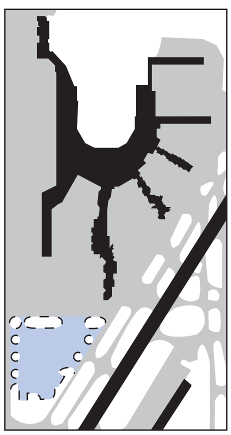
A reconstruction and extension of Runway 18C/36C is under way. Construction is expected to be completed by 2000 at a cost of $103 million. The extended runway will allow departures by aircraft with heavier payloads and/or greater haul-lengths.



MIA — Miami International Airport

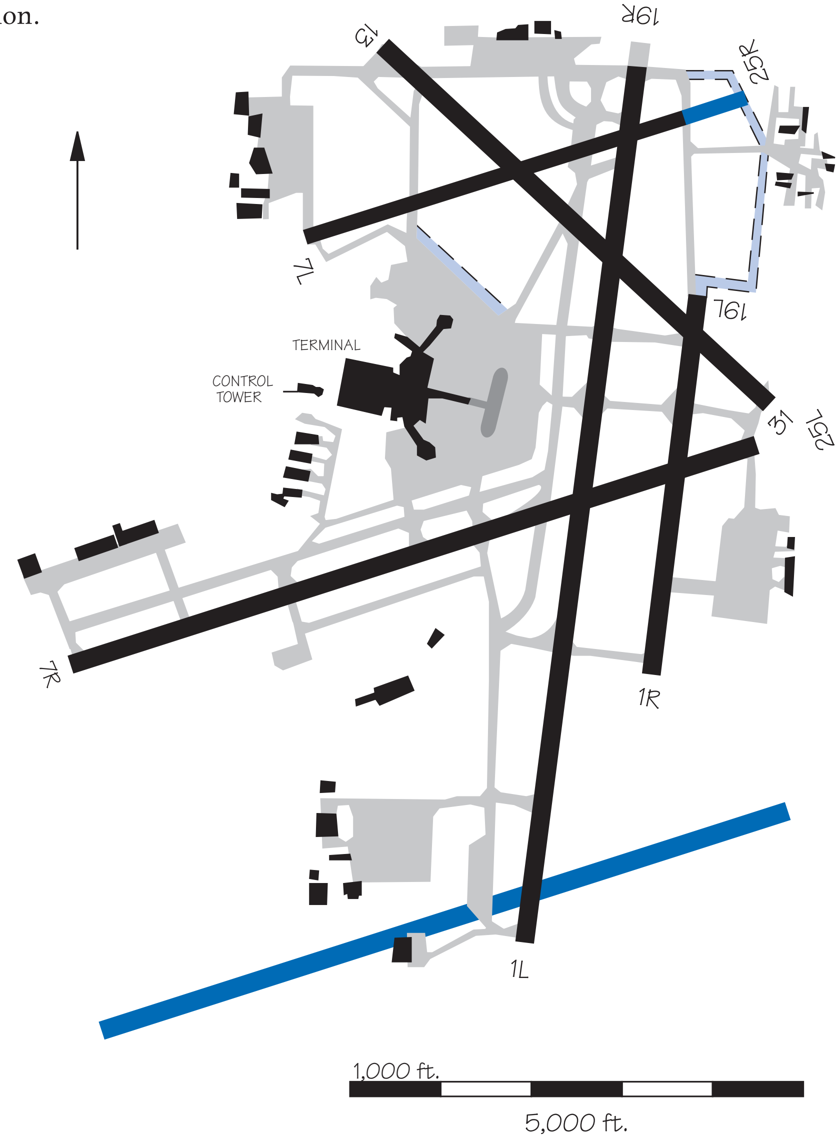
Construction of a new air carrier runway, 8,600 ft. long and 800 ft. north of existing Runway 9L/27R, is expected to start in 1999 and be completed by 2002. The estimated cost of construction is $180 million. An EIS is expected to be completed in late 1998. The new runway is planned for use primarily as an arrival runway in VFR and non-precision IFR conditions.

New Terminal Design and Mid-field Hold Pad



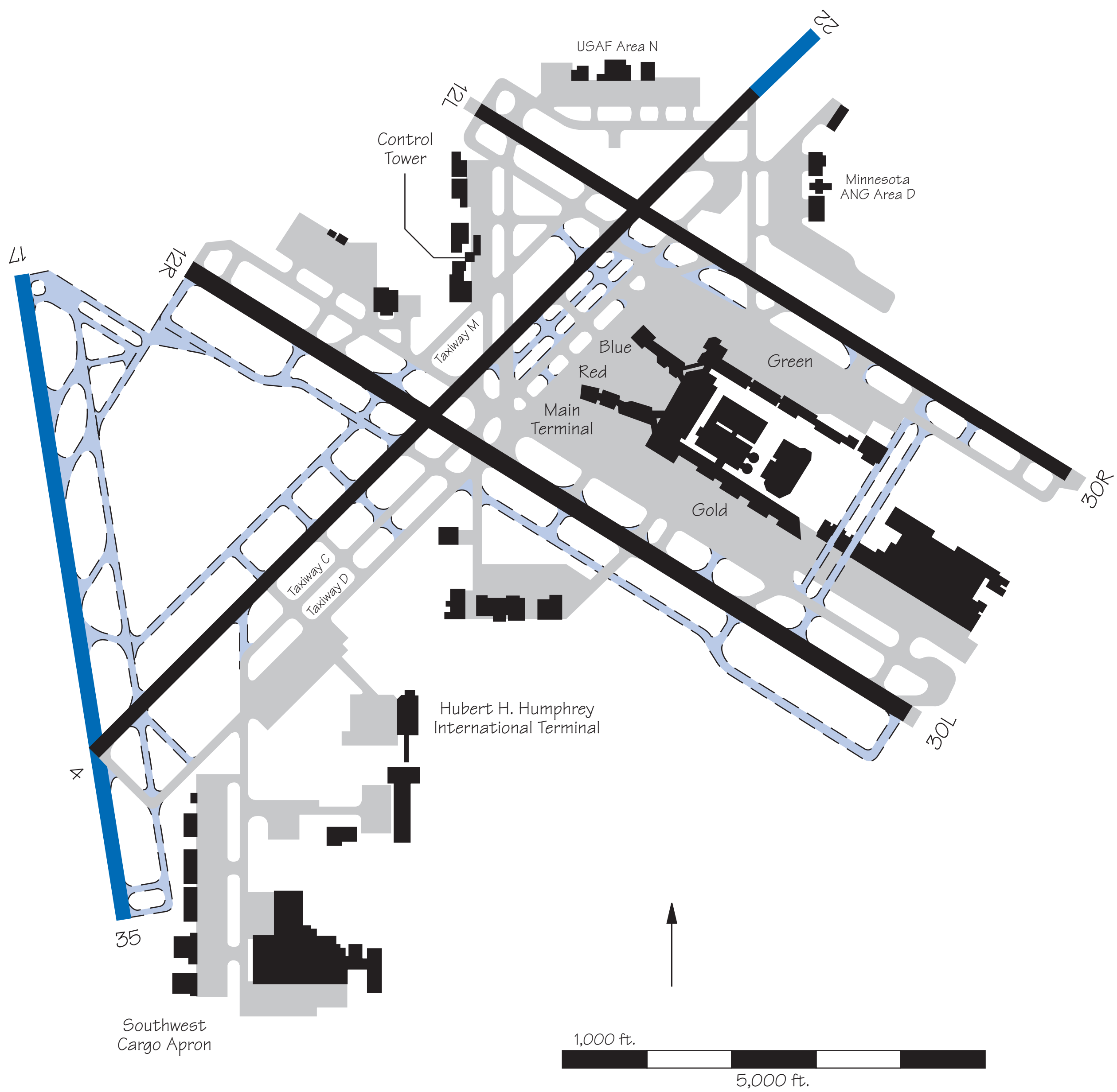
MKE — Milwaukee General Mitchell International Airport

A 700 ft. extension to Runway 7L/25R is to be completed in the summer of 1999. Extension of this runway from 4,100 ft. to 4,800 ft. will accommodate commuter aircraft and delay the need for a third parallel runway until about the year 2015. Anticipated cost of the runway extension is approximately $1.9 million.



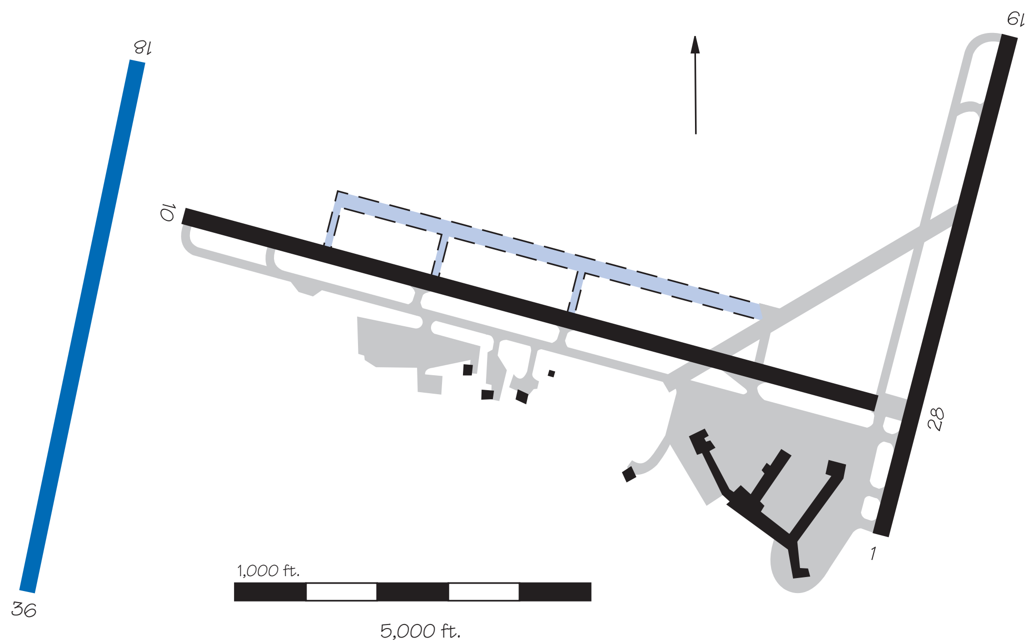
MSP — Minneapolis-St. Paul International Airport

Construction of the proposed 8,000 ft. Runway 17/35, at a cost of $175 million, will reduce the projected 2020 annual delay cost from $66 million to $38 million. The runway is expected to be operational in 2003 and will be used primarily for departures to the south and arrivals to the north. Construction of a 1,000 ft. extension to the northeast end of Runway 4/22, at a cost of $10 million, is planned to enhance non-stop flights to Hong Kong. The extension is to be operational in late 2000.

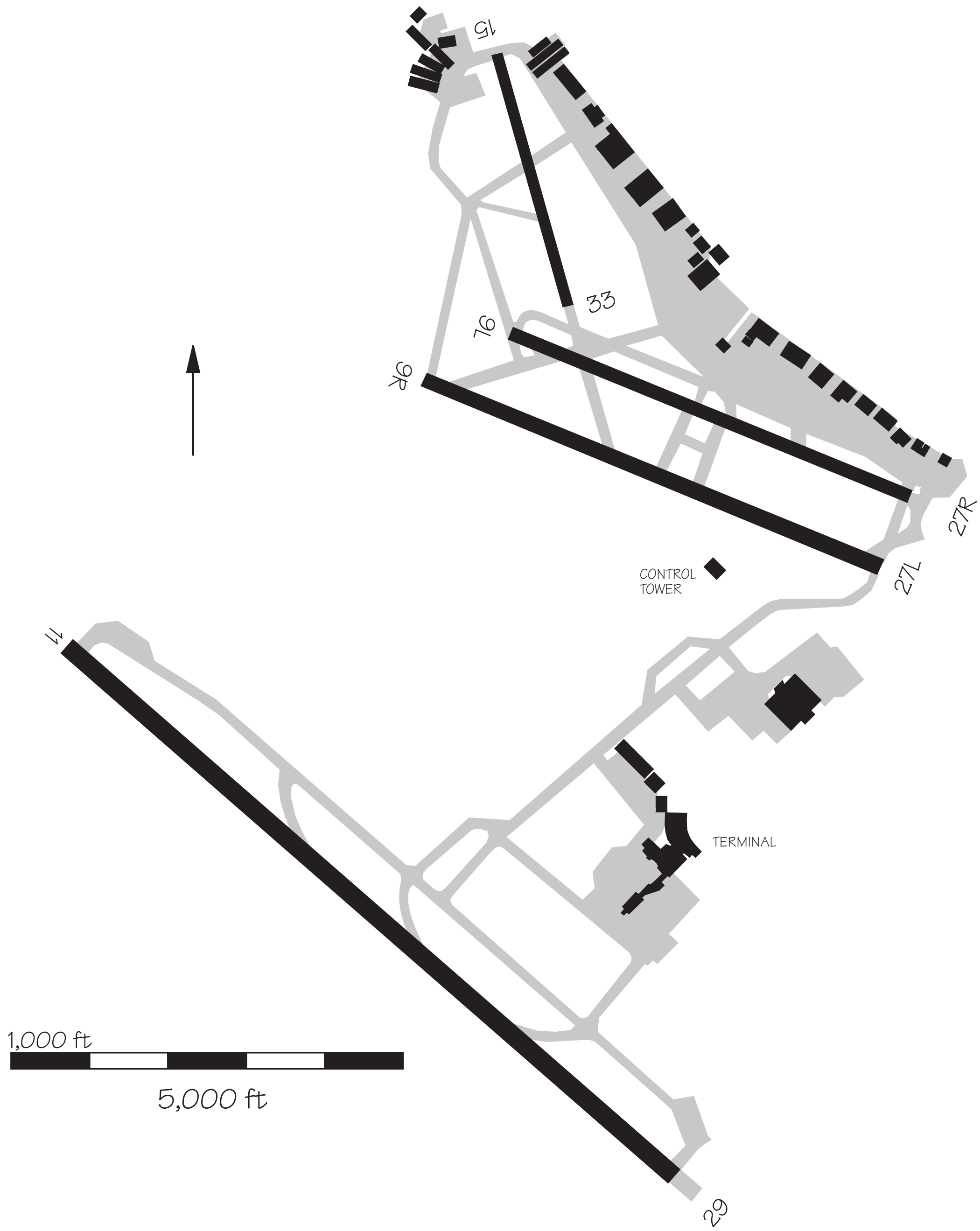


MSY — New Orleans International Airport

A new north-south runway, Runway 18/36, is planned. This new runway will be near parallel to the existing Runway 1/19 and will be located west of the threshold of Runway 10, approximately 11,000 ft. away from Runway 1/19. Pending environmental findings and funding availability, it is expected that the runway will be completed around 2010.

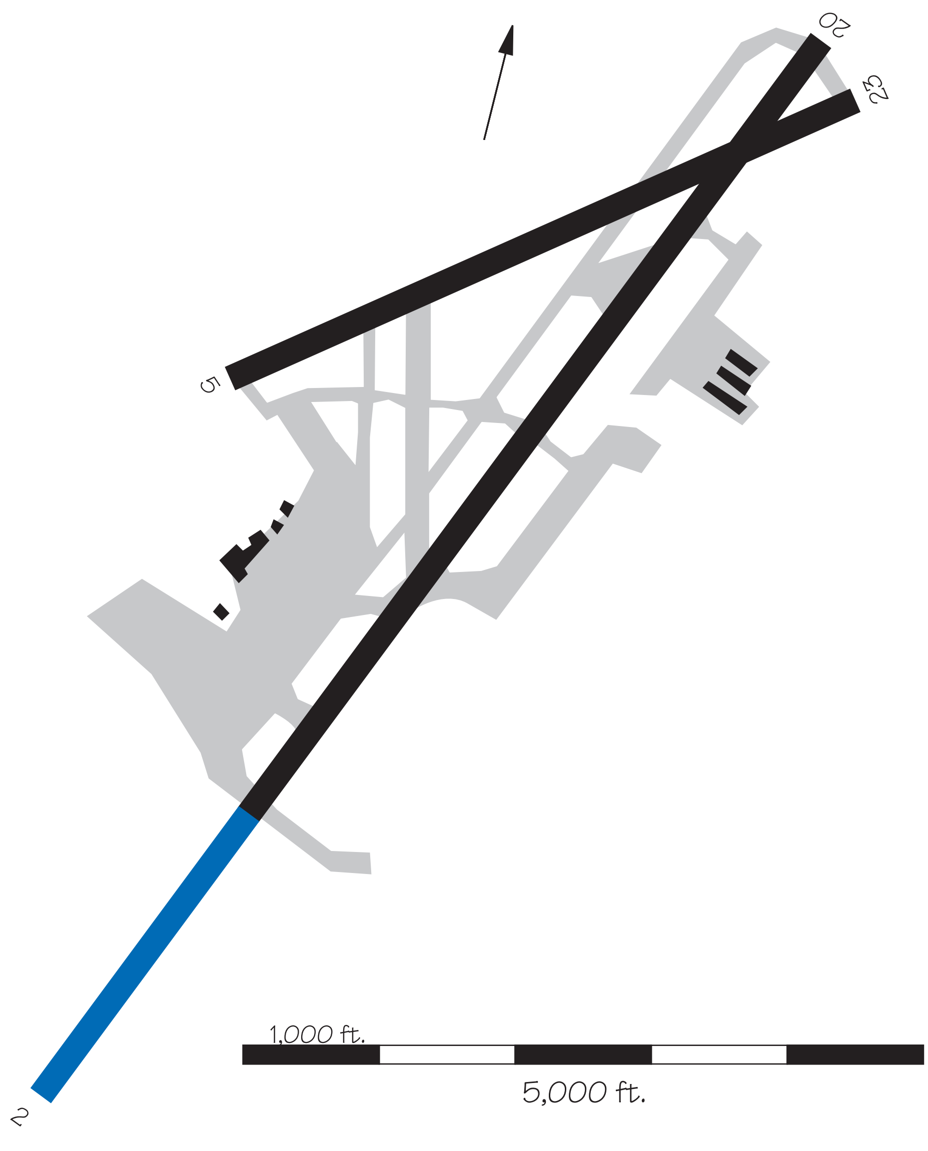


OAK — Metropolitan Oakland International Airport



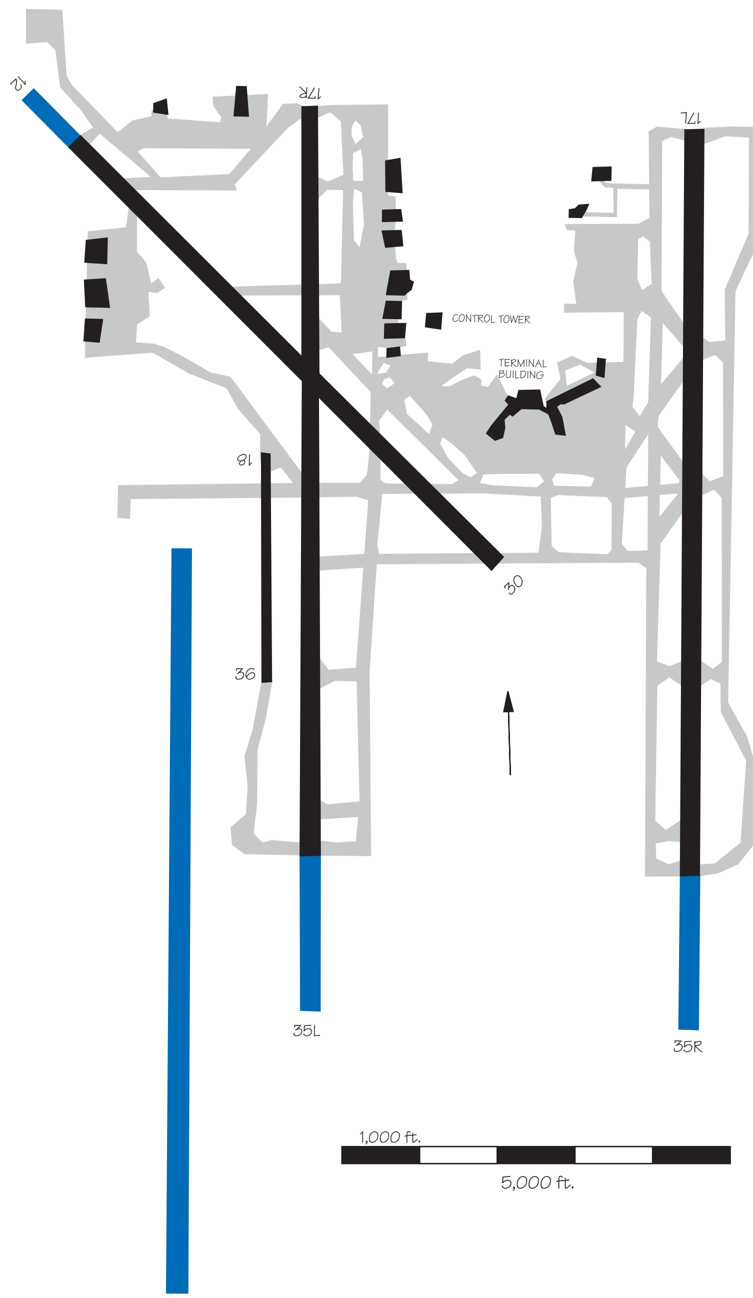
OGG — Kahului Airport

An extension of Runway 2/20 is being planned. An EIS is underway, and the extension could be operational by 2001, at a cost of $47 million.



