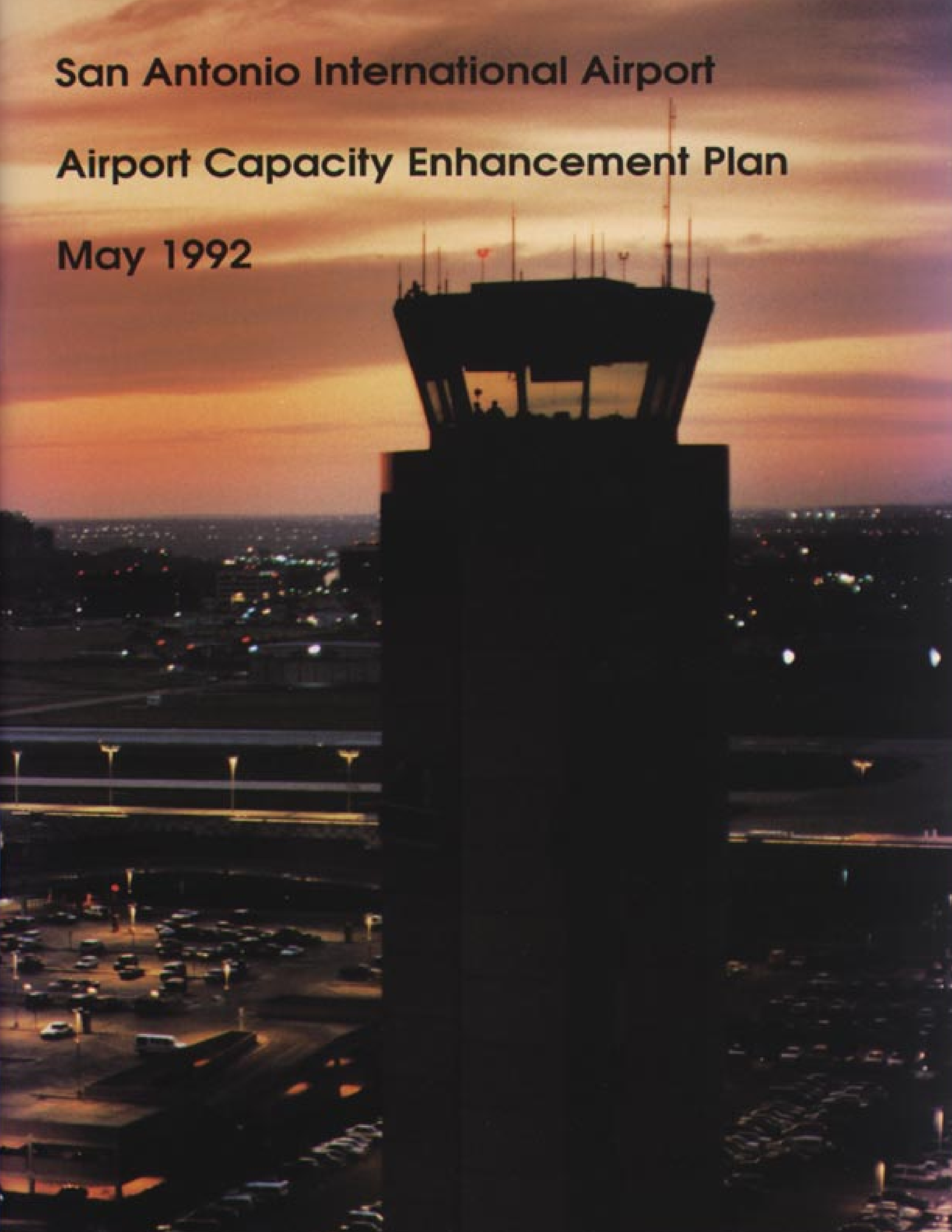
San Antonio International Airport

Airport Capacity Enhancement Plan

May 1992



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Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, the City of San Antonio, Department of Aviation, the airlines and general aviation interests serving San Antonio, and the military.

Preface

An Airport Capacity Design Team was formed to study the present and future capacity requirements at the San Antonio International Airport. The Capacity Team evaluated the airport using several growth scenarios and determined a list of capacity enhancement alternatives.

There are several trends that will likely affect the overall capacity of San Antonio's airspace. Some will directly impact civilian air transportation demand, and others, merely the use of the airspace.

First, the Defense Department's recent budget reductions may continue and could affect military aircraft operations in the San Antonio International airspace. Because this would change airspace capacity, the follow-on FAA airspace study will address scenarios which deal with this possibility.

Second, efforts to implement mass transit are gaining momentum nationally. In Texas, work continues on an agreed upon proposal for a high-speed rail system connecting San Antonio, Dallas-Fort Worth, and Houston. With the extremely high number of air travelers having these cities as their ultimate destination, the impact of high-speed rail will need additional study. Any prospective changes to the airport development plan should also be coordinated with other public works projects in the area, including the Texas Highway Department's proposed Wurzback Parkway.

Finally, the airline industry has yet to stabilize since it was deregulated 14 years ago. The current trend to fewer but larger carriers or some new approach in the market place may well affect the needs of San Antonio.

