Aviation Planning Services

Executive Summary

San José, Costa Rica

V.I

1993

ACKNOWLEDGEMENTS

The Consultants would like to express their appreciation of the support and assistance during the course of this study, which was received from the staff of MOPT, ICT, Banco Central, Canatur and many others. In particular, the efforts of Sr. Alvaro Escalante, Director General, DGAC and Ing. Fernando Mendez A., Chief of the Aeronautical Infrastructure Department, have been most supportive and without whose assistance, this study would have been much more difficult to accomplish.

In addition, we would like to acknowledge the contribution of the Canadian International Development Agency, through the Industrial Cooperation Program, since the project would not have been possible without their support.

SECTION NUMBER | **PAGE NUMBER**

FIGURE NUMBER		PAGE NUMBER

TABLE NUMBER		PAGE NUMBER

1. INTRODUCTION

This document presents a summary of the study for the possible development of a replacement for Juan Santamariá International Airport in San José, Costa Rica (see Figure 1.1). The study was commissioned by the Ministry of Public Works and Transportation (MOPT) in Costa Rica, which was sponsored by the Canadian International Development Agency (CIDA) under the Capital Project Preliminary Study mechanism of the Professional Services section, within CIDA's Industrial Cooperation Program.

This report constitutes Volume I of a four volume set of documents presented to the MOPT, which are as follows:

- **Volume I: Executive Summary;**
- Volume II: Air Traffic Demand Forecasts;
- Volume III: Site Selection;
- Volume IV: Economic Feasibility.

The overall objective of the entire study is described in the Terms of Reference, supplied by the MOPT. Specifically, the Terms of Reference states that the Consultants were to work with technicians from the MOPT to undertake the following:

A. Compile all available information of previous studies as well as all statistical information required for this study.

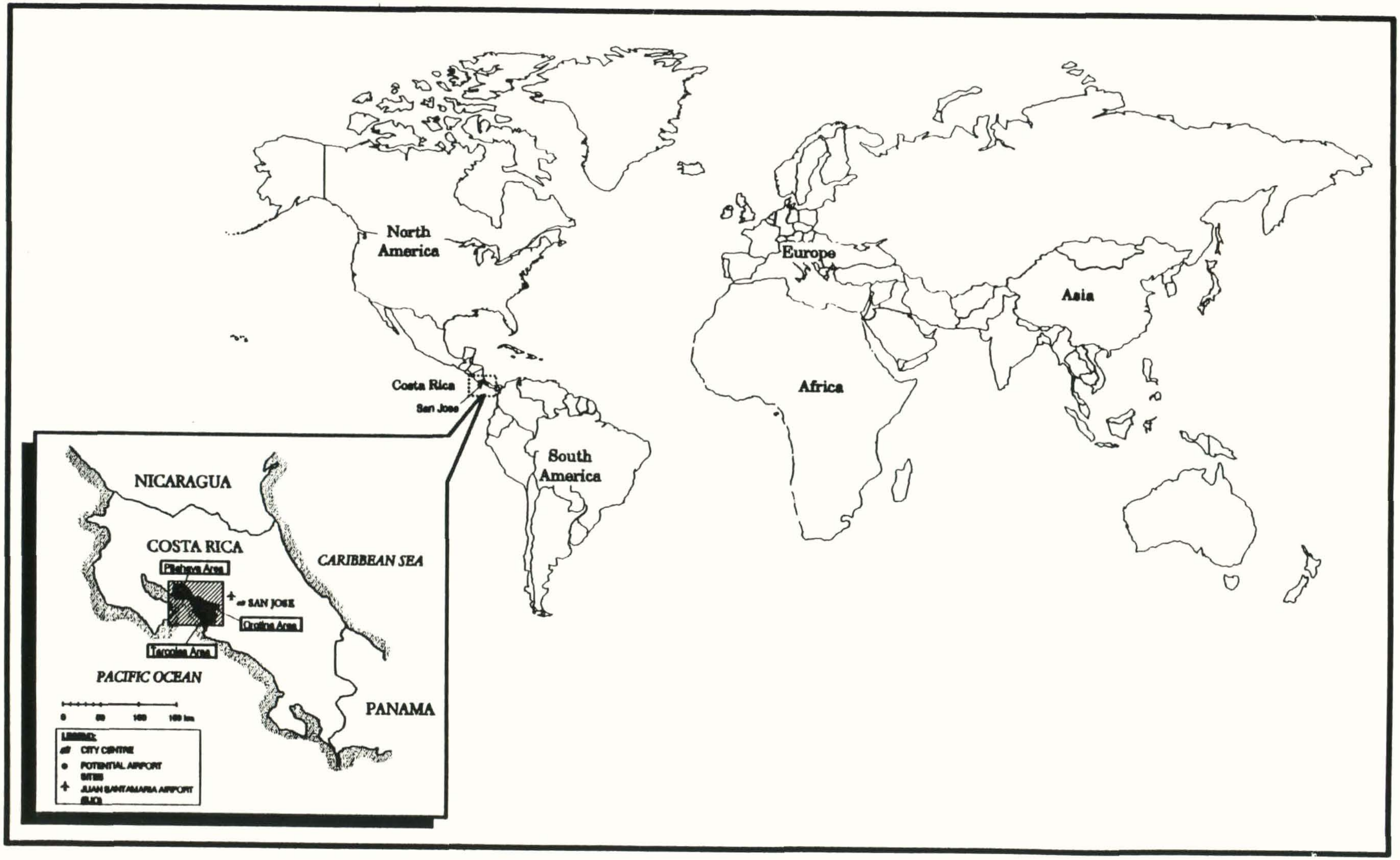
B. Corroborate and update demand forecasts for passengers and cargo in international services.

C. Undertake a technical analysis of the different possible sites mentioned in previous studies, as well as others which may appear feasible.

D. Recommend, from a technical/economic evaluation, the best site.

E. Perform an assessment of the environmental impact of the proposed site.

FIGURE 1.1
GENERAL SITE LOCATION



F. Prepare conceptual plans for the proposed new airport.

G. Prepare an economic and financial analysis of the selected site.

As described in the study completed by the Japan International Cooperation Agency (JICA) under the long term development policy section, Juan Santamariá (SJO) airport has fundamental deficiencies. Some of the problems with the current airport at Juan Santamariá are as follows:

- International obstacle clearance surfaces are currently violated, particularly for aircraft parked on the apron.
- The requirement for the construction of a new runway at SJO would result in a very large investment and at the same time would not alleviate many of the problems.
- Poor meteorological conditions will still remain at SJO.
- Noise pollution will still remain and likely get worse at SJO

The above deficiencies have resulted in the MOPT requirement for a study to examine the feasibility of a new international airport.

2. AIR TRAFFIC DEMAND FORECAST

This section presents a summary of the complete set of aviation forecasts for the period 1991-2010 with projections to the year 2030 for the new international airport, which is to replace Juan Santamariá International Airport. The task of the study was to update and corroborate previous studies. As the report by the Japanese International Cooperation Agency (JICA) was the most recently completed of those reviewed, the JICA results were chosen for review and corroboration.

The Consultants reviewed the assumptions and methodology employed in the JICA study. Although the assumptions were changed by the Consultants, the results are largely similar; however, the importance of the alterations should not be overlooked as they relate to such aspects as aircraft fleet characteristics, timing of demand growth, etc.

2.1 Air Traffic Demand

International passenger growth rates, including charter traffic, averaged 8.5% annually from 1981 to 1991. The latter part of this period, from 1988 to 1991, saw growth rates of 12.9% per annum. The greatest demand for air travel to Costa Rica originates in North America and Central America. Tourism is increasing dramatically in Costa Rica (over 15% per annum since 1988) and is expected to place first in 1992 foreign exchange earnings over the traditional banana and coffee export earnings.

Until the year 2010, North America and Europe are expected to provide the largest increases in the annual growth rate of demand. Table 2.1 summarizes the anticipated growth rates in international passenger demand with projections to the year 2030. By the year 2010, over 2.6 million international passengers are expected to be utilizing the new airport. This figure is projected to rise from over 3.6 million by the year 2020, and over 5 million by the year 2030, less than 40 years away.

TABLE 2.1
International Passenger Demand, 1991-2030
Average Annual Growth Rates

Period	North America	Central America	Europe	Other	Total
1991-2000	6.5%	3.1%	6.2%	2.8%	5.3%
2000-2010	5.0%	3.6%	4.9%	4.4%	4.7%
2010-2030	3.0%	3.2%	4.0%	5.0%	3.3%

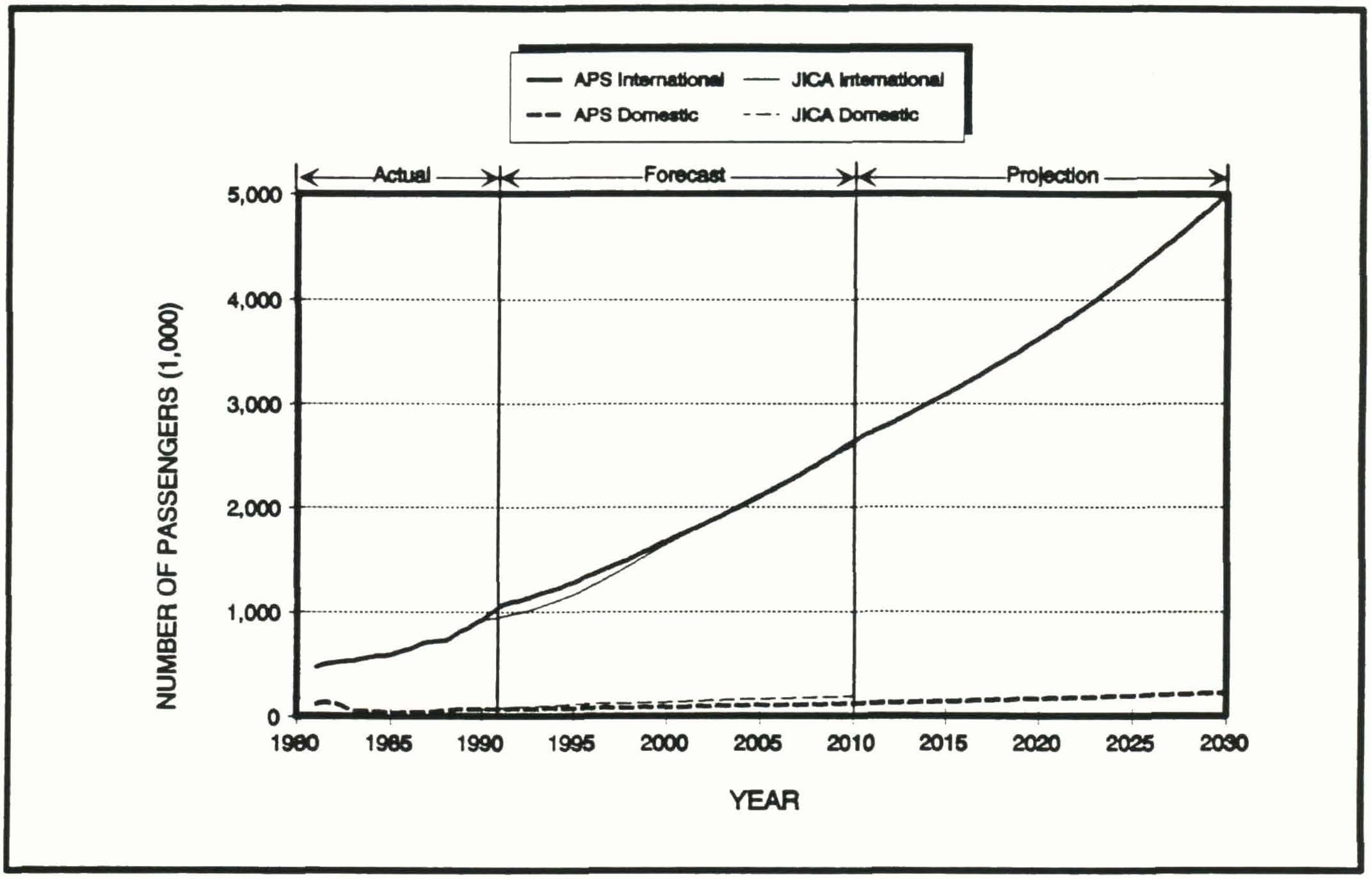
Source: APS Analysis

The domestic demand for air transport is approximately ten percent of all scheduled and charter passenger traffic. Costa Ricans have a demonstrated preference for road travel. Between 1982 and 1983, domestic air traffic dropped by more than 50% when the road system was improved.

The growth in domestic demand is not expected to increase dramatically. For the period 1991 to 2000, an average annual growth rate of 2.9% is forecasted. This figure is projected to increase to 3.2% until the year 2030. Figure 2.1 graphs a comparison of the APS and JICA international and domestic passenger forecasts.

International cargo volumes grew at an average annual rate of 15% during the period 1985 to 1991 fuelled largely by export and import growth to and from North America and import growth from the Caribbean. Central and South America cargo traffic showed negative growth while European cargo traffic growth was minimal. The forecasted growth rates and tonnage are listed in Table 2.2. The growth in cargo occurred during an economic boom in North America. The lower growth rates forecasted reflect the substantial downturn in the world economics.