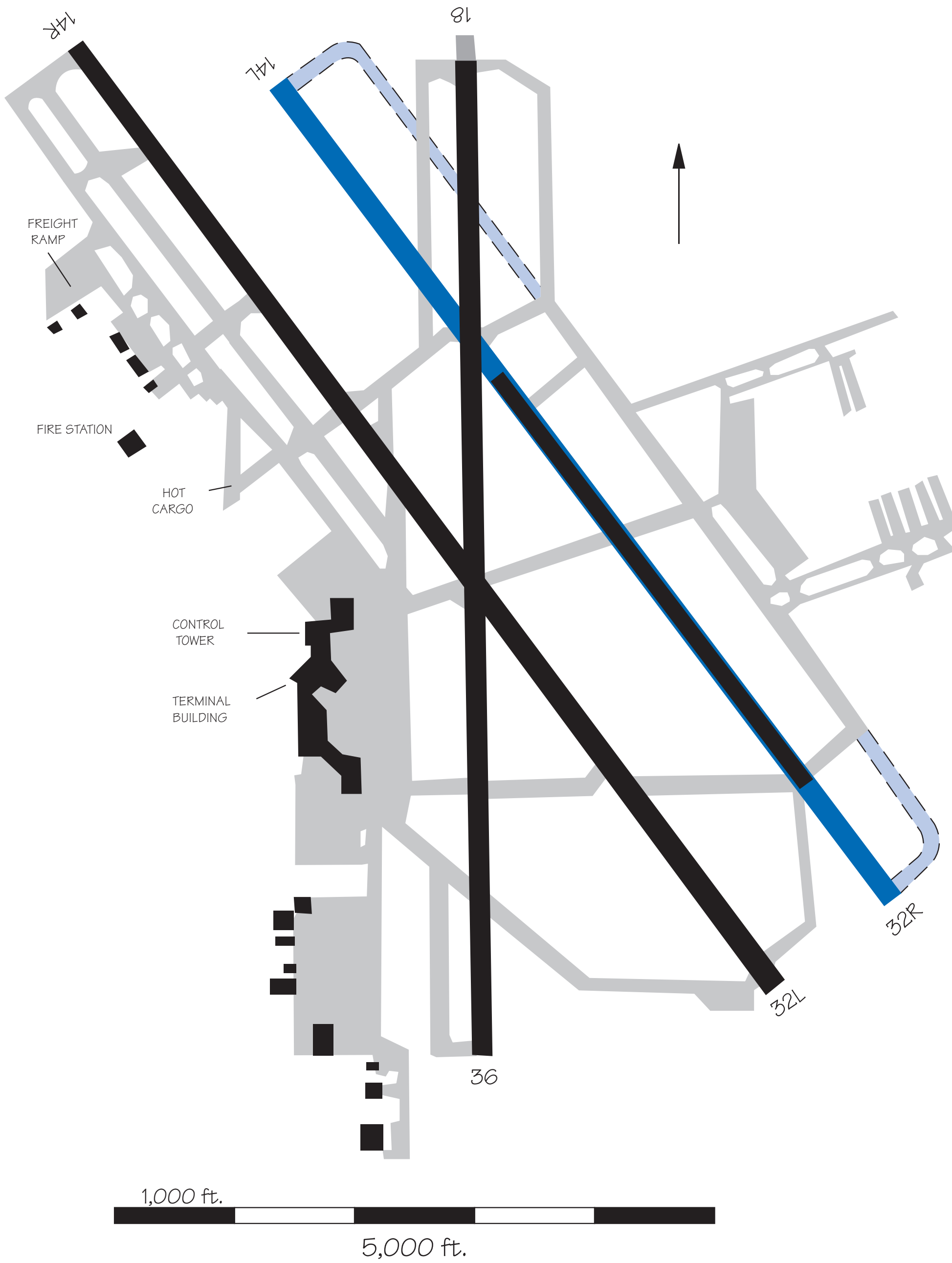
OKC — Oklahoma City Will Rogers World Airport

Construction of a new west parallel runway 1,600 ft. west of Runway 17R/35L is planned to be operational by 2012. Estimated cost of construction is $13 million. Extensions to both north/south runways, Runways 17L/35R and 17R/35L, are also planned. The estimated cost of extending the runways is $8 million each. Construction of the extension to Runway 17R/35L is expected to start in 2010 and be completed by 2014. A 1,200 ft. extension to the northwest of Runway 13/31 is planned as well. Construction is slated to begin in 2003, be completed in 2005, and cost $5 million.

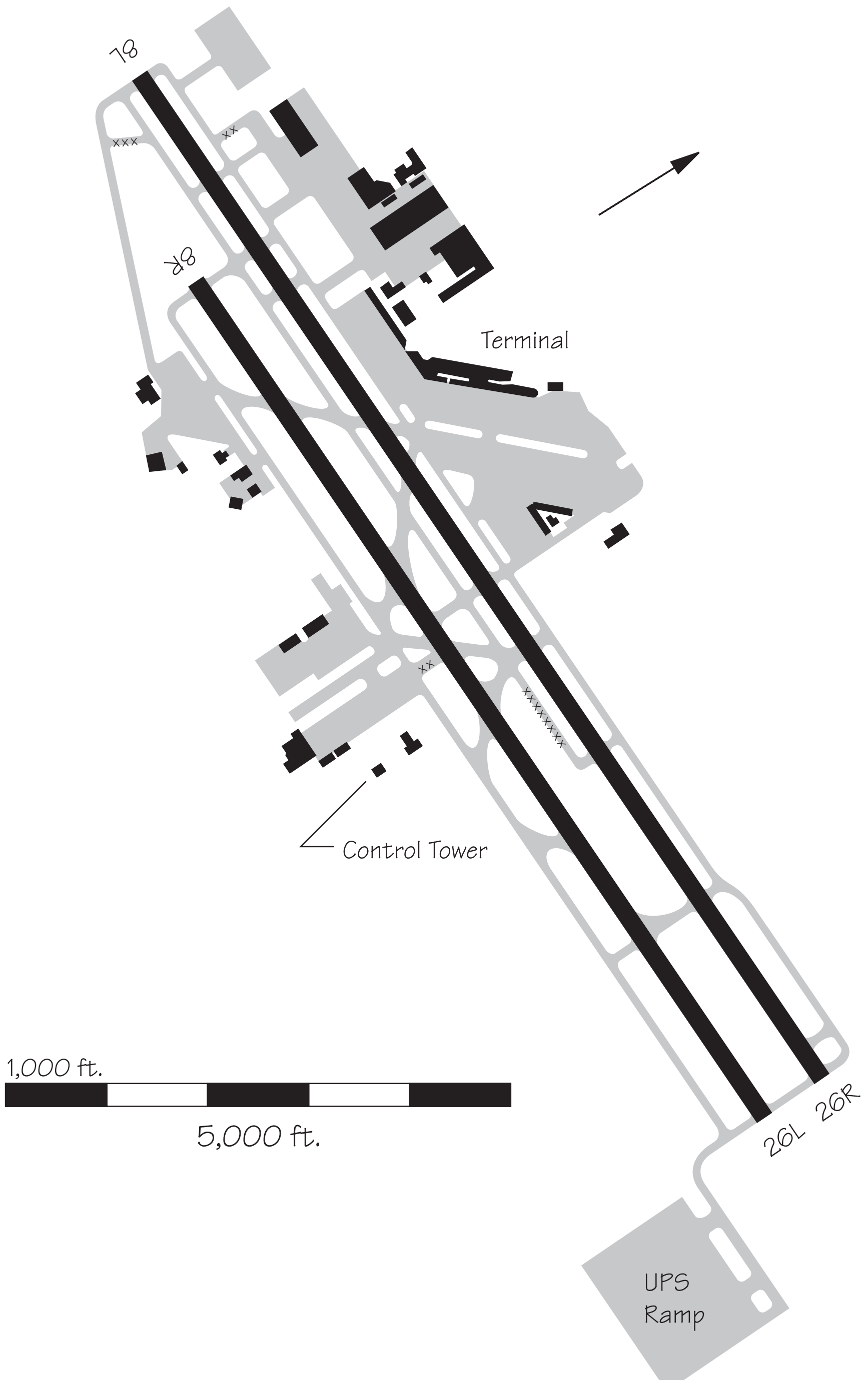


OMA — Omaha Eppley Airfield

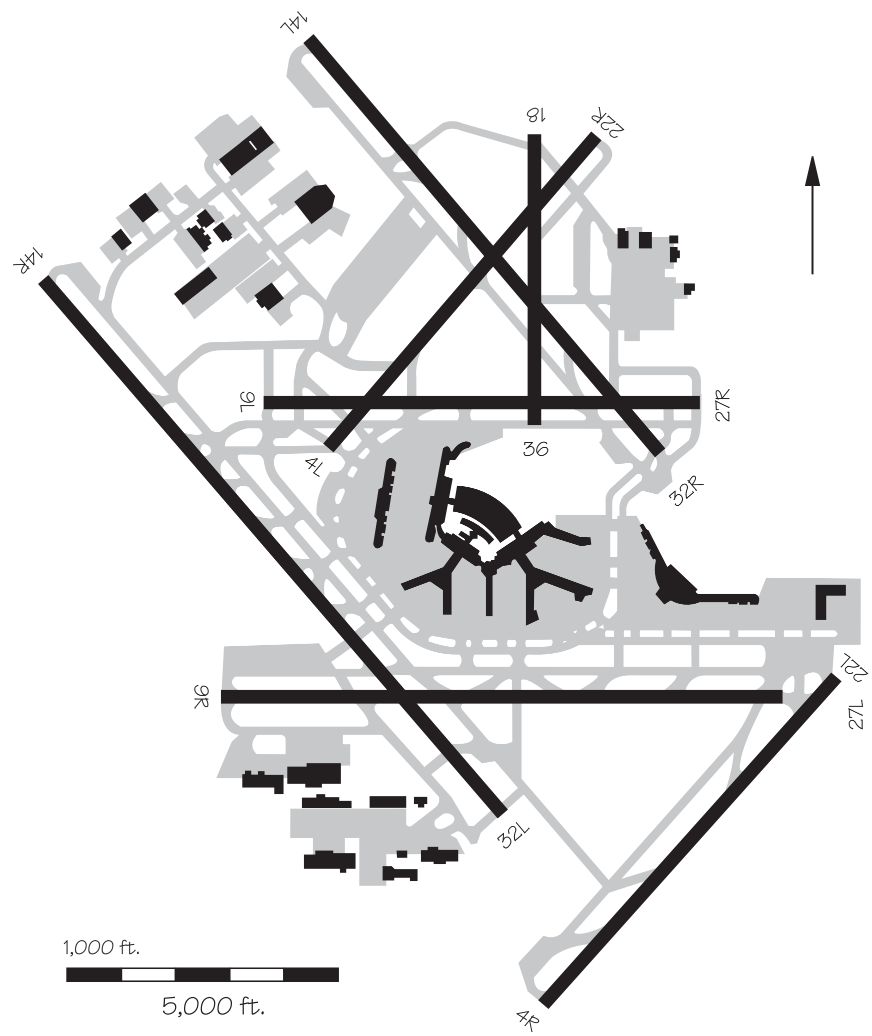
A 1,000 ft. extension to Runway 32R and a 3,400 ft. extension to Runway 14L are planned. No estimate of cost or completion dates are available at this time.