Figure 1 San Antonio International Airport

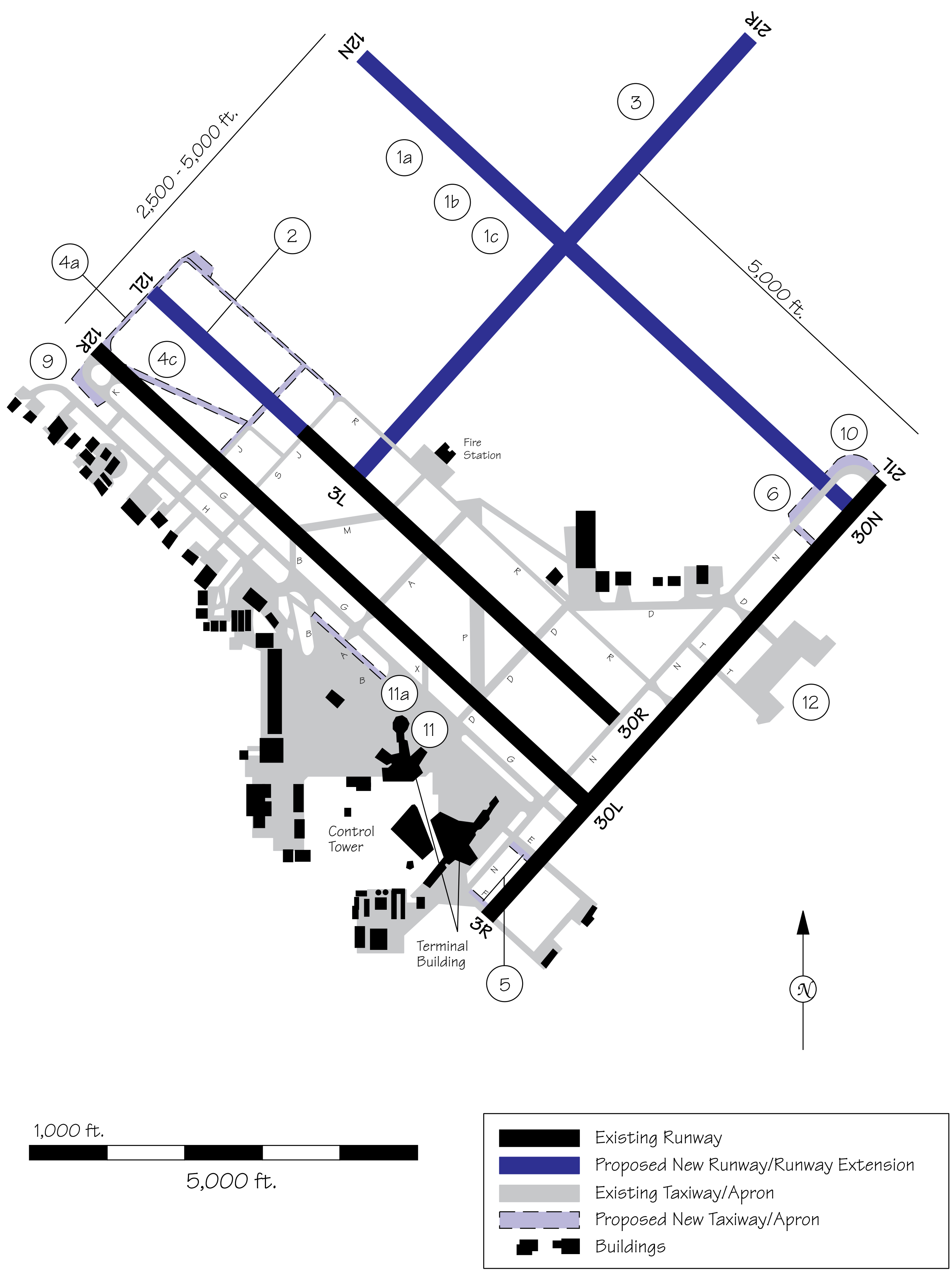

Figure 2 Capacity Enhancement Alternatives and Annual Delay Savings

Alternatives	Estimated Annual Delay Savings* (in hours and millions of 1992 dollars) Baseline (204,000)	Future 1 (300,000)	Future 2 (433,000)
Airfield Improvements			
1. Construct new Rwy 12N/30N NE of Rwy 12R/30L	—	—	—
1a. Construct dependent air carrier length Rwy 12N/30N	1,960/$2.35	14,250/$17.12	254,560/$306.23
1b. Construct independent air carrier length Rwy 12N/30N	2,060/$2.47	14,780/$17.74	266,430/$322.86
1c. Construct independent regional air carrier/ general aviation (GA) Rwy 12N/30N	1,980/$2.36	13,500/$16.20	253,630/$304.34
2. Extend Rwy 12L/30R to air carrier length and operate without restrictions	1,480/$1.78	13,580/$16.31	202,340/$242.81
2a. Extend Rwy 12L/30R and operate with restrictions	950/$1.15	8,910/$10.69	111,690/$133.77
3 Construct independent air carrier Rwy 3L/21R	390/$0.47	5,610/$6.73	115,150/$138.18
4. Construct new and improve existing taxiway system to extended Rwy 12L/30R	340/$0.41	2,240/$2.69	87,040/$104.45
4a. Widen and strengthen Twy K and extend to Twy R			
4b. Improve Twys M and P and part of Twy N near end of Rwy 30L			
4c. Construct new diagonal Twy J1 near approach end of Rwy 12R			
5. Widen Twy F and Twy E west to ramp at end of Rwy 3		†	
6. Construct new Twy N1 at end of Rwy 21		†	
7. Construct new or improve existing taxiway system to new Rwy 12N/30N	450/$0.53	2,920/$3.50	64,380/$77.25
8. Provide shoulders for Twy G to accommodate four-engine and wide-bodied jets		†	
9. Construct bypass areas at departure ends of Rwys 12R, 3, and 30L		†	
10. Construct holding pads at departure end of Rwy 21		†	
11. Expand Terminal to 60 gates	240/$0.29	1,230/$1.48	21,430/$25.71
11a. Construct Twy H1 to support terminal expansion		(benefits included in alternative 11)	
12. Expand east cargo ramp		†	
13. Construct arrival holding areas		†	
14. Improve exit turnoffs for existing runways	80/$0.10	1,370/$1.65	23,340/$28.01
15. Provide stabilized shoulders for Rwy 12R/30L		†	

Alternatives	Estimated Annual Delay Savings* (in hours and millions of 1992 dollars) Baseline (204,000)	Future 1 (300,000)	Future 2 (433,000)
Facilities and Equipment Improvements			
16. Install doppler radar for wind shear detection		†	
17. Install Precision Runway Monitor (PRM)	710/$0.85	1,450/$1.74	15,070/$18.08
18. Install Airport Surface Detection Equipment (ASDE)		†	
19. Upgrade ILS on Rwy 12R to CAT IIIB		†	
20. Install CAT II/III ILS on Rwy 12N and CAT I ILS on Rwy 30N with associated approach light system (ALS)	50/$0.06	400/$0.50	9,600/$11.50
21. Install CAT I ILS on extended Rwy 12L/30R with associated ALS	80/$0.09	470/$0.57	30,290/$36.35
22. Install Microwave Landing System (MLS) on Rwy 21		†	
23. Install Localizer Directional Aid (LDA) on Rwy 12L/30R	540/$0.65	6,020/$7.22	104,090/$124.91
24. Install multiple Runway Visual Range (RVR) on Rwy 3	10/$0.01	80/$0.09	4,090/$4.90
Operational Improvements			
25. Reduce in-trail arrival separations to 2.5 miles	110/$0.14	1,410/$1.70	32,710/$39.25
26. IFR dependent approaches to Runways 12R and 21	80/$0.10	580/$0.70	23,800/$28.58
27. Segregate traffic on runways	—	—	—
27a. Segregate by aircraft type	(470/$0.57)	(10,930/$13.12)	(85,820/$102.97)
27b. Segregate by arrivals and departures	(630/$0.76)	(16,780/$20.14)	(142,580/$171.11)
28. Install Wake Vortex Advisory System (WVAS) (existing configuration)	230/$0.28	2,490/$2.99	60,370/$72.34
28a. Install WVAS (with Rwy 12L/30R extension)	270/$0.32	2,280/$2.74	24,370/$29.24
29. Relocate general aviation (GA)/fixed base operator (FBO) areas to NW side of Rwy 12L	80/$0.09	1,040/$1.25	52,420/$62.90
30. Relocate non-air carrier operations	—	—	—
30a. Relocate 25% of non-air carrier operations	710/$0.85	9,360/$11.23	119,490/$143.39
30b. Relocate 50% of non-air carrier operations	1,340/$1.61	14,570/$17.48	237,440/$284.93
31. Distribute traffic more uniformly	200/$0.24	1,210/$1.45	16,150/$19.38
32. Conduct an airspace capacity design project and re-structure San Antonio area airspace		†	
33. New commercial airport planning		†	

* 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, the U.S. military and aviation industry groups have initiated 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 San Antonio International Airport (SAT) was formed in 1991.

SAT has remained one of the busier airports in the country. Activity has increased from 1,867,000 passenger enplanements in 1983 to 2,606,403 in 1991. In 1991, the airport handled 209,052 aircraft operations (takeoffs and landings).

The SAT Capacity Team identified and assessed various actions which, if implemented, would increase SAT'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. The Capacity Team's effort was limited in scope and focused only on the relative merits of airport improvements; therefore, additional studies are needed to assess environmental, socioeconomic, and political issues associated with these alternatives. In order to adequately assess the facilities that must be in place to meet San Antonio's future aviation demand, this study will be followed by three studies, an FAA Airspace Study, San Antonio Master Plan Update, and Environmental Assessment.

This study assumes that the regional airspace has the capacity to deliver and receive aircraft to and from SAT as fast as the airport can accept and dispatch them. Since SAT's regional airspace is very complex, airspace capacity is limited and warrants a separate FAA airspace capacity design study.

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 — 204,000 operations;
Future 1 — 300,000 operations; and
Future 2 — 433,000 operations.

If no improvements are made at SAT (the Do Nothing scenario), the annual delay costs will increase from 3,970 hours or $4.76 million at the Baseline level of operations to 377,300 hours or $452.76 million by Future 2. Average delay per operation would increase from 1.2 minutes at Baseline to 52.3 minutes per operation in Future 2.

Figure 3 **Airport Capacity Curve — Hourly Flow Rate vs. Average Delay — IFR Conditions**

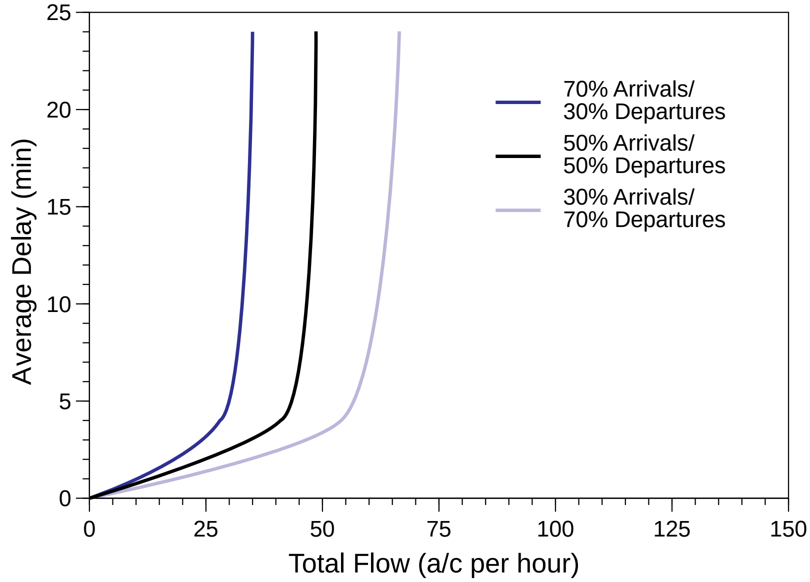

Figure 4 **Profile of Daily Demand — Hourly Distribution**

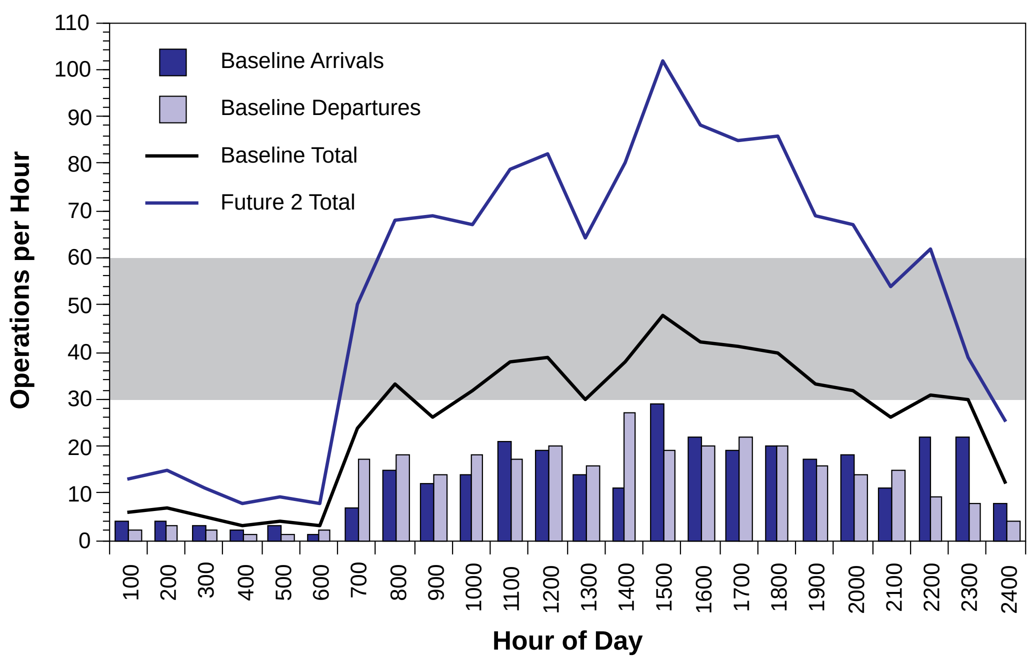

Figure 3 illustrates the capacity and delay curves for the current airfield configuration at SAT under instrument flight rules (IFR) conditions. It shows that aircraft delays will begin to escalate rapidly as hourly demand exceeds 30 operations per hour. Figure 4 shows that, while hourly demand exceeds 30-60 operations during certain hours of the day at Baseline demand levels, 30-60 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

