REPUBLIC OF BOLIVIA

# VIRU VIRU INTERNATIONAL AIRPORT DEVELOPMENT

## FEASIBILITY STUDY

FINAL REPORT

NOVEMBER 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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## FOREWORD

In response to the request of the Government of the Republic of Bolivia, the Government of Japan has agreed to extend cooperation in making a feasibility study for the development of the Viru Viru International Airport in Santa Cruz, Bolivia, and the study was carried out by Japan International Cooperation Agency (JICA).

Recognizing the national significance of the project for that country in contributing to the safety of air transport in Bolivia as well as to the development of the vast land-locked territory of the Republic, JICA undertook the study with enthusiasm, and commenced the work with the preliminary study in February 1977, followed by the feasibility study starting in May 1977. The JICA study team held discussions in July and September of the same year with the officials concerned of the Bolivian Government on the interim report, and the draft final report was submitted in November 1977. The report has now been finalized for official submission herewith to the Government of Bolivia.

I hope that the present study will help expedite the implementation of the project, and thereby contribute toward furthering the goodwill and amicable relationship between our two countries.

I would like to take this opportunity to express my heartfelt appreciation to all the people who participated in this study and to all the Bolivian authorities for their cooperation.

November 1977

Shinsaku HOGEN
President
JAPAN INTERNATIONAL COOPERATION AGENCY
Tokyo, Japan

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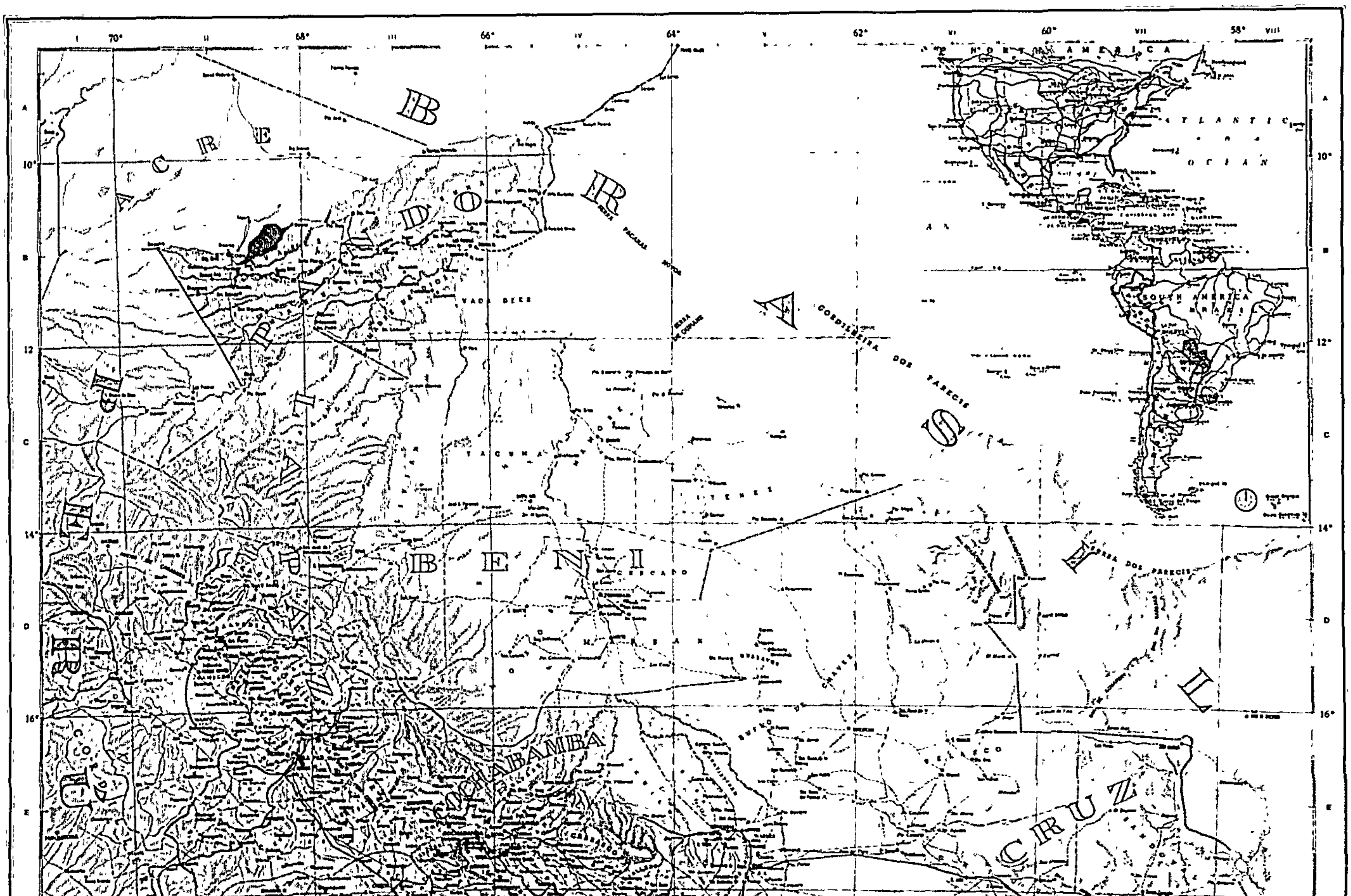
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PARAGUAY
OCEANO PACIFICO
CORDILLERA DOS PARECIS
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# SUMMARY AND CONCLUSIONS

# SUMMARY AND CONCLUSIONS

## OBJECTIVE OF STUDY

The objective of this study is to examine the feasibility of the new international airport project contemplated for construction in Viru Viru in the vicinity of Santa Cruz City, Republic of Bolivia.

## SUMMARY

### 1. Background of Project

Statistics show that air transport demand in Bolivia has grown considerably during the last decade, and the trend has been especially remarkable in Santa Cruz in recent years.

The existing Santa Cruz-El Trompillo International Airport is unable to meet the future avaiation demands with the present facilities. Furthermore, the airport being situated within the urban area of Santa Cruz City, aircraft noise hazard and constant threat of air crash could cause social problems.

Under the circumstances, the Government of Bolivia has long been planning, in a perspective of a score of years into the future, on constructing a new international airport in Viru Viru to replace the existing Santa Cruz International Airport both physically and functionally. To that end a master plan was completed in 1973.

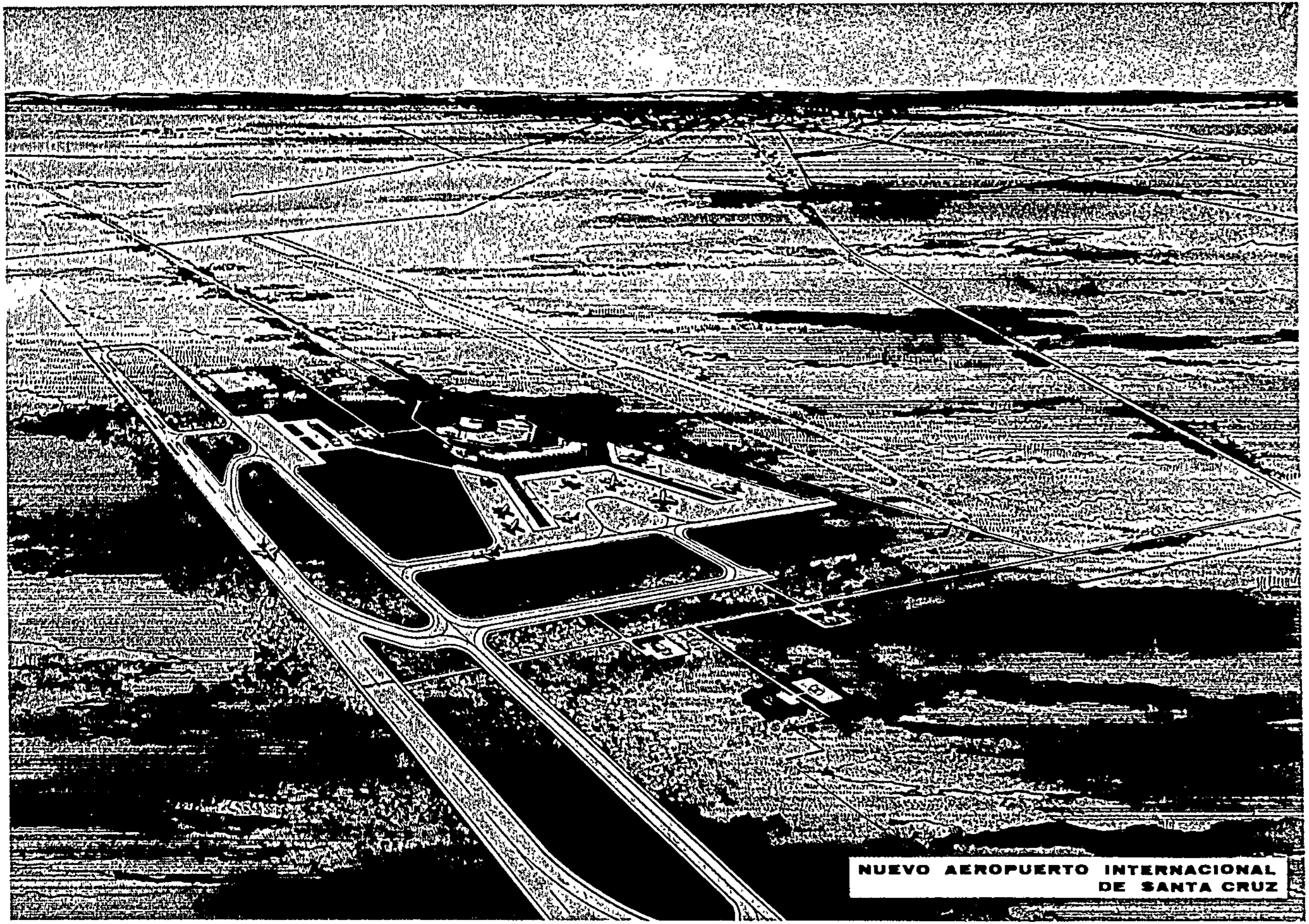
However, circumstances prevented the project from being implemented as originally scheduled, and the situation has caused the necessity to review the master plan on the basis of updated traffic projections.

Such a review made as part of the present study has found the master plan to be quite satisfactory in general, except for some slight over-investment in design and, with certain modifications, the master plan was made the basis of the new airport construction plan hereinafter presented.

The project is being given the first priority by the Bolivian Government who is desirous of opening the new airport to traffic at the earliest possible date.

## 2. Air Transport Demand Forecast

In order that the future air traffic demand projected for Santa Cruz International Airport may duly represent its potential in line with the overall national air transport demand, the total national air passenger and cargo traffic was first projected through correlation analysis with the gross domestic products of Bolivia. Based on the figures thus obtained, the portion due for Santa Cruz was projected by means of a distribution model into which was incorporated the demand growth potential of the airport, with the results as shown in the following table.


NUEVO AEROPUERTO INTERNACIONAL
DE SANTA CRUZ

| Item \ Year | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| Total Annual Passengers (1,000) | 544 | 986 | 1,681 | 2,867 | 4,289 |
| Domestic Passengers | 381 | 631 | 1,004 | 1,579 | 2,214 |
| Arrival & Departure | 305 | 505 | 803 | 1,263 | 1,771 |
| Transit | 76 | 126 | 201 | 316 | 443 |
| International Passengers | 163 | 355 | 677 | 1,288 | 2,075 |
| Arrival & Departure | 98 | 214 | 408 | 776 | 1,250 |
| Transit | 65 | 141 | 269 | 512 | 825 |
| Total Annual Cargo Tonnage | 5,040 | 9,690 | 18,700 | 26,400 | 37,000 |
| Domestic | 4,300 | 8,100 | 15,300 | 21,600 | 30,300 |
| International | 740 | 1,590 | 3,400 | 4,800 | 6,700 |
| Annual Aircraft Movements | 29,830 | 43,880 | 62,970 | 95,670 | 132,060 |

## 3. Development Plans

Besides the proposed New Airport Construction Plan, an alternative plan to expand the existing airport to such an extent as to be able to provide a service level equal to that envisaged for the new airport has been established for the sake of comparative evaluation of the proposed plan against a practicable alternative for the purpose of the present study. The general outline of the two plans are presented hereunder.

### (1) General Facility Requirements

| Facilities \ Design Year | | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| Airfield Facilities | Runway (m) | 3200x45 | 3500x45 | 3500x45 | 3500x45 |
| | Taxiway Width (m) | 23 | 23 | 23 | 23 |
| | Passenger Apron Parking Positions | 5 | 8 | 10 | 13 |
| | Cargo Apron Parking Positions | 2 | 2 | 3 | 4 |
| Radio Navigational Aids, Telecomunications, and Meteoro-logical Facilities | | CAT-1 ILS, VOR/DME, NDB, etc. | | | |
| Lighting | | Facilities to meet CAT-1 ILS | | | |
| Buildings | Passenger Terminal | 11,000 | 16,000 | 23,000 | 29,000 |
| | Cargo Terminal | 900 | 1,800 | 2,600 | 3,600 |
| | Customs, Quarantine, and Post Office for Cargo, Presidential Pavilion, Control Tower, Fire-Fighting and Rescue Station | | | | |
| Car Parking (Number of Cars) | | 1,000 | 1,400 | 2,000 | 2,300 |
| Others | | Utilities, Fuel Supply, etc. | | | |

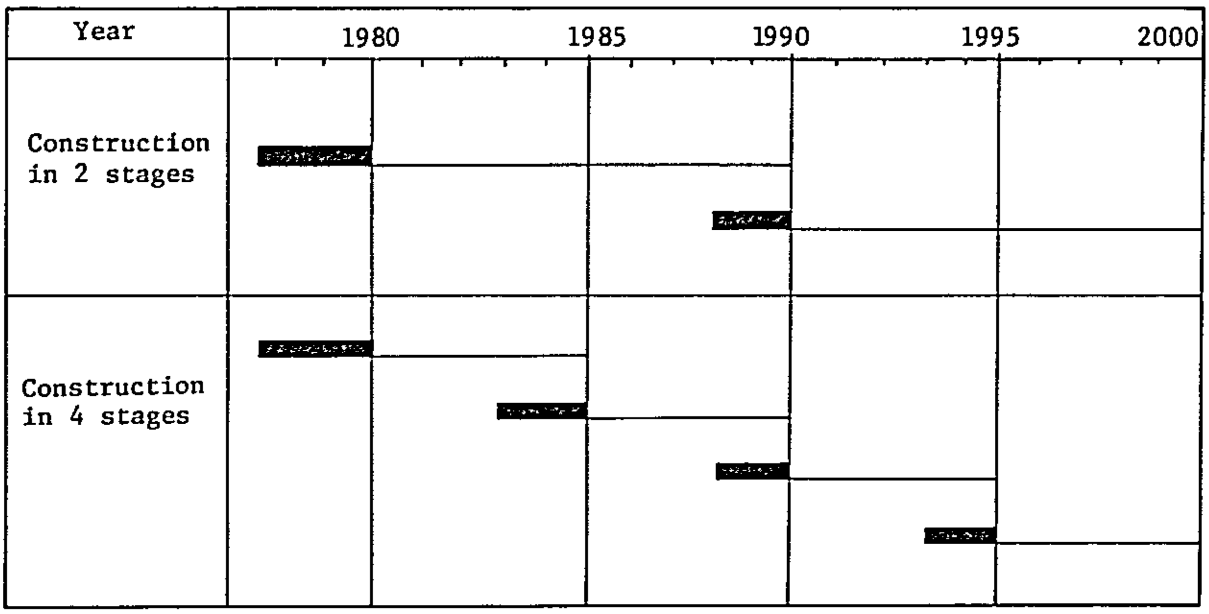
(2) Airpot Layout Plan

Facility layout of the New Airport Construction Plan is primarily based on the existing master plan of the Bolivian Government.

The Existing Airport Expansion Plan envisages extension of the present runway toward the south, with the new terminal area located on the opposite side of the runway to its present location. (See attached Drawings 1 - 8)

(3) Staging and Timing of Construction

For both of the two plans identical staging and timing of construction have been established as illustrated below, for the purpose of this study, with the ultimate design year of 2000 for both.




Legend: ▬ Construction period.

——— Airport in operation.

(4) Project Cost

The estimated investments for each construction stage of the two plans are summarized as tabulated below:

(In Million US Dollars)

| Plan \ Design Year | | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| New Airport Construction Plan | 2-Stage Construction Plan | - | 82 | - | 69 |
| | 4-Stage Construction Plan | 71 | 15 | 36 | 44 |
| Existing Airport Expansion Plan | 2-Stages Construction Plan | - | 103 | - | 48 |
| | 4-Stage Construction Plan | 79 | 28 | 24 | 31 |

Note 1) The estimates do not include land acquisition cost.

Note 2) The estimate of Existing Airport Expansion Plan includes road tunnel construction cost.

Note 3) The costs are converted at the rate of ¥260 to One US Dollar.

4. Economic Analysis

To determine the economic feasibility of the New Airport Construction Plan, cost-benefit analysis was first made with benefits identified through comparison of the proposed plan with the Base Plan (continued use of the El Trompillo Airport at the present facility level) from the view point of the national economy, followed by a study to examine whether the plan under contemplation is truly the most advantageous of all practicable alternatives. This was done by comparing the total net cost for the entire project life of 20 years of the new airport plan against that of the expansion plan, in both cases using the discount rate of 12% per annum. The two-step analysis resulted in an internal economic rate of return of 15.0%, for the New Airport Construction Plan, and a difference in net cost, representing the net benefit, of US$8.39 million in favor of the new airport plan, which is considered to be enough to justify the contemplated investment in the development of the new airport.

5. Financial Analysis

The financial internal rate of return of the New Airport Construction Plan was calculated with the total potential airport revenue for the project life of 20 years estimated on the basis of the currently prevailing level of airport charges. This amounted to 0.15%, admittedly a low figure, which indicates the desirability of substantial upward adjustment of the airport charges level. An example of a cumulative increase of 45% by 1985 to be achieved by a 20% raise in 1981 and 10% each in 1983 and 1985, would bring the financial internal rate of return to 4%, provided that the cost factors remain unchanged.

## CONCLUSIONS AND RECOMMENDATIONS

1. As a result of the present study sufficient significance and necessity for the construction of the proposed new international airport have been identified in the light of the national and regional economic development, social requirements of the surrounding community, and of the projected future air transport demand.

2. The Viru Viru site selected by the Government of Bolivia for the new airport is satisfactory in all respects.

3. The New Airport Construction Plan is technically and economically feasible.

4. It is desirable to make upward adjustment of the current airport charges to a practical and sufficient level so as to attain adequate financial rate of return for the proposed new airport project.

5. Considering all aspects involved in the project implementation, particularly that of the project management and safety elements, it is recommended that the project be executed in two stages, with the first phase facilities aimed to accommodate the requirements of up to 1990.

6. It is desirable to establish adequate, practical and well coordinated arrangements among all concerned in order to ensure smooth and efficient implementation of the project.

# 1. BACKGROUND OF PROJECT

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## 1-1 GENERAL BACKGROUND

### 1-1-1 Air Transport in Bolivia

Air transport in Bolivia has made a rapid progress in recent years both in the international and domestic services. During the 10-year period between 1966 and 1975 the total number of air passengers at major airports in Bolivia increased at an average rate of 11% per annum, and the tendency has been especially remarkable at Santa Cruz-El Trompillo Airport.

This increase in air transport demand is largely due to the development of Bolivian economy which has enjoyed a steady growth at an average annual rate of more than 6%, and above all, to the rapid economic development in the Department of Santa Cruz.

The air transport, however, neither occupies important enough place in the overall national transport system of Bolivia, nor has it been developped to the necessary and satisfactory level.

The national transport system of Bolivia in general is handicapped by the two restrictive conditions as follows:

a. The territory is completely land-locked with no seaway access.

b. The topographic features of the country are such that a steep mountainous area lies to the west and vast undeveloped areas extend to the north and the east, with the population sparsely distributed over the entire territory, requiring a huge investment to provide an adequate transport service for the nation.

These adverse conditions have been hampering the development of the transport system of Bolivia as a whole. For example, the total extension of the road network in Bolivia is about 3,800 km, of which only 1,600 km is asphalt surfaced, and 6,600 km is gravel surfaced. As for the railway, its total extension throughout the country is only 3,400 km, and worse still, it is separated into two systems, the western system centering along the La Paz/Cochabamba route, and the eastern system centering around Santa Cruz. (See Fig. 1-1-1)

There also exist several waterways and a relatively well developed system of hydrocarbon pipelines. The majority of the Bolivian territory, however, is in general served only by one single mode of transport.

Such a situation is described in the Socio-Economic Development Plan (1976 - 1980) as quoted in an unofficial translation hereunder:

"The lack of an adequate transport infrastructure constitutes a serious obstacle in the development of the country. This deficiency impedes the incorporating into the economic activity of the nation an enormously extending territory with great potential in natural resources. The deficiency also makes physical integration of the nation difficult, restricts its external trade, and limits the development of tourism" (*)

In reality, it is this very situation that demands the civil aviation in Bolivia a contribution greater than in ordinary circumstances. In other words, in international aspects, the fact that the country is completely land-locked with no seaway access gives the air transport a vital importance both for the international transport and for the international trade. On the other hand, in domestic aspects, there is no way but depend on air transport for communication with or within the vast extension of the undeveloped area in the north and the east, in the absence of nationwide road and railway transport network.