ONT — Ontario International Airport

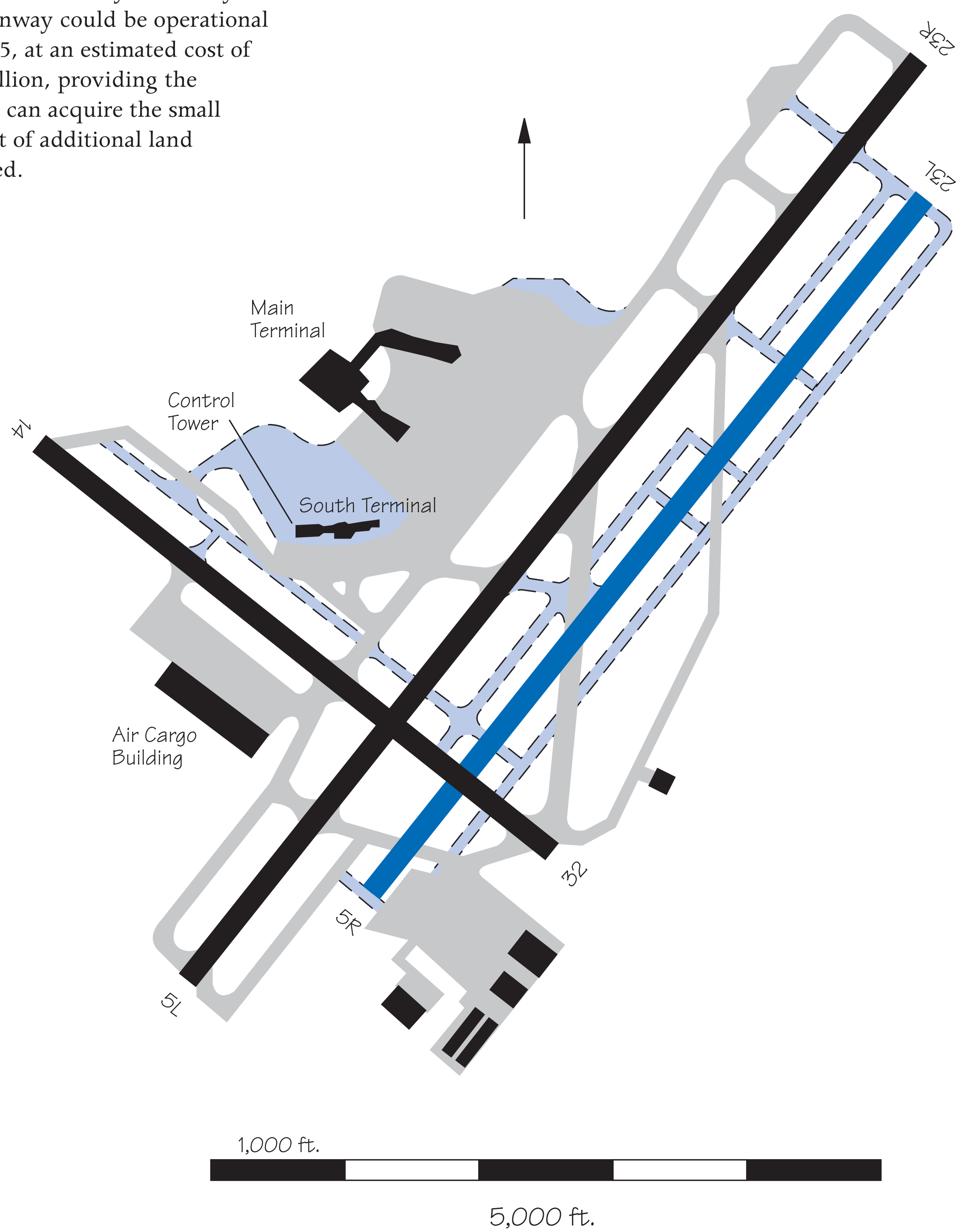


ORD — Chicago O'Hare International Airport



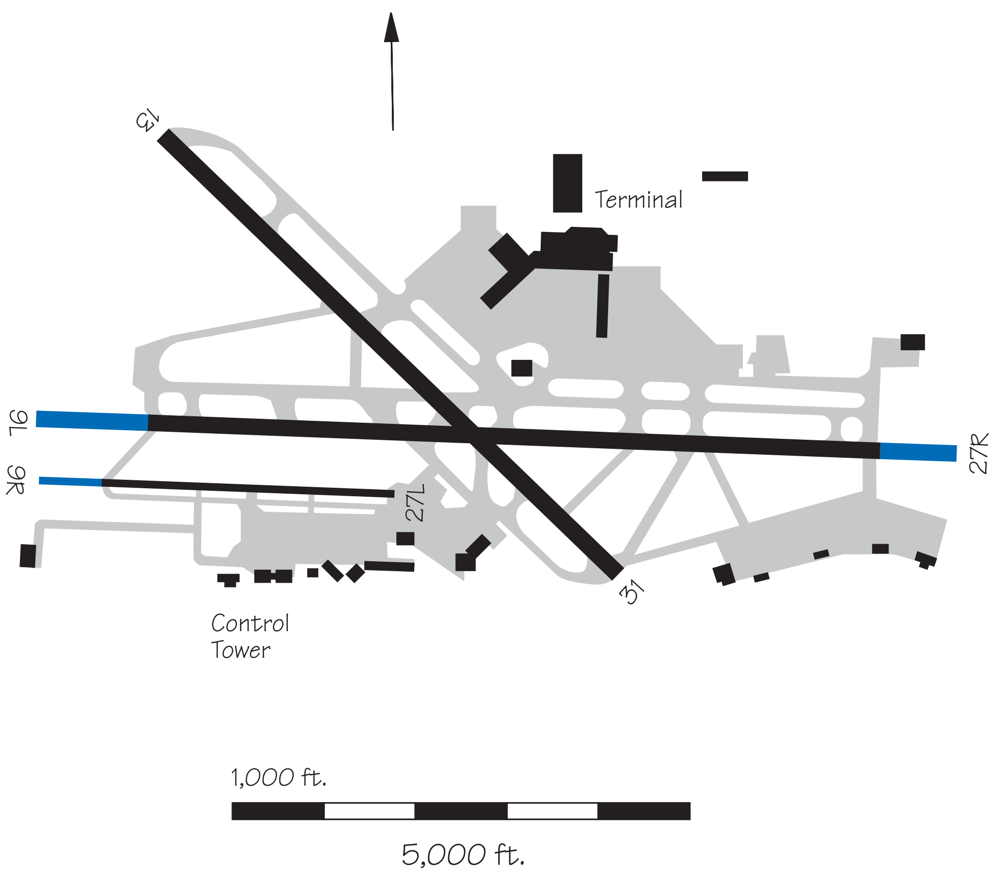
ORF — Norfolk International Airport

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



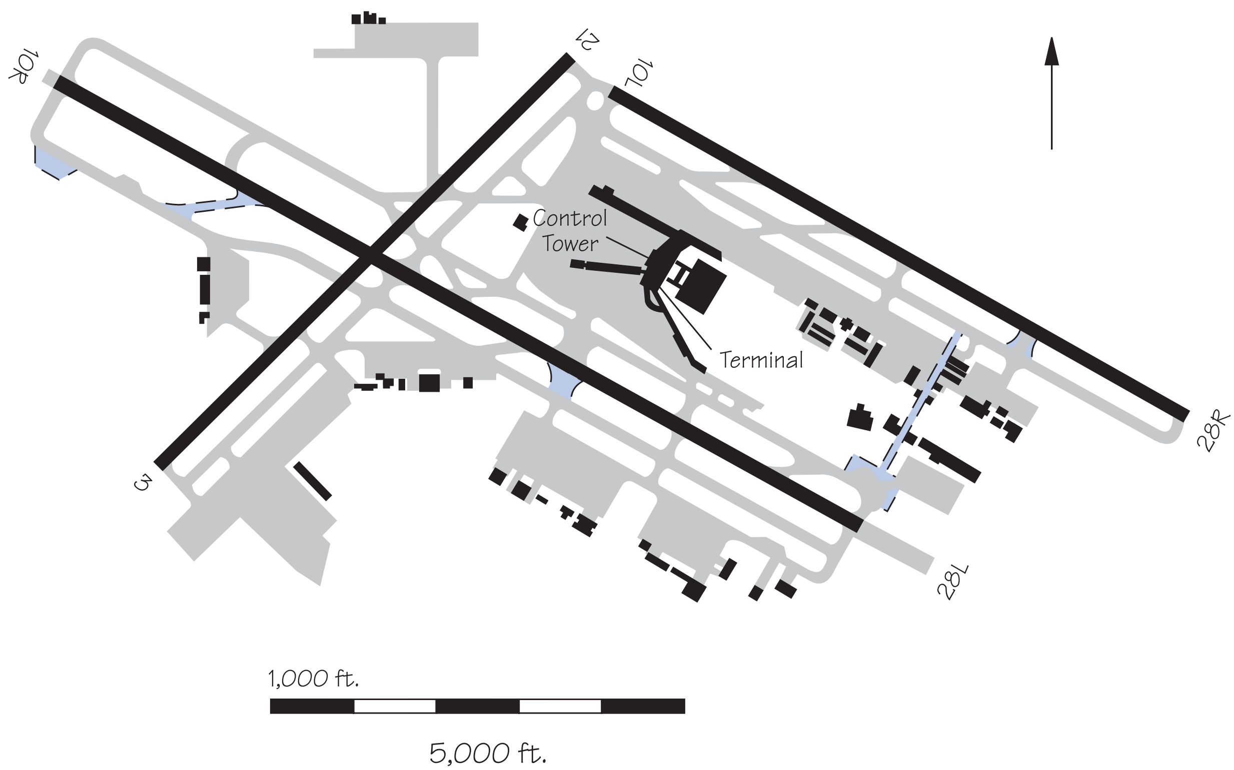
PBI — Palm Beach International Airport

Runway 9L/27R is planned to be extended 1,200 ft. to the west and 811 ft. to the east, for a total length of 10,000 ft.. The total estimated project cost is $12.9 million. An environmental assessment is planned to be completed in 1998. Construction is planned to start in 1999 and be completed in 2000. The runway thresholds will remain in their present locations, therefore, the extended length will only be used for departures.



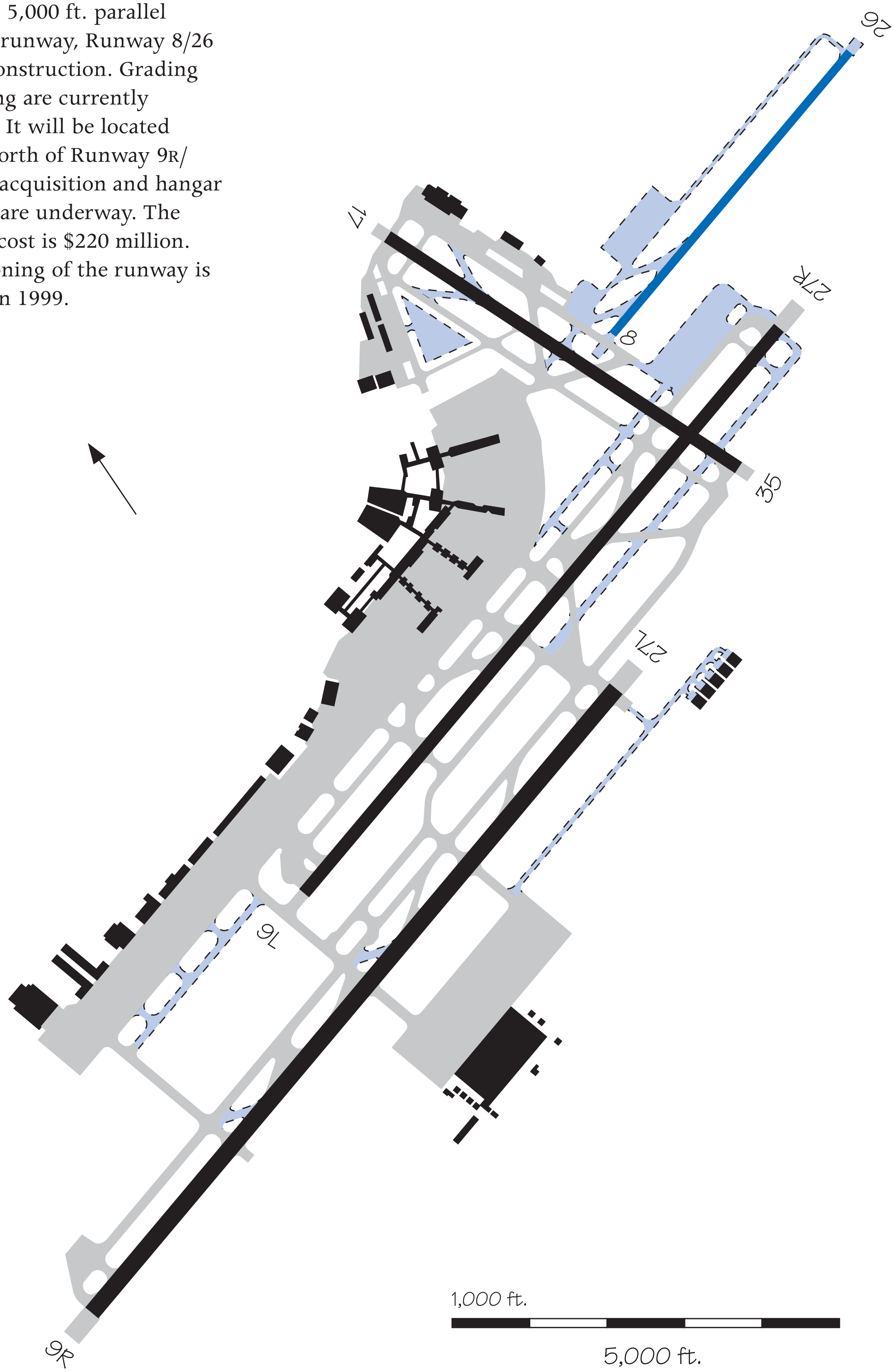
PDX — Portland International Airport

As a result of the 1996 Capacity Enhancement Plan, two new high speed taxiway exits along Taxiway B were constructed, and two exits along Taxiway C will be constructed in the future. A north/south taxiway is also recommended to connect the east ends of the parallel runways. Installation of an ILS on 28L is planned in 1999.



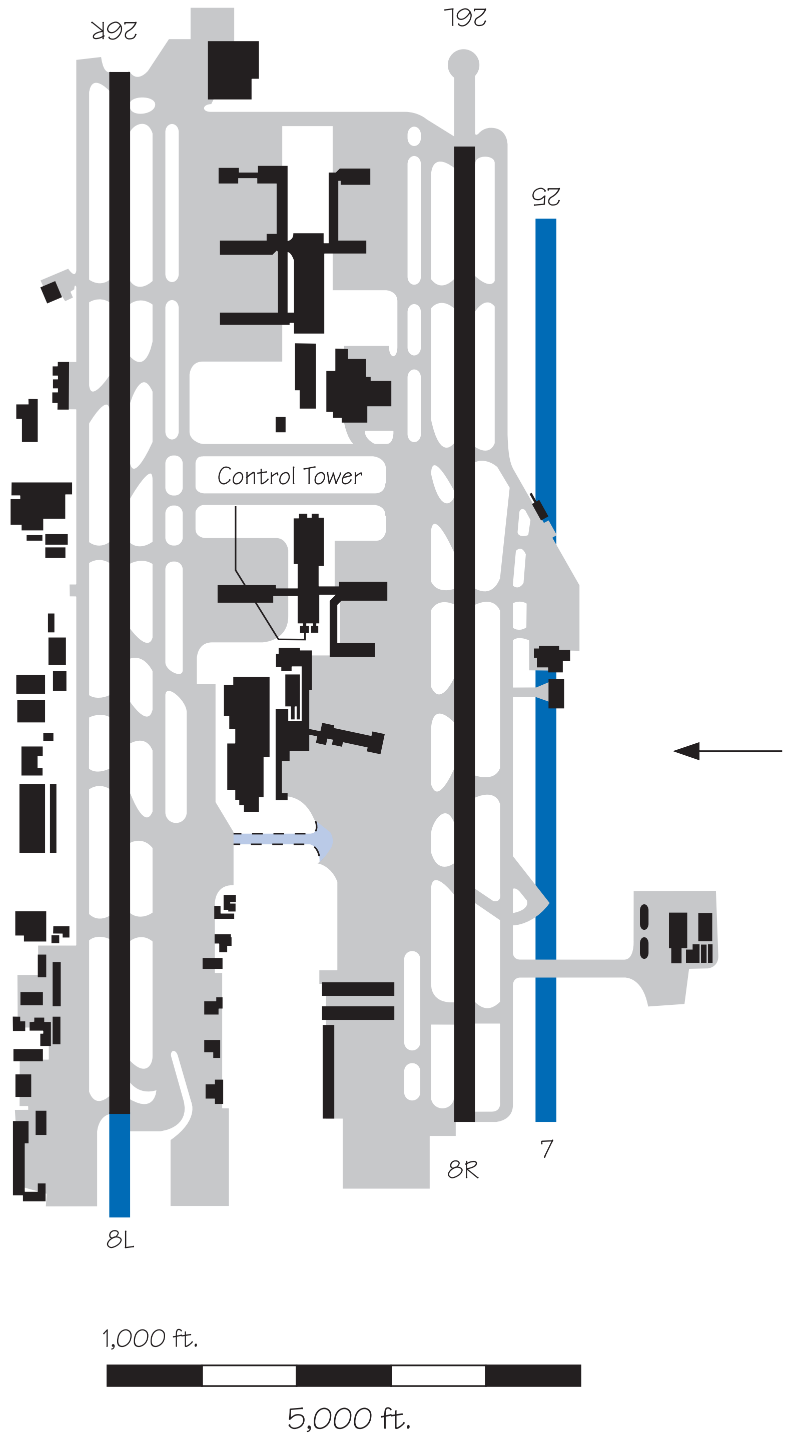
PHL — Philadelphia International Airport

A new 5,000 ft. parallel commuter runway, Runway 8/26 is under construction. Grading and phasing are currently underway. It will be located 3,000 ft. north of Runway 9R/27L. Land acquisition and hangar relocation are underway. The estimated cost is $220 million. Commissioning of the runway is expected in 1999.



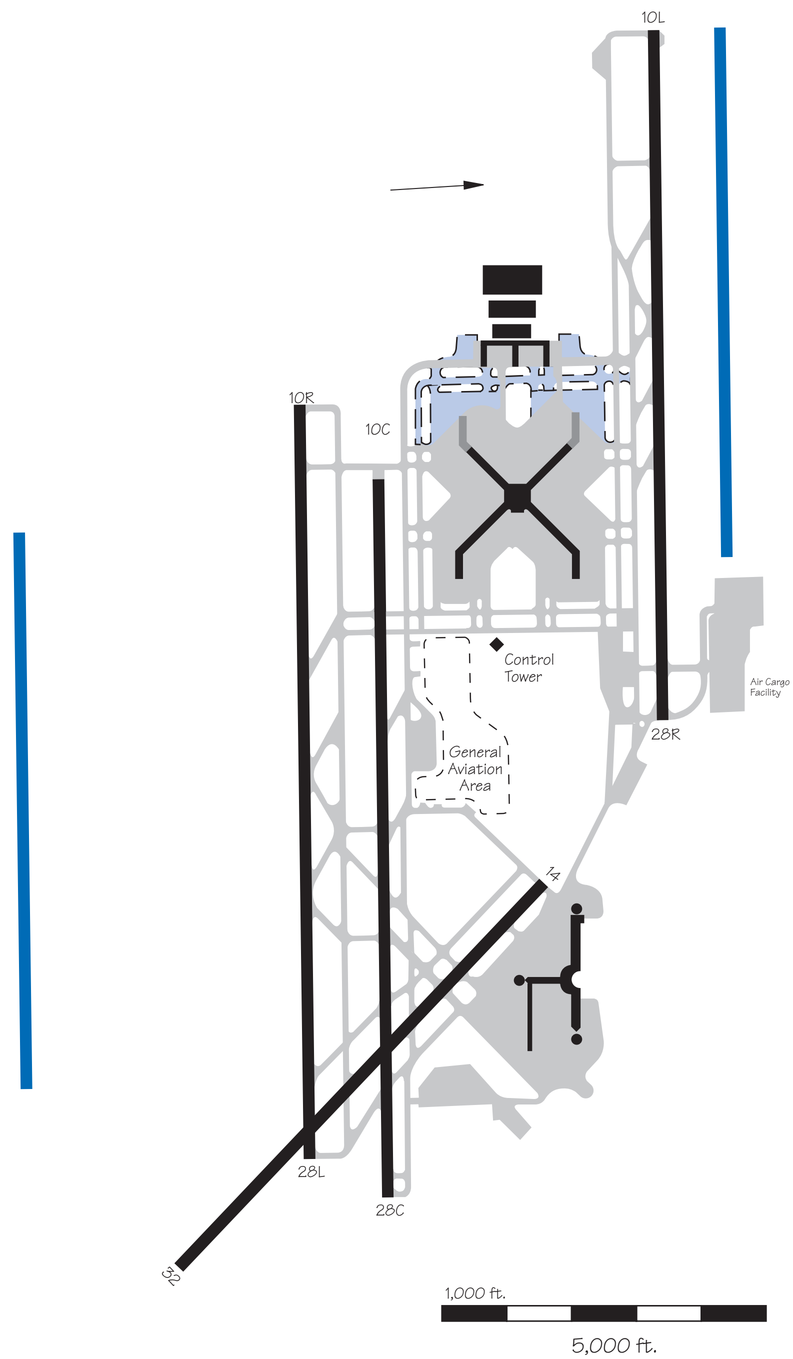
PHX — Phoenix Sky Harbor International Airport

A new third parallel runway, Runway 7/25, is currently under construction 800 ft. south of Runway 8R/26L. The planned operational date is September 1999. Runway 7/25 is being constructed to a length of 7,800 ft. The airport layout plan proposes an ultimate length of 9,500 ft., but further construction is not scheduled at this time.

