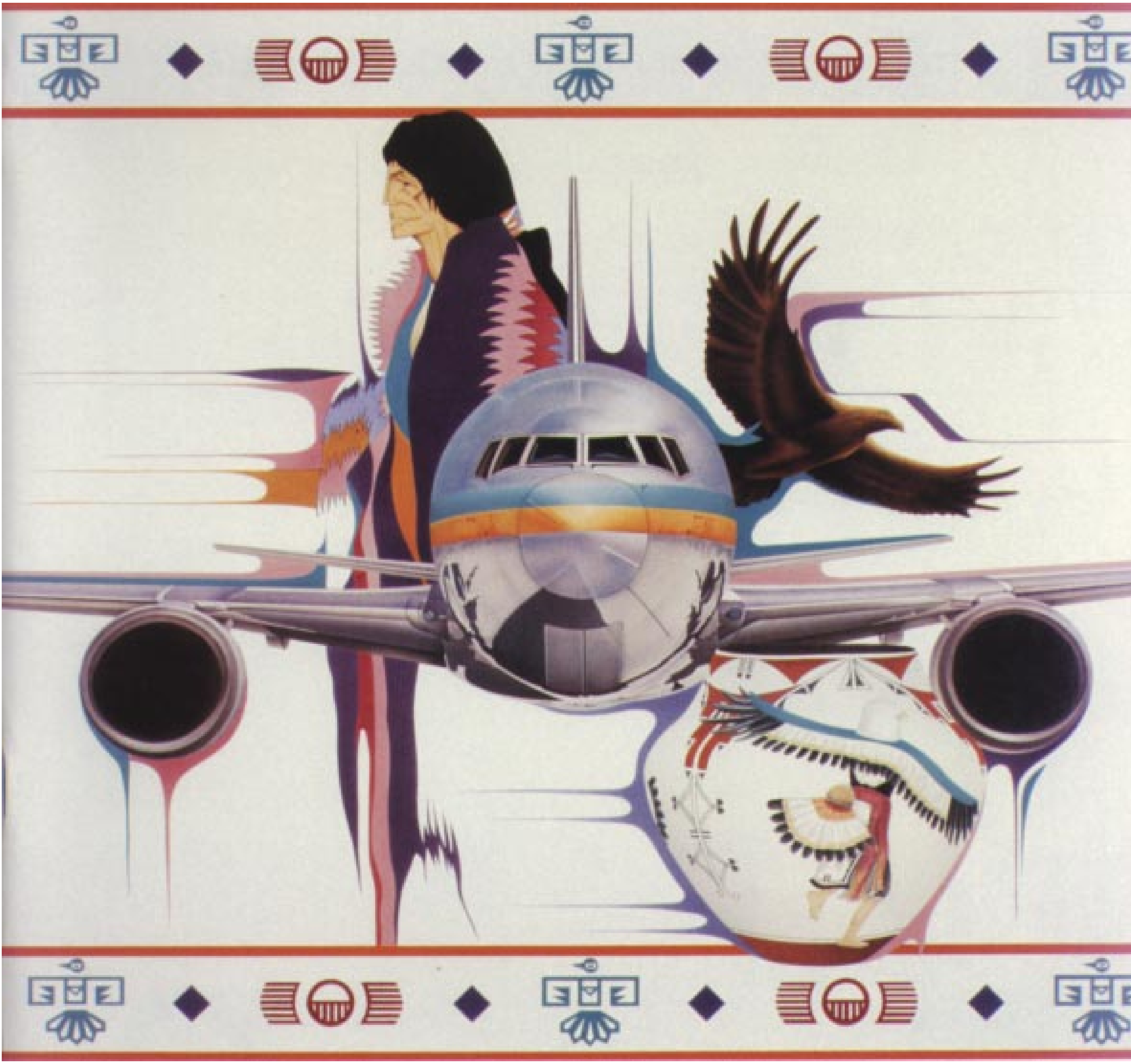
ALBUQUERQUE

INTERNATIONAL AIRPORT



CAPACITY ENHANCEMENT PLAN

Albuquerque International Airport

Airport Capacity Enhancement Plan

March 1993

Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, the City of Albuquerque Aviation Board, and the airlines and general aviation serving Albuquerque.

Figure 1. Albuquerque International Airport

Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Figure 1. Albuquerque International Airport

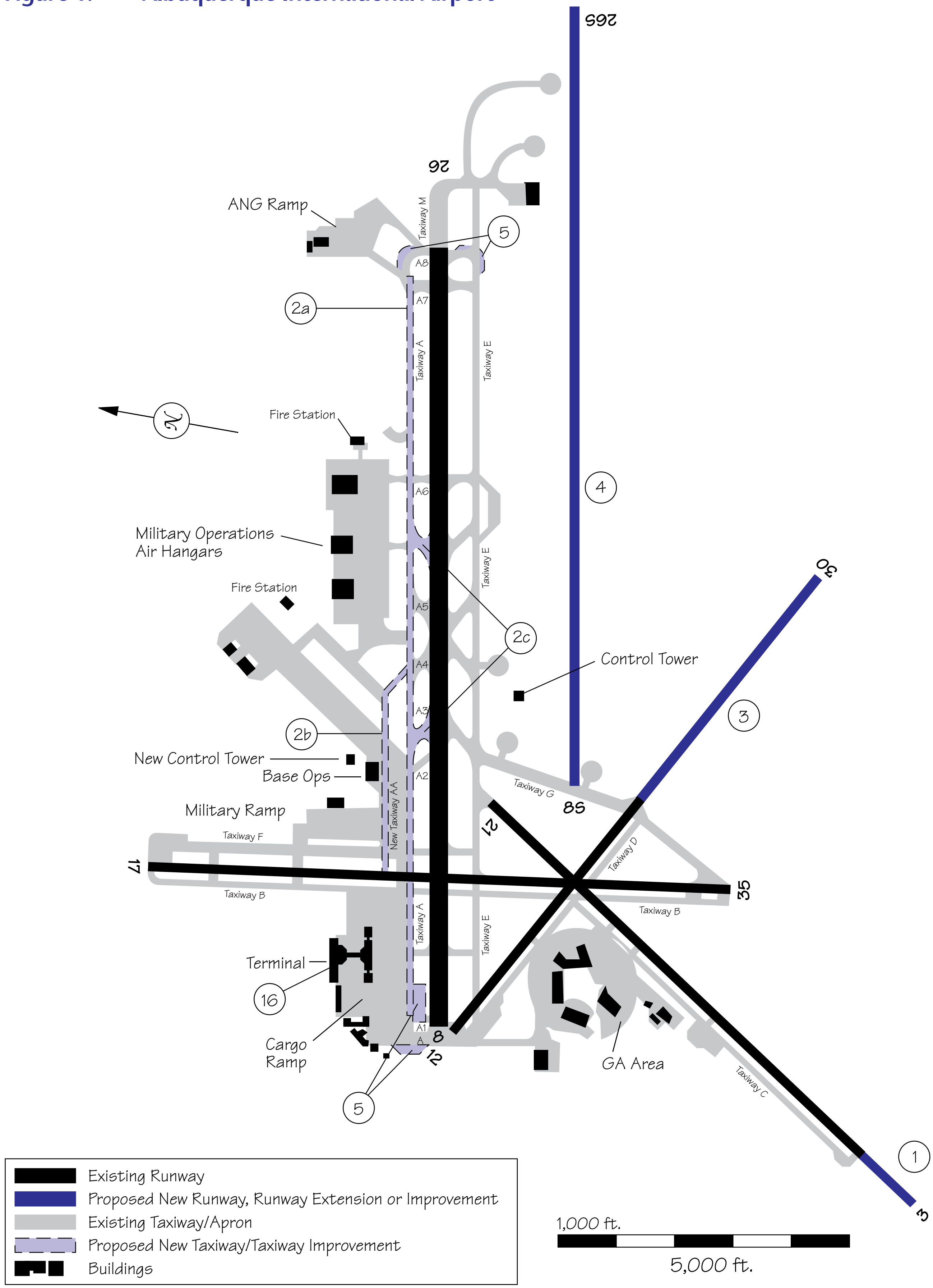


Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Alternatives	Estimated Annual Delay Savings* (in hours and millions of 1992 dollars) Baseline (202,000)	Future 1 (303,000)	Future 2 (404,000)
Airfield Improvements			
1. Extend, widen, and strengthen Runway 3/21 and operate as a 10,000-foot air carrier runway	750/$0.67	2,630/$2.36	19,520/$17.57
2. Construct new and improve existing taxiways and exits	20/$0.02	330/$0.29	5,040/$4.54
2a. Widen and strengthen Taxiway A along full length parallel to and north of Runway 8/26			
2b. Construct 4,000 foot Taxiway AA, parallel to and north of Taxiway A, from Runway 17/35 to Exit A4			
2c. Improve or add angled (high-speed) exits on Runway 8/26 to Taxiway A			
3. Extend Runway 12/30 to the southeast and operate as a 10,000-foot air carrier runway	80/$0.07	320/$0.29	1,320/$1.19
4. Construct new parallel air carrier runway south of Runway 8/26			
4a. Operate as a dependent IFR runway	450/$0.41	4,180/$3.76	39,280/$35.36
4b. Operate as an independent IFR runway	480/$0.43	4,370/$3.93	40,740/$36.66
5. Construct holding areas for Runway 8/26		†	
Facilities and Equipment Improvements			
6. Install ILS on Runway 3	260/$0.24	3,620/$3.26	33,090/$29.78
7. Install CAT II/III ILS on Runway 8	140/$0.12	490/$0.44	630/$0.57
8. Install ILS on Runway 35	10/$0.01	30/$0.03	310/$0.28
9. Install TVOR/DME		†	
10. Install ILS on Runway 30	10/$0.01	20/$0.02	40/$0.04
Operational Improvements			
11. Benefit of MLS procedures to Runway 26		†	
12. Reduce in-trail separations to 2.5 nm from 3 nm in IFR	90/$0.08	2,130/$1.91	9,980/$8.98
13. Evaluate impact of noise abatement procedures	70/$0.07	350/$0.32	1,240/$1.12
14. Implement dependent converging approaches with ILS Runways 3 and 8	240/$0.22	3,090/$2.78	28,740/$25.86
15. Enhance general aviation (GA) reliever airports	—	3,520/$3.16	43,100/$38.79
16. Terminal expansion (added gates)	4,620/$4.16	11,790/$10.61	46,300/$41.68
17. Assign designated areas for civil helicopters		†	

* The savings benefits of these alternatives are not necessarily additive.