FIGURE 2.1
ANNUAL PASSENGER FORECAST
1991 - 2030



Source: APS Analysis

TABLE 2.2
Export and Import Cargo Volume Forecasted
1991-2030

YEAR	EXPORTS (Tons)	IMPORTS (Tons)
1991 pr.	38,733	23,943
1992	38,000	19,750
1995	44,070	21,820
2000	58,970	26,410
2005	75,980	31,650
2010	96,970	38,114
2020	157,960	56,900
2030	257,300	87,500
pr. - Preliminary Figures		

PERIOD	AVERAGE ANNUAL GROWTH RATE
1991-2000	3.6%
2000-2010	4.7%
2010-2030	4.8%

Source: APS Analysis

2.2 Aircraft Movements

Narrow-body and wide-body aircraft are currently employed on international passenger routes to Costa Rica (July 1992). The use of wide-body aircraft is expected to increase during the period of the forecast, especially on the charter routes from North America and Europe and on heavy time slots between Miami and Costa Rica. Table 2.3 presents the aircraft movement forecast. Figure 2.2 graphs a comparison of the APS and JICA movement forecasts.

TABLE 2.3
APS Aircraft Movement Forecast, 1991-2030

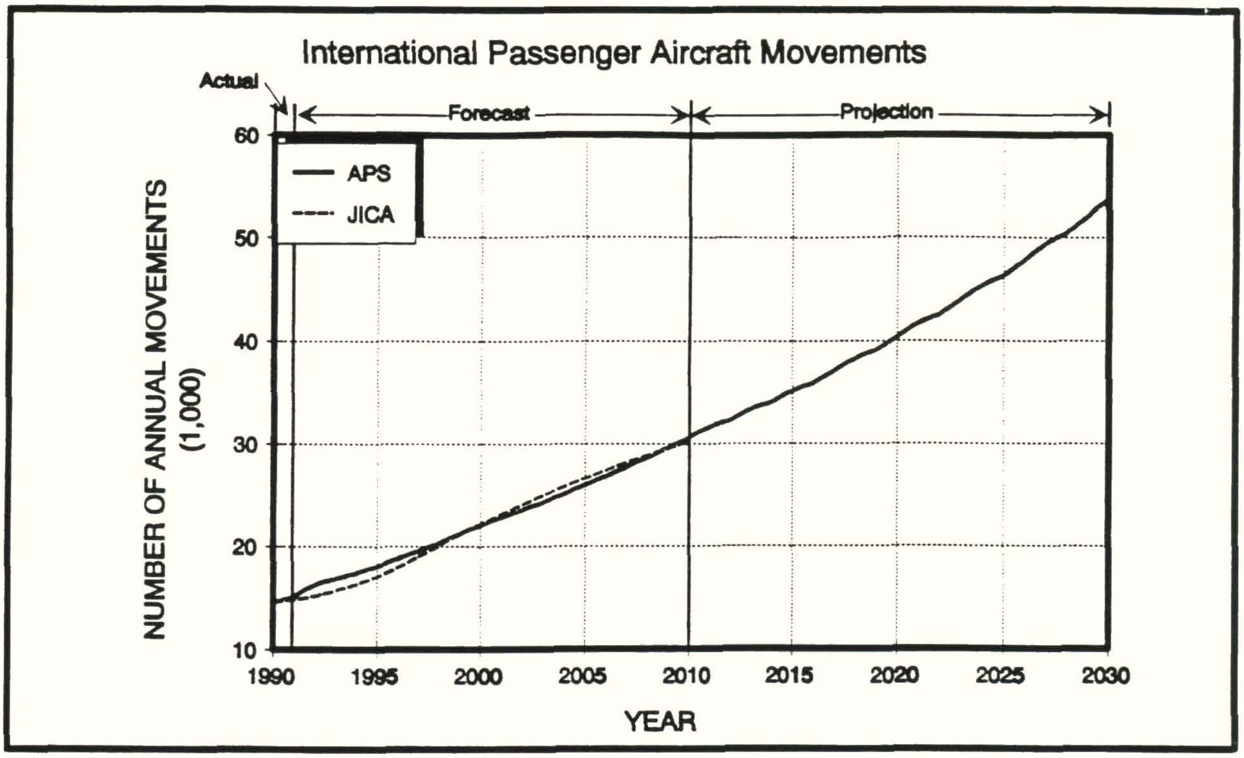
Year			1991	2000	2010	2020	2030
International Passenger Aircraft							
Number of Movements			15,180	21,976	30,622	40,280	53,833
AAGR*	1991-2000	4.2%					
	2000-2010	3.4%					
	2010-2030	2.9%					
Domestic Passenger Aircraft							
Number of Movements			2,931	4,331	4,565	5,421	6,367
AAGR*	1991-2000	4.4%					
	2000-2010**	0.5%					
	2010-2030**	1.7%					
International Cargo Aircraft							
Number of Movements			2,130	1,745	2,826	4,216	7,385
AAGR*	1991-2000	-2.2%					
	2000-2010	4.9%					
	2010-2030	7.5%					
General Aviation Aircraft							
Number of Movements			16,929	20,400	26,700	34,200	41,700
AAGR*	1991-2000	2.1%					
	2000-2010	2.7%					
	2010-2030	2.3%					
Total							
Number of Movements			37,170	48,452	64,712	84,117	109,285
AAGR*	1991-2000	3.0%					
	2000-2010	2.9%					
	2010-2030	4.2%					

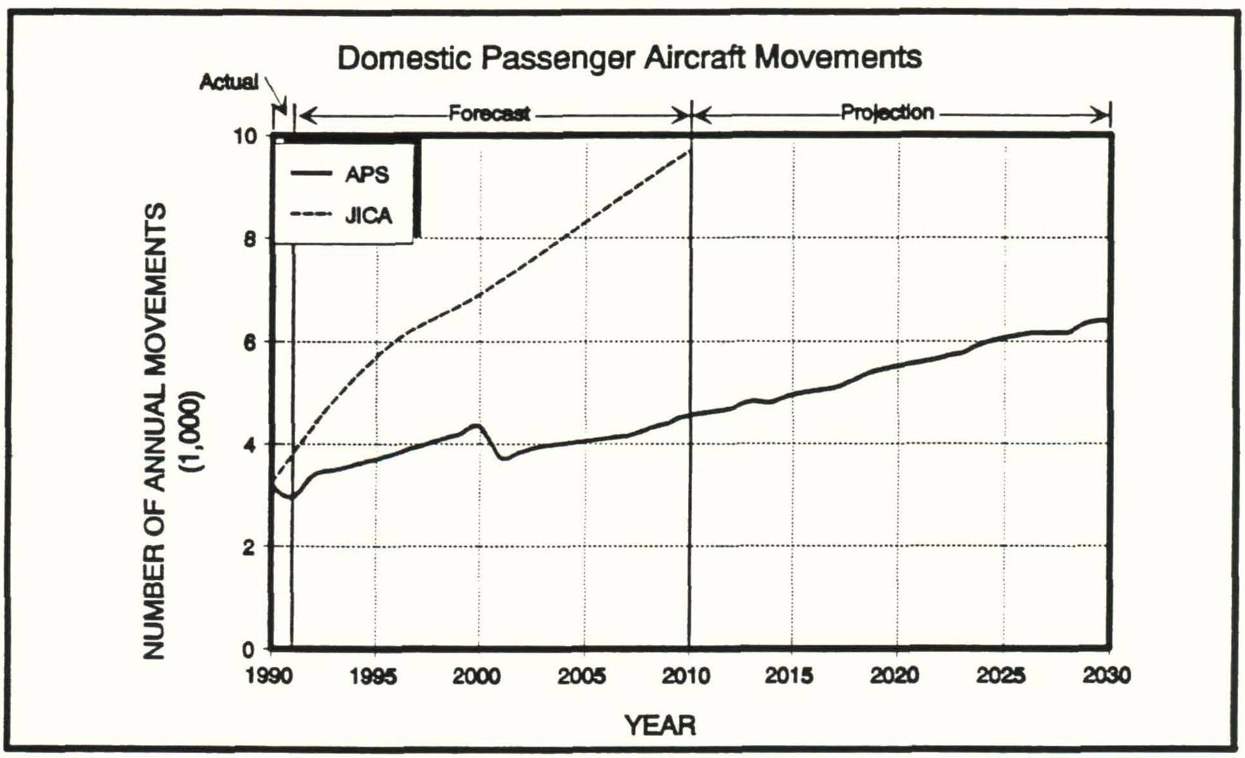
* AAGR is the Average Annual Growth Rate.
**Low growth rate in number of movements due to an increase in aircraft size after year 2000.

Source: APS Analysis

FIGURE 2.2

ANNUAL AIRCRAFT MOVEMENTS FORECAST





Domestic passenger aircraft, typically B.N. Islander 2A/B, CASA 212 and very old DC-3s, will be replaced as they age, presumably with aircraft of an increased capability. Domestic aircraft typically have high load factors averaging approximately 80% due to the limited seating.

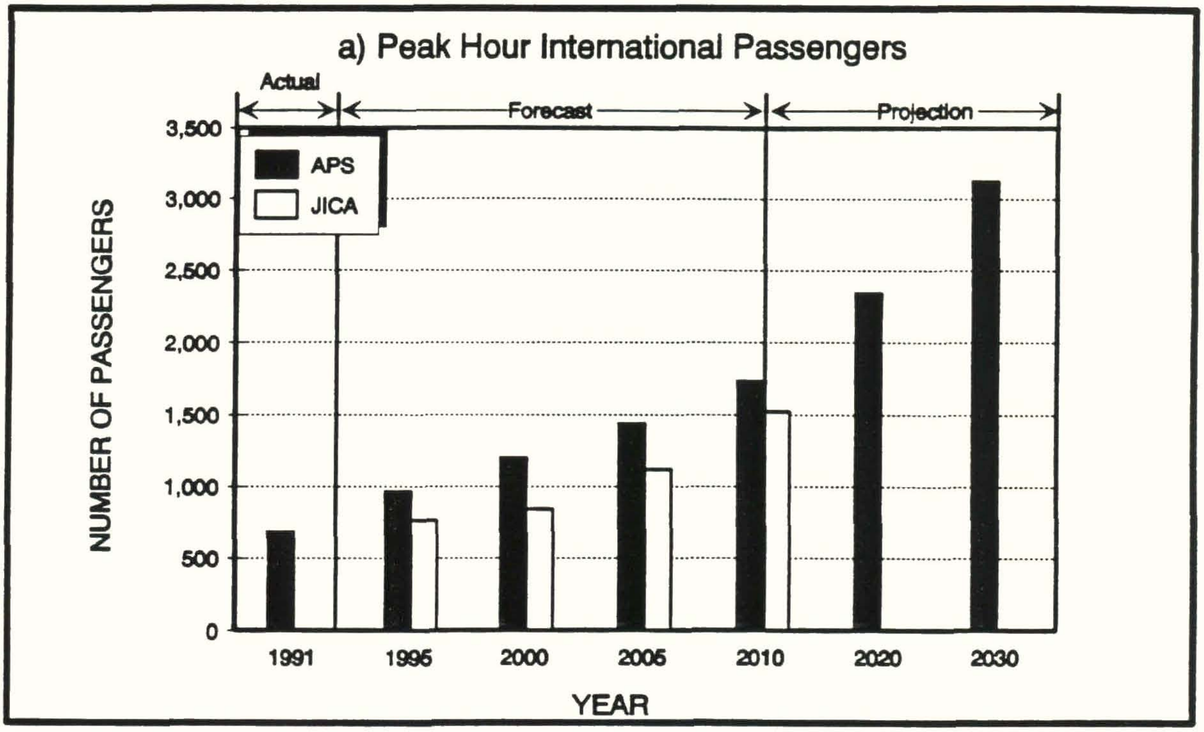
As the aircraft carrying international passengers increase in size, the capacity for belly cargo also increases. Thus, the Consultants anticipate an initial decline in the number of aircraft movements dedicated solely to cargo purposes up to the end of the 1990s. An increase in dedicated freighter movements is then anticipated because the belly cargo capacity on the heaviest route, which is to Miami, will likely be insufficient to carry the forecasted cargo.

