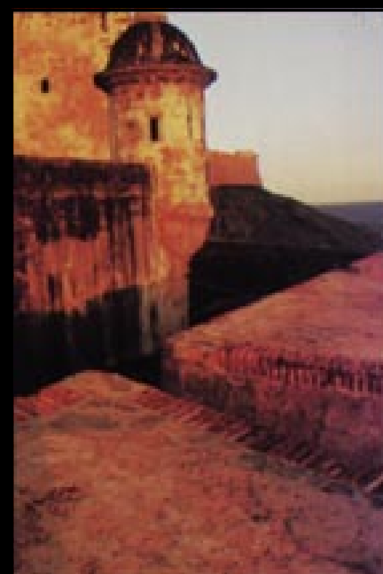
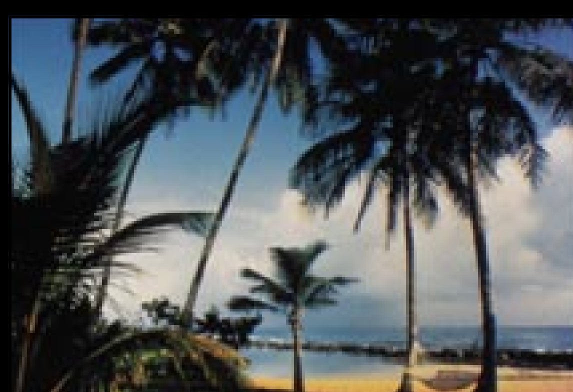
Luis Muñoz Marín International Airport

San Juan, Puerto Rico

Airport Capacity Enhancement Plan

September 1991





Luis Muñoz Marín International Airport

San Juan, Puerto Rico

Airport Capacity Enhancement Plan

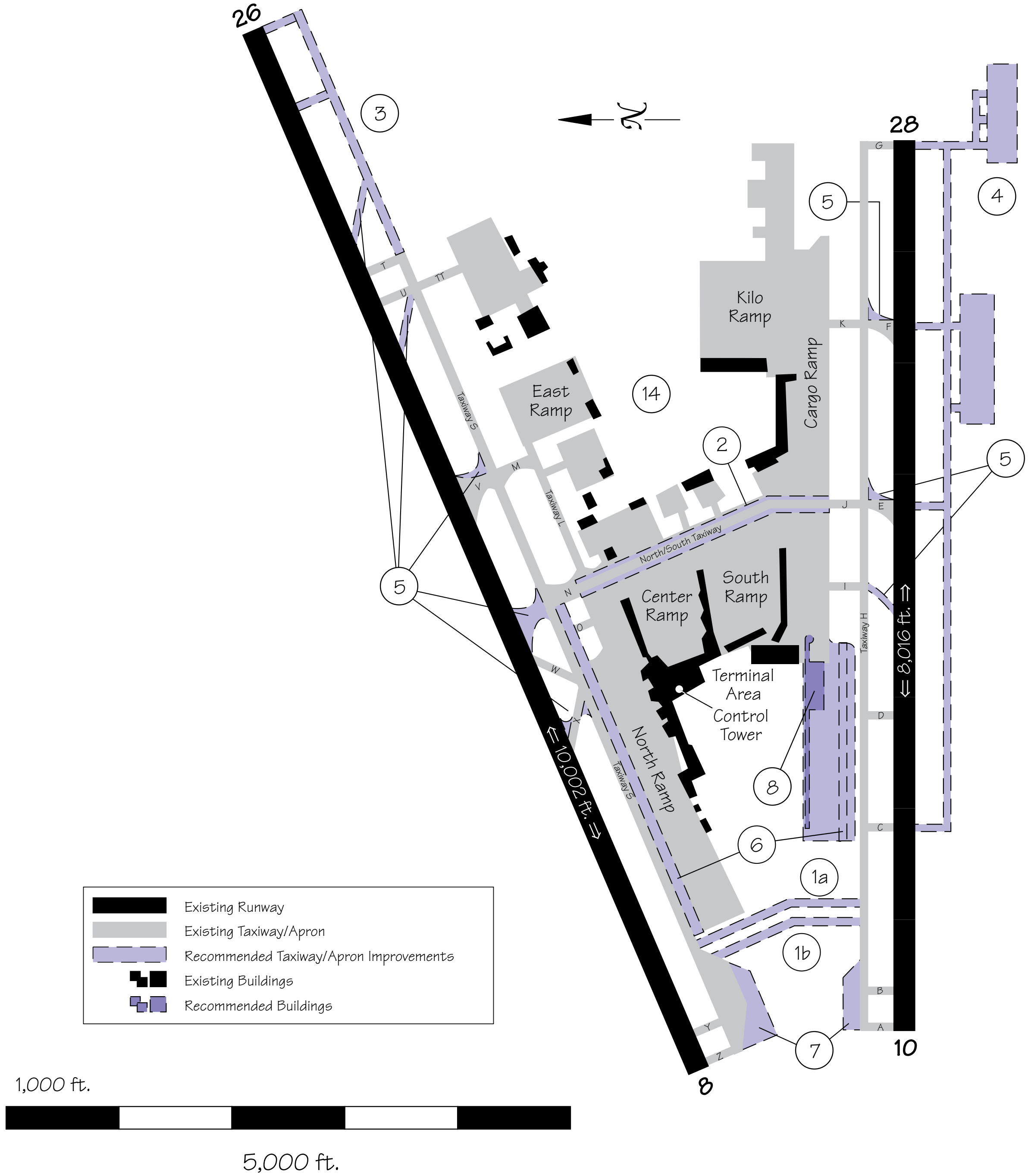
September 1991

Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, the Puerto Rico Ports Authority, and the airlines and general aviation serving Puerto Rico and San Juan.

Glossary

ADSIM	Airfield Delay Simulation Model
ATA	Air Transport Association of America
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
CERAP	Combined En Route/Radar Approach Control
DTP	Dynamic Traffic Planner
FAA	Federal Aviation Administration
FBO	Fixed Base Operator
GA	General Aviation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
NM	Nautical Mile
PAPI	Precision Approach Path Indicator
PRANG	Puerto Rico Air National Guard
RDSIM	Runway Delay Simulation Model
REIL	Runway End Identifier Lights
RVR	Runway Visual Range
SJU	San Juan Luis Muñoz Marín International Airport
SM	Statute Mile
TATCA	Terminal Air Traffic Control Automation
VASI	Visual Approach Slope Indicators
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	VHF navigational aid (omnidirectional course information)

Figure 1 Luis Muñoz Marín International Airport San Juan, Puerto Rico



Luis Muñoz Marín International Airport
San Juan, Puerto Rico

Figure 2 Recommended Capacity Enhancement Alternatives and Annual Delay Savings

Airfield Improvements	Baseline	Future 1	Future 2
	Estimated Annual Benefits (in hours and millions of 1990 dollars)		
1. Construct new north/south taxiway complex west end.			
1a. Single one-way taxiway.*			
1b. Two-directional taxiway.	—	1,499/$2.26	4,545/$6.85
2. Expand existing north/south taxiway to provide two-directional capability.**	—	6,005/$9.05	11,810/$17.8
3. Extend Taxiway S.		†	
4. Construct new ramp area on south side.**	—	7,477/$11.27	25,504/$38.44
5. Construct new/improve existing exits Runways 8 & 10.**	100/$0.15	577/$0.87	1,373/$2.07
6. Expand existing Taxiway S and H to a dual taxiway adjacent to north and south ramp.**		†	
7. Construct holding pads (staging areas) Runways 8 & 10.			
7a. With three hold positions.	350/$0.53	1,615/$2.43	5,583/$8.41
7b. With five hold positions.	447/$0.67	1,872/$2.82	7,717/$11.63
8. Construct new international passenger terminal.		†	
Facilities and Equipment Improvements			
13. Upgrade VOR to include doppler.		†	
14. Construct new air traffic control tower.		†	
15. Install wake vortex advisory system.	—	—	—
16. Install Terminal Air Traffic Control Automation (TATCA) enhancements.		†	
17. Install improved approach aids on Runway 26.		†	
17a. Install Precision Approach Path Indicator (PAPI)		†	
Operational Improvements			
18. Implement improved departure spacing.	673/$1.01	812/$1.22	3,101/$4.67
19. Use 2.5 NM separations on final approach.	—	—	—
20. Unrestricted use of Runway 10.***	586/$0.88	1,637/$2.47	7,639/$11.51
User Improvements			
21. Remove military operations.	150/$0.23	535/$0.8	773/$1.17
22. Enhance General Aviation (GA) reliever airports (and reduce GA activity by 50 percent).	913/$1.38	1,874/$2.82	5,955/$8.97

* Included in Baseline for modelling purposes as though this project were in place.
** These projects assume Project 1a is in place.
*** See page 13.
† 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 Airport Capacity Design Teams at various major air carrier airports to identify and evaluate alternative means to enhance existing airport and airspace capacity to handle future demand. A Capacity Team for San Juan's Luis Muñoz Marín International Airport (SJU) was formed in 1990.