† These improvements were not simulated. Therefore, no dollar figures are available. There is a description of each of these items in Section 2 — Capacity Enhancement Alternatives.

Summary

The Federal Aviation Administration (FAA), airport operators, and aviation industry groups have initiated joint Airport Capacity Design Teams at various major air carrier airports throughout the U.S. These Capacity Teams identify and evaluate alternative means to enhance existing airport and airspace capacity to handle future demand. A Capacity Team for Albuquerque International Airport (ABQ) was formed in 1992.

Steady growth at ABQ has made it one of the busier airports in the country. Activity at the airport has increased from 1,445,000 passenger enplanements in 1983 to 2,461,434 in 1991, a 70 percent increase. In 1991, the airport handled 210,230 aircraft operations (takeoffs and landings).

The ABQ Capacity Team identified and assessed various actions which, if implemented, would increase ABQ's capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

Selected alternatives identified by the Capacity Team were tested using computer models developed by the FAA to quantify the benefits provided. Different levels of activity were chosen to represent growth in aircraft operations in order to compare the merits of each action. These annual activity levels are referred to throughout this report as:

Baseline — 202,000 operations;
Future 1 — 303,000 operations; and
Future 2 — 404,000 operations.

If no improvements are made at ABQ (the Do Nothing scenario), the annual delay cost will increase from 9,900 hours or $8.91 million at the Baseline level of operations to 151,290 hours or $136.16 million by Future 2.

The major recommendations resulting from the ABQ study include:

Alternative	Future 2 Annual Delay Savings Hours	Future 2 Annual Delay Savings Millions of 1992 $
• Extend Runway 3/21 and operate as air carrier runway; install instrument landing system on Runway 3; construct new and improve existing taxiways and exits (combines alternatives 1, 2, and 6)	53,150	$47.84
• Terminal expansion (10 additional air carrier gates)	46,300	$41.68
• Enhance general aviation (GA) reliever airports	43,100	$38.79
• Construct parallel air carrier runway south of Runway 8/26; operate as a dependent IFR runway	39,280	$35.36
• Implement dependent converging approaches with ILS	28,740	$25.86
• Reduce in-trail separations to 2.5 nm from 3 nm in IFR	9,980	$8.98

Figure 3. Airport Capacity Curve — Hourly Flow Rate Versus Average Delay — East Flow

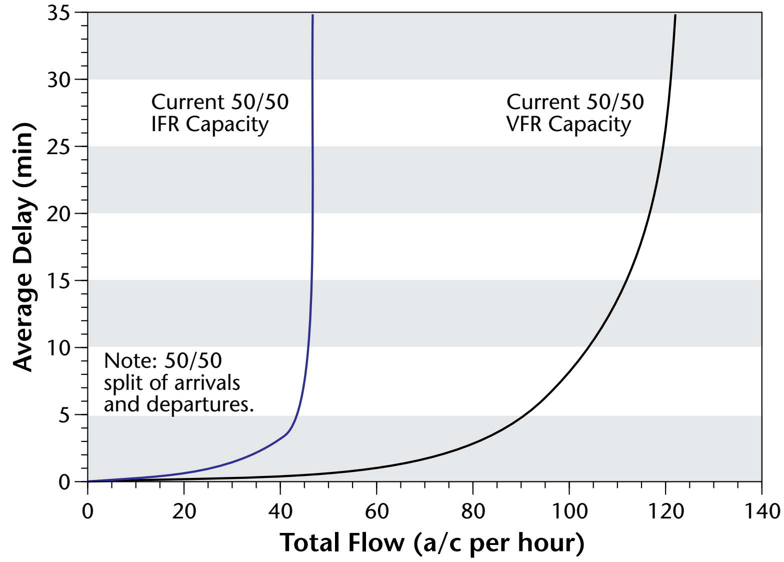


Figure 4. Profile of Daily Demand — Hourly Distribution

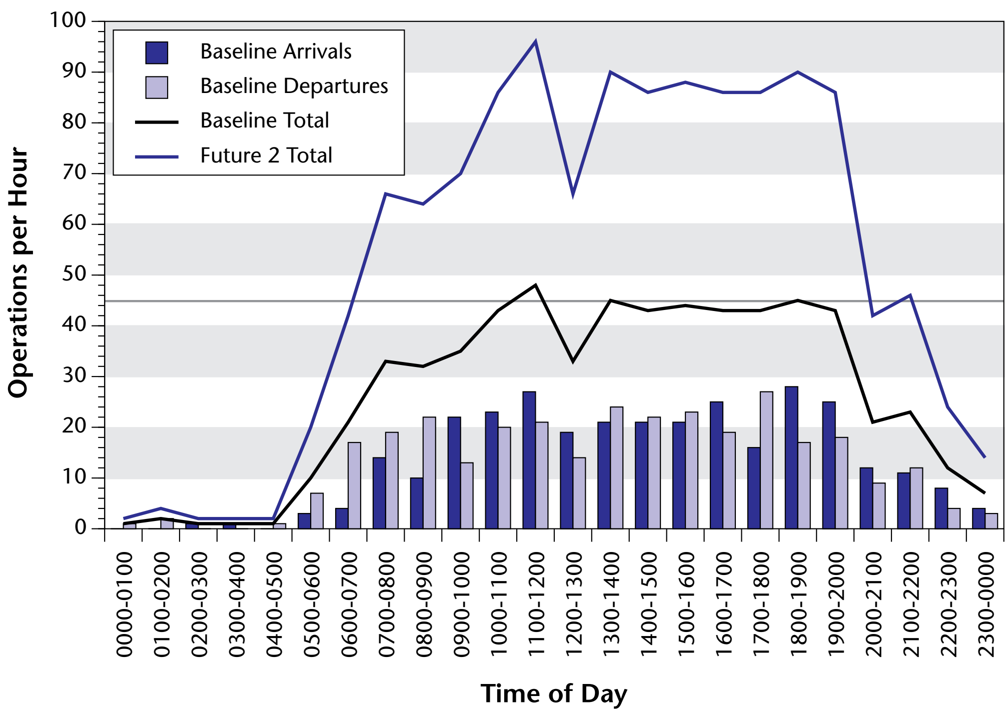


Figure 3 illustrates the capacity and delay curves for the current airfield at ABQ for an east flow runway configuration under both instrument flight rules (IFR) and visual flight rules (VFR) with a 50/50 split of arrivals and departures. It shows that aircraft delays will begin to escalate rapidly under IFR as hourly demand exceeds 45 operations per hour. Figure 4 shows that, while hourly demand exceeds 45 operations only during the peak hour of the day at Baseline demand levels, 45 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