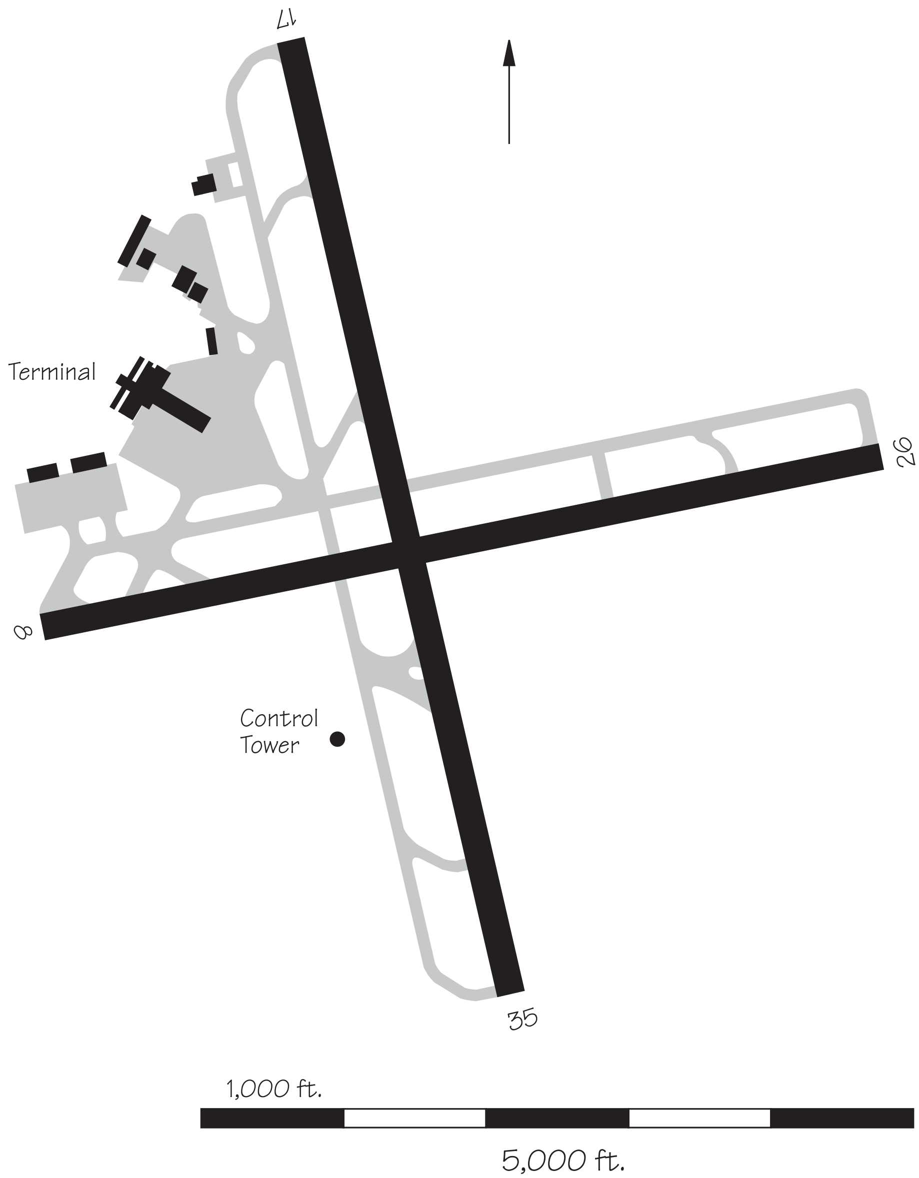


PIT — Greater Pittsburgh International Airport

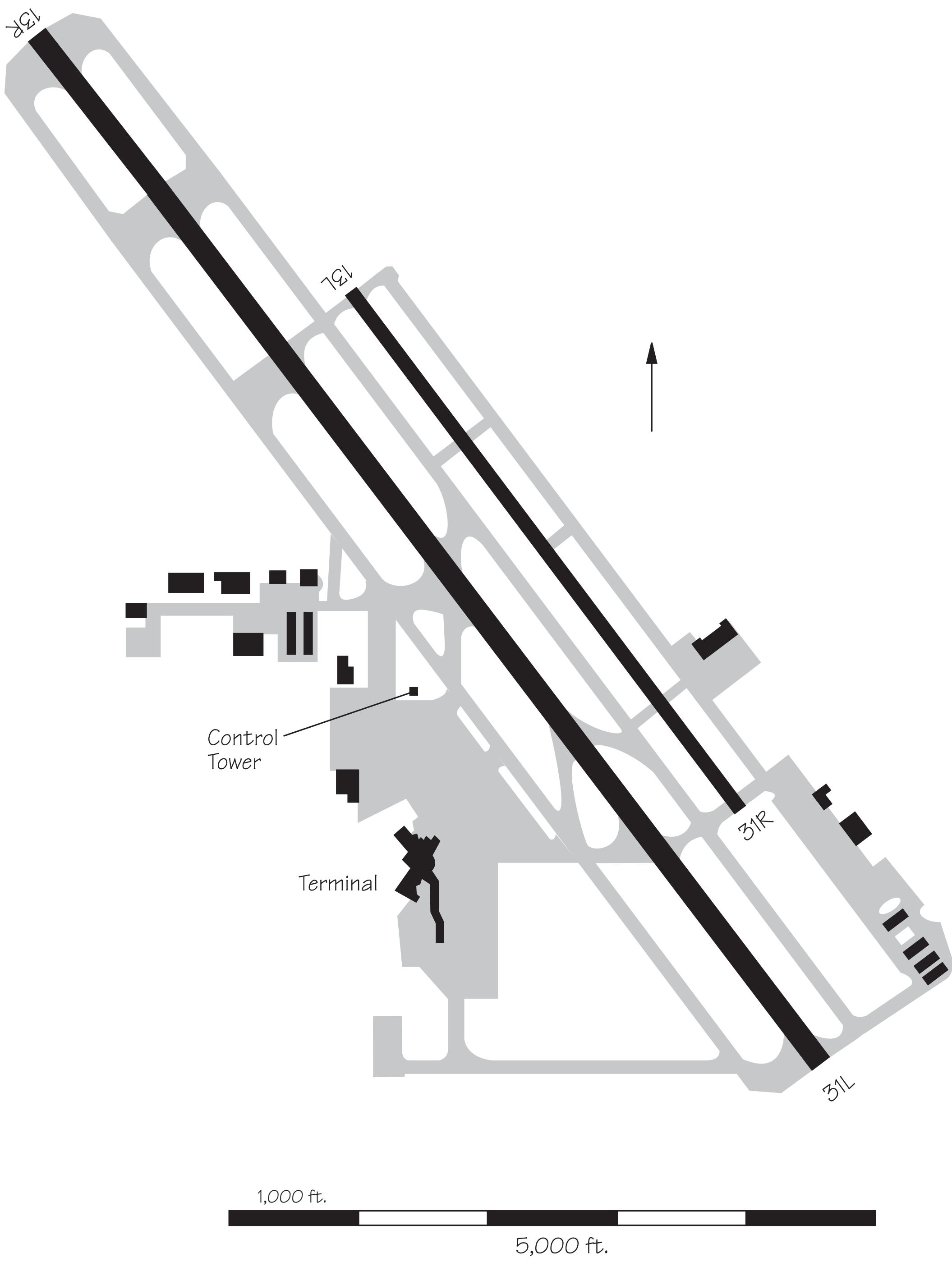
A recently completed Master Plan has recommended that at least two new runways will be needed within a twenty year planning period to accommodate projected Baseline (normal growth) forecast demands and achieve acceptable aircraft delay times and associated delay costs. Construction of the two east/west 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 ft. 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 ft. north of existing Runway 10L/28R and should be operational by the time the airport reaches 522,000 annual aircraft operations.



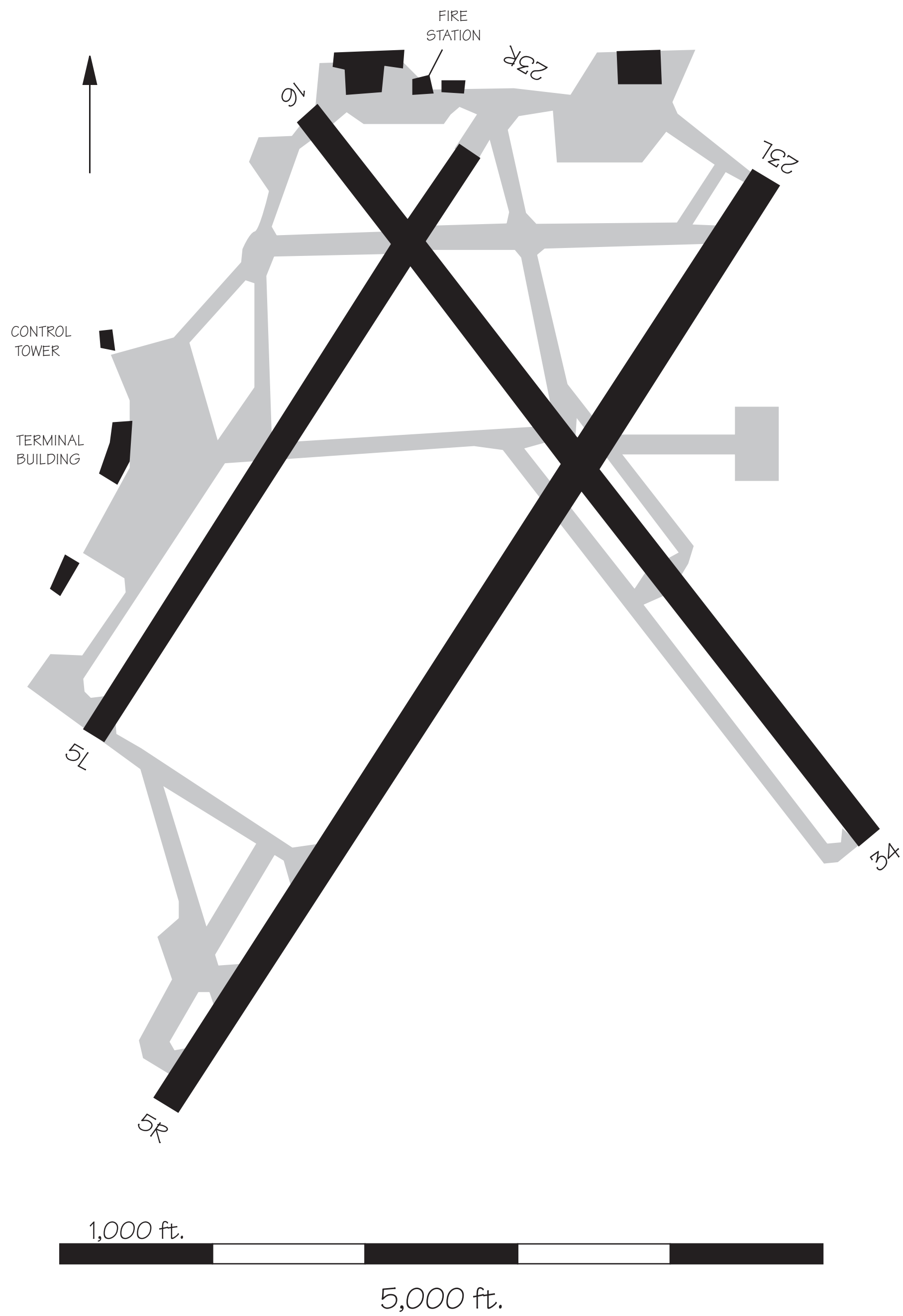
PNS — Pensacola Regional Airport



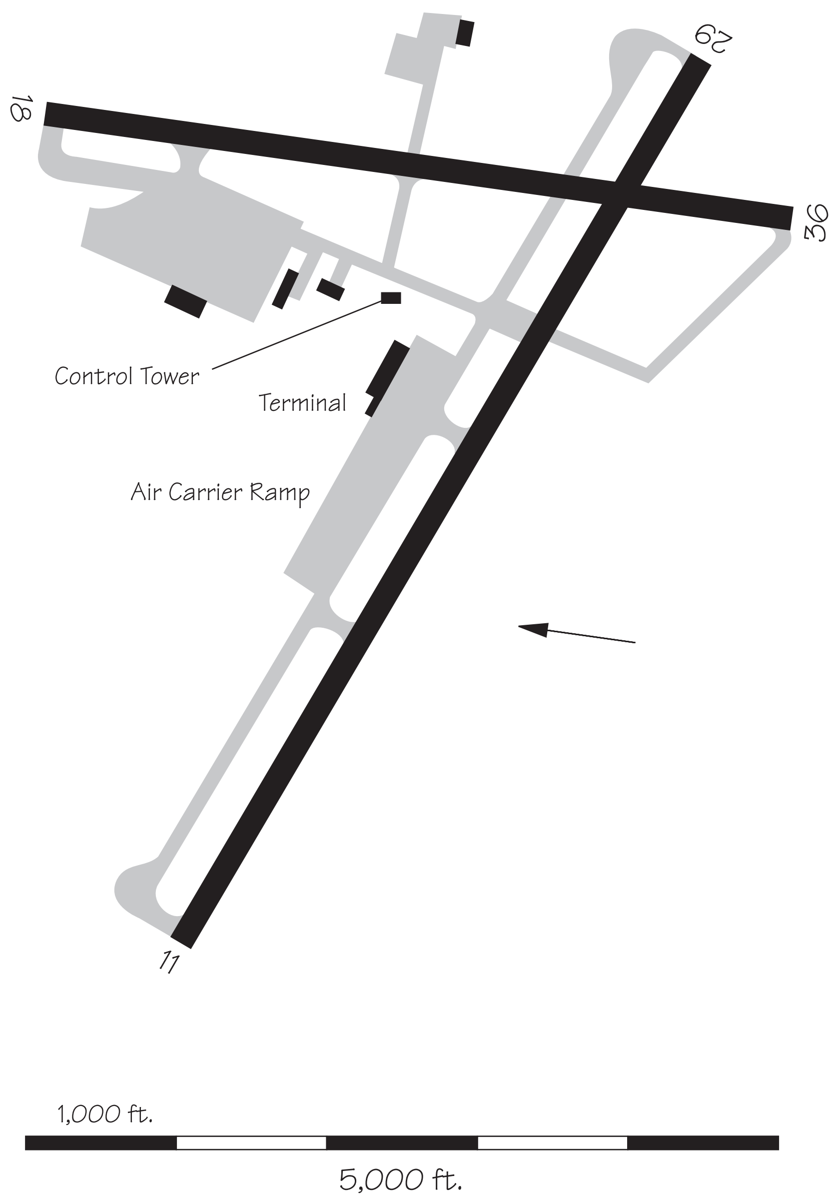
PSP — Palm Springs Regional Airport



PVD — Providence Theodore Francis Green State Airport

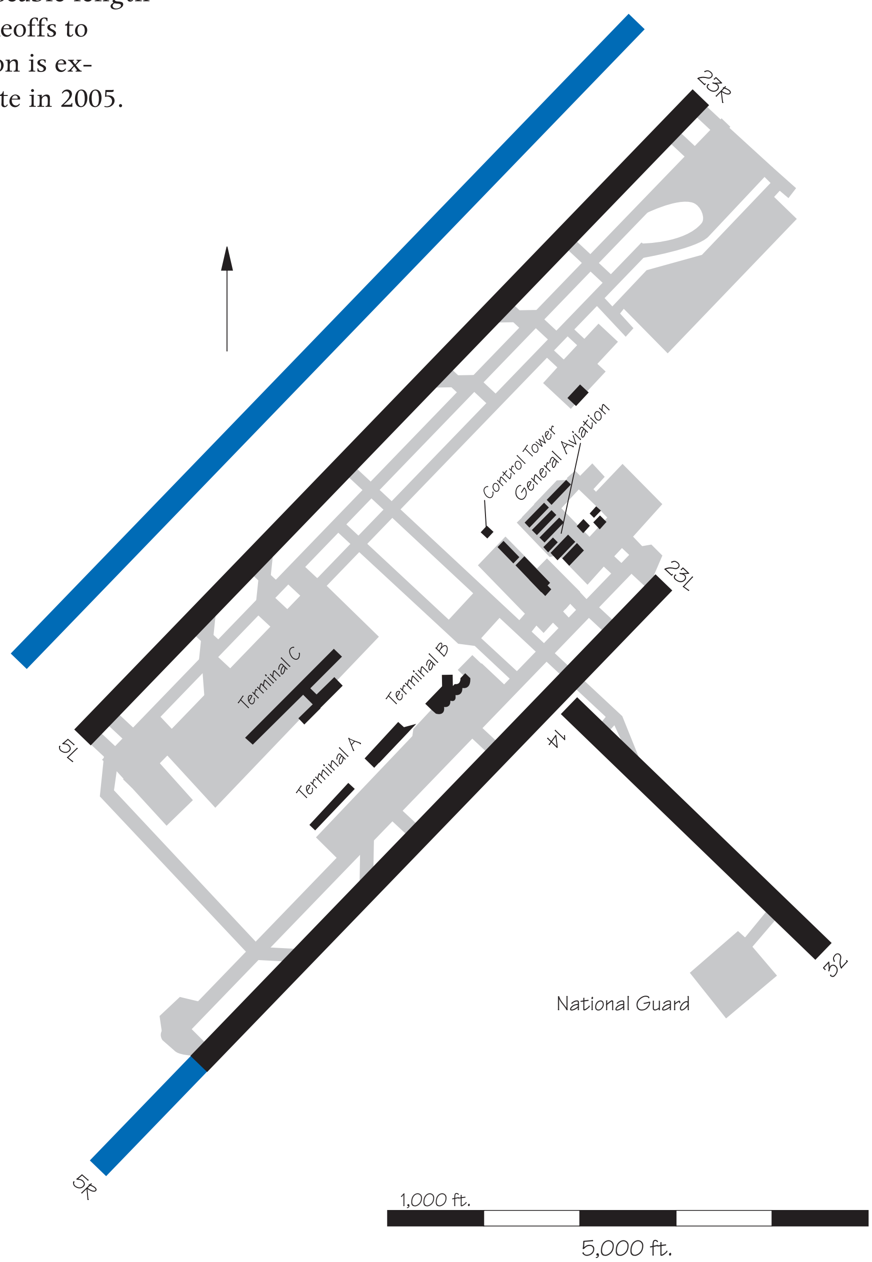


PWM — Portland International Jetport



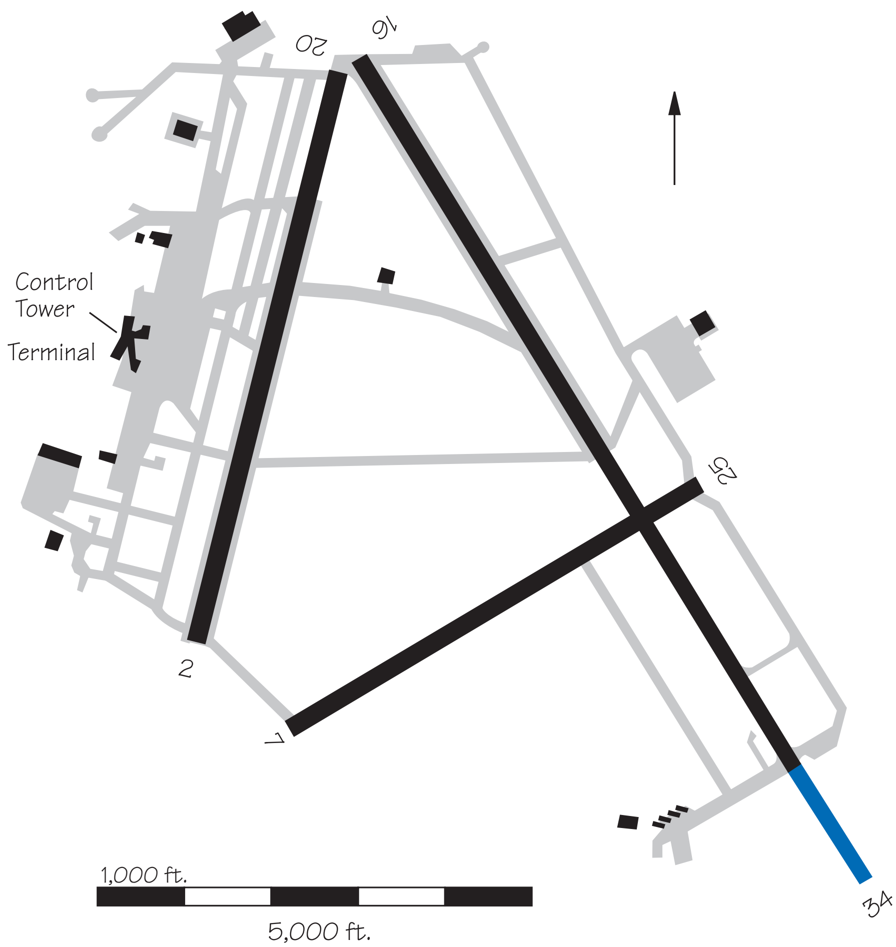
RDU — Raleigh-Durham International Airport

A new 9,500 ft. parallel runway, located approximately 1,050 ft. west of existing Runway 5L/23R, is planned for the future. Also planned is a 1,500 ft. runway extension to the south end of existing Runway 5R/23L, bringing the total useable length for landings and takeoffs to 9,000 ft. Construction is expected to be complete in 2005.