Steady growth at SJU has made it one of the busiest airports in the country. Activity at the airport has increased from 2,405,000 passenger enplanements in 1983 to 4,011,000 in 1988, a 67 percent increase. In 1989, the airport handled 194,000 aircraft operations (take-offs and landings).

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

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* – 200,000 operations; *Future 1* – 250,000 operations; *Future 2* – 300,000 operations.

Based on the initial results of the studies by the FAA's Technical Center, the capacity of the airport's existing taxiway system was not sufficient to handle the increase in the ground movement of aircraft at the higher activity levels forecast for Future 1 and Future 2. The Capacity Team agreed to include a proposed new north/south crossfield taxiway at the west end of the airfield in the baseline airfield configuration for modeling purposes, so that ground movement of aircraft could be simulated and further analysis of other capacity improvements would be possible. This taxiway must be constructed as a high priority in order for other improvements to be effective.

If no improvements are made at SJU (the "Do Nothing" scenario), the annual delay cost will increase from \$8.69 million at the Baseline (1990) level of operations to \$70.31 million by Future 2.

The major recommendations resulting from the San Juan study include:

	Future 2 Annual Delay Savings Hours	Millions of 1990 $
• Constructing new ramp area on south side	25,504	$38.44
• Expanding existing north/south taxiway to provide two-directional capability	11,810	$17.80
• Constructing holding pads (staging areas) at the ends of Runways 8 and 10 with positions for holding five aircraft	7,717	$11.63
• Unrestricted use of Runway 10	7,639	$11.51
• Enhancing general aviation (GA) reliever airports (and reducing GA activity by 50 percent)	5,955	$8.97
• Constructing a new north/south crossfield taxiway complex at the west end	4,545	$6.85
• Implementing improved departure spacing	3,101	$4.67

Figure 3 Airport Capacity Curves —Flow Rate Versus Average Delay

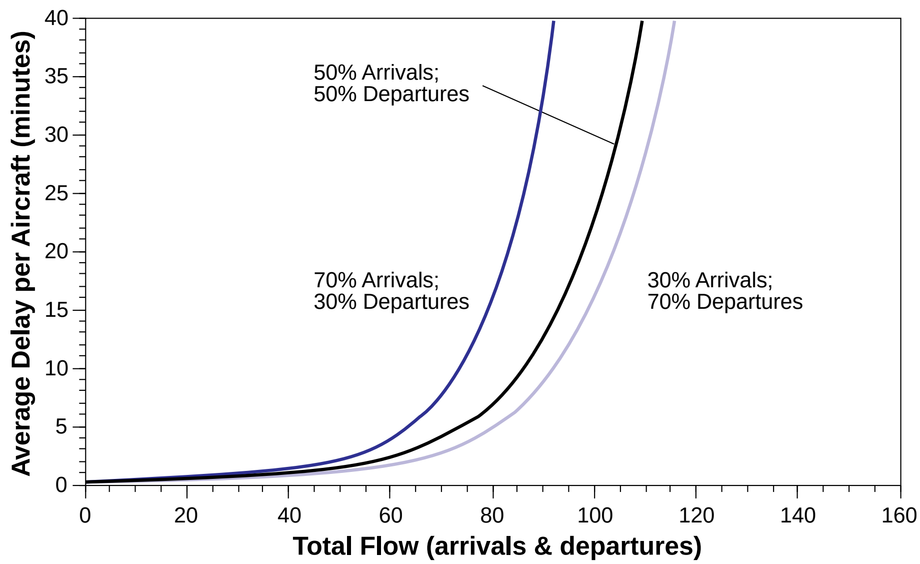


Figure 4 Profile of Daily Demand — Hourly Distribution

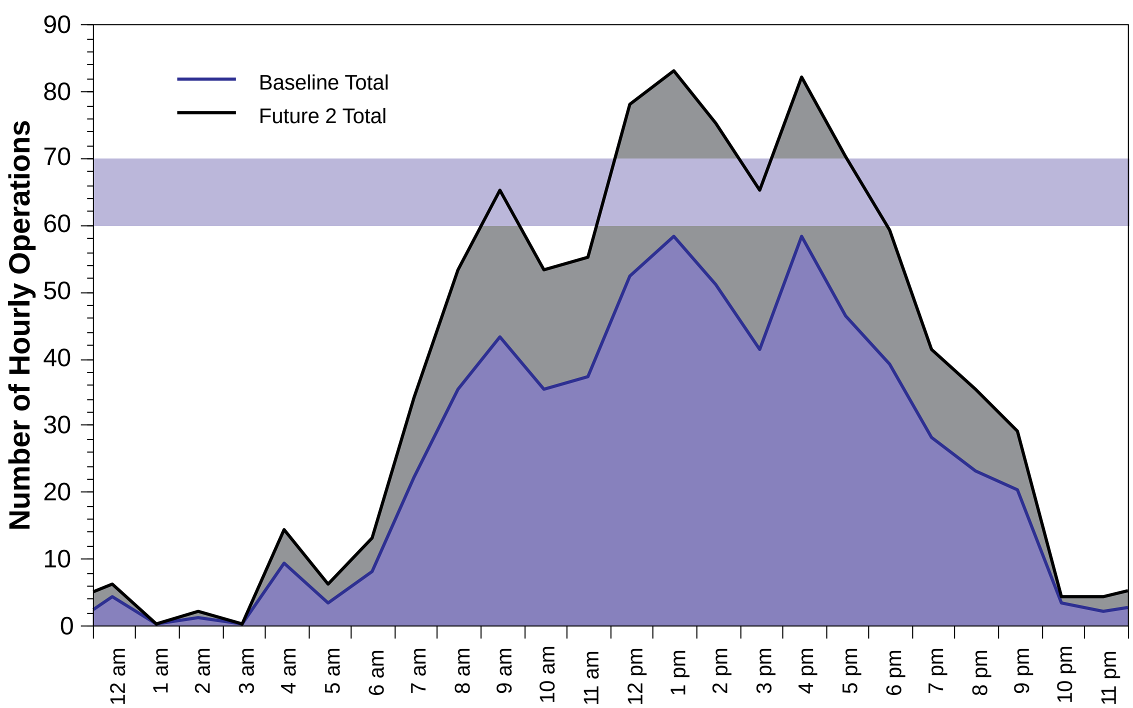
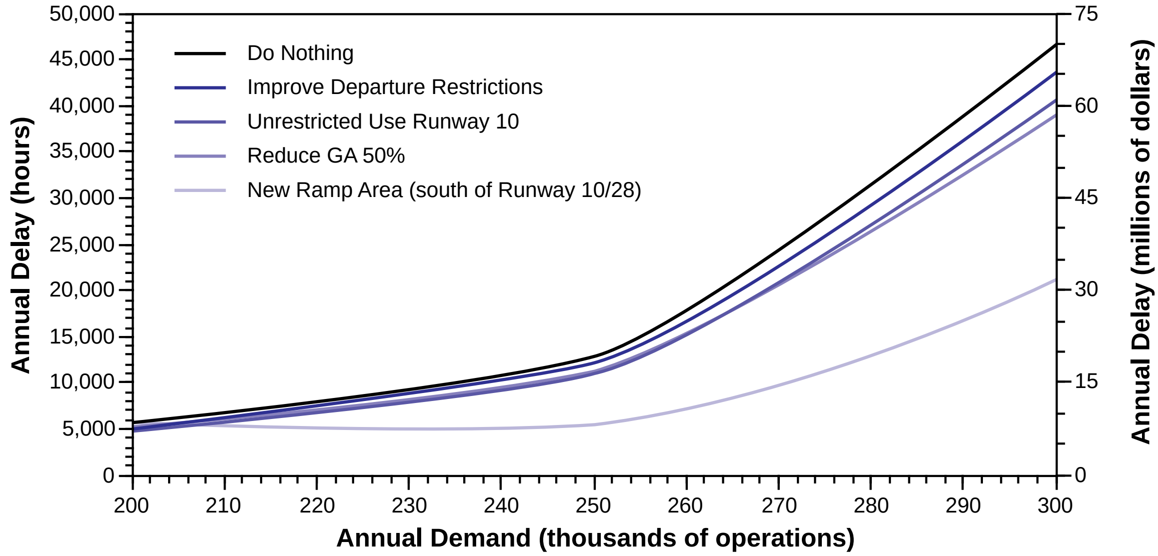