Figure 5. Annual Delay Costs — Capacity Enhancement Alternatives

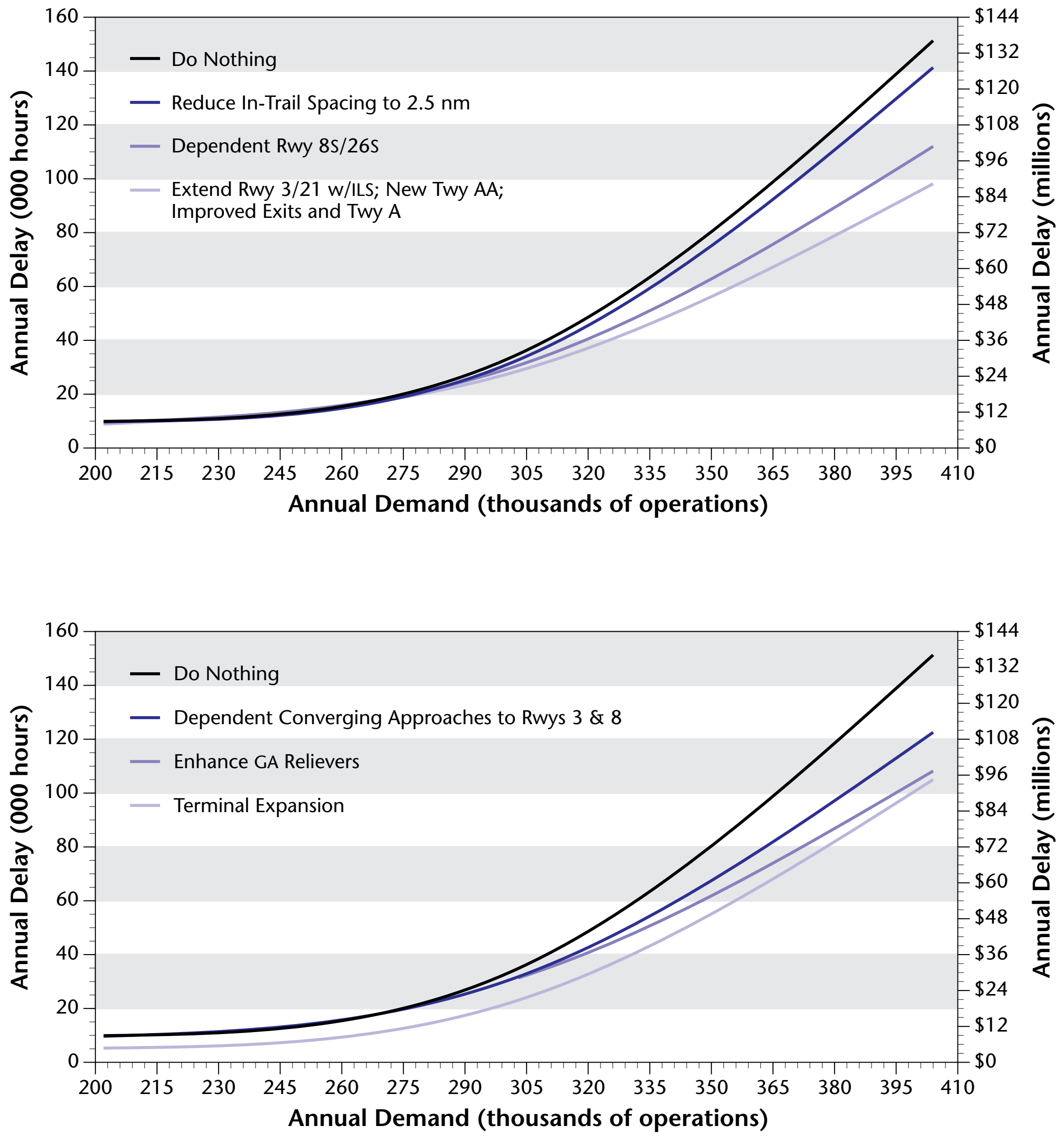


Figure 5 shows how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the Do Nothing scenario. Annual delay costs will increase from 9,900 hours or $8.91 million at the Baseline level of operations to 151,290 hours or $136.16 million by Future 2. The graphs also show that the greatest savings in delay costs would be provided by:

- Extending Runway 3/21 and operating as air carrier runway; installing instrument landing system on Runway 3; and constructing new and improving existing taxiways and exits (combines alternatives 1, 2, and 6)
- Terminal expansion (10 additional air carrier gates)
- Enhancing general aviation (GA) reliever airports
- Constructing parallel air carrier runway south of Runway 8/26; operating as a dependent IFR runway
- Implementing dependent converging approaches with ILS
- Reducing in-trail separations to 2.5 nm from 3 nm in IFR

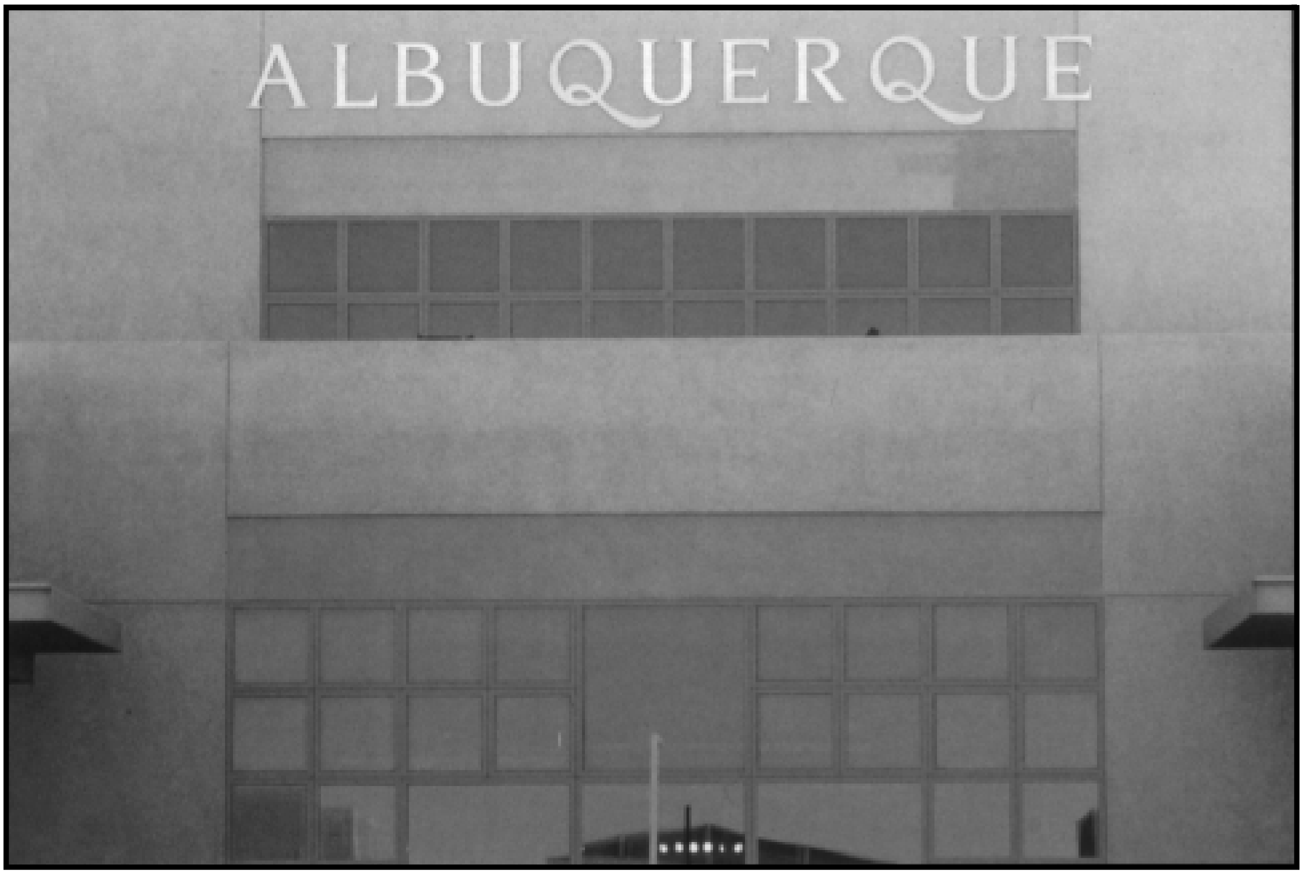
Table of Contents

Summary 5

Section 1 .... Introduction 11
Background 11
Objectives 12
Scope 12
Methodology 12
Section 2 .... Capacity Enhancement Alternatives 15
Airfield Improvements 16
Facilities and Equipment Improvements 18
Operational Improvements 19
Section 3 .... Summary of Technical Studies 23
Overview 23
Airfield Capacity 26
Aircraft Delays 29
Conclusions 30

Appendix A .... Participants 33
Appendix B .... Computer Models and Methodology 35
Computer Models 35
Methodology 36
Appendix C .... List of Abbreviations 36

Figure 1. .... Albuquerque International Airport .... foldout
Figure 2. .... Capacity Enhancement Alternatives and Annual Delay Savings 4
Figure 3. .... Airport Capacity Curve — Hourly Flow Rate Versus Average Delay — East Flow 6
Figure 4. .... Profile of Daily Demand — Hourly Distribution 6
Figure 5. .... Annual Delay Costs — Capacity Enhancement Alternatives 7
Figure 6. .... Capacity Enhancement Alternatives and Recommended Actions 14
Figure 7. .... Annual Distribution of Traffic 24
Figure 8. .... Airfield Weather 24
Figure 9. .... Runway Utilization (percentage use) 24
Figure 10. ...... Runway Configurations 25
Figure 11. ...... Airfield Demand Levels 26
Figure 12. ...... Airport Capacity Curves — Flow Rate Versus Average Delay — Current Configuration — East Flow 28
Figure 13. ...... Profile of Daily Demand — Hourly Distribution 28
Figure 14. ...... Airport Capacity Curves — Hourly Flow Rate Versus Average Delay — Future Configuration 29
Figure 15. ...... Annual Delay Costs — Capacity Enhancement Alternatives 31


ALBUQUERQUE

Section 1 Introduction

Background

The National air transportation system is being called on to handle unprecedented growth and ever increasing activities. The challenge for the air transportation industry in the nineties is to enhance existing airport and airspace capacity and to develop new facilities to handle future demand. As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the U.S., an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

To begin to meet this challenge, the Federal Aviation Administration (FAA), along with airport operators and aviation industry groups throughout the country, have initiated joint Airport Capacity Design Teams to study airport capacity enhancement at the major air carrier airports in the U.S. The objectives of these studies are to identify various alternatives for increasing capacity and to evaluate their potential for reducing delays.