Figure 5 Annual Delay Costs — Capacity Enhancement Alternatives

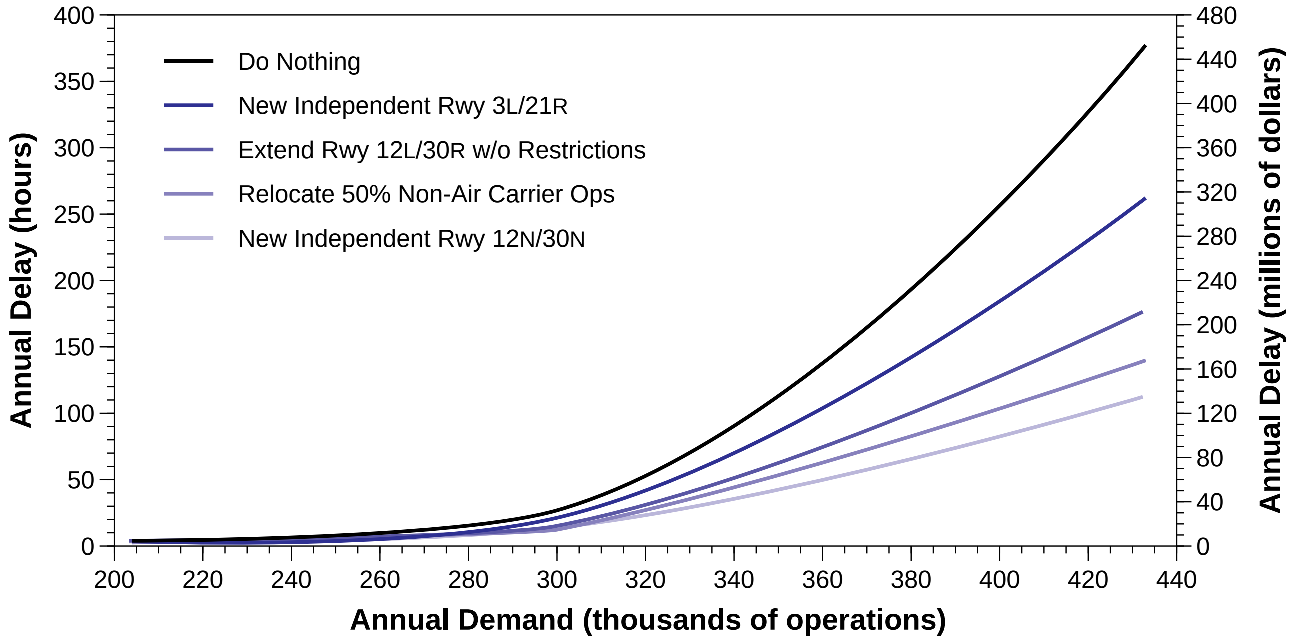

Figure 5 illustrates how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the Do Nothing scenario. Annual delay costs will increase from 3,970 hours or \$4.76 million at the Baseline level of operations to 377,300 hours or \$452.76 million by Future 2. The graph also shows that the greatest savings in delay costs would be provided by:

- Constructing independent air carrier length Runway 12N/30N northeast of Runway 12L/30R
- Relocating 50 percent of non-air carrier operations
- Extending Runway 12L/30R to air carrier length and operating without restrictions
- Constructing independent air carrier Runway 3L/21R

This study focuses only on the relative merits of airport improvements. To address environmental, fiscal, and political issues, this Capacity Enhancement Plan will be followed by an FAA Airspace Study, a San Antonio Master Plan Update, and an Environmental Assessment.

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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 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.

Passenger enplanements at San Antonio International Airport (SAT) rose from 1,867,000 in 1983 to 2,606,403 in 1991. Total aircraft operations reached 209,052.

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 204,000 aircraft operations (takeoffs and landings) was established for the base year of the study. Two future traffic levels, Future 1 and Future 2, were established at 300,000 and 433,000 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at San Antonio. If no improvements are made at SAT, annual delay levels and delay costs are expected to increase from an estimated 3,970 hours and $4.76 million at the Baseline activity level to nearly 377,300 hours and $452.76 million by the Future 2 demand level. Average delay per operation would increase from 1.2 minutes at Baseline to 52.3 minutes per operation in Future 2.

The Capacity Team studied various proposals with the potential for increasing capacity and reducing delays at SAT. The improvements evaluated as a part of the Capacity Team's efforts are delineated in Figure 2 and described in some detail in Section 2 — Capacity Enhancement Alternatives.

Objectives

The major goal of the Capacity Team at SAT was to develop an action plan of options 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 San Antonio International Airport Capacity Team limited its analyses to aircraft activity at SAT only and did not take into account the effect of any such improvements on activities at other adjacent airports or on the surrounding airspace. 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. This Capacity Team study assumes that the regional airspace has the capacity to deliver and receive aircraft to and from SAT as fast as the airport can accept and dispatch them. Since SAT's regional airspace is very complex, airspace capacity is limited and warrants a separate FAA airspace capacity design study.

Methodology

The Capacity Team developed a list of suggested improvements and 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 SAT. Proposed improvements were analyzed in relation to current and future demands with the help of two computer models, the Airfield Delay Simulation Model (ADSIM) and the Runway Delay Simulation Model (RDSIM). Appendix B briefly explains the two 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 visual flight rules (VFR) and instrument flight rules (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 list of alternatives for consideration, which is shown in Figure 6.

Figure 6 Capacity Enhancement Alternatives and Recommended Action

Alternatives Airfield Improvements	Action	Time Frame
1. Construct new Runway 12N/30N northeast of Runway 12R/30L	Recommended	Future 1
1a. Construct independent air carrier length Runway 12N/30N		
1b. Construct dependent air carrier length Runway 12N/30N		
1c. Construct independent regional air carrier/ general aviation (GA) Runway 12N/30N		
2. Extend Runway 12L/30R to air carrier length and operate without restrictions	Recommended	Baseline
2a. Extend Runway 12L/30R and operate with restrictions	Not Recommended	
3. Construct independent air carrier Runway 3L/21R	Study	
4. Construct new and improve existing taxiway system to extended Rwy 12L/30R		
4a. Widen and strengthen Taxiway K and extend to Taxiway R	Recommended	Baseline
4b. Improve Taxiways M and P and part of Taxiway N near end of Runway 30L	Recommended	Baseline
4c. Construct new diagonal Taxiway J1 near approach end of Runway 12R	Recommended	Baseline
5. Widen Taxiway F and Taxiway E west to ramp at end of Runway 3	Recommended	Baseline
6. Construct new Taxiway N1 at end of Runway 21	Recommended	Baseline
7. Construct new or improve existing taxiway system to new Runway 12N/30N and extended Runway 12L/30R	Recommended	Baseline
8. Provide shoulders for Taxiway G to accommodate four-engine jets	Recommended	Baseline
9. Construct bypass areas at departure ends of Runways 12R, 3, and 30L	Recommended	Baseline
10. Construct holding pads at departure end of Runway 21	Recommended	Baseline
11. Expand Terminal to 60 gates	Recommended	Future 1–Future 2
11a. Construct Taxiway H1 to support terminal expansion		
12. Expand east cargo ramp	Recommended	Future 1–Future 2
13. Construct arrival holding areas	Recommended	Future 1–Future 2
14. Improve exit turnoffs for existing runways	Recommended	Baseline
15. Provide stabilized shoulders for Runway 12R/30L	Recommended	Baseline

Alternatives	Action	Time Frame
Facilities and Equipment Improvements		
16. Install doppler radar for wind shear detection	Recommended	Baseline
17. Install Precision Runway Monitor (PRM)	Study	
18. Install Airport Surface Detection Equipment (ASDE)	Recommended	Baseline
19. Upgrade ILS on Runway 12R to Category IIIB	Recommended	Baseline
20. Install Category II/III ILS on Runway 12N and Category I ILS on Runway 30N with associated approach light system (ALS)	Recommended	Future 1
21. Install Category I ILS on extended Runway 12L/30R with associated ALS	Recommended	Baseline
22. Install Microwave Landing System (MLS) on Runway 21	Study	
23. Install Localizer Directional Aid (LDA) on Runway 12L/30R	Recommended	Baseline
24. Install multiple Runway Visual Range (RVR) on Runway 3	Recommended	Baseline
Operational Improvements		
25. Reduce in-trail arrival separations to 2.5 miles	Study	
26. IFR dependent approaches to Runways 12R and 21	Recommended	
27. Segregate traffic on runways 27a. Segregate by aircraft type 27b. Segregate by arrivals and departures	Not Recommended	
28. Install Wake Vortex Advisory System (WVAS) (existing configuration)	Recommended	Baseline–Future 1
28a. Install WVAS (with Runway 12L/30R extension)	Recommended	Baseline–Future 1
29. Relocate general aviation (GA)/fixed base operator (FBO) areas to northwest side of Runway 12L	Study	
30. Relocate non-air carrier operations 30a. Relocate 25 % of non-air carrier operations 30b. Relocate 50% of non-air carrier operations	Study	
31. Distribute traffic more uniformly	Not Recommended	
32. Conduct an airspace capacity design project and re-structure San Antonio area airspace	Study	
33. New commercial airport planning	Study	

* The term "Recommended" means that an alternative should be advanced to the next stage in the development process.