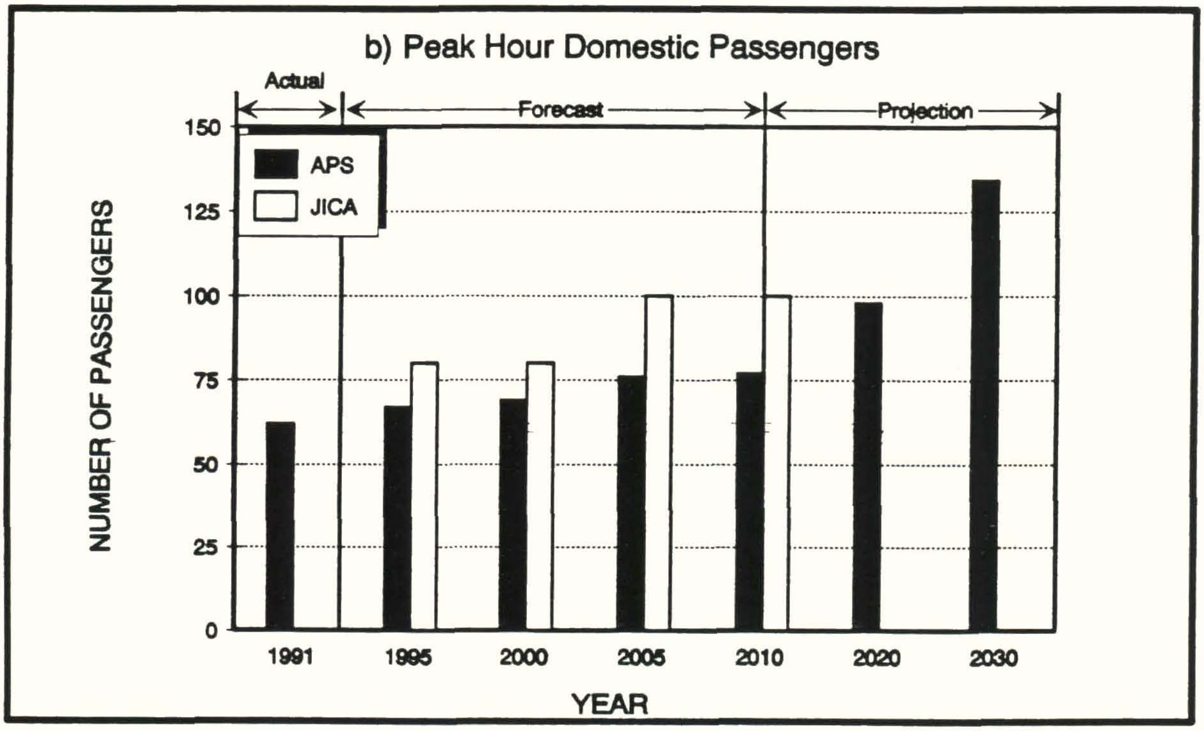
General Aviation movements should continue to be close to the number of international passenger aircraft movements until the year 2010, following which the growth in international passenger aircraft movements surpasses that of General Aviation.

2.3 Planning Peak Hour Passengers (PPHP)

During the period of the forecast, the peak period will receive significantly more passengers than are currently handled, however, on an overall basis, the peak hour will have proportionately less of the total passenger volume. In 1991, planning peak hour international passengers totalled 683, which is forecasted to rise to over 1,700 by the year 2010 and to over 3,100 by the year 2030. Domestic planning peak hour passengers are significantly less at 62 passengers in 1991 and just 134 by the year 2030. Figure 2.3, a) and b), graph the PPHP forecasts for international and domestic passengers.

FIGURE 2.3
PEAK HOUR PASSENGER FORECAST





2.4 Planning Peak Hour Movements (PPHM)

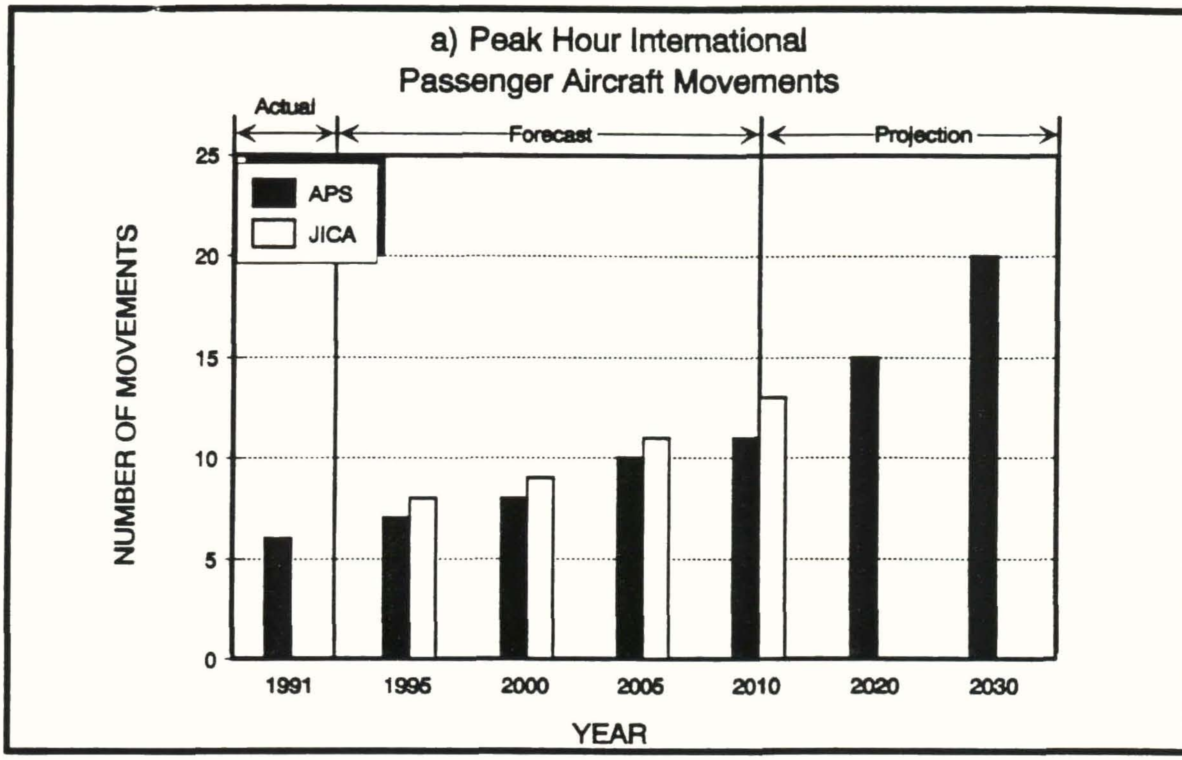
The number of total PPHM is forecasted to rise from the current 16 (1992) to 25 by the year 2010 and 41 by the year 2030. In addition to a peak for all operations considered together, each type of traffic will have its own particular peak hour, which will not necessarily occur simultaneously. For example, international PPHM for 2030 are forecasted at 20 movements while the cargo PPHM is forecasted to be just 5. These peaks will most probably never occur during the same hour as cargo traffic moves largely during the night and international passenger traffic during the day. Figure 2.4, a) and b), graph a comparison of the PPHM forecasts for international and domestic aircraft movements.

Table 2.4 presents the results of the complete APS forecast analysis.

2.5 Peak Times

Peak international passenger traffic occurs during the high tourist season from December to March and also in July. Thursday is the peak international aircraft arrival day of the week while Wednesday has the peak departures. In terms of movements, Thursday has the busiest international movement hour, which occurs between 0930 and 1030 with 2 arrivals and 4 departures.

FIGURE 2.4
PEAK HOUR AIRCRAFT MOVEMENT FORECAST



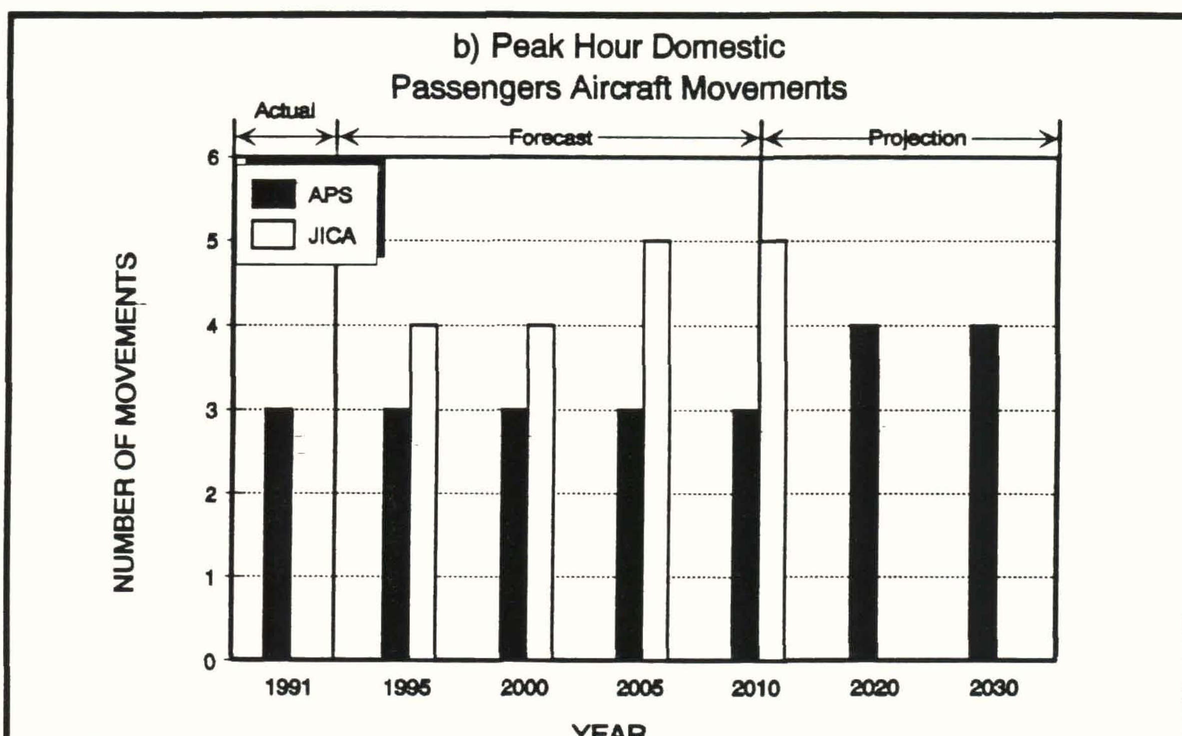


TABLE 2.4

Summary of APS Air Traffic Demand Forecasts & Projections
1991-2030

	Actual	Forecast				Projection	
	1991	1995	2000	2005	2010	2020	2030
Annual Passengers (1,000)							
International	1,051	1,278	1,670	2,096	2,633	3,625	5,006
Domestic	66	74	87	101	119	163	223
Total	1,117	1,352	1,757	2,197	2,752	3,788	5,229
Annual Cargo (tonnes)							
International	62,231	65,890	85,380	107,630	135,084	214,860	344,800
Domestic	N/A	---	---	---	---	---	---
Total	62,231	65,890	85,380	107,630	135,084	214,860	344,800
Planning Annual Aircraft Movements							
International Passenger Aircraft	15,180	18,007	21,976	25,882	30,622	40,280	53,833
Domestic Passenger Aircraft	2,931	3,700	4,331	4,056	4,565	5,421	6,367
International Cargo	2,130	2,190	1,745	2,172	2,826	4,216	7,385
General Aviation	16,929	17,900	20,400	23,300	26,700	34,200	41,700
Total	37,170	41,797	48,452	55,410	64,713	84,117	109,285
Planning Peak Hour Passengers (2-way)							
International	683	965	1,195	1,436	1,731	2,342	3,124
Domestic	62	67	69	76	77	98	134
Total	745	1,032	1,264	1,512	1,808	2,440	3,258
Planning Peak Hour Aircraft Movements (2-way)							
International	6	7	8	10	11	15	20
Domestic	3	3	3	3	3	4	4
General Aviation	7	8	9	10	11	14	17
Total	16	18	20	23	25	33	41
Planning Peak Hour Passengers (Arr)							
International	606	875	1,050	1,233	1,458	1,923	2,510
Domestic	41	47	48	58	58	71	95
Total	647	922	1,098	1,291	1,516	1,994	2,605
Planning Peak Hour Aircraft Movements (Arr) [Lo - High]							
International	[4 - 5]	[5 - 6]	[6 - 7]	[7 - 8]	[8 - 10]	[10 - 12]	[14 - 16]
Domestic	[1 - 2]	[2 - 2]	[2 - 2]	[2 - 2]	[2 - 2]	[2 - 3]	[2 - 3]
General Aviation	[4 - 5]	[5 - 6]	[6 - 7]	[6 - 8]	[7 - 9]	[9 - 11]	[11 - 13]
Total	[9 - 12]	[12 - 14]	[14 - 16]	[15 - 18]	[17 - 21]	[21 - 26]	[27 - 32]
Planning Peak Hour Aircraft Movements (Dep)	5	6	6	7	8	13	19

Source: APS Analysis

3. SITE SELECTION

The objective of the site selection study was to compile all available information from previous studies, and undertake a technical analysis of alternative sites for the selection of Juan Santamariá International Airport in San José, Costa Rica. This study includes an analysis and comparison of the advantages and technical/economic limitations of the alternative locations, which satisfy air traffic demand beyond the year 2010.