In the past decade, Albuquerque International Airport (ABQ) has been one of the nation's busier airports. Enplanements at ABQ rose from 1,445,000 in 1983 to 2,461,434 in 1991, a 70 percent increase. ABQ's total aircraft operations reached 210,230 in 1991.

This report has established benchmarks for development based upon traffic levels and not upon any definitive time schedule, since actual growth can vary year to year from projections. As a result, the report should retain its validity until the highest traffic level is attained regardless of the actual dates paralleling the development.

A Baseline benchmark of 202,000 aircraft operations (takeoffs and landings) was established based on the annual traffic level for 1991, the base year of the study. Two future traffic levels, Future 1 and Future 2, were established at 303,000 and 404,000 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at Albuquerque. If no improvements are made at ABQ, annual delay levels and delay costs are expected to increase from an estimated 9,900 hours and $8.91 million at the Baseline activity level to 151,290 hours and $136.16 million by the Future 2 demand level.

The Capacity Team studied various proposals with the potential for increasing capacity and reducing delays at

ABQ. The improvements evaluated by the Capacity Team are delineated in Figure 2 and described in some detail in Section 2 — Capacity Enhancement Alternatives.

Objectives

The major goal of the Capacity Team was to identify and evaluate proposals to increase airport capacity, improve airport efficiency, and reduce aircraft delays. In achieving this objective, the Capacity Team:

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

Scope

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

Methodology

The Capacity Team met periodically for review and coordination. The FAA Technical Center's Aviation Capacity Branch provided expertise in airport simulation modeling. Other Capacity Team members contributed suggested improvement options, data, text, and capital cost estimates.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions were based on actual field observations at ABQ. Proposed improvements were analyzed in relation to current and future demands with the help of two computer models, the Runway Delay Simulation Model (RDSIM) and the Airport and Airspace Simulation Model (SIMMOD). Appendix B briefly explains these models.

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

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

Following the evaluation, the Capacity Team developed a plan of recommended alternatives for consideration, which is included in Figure 6.

Figure 6. Capacity Enhancement Alternatives and Recommended Actions

Alternatives	Action	Time Frame
Airfield Improvements		
1. Extend, widen, and strengthen Runway 3/21 and operate as a 10,000-foot air carrier runway	Recommended	Future 1
2. Construct new and improve existing taxiways and exits	Recommended	—
2a. Widen and strengthen Taxiway A along its full length parallel to and north of Runway 8/26	—	Baseline
2b. Construct Taxiway AA 4,000 feet in length, parallel to and north of Taxiway A, from Runway 17/35 to Exit A4	—	Future 1
2c. Improve or add angled (high-speed) exits on Runway 8/26 to Taxiway A	—	Future 1
3. Extend Runway 12/30 to the southeast and operate as a 10,000-foot air carrier runway	Further Study	Future 2
4. Construct new parallel air carrier runway south of Runway 8/26		
4a. Operate as a dependent IFR runway	Further Study	Future 2
4b. Operate as an independent IFR runway	Not Recommended	—
5. Construct holding areas for Runway 8/26	Recommended	Baseline
Facilities and Equipment Improvements		
6. Install ILS on Runway 3	Recommended	Future 1
7. Install CAT II/III ILS on Runway 8	Recommended	Future 2
8. Install ILS on Runway 35	Not Recommended	—
9. Install TVOR/DME	Recommended	Baseline
10. Install ILS on Runway 30	Further Study	Future 2
Operational Improvements		
11. Benefit of MLS procedures to Runway 26	Further Study	Future 2
12. Reduce in-trail separations to 2.5 nm from 3 nm in IFR	Recommended	Baseline
13. Evaluate impact of noise abatement procedures	Further Study	Future 2
14. Implement dependent converging approaches with ILS on Runways 3 and 8	Recommended	Future 1
15. Enhance general aviation (GA) reliever airports	Recommended	Baseline
16. Terminal expansion (added gates)	Recommended	Future 1
17. Assign designated areas for civil helicopters	Further Study	Future 2

Note: "Further Study" suggests that a specific study be conducted or that it become part of a larger planning effort, such as a Master Plan update or a FAR Part 150 Airport Noise Compatibility Study. These individual proposals require further investigation at a level of detail that is beyond the scope of this effort.

Section 2 Capacity Enhancement Alternatives

Figure 1 shows the current layout of the airport, plus the airfield improvements considered by the Capacity Team.

Figure 2 lists the capacity enhancement alternatives evaluated by the Capacity Team and presents the estimated annual delay savings benefits for selected improvements. The annual savings are given for the activity levels Baseline, Future 1, and Future 2, which correspond to annual aircraft operations of 202,000, 303,000, and 404,000 respectively. The delay savings benefits of the improvements are not necessarily additive.

Figure 6 presents the recommended action and suggested time frame for each capacity enhancement alternative considered by the Capacity Team.

The capacity enhancement alternatives are categorized and discussed under the following headings:

- Airfield Improvements
- Facilities and Equipment Improvements
- Operational Improvements

Airfield Improvements

1. Extend, widen, and strengthen Runway 3/21 and operate as a 10,000-foot air carrier runway.

Widening and strengthening Runway 3/21 and extending it 1,500 feet would allow the runway to be used by larger and heavier aircraft and would effectively create a third air carrier runway. This would provide the capability for a second air carrier arrival runway while operating in an east flow. It would also provide an additional air carrier departure runway during a west flow

Estimated 1992 project cost is $17 million.

Annual savings at the Baseline activity level would be 750 hours or $0.67 million, and, at Future 2 activity levels, 19,520 hours or $17.57 million.

2. Construct new and improve existing taxiways and exits.

This comprehensive project would improve ABQ's taxiway structure and provide a more efficient taxiway system with more appropriate exits and high-speed turnoffs.

Estimated 1992 project cost is $26 million.

Annual savings at the Baseline activity level would be 20 hours or $0.02 million, and, at Future 2 activity levels, 5,040 hours or $4.54 million.

2a. Widen and strengthen Taxiway A.

Widen and strengthen Taxiway A along its full length, parallel to and north of Runway 8/26. Due to the deteriorating condition of Taxiway A, this portion of the taxiway and exit improvement project is necessary in order to retain this important taxiway as a usable element in the airport's infrastructure.

2b. Construct new parallel Taxiway AA.

An additional parallel taxiway, Taxiway AA, on the north side of Runway 8/26, 4,000 feet in length, north of Taxiway A and extending from Runway 17/35 to Exit A4, would allow two-way traffic for arriving and departing aircraft to taxi to and from the terminal and the runway, thereby improving the flow of ground traffic and reducing taxi interference and delays.

2c. Improve or add angled (high-speed) exits on Runway 8/26 to Taxiway A.

Angled, high-speed exits would reduce runway occupancy times and enhance runway capacity.

3. Extend Runway 12/30 to the southeast and operate as a 10,000-foot air carrier runway.

Runway 12/30 is currently 5,130 feet in length. Extending the runway and using it to support air carrier operations would allow air traffic control greater flexibility in the use of runways and thus enhance capacity.

Estimated 1992 project cost is $50 million.

Annual savings at the Baseline activity level would be 80 hours or $0.07 million, and, at Future 2 activity levels, 1,320 hours or $1.19 million.

4. Construct new parallel air carrier runway south of Runway 8/26.

Currently, the separation between parallel runway centerlines must be at least 4,300 feet for independent operations in all weather conditions. If parallel runway centerlines are less than 4,300 feet, the runways are considered dependent under instrument flight rules (IFR), and aircraft on approach to the two runways must be staggered. If parallel runways are less than 2,500 feet apart, they must be treated as a single runway under IFR operations.

However, a developmental program known as the Precision Runway Monitor (PRM) has demonstrated the potential for reducing parallel runway spacing requirements. This program relies on improved radar surveillance with higher update rates of aircraft positions and a new air traffic controller display system. National standards for simultaneous (independent) parallel approaches using the PRM to runways separated by 3,400 to 4,300 feet were published in November 1991.

4a. Operate as a dependent IFR runway.

If the new runway were constructed to support dependent operations under IFR, it would allow for two VFR arrival streams and two IFR arrival streams, one of which would be dependent.

Estimated 1992 project cost is $50 million.

Annual savings at the Baseline activity level would be 450 hours or $0.41 million, and, at Future 2 activity levels, 39,280 hours or $35.36 million.

4b. Operate as an independent IFR runway.

If the new runway were constructed to support independent IFR operations, it would allow for two independent arrival streams under both VFR and IFR.

Estimated 1992 project cost is $100 million.

Annual savings at the Baseline activity level would be 480 hours or $0.43 million, and, at Future 2 activity levels, 40,740 hours or $36.66 million.

5. Construct holding areas for Runway 8/26.

Air traffic flow control often dictates that aircraft hold at the runway thresholds before take-off because of departure flow restrictions. Construction of holding areas for Runway 8/26 would improve the ability of departing aircraft to bypass those aircraft waiting for departure clearance and relieve congestion on taxiways.

Estimated 1992 project cost is $5 million.

Facilities and Equipment Improvements

6. Install Instrument Landing System (ILS) on Runway 3.

Instrument flight rules (IFR) that restrict operations (IFR 1 and 2) occur about 10 percent of the time, and the impact of the associated delays can be significant. Installing an ILS on Runway 3 would provide the potential for a second arrival stream using dependent converging approach procedures on Runways 3 and 8 (see alternative 14) and would provide an improved precision approach during north wind conditions, thereby increasing capacity and reducing delays.