Figure 3 illustrates the capacity curves for the current airfield configuration at SJU under visual flight rules (VFR) conditions. (Instrument flight rules (IFR) conditions occur only about one percent of the time at SJU.) It shows that aircraft delays will begin to escalate rapidly as hourly demand exceeds 60-70 operations per hour. Figure 4 shows that, while hourly demand doesn't exceed 60-70 operations at Baseline demand levels, 60-70 operations per hour is frequently approached and exceeded at the demand levels forecast for Future 2.

Figure 5 Annual Delay Costs — Capacity Enhancement Alternatives



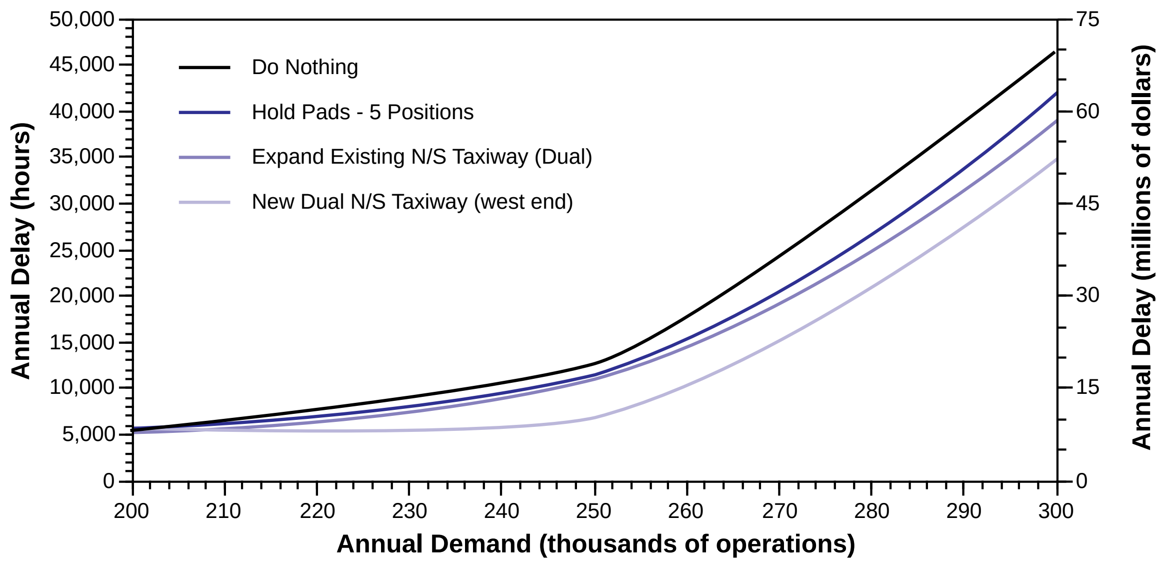


Figure 5 shows how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the "Do Nothing" scenario. The chart also shows that the greatest savings in delay costs would be provided by: implementing improved departure restrictions, unrestricted use of Runway 10, enhancing general aviation (GA) reliever airports (and reducing GA activity by 50 percent), constructing a new ramp area on the south side, constructing holding pads (staging areas) at the ends of Runways 8 and 10 with positions for holding five aircraft, expanding existing north/south taxiway to provide two-directional capability, and constructing a new north/south crossfield taxiway at the west end.

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Section 1

Introduction

Background

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. The national air transportation system is being called on to handle unprecedented growth and ever increasing activities. 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 industry and government airport Capacity 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 to reduce delays.

Puerto Rico, the third largest island of the Antilles chain that rings the Caribbean, covers an area of 3,435 square miles (8,897 square kilometers). The Luis Muñoz Marín International Airport, built in 1955, has a total of 35 passenger and cargo airlines averaging 16,438 inbound and outbound flights monthly to the United States and to other countries in Central and South America, Europe, and the Caribbean. Over the past decade, steady growth at San Juan's Luis Muñoz Marín International Airport (SJU) has made it one of the Nation's busiest airports. Enplanements at SJU rose from 2,405,000 in 1983 to 4,011,000 in 1988, a 67 percent increase. SJU's total aircraft operations reached 194,000 in 1989. During FY 1990, the airport showed a movement of 8,700,000 passengers in 135,913 flights. Cargo movement for the same period was 447,827,671 pounds in 69,890 flights.

San Juan's Luis Muñoz Marín International Airport, the largest of eleven commercial airports on the island, supports the continuous growth and development of the economy. It has become a significant hub for Caribbean and South American destinations and thus important for the development of regional markets and tourism. Conscious of this fact, the Ports Authority strives to provide services and facilities responsive to its client's profile. As part of this effort, they are improving facilities at other airports on the island to stimulate an increase in passenger and cargo movement in order to ensure that the Luis Muñoz Marín International Airport continues its operations below capacity levels.

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 for 1990 of 200,000 aircraft operations (takeoffs and landings) was established based on the 1989 annual traffic level. 1989 was chosen as the basis since it was the latest year for which complete traffic records were available prior to the time the study commenced. Two future traffic levels, *Future 1* and *Future 2*, were established at 250,000 and 300,000 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at San Juan. If no improvements are made at SJU, annual delay levels and delay costs are expected to increase from an estimated 5,766 hours and $8.69 million at the Baseline activity level to 46,649 hours and $70.31 million by the Future 2 demand level.

The improvements recommended 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 at SJU 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 user improvements.

- Examined the relationship between air traffic demand and delay, so that it could be used as an aid in establishing acceptable air traffic movement levels.

Scope

The Luis Muños Marín International Airport 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 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 proceeded along a formal sequence of events, with periodic meetings 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.

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. Selected 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.

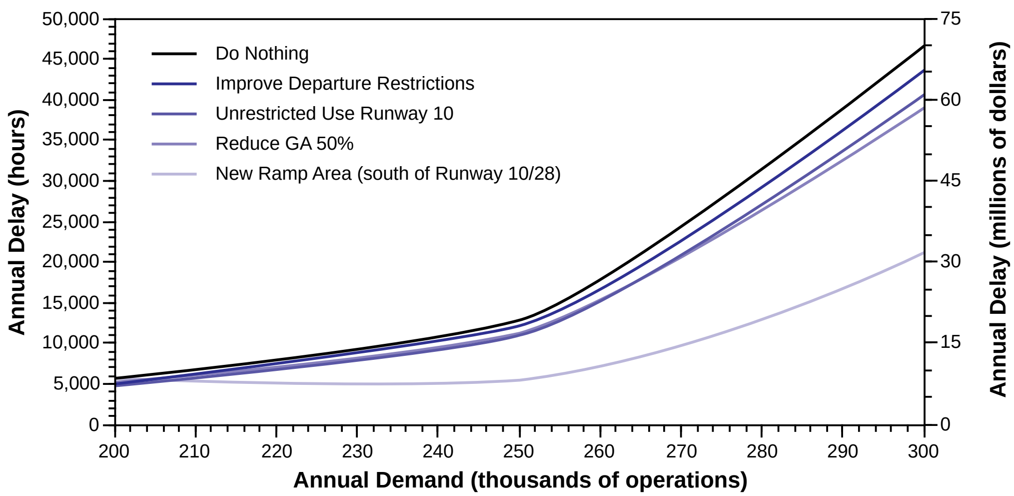
Air traffic demand levels were derived from *Official Airline Guide* data, historical data, and Capacity Team and other forecasts. Aircraft volume, mix, and peaking characteristics were considered for each of the three different demand forecast levels (Baseline, Future 1, and Future 2). From this, annual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