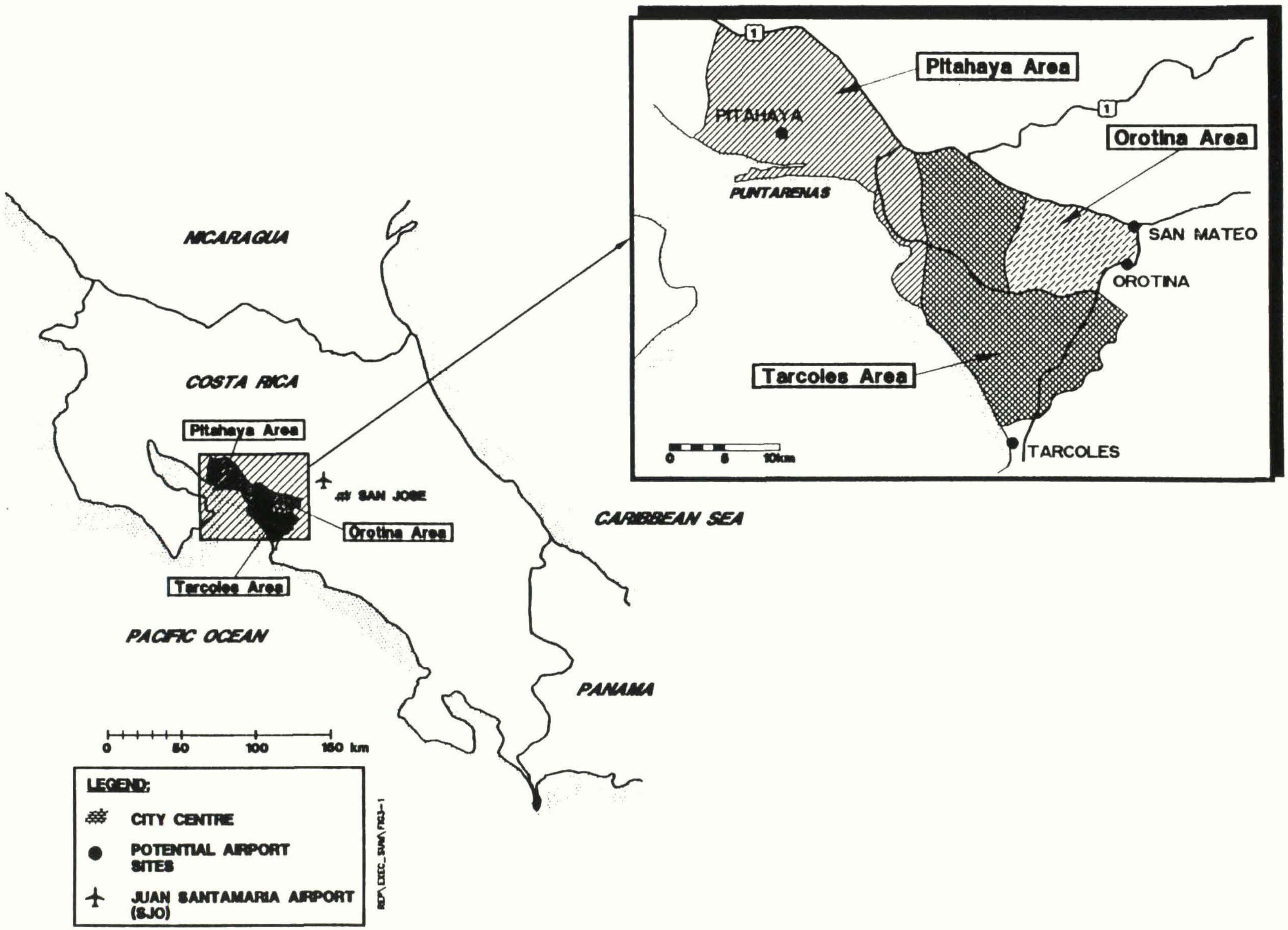
3.1 General Methodology

The major steps involved in the site evaluation and selection of the new airport included: a broad determination of the land are required; location of potential sites; evaluation of all factors affecting the airport location; and development of a ranking of the potential sites based on the evaluation factors.

The initial choice of potential sites was based on discussions with the MOPT and DGAC; the general locations studied in 1977 by R. Dixon Speas Associates (RDSA), which were west of San José; and a 1990 study by BEL Ingenieria for the locations in the same area.

Due to the mountainous terrain experienced in Costa Rica, each site was initially evaluated on the basis of obstacle clearance considerations, levelness of terrain in order to minimize earthwork, and distance to the demand centres. The general location of the sites considered are in Figure 3.1, which shows the sites being considered west of San José.

FIGURE 3.1
GENERAL LOCATION POTENTIAL SITES



3.2 Broad Determination of Land Area Required

Before searching for potential sites, it was necessary to make a broad assessment of the size and shape of the parcel of land required. This was achieved by considering the space necessary for runway, taxiway and apron development, which generally forms the major proportion of land required for an airport.

3.2.1 Runway Length

One of the primary considerations in the determination of land area required is runway length. A runway length of 3,000 metres is necessary to accommodate B-747-400 non-stop operations to Europe. This runway length was determined based on airport temperatures, enroute winds, international reserves, and payload sufficient for 400 passengers. Similarly, a 3,000 metre runway would be sufficient for non-stop operations to Europe with a B-777-200 aircraft. Consideration was given to B-747-100 and 200 series aircraft, however it is expected that these aircraft will be retired in the near future.

3.2.2 Meteorology

The wind systems at the proposed areas consist primarily of the trade winds from the east, and sea breezes. Substantial data was acquired from a number of meteorological stations including Juan Santamariá, Tobias Bolaños, San José, Puntarenas and three agrometeorological stations. It was concluded that the most representative winds expected at the areas being considered would be from the stations at Juan Santamariá and Puntarenas.

The winds in the Tarcoles area were considered to be a weighted average of the winds from the Puntarenas Station and the Juan Santamariá Station. A 75% weighting was applied to the windrose occurrences at Puntarenas, and a 25% weight to the occurrences at Juan Santamariá.

The winds near Orotina were considered to be an average of the wind occurrences from the Puntarenas Station and the Juan Santamariá Station. Near Pitahaya, it is expected that the representative winds would be the same as at Puntarenas.

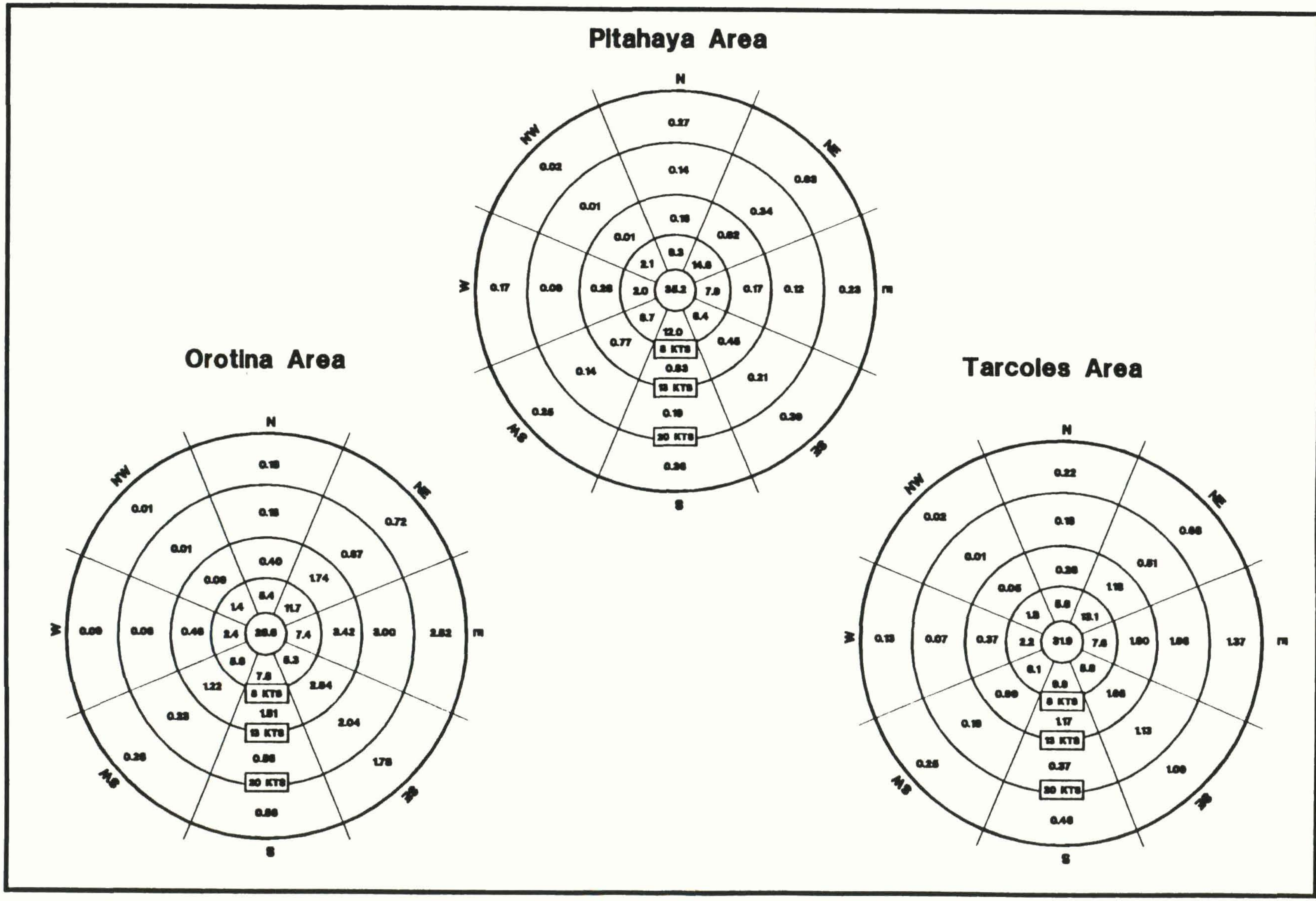
Based on the above, the resulting windrose at each of the areas is provided in Figure 3.2. Northeasterly trade winds are expected to be stronger and more frequent near Orotina. The frequency of nearby thunderstorms is also expected to be higher near Orotina during the wet season. Since a large proportion (more than 80%) of the current scheduled movements at San José are carried out with DC-9 or larger type aircraft, it is expected (based on the windroses) that a crosswind runway would not be required.

Due to the uncertainty of this wind data as being representative of the sites, it is recommended to install an automatic weather station near the selected sites.

3.2.3 Preliminary Airside and Landside Requirements

In the determination of land area, provision was made to allow for sufficient space for a future parallel runway which would provide for simultaneous, independent operations. A separation of 1,525 metres is recommended by ICAO. Based on ICAO requirements, a parallel taxiway is recommended when annual operations reach 50,000, or when

FIGURE 3.2
WINDROSES NEAR POTENTIAL SITES



the normal peak hour movements reach 20. This parallel taxiway, separated from the runway by a distance of 182.5 metres, has been accounted for in the airport layout.

In the sizing of each of the facilities all dimensions were based on ICAO Annex 14 for a Code 4E airport. For this type of airport ICAO recommends a runway width of 45 metres with 7.5 metre shoulders on each side. Taxiways should have a width of 23 metres with 10.5 metres shoulders at each side. The width of the runway strip, which should be obstacle free, is 150 metres.

In addition, adequate space has been provided for the following sub-systems:

- An apron size of approximately 575 by 250 metres would be required to accommodate the forecasted peak hour aircraft for the year 2010.
- Space from the runway to any aircraft parked on the apron is such that the ICAO 14.3% transitional surface would not be violated.
- Additional space has been provided for the terminal, cargo facilities, car park and access roads.
- In addition, a space of 900 metres was allotted at each end of the runway for a Category I approach lighting system.
- The lateral placement of the operational area will be site specific.
- Similarly, the placement of the future parallel runway can be staggered and is also site specific. A staggered parallel runway configuration would reduce taxi times if one runway was used for landing and the other for departures.

- Plans are for one runway, however sufficient space was allotted for a second future parallel runway.

In total, as shown in Figure 3.3, a parcel of land 5,000 by 1,825 metres would be required for this airport and would be sufficient for operations well into the future.

3.3 Location of Potential Sites

Based on the 5,000 metre by 1,825 metre parcel of land which would be required for the new airport, the specific location and assessment of the potential sites can be addressed. During initial meetings with the DGAC and MOPT, discussions regarding the siting of the future international airport led to a number of considerations, some which were previously mentioned. APS considered seven sites for the preliminary analysis, four of which were found by APS. Figure 3.4 shows the general location of each of the seven sites, as well as their location with respect to San José.

Following a site inspection, a topographic review of each site, as well as the consideration of other factors such as environment and access road availability, four of the seven sites were eliminated from the more detailed analysis.

San Mateo was eliminated due to mountainous terrain to the east and lack of expansion capability for a future parallel runway. Both of the Pitahaya sites were equivalent in terms of flight operations; however, the site east of Pitahaya was retained for further analysis since it was closer to San José. Of the two Tarcoles sites, one was eliminated because of excessive earthwork requirements. The site at Caldera was eliminated due to: insufficient space for the required runway length and Category I approach lighting systems; insufficient parallel taxiway space; and lack of expansion capability for a future, parallel runway.