** The term "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.

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 204,000, 300,000, and 433,000 respectively. The 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.

These capacity enhancement alternatives are categorized and discussed in more detail under the following headings:

- Airfield Improvements
- Facilities and Equipment Improvements
- Operational Improvements

Airfield Improvements

1. Construct new Runway 12N/30N northeast of Runway 12R/30L.

1a. Construct dependent air carrier length Runway 12N/30N.

Currently, if parallel runway centerlines are less than 4,300 feet apart, the runways are considered dependent under Instrument Flight Rules (IFR), and aircraft on approach to the two runways must be staggered. New technology may allow reduction of the separation requirement, possibly down to 3,000 to 3,400 feet (see alternative 17).

Estimated 1992 project development cost is $8.675 million, plus land costs.

Annual savings at the Baseline activity level for a new parallel runway that would permit dependent approaches under IFR conditions would be 1,960 hours or $2.35 million, and, at Future 2 activity levels, 254,560 hours or $306.23 million.

1b. Construct independent air carrier length Runway 12N/30N.

The exact lateral separation needed to permit closely spaced independent IFR arrival streams is under evaluation by the FAA. Currently, this requires 4,300 feet of separation between parallel runway centerlines. A developmental program known as the Precision Runway Monitor (PRM) has demonstrated the potential for reducing the required runway spacing down to 3,000 to 3,400 feet (see alternative 17).

Estimated 1992 project cost is $14.39 million, plus land costs.

For a new parallel runway that would permit independent IFR approaches, annual savings at the Baseline activity level would be 2,060 hours or $2.47 million, and, at Future 2 activity levels, 266,430 hours or $322.86 million.

1c. Construct independent regional air carrier/general aviation (GA) Runway 12N/30N.

This regional air carrier/GA runway would need to be at minimum of 6,500 feet in length and 100 feet in width.

Estimated 1992 project cost is $7.8 million.

Annual savings at the Baseline activity level would be 1,980 hours or $2.38 million, and, at Future 2 activity levels, 253,630 hours or $304.34 million.

2. Extend Runway 12L/30R to air carrier length and operate without restrictions.

Existing rules require that the separation between parallel runways be at least 2,500 feet to permit dependent staggered IFR operations. At SAT, the distance between the centerlines of Runways 12L/30R and 12R/30L is less than 1,000 feet.

Current restrictions preclude jet departures on Runway 12L and arrivals on Runway 30R. Space is minimal for expansion of this runway, due to the proximity of U.S. Highway 281 and Runway 3/21.

Estimated 1992 project cost is $2.33 million.

Annual savings at the Baseline activity level would be 1,480 hours or $1.78 million, and, at Future 2 activity levels, 202,340 hours or $242.81 million.

2a. Extend Runway 12L/30R and operate with restrictions.

Current restrictions limit jet aircraft operations to departures on Runway 12L and arrivals on Runway 30R. Under restricted use, annual savings for extending Runway 12L/30R would be 950 hours or $1.15 million at the Baseline activity level, and, at Future 2 activity levels, 111,690 hours or $133.77 million.

3. Construct independent air carrier Runway 3L/21R.

Construction of a new air carrier runway, parallel to and separated by approximately 5,000 feet from Runway 3R/21L, would allow independent operations during all weather conditions.

Although this addition would allow independent IFR approaches, wind conditions would limit its use. This project would be constrained by obstructions in the flight paths, future terminal development plans, and U.S. Highway 281 and Interstate 410. In addition, the adoption of this alternative would have a significant impact on adjacent military and civilian airports.

Estimated 1992 project cost is $7.425 million, plus land costs.

Annual savings at the Baseline activity level would be 390 hours or $0.47 million, and, at Future 2 activity levels, 115,150 hours or $138.18 million.

4. Construct new and improve existing taxiway system to extended Runway 12L/30R.

Annual savings at the Baseline activity level would be 340 hours or $0.41 million, and, at Future 2 activity levels, 87,040 hours or $104.45 million.

4a. Widen and strengthen Taxiway K and extend to Taxiway R.

Widening and strengthening Taxiway K and extending it to (the extended) Taxiway R would reduce runway occupancy times by improving ground circulation. This project would be most beneficial in conjunction with the extension of Runway 12L/30R. It will be required to provide taxiway access to new runways developed in the future and will provide alternate taxiway capability to expedite aircraft to and from the runway systems.

Estimated 1992 project cost is $1.1 million.

4b. Improve Taxiways M and P and the portion of Taxiway N near the approach end of Runway 30L.

Improving Taxiways M and P with air carrier strength and turnoff capability would be required to provide access to a newly extended air carrier Runway 12L/30R. Widening Taxiway N near the departure end of Runway 30L would reduce departure delays for taxiing aircraft when that runway is in use.

Estimated 1992 project cost is $0.725 million.

4c. Construct new diagonal Taxiway J1 near the approach end of Runway 12R.

This project will reduce runway occupancy times.

Estimated 1992 project cost is $1.31 million, plus lights.

5. Widen Taxiway F and Taxiway E west to ramp at end of Runway 3.

This project will provide bypass capability for taxiing aircraft when Runway 3 is being used and thereby substantially reduce ground delays.

Estimated 1992 project cost is $0.96 million.

6. Construct new Taxiway N1 at the end of Runway 21.

Widening the north end of Taxiway N will provide bypass capability for departing aircraft when Runway 21 is being used and thereby reduce departure delays. An additional taxiway entrance to Runway 21 from Taxiway N, within 400 feet of the the approach end of Runway 21, will also provide bypass capability and reduce departure delays.

Estimated 1992 project cost is $0.18 million.

7. Construct new or improve existing taxiway system to new Runway 12N/30N and extended Runway 12L/30R.

This project is required to provide departure and arrival access to the taxiway systems and reduce ground delays.

Estimated 1992 project cost is $11.6 million.

Annual savings at the Baseline activity level would be 450 hours or $0.53 million, and, at Future 2 activity levels, 64,380 hours or $77.25 million.

8. Provide shoulders for Taxiway G to accommodate four-engine and wide-bodied jets.

This project would reduce the potential for ingesting debris into the engines of large aircraft, provide takeoff and landing flexibility, reduce taxi delays, and reduce taxiway closures due to maintenance, thereby reducing maintenance costs, signage, and light repair and replacement.

Estimated 1992 project cost is $0.28 million.

9. Construct bypass areas at departure ends of Runways 12R and 12L.

Air traffic flow control often dictates that aircraft hold at the runway thresholds before take-off because of departure restrictions and departure and arrival spacing requirements. Expanding the staging areas, by creating bypass areas at the ends of the runways would improve the abilities of departing aircraft to bypass those aircraft waiting for departure clearance or release.

Estimated 1992 project cost is $0.33 million.

10. Construct holding pads at approach end of Runway 21.

Again, expanding the staging areas (holding pads) at the ends of the runways would improve the abilities of departing aircraft to bypass those aircraft waiting for departure clearance.

Estimated 1992 project cost is $0.20 million.

11. Expand Terminal to 60 gates.

Expansion of the Terminal would provide the additional gates needed to accommodate the expected growth in air traffic at SAT.

Estimated 1992 project cost is $15 to 20 million.

Annual savings at the Baseline activity level would be 240 hours or $0.29 million, and, at Future 2 activity levels, 21,430 hours or $25.71 million.

11a. Construct new Taxiway H1 to support terminal expansion.

Construction of Taxiway H1 to air carrier strength will provide bypass capability for aircraft using Taxiway G when either Runway 12R or 30L is being served and thereby reduce ground delays.

Estimated 1992 project cost is $1.975 million, plus lights.

12. Expand east cargo ramp.

Under this project, approximately 110,000 square yards of aircraft parking apron and 60,000 square feet of warehouse and office space would be constructed, doubling the available air cargo facilities. This would enable all air freight and package express carriers to operate from this one facility and thus separate cargo and passenger aircraft ground traffic.

Estimated 1992 project cost is $9.125 million.