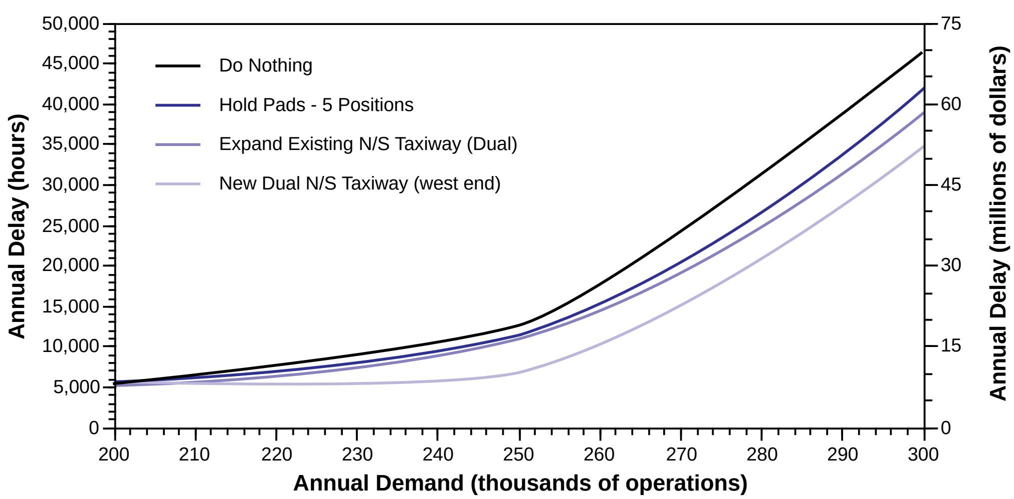
demand. The annual delay estimates for each configuration were then compared to identify delay reductions resulting from the improvements. Following the evaluation, the Capacity Team developed a plan of "Recommended Alternatives" for consideration, which is shown in Figure 2.

Figure 6 illustrates the impact of delays at San Juan 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. Annual delay cost will increase from $8.69 million at the Baseline (1990) level of operations to $70.31 million by Future 2. The chart also shows that the greatest savings in delay costs would be provided by:

- implementing improved departure restrictions,
- unrestricted use of Runway 10,
- enhancing general aviation (GA) reliever airports (and reducing GA activity by 50 percent),
- constructing new ramp area on south side,
- constructing holding pads (staging areas) at the ends of Runways 8 and 10 with positions for holding five aircraft,
- expanding existing north/south taxiway to provide two-directional capability, and
- constructing a new north/south crossfield taxiway at the west end.

Figure 6 Annual Delay Costs — Capacity Enhancement Alternatives





Section 2

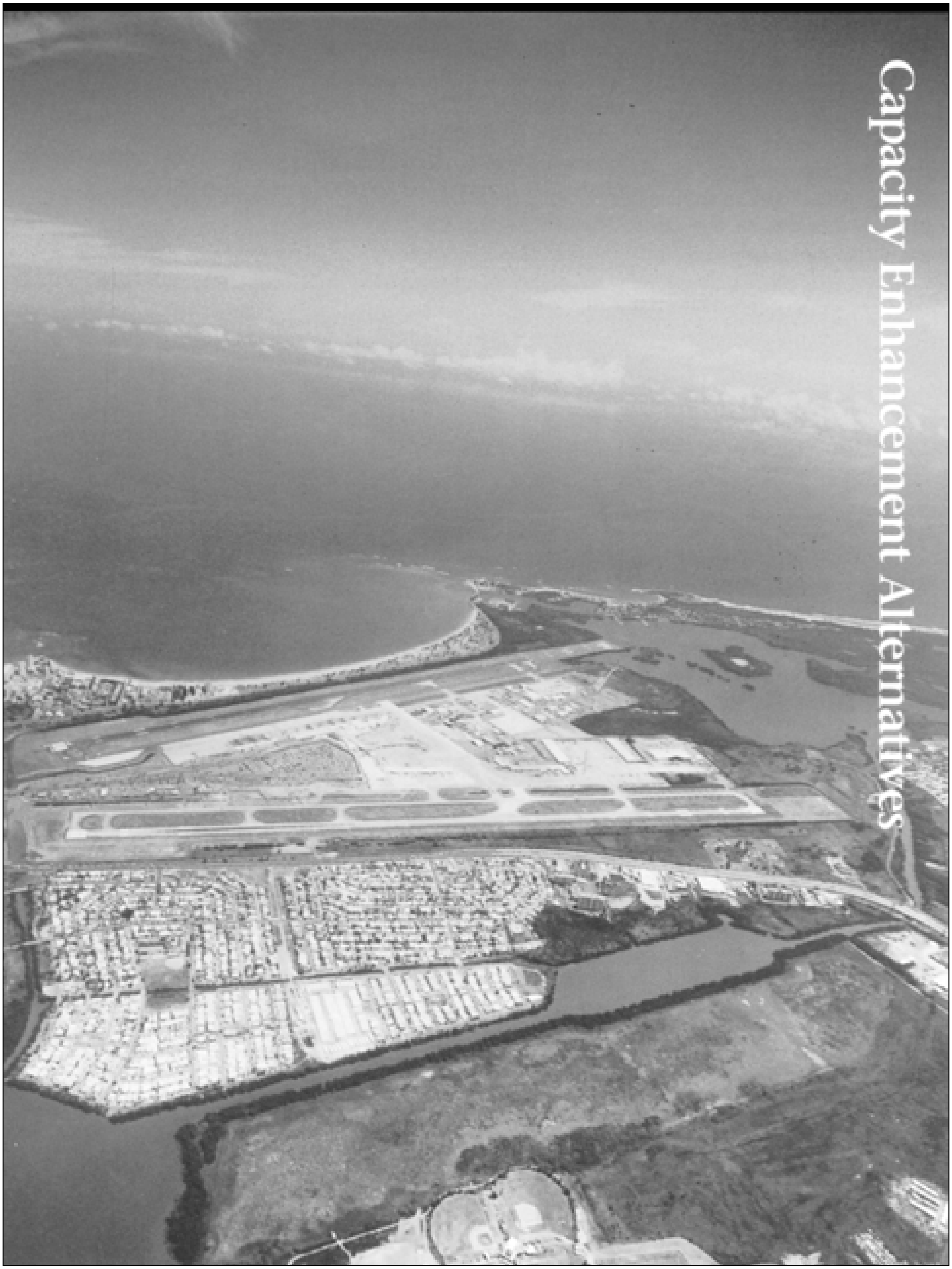


Figure 1 shows the current layout of the airport, plus the airfield improvements considered by the SJU Capacity Team.

Figure 2 presents the alternatives recommended by the Capacity Team and the estimated annual delay savings benefits for the recommended alternatives that were analyzed by model simulations. The savings benefits of these improvements are not necessarily additive.

Figure 7 lists the various capacity enhancement alternatives that were considered by the Capacity Team and the recommended action and suggested demand level for each improvement using the activity levels, Baseline, Future 1, and Future 2. These activity levels correspond to annual aircraft operations of 200,000, 250,000 and 300,000 respectively.

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

- Airfield Improvements.
- Facilities and Equipment Improvements.
- Operational Improvements.
- User Improvements.