FIGURE 3.3
BASIC AIRPORT LAYOUT FOR BROAD DETERMINATION OF LAND AREA REQUIRED

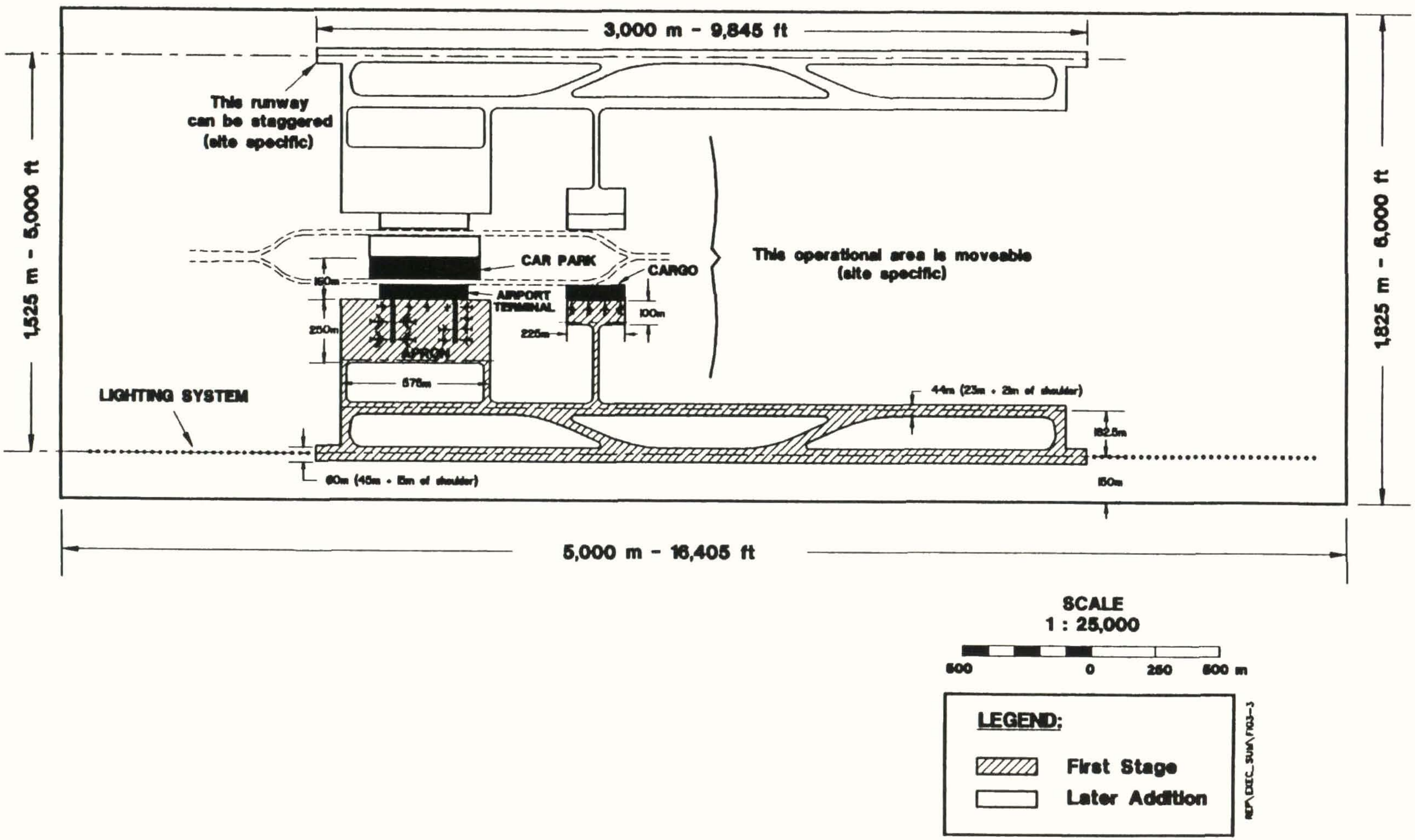


FIGURE 3.4
LOCATION OF POTENTIAL SITES

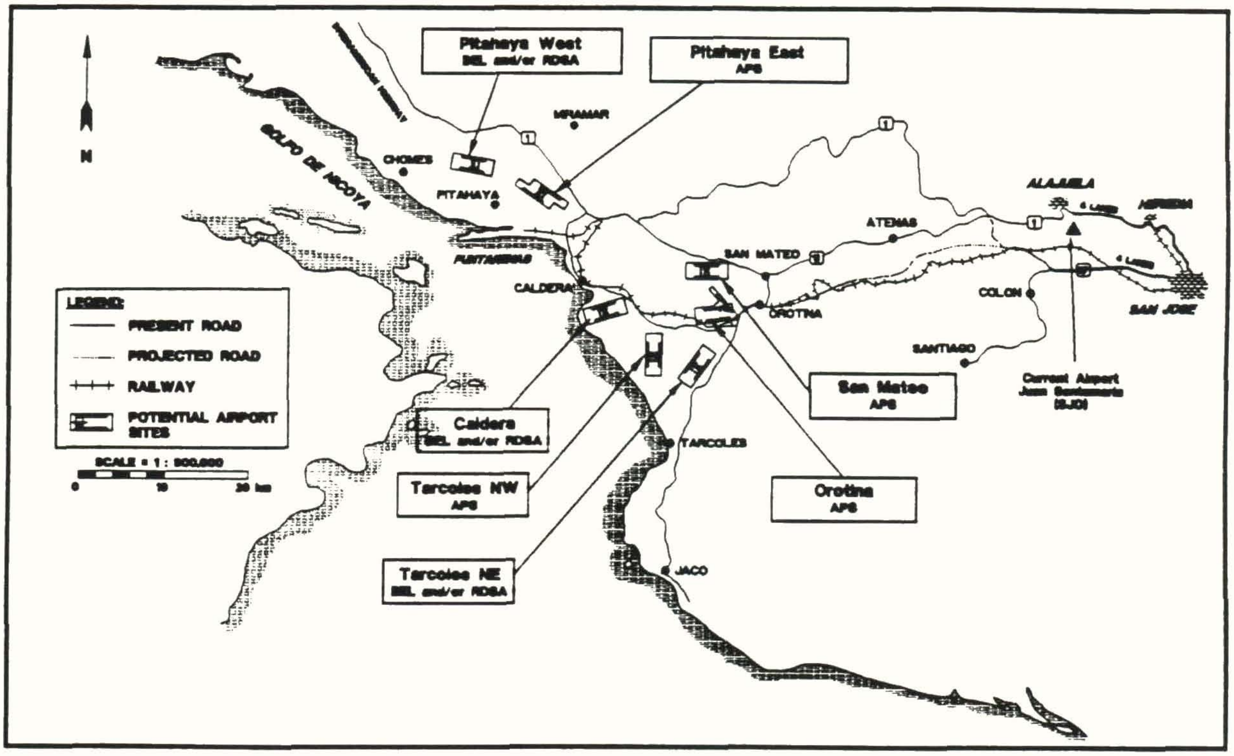
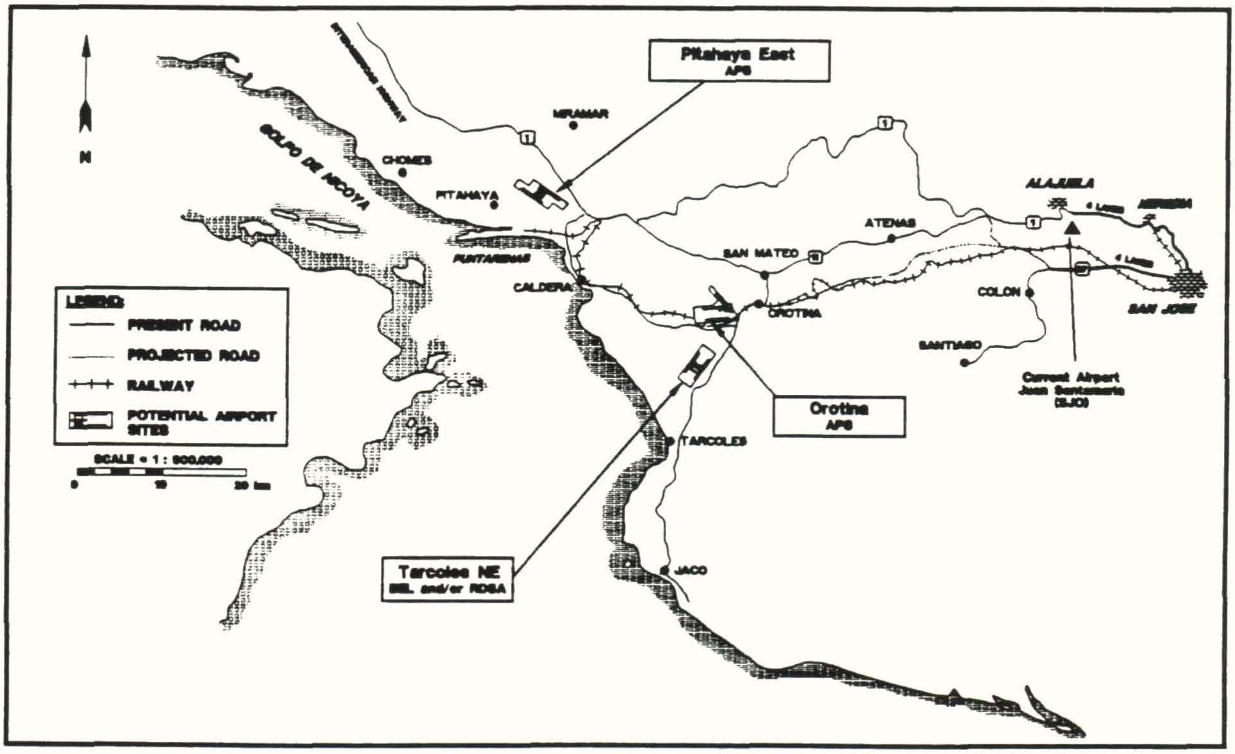


FIGURE 3.5
SITE CONSIDERED FOR FURTHER ANALYSIS



As a result, the three sites which were considered suitable for further detailed analysis are Orotina, Pitahaya (to the east) and Tarcoles (to the northeast) as shown in Figure 3.5.

3.4 Factors Considered for Analysis and Comparison

With the data developed thus far, the considerations affecting the location of the airport were addressed and are as follows:

- Operational Evaluation;
- Airside Capacity;
- Ground Access from Demand Centres;
  - ground transportation cost comparison
  - access time comparison
- Capital Cost Comparison;
- Environmental Concerns;
- Future Expansion Capability;

3.4.1 Operational Evaluation

Obstacle assessment is a major element in determining airport suitability, runway alignment and runway useability. The shaded area in Figure 3.6 represents mountainous terrain with elevations greater than 500 metres. The white area in the centre, which is where the sites are located, has elevations less than 500 metres. It should be noted that the orientation of the runway at Pitahaya allows for sufficient distance along the flight path, prior to reaching mountainous terrain. At Orotina and Tarcoles, there is less distance prior to reaching high terrain.