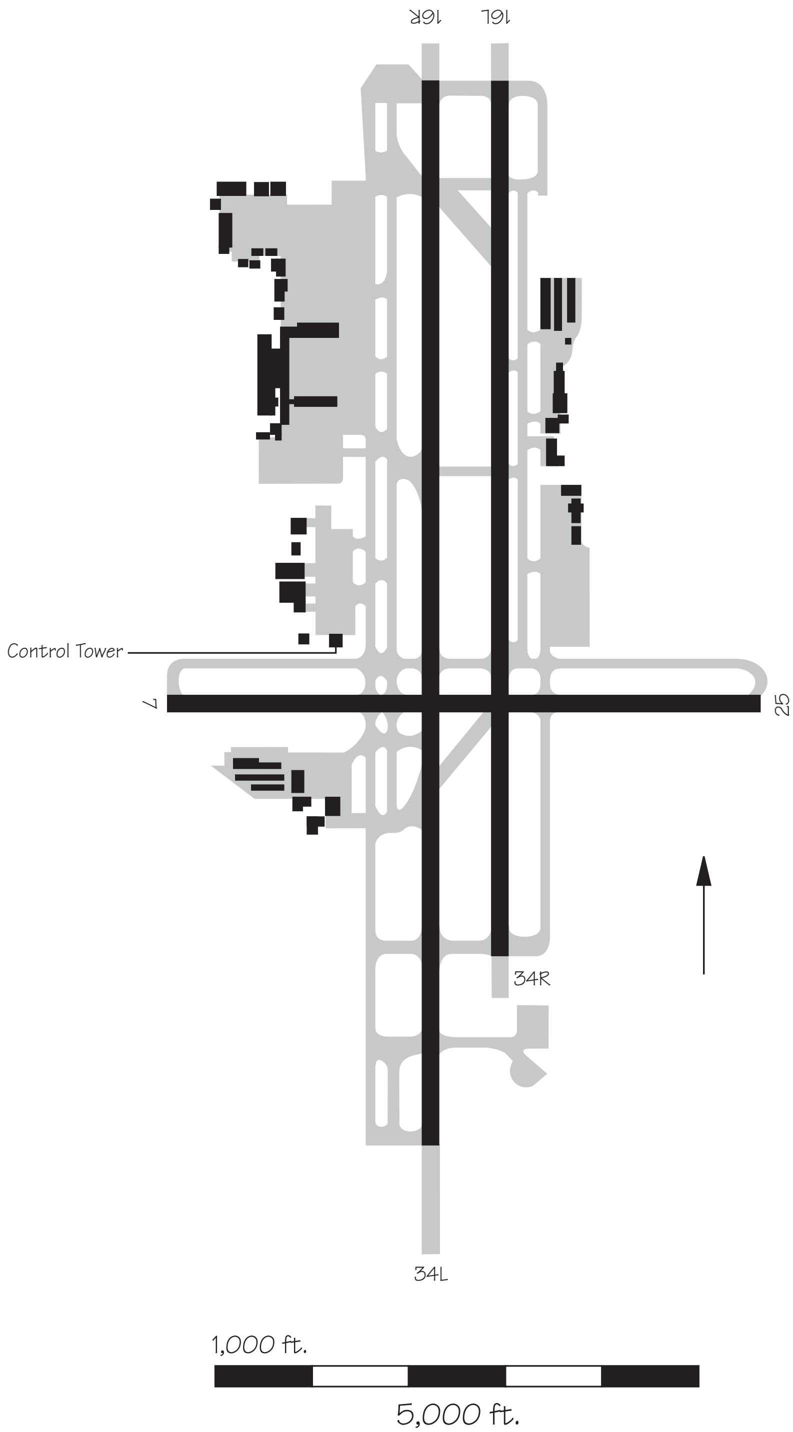


RIC — Richmond International Airport

An extension of Runway 16/34 is planned. Construction is expected to start in 2000.

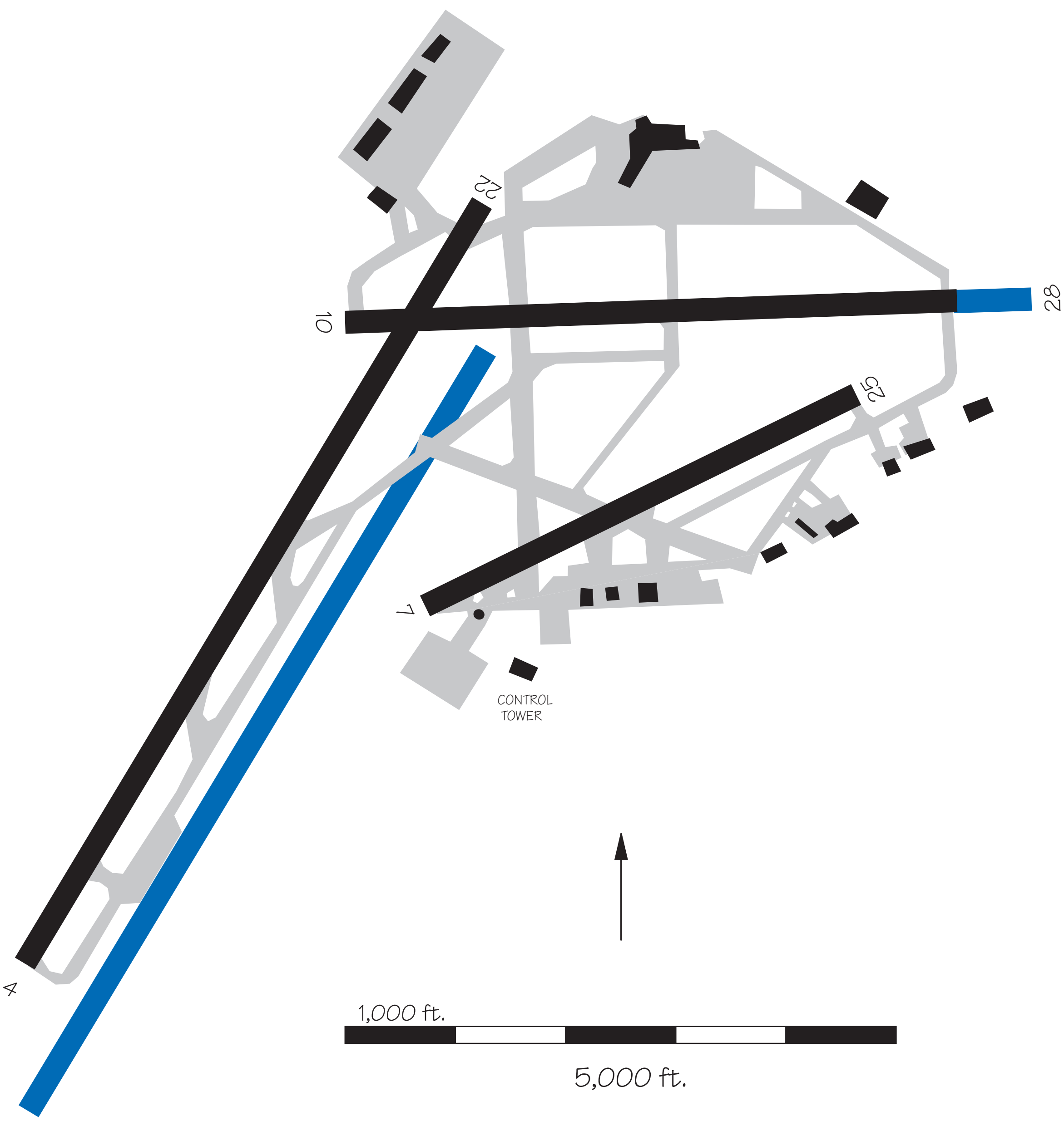


RNO — Reno Tahoe International Airport



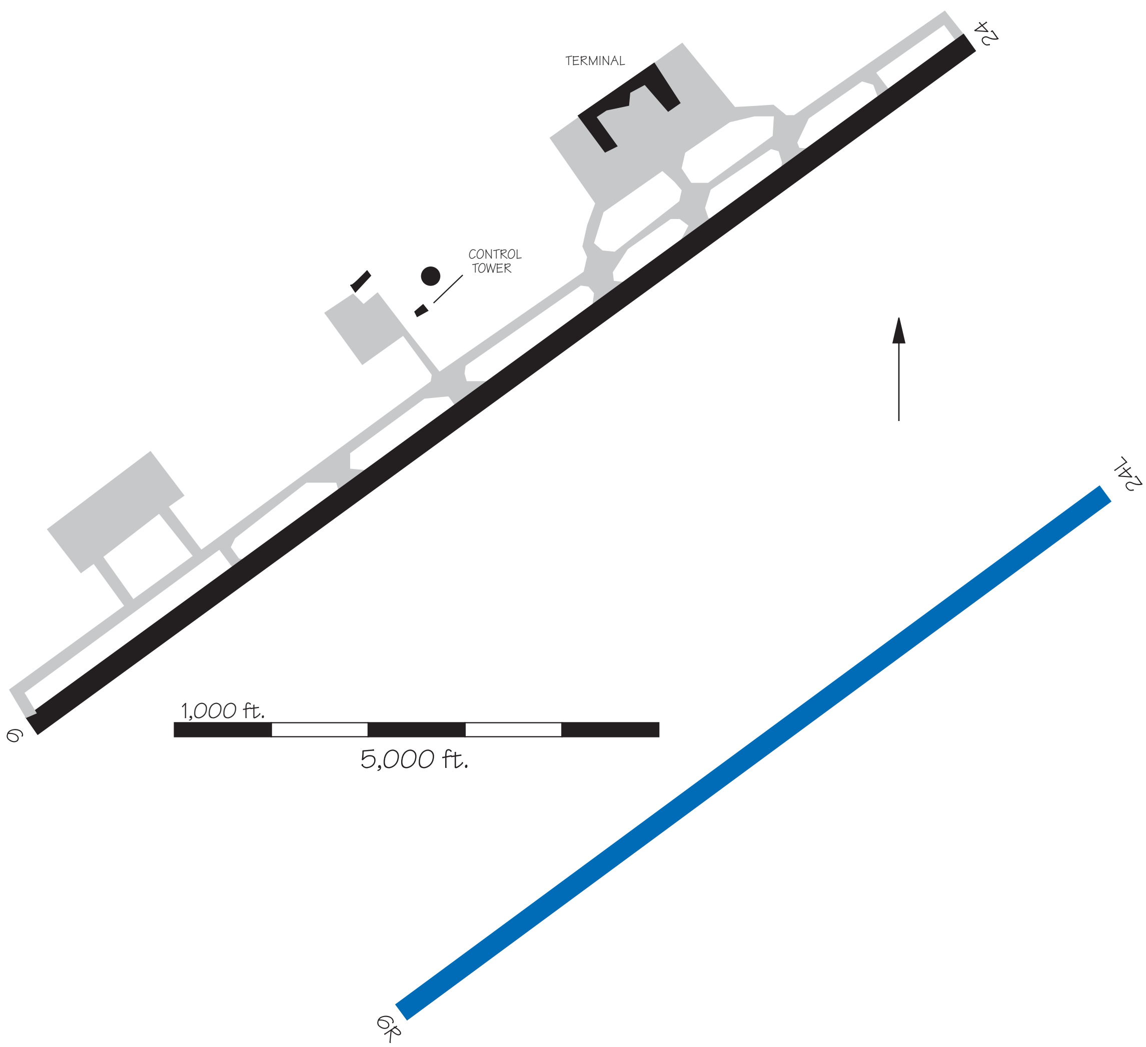
ROC — Greater Rochester International Airport

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 ft. 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.

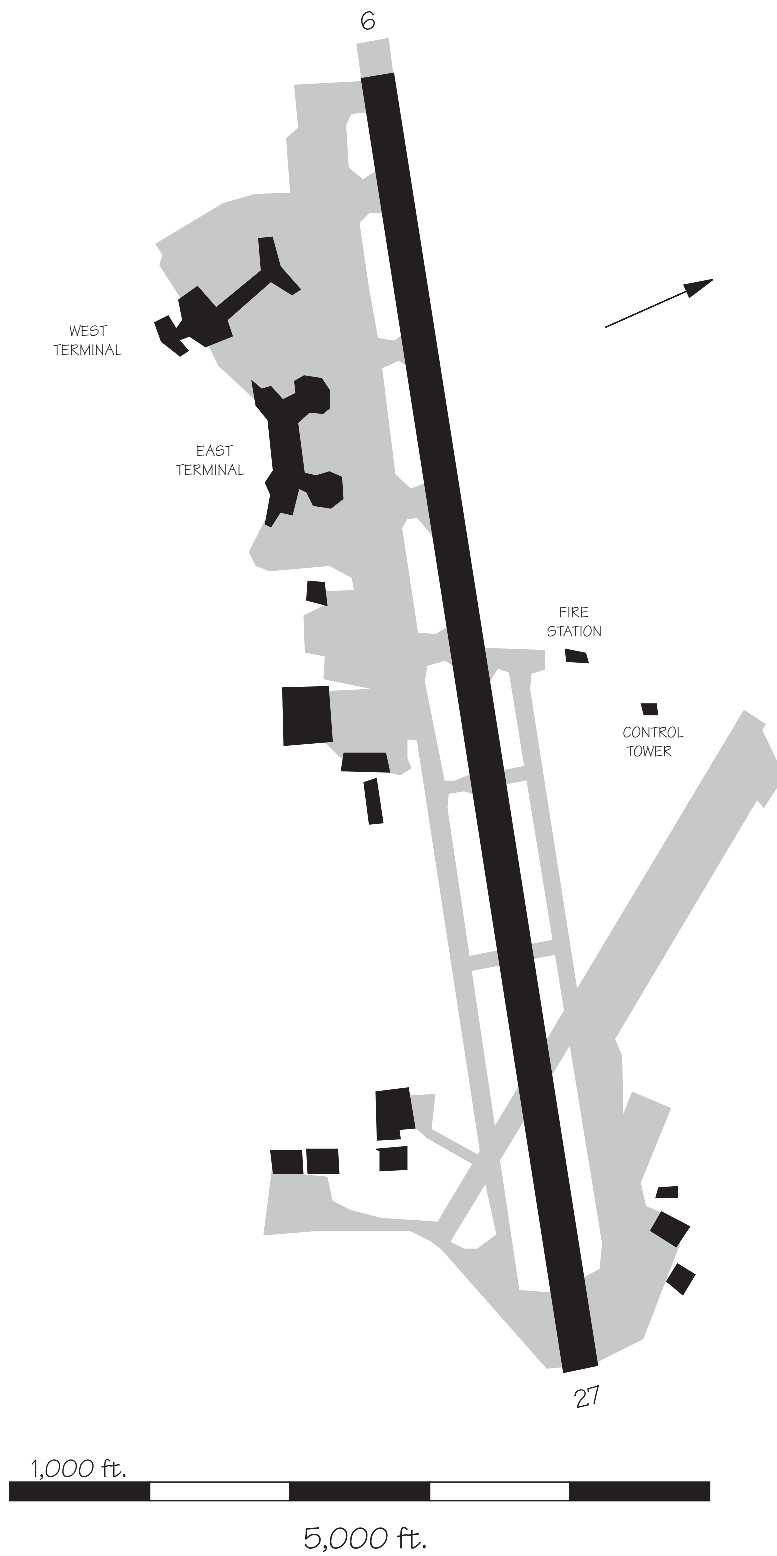


RSW — Fort Myers Southwest Florida Regional Airport

Planning has begun for a new 9,100 ft. parallel runway, Runway 6R/24L, 4,300 ft. or more southeast of Runway 6/24. Construction is expected to begin in 2002. The new runway should be operational by 2004. The estimated cost of the project is $80 million. This new runway will support independent parallel operations. A new terminal complex is planned to be located between the parallel runways.

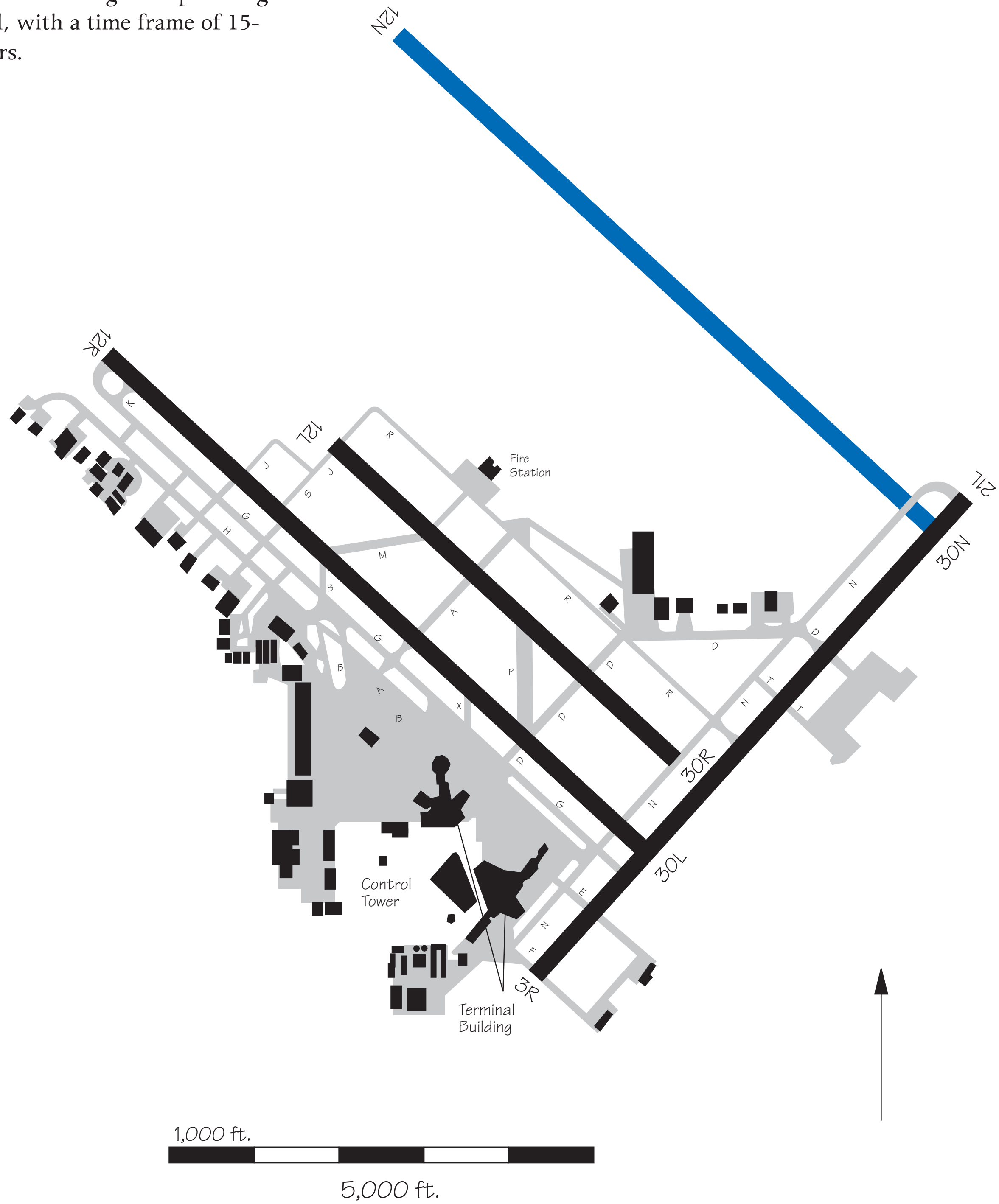


SAN — San Diego International Lindberg Field



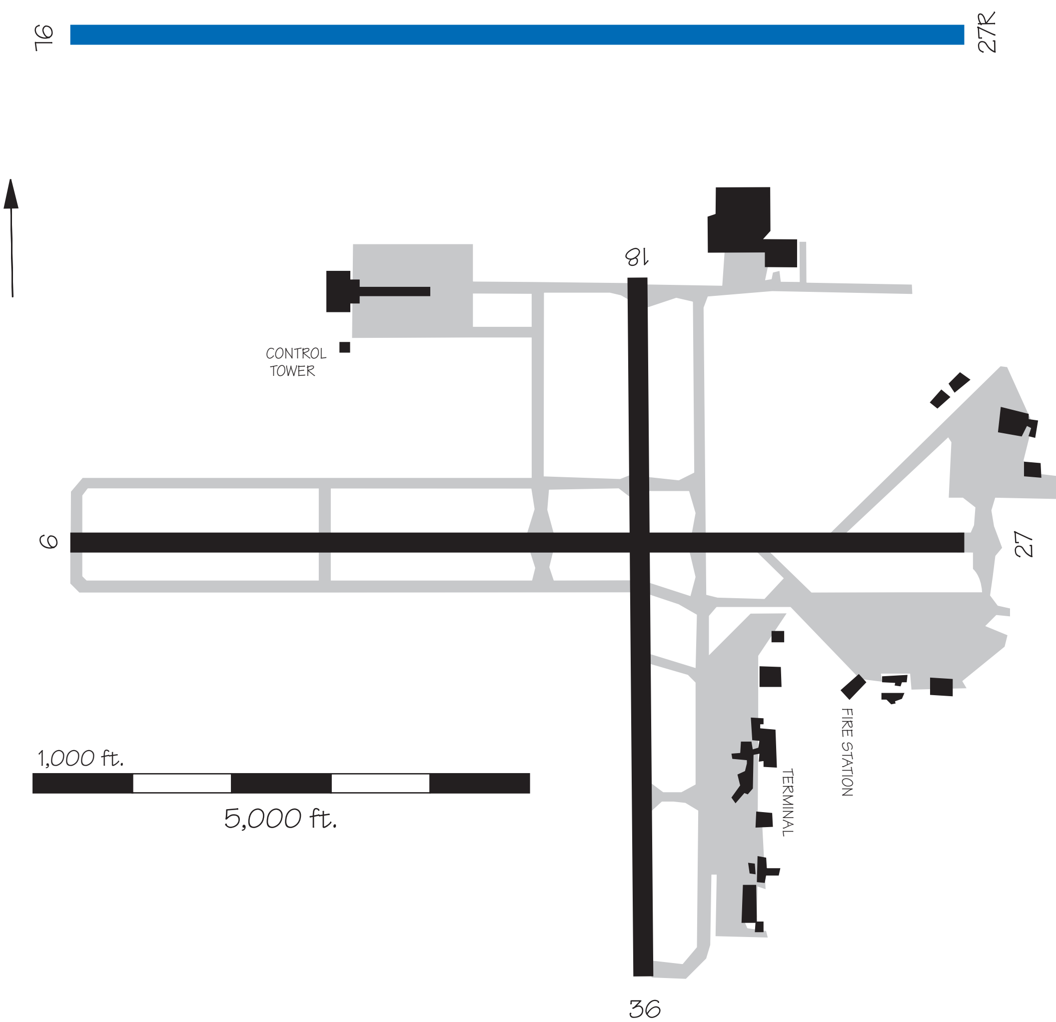
SAT — San Antonio International Airport

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.