Figure 7 Capacity Enhancement Alternatives Considered

Options	Action	Time Frame
Airfield Improvements		
1. Construct new north/south taxiway complex at west end.	Recommended	Baseline
2. Expand existing north/south taxiway to provide two-directional capability.	Recommended	Baseline
3. Extend Taxiway S.	Recommended	Baseline
4. Develop ramp area on south side of airport.	Recommended	Baseline
5. Construct new and improve existing exits on Runways 8 and 10.	Recommended	Baseline
6. Expand existing Taxiway S and H to dual taxiways adjacent to north and south ramps.	Recommended	Baseline
7. Construct holding pads at ends of Runways 8 and 10.	Recommended	Future 1
8. Construct new international passenger terminal.	Recommended	Baseline
9. Construct new north/south dual parallel taxiway between Runway 26 and Runway 28 thresholds.	Not Recommended**	
10. Realign Runway 10/28 parallel with Runway 8/26.	Not Recommended**	
11. Construct new general aviation (GA) runway.	Not Recommended**	
12. Extend Runway 10/28 to the east to 9,250 ft in length.	Study*	
Facilities and Equipment Improvements		
13. Upgrade VOR to include doppler.	Recommended	Future 1
14. Construct new airport traffic control tower.	Recommended	Baseline
15 Install wake vortex advisory system.	Recommended	Future 2
16. Install Terminal ATC Automation (TATCA) enhancements.	Recommended	Future 2
17. Install improved approach aids on Runway 26.	Recommended	Baseline
17a. Install Precision Approach Path Indicator (PAPI).		
17b. Install Instrument Landing System (ILS) Runway 26.		
Operational Improvements		
18. Implement improved departure spacing.	Recommended	Baseline
19. Use 2.5 NM separations on final approach.	Recommended	Baseline
20. Unrestricted use of Runway 10.	Recommended	Baseline
User Improvements		
21. Remove military operations.	Recommended	Future 2
22. Enhance General Aviation (GA) reliever airports (and reduce GA activity by 50 percent).	Recommended	Future 1

* The term "Study" suggests that a specific study be conducted on the subject 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. The individual proposal requires further investigation at a level of detail that is beyond the scope of this effort.

** See narrative description in Section 2 — Capacity Enhancement Alternatives.

Airfield Improvements

1. Construct new north/south taxiway at the west end.

Based on initial studies by the FAA's Technical Center, the capacity of the airport's existing taxiway system proved insufficient to handle aircraft ground movement at Future 1 and Future 2 demand levels.

1a. Construct single one-way taxiway (incorporated in the airfield's Baseline configuration).

The Capacity Team reviewed alternatives to satisfy the required ground movement capacity and concluded that a single west crossfield taxiway was critical to maintain adequate aircraft ground movement at increased activity levels. This taxiway connecting the thresholds of Runway 8 and Runway 10 would be about 1,500 feet in length and bridge over the airport entrance roads. The Capacity Team directed the FAA Technical Center to include a single west crossfield taxiway in the Baseline activity level and to study the benefit and, if required, the addition of a second west crossfield taxiway.

The estimated project cost in 1990 dollars for a single west crossfield taxiway is $25.0 million.

1b. Construct two-directional taxiway.

As a further operational efficiency improvement, a second taxiway would be constructed that would provide two-way flow, permitting arriving and departing aircraft to move unimpeded between the thresholds of Runways 8 and 10.

The cost in 1990 dollars to construct a second west crossfield taxiway is $10.0 million.

Annual savings at the Future 1 activity level would be 1,499 hours or $2.26 million, and, at Future 2 activity levels, 4,545 hours or $6.85 million.

Further analysis and criteria were based on:

- Indications from the airport's users that the airport will be approaching Future 1 traffic levels by 1992.
- The construction of these taxiways can begin immediately since the construction area has no major facilities requiring relocation compared to the east side north/south taxiway system, which requires major infrastructure development, lease negotiations, and tenant relocations.
- The construction of the west crossfield taxiway system provides improved ground traffic, reduced delays, and a financial payback in 18-36 months.
- A west crossfield taxiway sytem provides the Control Tower the flexibility and added capacity to use either Runway 8 or 10 for air carrier departures from any gate with minimum ground travel.

- Airports with the arrival/departure activity levels associated with hub operations normally have dual taxiways around the terminal areas to expedite ground movement. The airport should institute, if ultimately approved by the FAA, the recommended commuter taxi lanes on the north and south ramps and begin, as soon as possible, efforts to expand the ability of the north/south taxiway to provide dual capability.

2. Expand existing north/south taxiway to provide two-directional capability.

This project would provide an additional parallel north/south taxiway to the east of the existing north/south apron-edge taxiway, spaced to allow Boeing 747 aircraft to pass. By allowing two-way traffic for arriving and departing aircraft to taxi to and from the terminal and the runway, it would reduce taxi interference and delays. This would become a multi-year project that would require the following phased schedule:

a. buy out current leases presently occupying project site;

b. establish suitable replacement sites for relocation of affected tenants (see alternative 4);

c. demolish or relocate existing structures;

d. clear and grade project site; and

e. construct taxiway, install security fence, and relocate guard gate.

The estimated project cost in 1990 dollars is $8.0 million.

Annual savings at the Future 1 activity level would be 6,005 hours or $9.05 million, and, at Future 2 activity levels, 11,810 hours or $17.8 million.

3. Extend Taxiway S.

This project would extend parallel Taxiway S about 2,200 feet to the threshold of Runway 26. This extension is needed to enhance runway capacity by eliminating the need for Runway 8 arrivals and Runway 26 departures to back-taxi on the runway.

The estimated project cost in 1990 dollars is $4.5 million.

4. Develop a new ramp area on the south side of the airport.

This project would provide a new support area south of Runway 10/28 to allow additional airport growth and provide for the relocation of facilities from other airport areas. The project would include:

a. Construction of a general aviation taxiway system on the south side of and parallel to Runway 10/28 in order to develop this area for aviation related uses, such as FBO's, corporate hangars, etc. This taxiway segment would be about 3,200 feet long and 75 feet wide.

b. Development of general aviation aircraft aprons to serve the new FBO area. These aprons would be about 300 by 1,000 feet, with an additional support area of 300 by 1,000 feet.

The estimated project cost in 1990 dollars is $15.0 million.

Annual savings at the Future 1 activity level would be 7,477 hours or $11.27 million, and, at Future 2 activity levels, 25,504 hours or $38.44 million.

5. Construct new and improve existing exits on Runways 8 and 10.

This project would reduce runway occupancy times and enhance capacity through:

a. construction of a new spiral exit for commuter and general aviation aircraft on Runway 10 between existing Exits D and E approximately 3,200 feet from the Runway 10 threshold;

b. construction of a new spiral exit to serve smaller jet aircraft on Runway 8 between existing Exits W and V about 4,500 feet from the Runway 8 threshold connecting to the existing north/south taxiway; and

c. improvement of existing Exits V, X, and F to spiral exits.

The estimated project cost in 1990 dollars is $5.0 million.

Annual savings at the current Future 1 level would be 577 hours or $0.87 million, and, at Future 2 activity levels, 1,373 hours or $2.07 million.

6. Expand existing Taxiways S and H to dual taxiways (for commuter aircraft) adjacent to north and south ramps.

This project would re-stripe the north and south ramps to provide for commuter aircraft taxiways parallel to the existing Taxiways S and H. Completion of this project would improve the flow of ground traffic and reduce taxi interference and delays for commuter aircraft.

The estimated project cost is $10,000.

7. Construct holding pads (staging areas) at the ends of Runways 8 and 10.

Air traffic flow control often dictates that aircraft hold at the runway thresholds before takeoff because of departure fix restrictions. Expanding the staging areas at the ends of the runways would improve the ability of departing aircraft to bypass those aircraft waiting for departure clearance.

The Capacity Team evaluated expanding the existing threshold pads on Runway 8 and constructing three to five holding positions on Runway 10.

The estimate project cost in 1990 dollars is $6.0 million.

Annual savings at the current (Baseline) activity level if three holding positions were added on each runway would be 350 hours or $0.53 million, and, at Future 2 activity levels, 5,583 hours or $8.41 million.

Annual savings at the current (Baseline) activity level if five holding positions were added on each runway would be 447 hours or $0.67 million, and, at Future 2 activity levels, 7,717 hours or $11.63 million.,

8. Construct new international passenger terminal (Terminal A).

A new international passenger terminal, ultimately capable of handling seven Boeing 747 aircraft concurrently, is planned. The ramp area is currently under construction to the south and west of existing Terminal B.

9. Construct new north/south dual parallel taxiway on the east side between the thresholds of Runways 26 and 28.

This project would connect the Runway 26 and 28 thresholds and provide an alternate route between the north and south sides of the airport east of the central support area. It would serve primarily cargo, military, and general aviation aircraft destined for service, cargo, and maintenance areas in the central service area of the airport. The use of this taxiway would reduce demand on the existing north/south taxiway east of the terminal area.