FIGURE 3.4
LOCATION OF POTENTIAL SITES

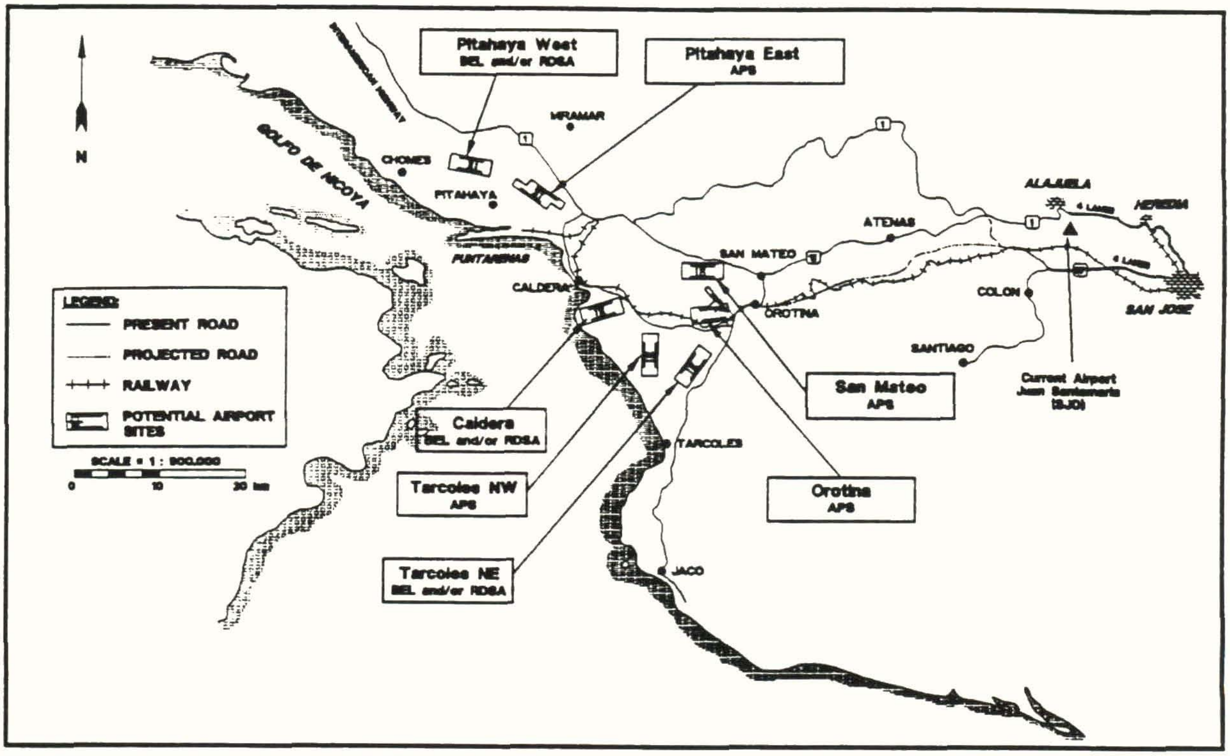


FIGURE 3.5
SITE CONSIDERED FOR FURTHER ANALYSIS

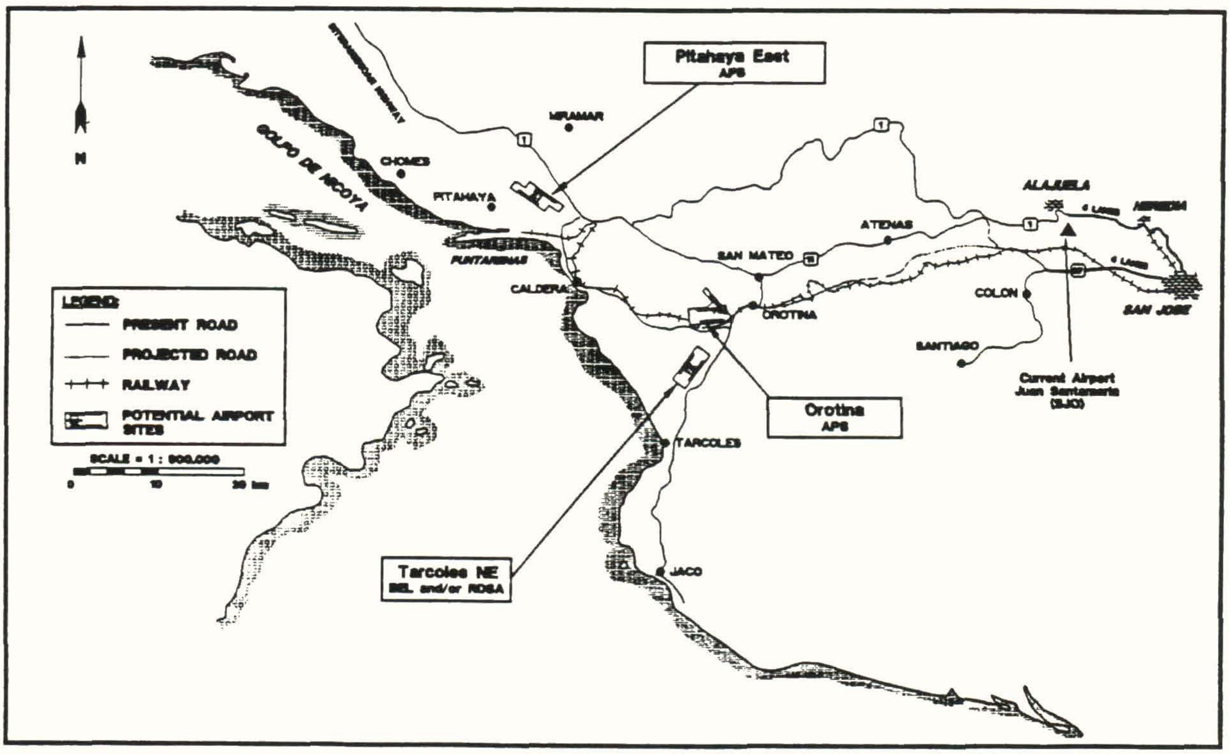
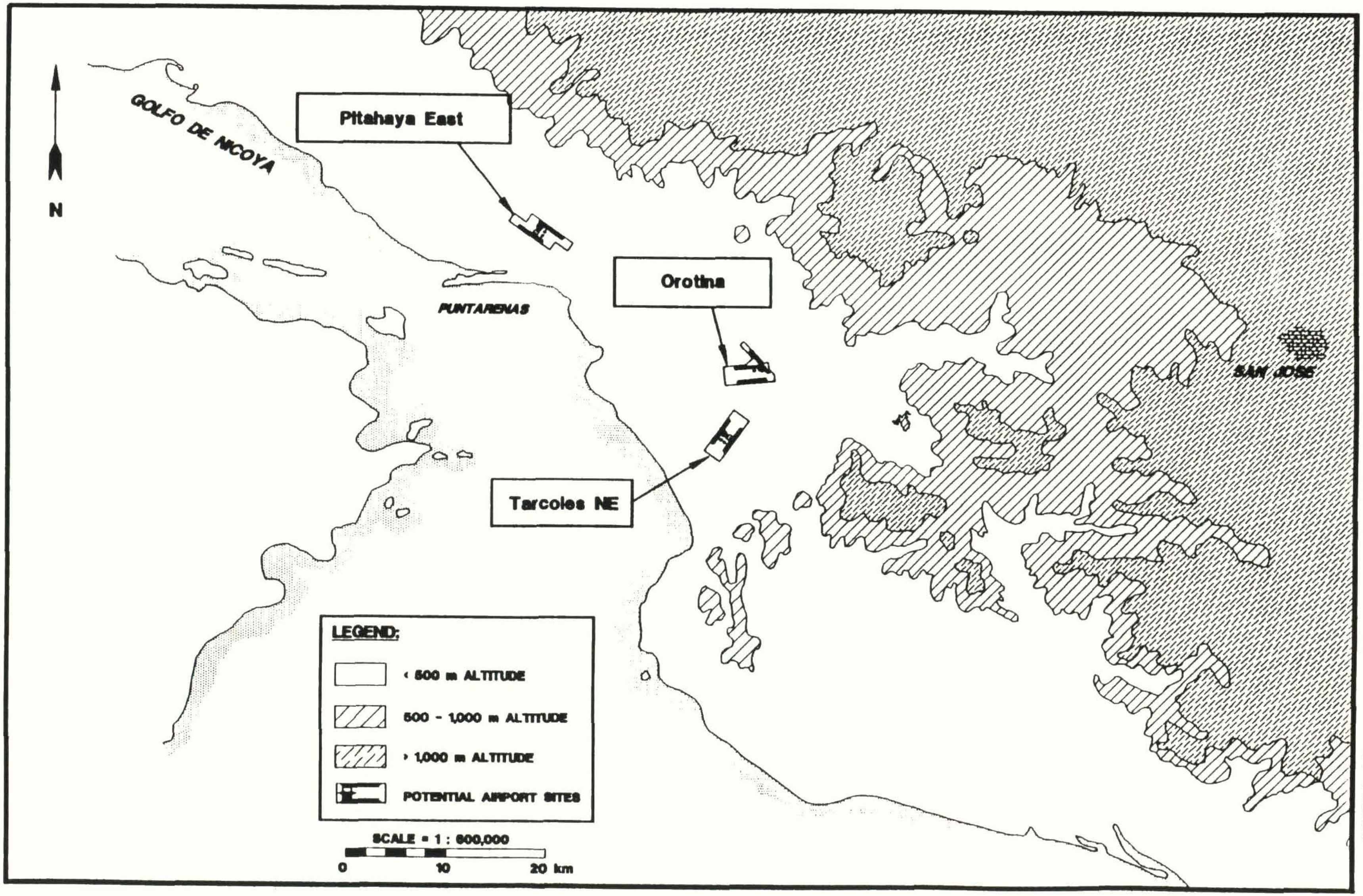


FIGURE 3.6
PROXIMITY OF MOUNTAINOUS TERRAIN



Various obstacle assessment surfaces (slopes) and splays (divergence on either side of the flight path centreline) were used to conform with the requirements of ICAO Annex 6, Annex 14 and PANSOPS.

3.4.1.1 **Orotina Site**

At Orotina, the mountainous terrain to the northeast and southeast will make flight operations more complex. Initially, only Runway 08/26 was analyzed.

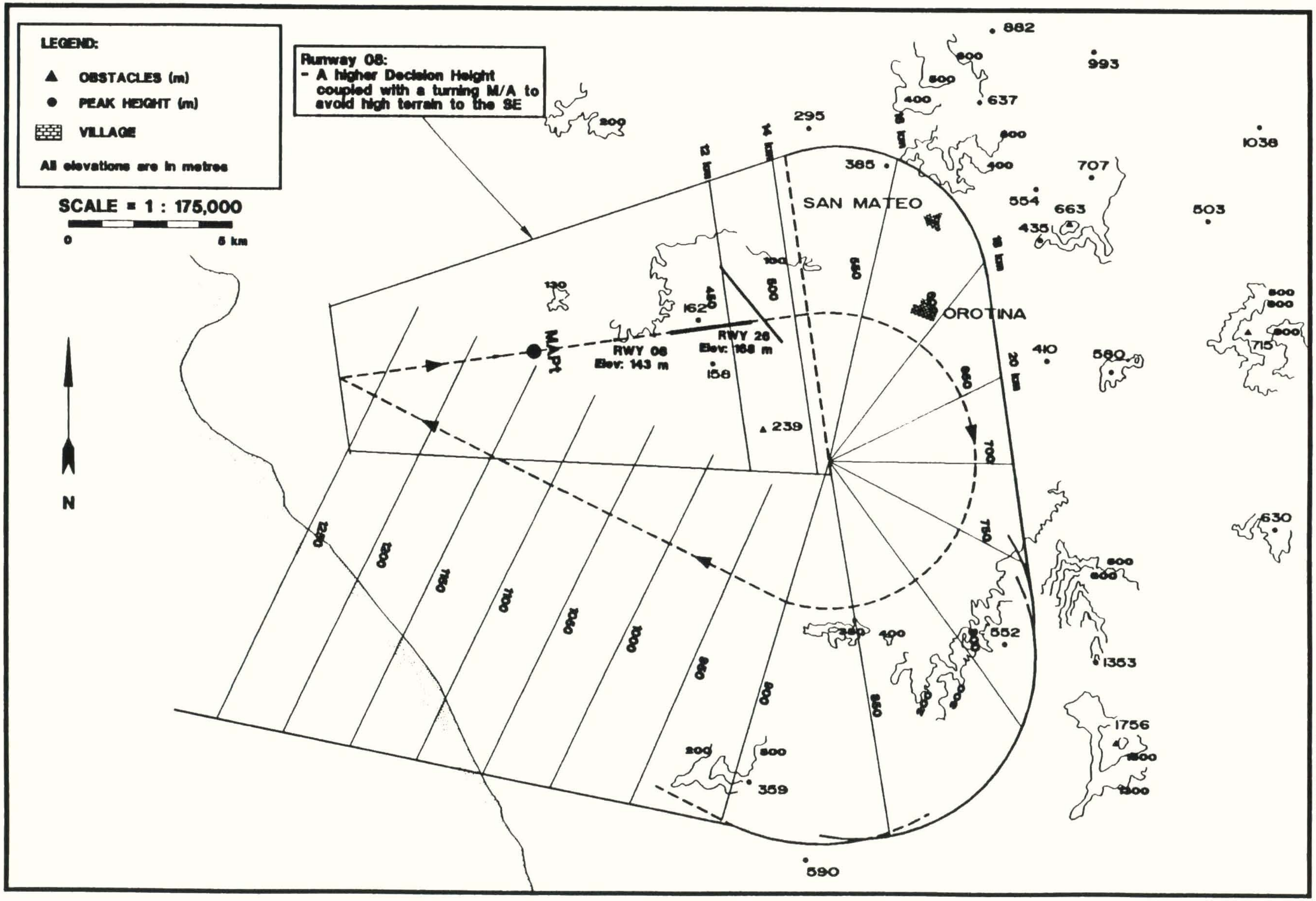
A number of procedures would be required to avoid mountainous terrain. Arrivals on Runway 26 require a steep glidepath, while departures and missed approaches are obstacle free, since these are towards the sea.

Departures on Runway 08 should be conducted only during VMC conditions, as a result of the high terrain on either side of the valley. Instrument approaches to Runway 08 can be achieved using either of the following methods:

- In the first method, a decision height of 200 feet is achievable, however, a minimum climb gradient must be specified for the missed approach, in order to clear the high terrain to the east.

- For the second method, which is illustrated in Figure 3.7, a higher decision height coupled with a turning missed approach procedure would avoid high terrain to the southeast.

FIGURE 3.7
ARRIVAL AND MISSED APPROACH FOR RUNWAY 08 AT OROTINA



Due to the complexity of these operations, a further review of other runway orientations, to supplement Runway 08/26, was carried out in order to provide improved operations.

A second orientation of 14/32 was selected for Orotina. When using Runway 14, departures and missed approaches require a procedure turn to the right, to clear the hills to the southeast. When using Runway 32, departures should include a left turn. Arrivals to Runway 32 can only be conducted during VMC conditions due to high terrain southeast of the airport.

To summarize, at Orotina, instrument operations can be carried out on all runways with the exception of a visual approach to Runway 32 and visual departures on Runway 08. The two runway configuration at Orotina is an effort to provide improved operations and more reliability.

3.4.1.2 Pitahaya Site

While Pitahaya is relatively free of obstacles, and precision approaches to both runways are feasible, the following procedures are required: when using Runway 13, departures and missed approaches require a procedure turn to the right; similarly, the missed approach procedure for Runway 31 should include a left turn.

3.4.1.3 Tarcoles Site

The Tarcoles site is less free from obstacle considerations, but with procedure turns, precision approaches can be flown to both runways. The following procedures would be required to avoid high terrain to the northeast: when using Runway 03, departures and missed approaches require a moderate left turn; approaches to Runway 21 require either, a high glidepath, an offset localizer, or a curved MLS approach.