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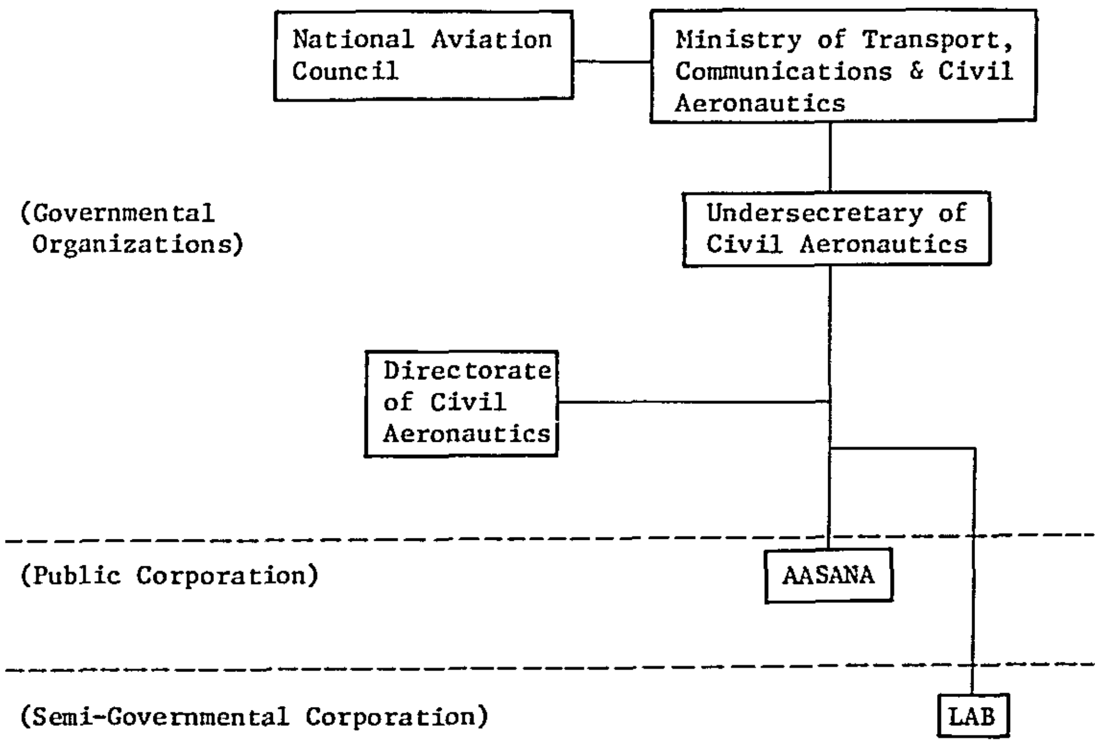
(*) República de Bolivia: Plan de Desarrollo Económico y Social, Tomo II, La Paz - Bolivia, 1976, p. 249.

The civil aviation in Bolivia, dedicated to satisfy these heavy national needs, has been developed mainly by the activities of the AASANA (Administración de Aeropuertos y Servicios Auxiliares a la Navegación Aérea) and of the LAB (Lloyd Aéreo Boliviano). The AASANA is an organization that offers, commissioned by the national government, the air transport infrastructure as owner and/or administrator of the airports of the country. On the other hand, the LAB offers air transport services of both cargo and passengers by operating the aircraft in its possession. (See Table 1-1-1 for the physical characteristics of the airports administrated by the AASANA, and Fig. 2-1-1 for air routes operated by the LAB).

The following diagram indicates the organization of the administrative system of air transport in Bolivia, including the two organizations mentioned above.



### 1-1-2 Air Transport in the Socio-Economic Development Plan

The Socio-Economic Development Plan, presently in effect, is an ambitious plan with an objective of realizing a high rate of economic growth based on promotion of exports (hydrocarbons, mineral products, agricultural products, and agro-industrial products). However, as mentioned above, the transport system is considered the major bottle-neck for the economic development of Bolivia, and, therefore, is treated as one of the most important items of the nation's development strategy.

For the national transport system as a whole, 15% is ear-marked out of the total capital formation of the national economy in the 5-year period, and it is expected that an integrated and coherent system of transport be established in such a manner that its components complement one another to achieve adequate means of transport and provide inexpensive, reliable, rapid and comfortable service. (*)

Of the total of some 900 million Dollars of the capital formation in the transport sector, about 23% is assigned to the air transport, in particular for the improvement and expansion of the local airports of Tarija, San Borja, Santa Ana, and Riberalta, (for these airports a World Bank loan of 25 Million Dollars is being granted), and also for the improvement of telecommunications and navigational aid facilities, maintenance equipment, etc.

### 1-1-3 Significance of Project

Under the circumstances, the present project has been planned by the AASANA as its executing agency.

In general airport projects are classified in two categories as follows:

---

(*) República de Bolivia: Plan de Desarrollo Económico y Social, Resumen, La Paz - Bolivia, 1976, p. 225.

a. Construction of a new airport in a location where no air transport service has been available.

b. Expansion of an existing airport whose facilities are inadequate to accommodate the transport requirements, or construction of a new airport to replace the existing airport.

The present project belongs to the second category.

In the international service, the proposed airport is to replace the functions of the existing airport of El Trompillo and to supplement the capacity of the La Paz-El Alto International Airport which is suffering from increasing congestion. The advantage of the New Santa Cruz-Viru Viru Airport being located in the center of the South American Continent will permit it to play an increasingly important role as the relaying point of the international routes running in both north-south and east-west directions. On the other hand, in the domestic service, the proposed Viru Viru Airport, by providing improved air transport service for both passengers and cargo, will play a significant role in promoting realization of the development potential of the Department of Santa Cruz which, as the "*polo de desarrollo*" (pole of development) of the nation, has developed and will continue to develop at a greater rate than in other departments of the country. The new Viru Viru Airport is also intended to be the hub of the domestic air service to serve the vast undeveloped lands extending in the northern and eastern parts of the country.

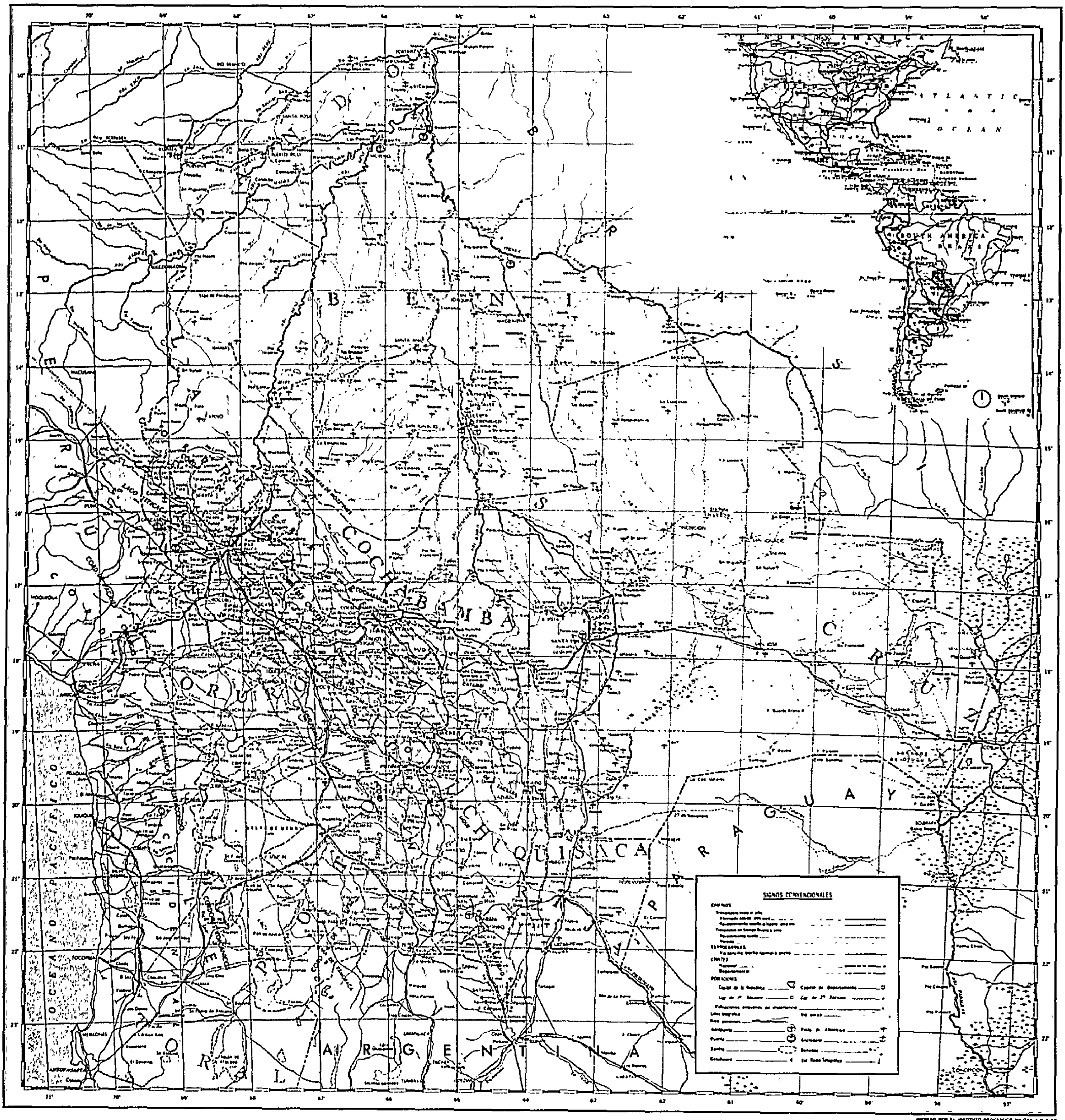



FIG.1-1-1 SISTEMA DE TRANSPORTES EN BOLIVIA

Table 1-1-1 Physical Characteristics of the Airports Administered by AASANA

| AIRPORT | RUNWAY | ORIENTATION MAGNETIC NORTH | DIMENSIONS IN METER | ELEVATION IN METER | GEOGRAPHICAL COORDINATES | | EFFECTIVE GRADIENT % | APRON AREA $M^2$ | TYPE OF RUNWAY SURFACE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | LATTD. | LONGTD. | | | |
| La Paz | 09-27 | 274/094 | 4.000 x 46 | 4,057.8262 | 16° 31' | 68° 11' | 1.55 | 34,970 | Concrete |
| Cochabamba | 04-22 | 217/037 | 2.500 x 45 | 2,547.2234 | 17° 25' | 66° 10' | 0.22 | 20,000 | Asfalt pavement |
| Cochabamba | 13-31 | 312/132 | 1.500 x 30 | -.- | --- | --- | -.- | -.- | --- |
| Santa Cruz | 14-32 | 325/145 | 2.780 x 40 | 417.1179 | 17° 48' | 63° 11' | -.- | 14,400 | Asfalt pavement |
| Trinidad | 13-31 | 314/134 | 2.600 x 30 | 154.3752 | 14° 48' | 64° 46' | 0.00 | 16,200 | Asfalt pavement |
| Riberalta | 17-35 | 345/165 | 1.100 x 50 | -.- | --- | --- | -.- | -.- | --- |
| Riberalta | 13-31 | 306/126 | 1.800 x 50 | 171.2976 | 11° 00' | 66° 07' | 0.45 | 26,600 | Earth, silt, rubble |
| Cuayaramerin | 16-34 | 342/162 | 1.800 x 50 | 169.7736 | 10° 48' | 65° 24' | 0.23 | 6,600 | Earth, sand covered with pasture |
| Sta. Ana de Yacuma | 13-31 | 317/137 | 1.500 x 500 | 219.7608 | 13° 46' | 65° 27' | -.- | 1,200 | Earth, silt with pasture |
| San Borja | 17-35 | 357/177 | 1.800 x 50 | 193.4672 | 14° 52' | 66° 52' | 0.06 | 13,500 | Earth, sand covered with pasture |
| Sucre | 04-22 | 216/036 | 1.500 x 30 | -.- | 19° 03' | 65° 16' | 2.26 | 5,400 | Rigid pavement |
| Oruro | 18-36 | 359/179 | 2.050 x 35 | 3,703.9296 | 17° 57' | 67° 07' | 0.00 | 4,800 | Earth, silt, rubble |
| Oruro | 9-27 | 269/089 | 2.000 x 35 | -.- | --- | --- | - - | -.- | Earth, silt, rubble |
| Apolo | 16-34 | 345/165 | 1.350 x 50 | 1,382.8776 | 14° 43' | 68° 30' | 1.48 | 1,800 | Earth, silt, clay |
| Ascención de Guarayos | 16-34 | 345/165 | 1.350 x 50 | 246.8880 | 15° 56' | 63° 08' | 0.34 | 1,400 | Earth, sand covered with pasture |
| Cobija | 15-33 | 330/150 | 1.100 x 50 | 251.7648 | 11° 01' | 68° 47' | 0.11 | 2,400 | Earth, silt, sand covered with pasture |
| Camiri | 15-33 | 332/152 | 1.165 x 50 | 871.1184 | 20° 01' | 63° 33' | 0.53 | 2,088 | Earth, sand, gravel |
| Magdalena | 15-33 | 336/156 | 1.400 x 50 | 236.5243 | 13° 20' | 64° 07' | 0.16 | 2,400 | Earth, sand covered with pasture |
| Yacuiba | 01-19 | 195/015 | 1.500 x 50 | 641.7558 | 21° 59' | 63° 42' | 0.16 | 7,200 | Silt, clay covered with pasture |
| Rurrenabaque | 18-36 | 360/180 | 1.300 x 50 | 274.3200 | 14° 28' | 67° 34' | 0.88 | 2,100 | Earth, silt, covered with pasture |
| San Javier | 18-36 | 360/180 | 1.450 x 40 | 579.1200 | 16° 16' | 62° 28' | 0.00 | 2,100 | Earth, sand covered with pasture |
| San Joaquin | 14-32 | 328/148 | 1.100 x 50 | 199.9488 | 13° 04' | 64° 49' | 0.16 | 7,200 | Earth, silt, rubble |
| San Ig. de Moxos | 14-32 | 322/142 | 1.300 x 50 | 240.7920 | 14° 58' | 65° 38' | 0.07 | 3,200 | Earth, silt, covered with pasture |
| San Ig. de Velasco | 17-35 | 352/172 | 1.200 x 40 | 399.8976 | 16° 22' | 60° 59' | -.- | 4,000 | Earth, silt, covered with pasture |
| Tarija | 14-32 | 320/140 | 2.000 x 46 | 1,861.3398 | 21° 32' | 64° 45' | 0.72 | 3,520 | Earth, silt, rubble |
| Tarija | 15-33 | 335/155 | 1.220 x 80 | -.- | --- | --- | -.- | -.- | --- |
| Puerto Suarez | 18-36 | 360/180 | 1.230 x 40 | 153.9240 | 18° 57' | 57° 52' | 1.00 | 3,000 | --- |
| Roboré | 16-34 | 348/168 | 1.200 x 40 | 266.6400 | 18° 20' | 59° 45' | 0.00 | 2,800 | --- |
| Concepción | 15-33 | 337/157 | 1.200 x 40 | 496.8240 | 16° 15' | 62° 03' | 0.54 | 3,600 | Earth, sand covered with pasture |
| San José de Chiquitos | 17-35 | 352/172 | 1.200 x 40 | 299.3136 | 17° 49' | 60° 48' | 0.00 | 3,000 | Earth, sand with rubble |
| Potosí | 5-23 | 237/057 | 2.100 x 60 | 3,934.0457 | 19° 35' | 65° 45' | 1.46 | 2,400 | Conglomerate rubble |
| Reyes | 18-36 | 360/180 | 1.350 x 40 | 245.3640 | 14° 17' | 67° 18' | 0.00 | 5,400 | --- |
| San Ramón | 16-34 | 340/160 | 1.200 x 40 | 213.3600 | 13° 17' | 64° 42' | 0.21 | 1,100 | --- |

SOURCE: DEPARTMENT OF CIVIL WORKS

## 1-2 PROBLEMS OF EXISTING AIRPORT

### 1-2-1 Existing Facilities

The existing El Trompillo Airport is located approximately 2 km to the south of the center of the City of Santa Cruz, close to the 2nd Loop Road that encircles the city area.

The principal facilities of the existing airport and its general plan are shown in Table 1-2-1 and Fig. 1-2-1 respectively.

Table 1-2-1 Existing Facilities of El Trompillo Airport

| Airport Facilities | | | Remarks |
|---|---|---|---|
| Runway | | 2,780 m x 40 m | Asphalt concrete |
| Runway Strip | | Width 150 m | - |
| Taxiway | | Connects Apron with Runway | |
| Apron | | 5 Parking Positions | |
| Passenger Terminal | | 2,440 $m^2$ | Baggage Clain Area Outdoors |
| Cargo Terminal | | 580 $m^2$ | - |
| Light Aircraft Hanger | | 7,000 $m^2$ | About 30 Aircraft Spaces (No. of Ordinarily Parked Aircrafts: 80) |
| Tele-Communi-cations | Aeronautical Fixed Service | Microwave Circuit | LAPAZ |
| | | HF/SSB | " |
| | | HF/MAS | International Circuits Campo Grande Domestic Circuits 8 Airports |
| | Aeronautical Mobile Service | HF, VHF | Ground - Air |
| Air Navigation Aids | | VOR, NDB, Locator | - |
| Meteorological Facilities | | Anemometer, Barometer | - |
| Airfield Lighting Facilities | | Medium Intensity Runway Edge Light | 1 set |
| | | Aerodrome Beacon | 1 set |
| | | Apron Lighting | 3 units |

(1) Runway, Taxiway, and Apron

The runway is 2,780 m long and 40 m wide, but due to the inadequacy of lighting facilities its nocturnal use is limited to the length of 2,075 m only.

The critical aircraft presently in service is B727-100. In order to accommodate DC-8 and B747 class aircraft which are expected to be among the future fleet serving this airport, it will be necessary to expand the runway both lengthwise and widthwise, as well as to enforce the pavement structure.

(2) Although there were an average of only 2 peak hour flights registered in 1976, the passenger terminal building is congested close to saturation. There is only one, not large enough lobby which is commonly used by both international and domestic passengers, each pax accompanying about 3 well-wishers on an average, which is relatively many compared with the number at airports of most other countries.

Furthermore, the baggage claim area for domestic service is located outdoors and is causing much inconveniences to passengers especially at times of rain.

(3) Radio Navigational Aids

The airport is equipped with VOR, NDB, and locator, but the navid facilities in general are quite worn out and obsolete.

(4) Airfield Lighting

Medium intensity runway edge lighting which is quite worn out is installed along the length of 2,075 m from the apron side end of the 2,780 m long runway.

(5) Rescue and Firefighting Facilities

The airport is equipped only with some portable-type fire extinguishers, with no system or organization whatsoever of the rescue and firefighting service.

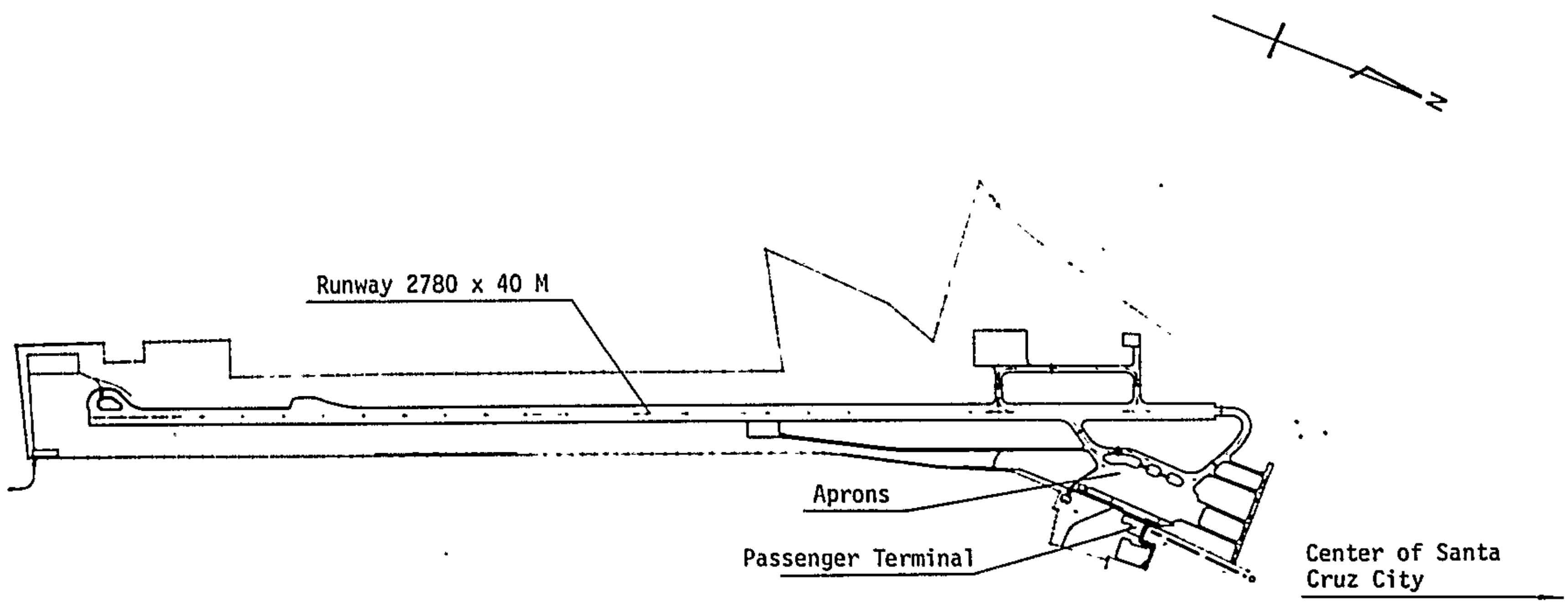



Fig. I—2—I
Facility Layout of El Trompillo Airport in Santa Cruz

## 1-2-2 Social Problems

### (1) Incompatibility with the Urban Planning

El Comité Departamental de Obras Públicas de Santa Cruz (the Public Works Committee of the Department of Santa Cruz) announced in 1967 the urban road development plan as illustrated in Fig. 1-2-2 which was to be implemented for completion by 1972. The plan is based on the premise that the new airport will be constructed in Viru Viru, and envisages removal of the existing runway except for the 1000 m portion from the north end (closer to the city center) which is to be used for general aviation, and to redevelop the remaining area of the existing airport into a green park.