Estimated 1992 project cost is $1 million.

Annual savings at the Baseline activity level would be 260 hours or $0.24 million, and, at Future 2 activity levels, 33,090 hours or $29.78 million.

7. Install Category II/III ILS on Runway 8.

IFR that severely restrict operations (IFR 2) only occur about 2 percent of the time, but the impact of the associated delays can be significant. Installing a Category II/III ILS on Runway 8 would reduce visibility minimums and enhance operational flexibility and thereby help to maintain capacity during very low instrument meteorological conditions (IMC).

Estimated 1992 project cost is $3 million.

Annual savings at the Baseline activity level would be 140 hours or $0.12 million, and, at Future 2 activity levels, 630 hours or $0.57 million.

8. Install ILS on Runway 35.

IFR that restrict operations (IFR 1) occur about 8 percent of the time, and the impact of the associated delays can be significant. Installing an ILS on Runway 35 would reduce visibility minimums and enhance operational flexibility and thereby help to maintain capacity during IMC.

Estimated 1992 project cost is $1 million.

Annual savings at the Future 1 activity level would be 10 hours or $0.01 million, and, at Future 2 activity levels, 310 hours or $0.28 million.

9. Install Terminal Very High Frequency Omnidirectional Range/Distance Measuring Equipment (TVOR/DME).

The installation of a TVOR/DME at Albuquerque would provide an additional source of accurate fix information to pilots performing instrument approaches to ABQ. The present VOR is located 10 miles west of the airport and only provides instrument approach services to Runway 8. The installation of a TVOR/DME would provide for improved instrument approaches, enhance safety, decrease approach minimums, increase airport capacity, and better serve the needs of the users.

Estimated 1992 project cost is $500,000.

10. Install ILS on Runway 30.

IFR that restrict operations (IFR 1) occur about 8 percent of the time, and the impact of the associated delays can be significant. Installing an ILS on Runway 30 would reduce visibility minimums during west flow and enhance operational flexibility and thereby help to maintain capacity during IMC.

Estimated 1992 project cost is $1 million.

Annual savings at the Baseline activity level would be 10 hours or $0.01 million, and, at Future 2 activity levels, 40 hours or $0.04 million.

Operational Improvements

11. Benefit of MLS procedures to Runway 26.

The Microwave Landing System (MLS) will be the international standard replacement for the current Instrument Landing System (ILS). MLS will provide positive course guidance for approaches and departures under IMC. MLS's ability to support improved instrument procedures, like curved approaches, reduced minimums, simultaneous arrivals, and diverse departures, could significantly improve capacity under instrument conditions.

12. Reduce in-trail separations to 2.5 nm from 3 nm in IFR.

Existing procedures for IFR operations require that arriving aircraft be separated by 3 nautical miles (nm) or more. Reducing separation minimums to 2.5 nm for aircraft of similar class and less than 300,000 pounds would increase arrival rates and runway capacity. Most of the savings occurs at the highest demand levels under IFR, but, if the runway exits are not visible from the tower, the 2.5 nm separation cannot be applied.

Annual savings at the Baseline activity level would be 90 hours or $0.08 million, and, at Future 2 activity levels, 9,980 hours or $8.98 million.

13. Evaluate impact of noise abatement procedures.

Departures on Runway 8 must maintain a straight course for a mile and a half. If aircraft operations at ABQ were conducted without these procedures, there would be a reduction in annual delays.

Annual savings at the Baseline activity level would be 70 hours or $0.07 million, and, at Future 2 activity levels, 1,240 hours or $1.12 million.

14. Implement dependent converging approaches with ILS on Runways 3 and 8.

Under VFR, it is common to use non-intersecting converging runways (see alternative 1) for independent streams of arriving aircraft. Because of the reduced visibility and ceilings associated with IFR, simultaneous (independent) use of runways is currently permitted for aircraft arrivals only during relatively high weather minimums. However, a program is under development that would allow dependent (alternating) arrivals on non-parallel runways through the use of a Converging Runway Display Aid (CRDA) for air traffic controllers.

Annual savings at the Baseline activity level would be 240 hours or $0.22 million, and, at Future 2 activity levels, 28,740 hours or $25.86 million.

15. Enhance general aviation (GA) reliever airports.

The percentage of general aviation (GA) activity is expected to remain relatively constant at 36 percent of annual operations for the three demand levels. GA is an integral part of the aviation system and provides a vital service to businesses and the local community. Every effort should be made to accommodate these aircraft at enhanced "reliever airports" with equal or better access to the metropolitan area. These reliever airports would need to provide services similar to those available at ABQ. "Similar services" would include longer and wider runways with associated lighting and increased pavement strength, all-weather approach capability, parallel taxiways, larger aprons, and such ancillary services as rental cars and easy access to public and private transportation.

The instrument systems needed to provide approach capability under IMC are limited in their availability. The FAA has reinstated the use of a localizer only/outer marker (LOC/OM) approach including a light lane (formerly known as a partial ILS). This provides for approach minimums of a 400 foot ceiling and 3/4 mile visibility. These lower approach minimums would allow the existing facilities, without precision instrument approach procedures, to be available for a larger percent of the time in IMC.

Annual savings at the Future 1 activity level would be 3,520 hours or $3.16 million, and, at Future 2 activity levels, 43,100 hours or $38.79 million.

16. Terminal expansion (added gates).

Expansion of the terminal would provide an additional 10 air carrier gates to accommodate the expected increase in aircraft operations at ABQ.

Estimated 1992 project cost is $10 million.

Annual savings at the Baseline activity level would be 4,620 hours or $4.16 million, and, at Future 2 activity levels, 46,300 hours or $41.68 million.

17. Assign designated areas for civil helicopters.

This project would be a near-term initiative to construct, mark, and light an approved helicopter pad adjacent to the GA ramp. Under this project, independent VFR day and night helicopter converging approaches, clear of fixed-wing traffic patterns, would have to be developed and published in order to reduce air traffic congestion due to airspeed differentials. A designated helicopter pad with paved hover taxi routes would reduce the likelihood of foreign object damage (FOD) from blowing debris and enhance overall operational safety for the Airport.

Estimated 1992 project cost is $0.5 million.

Section 3 Summary of Technical Studies

Overview

The Albuquerque International Airport Capacity Team evaluated the efficiency of the existing airfield and the proposed future configuration. Figure 7 shows the annual distribution of traffic, Figure 8, airfield weather conditions, and Figure 9, runway utilization for various runway configurations. Figure 10 illustrates these runway configurations. The potential benefits of various improvements were determined by examining airfield capacity, airfield demand, and average aircraft delays.

The Capacity Team used the Runway Delay Simulation Model (RDSIM) to determine aircraft delays during peak periods. Delays were calculated for current and future conditions.

Daily operations corresponding to an average day in the peak month were used for each of the forecast periods. Daily delays were annualized to measure the potential economic benefits of the proposed improvements. The annualized delays provide a basis for comparing the benefits of the proposed changes. The benefits associated with various runway use strategies were also identified.

The fleet mix at Albuquerque International Airport (ABQ) has an weighted-average direct operating cost of $900.00 per hour, or $15.00 per minute. This figure represents the costs for operating the aircraft and includes such items as fuel, maintenance, and crew costs, but it does not consider lost passenger time, disruption to airline schedules, or other intangible factors.

The cost of a particular improvement was measured against its annual delay savings. This comparison indicates which improvement will be the most effective.

For expected increases in demand, a combination of improvements can be implemented to allow airfield capacity to increase while aircraft delays are minimized.

Figure 7. Annual Distribution of Traffic

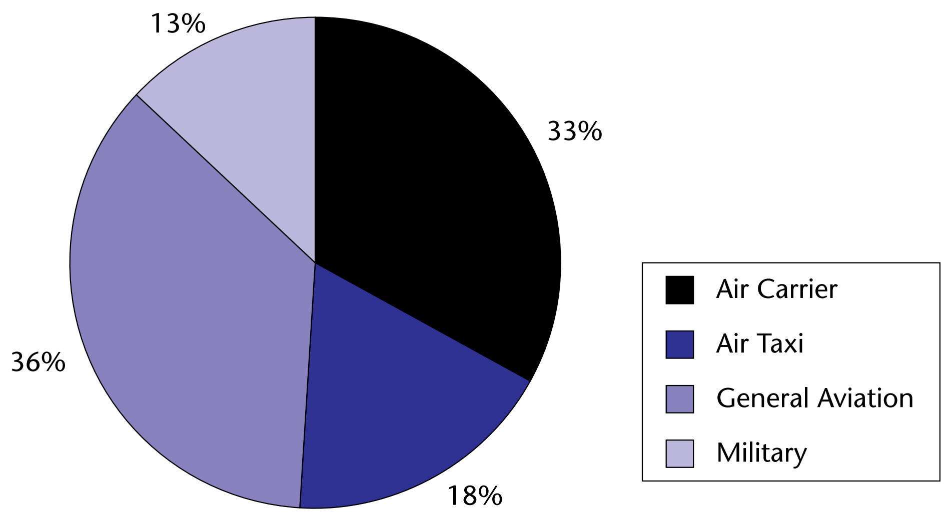


Figure 8. Airfield Weather

Ceiling/Visibility		Occurrence (%)
VFR	1,500 feet and above / 5 mi and above	90.0
IFR 1	200 feet to 1,500 feet / 0.5 to 5 mi	8.0
IFR 2	below 200 feet / below 0.5 mi	2.0
	Total	100.0