3.4.2 Demand Versus Capacity Analysis

The two runway system at Orotina would provide up to 40% additional capacity as compared to the single runway systems at Tarcoles and Pitahaya. Based on the long term projected traffic growth rates, the second runway at Orotina would defer investment for an additional parallel runway by about 10 to 20 years.

For the level of traffic forecast for the year 2010 (25 aircraft movements in the peak hour), a single runway system would be sufficient. It is prudent, however, to look further into the future at a time where the traffic could well grow to such extent as to require an extra, parallel runway for independent, simultaneous operations.

3.4.3 Ground Access Costs and Time from Demand Centres

The objective of the demand centre analysis was to carry out a comparative study of transportation costs, from various demand centres, to each of the sites. In addition, a comparison of access time, to each site, from the demand centres, was computed.

The methodology used is as follow:

- Costa Rica was segmented into 12 demand centres.
- For each demand centre, distances and travel times to each of the

3 sites, were acquired from maps and brochures.

- Only international air travellers were considered.
- Pleasure travellers made up 70%, while business travellers were only 30%.
- Travellers were distributed amongst car, bus and taxi based on data provided by the ICT.
- Passengers per vehicle, well-wishers and greeters, were determined based on information contained in the Dixon Speas report. This information should be updated for the design phase.
- Cost for transportation by each mode, was acquired from various sources including the ICT.
- It was also assumed that the highway from Colon to Orotina will be completed.

3.4.3.1 Transportation Cost Comparison

Based on the mode of transportation, the percentage of passengers originating from each demand centre, and the cost of ground transport, the average transportation cost for each passenger, well-wisher and greeter was computed.

Figure 3.8 shows that the average ground travel cost per passenger or well-wisher to and from Orotina is the least expensive. Costs to Tarcoles would be 89 colones more, while to Pitahaya would be 132 colones more. It should be noted that these costs will be incurred continuously throughout the life of the airport.

FIGURE 3.8
TRANSPORTATION COST COMPARISON

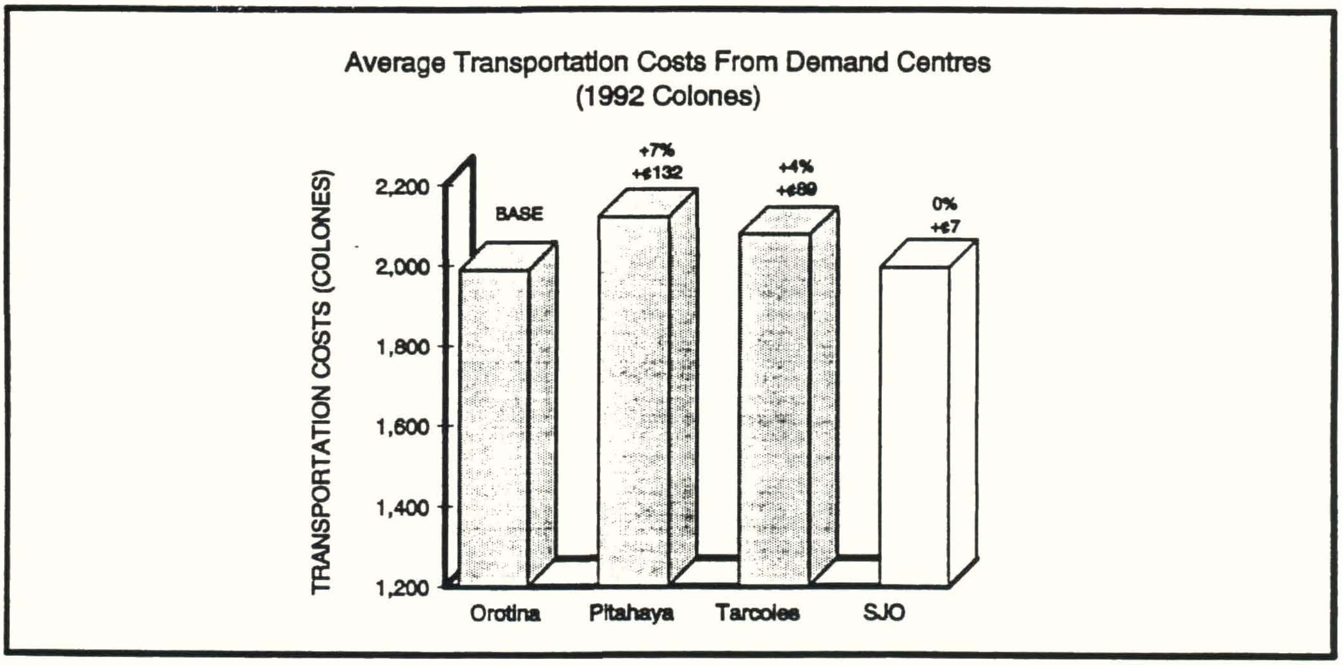
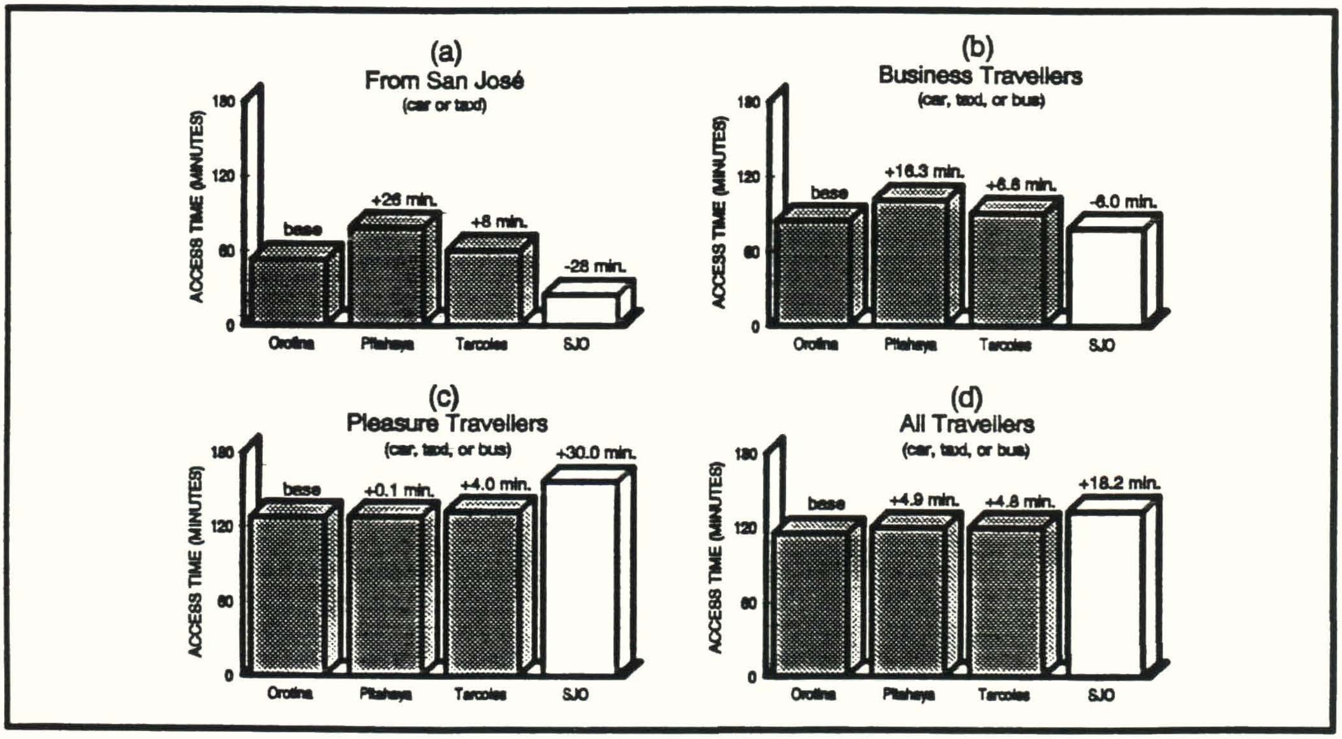


FIGURE 3.9
ACCESS TIME COMPARISON
MINUTES PER PASSENGER



SOURCE: AVIATION PLANNING SERVICES ANALYSIS

3.4.3.2 Access Time Comparison

The second element of the demand centre analysis is the time required to travel to the airport.

Figure 3.9a shows that the average car or taxi travel time from San José to the Orotina site can be accomplished in 53 minutes. Pitahaya requires an additional 26 minutes and Tarcoles an additional 8 minutes.

Figure 3.9b shows that for business travellers throughout the country, including San José, average access time again favours the Orotina site.

As Figure 3.9c illustrates, there is less of a difference when a comparison is made of average access time for pleasure travellers. The Orotina and Pitahaya sites require about the same access time, while the Tarcoles site requires only 4 additional minutes. The reason for the small time difference between sites is that a significant amount of tourists tend to visit the Guanacaste region.

When the relative ratios of business versus pleasure travellers are considered, the Orotina site requires an average access time of 1 hour and 55 minutes, while the other two sites both require an average of 2 hours. This is shown in Figure 3.9d.

3.4.4 Capital Cost Comparison

Preliminary airport capital costs were computed at each of the sites. For the comparative analysis of the three sites only the difference in capital costs would be significant. Table 3.1 shows the airport elements where such a difference could occur.

The major area where the costs differ considerably is site preparation, which includes cut and fill. The terrain in the Pitahaya area is relatively level, while at Tarcoles substantial earthwork would be required due to hilly terrain. The terrain at Orotina is not as hilly as Tarcoles, however the requirement of two runways augments the cost.

The second runway at Orotina not only affects the site preparation costs, but also: land acquisition costs; the runway/taxiway system costs; and lighting and navigational aid costs. As a result, Pitahaya is the least expensive to build, followed by Tarcoles and Orotina.

3.4.5 Environmental Concerns

This section identifies the areas of concern regarding the environment at each of the three sites.

Noise levels were a concern primarily at Orotina due to the close proximity of residential, noise sensitive areas. In terms of demographic development, the Orotina site would require relocation of significantly more local residents than other sites.

TABLE 3.1
PRELIMINARY AIRPORT CAPITAL COST COMPARISON

	OROTINA	PITAHAYA	TARCOLES
	Estimated Cost 1992 currency (Million Colones)	Estimated Cost 1992 currency (Million Colones)	Estimated Cost 1992 currency (Million Colones)
1 Land Acquisition	+264	BASE	-35
2 Site Preparation	+5,488		+4,353
3 Drainage	+56		+0
4 Runway System	+1,031		+0
5 Taxiway System	+634		+0
6 Lighting	+176		+0
7 Navigational Aids	+243		+0
8 Road Access	-200		-160
9 Engineering Services & Contingency	+1,308		+707
Difference (in Million Colones)	+8,999	BASE	+4,865
Difference (in Million USD)	+67	BASE	+36

Note: Pitahaya was used as the base since it was the least expensive.

The Tarcoles site could cause concern with regard to potential water pollution of the Tarcoles River and air pollution in the Carara Biological Reserve. The ecological process of wildlife habitats may be disrupted at the Carara Reserve. In addition, migratory areas around Tarcoles, as well as Orotina, are potentially dangerous to aircraft.

3.4.6 Future Expansion Capability

A subjective analysis of the impact of a future parallel runway, particularly on flight operations and capital costs, was addressed for each of the sites.

At Tarcoles, the construction of a "future" parallel runway would require a significant expenditure for cut and fill and would further disrupt the Carara Reserve.

At Orotina, the construction of a "future" parallel runway would require less earthwork than Tarcoles and could possibly present additional operational difficulties due to increased operations.

At Pitahaya, the construction of a "future" parallel runway would require minimal earthwork and would have little impact on flight operations.

3.5 Site Comparisons and Evaluation

In the previous sections, a number of criteria which would form the basis of selection of one of the three sites were defined. This section will provide a summary of discussions held with various officials in Costa Rica and an overview of a decision model used for evaluating the sites.

3.5.1 Discussions of Factors and Sites with Government of Costa Rica

The objective of this section is to provide a summary of the results of discussions held with various Government of Costa Rica officials. The meetings entailed discussions pertaining to the three sites discussed in Section 3.3 and the seven criteria discussed in Section 3.4.

The results of the analysis of Orotina were presented to the Government of Costa Rica officials. The Consultants and Costa Rica officials agreed that flight operations at Orotina would be too complex and costly. Therefore, this site was removed from further consideration based on the following:

- The analysis in Section 3.4.1 showed that operational considerations were a major concern at Orotina, due to mountainous terrain to the North, East and South. As a result, a two runway system was recommended in order to permit IFR operations in more directions. Furthermore, due to close proximity of the mountainous terrain to the site, operation would likely encounter precipitation with mechanical turbulence and wind shear adding to the complexity of this site. In the final analysis, it was considered that operations at this site would impose to great a work-load on the flight crews.

- It is known that there is a need to relocate SJO airport because of two important factors, namely the aircraft operational difficulties at SJO and lack of terminal space for future expansion. It is therefore not realistic to consider Orotina, with a two runway system, which would inherit one of the main operational problems of the current airport.