13. Construct arrival holding areas.

Construction of a holding area for arriving aircraft that must wait for gate space to become available would relieve congestion near the terminal area and permit more efficient taxiway and ramp utilization. Depending on traffic and runway flows, the availability of space could be limited after the expansion of the terminal to 60 gates (alternative 11).

Estimated 1992 project cost is $0.15 million.

14. Improve exit turnoffs for existing runways.

Adding improved exits would reduce runway occupancy time and increase individual runway capacity.

Estimated 1992 project cost is $0.49 million for improving existing turnoffs and $0.72 million for four new turnoffs.

Annual savings at the Baseline activity level would be 80 hours or $0.10 million, and, at Future 2 activity levels, 23,340 hours or $28.01 million.

15. Provide stabilized shoulders for Runway 12R/30L.

This project would reduce the potential for ingesting debris into the engines of large aircraft, provide takeoff and landing flexibility, reduce taxi delays, and reduce runway closures due to maintenance, thereby reducing maintenance costs, signage, and light repair and replacement.

Estimated 1992 project cost is $0.11 million.

Facilities and Equipment Improvements

16. Install doppler radar for wind shear detection.

The capability of doppler radar to detect wind shear and support wind shear advisories to pilots would provide an additional safety margin for pilots during severe weather or wind conditions. Delays could possibly be reduced, but to what extent is not known due to the variety of factors involved.

Estimated 1992 project cost is $1.2 million.

17. Install Precision Runway Monitor (PRM).

The most beneficial capacity enhancement alternative at SAT would be the addition of a new air carrier runway that permits independent parallel approaches in all weather conditions. Currently, this requires 4,300 feet of separation between parallel runway centerlines.

A developmental program known as the Precision Runway Monitor (PRM) has demonstrated the potential for reducing required runway spacing to 3,000 to 3,400 feet. This program relies on improved radar surveillance with higher update rates and new air traffic controller display systems.

Due to a variety of land constraints, reducing the required 4,300 foot separation between parallel runway centerlines with the installation of a PRM would provide several options for consideration in constructing an independent parallel runway and significantly reduce the associated costs. The ability to construct closely spaced parallel runways would reduce siting costs.

Annual savings at the Baseline activity level would be 710 hours or $0.85 million, and, at the Future 2 activity levels, 15,070 hours or $18.08 million.

18. Install Airport Surface Detection Equipment (ASDE).

Monitoring ground traffic flow during poor weather conditions is difficult and restricts the flow of aircraft to and from the runways and ramps. ASDE is a short-range high-resolution radar designed to support air traffic controllers in the monitoring and control of ground traffic. ASDE would eliminate the need to rely totally on pilot position reports when aircraft are not visible from the tower and would provide the ability to independently monitor movement of aircraft on the ground in all weather conditions. It would enable air traffic controllers to verify aircraft positions, provide definitive control instructions to guide aircraft to and from runways and ramps, and use anticipatory clearances to expedite air traffic movements.

Estimated 1992 project cost is $2.0 million.

19. Upgrade ILS on Runway 12R to Category IIIB.

The impact of delays under instrument meteorological conditions (IMC) can be significant. The addition of a capability to land on Runway 12R under CAT IIIB conditions would reduce visibility minimums, enhance operational flexibility, and ensure the integrity of operations in all weather conditions.

Estimated 1992 project cost is $0.5 million.

20. Install Category II/III ILS on Runway 12N and Category I ILS on Runway 30N with associated approach light system (ALS).

The impact of delays associated with IMC can be significant. The addition of a capability to land on the new Runway 12N under CAT II/III conditions would enhance operational flexibility and ensure the integrity of operations in response to wind and other limiting conditions. If the new runway is constructed to permit independent parallel operations, the addition of a second CAT II/III capability would support simultaneous parallel approaches during marginal weather conditions, effectively doubling airport arrival capacity during IMC.

Estimated 1992 project cost is $1.0 million.

Annual savings at the Baseline activity level would be 50 hours or $0.06 million, and, at Future 2 activity levels, 9,600 hours or $11.50 million.

21. Install Category I ILS on extended Runway 12L/30R with associated approach light system (ALS).

The impact of delays associated with IMC can be significant. The addition of a capability to land on Runway 12L/30R under at least CAT I conditions would enhance the operational flexibility and ensure the integrity of operations in response to wind and other limiting conditions. Current restrictions require staggered approaches; therefore, the increased capacity provided by conducting simultaneous approaches to Runway 12R/30L would not be realized. The availability of CAT I capability would, however, provide an alternative when Runway 12R/30L would be closed and allow for increased departure capability when weather and aircraft type permit.

Estimated 1992 project cost is $1.0 million.

Annual savings at the Baseline activity level would be 80 hours or $0.09 million, and, at Future 2 activity levels, 30,290 hours or $36.35 million.

22. Install Microwave Landing System (MLS) on Runway 21.

The 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 Instrument Meteorological Conditions (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. MLS provides the best opportunity to allow precision approach capability to Runway 21 at San Antonio.

The current criteria limit the proposed flexibilities that would be gained through the installation of an MLS on Runway 21 without greatly affecting ILS approaches currently being conducted at Randolph AFB. Air traffic control automation breakthroughs may provide some relief for this problem.

23. Install Localizer Directional Aid (LDA) on Runway 12L/30R.

The use of LDA approaches on Runways 12L and 30R with ILS arrivals on Runways 12R and 30L would require the installation of two instrument landing system (ILS) localizer antennas with their beams radiating parallel to the localizer beams for each runway. Under certain conditions of VFR and IFR weather, aircraft would approach the airport using the offset localizer beam until they break out under the cloud cover and then proceed visually to land on the runway with a banking maneuver. The LDA approach would provide for dual-stream operations and significantly increase airport capacity under these VFR and IFR weather conditions. The minimums for an LDA approach would be approximately 700 foot ceiling and 2 miles visibility; however, in many cases, weather conditions are such that significant delay reductions could be realized for arrivals with these minimums.

Annual savings at the Baseline activity level would be 540 hours or $0.65 million, and, at Future 2 activity levels, 104,090 hours or $124.91 million.

24. Install multiple Runway Visual Range (RVR) on Runway 3.

Meteorological visibility is often observed and reported at a point distant from the runway. Runway Visual Range (RVR) is measured along the runway itself and provides the pilot with the distance he can expect to see down the runway. From an operations viewpoint, RVR is far superior to other measurements of meteorological visibility.

The addition of a multiple site RVR installation on Runway 3 would allow for vastly improved departure capability on that runway and an overall improvement in operational efficiency during very low visibility conditions.

Currently, departures on Runway 3 are restricted to conditions of 0.25 mile prevailing visibility even though the runway is equipped with runway centerline lights. Therefore, when conditions of less than 0.25 mile visibility are encountered, both landings and takeoffs must be conducted solely on Runway 12R. This lessens efficiency because departures must be fit in between arriving aircraft. This translates into increased separation between arriving aircraft. With a multiple RVR installation of Runway 3, departures could be conducted on Runway 3 in weather conditions down to 600 feet RVR (0.10 mile), while arrivals continue at minimum spacing of 3 miles on Runway 12R. Such a configuration also makes for more of a one-way flow of ground traffic as well, which improves operational efficiency.

Estimated 1992 project cost is $0.3 million.

Annual savings at the Baseline activity level would be 10 hours or $0.01 million, and, at Future 2 activity levels, 4,090 hours or $4.90 million.

Operational Improvements

25. Reduce in-trail arrival separations to 2.5 miles.

Existing procedures for Instrument Flight Rules (IFR) conditions 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 occur at the highest demand levels during IFR conditions, 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 110 hours or $0.14 million, and, at Future 2 activity levels, 32,710 hours or $39.25 million.

26. IFR dependent approaches to Runways 12R and 21.

Under VFR conditions, it is common to use non-intersecting converging runways for independent streams of arriving aircraft. Because of the reduced visibility and ceilings associated with IFR conditions, 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 under IFR conditions through the use of a converging runway display aid (CRDA) for air traffic controllers.

Annual savings at the Baseline activity level would be 80 hours or $0.1 million, and at Future 2 activity levels, 23,800 hours or $28.58 million.

27. Segregate traffic on runways.

Segregating traffic could reduce delays in some situations, but other major changes would be required to implement it effectively. For example, general and corporate aviation operations should be relocated to the northwest side of the airport (see alternative 28) in order to alleviate the crossing of traffic on the ground, the consequent ground delays, and the potential for runway incursion problems. In the current configuration, segregating traffic by aircraft type or by arrivals and departures results in increased aircraft delays.

27a. Segregate traffic by aircraft type.

Additional annual delay costs at the Baseline activity level would be 470 hours or $0.57 million, and, at Future 2 activity levels, 85,820 hours or $102.9 million.

27b. Segregate traffic by arrivals and departures.

Additional annual delay costs at the Baseline activity level would be 630 hours or $0.76 million, and, at Future 2 activity levels, 142,580 hours or $171.11 million.

28. Install Wake Vortex Advisory System (existing configuration).

Since the turbulence created by heavy aircraft at landing and take-off speeds (wake vortices) can be hazardous to trailing aircraft, the FAA has established minimum separations to eliminate the hazards of wake vortices. These separations are 2.5, 3, 4, 5, and 6 nautical miles (NM), depending on the relative size of the the aircraft in the arrival stream. Installation of a wake vortex advisory system would allow for improved separation.