VFR – visual flight rules
IFR – instrument flight rules
mi – miles

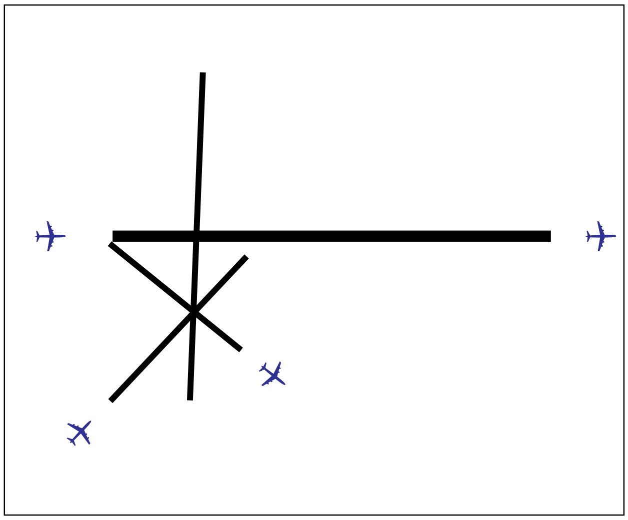
Figure 9. Runway Utilization (percentage use)

	East Flow	West Flow	North Flow	South Flow	Total
VFR	72.0	13.5	2.5	2.0	90.0
IFR 1 (Current)	6.8	0.0	0.4** (0.4)*	0.4**	8.0
IFR 1 (Future)	5.8	1.0	0.8	0.4**	8.0
IFR 2	(2.0)*	0.0	0.0	0.0	2.0
Total	80.8	13.5	3.3	2.4	100.0

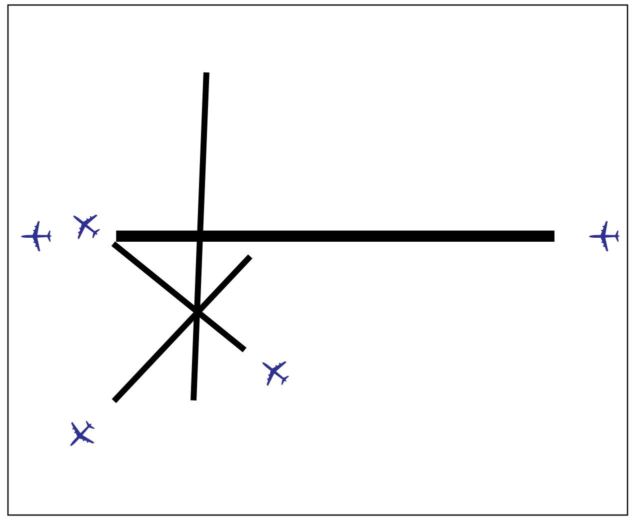
* Not feasible with current NAVAIDs/procedures
** Only NDB available

Figure 10. Runway Configurations

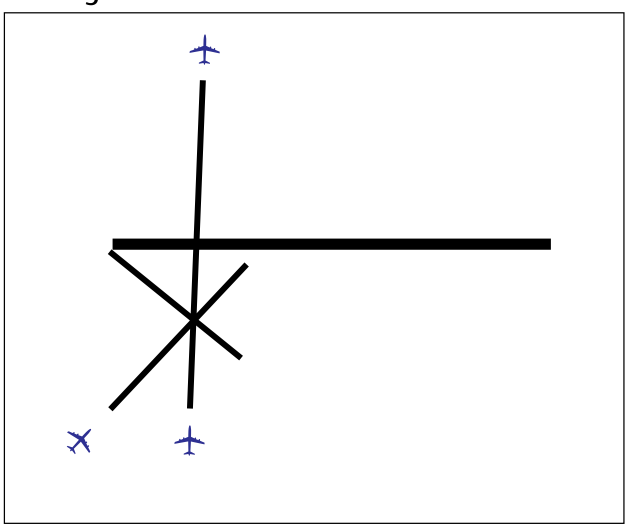
Configuration 1 — East Flow



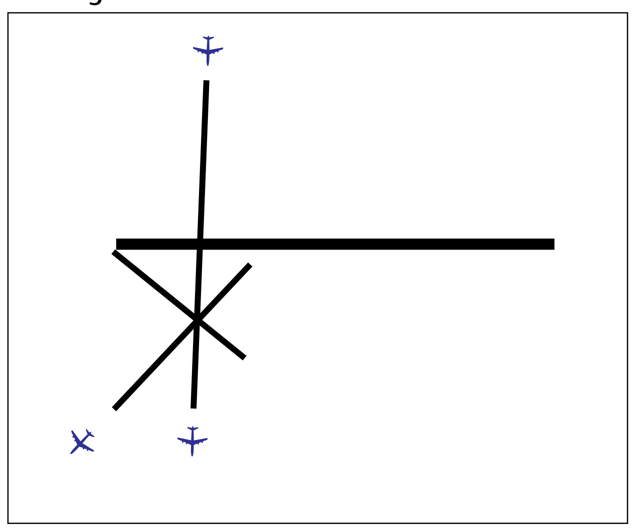
Configuration 2 — West Flow



Configuration 3 — North Flow



Configuration 4 — South Flow



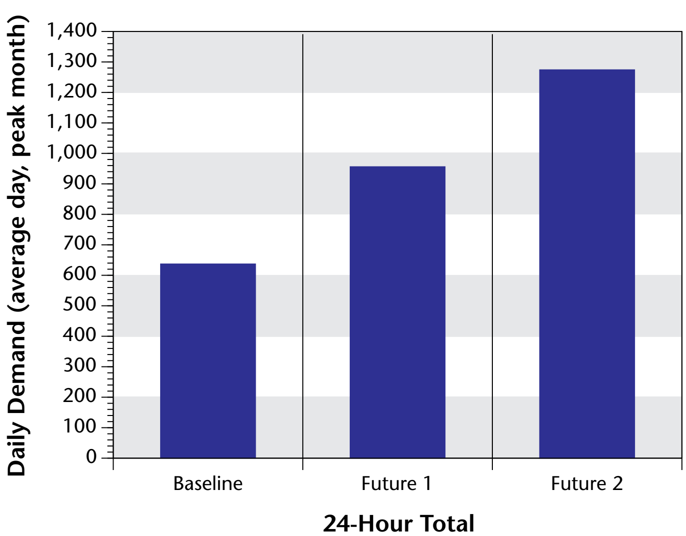
Airfield Capacity

The ABQ Capacity Team defined airfield capacity to be the maximum number of aircraft operations (landings or takeoffs) that can take place in a given time. The following conditions were considered:

- Level of delay
- Airspace constraints
- Ceiling and visibility conditions
- Runway layout and use
- Aircraft mix
- Percent arrival demand

Figure 11 illustrates the average-day, peak-month arrival and departure demand levels for ABQ for each of the three annual activity levels used in the study, Baseline, Future 1, and Future 2.

Figure 11. Airfield Demand Levels



	Annual	24-Hour Day*	Peak Hour
Baseline	202,000	630	48
Future 1	303,000	948	72
Future 2	404,000	1,260	96

* Average Day, Peak Month

Figure 12 presents airport capacity curves for ABQ. The curves were developed for the east flow runway configuration, under both visual flight rules (VFR) and instrument flight rules (IFR), with a 50/50 split of arrivals and departures. These curves are based on the assumption that arrival and departure demand is randomly distributed within the hour. Other patterns of demand can alter the demand/delay relationship.

The curves in Figure 12 illustrate the relationship between airfield capacity, stated in the number of operations per hour, and the average delay per aircraft. They show that, as the number of aircraft operations per hour increases, the average delay per operation increases exponentially.

Figure 13 illustrates the hourly profile of daily demand for the Baseline activity level of 202,000 aircraft operations per year. It also includes a curve that depicts the profile of daily operations for the Future 2 activity level of 404,000 aircraft operations per year.

Comparing the information in Figures 12 and 13 shows that:

- Aircraft delays will begin to escalate rapidly under IFR as hourly demand exceeds 45 operations per hour, and,
- While hourly demand exceeds 45 operations only during the peak hour of the day at Baseline demand levels, 45 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

Figure 14 presents additional airport capacity curves. These curves represent a future runway configuration that includes the extension, widening, and strengthening of Runway 3/21 (alternative 1), improved exits on Runway 8/26 (alternative 2), and installation of an ILS on Runway 3 (alternative 6). Like Figure 12, they illustrate the relationship between airfield capacity and the average delay per aircraft. Again, the curves were developed for an east flow runway configuration, under both VFR and IFR, with a 50/50 split of arrivals and departures.