The execution of the said plan is considerably behind schedule, and as of 1977, only the inner lane of the 3rd Loop Road is in the stage of pavement work. One of the major causes of this delay is the fact that due to the continued use of the El Trompillo Airport, the existing runway is preventing the linking up of the 3rd Loop (both inner and outer lanes) and the 4th Loop roads as shown in Fig. 1-2-2.

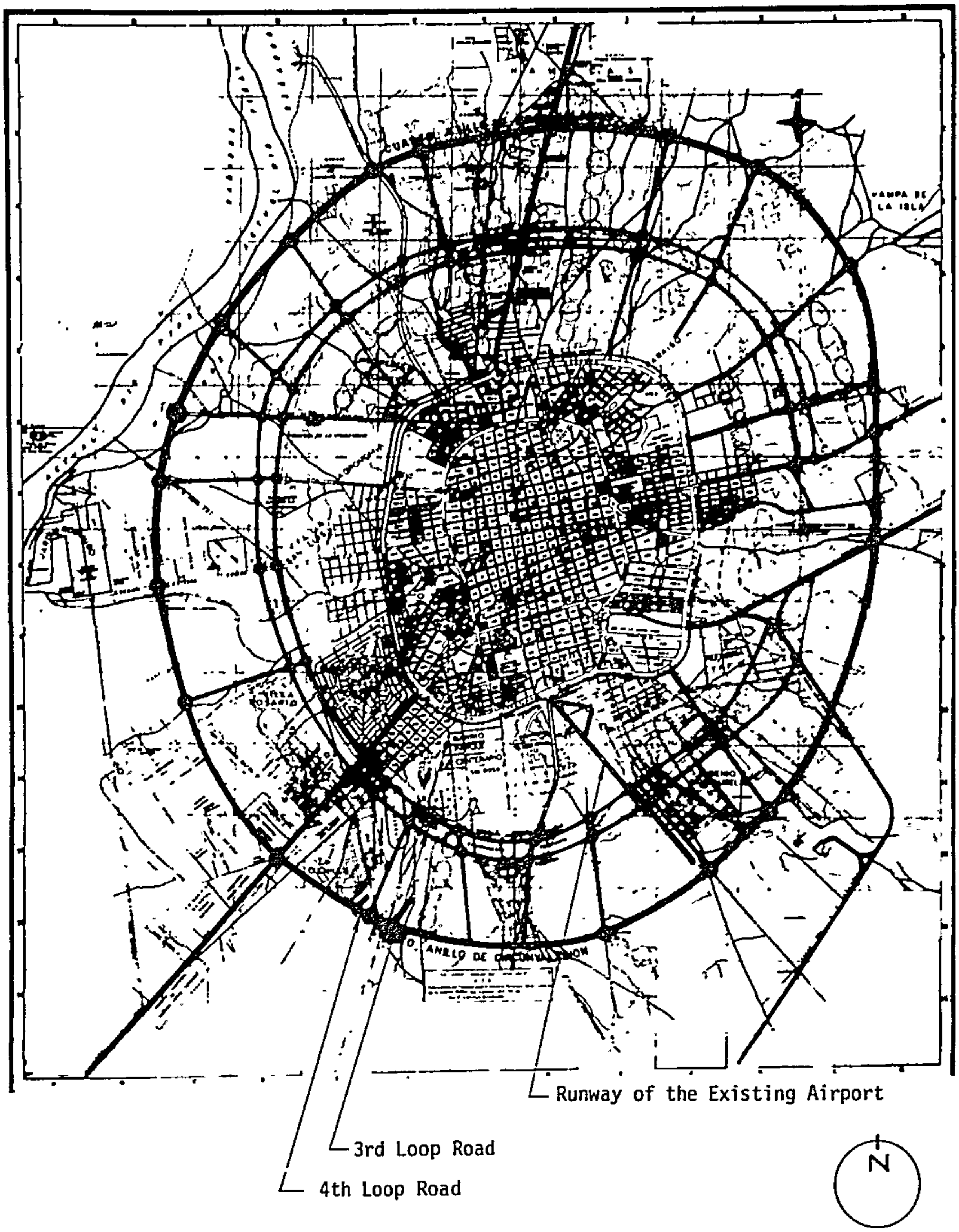



Fig. 1-2-2 Urban Plan of the City of Santa Cruz

(2) Aircraft Noise

Since the El Trompillo Airport is situated within the urban area, even at the present level of flight operations, aircraft noise is already causing complaints among the nearby inhabitants, and it could well lead to a social problem as the flight increases in future.

(3) Aircraft Accident

Aircraft accidents recorded during the 3 years between 1974 and 1976 are as shown in Table 1-2-2. Since the airport is located within the urban area, an aircraft accident, once it occurs, can cause serious damages on the part of the surrounding population.

Table 1-2-2 Statistical Data on Aircraft Accidents in El Trompillo Airport

| Year | Aircraft Movement (A) | Aircraft Accident (B) | Fatality | $\frac{(B)}{(A)} \times 1,000$ |
|---|---|---|---|---|
| 1974 | 18,216 | 59 | 22 | 3.24 |
| 1975 | 20,598 | 69 | 11 | 3.35 |
| 1976 | 20,000 | 40 | 21 | 2.10 |

Source: AASANA

Though not included in the records of the above table, one accident of B707 freighter which failed in take-off and crashed in October 1976 caused damages and losses involving a total of 169 victims, including 80 fatalities, 78 heavily or slightly injured, and 11 missing.

## 1-3 REVIEW OF THE MASTER PLAN (ITALCONSULT) OF THE GOVERNMENT OF BOLIVIA

A thorough review was made of the existing Master Plan of the Government of Bolivia (Italconsult) for the construction of the New International Airport in Viru Viru, with the findings as summaried hereunder.

### 1-3-1 Outline of the Master Plan (Italconsult)

The ultimate design year of the Master Plan is set at 1995, and the construction is planned in 2 stages, with the 1st stage facilities intended to satisfy requirements of up to 1985.

Fig. 1-3-1 shows the general layout plan of the Viru Viru Airport as presented in the Master Plan (Italconsult).

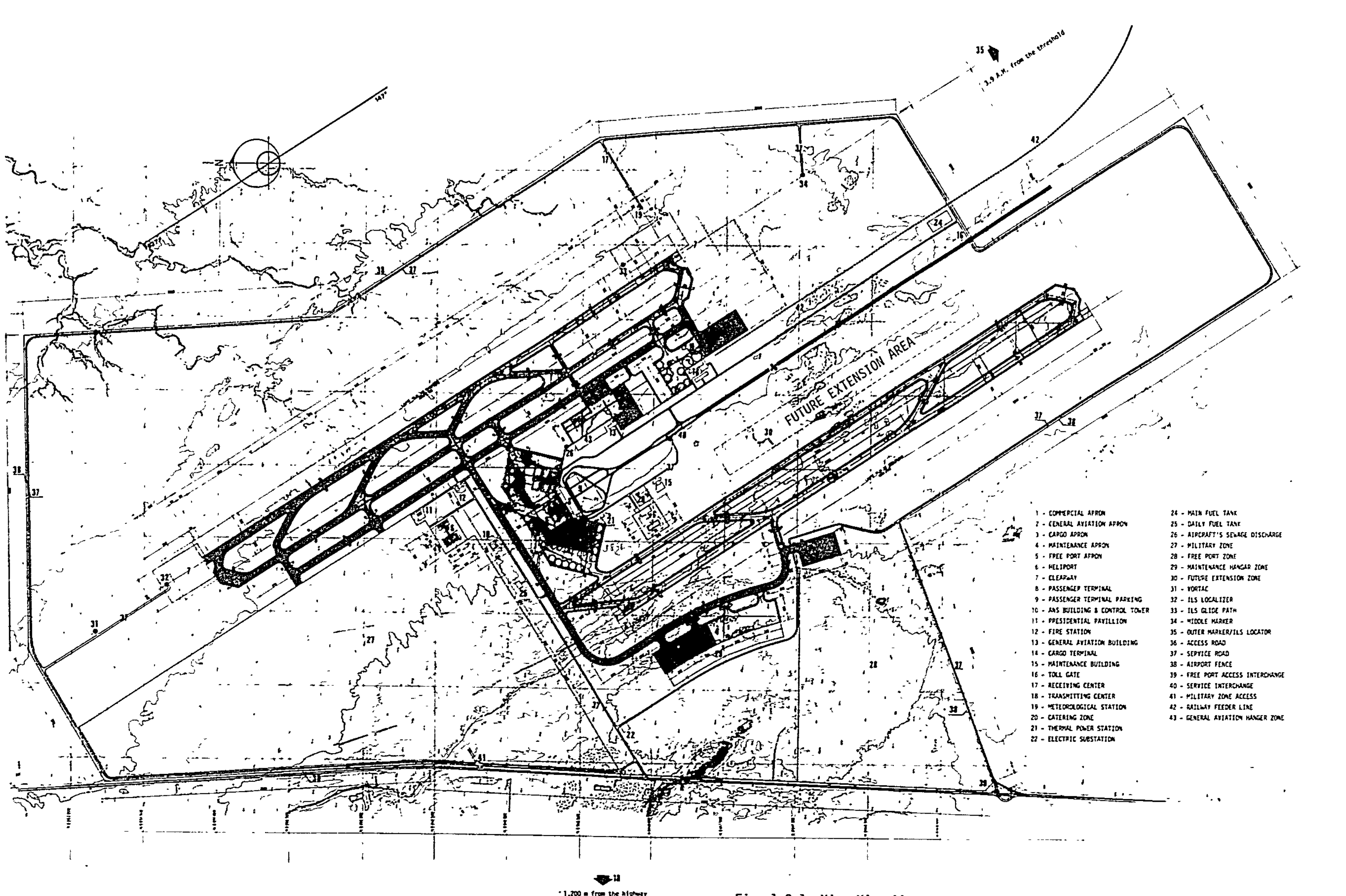



Fig. 1-3-1 Viru Viru Airport Master Plan by Italconsult

Table 1-3-1 below shows the outline of the facilities of the Viru Viru Airport as proposed in the Master Plan (Italconsult).

Table 1-3-1 Outline of Viru Viru Airport Facilities by Master Plan (Italconsult)

| Design Year | | | 1985 | 1990 |
|---|---|---|---|---|
| Annual Air Transport Demand Forecast | No. of Passengers | (Domestic & International) | 590,000 | 1,840,000 |
| | Cargo Tonnage | (Domestic & International) | 10,000 | 22,000 |
| | No. of Aircraft Movements | (Scheduled & Nonscheduled) | 45,000 | 97,000 |
| | No. of Aircraft Parking Positions | (Passengers & Cargo) | 20 | 36 |
| Aerodrome | Runway Strip | | 3,820 m x 300 m | |
| | Clearway | | 350 m x 250 m | |
| | Runway | First | 3,700 m x 45 m | |
| | | Second | - | 3,700mx45m |
| | Taxiway | Parallel | 1 | 2 |
| | | High-Speed Exit | 3 | 5 |
| | Distance | Between Runways | 1,800 m | |
| | | Runway-Taxiway | 250 m | |
| | | Between Taxiways | 150 m | |
| Radio Navigational Aids | | | one set of NDB, VORTAC, & ILS | To be expanded |
| Airfield Lighting Facilities | | | " | " |
| Telecommunications and Meteorological Facilities | | | " | " |

| Design Year | | 1985 | 1990 |
|---|---|---|---|
| Buildings | Passenger Terminal | 21,000 $m^2$ | To be expanded |
| | Cargo Terminal | 5,200 $m^2$ | To be expanded |
| | Control Tower | 2,400 $m^2$ | |
| | Fire Station, Presidential Pavilion, General Aviation Building, Transmitting Center, Receiving Center, Substations | To be installed | To be expanded |
| Others | Heliport | Newly installed | To be expanded |
| | Road, Parking | Newly installed | To be expanded |
| | Fuel Distribution Facilities | Newly installed | To be expanded |
| | Aircraft Maintenance Building | To be planned | |
| | Railway for Cargo Transport | Newly installed | |
| | Free Port | To be planned | |
| | Catering Building | Newly installed | To be expanded |
| | Incinerator | Newly installed | To be expanded |

1-3-2 Summary of Review Results

(1) Air Transport Demand Forecast

The air traffic demand projections presented in the Master Plan are based on the statistics of up to 1971, and its method is that of simple extrapolation of the historical trend. It will be necessary, therefore, to revise the existing projection based on updated traffic records.

(2) Proposed Site

For the construction of the new airport, the Government of Bolivia has selected the Viru Viru site approximately 17 km north of the City of Santa Cruz, and the necessary land acquisition has already been completed. This site satisfies the overall requirements for the construction of the new airport in the vicinity of Santa Cruz, where there is no other comparable alternative.

(3) Runway Length

The runway length proposed in the Master Plan needs to be re-examined in the light of the traffic projections of the Master Plan itself and of the revised and updated traffic projections, as well as from the technical view point of aircraft operations, etc.

(4) Airport Layout

1) As the general aviation area exists between the passenger terminal and cargo terminal, it will seriously inconvenience transporting of belly cargo to and from the passenger aircraft and cargo terminal building.

2) Construction of railway for the cargo terminal as proposed in the Master Plan is considered unnecessary judging from the cargo traffic demand projected.

3) The projected air transport demand hardly seems to justify provision of two parallel runways as proposed in the Master Plan.

(5) Civil Engineering Works

1) Proposed drainage plan and design are uneconomical and without due regard for the natural physical conditions of the site such as the high ground water level or for the availability of construction materials such as the difficulty in obtaining gravel.

2) The necessary earth fill materials need not be transported from outside the airport site as proposed in the Master Plan, since the earth excavated in the drainage work may be used for the fill.

3) Regarding the pavement design, the ratio of cement contents is excessive in the soil cement mixture to be used for the subbase.

(6) Radio Navigational Adis, Telecommunications and Meteorological Facilities

After completion of the Master Plan in December 1973, the National Plan for Air Navigation (1977-1981) has been formulated by AASANA, necessitating revision of the pertinent parts of the master plan to satisfy the new requirements.

(7) Airfield Lighting Facilities

1) Arrangement of the runway threshold lights needs to be rectified in accordance with the requirements of ICAO ANNEX 14, Part IV.

2) In consideration of the expected aircraft types to serve the airport, it is necessary to provide 3-bar VASIS.

3) It is desirable to install simple approach lighting system on Runway 15.

(8) Electrical Power Supply

1) The new airport requires a 69KV/10KV substation.

2) The design capacity of the secondary power supply for the passenger terminal and the cargo terminal is insufficient.

(9) Buildings

The passenger terminal building as well as its curbside front are both designed in 2 levels, which is considered excessive in view of the projected traffic demand. Furthermore, the building as a whole lacks flexibility for future expansion to accommodate demand increase.

### 1-3-3 Conclusion of Review

As a result of the review as summarized in the foregoing, it was concluded to re-examine and update the air transport demand forecast of the Master Plan, make the necessary modifications on the Master Plan accordingly, and to use the modified Master Plan as the basis of the proposed new development plan for the Viru Viru International Airport, which is presented in Chapter 3 of the present report.

# 2. AIR TRANSPORT DEMAND FORECAST

## 2. AIR TRANSPORT DEMAND FORECAST

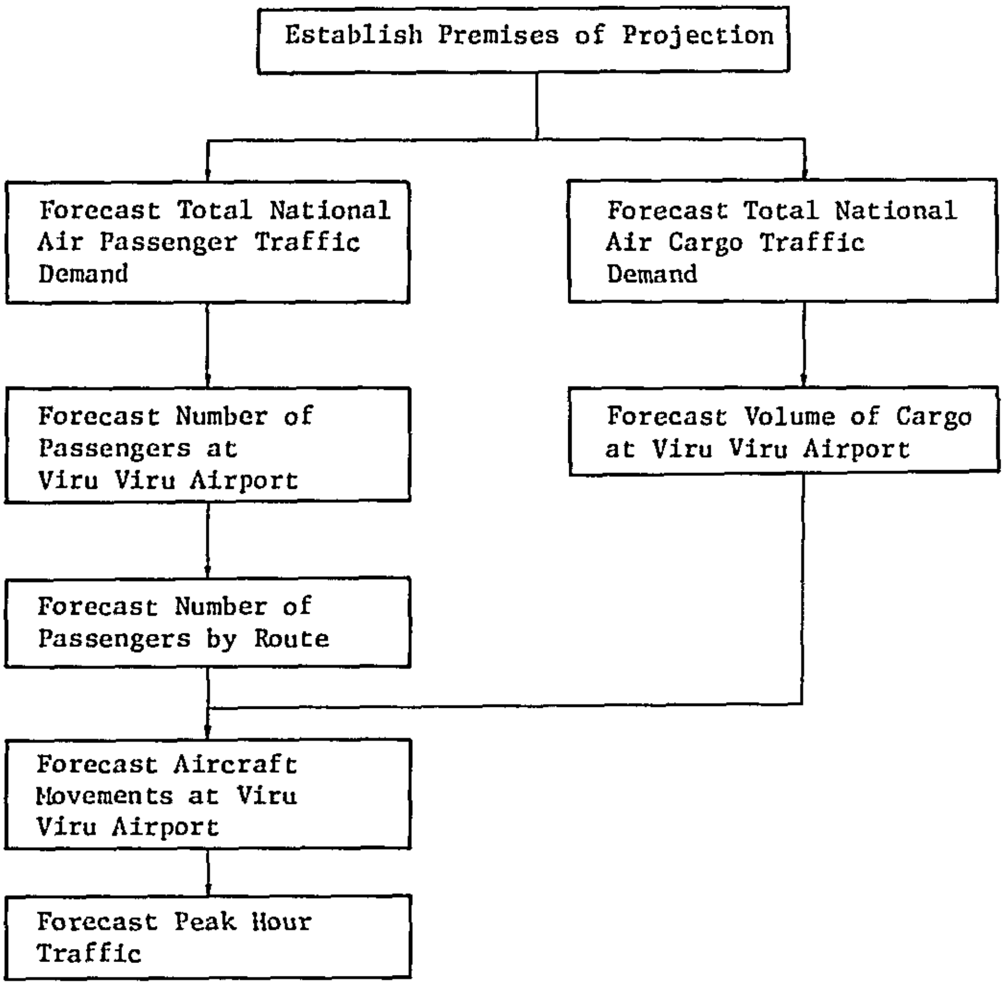
### 2-1 PREMISE

#### 2-1-1 Basic Approach

When the air transport demand of a certain airport is projected solely on the basis of the historical data of performance of that particular airport, there always is a danger that the resultant figures fall outside the tolerable margin of errors either upward or downward. This is especially true in cases of long range projections. To avoid such a danger, projection should be made firstly of the overall air transport demand of the nation or the region to which the airport belongs, and within the framework of such total demand, the figures attributable to the airport in question should then be projected.

In the present study the projection was made for the period of 20 years between 1980 and 2000. The overall air transport demand of passengers and cargo for the entire nation was projected in the first place, and the respective portions attributable to Santa Cruz were then calculated taking into consideration the development potential of air transport demand for the Viru Viru Airport. Projection of the national air transport demand of both passengers and cargo was made through correlation analysis with the Gross Domestic Project.

Sequence of the projection procedures is as outlined below:




2-1-2 Estimation of Gross Domestic Product

The economy of Bolivia has made a relatively favorable progress during the past decade between 1965 and 1975. (See Table 2-1-1). The average annual growth rate in real terms of the GDP during this period amounted to 6.0%, which exceeds the corresponding average figure of 5.3% for the South American nations during the same period. During the recent 3 year period ending in 1975, the progress was especially steady with the average growth rate in real terms reaching a high of 6.8%. The principal factors responsible for such a steady growth of the national economy are, for one thing, the increase in production in the agricultural sector which accounts for 14.4% of the GDP, and for the other, the stable growth in the mining sector accounting for 10.5% of the GDP, and lastly the improved productivity in the industrial sector which accounts for 15% of the GDP. The Socio-Economic Development Plan (1976 - 1980) of the Government of Bolivia sets forth the average annual growth rate of GDP at 7.7% in real terms for the period of the Plan, on the strength of the anticipated growth in the above three sectors.

Table 2-1-1 Evolution of Gross Domestic Product

(In Million Bolivian Pesos in 1970 prices)

| Year | Gross Domestic Product | % Increase over Previous Year |
|---|---|---|
| 1965 | 8,885 | |
| 1966 | 9,522 | 7.2 |
| 1967 | 10,123 | 6.3 |
| 1968 | 10,974 | 8.4 |
| 1969 | 11,476 | 4.6 |
| 1970 | 12,080 | 5.3 |
| 1971 | 12,540 | 3.8 |
| 1972 | 13,181 | 5.1 |
| 1973 | 14,086 | 6.9 |
| 1974 | 15,034 | 6.7 |
| 1975 | 16,057 | 6.8 |

Source: Ministry of Planning and Coordination.

In the present study the average annual growth rate of the GDP was assumed in three possible cases of low, medium and high growth patterns as shown in Table 2-1-2. The rates for the period between 1975 and 1985 were assumed considering the above mentioned circumstances, and for the period of 1985 to 1995 somewhat lower set of rates were assumed in anticipation of a slackened growth trend. Table 2-1-3 shows the estimated Gross Domestic Product for 1985 and 1995 calculated on the basis of these assumed growth rates.