Annual savings at the Baseline activity level, eliminating the 5 and 6 NM separation requirement, would be 230 hours or $0.28 million, and, at Future 2 activity levels, 60,370 hours or $72.34 million.

28a. Install Wake Vortex Advisory System (with Runway 12L/30R extension).

Annual savings at the Baseline activity level would be 270 hours or $0.32 million, and, at Future 2 activity levels, 24,370 hours or $29.24 million.

29. Relocate general aviation (GA)/fixed base operator (FBO) areas to northwest side of Runway 12L.

Relocating GA operations to the north side of the airport would facilitate segregating traffic (see alternative 26) and serve to alleviate the crossing of traffic on the ground, the consequent ground delays, and the potential for runway incursion problems.

Estimated 1992 project cost is $8.27 million.

Annual savings at the Baseline activity level would be 80 hours or $0.09 million, and, at Future 2 activity levels, 73,440 hours or $88.13 million.

30. Relocate non-air carrier operations.

To encourage general aviation (GA) aircraft to use other airports to serve the San Antonio area, safe and reliable facilities and attractive service would need to be provided at reliever airports. Ground transportation connections may be necessary.

To determine the benefits of retaining only a portion of GA operations at SAT, the Capacity Team evaluated the effects of relocating non-air carrier operations.

30a. Relocate 25 percent of non-air carrier operations.

A 25 percent reduction in the anticipated GA activity at SAT would result in annual savings at the Baseline activity level of 710 hours or $0.85 million, and, at Future 2 activity levels, 119,490 hours or $143.39 million.

30b. Relocate 50 percent of non-air carrier operations.

A 50 percent reduction in the anticipated GA activity at SAT would result in annual savings at the Baseline activity level of 1,340 hours or $1.61 million, and, at Future 2 activity levels, 237,440 hours or $284.93 million.

31. Distribute traffic more uniformly.

A more uniform distribution of airline flights during peak periods would promote a more orderly flow of traffic, reduce arrival and departure delays, and reduce ground congestion near the terminal and on the taxiway system.

SAT is an integral part of the hub-and-spoke system. Hubbing creates efficiencies that cannot be measured in a delay study of this type. This system of operations provides frequent service between city-pairs that could not support frequent direct service. Frequent flights provide an economic benefit to consumers, in particular the business flyer. Although annual savings at the Baseline activity level would be 200 hours or $0.24 million, and, at Future 2 activity levels, 16,150 hours or $19.38 million, in order to properly evaluate the overall impact of hubbing and the redistribution of scheduled operations, the entire system must be studied, not any one individual airport.

32. Conduct an airspace capacity design project and re-structure San Antonio area airspace.

The major impact on capacity in San Antonio area airspace, and ultimately at the three major airports in the area, San Antonio International (SAT), Kelly AFB (SKF), and Randolph AFB (RND), occurs when SAT is required to be in a north flow, using Runway 3 or 30, or when using Runway 21. Due to the stratification of airspace over the satellite airports, all area airports are affected when these procedures are in use at SAT. When all the airports in the local area are in a south-flow configuration, their runway alignments are similar, and traffic flows in the area are more compatible. Continued use and further development of Runway 3 or 21 at SAT will only make system and runway delays worse as traffic demand in the area continues to build.

The Capacity Team highly recommends a complete analysis of all of the airspace in the San Antonio area. This analysis should include concepts of airspace restructuring that offer the potential for improving arrival and departure air route capacity in conjunction with area airport improvements. New technology and operating concepts need to be reviewed in an effort to improve flow-control procedures and reduce or eliminate miles-in-trail restrictions that exceed optimal aircraft spacing. The goal would be to ensure sufficient airspace capacity to fully utilized area airport surface capacity.

33. New commercial airport planning.

Forecasts indicate that, without major airfield improvements or a relocation of some general aviation operations, annual aircraft delay costs at San Antonio International Airport will begin to escalate rapidly when aircraft operations reach a level between 300,000 and 400,000 per year. The annual increase in aircraft operations for the last ten years has averaged 1.8 percent.

The SAT Capacity Team recommends an Airspace Capacity Study and a follow-up Master Plan Update for SAT, including public coordination, to determine the feasibility of constructing additional runways. If that proves impractical for socioeconomic, political, or environmental reasons, the Capacity Team recommends a site selection process to consider a new, long-range airport site.

Figure 7 illustrates the impact of delays at San Antonio 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 chart presents comparisons between the Do Nothing alternative and selected capacity enhancement alternatives. The chart shows the benefits that would result from implementing the individual alternatives and indicates the savings in delay costs that would be provided by:

- Constructing independent air carrier length Runway 12N/30N northeast of Runway 12L/30R
- Relocating 50 percent of non-air carrier operations
- Extending Runway 12L/30R to air carrier length and operating without restrictions
- Constructing independent air carrier Runway 3L/21R

Figure 8 illustrates the average delay in minutes per aircraft operation for these same alternatives. Under the Do Nothing alternative, if there are no improvements made in airfield capacity, the average delay per operation of about 1.2 minutes per operation in Baseline will increase to 52.3 minutes per operation by Future 2.

Figure 7 Annual Delay Costs — Capacity Enhancement Alternatives

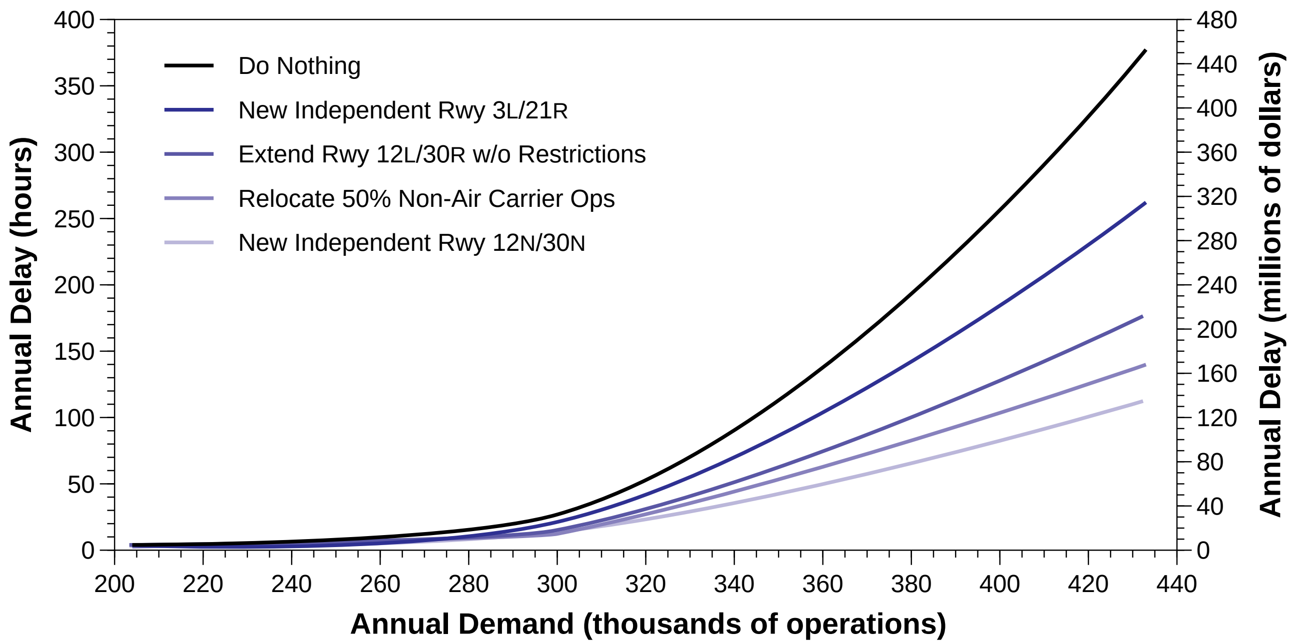
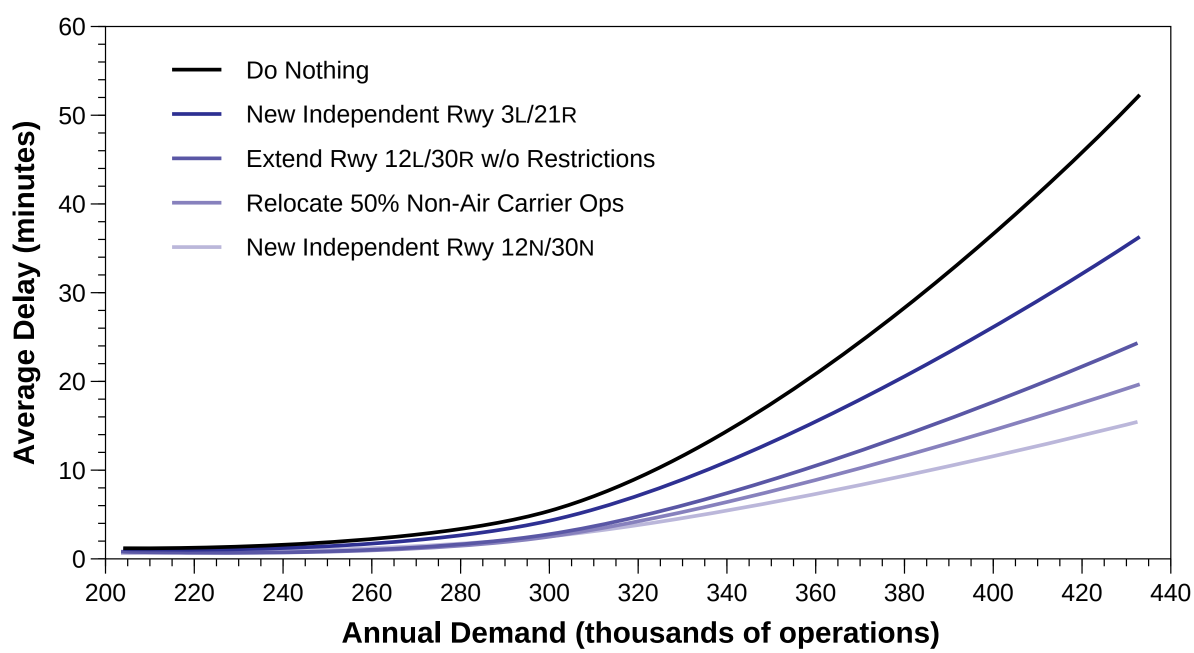