Figure 12. Airport Capacity Curves — Flow Rate Versus Average Delay — Current Configuration — East Flow

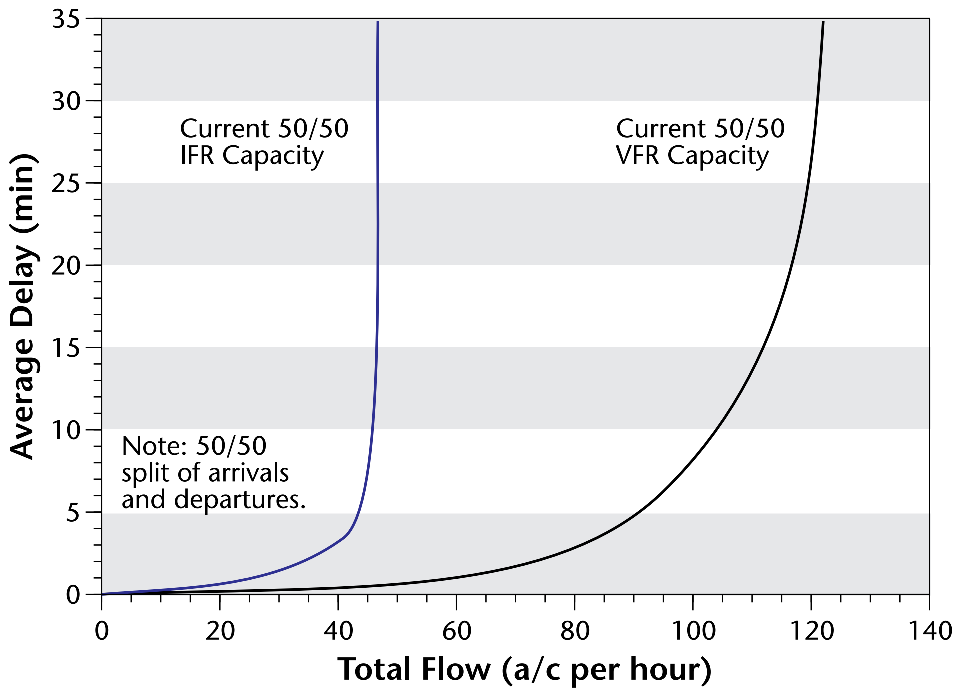


Figure 13. Profile of Daily Demand — Hourly Distribution

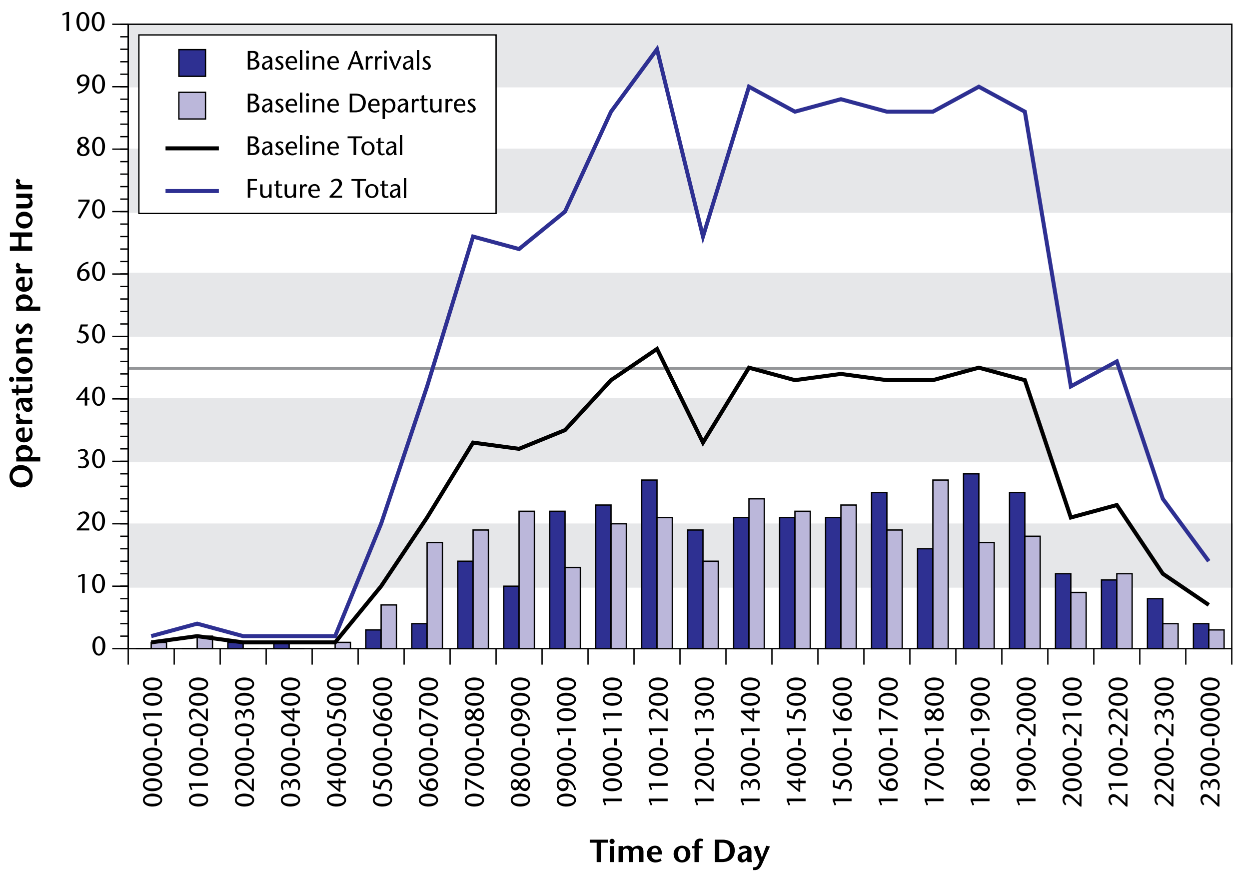
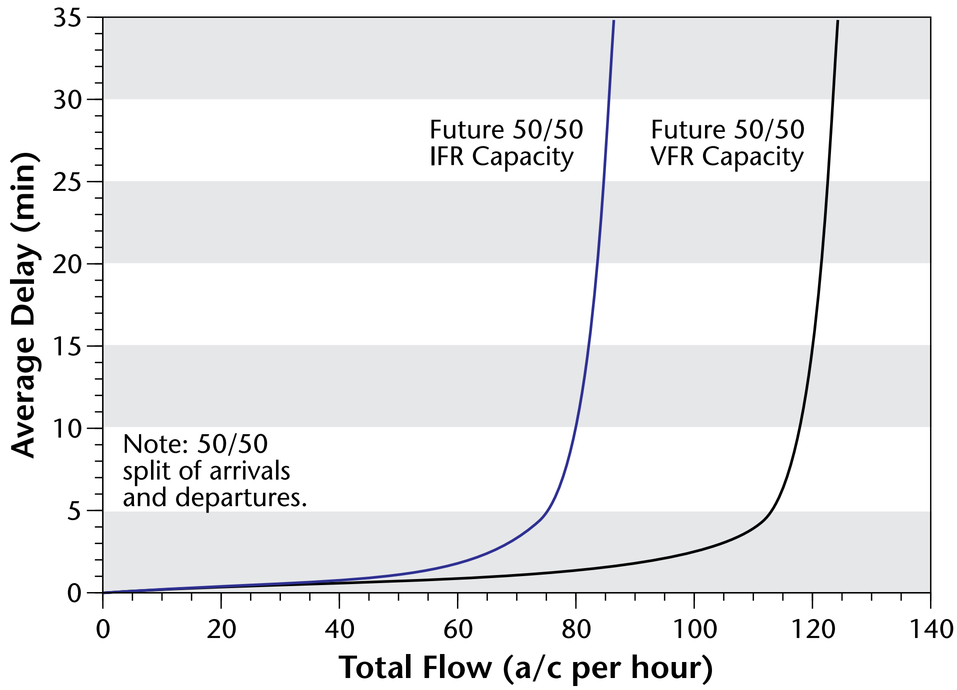


Figure 14. Airport Capacity Curves — Hourly Flow Rate Versus Average Delay — Future Configuration



Aircraft Delays

Aircraft delay is defined as the time above the unimpeded travel time for an aircraft to move from its origin to its destination. Aircraft delay results from interference from other aircraft competing for the use of the same facilities.

The major factors influencing aircraft delays are:

- Weather
- Airfield and ATC system demand
- Airfield physical characteristics
- Air traffic control procedures
- Aircraft operational characteristics

Average delay in minutes per operation was generated by the Airport and Airspace Simulation Model (SIMMOD). A description of this model is included in Appendix B. If no improvements are made in airport capacity, the average delay per operation of 2.9 minutes in Baseline will increase to 22.5 minutes per operation by Future 2.