Table 2-1-2 Assumed Growth Rates of Gross Domestic Product

(In percent)

| Period \ Case | I | II | III |
|---|---|---|---|
| 1975 ~ 85 | 6.0 | 6.8 | 7.7 |
| 1985 ~ 95 | 5.0 | 5.5 | 6.0 |

Table 2-1-3 Estimated Gross Domestic Product

(In Million Bolivian Pesos in 1970 prices)

| Year \ Case | I | II | III |
|---|---|---|---|
| 1985 | 28,756 | 31,001 | 33,715 |
| 1995 | 46,840 | 52,954 | 60,378 |

### 2-1-3 Estimation of Population

Table 2-1-4 shows the population of Bolivia based on the census in 1950 and 1976. Average annual increase rate for the period between the two censuses amounts to 2.14%, which is slightly lower than the average for South American countries of 2.5% for the 10 years period of 1965 to 1974.

The Socio-Economic Development Plan foresees a relative decline in mortality rate against the birth rate on account of the improved living environment anticipated for the period of the Plan, and assumes on an average annual growth rate of population of 2.8% for the same period.

In the present study the average annual population growth rates are assumed at 2.14% for the lower limit, 2.5% for the intermediate, and

2.8% for the upper limit of the growth range respectively. The national population of Bolivia in 1985 and 1995 estimated on the basis of these assumed growth rates are as presented in Table 2-1-5.

Table 2-1-4 Evolution of the Population in the Bolivian Departments and their Capitals

(In Persons)

| Year / Department & Capital | 1950 | 1976 | Annual Growth Rate (1950 - 76) |
|---|---|---|---|
| Total | 2,704,165 | 4,687,718 | 2.14 |
| La Paz | 854,079 | 1,484,151 | 2.15 |
| La Paz | 267,008 | 654,713 | 3.51 |
| Oruro | 192,356 | 310,983 | 1.86 |
| Oruro | 58,558 | 124,121 | 2.93 |
| Potosí | 509,087 | 657,703 | 0.99 |
| Potosí | 43,306 | 77,233 | 2.25 |
| Cochabamba | 452,145 | 777,807 | 2.11 |
| Cochabamba | 74,819 | 204,414 | 3.94 |
| Chuquisaca | 260,479 | 357,717 | 1.23 |
| Sucre | 38,404 | 63,259 | 1.94 |
| Tarija | 103,441 | 187,791 | 2.32 |
| Tarija | 16,398 | 39,087 | 3.40 |
| Pando | 16,284 | 34,314 | 2.91 |
| Cobija | 1,711 | 3,649 | 2.96 |
| Beni | 71,636 | 164,850 | 3.26 |
| Trinidad | 10,607 | 27,583 | 3.74 |
| Santa Cruz | 244,658 | 712,402 | 4.20 |
| Santa Cruz | 41,461 | 255,568 | 7.25 |

Source: National Institute of Statistics

Table 2-1-5 Estimated Total Population of Bolivia

(In Persons)

| Growth Range | Assumed Annual Growth Rate (%) | 1985 | 1995 |
|---|---|---|---|
| Upper Limit | 2.8 | 6,010,000 | 7,922,000 |
| Intermediate Value | 2.5 | 5,854,000 | 7,494,000 |
| Lower Limit | 2.14 | 5,672,000 | 7,009,000 |

## 2-1-4 Development Potential of the Regional Economy in the Department of Santa Cruz

The Department of Santa Cruz is the largest of all the Bolivian departments with a total area of 370,000 $km^2$ extending over the south-eastern plains of the country. It has a population density of 1.9 persons/$km^2$, less than one half of the national average. The population growth of the department, however, has been quite remarkable, and the 1976 census recorded 712,000 inhabitants, representing a growth over the figure of the 1950 census at an average annual rate of 4.2%, which claims to be the highest among all 9 departments of the country. (See Table 2-1-4)

The departmental capital, City of Santa Cruz, above all, has witnessed acute concentration of population in recent years, leaping from the 5th position among all the cities of the country in 1950 to the 2nd position after La Paz in the 1976 census, registering 256,000 inhabitants, and representing a very high 25-year average annual growth rate of 7.25%.

This rapid increase in population in the city of Santa Cruz is considered to be largely due to the increase in labor demand resulting from the increasing exports of petroleum, natural gas, and cotton, as well as from the activated production in the industrial complex, etc.

If in future the exploration of the Mutun mine situated close to the Brazilian border, which is believed to have one of the largest deposits of manganese and iron ore in the world, should be duly developed, along with the continued production of petroleum, then the Department of Santa Cruz would become a center of heavy chemical industry of Bolivia. Furthermore, with the due implementation of the Rosita Project involving construction of a dam on the upper stream of the Rio Grande, designed to provide electrical power as well as water for irrigation over the 160,000 hectares of land of the region, the Department of Santa Cruz is likely to develop as a great agricultural region of the country, thanks also to its favorable climatic conditions. In view of its advantageous geographical position, and of the abundant natural resources, the Department of Santa Cruz is considered to have the greatest development potential in Bolivia and to maintain a higher population growth than in other departments of the Republic. Assuming on the same growth trend for the future as in the past, it is estimated that in 1985 the population in the Department of Santa Cruz will be 1,032,000, and that of the City of Santa Cruz 480,000, and in 1995 it will be 1,557,000 and 966,000 respectively.

### 2-1-5 National Airport Development Plan

In the present study it is assumed that the airports in Bolivia will be developed in accordance with the air transport demand during the period of projection.

### 2-1-6 Air Route Plan

As shown in Fig. 2-1-1, the existing domestic air route network is fairly well developed, and as far as the air routes serving Santa Cruz are concerned, no further routes for the new airport have been assumed during the period of projection as it is considered there is no need for such.

The continuous lines in Fig. 2-1-2 indicate the existing international air routes in Bolivia. As for Santa Cruz, applications for commencement of service are presently being filed by several foreign airlines including LANCHILE (Chile), IBERIA (Spain), and AERO PERU (Peru), while LAB is also planning to develop new routes. Considering the above, the present study assumes on the development of new routes in international service as shown by the broken lines in Fig. 2-1-2.

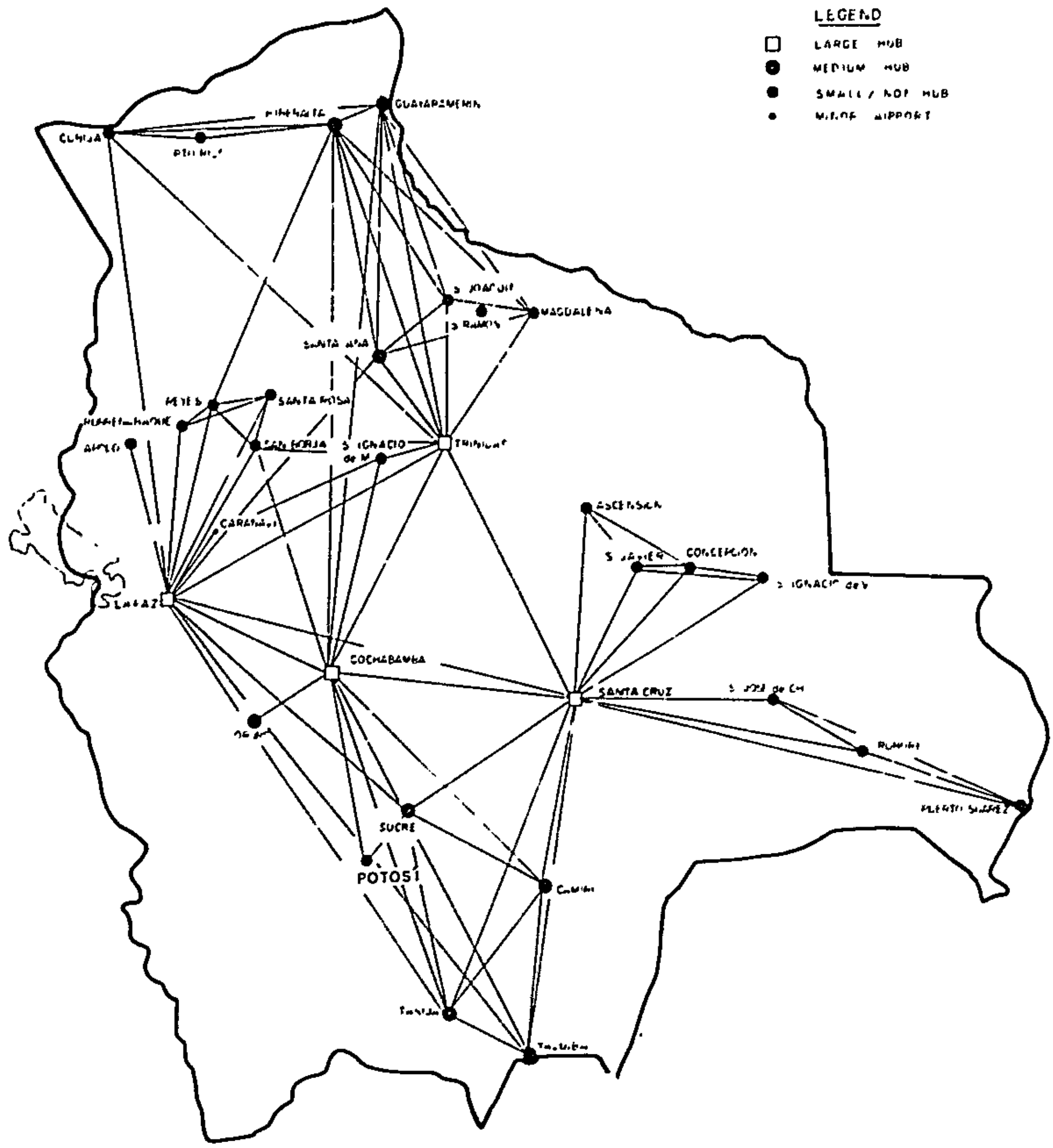



Fig. 2-1-1 Existing Domestic Air Routes

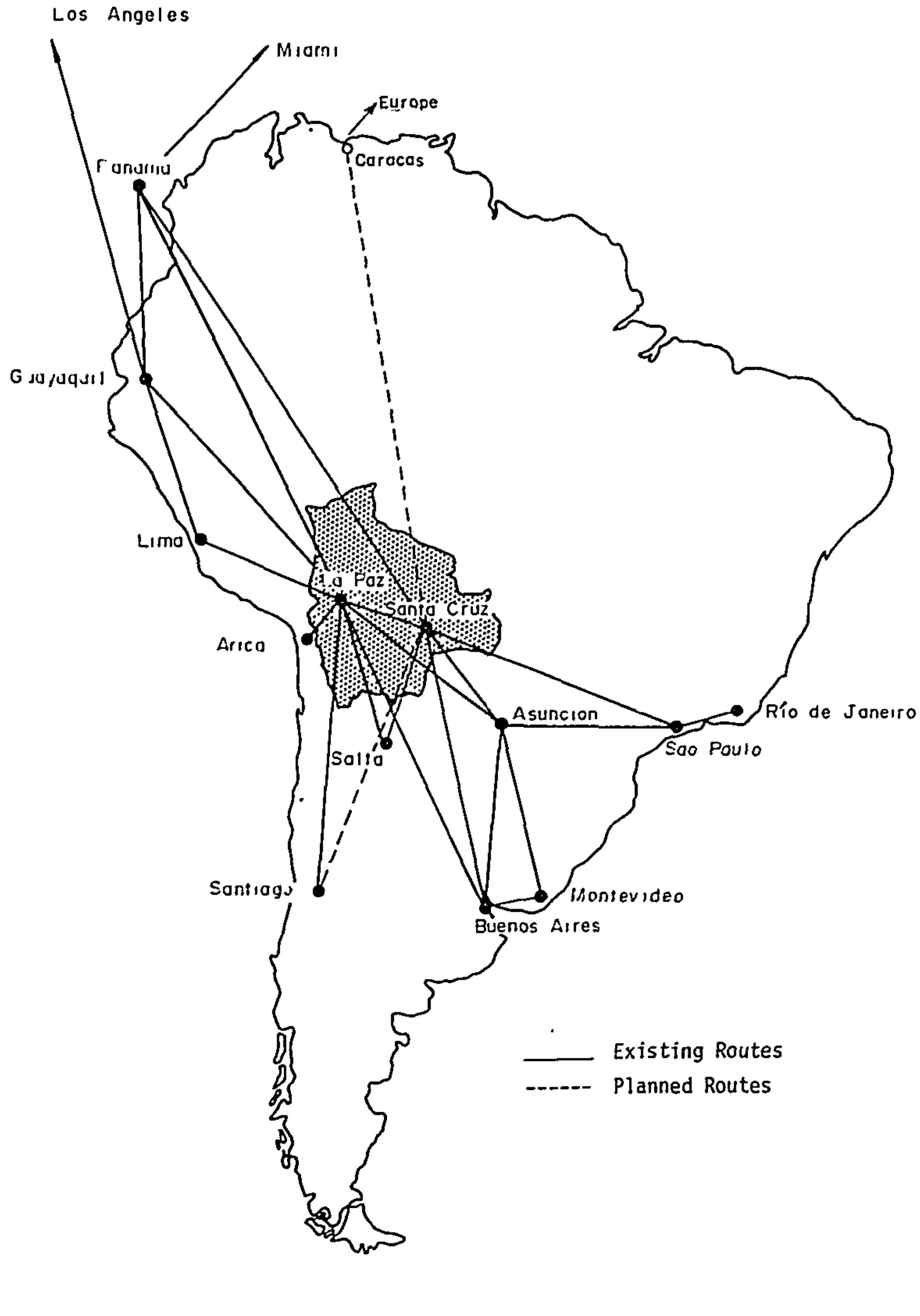



Fig. 2-1-2 International Air Route Map

## 2-2 AIR PASSENGER TRANSPORT DEMAND FORECAST

### 2-2-1 Hitorical Trends of Air Passenger Traffic

The number of arriving and departing passengers in all Bolivian airports has steadily increased at an average annual rate of 11% during the past 10 years between 1965 and 1975, amounting to a total of 987,000 in 1975. (See Table 2-2-1). This trend can be attributed for the most part to the increase in individual personal income resulting from the favorable growth in the Gross Domestic Product during the same period. The international service in particular recorded a relatively high increase rate of 14% on an average per annum, and in view of the geographical features of Bolivia, it is expected that international air transport of the country will assume increasing importance in future.

In 1975 the total arriving and departing passengers at Santa Cruz Airport numbered 224,000, ranking second only to La Paz Airport with 326,000 passengers. (See Table 2-2-1). The average annual increase rate during the '65 - '75 period for the total passengers at this airport amounted to 15%, with even higher rate of 21% for the international passengers. With such an increase in the number of passengers, its share in the country also continued to increase each year as shown in Table 2-2-1, and in 1975 amounted to 23% each both in international and domestic services. In view of the geographic situation of the airport and of the economic development potential of the Department of Santa Cruz, the share of this airport is expected to increase even more in the future, especially for international passengers, of which the share of La Paz International Airport will in contrast tend to decline.

Table 2-2-1 Evolution of Arriving and Departing Passengers

(In Thousands)

| Year | All Bolivian Airports | | | Santa Cruz Airport | | |
|---|---|---|---|---|---|---|
| | International | Domestic | Total | International | Domestic | Total |
| 1965 | 49 | 256 | 305 | 7 | 41 | 48 |
| 1966 | 56 | 307 | 363 | 6 | 49 | 55 |
| 1967 | 62 | 331 | 393 | 9 | 55 | 63 |
| 1968 | 69 | 360 | 429 | 9 | 62 | 71 |
| 1969 | 71 | 386 | 457 | 11 | 67 | 78 |
| 1970 | 91 | 403 | 494 | 13 | 72 | 85 |
| 1971 | 103 | 434 | 537 | 16 | 81 | 97 |
| 1972 | 123 | 495 | 618 | 21 | 96 | 117 |
| 1973 | 128 | 458 | 586 | 23 | 92 | 115 |
| 1974 | 160 | 618 | 778 | 35 | 136 | 171 |
| 1975 | 195 | 791 | 987 | 44 | 180 | 224 |
| Average Annual Increase | 14% | 10% | 11% | 21% | 13% | 15% |

Note: Transit passengers not included.

Source: AASANA "STATISTICAL BULLETIN 1971 - 1975"

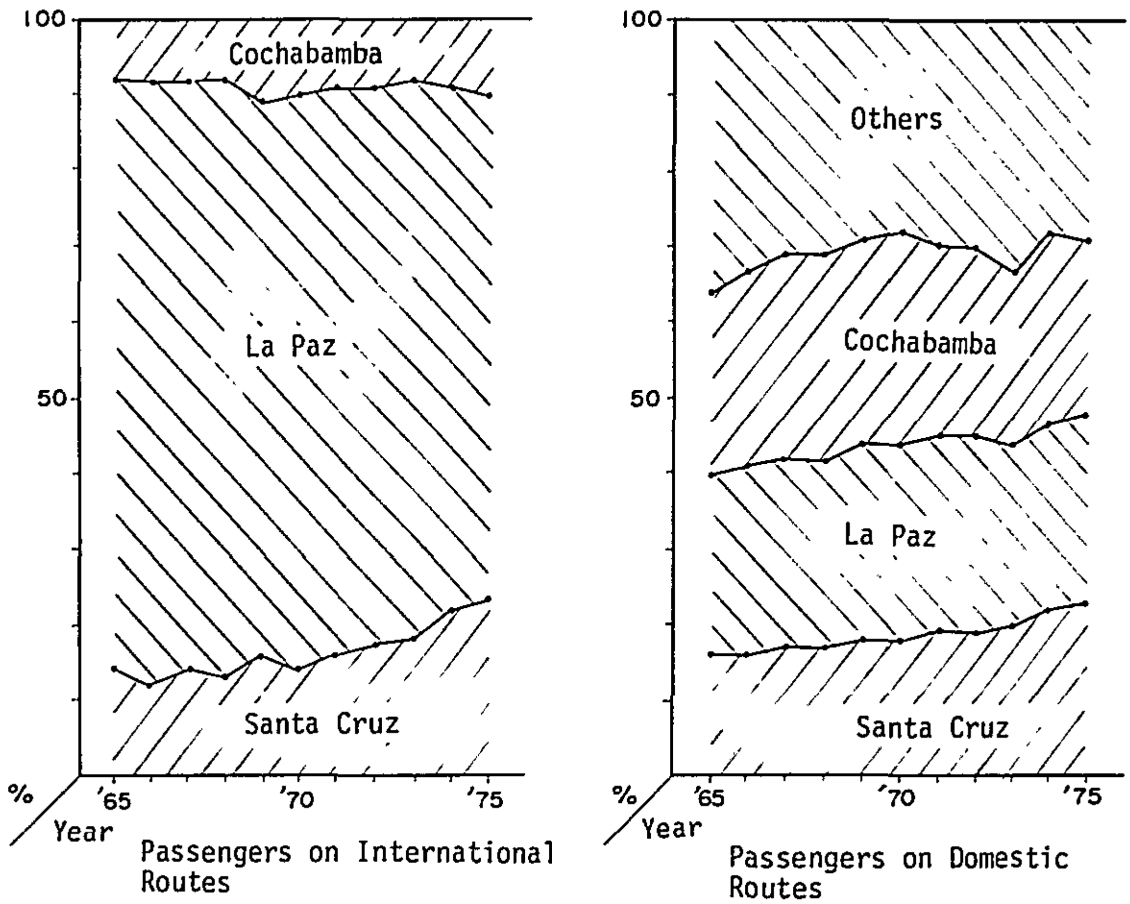



Fig. 2-2-1 Evolution of Passenger Shares of 3 Principal Airports in Bolivia

### 2-2-2 Projection of Air Passenger Traffic in Bolivia

Air passenger transport demand is said to be closely correlated with the national income. In the present study a correlation analysis with the Gross Domestic Product of Bolivia was made of the total arriving and departing air passengers in Bolivia separately in respect of international and domestic services for the '65 - '75 period. The analysis resulted in the correlation coefficients of 0.987 (Note 1) and 0.967 (Note 2) for the international and domestic passengers respectively, indicating a close correlation in both cases. Assuming that future air passenger traffic demand in Bolivia will continue to be as highly correlated with the Gross Domestic Product as in the past, the projected number of arriving and departing passengers in international and domestic services for all the airports in Bolivia in 1985 and 1995 were calculated for each of the three cases of the estimated Gross Domestic Product, as mentioned earlier, using the correlation formula obtained in the above mentioned correlation analysis, with the results as shown in Table 2-2-2.

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(Note 1) Results of correlation analysis between the GDP and the international air passengers of Bolivia

$\log Y_I = 2.356 \log X - 10,703$

Where, $Y_I$ : Total number of international air passengers (Unit: person)

$X$ : Gross Domestic Product (Unit: 1 million pesos)

Correlation Coefficient : 0.987

Period of Data: 1965 - 1975

(Note 2) Results of the correlation analysis between the GDP and the domestic air passengers of Bolivia

$\log YD - 1.639 \log X - 2,443$

Where, $Y_D$ : Total number of domestic air passengers (Unit: person)

$X$ : Gross Domestic Product (Unit: 1 million pesos)

Correlation Coefficient: 0.967

Period of Data: 1965 - 1975

Table 2-2-2 Projection of Arriving and Departing Passengers at All Bolivian Airports

(Based on correlation analysis with Gross Domestic Product)

(In Thousands)

| Gross Domestic Product | 1985 | | | 1995 | | |
|---|---|---|---|---|---|---|
| | International | Domestic | Total | International | Domestic | Total |
| Case I | 719 | 1,766 | 2,485 | 2,268 | 3,928 | 6,196 |
| Case II | 858 | 1,997 | 2,885 | 3,029 | 4,803 | 7,832 |
| Case III | 1,045 | 2,292 | 3,337 | 4,126 | 5,955 | 10,081 |

To ascertain the credibility of the figures presented in the above table, projection was made of the total air passengers in Bolivia in a different approach, namely from the view point of air trips per capita, which, for the purpose of this study, is defined to be the ratio of the total passenger arrivals and departures in all Bolivian airports to the population of the country. This ratio may be regarded as an indication of the average frequency of air trips made by each Bolivian. Table 2-2-3 presents such ratios calculated for the years 1965 through 1975, which indicate an annual increase by an average of 8% for the 10 year period. Assuming that the number of air trips per capita would increase at the same rate of 8%, it is estimated that the ratios will amount to 0.5 in 1985, and 1.0 in 1995. By multiplying these ratios by the population of the corresponding years as estimated in Subsection 2-1-3 hereinabove, the number of total air passengers in Bolivia turns out to be between 2.8 and 3.0 million in 1985, and 7.0 to 7.9 million in 1995, showing a close similarity to the figures in Case II presented in Table 2-2-2.