However, after review of the potential location, the Capacity Team determined that such a taxiway would not be feasible due to the high cost and the severe environmental impact on the east-side wetlands.

10. Realign Runway 10/28 parallel with Runway 8/26.

This project would reorient Runway 10/28 to allow simultaneous arrivals and departures. This proposed realignment would have significant environmental (noise) impact on the existing communities and would require the relocation of major portions of the surrounding communities to provide the land necessary for development. In view of these impacts, the Capacity Team agreed that this alternative was not feasible.

11. Construct new commuter/ general aviation (GA) runway.

This project would construct a 4,000 foot commuter/general aviation runway parallel to existing Runway 8/26 to allow simultaneous landings and take-offs for commuters and GA aircraft. The location of this runway would require bridging the access road to the central support area and would have an impact on the wetlands on the east side of the airport. Due to the cost and environmental problems and the success of the "Olympic Approach," which allows simultaneous landing of commuters on Runway 10 with air carriers on Runway 8, the Capacity Team did not consider this project of sufficient merit to warrant further study.

12. Extend Runway 10/28 1,250 feet to the east for a total length of 9,250 feet.

Runway 10/28 is currently 8,000 feet in length; Runway 8/26, 10,000 feet. Larger and heavier aircraft tend to prefer use of Runway 8 for landing. In order to allow air traffic control greater flexibility in the use of runways and thus enhance capacity, the Capacity Team recommends that the Puerto Rico Ports Authority study the feasibility of extending Runway 10/28 to 9,250 feet. The future use of Runway 10/28 by Stage III aircraft would also benefit from a longer runway length.

Facilities and Equipment Improvements

13. Upgrade VOR to include Doppler.

The existing VOR facility at the airport is used to radiate azimuth information for instrument approach procedures. Located in the northeast quadrant of the airport, it requires a sterile clear zone in order to maintain signal integrity The amount of land required and the severe grading and clearance criteria to maintain this clear zone severely restricts development of land-side facilities

If an acceptable alternate site could be identified when the facility is upgraded, additional land on the airport might become available for air-side or land-side development.

14. Construct new air traffic control tower.

Air traffic controllers are required to have a clear view of all operational surfaces in order to route traffic safely and efficiently. Engineering analyses have determined that airfield improvements will be limited unless a new, taller air traffic control tower is built.

15. Install wake turbulence advisory system.

Since the turbulence created by heavy aircraft at landing and take-off speeds can be hazardous to trailing aircraft, the FAA has established minimum separations to eliminate the hazards of these wake vortices. By providing the ability to predict wake turbulence, installation of a wake turbulence advisory system would allow for improved separation.

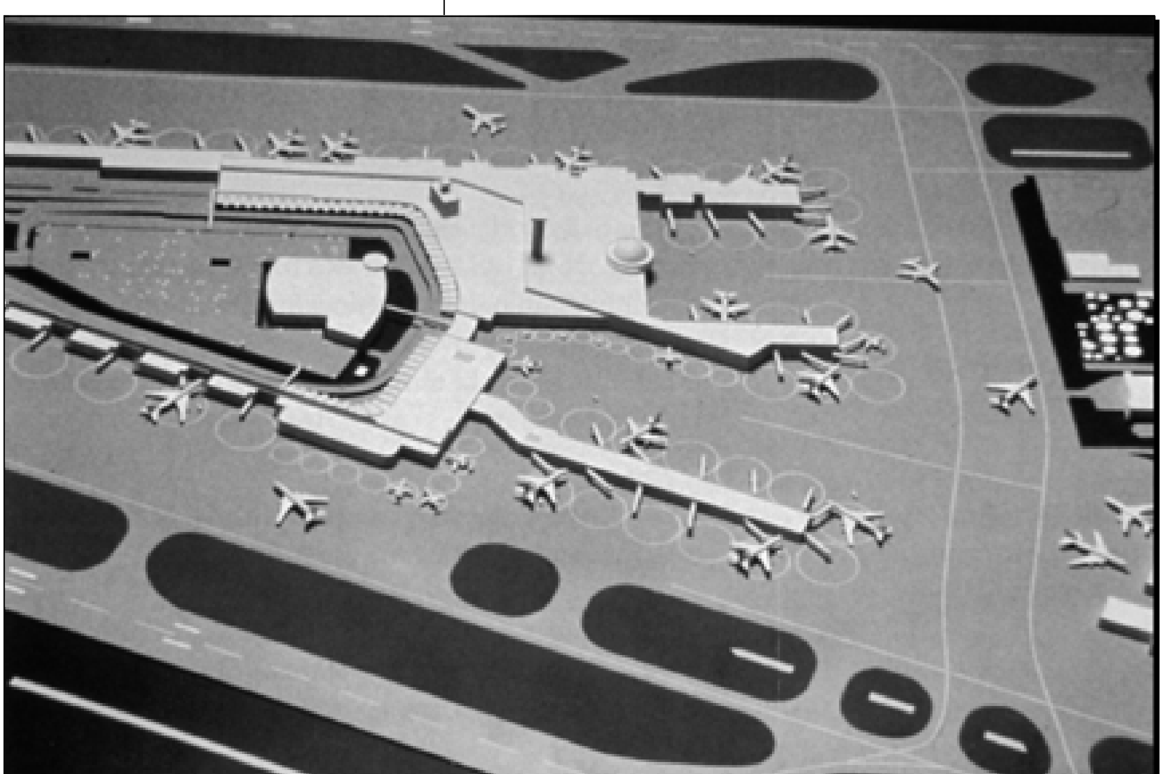
16. Install Terminal Air Traffic Control Automation (TATCA) enhancements.

The development and implementation of new technologies offer significant promise to improve capacity. TATCA is a research and development program that is developing Air Traffic Control (ATC) automation aids. TATCA automation aids will help controllers use the available capacity of terminal airspace more fully and increase the safety and efficiency of aircraft operations into and out of terminal areas, particularly under Instrument Meteorological Conditions (IMC).

The TATCA program includes the Dynamic Traffic Planner (DTP), a comprehensive traffic planning and coordination aid that will automatically derive current traffic demand information from surveillance, flight plan, and manual input data. It will use this information to suggest acceptance rates and other important planning measures and to calculate efficient landing sequences. It will provide a final approach spacing aid, a converging approach delivery aid, speed control and holding advisories, and descent advisories. The DTP will present its products to individual members of the terminal controller team via a customized local display of the landing plan in the form of coordinated displays of aircraft arrival times and landing sequences.

A related TATCA activity is the accelerated development of a final approach spacing aid, specifically for airports with converging approaches. The converging-approach delivery aid will assist controllers in feeding staggered approach streams to converging runways.

The TATCA program was initiated in FY 1989. Evaluation of the initial arrival planning functions is planned for FY 1993, with evaluation of the integrated arrival and departure planning function and controller advisories to begin in the following year. The results of these evaluations will provide the basis for the preparation of specifications for operational implementation.



17. Install improved approach aids on Runway 26.

The current approach to Runway 26 is equipped with visual approach slope indicators (VASI) and runway end identifier lights (REIL). Comments from pilots landing on this runway at night indicate that a "black hole" effect, or perceived blind spot, occurs during approaches and makes landings more difficult.

17a. Install Precision Approach Path Indicator on Runway 26.

A Precision Approach Path Indicator (PAPI) could be installed relatively soon and would improve the approach to Runway 26 by providing pilots a greater degree of visual enhancement .

17b. Install Instrument Landing System (ILS) on Runway 26.

Adding ILS will improve operating capability under instrument meteorological conditions (IMC). This will reduce visibility minimums and thereby maintain capacity during IMC.

Operational Improvements

18. Implement improved departure spacing.

Improving the minimum in-trail departure spacing from 10 to 5 minutes per departure over the north departure fix would enhance efficiency and capacity and reduce costs and delay.

Annual savings at the current (Baseline) activity level would be 673 hours or $1.01 million, and, at Future 2 activity levels, 3,101 hours or $4.67 million.

19. Use 2.5 NM separations on final approach.

Existing procedures for Instrument flight Rules (IFR) conditions require that arriving aircraft be separated by 3 NM or more. Reducing separation minimums to 2.5 NM would increase runway capacity. Most of the savings occurs at the highest demand levels during IFR conditions.