Figure 8 Average Delay Per Operation — Capacity Enhancement Alternatives



Overview

The San Antonio International Airport Capacity Team evaluated the efficiency of the existing airfield and the proposed future configuration. Figure 9 illustrates the current annual distribution of aircraft traffic, Figure 10, airfield utilization, and Figure 11, runway utilization. Figure 12 depicts the various existing runway configurations, and Figure 13 shows future 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 San Antonio International Airport (SAT) has an average direct operating cost of $20.00 per minute, or $1200.00 per hour. 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 any 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.

This report will allow SAT to implement improvements to keep delays at acceptable levels as demand increases.

Figure 9 Annual Distribution of Traffic

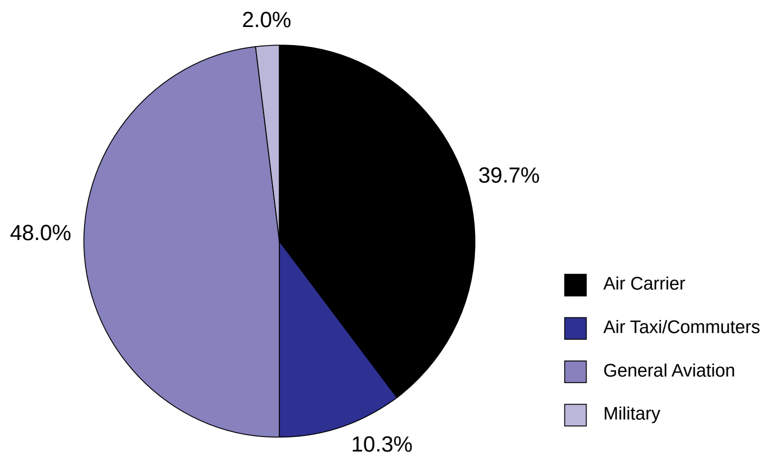


Figure 10 Airfield Utilization

	Ceiling/Visibility	Utilization (%)
VFR 1	2,500 feet and above /5 MI and above	65.0
VFR 2	1,000 to 2,500 feet /3 to 5 MI	20.2
IFR 1	200 to 1,000 /0.5 to 3 MI	13.3
IFR 2	Below 200 feet /below 0.5 MI	1.5
	Total	100.0

VFR - Visual Flight Rules
IFR - Instrument Flight Rules
MI- Statute Miles

Figure 11 Runway Utilization (percentage use)

	Runways 12R &12L	Runways 30R & 30L	Runway 3	Runway 21	Runways 12R, 12L, & 3	Total
VFR 1	42.5	8.2	6.6	1.7	6.0	65.0
VFR 2	12.0	2.6	2.4	0.2	3.0	20.2
IFR 1	10.0	1.2	1.0	(0.1)	1.0	13.3
IFR 2	1.5	0.0	0.0	0.0	0.0	1.5
					Total	100.0

Note: “( )” indicates not feasible with current NAVAIDs/procedures

Figure 12 Existing Runway Configurations

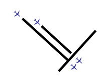
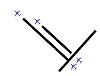
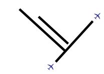
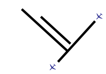
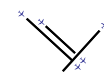
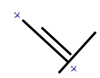
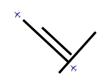
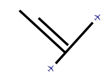
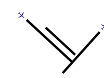
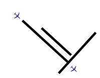
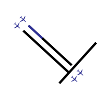
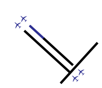
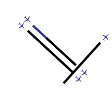
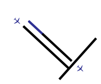
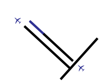
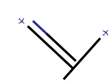
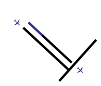
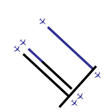
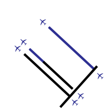
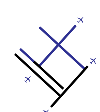
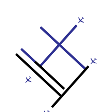
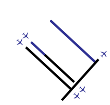
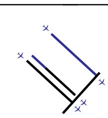
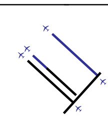
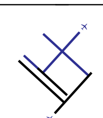
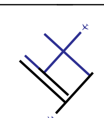
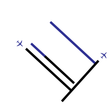
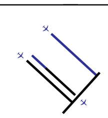
San Antonio Int'l Airport — Current Configurations					
Op Plan / Flight Rules	1	2	3	4	5
VFR 1&2 Configurations					
IFR 1 Configurations					
IFR 2 Configuration					

Figure 13 Future Runway Configurations

San Antonio Int'l Airport — Future Configurations					
Op Plan / Flight Rules	1	2	3	4	5
Improvement	Rwy 12L Ext	Rwy 12L Ext			Rwy 12L Ext
VFR 1&2 Configurations					
IFR 1 Configurations					
IFR 2 Configuration					
Improvement	Rwy 12N Added	Rwy 12N Added	Rwy 3L Added	Rwy 3L Added	Rwy 12N Added
VFR 1&2 Configurations					
IFR 1 Configurations					
IFR 2 Configuration					

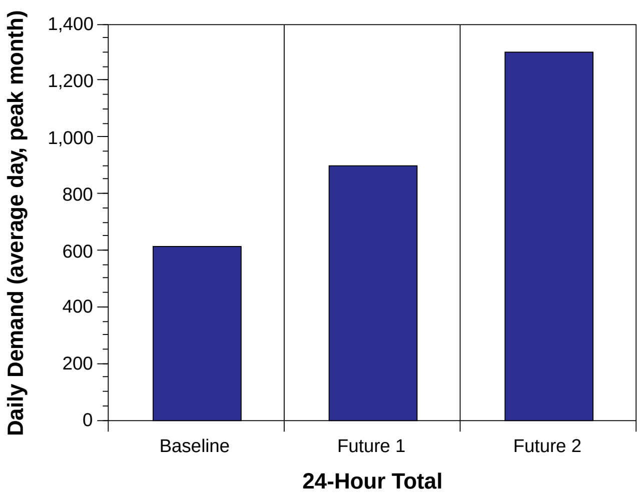
Airfield Capacity

The SAT 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
- Ceiling and visibility conditions
- Runway layout and use
- Aircraft mix
- Percent arrival demand

Figure 14 illustrates the average-day, peak-month arrival and departure demand levels for SAT for each of the three annual activity levels used in the study, Baseline, Future 1, and Future 2.

Figure 14 Airfield Demand Levels — Aircraft Operations and Average Day of Peak Month



	Annual	24-Hour Day (Average Day, Peak Month)	Peak Hour
Baseline	204,000	612	48
Future 1	300,000	900	73
Future 2	433,000	1,300	102

Note: When compared to the FAA's terminal area forecast for SAT, Future 1 generally corresponds to the year 2000, and Future 2, to 2010. However, this study considers demand levels rather than calendar years and should remain valid regardless of when demand materializes at the forecast levels.

Figure 15 presents the airport capacity curves for SAT. The curves were developed for various runway configurations, under Instrument Flight Rules (IFR) conditions, with a 70/30, 50/50, and 30/70 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 15 illustrate the relationship between airfield capacity, stated in the number of operations per hour, and the average delay per aircraft. It shows that, as the number of aircraft operations per hour increases, the average delay per operation increases exponentially.

Figure 16 illustrates the hourly profile of daily demand for the Baseline activity level of 204,000 aircraft operations per year. It also includes a curve that depicts the profile of daily operations for the Future 2 activity level of 433,000 aircraft operations per year.