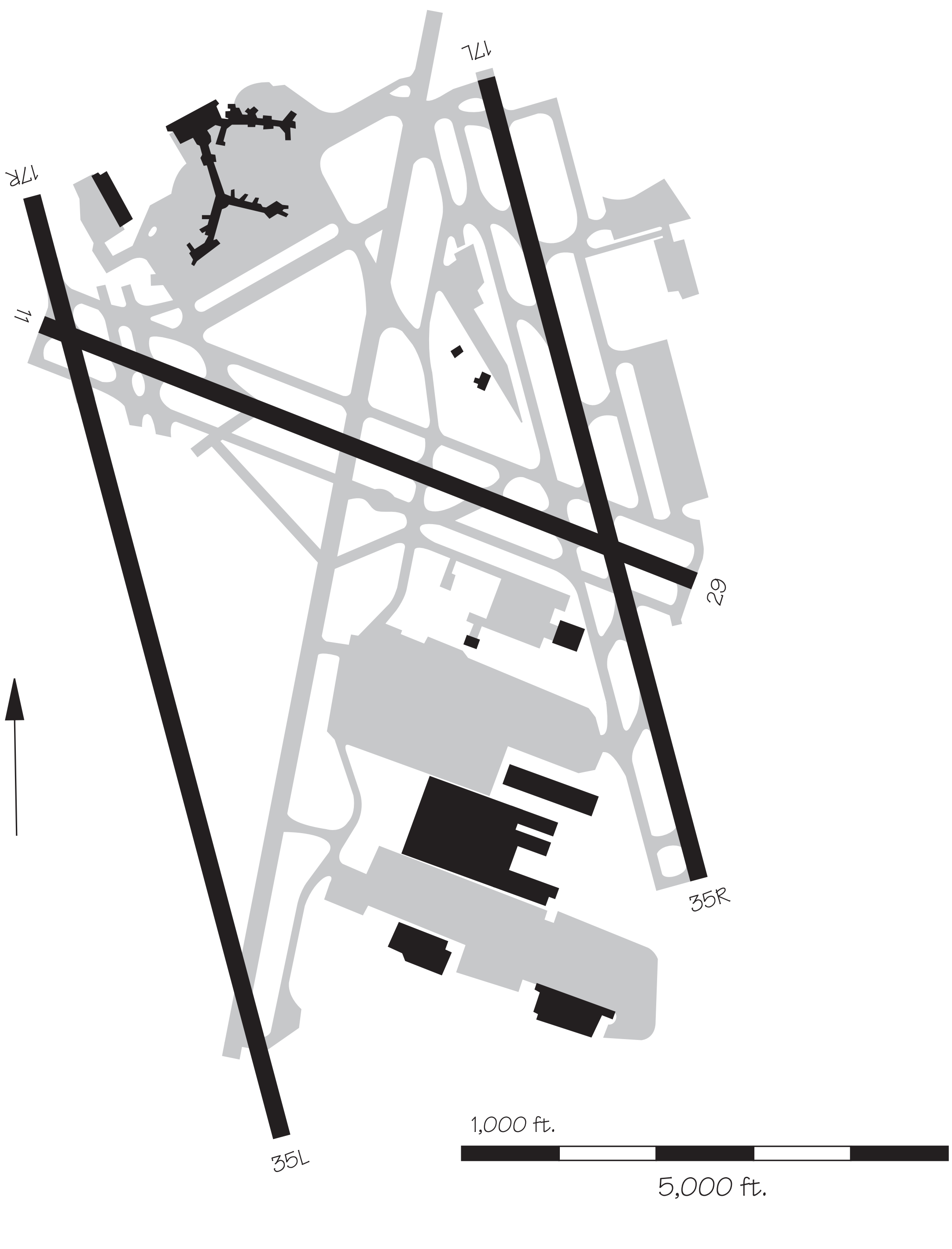


SAV — Savannah International Airport

A new 9,000 ft. parallel runway, Runway 9L/27R, approximately 5,000 ft. north of Runway 9/27, is expected to be constructed in 2020, with an estimated cost of $20 million. This runway would allow independent parallel operations, thereby potentially doubling hourly capacity.

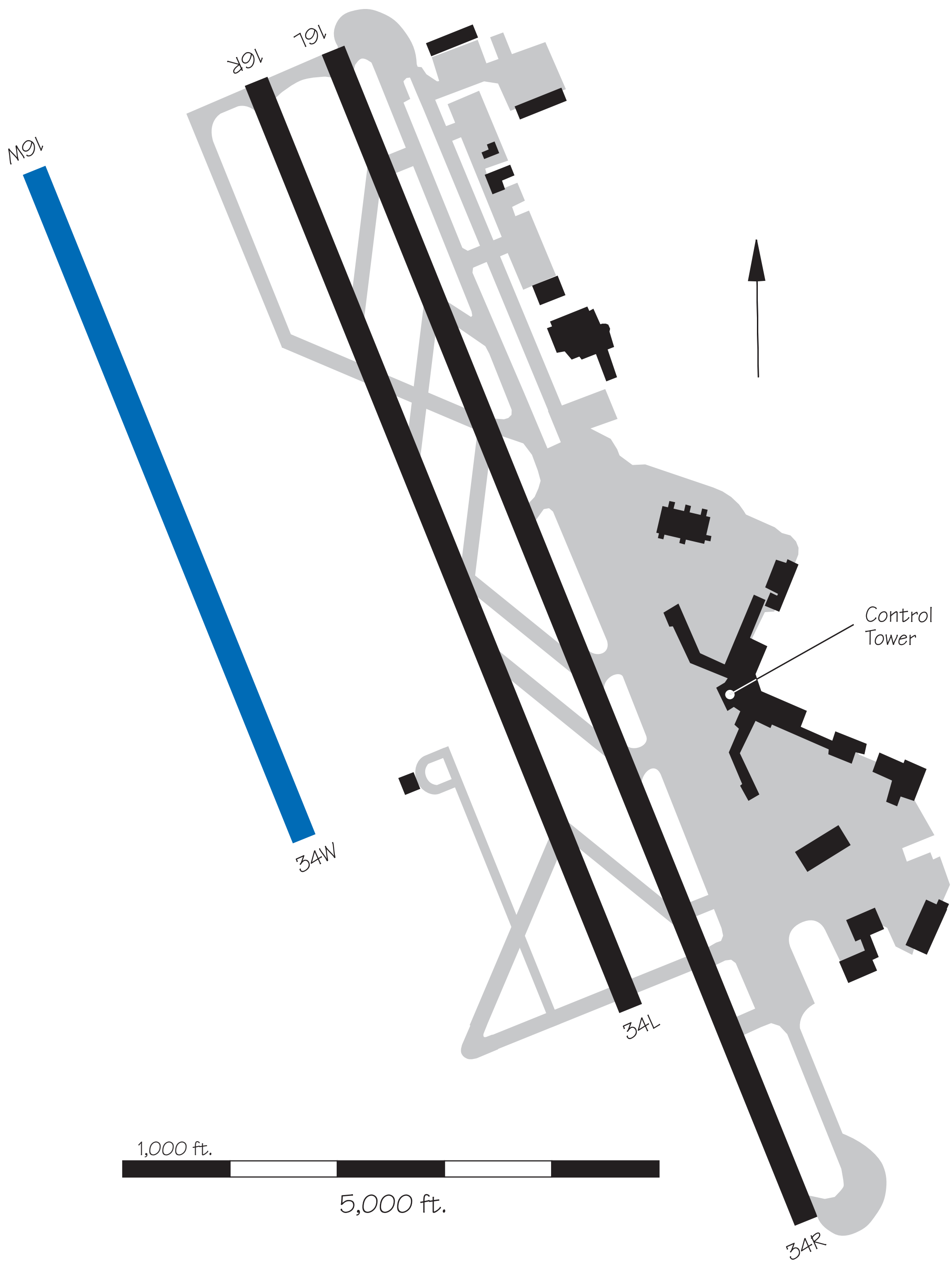


SDF — Louisville International Airport

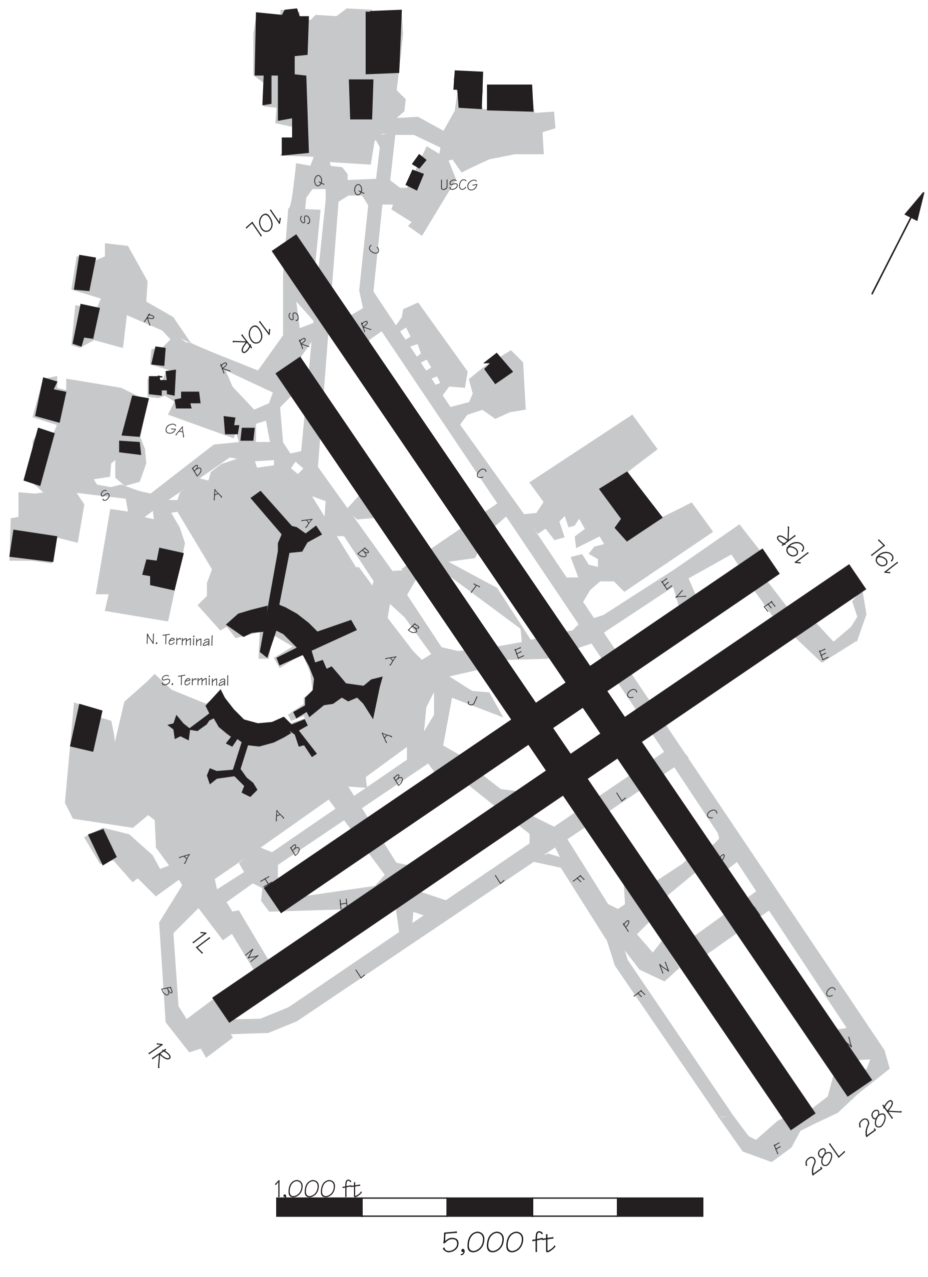


SEA — Seattle-Tacoma International Airport

Airport improvements include a new Runway 16W/34W, 8,500 ft. in length, which will be located 2,500 ft. from Runway 16L/34R. Construction began in 1997. The runway will be completed by 2004 for $585 million.

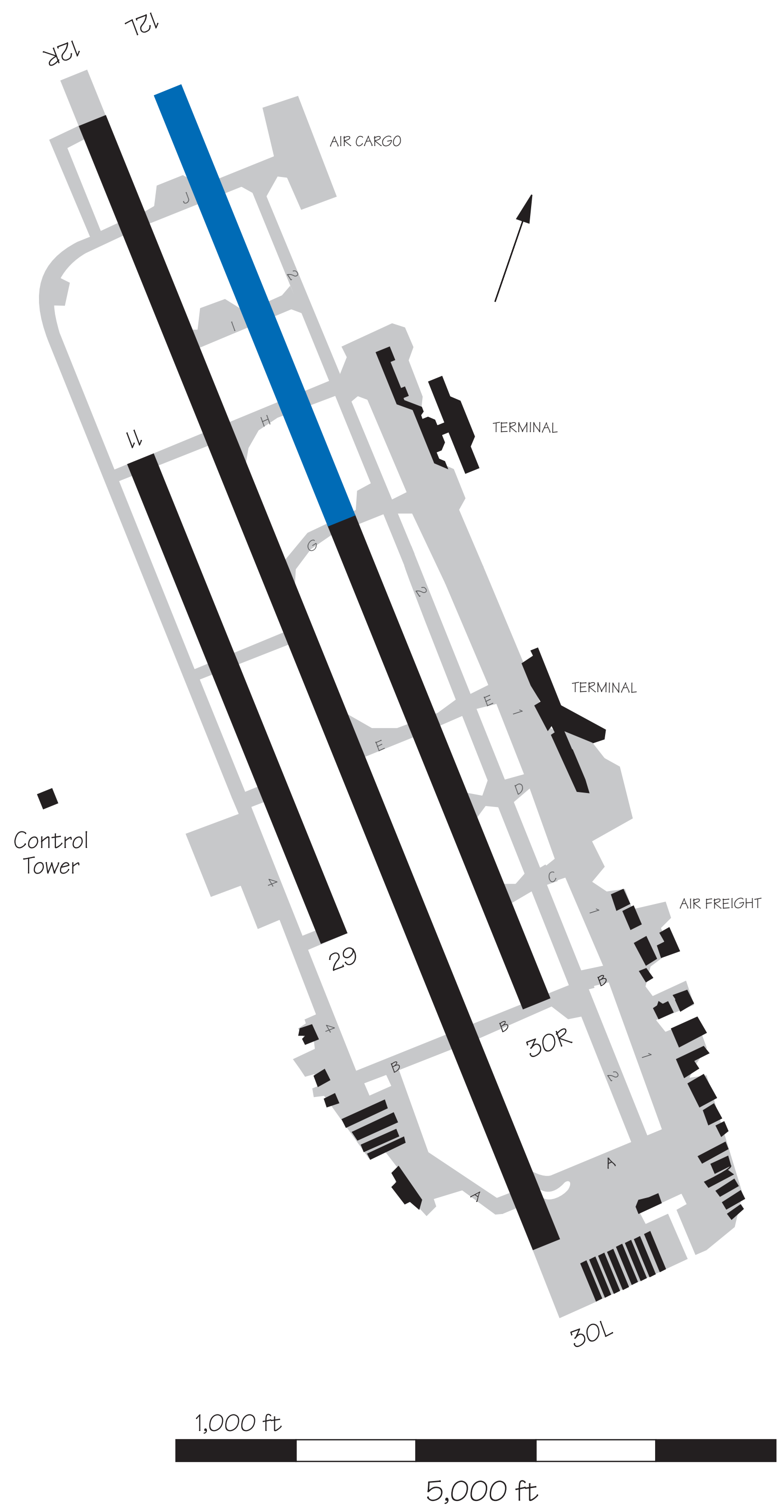


SFO — San Francisco International Airport



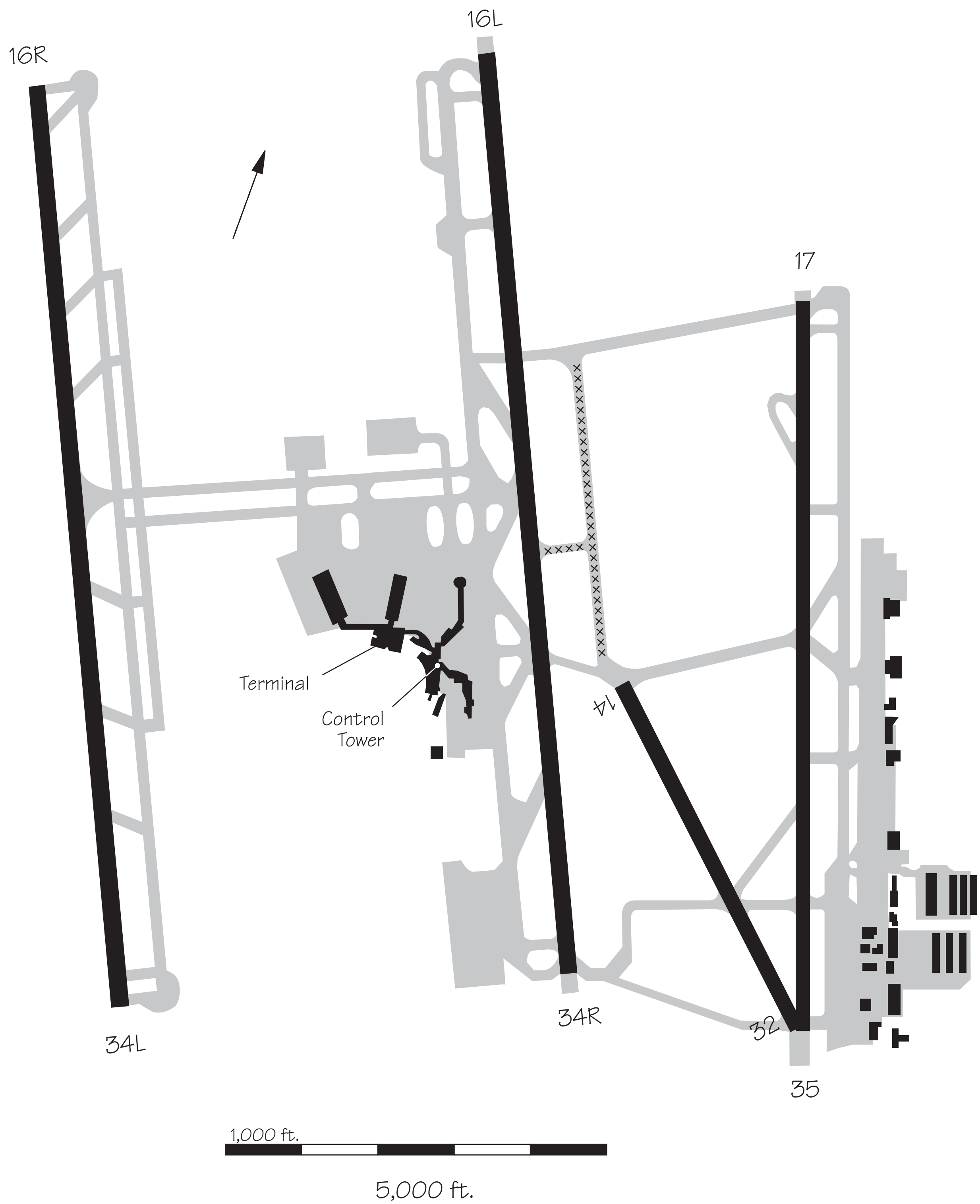
SJC — San Jose International Airport

Environmental documentation is currently being prepared in support of the extension of Runway 12L/30R. If this option is determined to be environmentally acceptable and is adopted by the sponsor, construction will begin in 1999.