20. Unrestricted use of Runway 10.

If all aircraft presently operating at SJU were allowed to operate free of noise restrictions on Runway 10, there would be a significant reduction in annual delays. Annual savings at the current (Baseline) activity level would be 586 hours or $0.88 million, and, at Future 2 activity levels, 7,639 hours or $11.51 million.

Currently, about 40 percent of the fleet of air carrier aircraft serving SJU meet Stage III noise requirements, with even higher percentages forecast for Future 1 and 2 activity levels. If only Stage III aircraft were allowed to follow relaxed noise abatement procedures now on Runway 10 instead of all aircraft, the savings would be somewhat less, but still significant. The Capacity Team recommends revised noise abatement procedures for Stage III aircraft to encourage the airlines to use more Stage III aircraft in their fleets serving SJU.

User Improvements

21. Remove military operations.

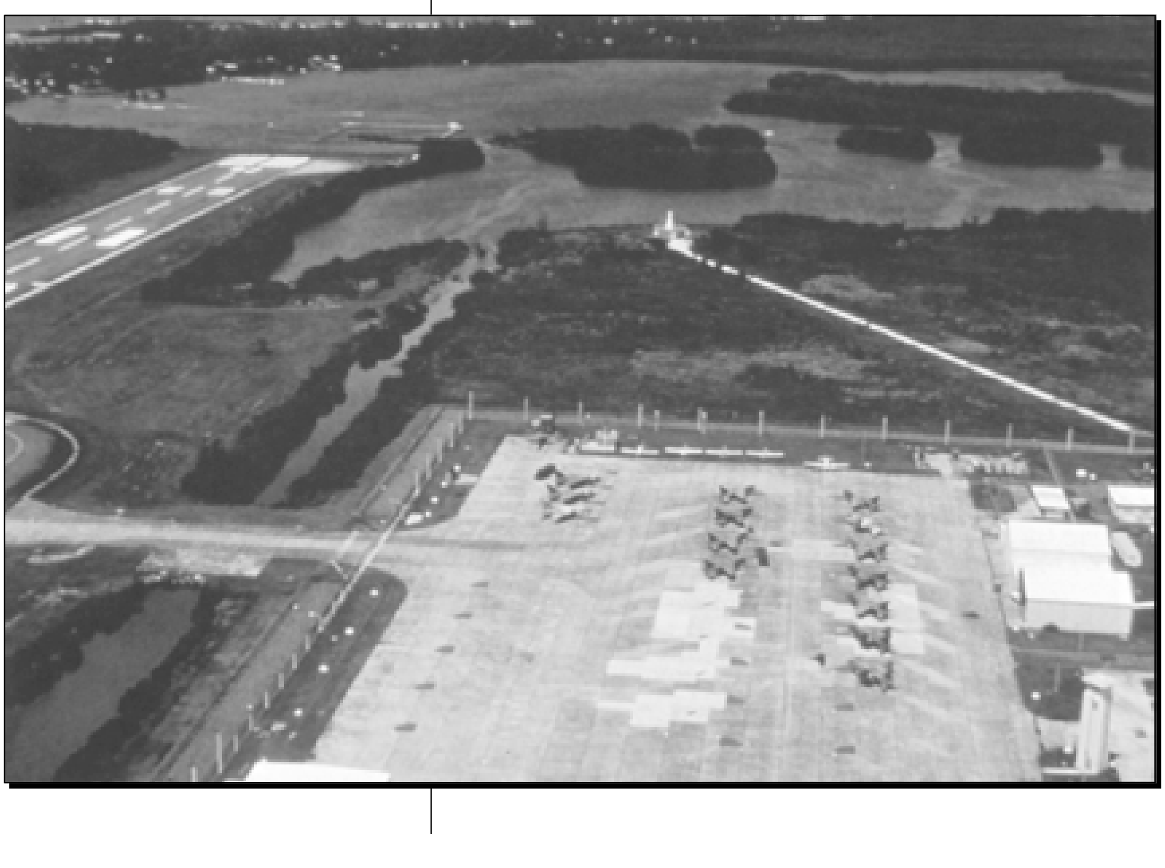
If military aircraft were relocated to other airports, airfield capacity at SJU would become available for additional commercial aircraft and for terminal expansion.

Annual savings at the current (Baseline) activity level would be 150 hours or $0.23 million, and, at Future 2 activity levels, 773 hours or $1.17 million. It should be noted that replacement of the removed military operations with other aircraft will produce less than the stated benefit.

22. Enhance general aviation (GA) reliever airports.

The percentage of general aviation activity is expected to remain constant at 16 percent of the annual operations for the three demand levels. GA should be encouraged to use other airports to serve the San Juan metropolitan area. Safe and reliable facilities and attractive service would need to be provided at reliever airports. Ground transportation connections may be necessary.

A 50 percent reduction in the anticipated GA activity at SJU would result in an annual savings of 913 hours or $1.38 million at the current (Baseline) activity level, and, at Future 2 activity levels, of 5,955 hours or $8.97 million. It should be noted that replacement of the removed general aviation operations with other aircraft will produce less than the stated benefit.



Section 3

Overview

The San Juan Luis Muñoz Marín International Airport Capacity Team evaluated the efficiency of the existing airfield and the proposed future configuration. Figure 8 illustrates airfield weather conditions, Figure 9, runway utilization, and Figure 10, the annual distribution of traffic at SJU. 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 Juan International Airport (SJU) has an average direct operating cost of $25.12 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 any other intangible factors.

The cost of a particular improvement is measured against its annual delay savings. This comparison indicates which improvements would 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 8 Airfield Weather

	Ceiling/Visibility	Occurrence (%)
VFR 1	2,000 feet or above / 5 SM or above	95
VFR 2	Between 1,999 and 1,000 feet / 5 and 3 SM	4
IFR	Below 1,000 feet / less than 3 SM	1

VFR — Visual Flight Rules

IFR — Instrument Flight Rules

SM — Statute Miles

Figure 9 Runway Utilization (%)

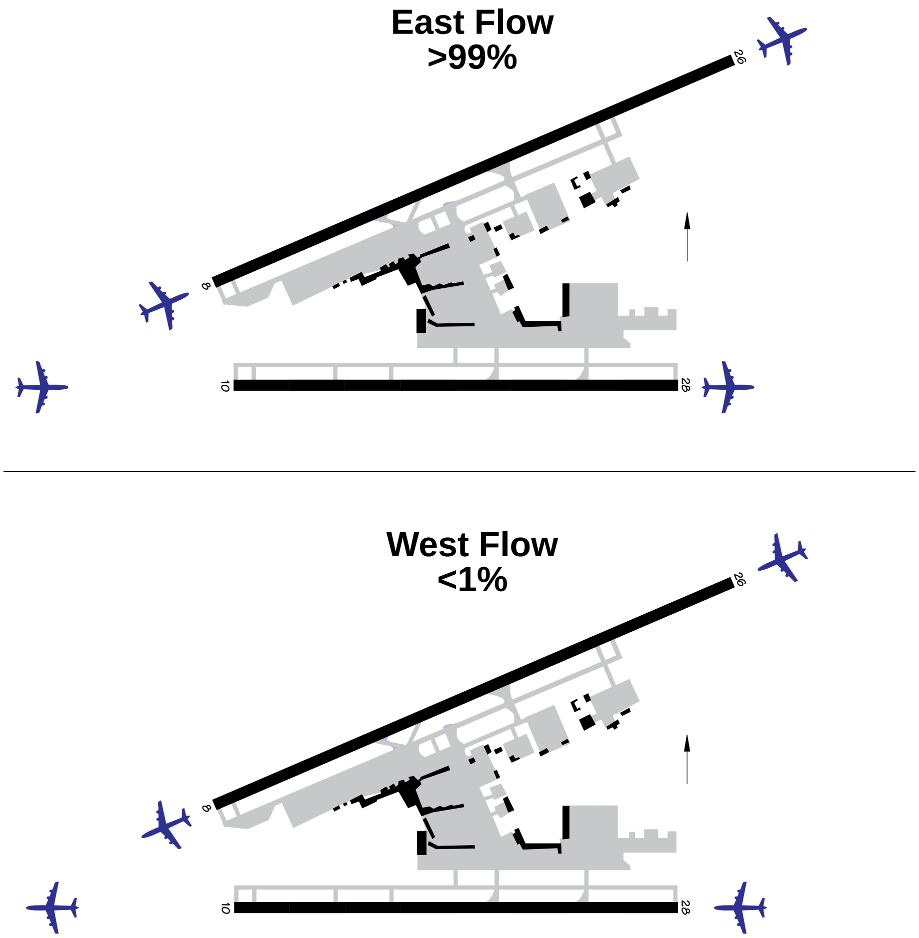
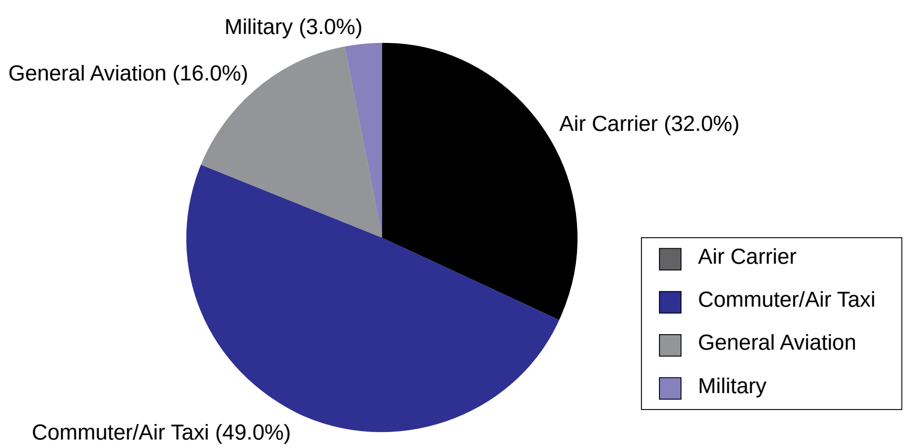