Comparing the information in Figures 15 & 16 shows that:

- aircraft delays will begin to rapidly escalate as hourly demand exceeds 30 operations per hour, and,
- while hourly demand exceeds 30 operations during certain hours of the day at Baseline demand levels, 30–60 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

Figure 15 Airport Capacity Curve — Hourly Flow Rate vs. Average Delay — IFR Conditions

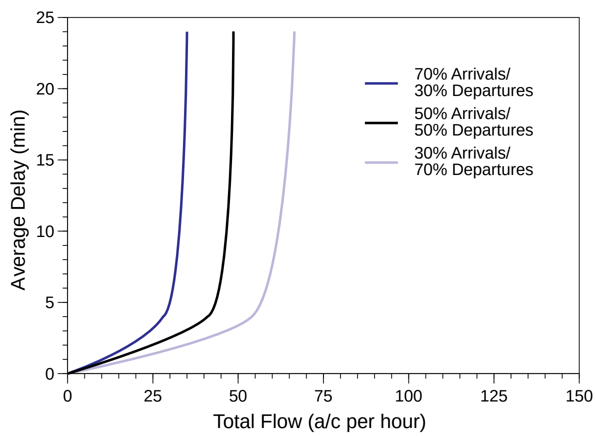
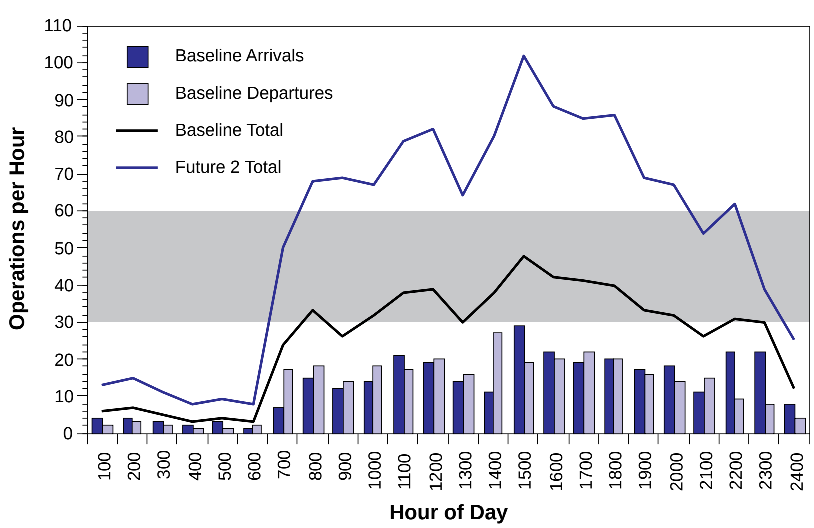


Figure 16 Profile of Daily Demand — Hourly Distribution



To complete the picture, Figure 17 presents the airport capacity curves for SAT under Visual Flight Rules (VFR) conditions (VFR 1), and Figure 18 summarizes the details of the capacity data for various existing runway configurations under both visual and instrument conditions.

Figure 17 Airport Capacity Curve — Hourly Flow Rate vs. Average Delay — VFR Conditions

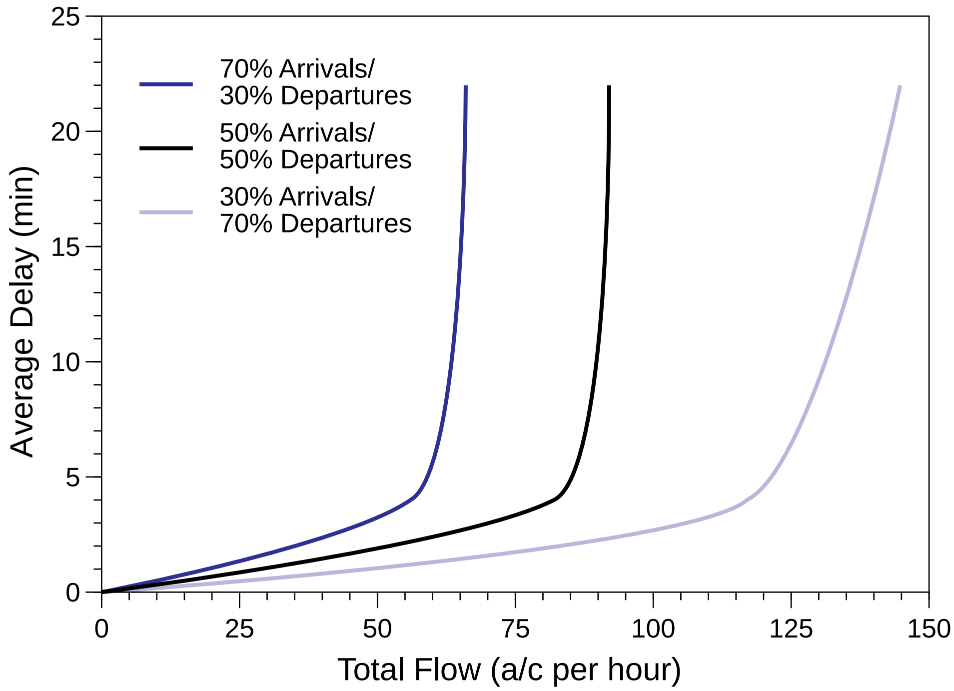
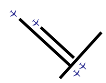
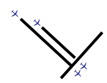
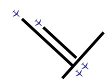
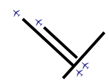
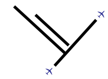
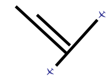
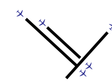
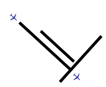
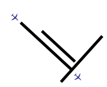
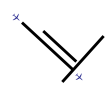
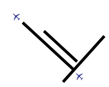
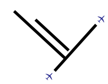
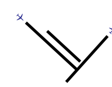


Figure 18 Airport Capacity — Existing Configurations — VFR and IFR Conditions

San Antonio Int'l Airport — Current Conditions

Weather / Op Plan	1 70/30		1 30/70		1 50/50		2 50/50		3 50/50		4 50/50		5 50/50	
VFR 1&2 Configurations														
VFR Configuration	1	2	1	2	1	2	1	2	1	2	1	2	1	2
4 min Bal Flow	56		117		82	59	81	66	55		55		88	63
4 min Unbal Flow	59		117		86	65	86	65	56		57		96	69
*Max Bal Flow	66		139		92	67	92	67	62		63		97	70
*Max Unbal Flow	84		139		108	91	112	93	66		66		132	97
(*Delay at max)	(22)		(17)		(22)	(26)	(26)	(26)	(30)		(29)		(24)	(22)
IFR 1 Configurations **														
IFR Configuration	1	2	1	2	1	2	1	2	1	2	1	2	1	2
4 min Bal Flow	28		54		41	16	40		39				40	
4 min Unbal Flow	30		54		51	16	42		41				43	
*Max Bal Flow	35		62		46	26	46		46				47	
*Max Unbal Flow	47		62		53	26	53		52				54	
(*Delay at max)	(24)		(14)		(14)	(76)	(22)		(34)				(33)	

Note: Flow values represent the number of arrivals and departures per hour.
Unbalanced flow shows surplus departure capacity available for the given configuration.

* Note: Not practical because of high delays associated with achieving these flows.
Delay at max in minutes applies to both balanced and unbalanced flows.

** Note: Configurations 2, 3, 4, and 5 do not apply to IFR 2 Conditions.

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 Runway Delay Simulation Model (RDSIM). A description of this model is included in Appendix B. If no improvements are made in airport capacity, the average delay per operation of 1.2 minutes in Baseline will increase to 52.3 minutes per operation by Future 2. The results of the simulation analysis were then appropriately weighted and annualized to develop annual costs.

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

	Annual Delay Costs	
	Hours	**Millions of 1992$**
Baseline	3,970	$4.76
Future 1	26,880	$32.26
Future 2	377,300	$452.76

Appendix A — Participants

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The SAT 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 several computer modeling techniques. A brief description of the models and the methodology employed follows.

Computer Models

Airfield Delay Simulation Model (ADSIM)

This is a fast-time, discrete event model that employs stochastic processes and Monte Carlo sampling techniques. It describes significant movements of aircraft on the airport and the effects of delay in the adjacent airspace. The model was validated in 1978 at Chicago O'Hare International Airport against actual flow rates and delay data. It was calibrated for this study against field data collected at SAT to insure that the model was site specific.

Inputs for the simulation model were derived from empirical field data. The model repeated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability, which occurs on a daily basis in actual airport operations. The results were averaged to produce output statistics. Total and hourly aircraft delays, travel times, and flow rates for the airport and for the individual runways were calculated.

Runway Delay Simulation Model (RDSIM)

RDSIM is a short version of the ADSIM model that 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 forty 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 a given demand, the model calculates 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.

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, the FAA used different airfield configurations 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.

The RDSIM model, in its capacity mode, was used to perform the capacity analysis for SAT.

Appendix C — Glossary

ADSIM	Airfield Delay Simulation Model
AFB	Air Force Base
ALS	Approach Light System
ARTCC	Air Route Traffic Control Center
ASDE	Airport Surface Detection Equipment
ATC	Air Traffic Control
FAA	Federal Aviation Administration
FBO	Fixed Base Operator
GA	General Aviation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LDA	Localizer Directional Aid
MI	Miles
MLS	Microwave Landing System
MOA	Military Operating Area
MOU	Memorandum of Understanding
NAVAID	Navigational Aid
NM	nautical miles
PRM	Precision Runway Monitor
RDSIM	Runway Delay Simulation Model
RND	Randolph Air Force Base
RVR	Runway Visual Range
Rwy	Runway
SAT	San Antonio International Airport
SKF	Kelly Air Force Base
SSF	Stinson Municipal Airport
TCA	Terminal Control Area
Twy	Taxiway
UHF	Ultra High Frequency
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range — course information only
WVAS	Wake Vortex Advisory System

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