Consequently, the present study determined the Case II figures of Table 2-2-2 to be the optimum values of projection of the total air passengers in Bolivia for the years 1985 and 1995 respectively, with the figures of Case I and Case III determined respectively to be the lower and upper limits of the range of projection.

Table 2-2-3 Evolution of Number of Air Trips per Capita

| Year | Number of Air Trips per Capita |
|---|---|
| 1965 | 0.082 |
| 1966 | 0.096 |
| 1967 | 0.101 |
| 1968 | 0.108 |
| 1969 | 0.113 |
| 1970 | 0.120 |
| 1971 | 0.127 |
| 1972 | 0.143 |
| 1973 | 0.133 |
| 1974 | 0.173 |
| 1975 | 0.215 |

### 2-2-3 Projection of Air Passenger Traffic at Santa Cruz Airport

The distribution model to be used for projecting the future passenger traffic share of the Santa Cruz Airport within the total passenger traffic of Bolivia must duly reflect the expected growth trend of such a share. Correlation analysis with the total passenger arrivals and departures in Bolivia was made of the passenger arrivals and departures at Santa Cruz Airport separately in respect of international and domestic services for the '65 - '75 period, and produced high correlation coefficients of 0.988 (Note 1) for the international and 0.998 (Note 2) for the domestic passengers respectively. Consequently, the formula obtained from the above correlation analysis may be termed an adequate distribution model duly reflecting the growth trend of the airport's passenger share in the country as mentioned above. Table 2-2-4 shows the projection of arriving and departing passengers at Santa Cruz Airport for years 1985 and 1995 calculated by means of these distribution models.

---

(Note 1) Distribution model of international passengers

$$Y_I = 0.259\ X_I - 8,477$$

Where, $Y_I$ : Number of international passenger arrivals and departures at Santa Cruz Airport

$X_I$ : Number of international passenger arrivals and departures at all airports in Bolivia

Correlation Coefficient : 0.988

Period of Data: 1965 - 1975

(Note 2) Distribution model of domestic passengers

$$Y_D = 0.270\ X_D - 34,098$$

Where, $Y_D$ : Number of domestic passenger arrivals and departures at Santa Cruz Airport

$X_D$ : Number of domestic passenger arrivals and departures at all airports in Bolivia

Correlation Coefficient : 0.997

Period of Data : 1965 - 1975

Table 2-2-4 Projection of Arriving and Departing Passengers at Santa Cruz Airport

(In Thousands)

| Range of Projection | Year 1985 | | | Year 1995 | | |
|---|---|---|---|---|---|---|
| | International | Domestic | Total | International | Domestic | Total |
| Upper Limit | 262 | 585 | 847 | 1,060 | 1,574 | 2,634 |
| Optimum Value | 214 | 505 | 719 | 776 | 1,263 | 2,039 |
| Lower Limit | 178 | 443 | 621 | 579 | 1,026 | 1,605 |

Fig. 2-2-2 presents comparison in graphic form of the passenger projections of the present study as presented in Table 2-2-4 against those of the AASANA and of the existing Master Plan (Italconsult).

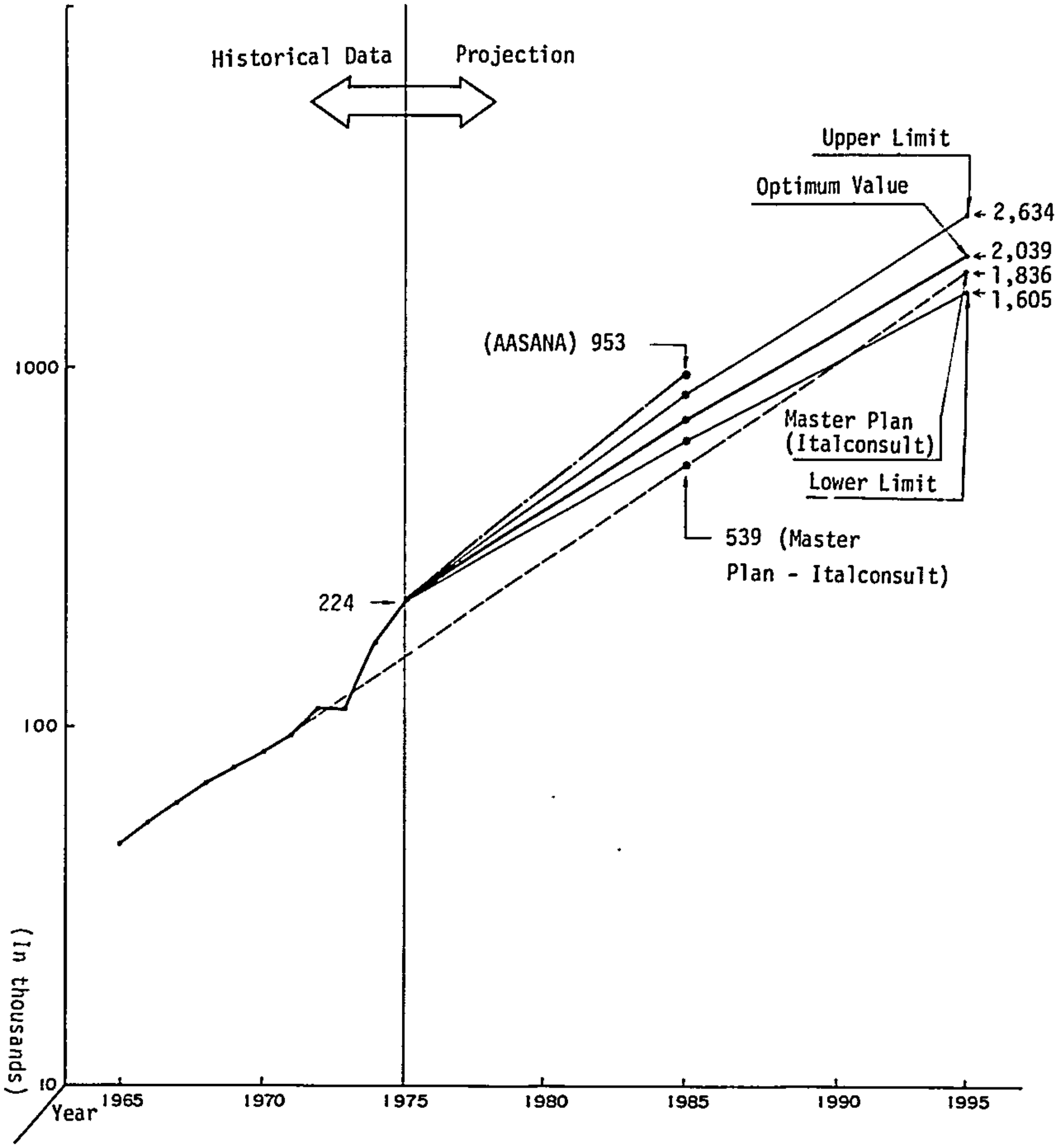



Fig. 2-2-2 Comparison of Various Forecasts of Arriving and Departing Passengers at Santa Cruz Airport

Projections for the years 1980, 1990, and 2000 were then made by either interpolating or extrapolating the optimum values of the projection as shown in Table 2-2-4 above.

As for the transit passenger traffic, its ratio against the total terminal passenger traffic in 1975 was 0.66 in international service and 0.25 in domestic service, and these ratios are assumed to remain unchanged throughout the projection period of the present study on account of the geographic features of the airport as discussed above.

The overall passenger projections for the Santa Cruz Airport resulting from the above considerations are presented in Table 2-2-5.

## 2-2-4 Projection of Passenger Traffic by Route at Santa Cruz Airport

### (1) Domestic Passengers by Route

Table 2-2-6 shows the projection of the by-route domestic passenger traffic at Santa Cruz Airport, calculated on the assumption that the present pattern of the share distribution by route will remain unchanged throughout the projection period.

Table 2-2-5 Projection of Total Air Passengers at Santa Cruz Airport

(In thousands)

| Year | Terminal/ Transit | Domestic Passengers | International Passengers | Total |
|---|---|---|---|---|
| 1980 | Arriving and Departing Passengers | 305 | 98 | 403 |
| | Transit Passengers | 76 | 65 | 141 |
| | Total | 381 | 163 | 544 |
| 1985 | Arriving and Departing Passengers | 505 | 214 | 719 |
| | Transit Passengers | 126 | 141 | 267 |
| | Total | 631 | 355 | 986 |
| 1990 | Arriving and Departing Passengers | 803 | 408 | 1,211 |
| | Transit Passengers | 201 | 269 | 470 |
| | Total | 1,004 | 677 | 1,681 |
| 1995 | Arriving and Departing Passengers | 1,263 | 776 | 2,039 |
| | Transit Passengers | 316 | 512 | 828 |
| | Total | 1,579 | 1,288 | 2,867 |
| 2000 | Arriving and Departing Passengers | 1,771 | 1,250 | 3,021 |
| | Transit Passengers | 443 | 825 | 1,268 |
| | Total | 2,214 | 2,075 | 4,289 |

Table 2-2-6 Projection of Domestic Passengers by Route Serving Santa Cruz Airport

(In thousands)

| Route \ Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Santa Cruz-La Paz | 171 | 272 | 427 | 599 |
| " -Cochabamba | 278 | 442 | 695 | 974 |
| " -Trinidad | 67 | 107 | 168 | 236 |
| " -Sucre | 12 | 19 | 30 | 42 |
| " -Camiri | 15 | 23 | 36 | 51 |
| " -Tarija | 5 | 8 | 13 | 19 |
| " -Yacuiba | 4 | 6 | 9 | 13 |
| " -Puerto Suarez | 12 | 19 | 31 | 43 |
| " -San Javier | 14 | 21 | 34 | 47 |
| " -Robore | 5 | 7 | 11 | 16 |
| " -Ascencion | 14 | 22 | 35 | 49 |
| " -Concepcion | 15 | 24 | 37 | 52 |
| " -San Ignaciodel | 18 | 28 | 45 | 62 |
| " -San Jose | 3 | 4 | 6 | 9 |
| Total | 631 | 1,004 | 1,578 | 2,214 |

Note: Transit passengers included.

(2) International Passengers by Route

In the present study it is assumed in the first place that the present ratio of 62:38 between the non-resident and the resident passengers in the international service at Santa Cruz Airport will remain unchanged throughout the period of projection. The future pattern of passenger distribution by route were determined for the purpose of this forecast by applying the presently prevailing pattern of distribution by route as far as the resident passengers are concerned, and as for the non-resident passengers, based on the assumption that they originate from the principal airport of their respective countries of origin, arriving at Santa Cruz via the shortest available route. Table 2-2-7 shows the results of projections based on the above assumptions.

Table 2-2-7 Projection of Arriving and Departing International Passengers by Route Serving Santa Cruz Airport

(In thousands)

| Routes \ Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Santa Cruz-Panama-Miami | 69 | 132 | 251 | 405 |
| Santa Cruz-Caracas | 79 | 150 | 285 | 459 |
| Santa Cruz-São Paulo-Rio | 75 | 144 | 273 | 440 |
| Santa Cruz-Asuncion-Montevideo | 9 | 17 | 32 | 52 |
| Santa Cruz-Salta-Buenos Aires | 66 | 126 | 239 | 386 |
| Santa Cruz-Lima | 38 | 73 | 138 | 222 |
| Santa Cruz-Arica-Santiago | 19 | 36 | 69 | 112 |
| Total | 355 | 677 | 1,288 | 2,075 |

## 2-3 AIR CARGO TRANSPORT DEMAND FORECAST

### 2-3-1 Historical Trends of Air Cargo Traffic

As seen in Table 2-3-1 showing the evolution of air cargo traffic in Bolivia in the past 5 years, domestic cargo in 1975 accounted for 94.1% of the total cargo traffic in Bolivia as against 5.9% occupied by the international cargo. 82.6% of the total cargo in Bolivia in the same year was transported by non-scheduled domestic airlines as shown in Table 2-3-2. In terms of tonnage distribution by airport, local airports altogether occupied the greatest share in the domestic cargo traffic accounting for 58.3%, as against the mere 3.4% handled at Santa Cruz Airport. As for the international cargo, La Paz occupied a majority share at 83.6%, while Santa Cruz handled only 8.7% of the total international cargo.

While the records presented in Table 2-3-3 would indicate a stagnant trend in the total cargo volume evolution at Santa Cruz Airport, the volume handled by scheduled airlines in both domestic and international services is on the increase, while that of the non-scheduled airlines shows a declining tendency.

Table 2-3-1 Evolution of Air Cargo Traffic in Bolivia

(In tons)

| Year | 1971 | 1972 | 1973 | 1974 | 1975 | % |
|---|---|---|---|---|---|---|
| International Cargo | 3,155 | 3,697 | 3,259 | 3,971 | 4,602 | 6% |
| La Paz | 2,039 | 2,007 | 2,526 | 3,429 | 3,848 | (83.6) |
| Cochabamba | 37 | 92 | 194 | 204 | 356 | ( 7.6) |
| Santa Cruz | 1,079 | 1,598 | 539 | 339 | 398 | ( 8.7) |
| Domestic Cargo | 44,620 | 39,596 | 42,990 | 73,434 | 73,137 | 94.1 |
| La Paz | 20,072 | 14,816 | 14,660 | 17,685 | 20,327 | (27.8) |
| Cochabamba | 3,957 | 4,255 | 6,265 | 9,434 | 7,676 | (10.5) |
| Santa Cruz | 2,050 | 2,422 | 2,056 | 2,946 | 2,505 | ( 3.4) |
| Other Airports | 18,541 | 18,103 | 20,009 | 43,369 | 42,629 | (58.3) |
| Total | 47,775 | 43,293 | 46,249 | 77,405 | 77,739 | 100 |

Source: AASANA BOLETIN ESTADISTICO (STATISTICAL BULLETIN) 1971 ~ 1975

Table 2-3-2 Evolution of Air Cargo Traffic Shares in Bolivia

| Description \ Year | 1974 | | 1975 | |
|---|---|---|---|---|
| | Tonnage | Share (%) | Tonnage | Share (%) |
| International Cargo | 3,971 | 5.1 | 4,602 | 5.9 |
| Domestic Cargo | 73,434 | 94.9 | 73,137 | 94.1 |
| Scheduled Services | 9,546 | 12.4 | 8,950 | 11.5 |
| Nonscheduled Services | 63,888 | 82.5 | 64,187 | 82.6 |
| Total | 77,405 | 100 | 77,739 | 100 |

Source: AASANA BOLETIN ESTADISTICO (STATISTICAL BULLETIN) 1971~1975

Table 2-3-3 Evolution of Cargo Traffic at Santa Cruz Airport
Aeropuerto de Santa Cruz

(In tons)

| Description \ Year | 1971 | 1972 | 1973 | 1974 | 1975 | 75/71 (%) |
|---|---|---|---|---|---|---|
| International Routes | 1,079.3 | 1,597.5 | 539.3 | 338.6 | 398.3 | ∇22.1 |
| Scheduled Services | 358.9 | 356.0 | 468.4 | 338.6 | 398.3 | 2.6 |
| Non-scheduled Services | 720.4 | 1,241.5 | 70.9 | - | - | - |
| Domestic Routes | 2,050.2 | 2,421.9 | 2,055.5 | 2,945.8 | 2,505.3 | 5.1 |
| Scheduled Services | 1,380.5 | 1,563.0 | 1,931.0 | 2,278.9 | 1,955.6 | 9.1 |
| Non-scheduled Services | 669.7 | 858.9 | 124.5 | 666.9 | 549.7 | ∇4.7 |
| Total | 3,129.5 | 4,019.4 | 2,594.8 | 3,284.4 | 2,903.6 | ∇1.9 |

Source: AASANA BOLETIN ESTADISTICO (STATISTICAL BULLETIN) 1971 - 1975

## 2-3-2 Projection of Air Cargo Traffic in Bolivia

As a result of a correlation analysis between the Gross Domestic Product and the total tonnage of air cargo handled at all airports in Bolivia during the '71 - '75 period, the following formula was obtained:

$$Y = 10.843\,X - 95{,}256$$

Where Y : Total Air Cargo Tonnage in Bolivia

X : Gross Domestic Product (1 million pesos)

Correlation Coefficient : 0.874

Period of Data: 1971 - 1975

The projection of the total air cargo traffic in Bolivia in 1985 and 1995 calculated by the above formula is shown in Table 2-3-4 below.

Table 2-3-4 Projection of Total Air Cargo Traffic in Bolivia

| Year | Air Cargo Tonnage | Average Annual Increase Rate |
|---|---|---|
| 1975 | 77,739 | - |
| 1985 | 241,000 | 12.0% |
| 1995 | 479,000 | 7.1% |

Distribution between the international and domestic air cargo traffic in Bolivia, as well as the share of air cargo handled at Santa Cruz Airport, were assumed considering the future trend, as shown in Table 2-3-5.

Table 2-3-5 Assumed Distribution of Air Cargo in 1995

| Total Air Cargo in Bolivia (100%) | | | Share of Santa Cruz |
|---|---|---|---|
| 100% (T) | International Cargo | 10% (A) | 10% of (A) or 1% of (T) |
| | Domestic Cargo | 90% (B) | 5% of (B) or 4.5% of (T) |

Table 2-3-6 shows the projected tonnage of air cargo to be handled at Santa Cruz Airport, calculated on the basis of the assumed distribution ratios as presented in Table 2-3-5.

Table 2-3-6 Projection of Cargo Transport Demand at Santa Cruz Airport

(In tons)

| Description \ Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Total Air Cargo in Bolivia | 241,000 | 340,000 | 479,000 | 611,000 |
| International Cargo | 24,000 | 34,000 | 48,000 | 61,000 |
| Domestic Cargo | 217,000 | 306,000 | 431,000 | 550,000 |
| Total Air Cargo at Santa Cruz | 9,690 | 18,700 | 26,400 | 37,000 |
| International Cargo | 1,590 | 3,400 | 4,800 | 6,700 |
| Domestic Cargo | 8,100 | 15,300 | 21,600 | 30,300 |

## 2-4 PROJECTION OF AIRCRAFT MOVEMENTS

### 2-4-1 Historical Data of Aircraft Movements

Table 2-4-1 shows the records of past 10 years of aircraft movements at Santa Cruz-El Trompillo Airport.

Table 2-4-1 Evolution of Aircraft Movements at Santa Cruz Airport

| Description / Year | International Passenger (Note 1) | Domestic Passenger (Note 2) | Non-scheduled (Note 3) | General Aviation (Note 4) | Others (Note 5) | Total |
|---|---|---|---|---|---|---|
| 1966 | ... | ... | ... | ... | ... | 5,970 |
| 1967 | ... | ... | ... | ... | ... | 6,690 |
| 1968 | ... | ... | ... | ... | ... | 7,888 |
| 1969 | ... | ... | ... | ... | ... | 7,632 |
| 1970 | ... | ... | ... | ... | ... | 7,588 |
| 1971 | 728 | 2,946 | 2,342 | 2,488 | 684 | 9,188 |
| 1972 | 628 | 2,874 | 1,261 | 6,306 | 2,016 | 13,080 |
| 1973 | 719 | 3,396 | 630 | 6,971 | 2,630 | 14,336 |
| 1974 | 785 | 3,512 | 1,621 | 8,876 | 3,422 | 18,216 |
| 1975 | 1,486 | 4,360 | 994 | 10,384 | 3,374 | 20,598 |

( ... ) Data not available

Note 1) Cruzeiro Do Sul, Líneas Aéreas Paraguayas, Aerolíneas Argentinas and Lloyd Aéreo Boliviano

Note 2) Lloyd Aéreo Boliviano

Note 3) Other Commercial Aircraft

Note 4) Air Taxi, Private Aircraft Training Aircraft and other small aircraft weighing 6 tons or less.

Note 5) Aircraft belonging to governmental agencies.

Source: AASANA BOLETIN ESTADISTICO (STATISTICAL BULLETIN) 1971 ∿ 1975

## 2-4-2 Projection of Domestic Passenger Aircraft Movements

(1) Assumed Aircraft Types in Domestic Service

The following 4 classes of aircraft types were assumed to serve the domestic routes during the period of the present projection, with an average load factor of 60%.

Table 2-4-2 Assumed Aircraft Types for Domestic Service

| Class of Aircraft | Type of Aircraft | Load Factor (%) | Payload (seats) |
|---|---|---|---|
| 160 seater | B727-200, etc. | 60 | 96 |
| 120 seater | B727-100, B737 etc. | 60 | 72 |
| 60 seater | YS11, etc. | 60 | 36 |
| 40 seater | E27, etc. | 60 | 24 |

(2) Selection Criteria of Aircraft Types by Route

Table 2-4-3 shows the criteria in terms of the number of air passengers for determining assumed aircraft types for each route.

Table 2-4-3 Aircraft Class Selection Criteria by Route

| Aircraft Class | Annual Passengers by Route | Remarks |
|---|---|---|
| 160 seater | More than 100,000 | |
| 120 seater | 20,001 100,000 | 72 seats x 52 weaks x 6 trips = 22,464 |
| 60 seater | 7,501 20,000 | 36 seats x 52 weaks x 4 trips = 7,488 |
| 40 seater | 7,500 and less | To be retired after 1986 |

(3) Projection of Domestic Passenger Aircraft Movements by Type and by Route

Having determined the type of aircraft for each route by applyihg the above criteria to the number of passengers by route as projected in Table 2-2-6, and further by dividing the number of passengers by route by the number of payload seats of corresponding aircraft, aircraft movements by type and by route are projected as shown in Table 2-4-4 below.