Figure 10 Annual Distribution of Traffic



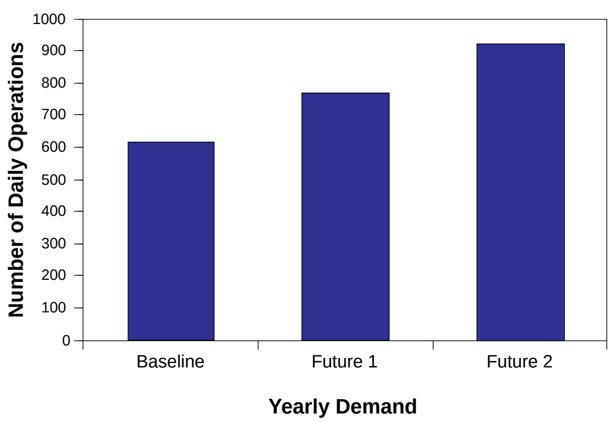
Airfield Capacity

The SJU 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:

- Levels of delay
- Airspace constraints
- Ceiling and visibility conditions
- Runway layout and use
- Aircraft mix
- Percentage of arrival demand versus departure demand

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

Figure 11 Airfield Demand Levels — Aircraft Operations and Average Day of Peak Month



Number of Operations

Annual	24-Hour Day (Average Day, Peak Month)	Peak Hour
Baseline — 200,000	618	58
Future 1 — 250,000	772	70
Future 2 — 300,000	926	83

Figure 12 presents the airport capacity curves for SJU. These curves were developed for various runway configurations, under visual flight rules (VFR) conditions (instrument flight rules (IFR) conditions occur only about one percent of the time at SJU), with a 70/30, 50/50, and a 30/70 ratio of arrivals to 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 flow (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 200,000 aircraft operations per year. It also includes a curve that depicts the profile of daily operations for the Future 2 activity level of 300,000 aircraft operations per year.

Comparing the information in Figures 12 and 13 shows that

- aircraft delays will begin to escalate rapidly as hourly demand exceeds 60-70 operations per hour, and,
- while hourly demand doesn't exceed 60-70 operations at Baseline demand levels, 60-70 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

Figure 12 Airport Capacity Curves — Flow Rate Versus Average Delay

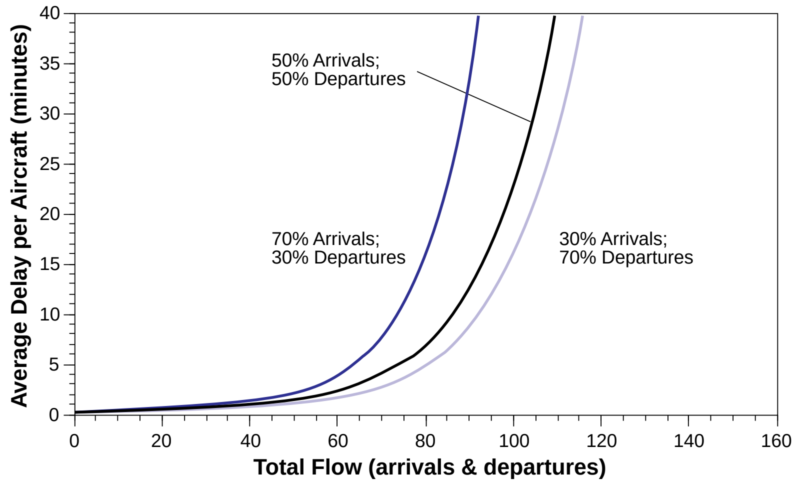
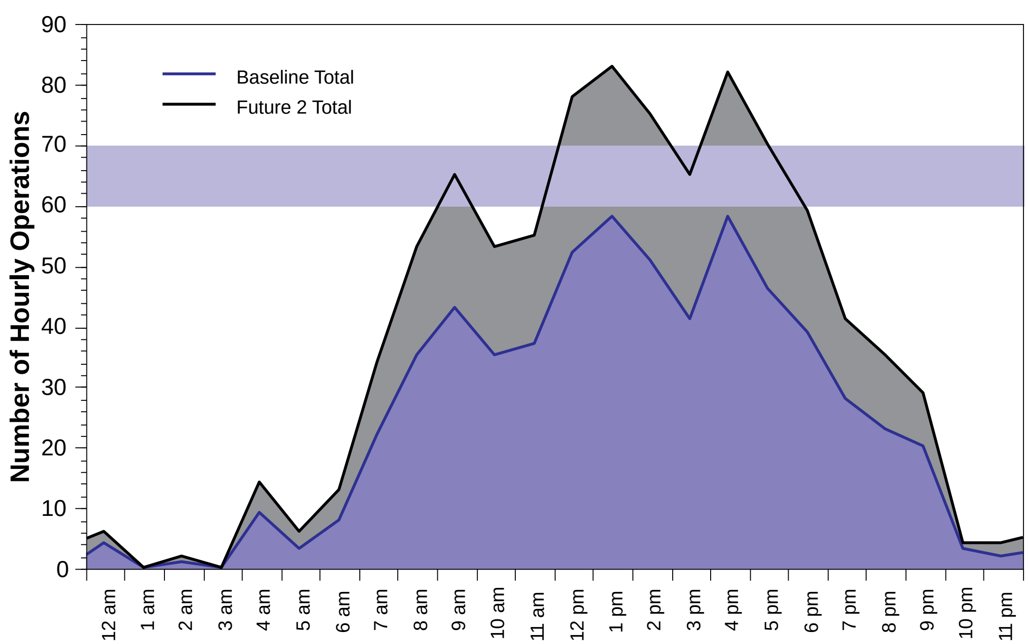


Figure 13 Profile of Daily Demand — Hourly Distribution



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 in the system 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 1.7 minutes in Baseline will increase to 9.3 minutes per operation by Future 2.

Under the "Do Nothing" situation, if no improvements were made in airfield capacity, annual delay costs would increase as follows:

Annual Operations	Annual Delay Costs Hours	Annual Delay Costs Millions of 1990$
Baseline (1990) — 200,000	5,766	$8.69
Future 1 — 250,000	12,891	$19.43
Future 2 — 300,000	46,649	$70.31

Appendix A

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Appendix B

Computer Models and Methodology

The SJU 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 SJU 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. 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)

There are two forms of the RDSIM model. The first is a short version of the ADSIM model that simulates only the runways and runway exits. This version ignores the taxiway and gate complexes for a user-specified daily traffic demand. The second version, also simulates the runway and runway exits, 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 SJU.

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