Since the site near Tarcoles is less than 10 km from the site proposed at Orotina, and further from residential, noise-sensitive areas, the Costa Rican officials agreed to remove Orotina from further analysis. Therefore, the analysis of each factor for Orotina, carried out in Section 3.4, was not be used in the Binary Analysis discussed below.

3.5.2 Model Overview

This decision analysis model is used for resolving complex problems involving quantitative and qualitative data. The model was developed by Westinghouse and modified by APS. The methodology behind the model is a series of one-on-one comparisons resulting in a score of one or zero for each comparison. The large number of decisions should remove any subjective bias.

The general methodology essentially involves four steps. The first step in the analysis involves selection of criteria relevant to the decision. It should be stressed that the selected criteria must be mutually exclusive and collectively exhaustive. The second step is to develop a weighting of the criteria in order of importance. The third step involves developing a weight for each site, for each of the criterion. In step four, based on the criteria weight and the weighting of each site, composite scores are computed.

3.5.2.1 Criteria Selection (Step 1)

As was mentioned earlier, a number of criteria were described and analyzed in the previous sections, and are as follows:

- Operational Evaluation;
- Ground Transportation Cost Comparison;

- Access Time Comparison;
- Capital Cost Comparison;
- Environmental Concerns;
- Future Expansion Capability.

It should be noted that capacity was removed from further analysis since Orotina is no longer being considered.

3.5.2.2 **Site Weighting for Each (Step 2)**

The three sites were compared in pairs along each criterion. Section 3.4 presented the rationale behind the scoring of the sites along the individual criteria. The various factors described in the previous sections are summarized in Table 3.2. The table provides an overall summary of the comparisons of the two sites for each criteria.

3.5.2.3 **Weighting of the Six Criteria (Step 3)**

The six criteria identified were compared in pairs to determine their relative importance, with a score of "1" given to the more favourable criterion and a score of "0" to the other. The frequency count of favourable outcomes for each criterion is taken as a measure of its relative importance.

The "scoring" of the criteria was based on the judgement of APS professionals. The combined results indicate that "access time" was considered the most important criterion with a relative weight of 29%, followed by:

- transportation costs with 24%;
- flight operations with 19%;
- capital costs with a weight of 14%;

TABLE 3.2
RELATIVE COMPARISON OF SITES

		PITAHAYA	TARCOLES
Operational Analysis		Most Favourable	Less Favourable
Transportation Costs (1992 Colones)	Absolute	2119	2076
	Relative	+43 +2%	Base Base
Access Time	Absolute Overall Absolute Pleasure Absolute Business	120 minutes 128 minutes 110 minutes	120 minutes 132 minutes 91 minutes
	Relative Overall Relative Pleasure Relative Business	Equal Base +19 minutes	Equal + 4 minutes Base
Capital Cost Differential in year 1992 $US Million	Relative	Base	+36
Environment		Most Favourable	Less Favourable
Expansion Capability		Most Favourable	Less Favourable

Source: Aviation Planning Services Ltd.

- environment with 10%; and
- expansion capability with 5%.

3.5.2.4 Composite Site Scores (Step 4)

The final step in the binary analysis was the combination of all the relative scores with the criterion weights. Based on the criteria weight, and the weighting of the sites, which were shown in the previous sections, composite scores were computed for each site. These composite scores were computed by multiplying the individual site scores for each criteria by the criteria weight and dividing by 100. The results, weighted by criterion scores and combined into a single value, are presented in Table 3.3.

From the results of the binary analysis it is seen that, although each site has its own merits, Tarcoles would be the most suitable site followed closely by Pitahaya.

3.5.3 Sensitivity Analysis

A sensitivity analysis on the Binary Decision Model was conducted in order to test the results from Table 3.3. Due to unknown factors in the costing and since the criterion weighting will vary according to what each individual may consider important, a number of different tests were developed.

For example, there is a great degree of uncertainty in the overall costing for the airport at Pitahaya which will be fine tuned during the detailed design phase. The costs at Pitahaya may increase due to unfavourable soil conditions, high potential for tidal waves, cost for removal of the sugar mill, and expansion of highway from two to four lanes. As a result, if one considers Pitahaya as expensive to build as Tarcoles, then the margin in the scoring of Tarcoles over Pitahaya would increase.

TABLE 3.3
COMPOSITE SITE SCORES AND RELATIVE RANKING

	AIRPORT SITES		
	PITAHAYA	**TARCOLES**	**TOTAL**
OPERATIONAL ANALYSIS	12.7	6.3	**19**
TRANSPORTATION COST	7.9	15.9	**24**
ACCESS TIME	9.5	19.0	**29**
CAPITAL COST	9.5	4.8	**14**
ENVIRONMENT	6.3	3.2	**10**
FUTURE EXPANSION	3.2	1.6	**5**
TOTAL SCORE	**49.1**	**50.8**	**100**

Note: Composite site score per criterion = Individual Site Score per Criterion x Criterion Weight / 100

Source: Aviation Planning Services Ltd.

One very important factor which has not been discussed thus far is the relative impact that the selection of either site could have on the current airport in San José. In the case that the airport was constructed at Pitahaya, there would undoubtedly be much more pressure from the local business community to maintain air carrier activities at the current airport. If the new airport were constructed at Tarcoles, then the pressures to maintain the current airport open would not be as strong and SJO could be reduced in size but be maintained open for General Aviation (GA) and local commuter traffic only. This scenario could provide for the sale of land at Tobais Bolaños and partially at SJO which could be used to reduce the up-front cash requirements for the new airport.

Furthermore, it was indicated to the Consultants that Liberia Airport would have a role for future charter operations. As a result, a small portion of the passenger tourist traffic would not be arriving at the new airport. This would have the effect of increasing the importance of time for the business travellers, resulting in increased importance of Tarcoles in relations to Pitahaya. Based on the above discussion, if an additional criterion, future economic impact, were input to the BDM, then Tarcoles would still be the more favourable site, but by a greater margin than the base case.

A third test was developed by combining the tests produced in the first two scenarios. With the capital costs considered to be equal and the additional criterion included, the results show that Tarcoles is the more favourable site, by a greater margin than the other scenarios.

A fourth test was developed from an "investor's perspective". The test was developed using potential future economic impact as a criterion and capital costs considered equal at Pitahaya and Tarcoles. Similarly, two additional tests were performed from a government (the MOPT or DGAC may prefer this order of importance) and a passenger perspective. From the above sensitivity tests, Tarcoles is still the most favourable site.

To summarize, it can be concluded that reasonable variations in the criteria weighting will not significantly change the overall ranking.

3.5.4 Site Recommendation

Based on the detailed examination and evaluation of each of the potential sites, and the decision analysis from Section 3.5, the final ranking of the sites in order of merit is as follows:

1) Tarcoles
2) Pitahaya

In summary, Tarcoles is considered the most favourable site since:

- access time is the shortest; and
- transportation cost is the least.

In addition, greater positive impacts to the overall economic environment of Costa Rica would result from the selection of Tarcoles over Pitahaya.

4. ECONOMIC FEASIBILITY

4.1 Objective

The objective of the economic feasibility study is to provide a financial and economic analysis of the proposed airport. An environmental impact study and the economic impact of the selected site are also included. The financial analysis included an analysis of costs (capital costs and annual operating and maintenance costs), revenue projections, cash flow statements, and calculation of the net present value (NPV) for the project. The economic impact considers the benefits, advantages and disadvantages of the new airport to the Costa Rican economy.

4.2 Cost Analysis

Before developing revenue projections, the capital and operating costs for the new airport project need to be forecasted. This section will provide a broad order-of-magnitude of the capital costs estimated for land acquisition, construction and operating costs at Tarcoles.

4.1.1 Capital Costs

In order to achieve suitable return for the investment required for their construction, airports should be located so that the cost of development work is minimized. Therefore, topography, soil conditions, construction material availability, access costs, as well as services and land values, are of particular importance.

Costs were estimated for the following elements:

- Land Acquisition
- Runway, Taxiway & Apron
- Earth Moving
- Car Park
- Access Roads
- Lighting Systems
- Terminal & Cargo Facilities
- Rescue & Fire Fighting
- Air Traffic Control
- Navigational Aids
- Buildings
- Other Airport Facilities

The total estimated cost for construction of the new airport is provided in Table 4.1.

4.1.2 Annual Operating & Maintenance Costs

Annual operating and maintenance costs at SJO, followed by a 30 year projection of the expenses for the new airport are summarized below.

The analysis of DGAC expenses shows clearly that the new airport's financial structure will have to be dramatically different than current practice if it is to operate efficiently and effectively.

Due to the lack of significant statistical results, no valid relationship between airport expenses and air traffic volume could be established.

Therefore, after considerable evaluation of several alternatives, the Consultants found the most feasible solution was to utilize the current SJO expense per passenger, exclusive of capital costs, which would be applied to the forecasted number of passengers. This expense figure can then be added to any capital costs and interest costs incurred.

TABLE 4.1
PRELIMINARY AIRPORT CAPITAL COST ESTIMATE

	TARCOLES Estimated Cost 1992 currency (Million Colones)
1 Land Acquisition	401
2 Site Preparation	5,613
3 Drainage	78
4 Runway System	1,236
5 Taxiway System	649
6 Apron	1,829
7 Car Park	95
8 Lighting	324
9 ATC Equipment	585
10 Terminal Facility & Gates	8,640
11 Cargo Facility	1,755
12 Fire Station & Equipment	267
13 Navigational Aids	432
14 Road Access	720
15 Other (eg. Fuel, Auxil. Power, Comm., Sewage, etc.)	2,700
16 Engineering Services & Contingency	4,305
Total (in Million Colones)	29,629
Total (in Million USD)	219

4.2 Revenue Analysis

The revenue analysis examined the current fee schedule charged by Juan Santamariá International Airport. This schedule was then compared with those of neighbouring countries in order to determine a more viable and rational schedule for SJO. The results were then used to project revenues based on the forecasted growth in air traffic.

An examination of the revenue items and discussions with the DGAC resulted in a number of observations regarding the revenue earning efficiency of SJO:

- The level of charges at SJO is very low (e.g. passenger tax, fuel charge, landing fees).
- The reporting method of DGAC revenues collected jointly with other agencies masks the true financial picture of the airport.
- Concession fees are levied in disregard of their earning capability and only on the basis of the space they occupy.
- Not all occupants earning revenue actually pay the designated fee.
- Revenues per enplaned passenger at Managua were 3½ times greater than SJO.
- SJO landing fees and the passenger tax are approximately half those of Managua.
- The fuel charges at Managua are almost 200 times greater than those at SJO.
- Other concessions earn five times more revenue at Managua.

Repeated regression analyses failed to yield distinctive revenue patterns at SJO. It was decided therefore, to base the new airport's revenues on a combination of revenue per passenger from selected airports, with a positive net income. The selected airports were Cancun for the pleasure traffic and Mexico City for the business traffic.

A weighted average revenue per passenger was calculated based on CUN and MEX as representative of pleasure and business traffic respectively. Average yields of $10.70 ($US 1990) per enplaned/deplaned passenger was the result for these two airports as opposed to yields of only $5.10 ($US 1991) for SJO.

4.3 Financial Analysis

It is recalled from previous sections that the following estimates were developed for revenues and costs:

- Estimated annual revenue/passenger: $US 10.70 (1990)
- Estimated annual cost/passenger excluding capital costs: $US 2.03 (1992)

These figures were escalated to the year 2000 and then applied to the annual passenger forecast to arrive at escalated revenue and expense figures.

Discount factors were then applied to the net figure income figures in order to calculate the PV net income. The PV of revenues less cash expenses was also calculated.

The present value (1993) of the stream, the difference between revenues and expenses for the years 2000 to 2030, is estimated to be $US 851M which would appear adequate to cover the proposed investment.

The amount to be financed may be reduced from the full capital cost by one or a combination of the following:

1) equity investment,
2) passenger facility charge for SJO operations up to the opening of the new airport,

3) sale of a portion of land currently occupied by Juan Santamariá International,

4) sale of land currently occupied by Tobias Bolaños airport.

4.4 Environmental Impact Study

From an environmental standpoint, it is obvious that consideration must be given to study measures to alleviate potential noise, bird hazards, and wildlife disruptions. A detailed environmental impact study should be carried out at the proposed site of Tarcoles during the detailed design phase.

4.5 Economic Impact

The benefits from the responsible long term development of a new airport far outweigh the disadvantages associated with its construction. Economic benefits will be derived from improved passenger and cargo services, improved maintenance and security and increased food, fuel and other concessions. The newly developed area will benefit from the airport as most of the purchases by or for the airport will be made from suppliers, dealers, manufacturers and service organizations in the region. More than likely, the majority of these purchases will continue to be from the same businesses given the close proximity of the current airport to the new site and the anticipation of direct and fast road transport between the Central Valley and proposed site. However, there is an opportunity for increased economic activity around the airport site.

The entire country will benefit from the ability to handle the forecasted increase of tourists, while the security and convenience of the new airport will assure the quality of service expected by the travelling public. The future investments in infrastructure and tourist related industries will lead to substantial job creation opportunities, technology transfers and foreign exchange generation

The net outcome of the cost benefit analysis would suggest that the proposed new airport could lead to significant increases in economic activity enabling the sustainable development of the country and the generation of new foreign exchange required to meet external financial commitments.