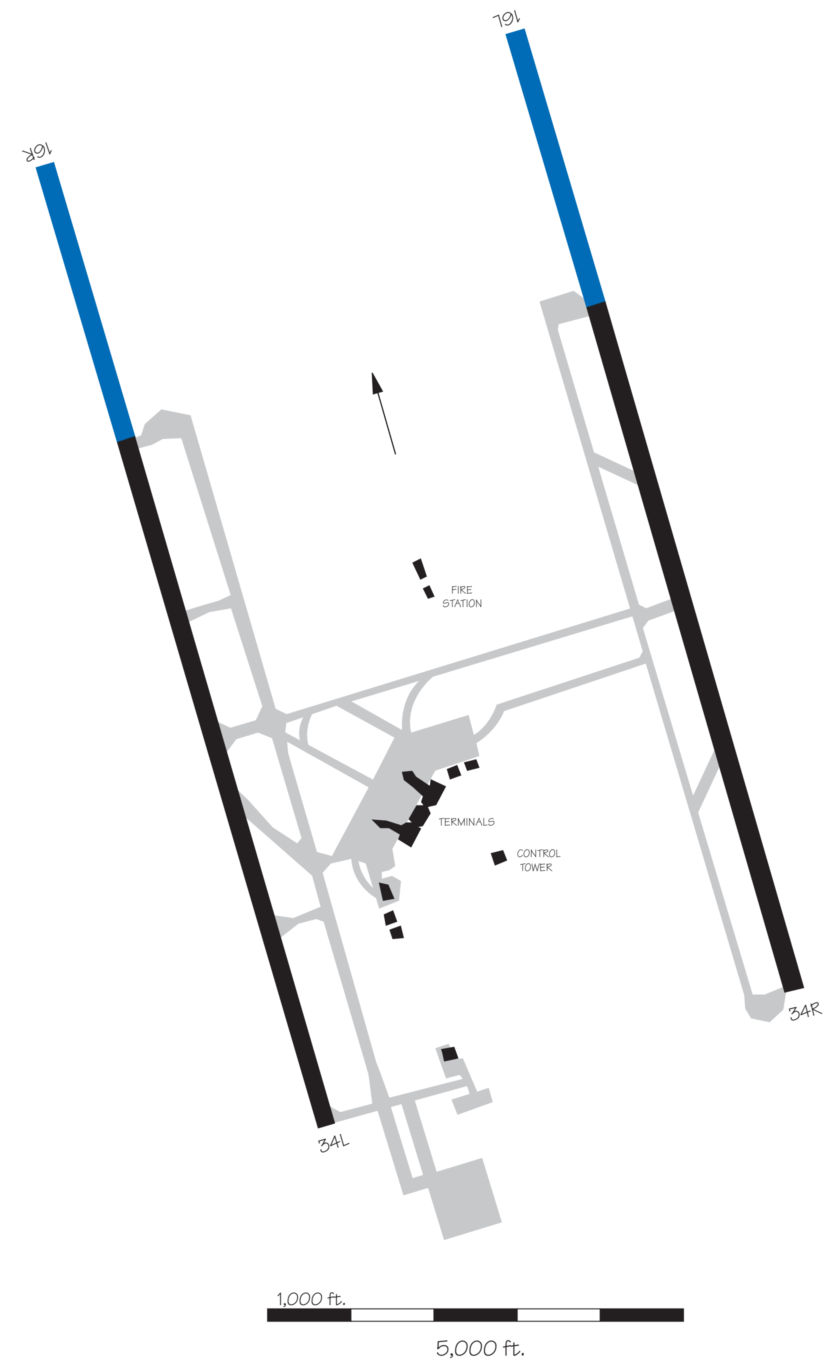
SJU — San Juan Luis Muñoz Marín International Airport

SLC — Salt Lake City International Airport



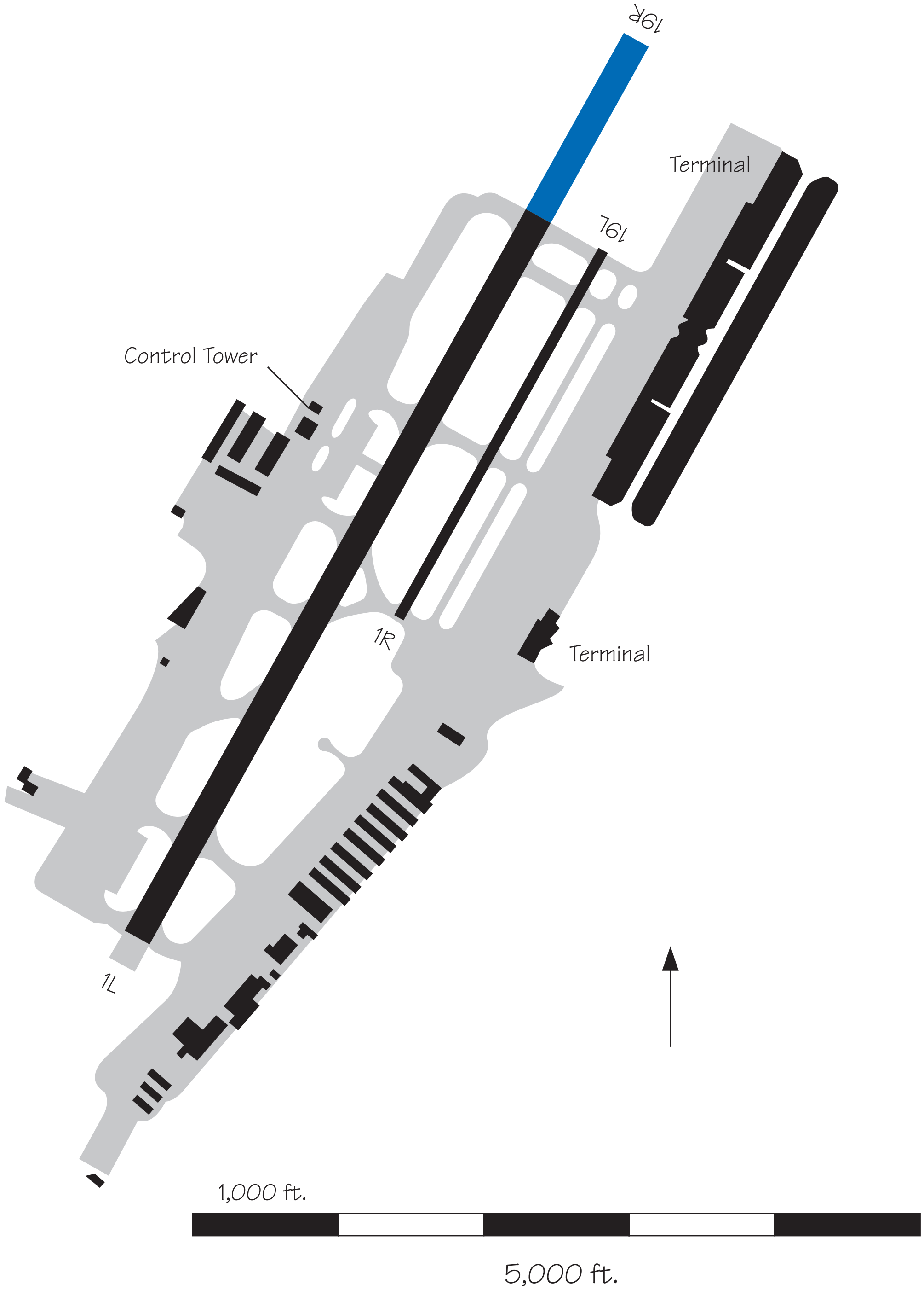
SMF — Sacramento international Airport

Northerly extensions to both runways, to an ultimate length of 12,000 ft. each, are proposed as long term development items. No specific time frame for this development has been identified.



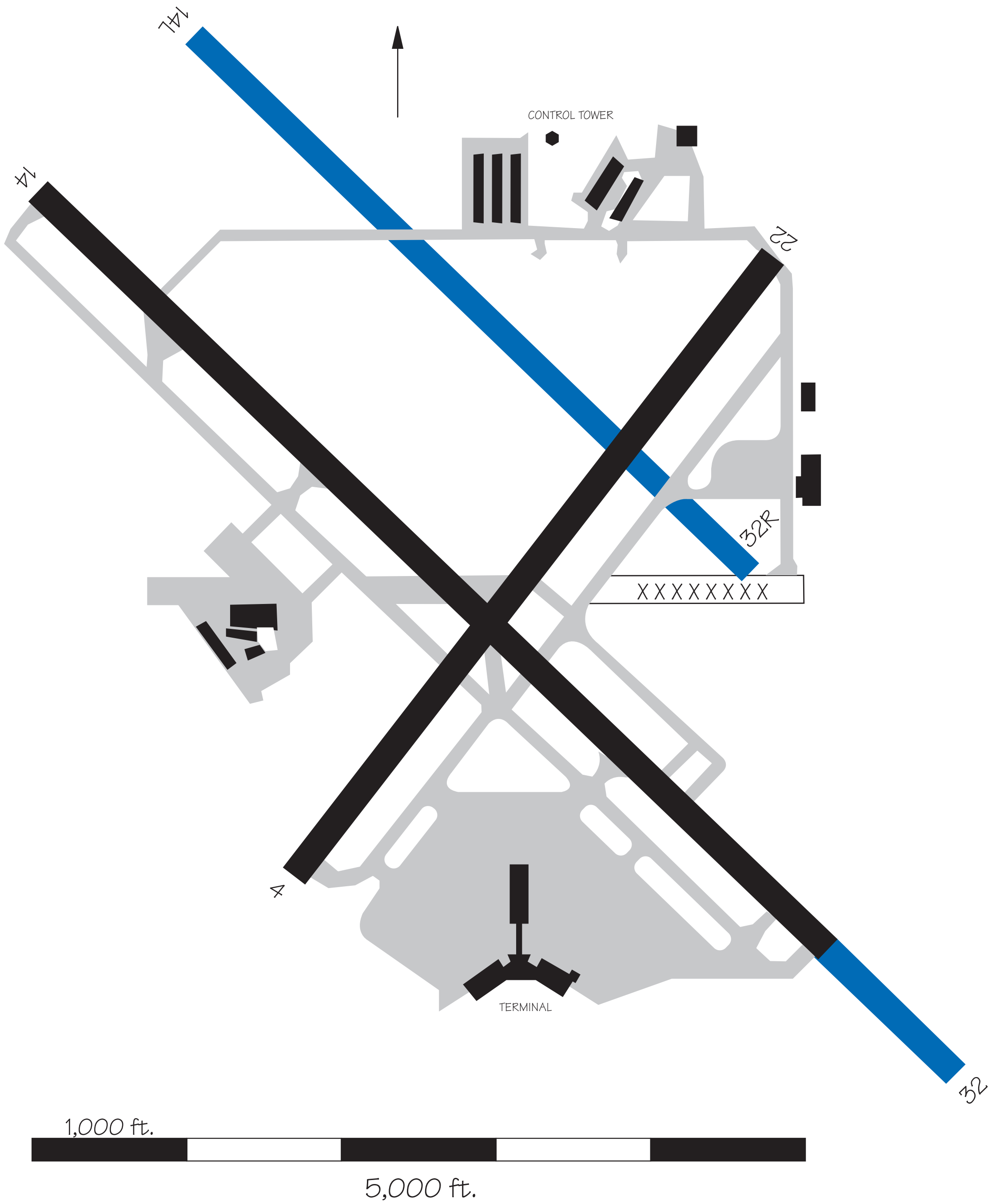
SNA — John Wayne Airport - Orange County

An extension of Runway 1L/19R is proposed but is not being considered at this time.



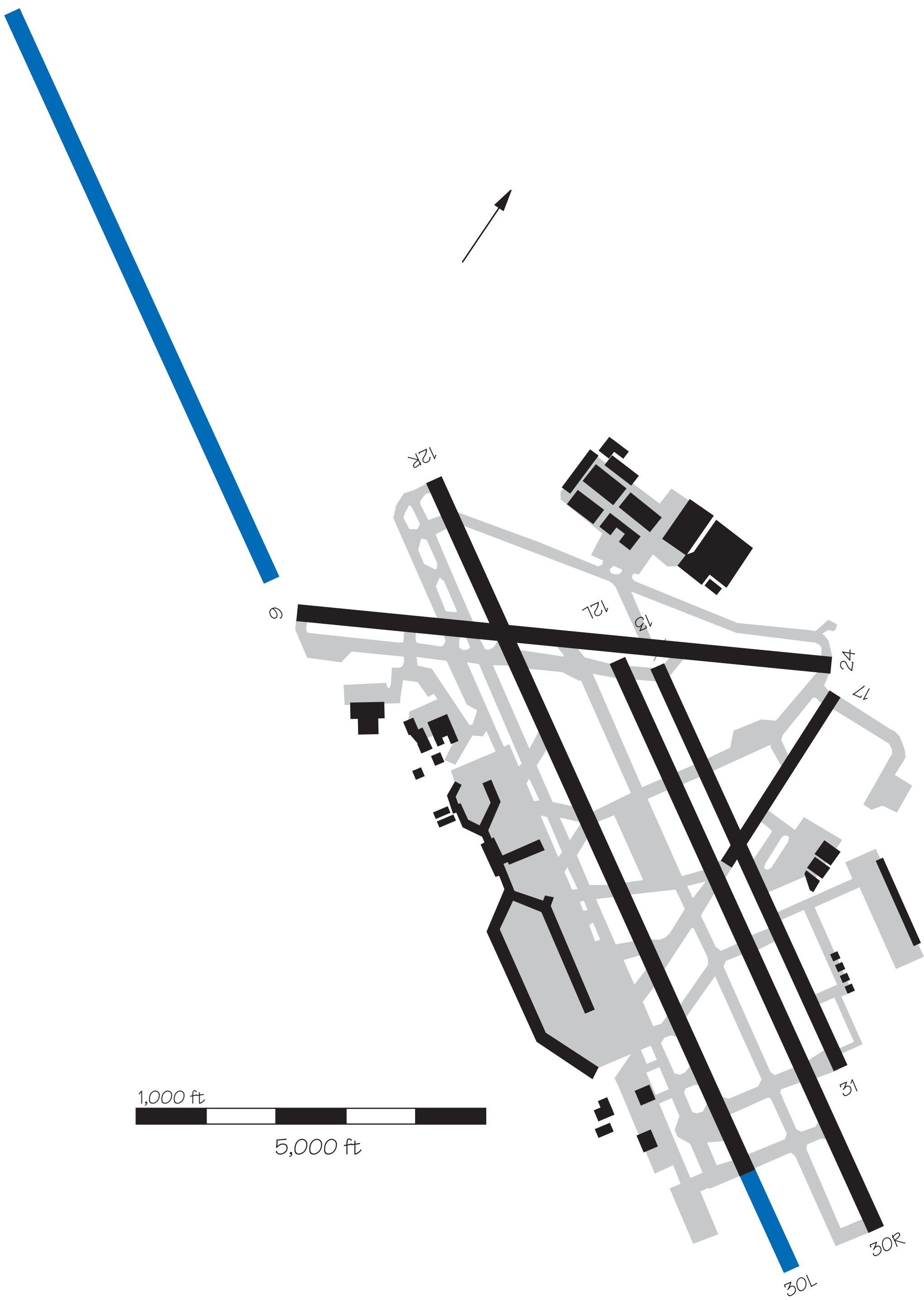
SRQ — Sarasota Bradenton Airport

A new parallel Runway 14L/32R 1,230 ft. northwest of Runway 14/32 is being planned at an estimated cost of $10 million. It is expected to be operational beyond 2002. IFR arrivals and departures on the new runway will be dependent on Runway 14/32 operations. In addition, an extension of the existing Runway 14/32 is planned at a cost of $5.1 million. It is expected to be operational beyond 2002. The runway extension will allow departures by larger and heavier aircraft and by aircraft with longer haul-lengths.