Table 2-4-4 Projection of Passenger Aircraft Movements by Class and by Route in Domestic Service at Santa Cruz Airport

| Year / Class of Aircraft | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| 160 seater | 2,820 | 4,672 | 8,548 | 13,444 | 18,758 |
| 120 seater | 664 | 1,100 | 1,916 | 3,440 | 4,798 |
| 60 seater | - | 2,420 | 1,256 | 1,124 | 1,564 |
| 40 seater | 2,598 | 674 | - | - | - |
| Total | 6,082 | 8,866 | 11,720 | 18,008 | 25,120 |

2-4-3 Projection of International Passenger Aircraft Movements

(1) Assumed Aircraft Types in International Service

The following 4 classes of aircraft types are assumed to serve the international routes during the period of the present projection, with an average load factor of 50%.

Table 2-4-5 Assumed Aircraft Types in International Service

| Class of Aircraft | Type of Aircraft | Load Factor (%) | Payload (seats) |
|---|---|---|---|
| 360 seater | B747 | 50 | 180 |
| 275 seater | DC10, L10-11, etc. | 50 | 138 |
| 160 seater | B707, DC8, B727-200,etc. | 50 | 80 |
| 120 seater | B727-100, B737, etc. | 50 | 60 |

(2) Assumed Aircraft Mix in International Service

Aircraft mix for each key year of projection is assumed as shown in Table 2-4-6.

Table 2-4-6 Assumed Aircraft Mix in International Service

(In percent)

| Class of Aircraft \ Year | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| 360 seater | - | - | 5 | 10 | 10 |
| 275 seater | - | 30 | 45 | 50 | 50 |
| 160 seater | 50 | 50 | 50 | 40 | 40 |
| 120 seater | 50 | 20 | - | - | - |

(3) Projection of International Passenger Aircraft Movements by Type

Table 2-4-7 shows the results of projection of the international passenger aircraft movements by type, calculated on the basis of the assumptions as presented in (1) and (2) above.

Table 2-4-7 Projection of Passenger Aircraft Movements by Class in International Service at Santa Cruz Airport

| Class of Aircraft \ Year | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| 360 seater | - | - | 304 | 1,082 | 1,744 |
| 275 seater | - | 1,140 | 2,736 | 5,410 | 8,720 |
| 160 seater | 1,164 | 1,902 | 3,040 | 4,328 | 6,976 |
| 120 seater | 1,164 | 760 | - | - | - |
| Total | 2,328 | 3,802 | 6,080 | 10,820 | 17,440 |

### 2-4-4 Projection of Cargo Aircraft Movements

As for the international cargo, the present study assumes, taking the future trend into consideration, on the distribution ratio of 2:1 between the volumes transported by passenger aircraft and by freighter, as well as on the type of freighter of DC-8-62F, and a load factor of 50%. (Table 2-4-8).

Domestic cargo is assumed to be distributed 1:1 between the volumes transported by LAB and by all other non-scheduled airlines. Cargo traffic of LAB is assumed to be distributed 4:1 between the passenger aircraft and freighter, the type of which is assumed to be B727-100QC. For all other non-scheduled airlines YS-11 class freighter is assumed to be in service. (Table 2-4-8).

### 2-4-5 Projection of General Aviation Aircraft Movements

Majority of the general aviation traffic at Santa Cruz Airport is that of air taxi, which in effect serves to supplement the scheduled domestic service.

The elasticity coefficient of the increase rate in the general aviation traffic as against the increase rate in the movements of scheduled domestic flights for the '72 - '75 period was calculated to amount to 1.086. On the basis of this coefficient, the total aircraft movements of general aviation in 1995 is projected at 46,600, representing an average annual increase rate of 7.8%. Projection of the movements for the other milestone years were made by interpolating or extrapolating at the same increase rate of 7.8% per annum, with the results as shown in Table 2-4-8 below.

### 2-4-6 Projection of Other Aircraft Movements

Movements of aircraft other than those mentioned above are mostly those of the aircraft belonging to the governmental agencies of Bolivia, and are exempt from landing charges. The ratio of such aircraft movements to the total movements of the scheduled and non-scheduled (cargo) service and of general aviation for the '72 - '75 period is almost constant at an average of 0.2%. On an assumption that this ratio will remain unchanged throughout the period of projection under the present study, the movements of 'other aircraft' as described herein are projected as shown in Table 2-4-8.

Table 2-4-8 Projection of Aircraft Movements at Santa Cruz Airport

| Description \ Year | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| Passenger Aircraft | 8,410 | 12,670 | 17,800 | 28,830 | 42,560 |
| International Routes | 2,330 | 3,800 | 6,080 | 10,820 | 17,440 |
| Domestic Routes | 6,080 | 8,870 | 11,720 | 18,010 | 25,120 |
| Cargo Aircraft | 1,350 | 1,900 | 2,670 | 4,280 | 5,290 |
| International Routes | 50 | 70 | 100 | 150 | 200 |
| Domestic Routes | 1,300 | 1,830 | 2,570 | 4,130 | 5,090 |
| General Aviation | 15,100 | 22,000 | 32,000 | 46,600 | 62,200 |
| Other Aircraft | 4,970 | 7,310 | 10,500 | 15,960 | 22,010 |
| Total | 29,830 | 43,880 | 62,970 | 95,670 | 132,060 |

## 2-5 PROJECTION OF PEAK HOUR TRAFFIC

Rate of peak hour concentration at Santa Cruz Airport was assumed as shown in Table 2-5-1 by referring to the traffic distribution data of annual to peak hour passenger ratios published by the US Federal Aviation Administration, as well as referring to the similar data of the Japan Civil Aviation Bureau.

Table 2-5-1 Peak Hour Concentration Ratio

| Design Year | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| Domestic Passenger Flights | 1/4.6 | 1/5.6 | 1/6.2 | 1/7.2 | 1/7.9 |
| International Passenger Flights | 1/2.6 | 1/3.6 | 1/4.7 | 1/6.0 | 1/7.2 |
| Cargo Flights | 1/2.0 | 1/2.0 | 1/2.8 | 1/3.8 | 1/4.3 |

Projections of the peak hour traffic of passengers and of aircraft movements calculated on the basis of the assumed peak day coefficient of 1/315 are as shown in Tables 2-5-2 and 2-5-3 respectively.

Table 2-5-2 Projection of Peak Hour Passengers

| Year | | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|
| Domestic Passengers | Arrivals and Departures | 210 | 290 | 411 | 557 | 712 |
| | Transit | 52 | 71 | 103 | 139 | 195 |
| | Total | 262 | 361 | 514 | 696 | 907 |
| International Passengers nacionales | Arrivals and Departures | 120 | 189 | 277 | 410 | 511 |
| | Transit | 81 | 125 | 180 | 272 | 364 |
| | Total | 201 | 314 | 457 | 682 | 875 |

Table 2-5-3 Projection of Peak Hour Flight Movements

| Year | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| Domestic Passenger Flights | 4 | 5 | 6 | 8 | 10 |
| International Passenger Flights | 3 | 4 | 4 | 6 | 8 |
| Cargo Flights | 2 | 3 | 3 | 4 | 4 |

# 3. DETERMINATION OF DEVELOPMENT PLANS

# 3. DETERMINATION OF DEVELOPMENT PLANS

## 3-1 IDENTIFICATION OF CONDITIONS OF PLANNING

### 3-1-1 Development Alternatives

The existing El Trompillo Airport is already saturated as discussed in subsection 1-2-1 above, and is unable to meet the future air transport demand with the facilities of the present level. In order to meet the increasing aviation demand in Santa Cruz as projected in the preceding paragraph, two development plans are established under the present study, namely the construction of a new airport, and the expansion of the existing El Trompillo Airport.

The New Airport Construction Plan adopts Viru Viru as its prospective site of construction. The Existing Airport Expansion Plan envisages provision of a service level equal to that of the proposed new airport in Viru Viru while making use of the existing facilities to the maximum possible extent.

Basic planning requirements of the airport facilities applicable to both plans are presented in the following.

### 3-1-2 Airport Facility Requirements

Airport facility requirements for the two development alternatives planned to offer an identical level of service, are established for the period of 20 years between 1981 and 2000. Wherever necessary, the requirements were set forth for each of the four equally divided stages of development.

(1) Airfield Facilities

1) Runway Length

The length of the runway were determined by taking into consideration: a) requirements of the Government of Bolivia; b) type of aircraft to serve; c) take-off runway length requirements; and d) longest stage length.

a) Requirements of the Government of Bolivia

Government of Bolivia is hopeful of establishing a direct route between Santa Cruz and New York, and is feeling the necessity for direct routes to Madrid, Frankfurt, etc. It has also expressed a strong desire to have the runway designed so as to be able to accommodate the DC-8-62/63 or B747-SP for direct flights to USA.

b) Type of Aircraft to Serve

The principal aircraft presently in scheduled service at El Trompillo is of the B727 class. In the perspective of up to the year 2000, however, introduction of B747 class aircraft is expected.

c) Take-off Runway Length

Table 3-1-1 shows the runway lengths required for maximum take-off weight of the various types of aircraft under consideration.

Table 3-1-1 Runway Length Required for Maximum Takeoff Weights

| Aircraft | Length (m) |
|---|---|
| B727-200 | 3,000 |
| DC-8-62/63, B747-SP | 3,200 |
| B747-200 | 3,500 |
| DC-10-30 | 3,800 |

Note: Based on maximum takeoff weight authorized by manufacturers.

d) Longest Stage Length

Considering that close economic and social interchange will continue in the future between Bolivia and USA/Europe, and also in view of the fact that maintenance work of LAB aircraft is being carried out in Miami, the present study assumes on the Santa Cruz - Miami route to be the longest stage length in the initial stage of development, and on the Santa Cruz - New York route for the second half of the '80s and thereafter.

Considering the above, and on the basis of the figures in Table 3-1-1, the study concluded that the ultimate runway length of the proposed development plan should be 3,500 m, so as to be able to accommodate take-offs by B747 class aircraft without much operational restrictions being imposed.

For the initial stage of development, however, the length of 3,200m is considered sufficient in order to be able to accommodate, as a minimum requirement, unrestricted operation of DC-8-62/63 and B747-SP as desired by the Bolivian government, for the longest flight stage of between Santa Cruz and Miami.

2) Widths of Runway and of Taxiway

Table 3-1-2 shows the widths of the runway and of the taxiway that are determined in accordance with the recommendations of the ICAO Annex 14.

Table 3-1-2 Runway and Taxiway Widths

| Description | Width (m) |
|---|---|
| Runway | 45.0 |
| Shoulder | 7.0 |
| Taxiway | 23.0 |
| Shoulder | 10.5 |

3) Apron

Based on the peak hour flight movements projected in Chapter 2 (Table 2-5-3), parking position requirements for passenger, cargo and general aviation aircraft were determined with due consideration for the necessary reserves, as shown in Table 3-1-3.

Table 3-1-3 Number of Aircraft Parking Positions

| Design Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Passenger Apron | 5 | 8 | 10 | 13 |
| Cargo Apron | 2 | 2 | 3 | 4 |
| General Aviation Apron | 65 | 95 | 140 | 185 |

The above parking position requirements are based on the assumed average occupancy time per flight of 90 minutes and 45 minutes respectively for the international and domestic passenger aircraft.

(2) Radio Navigational Aids, Telecommunications, and Meteorological Service Facilities

In order to ensure safe and efficient operation of aircraft landing and taking off at the new Santa Cruz Airport, as well as of aircraft en route within the Santa Cruz FIR which is expected to be established shortly, the facility requirements of the radio navigational aids, telecommunications, and meteorological service facilities are determined so as to:

a) satisfy the requirements of the existing development plan of the telecommunication facilities at Santa Cruz Airport which constitutes part of the National Air Navigation Plan (1977 - 1981);

b) be in line with the ICAO Air Navigation Plan;

c) be compatible with the exising aeronautical telecommunication systems on and around the El Trompillo Airport; and to

d) provide a dual equipment system, or a system with standby units as far as the principal equipment of the facilities are concerned.

(3) Airfield Lighting Facilities

Airfield lighting facilities should satisfy the requirements of precision approach runway with Cat-I ILS.

(4) Buildings

Table 3-1-4 shows the floor area requirements of the buildings to accommodate the demands in each of the four development stages, calculated in the following manner.

1) Area requirements of the passenger terminal building are based on the unit space of 30 $m^2$ and 15 $m^2$ per peak hour passenger in international and domestic services respectively.

2) Cargo terminal floor area is calculated on the basis of the assumed annual handling capacity of 12 tons/$m^2$ and 6 tons/$m^2$ for the domestic and international cargo respectively.

3) Floor areas of the customs shed and the post office for cargo are determined basically in accordance with the Master Plan of the Bolivian Government (Italconsult). As for the post office, reference was made also to the number of personnel and the volume of mail handled at the post offices of the existing airport of El trompillo and of La Paz.

4) Area requirements of the rescue and fire fighting station are determined so as to accommodate the vehicles required for Category 8 aerodromes by ICAO Standards.

5) Space requirements of the general aviation hangars are calculated so as to accommodate 35% of the projected number of aircraft to be parked ordinarily at the new airport.

6) Facility requirements of the control tower, substation, and transmitting and receiving stations are determined so as to satisfy the functional requirements of the equipment rooms, offices, etc. that need to be accommodated in each building.

7) Areas of the presidential pavilion and of the AASANA offices are determined in accordance with the Master Plan (Italconsult).

Table 3-1-4 Building Floor Area Requirements

(In $m^2$)

| | | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| Passenger Terminal | Domestic | 5,400 | 7,700 | 11,000 | 14,000 |
| | International | 5,700 | 8,300 | 12,000 | 15,000 |
| | Total | 11,000 | 16,000 | 23,000 | 29,000 |
| Cargo Terminal | Domestic | 675 | 1,275 | 1,800 | 2,500 |
| | International | 265 | 570 | 800 | 1,120 |
| | Total | 940 | 1,845 | 2,600 | 3,620 |
| Customs and Post Office for Cargo | Customs | 150 | 230 | 340 | 460 |
| | Post Office | 200 | 270 | 400 | 540 |
| | Total | 350 | 500 | 740 | 1,000 |
| Fire Station | | 700 | 900 | 900 | 1,000 |
| General Aviation Hangers | | 5,300 | 7,750 | 11,420 | 15,100 |
| Presidential Pavilion | | 350 | | | |
| Control Tower | | 1,890 | | | |
| Electric Substation No.1 | | 1,000 | | | |
| Office of AASANA | | 200 | 300 | 400 | 500 |
| Transmitting Center | | 600 | | | |
| Receiving Center | | 260 | | | |
| OM Station | | 80 | | | |
| Emergency Power Station for ILS | | 45 | | | |
| Emergency Power Station for VOR/DME | | 45 | | | |
| Maintenance Building | | 500 | | | |
| Toll Gate | | 50 | 50 | 100 | 150 |

(5) Roads and Automobile Parking

1) Airport Approach Road

Road traffic demand on which the planning of the approach road is to be based is calculated as shown in Table 3-1-5 on the basis of the air traffic projected in Chapter 2.

Table 3-1-5 Estimated Road Traffic

| Design Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Annual Enplaning and Deplaning Passengers (In thousands) | 719 | 1,211 | 2,039 | 3,021 |
| Average Day Passengers and Visitors Entering the Airport | 8,100 | 13,700 | 23,100 | 34,300 |
| Peak Hour Passengers and Visitors Entering the Airport | 1,300 | 2,400 | 4,100 | 6,100 |
| Peak Houra Automobile Traffic | 340 | 630 | 1,060 | 1,580 |

2) Automobile Parking

Parking space requirements are determined as shown in Table 3-1-6.

Table 3-1-6 Automobile Parking

| Design Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Parking Spaces | 960 | 1,400 | 1,960 | 2,320 |
| Total Area ($m^2$) | 24,000 | 35,000 | 49,000 | 58,000 |

(6) Utilities

Based on the projected air traffic, utility facility requirements in terms of unit capacity are determined as shown in Table 3-1-7.

Table 3-1-7 Utility Service Capacity Requirements

| Design Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Water ($m^3$/day) | 450 | 770 | 1,320 | 1,970 |
| Sewerage ($m^3$/day) | 450 | 770 | 1,320 | 1,970 |
| Telephones (circuits) | 112 | 166 | 232 | 295 |
| Garbage (ton/month) | 59 | 87 | 124 | 517 |
| LPG (ton/month) | 5.0 | 7.0 | 9.7 | 12.1 |

(7) Aviation Fuel

Aviation fuel supply requirements calculated on the basis of the projected air traffic are as shown in Table 3-1-8.

Table 3-1-8 Aviation Fuel Requirements

(Kℓ/day)

| Design Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| International Service | 54 | 86 | 135 | 185 |
| Domestic Service | 158 | 440 | 510 | 822 |
| Total | 212 | 526 | 645 | 1,007 |

## 3-2 NEW AIRPORT CONSTRUCTION PLAN

The plan for the construction of the new Santa Cruz-Viru Viru Airport is made for the four stages of development with the corresponding design years of 1985, 1990, 1995, and 2000 respectively, on the basis of the facility requirements set forth in the preceding Subsection 3-1-2.

### 3-2-1 Airport Facility Layout Plan

Fig. 3-2-1 shows the facility layout plan of the proposed new airport for each of the four design years. The runway, which constitutes the basic element in airport layout, is oriented 147°E to true north. For the design years of 1985 and 1990, the passenger terminal apron configuration is of the "frontal" type, and for 1995 and 2000 it will be changed to the "finger" type to permit centralized configuration of the apron and terminal, which are sited with due consideration for a future second parallel runway. Aprons for cargo and general aviation aircraft are arranged parallel to the runway.

Taxiways connecting the runway and the aprons are planned with separate entries and exits so as to ensure smooth surface movements of aircraft.

Since approach to the runway will be made principally from the south, Calvert type approach lighting system is provided on the south end, and simplified system on the north end.

Approach Road is planned to feed from the Montero Highway which connects Santa Cruz and Montero. Beyond the second development stage with the corresponding design year of 1990, an additional approach road is planned to feed from the new expressway linking the two cities which is expected to be completed in time.

For the long range planning purposes beyond the year 2000, a second parallel runway is shown in dotted line on the layout plan for the design year 2000 in Fig. 3-2-1.

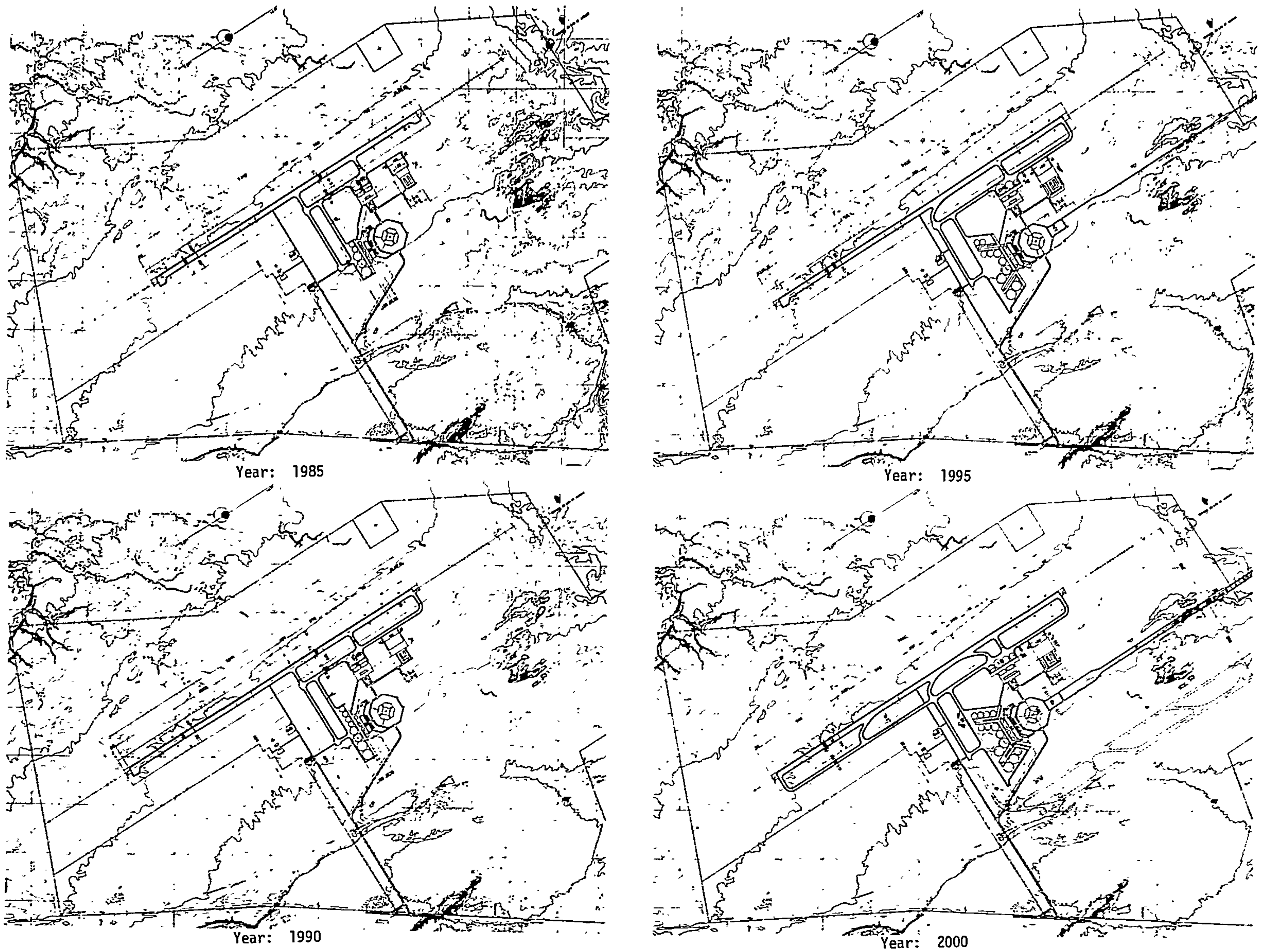



Fig. 3-2-1 Facility Layout of New Santa Cruz - Viru Viru International Airport

## 3-2-2 Facility Planning

### (1) Airfield Facilities

#### 1) Pavement

There basically are two types of airport pavement, namely the *flexible* and the *rigid*. As a result of comparison of the unit cost in each type, rigid pavement was adopted for the proposed new airport in Viru Viru. The factors of the pavement design are as shown in Table 3-2-1.