Under the Do Nothing situation, if there are no improvements in airfield capacity, the annual delay cost could increase as follows:

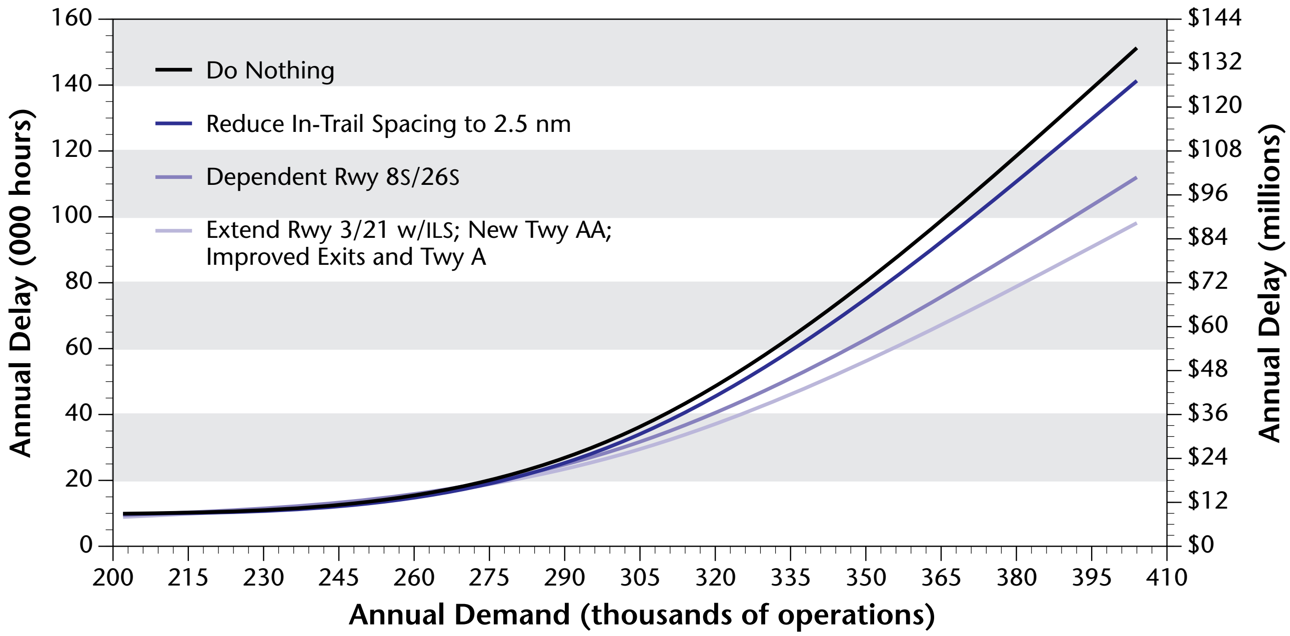
	Hours	Annual Delay Costs Millions of 1992 $
Baseline	9,900	$8.91
Future 1	34,870	$31.39
Future 2	151,290	$136.16

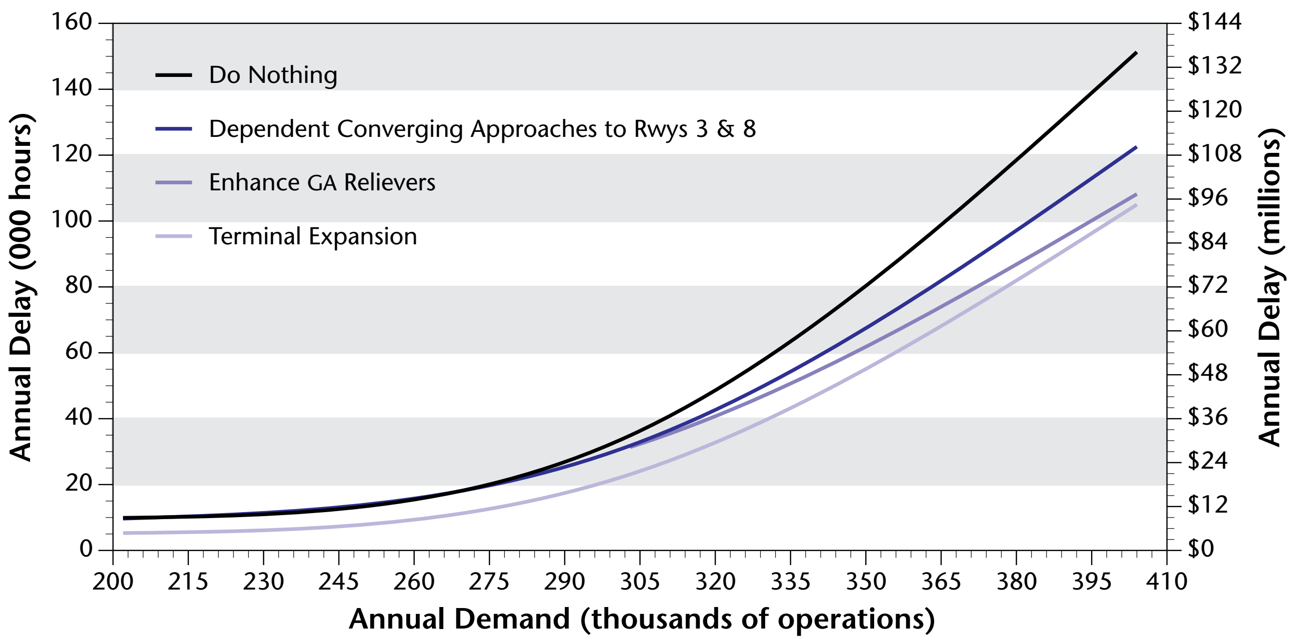
Conclusions

Figure 15 demonstrates the impact of delays at Albuquerque International Airport. The chart shows how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the Do Nothing scenario. The graphs also show that the greatest savings in delay costs would be provided by:

- Extending Runway 3/21 and operating as air carrier runway; installing instrument landing system on Runway 3; and constructing new and improving existing taxiways and exits (combines alternatives 1, 2, and 6)
- Terminal expansion (10 additional air carrier gates)
- Enhancing general aviation (GA) reliever airports
- Constructing parallel air carrier runway south of Runway 8/26; operating as a dependent IFR runway
- Implementing dependent converging approaches with ILS
- Reducing in-trail separations to 2.5 nm from 3 nm in IFR

Figure 15. Annual Delay Costs — Capacity Enhancement Alternatives





Appendix A Participants

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Appendix B Computer Models and Methodology

The Albuquerque Capacity Team studied the effects of various improvements proposed to reduce delay and enhance capacity. The options were evaluated considering the anticipated increase in demand. The analysis was performed using two computer modeling techniques. A brief description of the models and the methodology employed follows.

Computer Models

Runway Delay Simulation Model (RDSIM)

RDSIM is a short version of the Airfield Delay Simulation Model (ADSIM). ADSIM is a fast-time, discrete event model that employs stochastic processes and Monte Carlo sampling techniques and describes significant movements of aircraft on the airport and the effects of delay in the adjacent airspace. ADSIM was validated in 1978 at Chicago O'Hare International Airport against actual flow rates and delay data.

RDSIM, on the other hand, simulates only the runways and runway exits. There are two versions of the model. The first version ignores the taxiway and gate complexes for a user-specified daily traffic demand and is used to calculate daily demand statistics. In this mode, the model replicated each experiment fifty times, using Monte Carlo sampling techniques to introduce daily variability of results, which were averaged to produce output statistics. The second version also simulates the runway and runway exits only, but it creates its own demand using randomly assigned arrival and departure times. The demand created is based upon user-specified parameters. This form of the model is suitable for capacity analysis.

For this study, RDSIM was calibrated against field data collected at ABQ to insure that the model was site specific. For a given demand, the model calculated the hourly flow rate and average delay per aircraft during the full period of airport operations. Using the same aircraft mix, computer specialists simulated different demand levels for each run to generate demand versus delay relationships.

Airport and Airspace Simulation Model (SIMMOD)

SIMMOD is a fast-time, event-step model that simulates the real-world process by which aircraft fly through air traffic controlled en route and terminal airspace and arrive and depart at airports. SIMMOD traces the movement of individual aircraft as they travel through the gate, taxiway, runway, and airspace system and detects potential violations of separations and operation procedures. It simulates the air traffic control actions required to resolve potential conflicts to insure that aircraft operate within procedural rules. Aircraft travel time, delay, and traffic statistics are computed and provided as model outputs. The model was calibrated for this study against field data collected at ABQ to ensure it was site specific. Inputs for the simulation model were also derived from empirical field data. The model repeated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability. The results were then average to produce output statistics.

Methodology

Model simulations included present and future air traffic control procedures, various airfield improvements, and traffic demands for different times. To assess the benefits of proposed airfield improvements, different airfield configurations were derived from present and projected airport layouts. The projected implementation time for air traffic control procedures and system improvements determined the aircraft separations used for IFR and VFR weather simulations.

For the delay analysis, agency specialists developed traffic demands based on the *Official Airline Guide*, historical data, and various forecasts. Aircraft volume, mix and peaking characteristics were developed for three demand periods, Baseline, Future 1, and Future 2. The estimated annual delays for the proposed improvement options were calculated from the experimental results. These estimates took into account the yearly variations in runway configurations, weather, and demand based on historical data.

The potential delay reductions for each improvement were assessed by comparing the annual delay estimates with the Do Nothing case.

Appendix C List of Abbreviations

ABQ	Albuquerque International Airport
ADSIM	Airfield Delay Simulation Model
ATC	Air Traffic Control
CAT	Category
CRDA	Converging Runway Display Aid
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
FOD	Foreign Object Damage
GA	General Aviation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LOC	Localizer
MI	Miles
MLS	Microwave Landing System
NAVAID	Navigation Aid — air navigation facility
NDB	Non-directional Radio Beacon
NM	Nautical Miles
OM	Outer Marker
PRM	Precision Runway Monitor
RDSIM	Runway Delay Simulation Model
SIMMOD	Airport and Airspace Simulation Model
TERPS	Terminal Instrument Procedures
TVOR	Terminal VOR
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range — course information only

Credits:

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