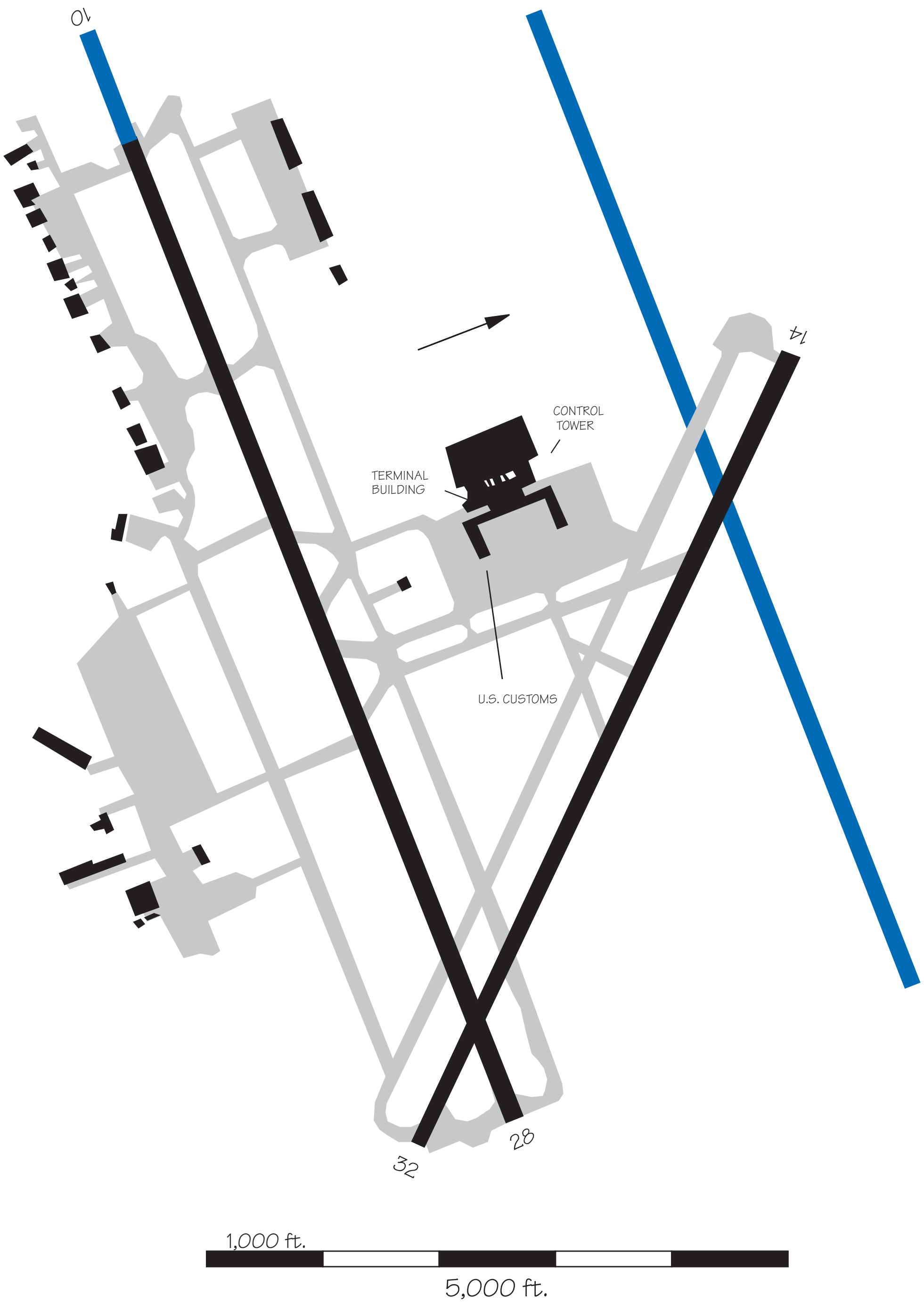
STL — Lambert St. Louis International Airport

A new parallel Runway 12R/30L has been recommended in the St. Louis Airport Master Plan Update. The Plan calls for a parallel runway supporting independent IFR arrivals. The Final Environmental Impact Statement (FEIS) was completed in December 1997, and construction could begin in 1998. Estimated completion date is 2003.



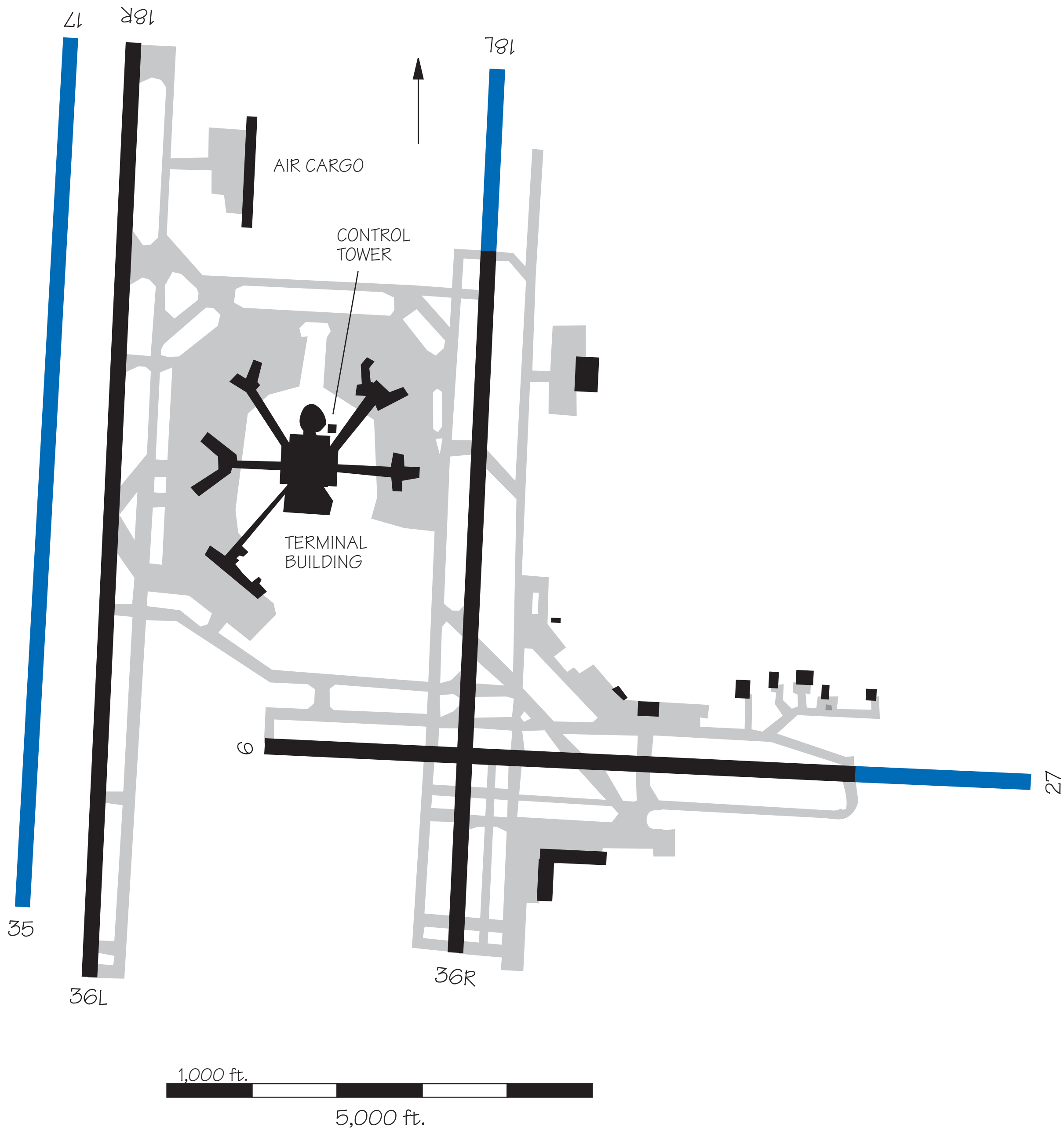
SYR — Syracuse Hancock International Airport

A new parallel Runway 10L/28R, 9,000 ft. long and separated from the existing Runway 10/28 by 3,400 ft. is being considered. It would provide independent parallel IFR operations, doubling hourly IFR arrival capacity. The cost of construction is estimated to be $55 million for the first phase of the new runway, which would be 7,500 ft. long, including a parallel taxiway and connections to the ramp. The final length of the runway would be 9,000 ft. A capacity analysis and needs study is presently underway. Runway 10R/28L is planned to be extended 2,000 ft. to an ultimate length of 11,000 ft.



TPA — Tampa International Airport

A third parallel Runway, 17/35, 10,200 ft. long and 700 ft. west of Runway 18R/36L, is being considered. The new runway would primarily be used for arrivals with the existing Runway 18R/36L being used for departures. A 2,200 ft. extension of Runway 18L/36R is also being considered for the time frame beyond 2005. The Runway 36R threshold would be relocated 2,600 ft. north. This may allow for less restricted use of the runway by reducing noise impacts on communities south of the airport. Finally, reconstruction and a 1,200 ft. extension of Runway 9/27 is being considered for the time frame beyond 2010. The extended runway would be used for arrivals and departures. Arrivals may be able to land-and-hold-short of Runway 18L, therefore, the extended runway may allow dependent converging approaches to Runways 36L and 27.

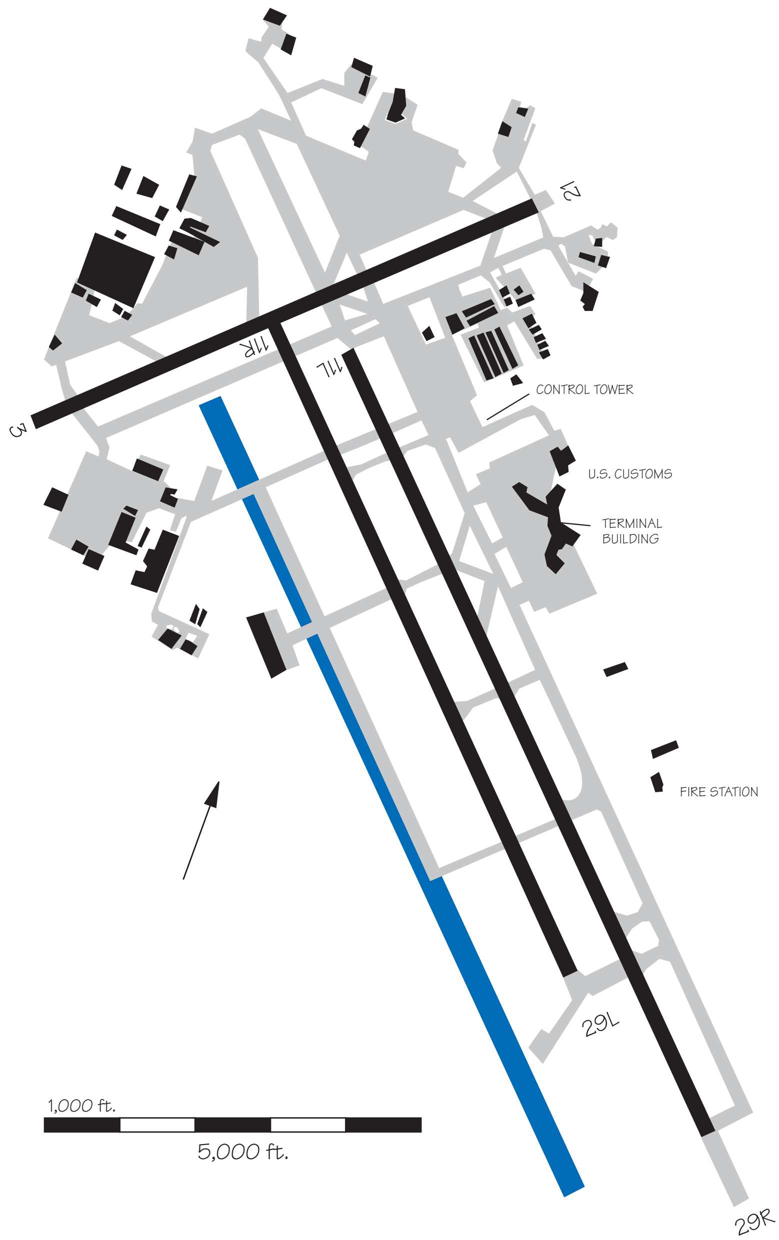


TUL — Tulsa International Airport

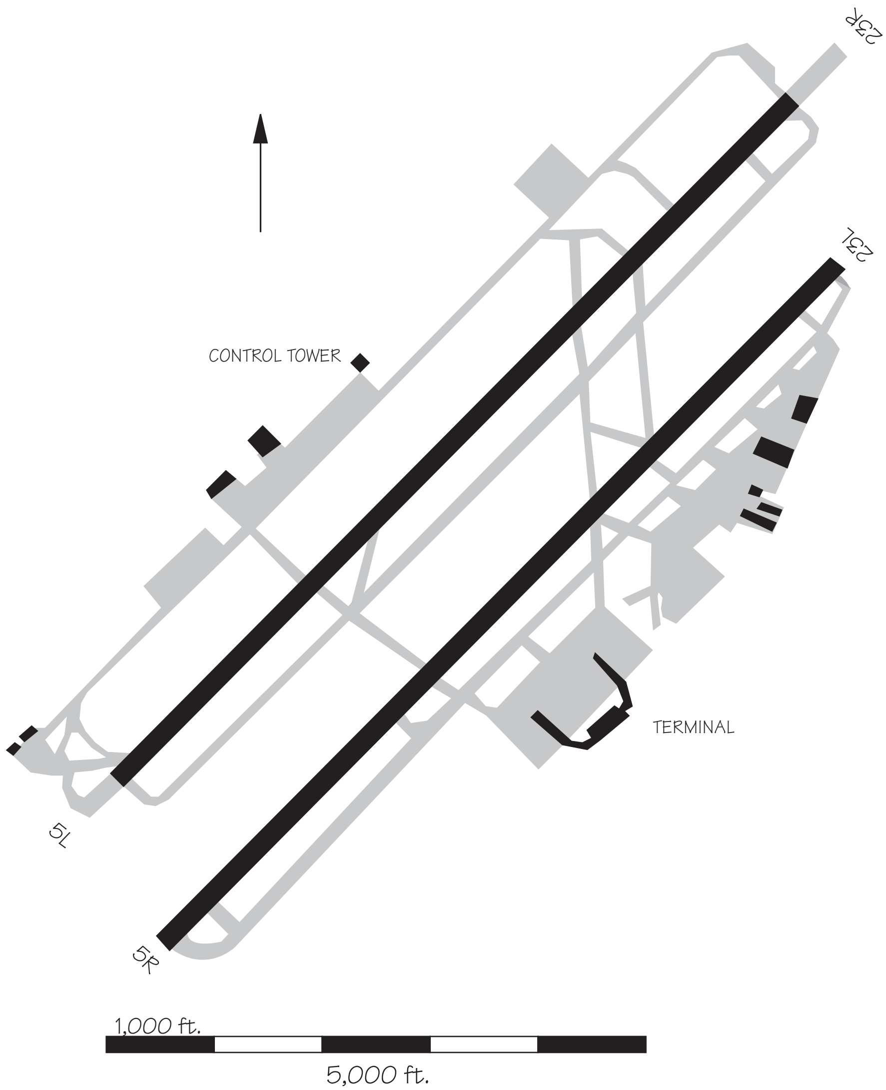
A new parallel runway, Runway 18L/36R, located 6,400 ft. east of the present 18L/36R and 9,600 ft. long, is being considered. The new runway would permit IFR triple independent approaches, if approved, to Runways 18L, 18C, and 18R.

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. Current plans call for construction to start in 2003 to be operational in 2005. The cost of construction is estimated to be $30 million.



TYS — Knoxville McGhee-Tyson Airport



APPENDIX C: GLOSSARY

AAC .... Advanced AERA Concepts
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
ALT .... Airspace Liaison Team
ACF .... Area Control Facility
ADR .... Automated Demand Resolution
ADS .... Automatic Dependent Surveillance
ADSIM .... Airfield Delay Simulation Model
AEP .... Arrival Enhancement Procedure
AERA .... Automated En Route Air Traffic Control
AEX .... Automated Execution
AF .... Airway Facilities
AFB .... Air Force Base
AFSS .... Automated Flight Service Stations
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
AOCNET .... Airline Operations Center Network
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
AST .... Associate Administrator for Commercial Space Transportation
ASQP .... Airline Service Quality Performance
ASR .... Airport Surveillance Radar
ASTA .... Airport Surface Traffic Automation
ATA .... Air Transport Association
ATC .... Air Traffic Control
ATCAA .... Air Traffic Control Assigned Airspace
ATCSCC .... Air Traffic Control System Command Center
ATCT .... Air Traffic Control Tower
ATIS .... Automated Terminal Information Service
ATMS .... Advanced Traffic Management System
ATN .... Aeronautical Telecommunications Network
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
BRAC .... Base Realignment Closure Program
CAA .... Civil Aviation Authority
CAEG .... Computer Aided Engineering Graphics
CAEP .... Committee on Aviation Environmental Protection
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
CDM .... Collaborative Decision Making
CFWSU .... Central Flow Weather Service Unit
CIP .... Capital Investment Plan
CIS .... Cockpit Information System
CNS .... Communication, Navigation, and Surveillance

CODAS .... Consolidated Operations and Delay Analysis System
CONDAT .... CONUS National Airspace Data Access Tool
CONUS .... Continental United States
CPDLC .... Controller to Pilot Data Link Communications
CRDA .... Converging Runway Display Aid
CRS .... Computer Reservation System
CSD .... Critical Sector Detector
CTAP .... Chicago Terminal Airspace Project
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
DATIS .... Digital Automated Terminal Information Service
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
DSR .... Display System Replacement
DSUA .... Dynamic Special-Use Airspace
DUATS .... Direct User Access Terminal Service
DVOR .... Doppler VOR
EA .... Environmental Assessment
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
EPA .... Environmental Protection Agency
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
FFP1 .... Free Flight Phase 1
FIS .... Flight Information Services
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 Schedule Monitor
FSS .... Flight Service Station
FT .... Feet
FTMI .... Flight Operations and Air Traffic Management Integration
FY .... Fiscal Year
GA .... General Aviation
GAO .... General Accounting Office
GDP .... Gross Domestic Product
GDP .... Ground Delay Program
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
HFDL .... High Frequency Data Link
ICAO .... International Civil Aviation Organization
ICP .... Initial Conflict Probe
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
LAAS .... Local Area Augmentation 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
MAMS .... Military Airspace Management System
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
NASA .... National Aeronautics and Space Administration
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
NCARC .... National Civil Aviation Review Commission
NCF .... National Control Facility
NCT .... Northern California TRACON
NCP .... NAS Change Proposal
NEPA .... National Environmental Policy Act
NEXCOM .... Next Generation Air/Ground Communication
NEXRAD .... Next Generation Weather Radar
NFDC .... National Flight Data Center
NLA .... New Large Aircraft
NMC .... National Meteorological Center
NMCC .... National Maintenance Coordination Complex

NM .... Nautical Mile
NOAA .... National Oceanic and Atmospheric Administration
NOX .... Oxides of Nitrogen
NPIAS .... National Plan of Integrated Airport Systems
NRP .... National Route Program
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
pFAST .... Passive Final Approach Spacing Tool
PFC .... Passenger Facility Charge
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
RHSM .... Reduced Horizontal Separation Minima
RLV .... Reusable Launch Vehicle
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

RVR .... Runway Visual Range
RVSM .... Reduced Vertical Separation Minima
SAMS .... Special Use Airspace Management System
SAR .... System Analysis Recording
SARPS .... Standards and Recommended Practices
SATCOM .... Satellite Communications
SATS .... Small Aircraft Transportation System
SCIA .... Simultaneous Converging Instrument Approaches
SCT .... Southern California TRACON
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
SMA .... Surface Movement Advisor
SMARTFLOW .... Knowledge-Based Flow Planning
SMGC .... Surface Movement Guidance and Control
SMS .... Simulation Modeling System
SOIA .... Simultaneous Offset Instrument Approaches
SOIR .... Simultaneous Operations on Intersecting Runways
SOIWR .... Simultaneous Operations on Intersecting Wet Runways
STAR .... Standard Terminal Arrival Route
STARS .... Standard Terminal Automation Replacement System
SUA .... Special Use Airspace
TACAN .... Tactical Air Navigation
TAP .... Terminal Area Productivity
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
TDLS .... Tower Data Link System
TDP .... Technical Data Package
TDWR .... Terminal Doppler Weather Radar
TERPS .... Terminal Instrument Procedures
TFM .... Traffic Flow Management
TIBS .... Telephone Information Briefing System
TIDS .... Tower Integrated Display System
TIS .... Traffic Information System
TMA .... Traffic Management Advisor
TMCC .... Traffic Management Computer Complex
TMS .... Traffic Management System

TMU .... Traffic Management Unit
T-NASA .... Text Navigation and Situation Awareness
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
TWIP .... Terminal Weather Information for Pilots
UHF .... Omnidirectional Course and Distance Information
UPT .... User Preferred Trajectory
USWRP .... U.S. Weather Research Program
VASI .... Visual Approach Slope Indicators
VDL .... VHF Digital Link
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
WARP .... Weather and Radar Processor