Table 3-2-1 Pavement Design Factors

| | |
|---|---|
| Critical Aircraft | DC-8-63 |
| Subgrade CBR | 10% |
| Subbase Material | Soil Cement |

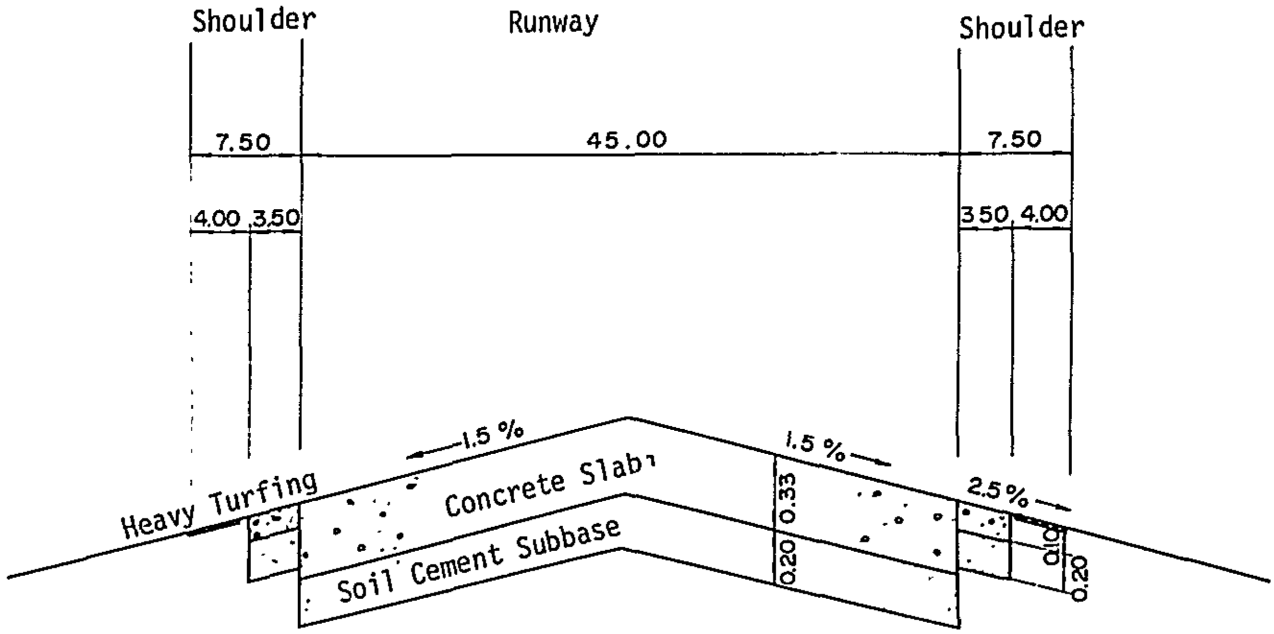



Fig. 3-2-2 Standard Cross Section of Rigid Pavement - Runway

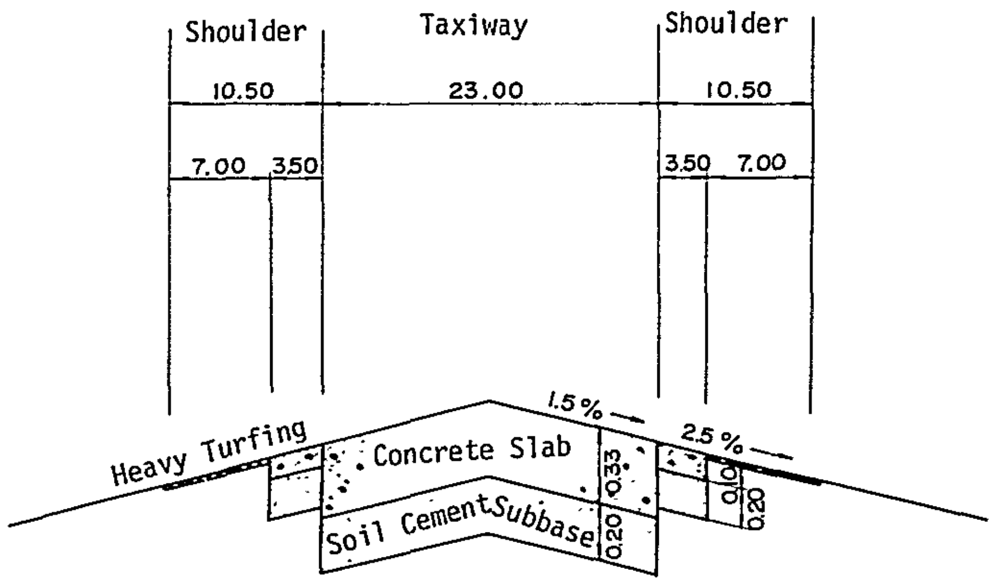



Fig. 3-2-3 Standard Cross Section of Rigid Pavement - Taxiway

Table 3-2-2 shows the thickness of the pavement calculated on the basis of the design factors shown in Table 3-2-1.

Table 3-2-2 Thickness of Aerodrome Pavement

(In cm)

| | Concrete Slab | Soil Cement Subbase |
|---|---|---|
| Runway, Taxiway, Apron | 33 | 20 |
| Shoulder | 10 | 20 |

2) Earth Work

Natural topography of the proposed construction site is such that not much earth work is required. Grading work is planned so as to minimize earth moving distances and to balance the volumes of cuts and fills as much as possible.

3) Drainage

The drainage system of the new airport includes the open canal to be built along the perimeter of the airport to prevent invasion of the rain water from outside the airport premises. Water collected in the open canal is designed to discharge in the lower swamps off to the north of the airport. Drainage design is based, as is normally practiced, on the maximum probable rainfall expected once in 5 years. Since the rainfall intensity is great at this site despite the low annual precipitation, a somewhat high runoff coefficient is adopted in the design. Design velocity for the unlined canals is kept low to minimize errosion on the fine-sanded bottom.

Ground water level at the proposed site rises considerably during the rainy season, reaching as high as GL -20 cm in places. In order to preserve the pavement strength as much as possible under such condition, open canals are designed deeper than usual, so as to be deep enough to keep the ground water level below that of the sub-base. Any extra amount of earth excavated as a result of such drainage design will be used as the fill material on the airport as mentioned earlier.

(2) Radio Navigational Aids, Telecommunications and Meteorological Service Facilities

On the basis of the facility requirements set forth in Section 3-1-2 above, the radio navigational aids, telecommunications and meteorological service facilities are planned as shown in Table 3-2-3. Drawings 9 and 10 respectively show the system diagram and the layout plan of these facilities.

(3) Airfield Lighting

Airfield lighting is planned as shown in Table 3-2-4, and in Drawings 9 through 14, based on the facility requirements set forth in Subsection 3-1-2, and in accordance with the standards and recommendations of the ICAO Annex 14 and Aerodrome Manual.

Table 3-2-3 Telecommunications, Radio Navigational Aids and Meteorological Service Facility Plan

| Item | Facilities | |
|---|---|---|
| Aeronautical Fixed Service | HF/ISB Internaional Circuits for Asunción, Campo Grande, Córdoba and Port Velho | 4 sets |
| | HF/ISB Domestic Circuits for La Paz and Domestic Airports | 4 sets |
| | Local Teletypewriter and Telephone Circuits | 1 set |
| Aeroneutical Mobile Service | HF/SSB Air-Ground Communication for SW-SAM, SE-SAM and FIR Santa Cruz | 3 sets |
| | VHF/UHF Air-Ground Communication for Aerodrome Control, Surface Control, Approach Control, and Emergency Control | 1 set |
| | ATIS | 1 set |
| Radio Navigational Aids | ILS (Category I), VOR/DME, NDB, and Locator | 1 set |
| Meteorological Service | Anemometer, Thermometer, Hygrometer and Pluviometer, RVR, Ceilometer, Meteorological Radar, Radiosonde, APT, and Facsimile | 1 set |

Table 3-2-4 Airfield Lighting

| Description | System, Quantity | | |
|---|---|---|---|
| Approach Lighting System | Runway 33, Calvert System<br>Runway 15, Simple System | 900m<br>420m | 1 set<br>1 set |
| Visual Approach Slope Indicator | Runway 33 and Runway 15, 3-3-Bar VASIS | | 1 set each |
| Runway Edge Lights | High Intensity Elevated Type | | 1 set |
| Runway End Lights | High Intensity Inset Type | | 1 set |
| Runway Treshold Lights | " | | 1 set |
| Taxiway Lights | Medium Intensity Elevated Type | | 1 set |
| Aerodrome Beacon | | | 1 unit |
| Illuminated Wind Cone | | | 2 units |
| Apron Lights | | | 1 set |

(4) Buildings

1) Passenger Terminal

Passenger terminal building is planned with due regard for the flexibility for future expansion to meet the increasing demand. The one-and-half-level building consists basically of the international block and the domestic block connected by a corridor. Passengers are to board the aircraft on foot in principle, but the building is designed to facilitate addition of the fingers in future so as to be able to accommodate boarding bridges as necessary. (See Drawing 21)

2) Cargo Terminal

Cargo terminal is planned to handle both the international and domestic cargo in one and same shed, where separation of incoming and outgoing cargo flow is ensured. No particular mechanization of the cargo handling system is considered under the plan since the projected cargo traffic does not justify such investment. (See Drawing 22)

3) Customs Shed and Post Office (For Cargo)

Separate buildings for each of these functions are planned independent of the cargo shed, from the view points of operational efficiency and of future expansion of the facilities. (See Drawing 22)

4) Rescue and Fire Fighting Station

The building comprises of spaces to house vehicles with chemical extinguishers and water tanks, as well as the various fire fighting equipment, personnel lounge, dining and training rooms, etc.

5) Technical Block

Technical block consists of the control tower which houses facilities of telecommunications, ACC, and meteorological service, and of the substation with power supply system for all facilities of the airport.

These facilities are concentrated in the technical block which is sited independent of the passenger terminal and other facilities of the terminal complex for reasons of security, and also to facilitate efficient control and maintenance of the systems. (See Drawing 22)

(5) Road and Automobile Parking

An approach road feeding from the existing Montero Highway is planned with 2 lanes of 3.5 m width each. To accommodate the future traffic increase, an additional approach road is planned for the design year of 1995 with two 3.5 m wide lanes, connecting to the new Santa Cruz-Montero Expressway which is expected to be completed by then. For the design year of 2000, the approach road will be widened to 4 lanes. One-way traffic system is adopted for the portion of the approach road leading to the passenger terminal where 2 lanes will be provided at the curbside, with a separate lane intended for the through traffic, totalling in 3 lanes altogether.

Separate automobile parking is provided for the passenger terminal, cargo terminal, general aviation, fire station, and for the technical block, each located conveniently for the respective facilities. Separate entrance and exist are provided for the passenger terminal parking to ensure smooth flow of vehicles.

Table 3-2-5 Width and Number of Lanes of Approach Road

| Design Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Width of Lane (m) | 3.5 | 3.5 | 3.5 | 3.5 |
| Number of Lanes | 2 | 2 | 2 | 4 |

Drainage of the approach road is planned with unlined open ditches on either side with the depth of around 1 m to ensure effective subsurface drainage during the rainy season. A road lighting system is also planned for the approach road, which will have a rigid pavement with the thickness as shown in Table 3-2-6.

Table 3-2-6 Thickness of Pavement

(In cm)

| Description | Concrete Slab | Soil Cement |
|---|---|---|
| Roads and Automobile Parking | 20 | 20 |

(6) Utilities

1) Electric Power Supply System

A 69KV/10KV main substation is planned near the airport entrance to receive power from the 69KV supply line of the Empresa Nacional de Electricidad S.A. (National Electric Corporation), and to supply the power dropped to 10 KV to substations No. 1 (technical block) and No. 10 (transmitting station). Substation No. 1 supplies power to various other substations within the airport and at the ILS/OM site.

Air navigational aid facilities, building emergency lighting, and other essential facilities of the airport are provided with the secondary power supply system comprising an individual engine generator with automatic on-off controls for each of such facilities.

Schematic diagram of the electric power supply system is shown in Fig. 3-2-4.

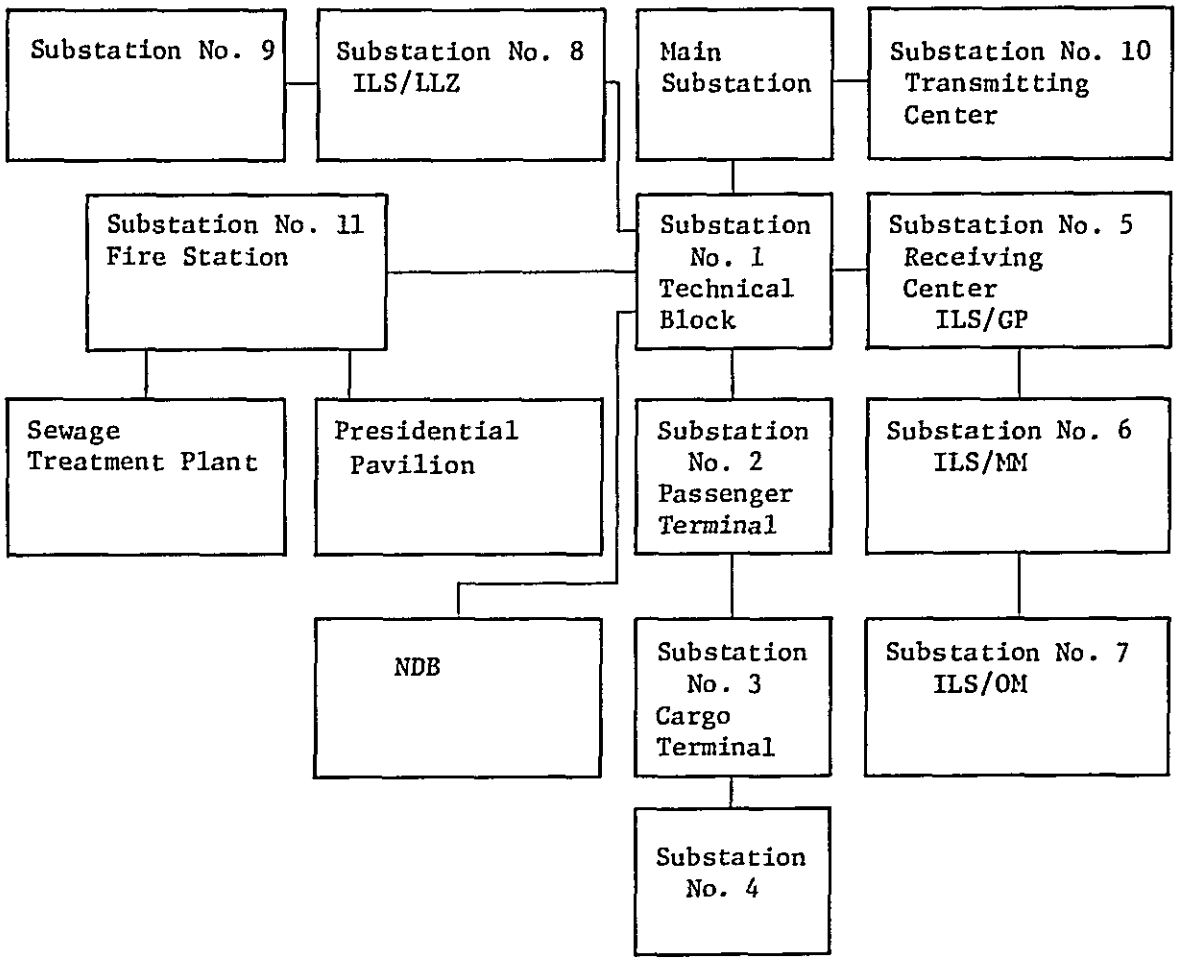



Fig. 3-2-4 Electric Power Distribution Diagram

2) Water Supply

Water supply system of the new airport comprises the water tank to hold the water pumped out of the several artesian wells within the airport premises, elevated water tower, and a piping system of distribution for the various airport facilities. Transmitting and receiving stations will be provided each with a separate water supply system.

3) Sewerage

Sewage and waste water coming out of each airport building is piped to the treatment plant of the airport for processing by soil infiltration method, and thereafter discharged into the canals of the airport drinage system.

4) Telephone

Telephone communications to and from within and outside the airport premises will have to depend on the lines of the COTAS (Cooperativa de Teléfonos Automáticos de Santa Cruz) whose exclusive operation covers the entire area of the Department of Santa Cruz. It is, therefore, expected under the present plan that COTAS will undertake both the planning and actual construction of the necessary installations up to the dividing point of responsibility normally agreed between the COTAS and its client.

5) Garbage Disposal

It is planned that the garbage disposal of the new airport will be undertaken by the Servicio de Limpeza which takes care of the garbage services for the entire area of Santa Cruz. In addition, the new airport will be equipped with its own incinerator with a capacity to process 10% of the total amount of garbage expected at the airport.

6) Gas

LPG will be used for the airport's gas supply system with individual cylinders provided for each building.

(7) Aviation Fuel Supply

The aviation fuel supply system of the new airport comprises a fuel storage tank with a 10-day capacity and a hydrant system to cover the passenger and cargo aircraft parking positions, and a separate supply system for the general aviation complete with a storage tank and a hydrant. A new pipe line will be constructed between the fuel depository in the City of Santa Cruz and the storage tank on the airport.

3-2-3 Staging and Timing of Construction

Two alternatives of construction staging are envisaged under the present plan, namely one in 2 stages and another in 4 stages, with the time schedules as shown in Fig. 3-2-5. Since it requires about 30 months in the 1st phase construction in both cases, opening of the new airport to traffic can be expected no earlier than the beginning of 1981 even if the work is started at the earliest possible date.

3-2-4 Project Cost

The project cost of the new airport construction was estimated for each of the two cases of staging as mentioned above. The estimate for either case comprises the aggregate cost of the various construction works, an engineering fee at 6% thereof, a physical contingency equal to 10% of the sum of the aggregate cost of the construction works and of the engineering fee, plus a price contingency estimated at 6% per annum. Tables 3-2-7 and 3-2-8 show the estimated project cost for the 2-stage and 4-stage construction respectively of the new airport in Viru Viru, with the local and foreign portions separated. The estimates, however, do not include the land acquisition cost in either case.

Fig. 3-2-5 Timing and Staging of Construction

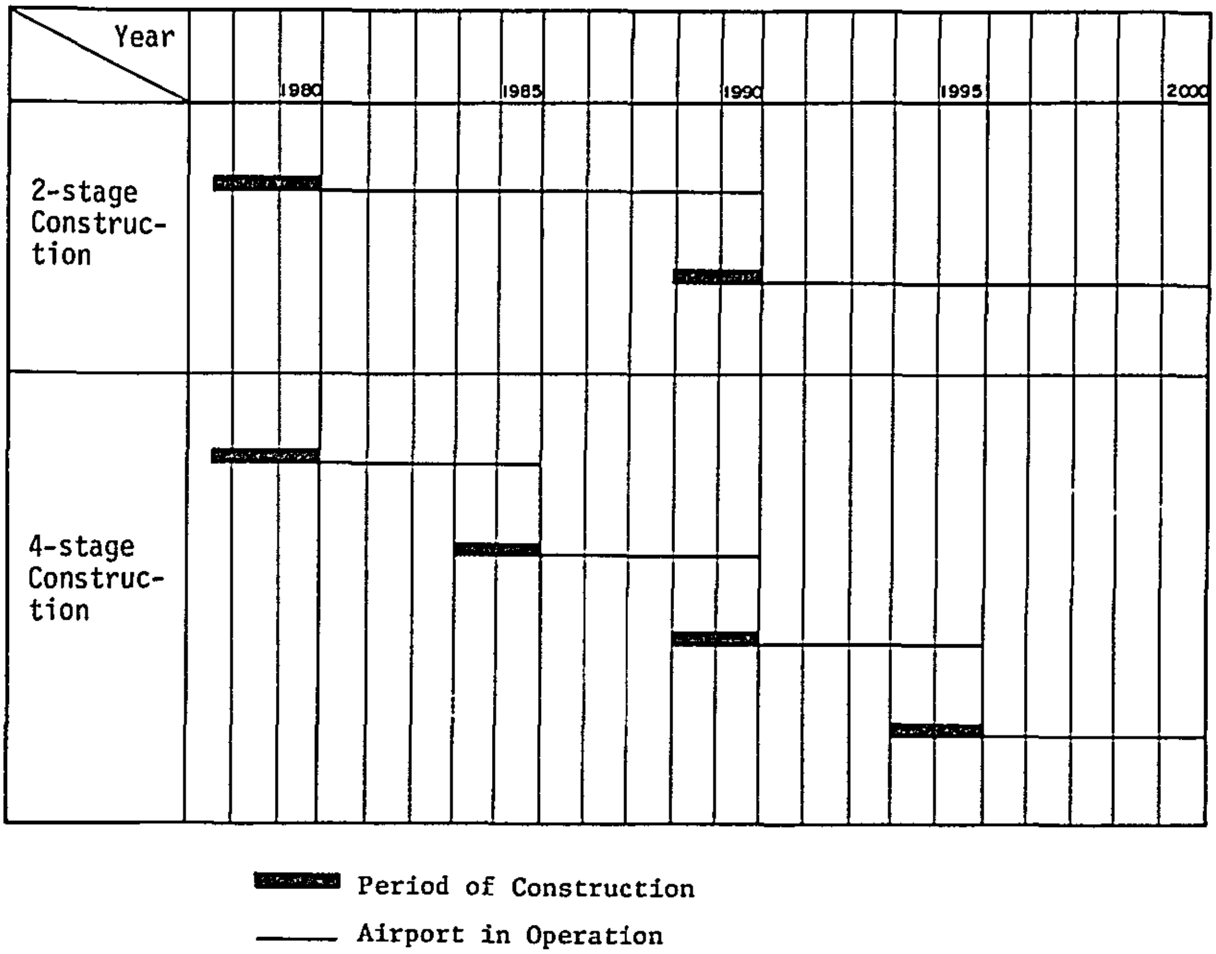


Table 3-2-7 Project Cost of Santa Cruz - Viru Viru International Airport for Construction in 2 Stages

(In Thousand US Dollars)

| Cost Items / Cost Distribution / Design Year | 1990 | | | 2000 | | |
|---|---|---|---|---|---|---|
| | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total |
| Civil Engineering Work | 10,549 | 17,308 | 27,857 | 5,115 | 9,593 | 14,708 |
| Building Work | 6,812 | 9,032 | 15,844 | 4,572 | 6,073 | 10,645 |
| Radio Navigational Aids, Telecommunications and Meteorological Service Facilities | 644 | 5,800 | 6,444 | 0 | 0 | 0 |
| Electric Power and Airfield Lighting Facilities | 1,755 | 7,020 | 8,775 | 247 | 986 | 1,233 |
| Utilities, Fuel and Lubricant Supply Facilities | 645 | 2,583 | 3,228 | 369 | 1,477 | 1,846 |
| Subtotal | 20,405 | 41,743 | 62,148 | 10,303 | 18,129 | 28,432 |
| Engineering Cost (6% of subtotal) | 1,224 | 2,505 | 3,729 | 618 | 1,088 | 1,706 |
| Total w/o Contingencies | 21,629 | 44,248 | 65,877 | 10,921 | 19,217 | 30,138 |
| Physical Contingency (10%) | 2,163 | 4,425 | 6,588 | 1,092 | 1,922 | 3,014 |
| Price Contingency (6% per annum) | 3,344 | 6,790 | 10,134 | 12,929 | 22,986 | 35,915 |
| Grand Total | 27,136 | 55,463 | 82,599 | 24,942 | 44,125 | 69,067 |

Table 3-2-8 Project Cost of Santa Cruz - Viru Viru International Airport for Construction in 4 Stages

(In Thousand US Dollars)

| Cost Items (Design Year / Cost Distribution) | 1985 | | | 1990 | | | 1995 | | | 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total |
| Civil Engineering Work | (38) 9,229 | (62) 15,060 | 24,289 | (37) 1,325 | (63) 2,307 | 3,582 | (35) 3,026 | (15) 5,619 | 8,645 | (35) 2,292 | (65) 4,256 | 6,548 |
| Building Work | (43) 5,001 | (57) 6,630 | 11,631 | (43) 1,811 | (57) 2,402 | 4,213 | (43) 2,415 | (57) 3,201 | 5,616 | (43) 2,162 | (53) 2,869 | 5,029 |
| Radio Navigational Aids, Telecommunications and Meteorological Service Facilities | (50) 644 | (90) 5,800 | 6,444 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Electric Power and Air-field Lighting Facilities | (20) 1,712 | 6,847 | 8,559 | (20) 43 | (80) 173 | 216 | 89 | 358 | 447 | 166 | 664 | 830 |
| Utilities, Fuel and Lubricant Supply Facilities | (20) 583 | (80) 2,334 | 2,917 | 62 | 249 | 311 | 161 | 646 | 807 | 208 | 831 | 1,039 |
| Subtotal | (32) 17,169 | (68) 36,671 | 53,840 | (39) 3,241 | (61) 5,081 | 8,322 | (36) 5,585 | (64) 9,930 | 15,515 | (36) 4,828 | (64) 8,618 | 13,446 |
| Engineering Cost (6% of subtotal) | (32) 1,034 | (68) 2,197 | 3,231 | 194 | 305 | 499 | 335 | 596 | 931 | 291 | 516 | 807 |
| Total w/o Contingencies | 18,263 | 38,868 | 57,071 | 3,435 | 5,386 | 8,821 | 5,921 | 10,525 | 16,446 | 5,131 | 9,122 | 14,253 |
| Physical Contingency (10%) | (32) 1,826 | (68) 3,881 | 5,708 | (39) 343 | (61) 538 | 882 | (36) 592 | (64) 1,052 | 1,645 | 513 | 912 | 1,426 |
| Price Contingency (6% per annum) | 2,543 | 5,406 | 7,948 | 1,962 | 3,070 | 5,032 | 6,525 | 11,689 | 18,264 | 9,353 | 16,628 | 25,981 |
| Grand Total | 22,633 | 48,094 | 70,727 | 5,740 | 8,974 | 14,735 | 13,088 | 22,266 | 36,354 | 14,998 | 26,662 | 41,660 |

## 3-3 EXISTING AIRPORT EXPANSION PLAN

The plan to expand the existing airport of El Trompillo is made for the 4 development stages identical to those of the new airport construction. Under the plan, the existing airport is to be expanded to such an extent as to be capable of providing a service level equal to that of the new airport of Viru Viru.

### 3-3-1 Airport Facility Layout Plan

Fig. 3-3-1 shows the general layout plans of the airport facilities for each of the 4 design years. The expansion concept comprises primarily of the extention of the existing runway to 3,500 m toward the south, avoiding the heavily populated area to the north of the airport. Furthermore, the northern end of the runway is relocated 300 m to the south in the exact direction of the runway orientation so that the localizer of the radio navigational aid system as well as the simple approach lighting system may be adequately installed within the airport premises. The plan also includes rerouting of the existing railway to detour for about 500 m to the south, which is necessitated by the extention of the runway as mentioned above.

The terminal area is planned in a scarcely populated area adjacent to and southwest of the existing airport premises. The passenger terminal and the cargo terminal buildings and aprons are sited parallel to the runway. Separate international and domestic passenger buildings are sited to match the frontal type configuration of the apron. General aviation is planned to utilize the existing general aviation aprons and those of passenger aircraft.

The CALVERT approach lighting system is planned on the south end of the runway as in the case of the new airport.

Approach road is planned to connect to the branch of the 2nd Loop Road of the City of Santa Cruz.

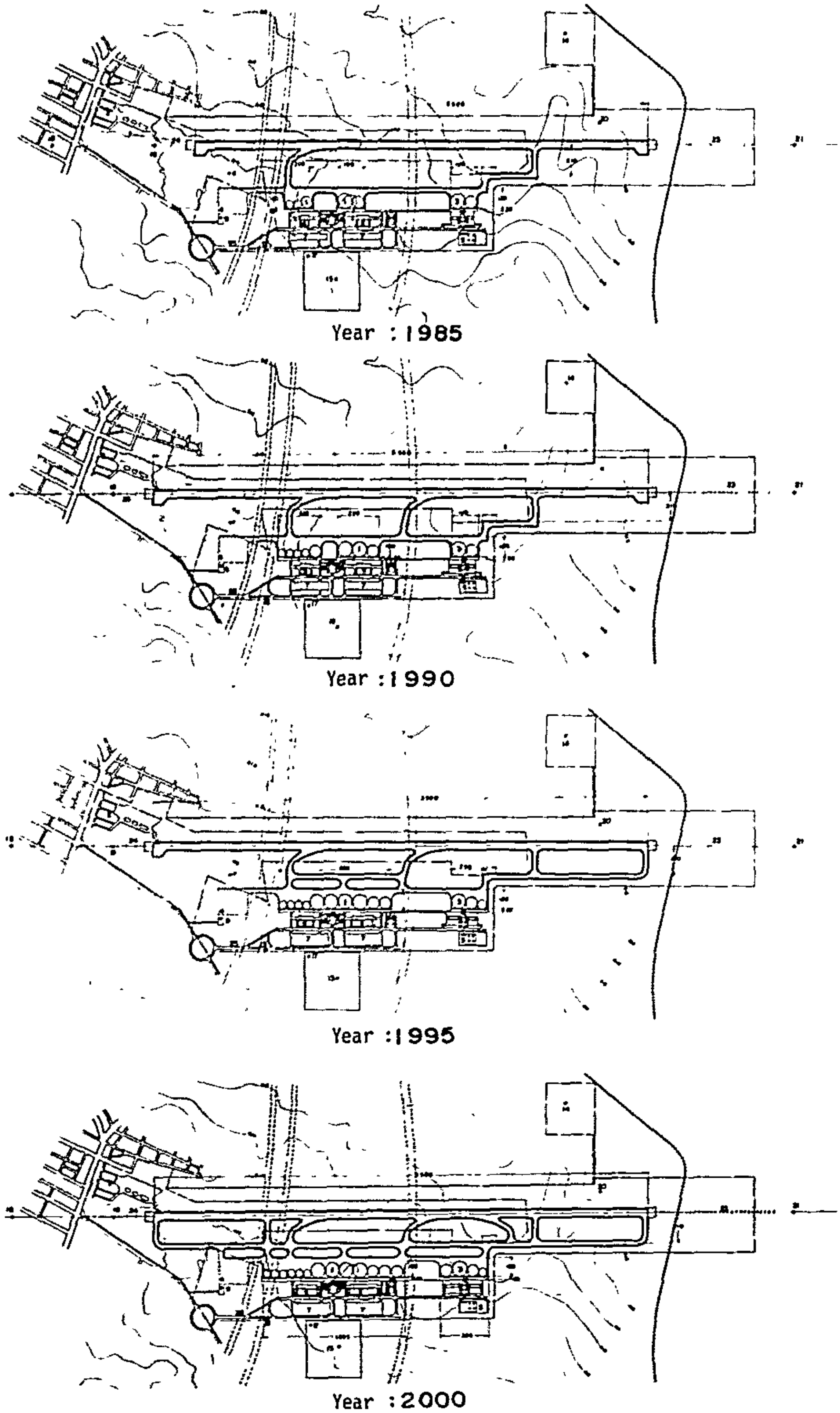



Fig. 3-3-1 Facility Layout of El Trompillo Airport Expansion Plan

### 3-3-2 Facility Planning

#### (1) Airfield Facilities

1) Pavement

The existing runway measuring 2,780 m x 40 m has a rigid pavement, designed for the critical aircraft of B727-100. An overlay to the full length and width is planned to enable the runway to withstand the operating load of DC-8-63. In addition to the extension to 3,500 m of the runway length, its width will also be broadened by 5 m to 45 m. The widened parts will have a flexible pavement, while the prolonged parts of the runway as well as the entire taxiways and aprons will have a rigid pavement of a uniform thickness as in the case of the new airport.

Fig. 3-3-2 shows the standard cross section of the runway improvement work by overlay and broadening as mentioned above.

2) Earth Work

Earth work of the existing airport expansion is planned with a similar basic design concept as in the case of the new airport construction plan in terms of the amount and distance of earth movements, and also to have the formation height of the improved runway identical to the overlay height of the existing runway.

3) Drainage

The drainage system is planned more or less with a similar design concept to that of the new airport. However, the natural topography of the existing airport site is such that rising of the ground water level during the rainy season is expected to be negligible, and consequently no particular consideration is made for the subsurface drainage.

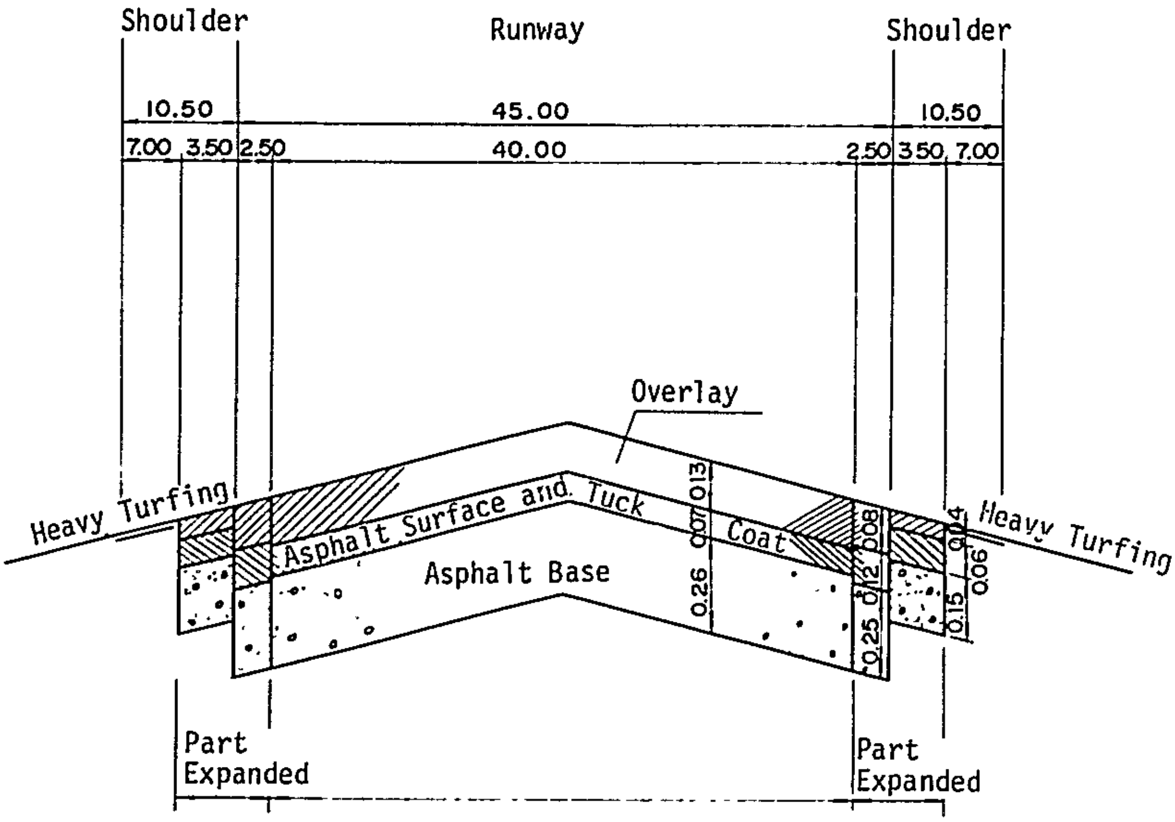



Fig. 3-3-2 Standard Cross Section of Flexible Pavement - Runway

(2) Radio Navigational Aids, Telecommunications, and Meteorological Service Facilities

As mentioned earlier, total renovation of the radio navigational aids, telecommunications and meteorological service facilities of the existing airport is recommendable. Under the present expansion plan, therefore, the entire systems of the captioned services will be thoroughly replaced with the new systems which are planned similar to those of the new airport. General layout of these facilities are shown in Drawing 11.

(3) Airfield Lighting

With the extension of the runway, the existing lighting system will have to be replaced in its entirety with the new system which is to be identical to that of the new airport of Viru Viru.

(4) Buildings

1) Terminal Area

As shown in Table 3-3-1 there are three alternative siting plans for the terminal area, out of which Alternative III has been selected because of its comparative advantages in cost, future expandability, and functional efficiency.

Table 3-3-1 Terminal Area Siting Alternatives

| | Passenger Terminal | | Cargo Terminal | General Aviation |
|---|---|---|---|---|
| | International | Domestic | | |
| Alternative I | Existing | Existing | Existing | Existing |
| Alternative II | Existing | New | New | Existing |
| Alternative III | New | New | New | Existing |

Alternative I is based on the concept of expanding the existing terminal buildings. It is, however, almost impracticable on account of the fact that little or no space is available for expansion in reality since the terminal is surrounded by the heavily populated urban area.

Alternative II, with the new domestic passenger terminal building planned at the new site and the new international passenger building at the present site, may be considered desirable from the view point of maximum possible utilization of the existing facilities. It is, however, handicapped by the prohibitingly high relative cost of operation including such additional cost as that incurred by the necessitated bus service between the international and domestic passenger terminal buildings and also that resulting from longer ground time and increased surface movements of aircraft.

2) Passenger Terminal Building

Passenger terminal buildings are sited between the 3rd and the 4th Loop Road in consideration of the ultimate size of the buildings required for the design year of 2000. Separate international and domestic buildings are arranged parallel to the runway to match the planned apron configuration so as to minimize the walking distance for the passengers. As in the case of the new airport, one-and-half-level passenger processing is planned for the Existing Airport Expansion Plan, with an on-foot boarding scheme in principle.

3) Cargo Terminal Building

The cargo terminal building is sited next to the new passenger terminal across on the opposite side of the 4th Loop Road. Size and layout of the cargo terminal building is planned similar to those of the new airport. (See Drawing 22).

4) Technical Block

Technical block is sited between and equi-distant from the international and domestic passenger terminals, allowing enough space for future expansion of both buildings. Size and layout of the control tower and the substation are planned similar to those of the new airport. (See Drawing 22).

5) Other Buildings

Other buildings of the existing airport including the rescue and fire fighting station, presidential pavilion, transmitting and receiving stations, etc., are planned with identical floor areas as in the New Airport Construction Plan. Layout of these facilities are as shown in Drawings 5 through 8.

(5) Road and Automobile Parking

Planning of the approach road and of the automobile parking is based on similar design concept as in the case of the new airport. The 500 m approach road to be built newly is planned to connect to the branch of the 2nd Loop Road, with two 3.5 m wide lanes up to the design years of 1995, and two each lanes of the same width in each direction for the ultimate design year of 2000. (See Table 3-3-2).

Table 3-3-2 Width and Number of Lanes of Approach Road

| Design Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Width of Lane (m) | 3.5 | 3.5 | 3.5 | 3.5 |
| Number of Lanes | 2 | 2 | 2 | 4 |

(6) Utilities

1) Electric Power Supply System

Electric power will be supplied by the nearby 10 KV distribution line of the CRE (Cooperativa Rural de Electrificación). The Substation No. 1, located next to the passenger terminal and the control tower, receives the power from the CRE line, and supplies the power to the passenger terminal and the technical block, as well as to other substations of the airport and to ILS/OM sites.

Air navigational aid facilities, building emergency lighting, and other essential facilities of the airport are provided with the secondary power supply system comprising an individual engine generator with automatic on-off controls for each such facility.

Schematic diagram of the electric power supply system is shown in Fig. 3-3-3.

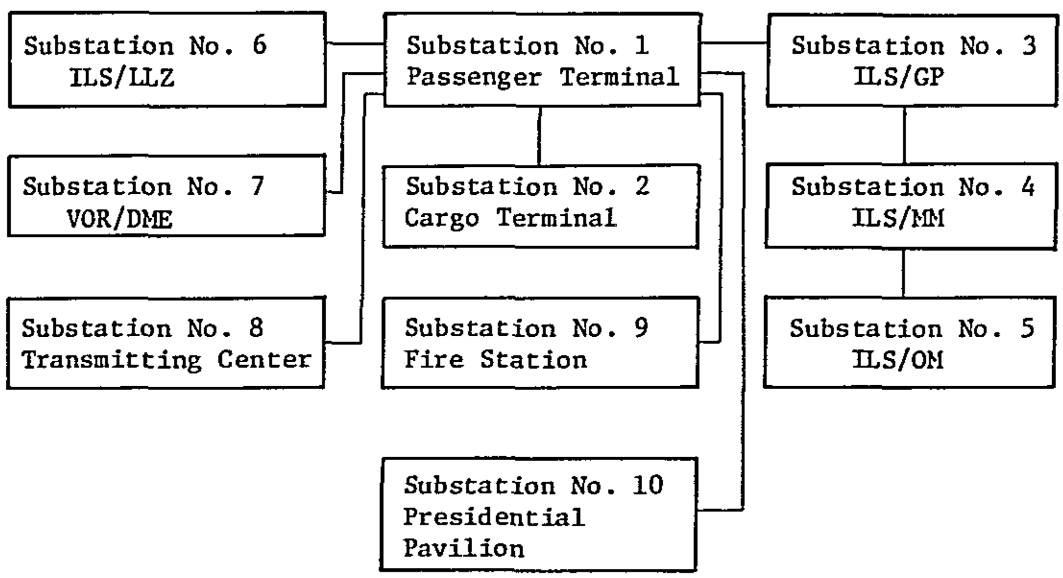



Fig. 3-3-3 Electric Power Distribution Diagram

2) Water Supply

Water for the existing airport is supplied from the city water supply pipe of SAGUAPAC (Servicio de Agua Potable y Alcantarillado de Santa Cruz), and is distributed to the various facilities of the airport through the piping system to be constructed under the expansion plan.

3) Sewerage

Sewage and waste water ducting system of the airport is planned to connect to the sewerage system of the SAGUAPAC.

4) Telephone

Similar to the New Airport Construction Plan.

5) Garbage Disposal

Similar to the New Airport Construction Plan.

6) Gas Supply

Similar to the New Airport Construction Plan.

(7) Aviation Fuel Supply

Out of the existing fuel supply facilities, only that of the general aviation will be kept at the present site, with all others moved to the corresponding new sites under the expansion plan. The pipe line connecting the airport's fuel distribution system with the fuel depository in the City of Santa Cruz will be approximately 2 km in length.

(8) Works Related to Urban Road Plan and Existing Railroad

1) Construction of Road Tunnels under the Runway

The urban road plan presently under implementation as mentioned in Chapter 1 includes roads planned on a premise that the existing airport will be transferred elsewhere, and, therefore, the existing runway is intersected at 3 places by the planned routes of the 3rd Loop Road (both inner and outer tracks) and the 4th Loop Road. (See Fig. 3-3-4).

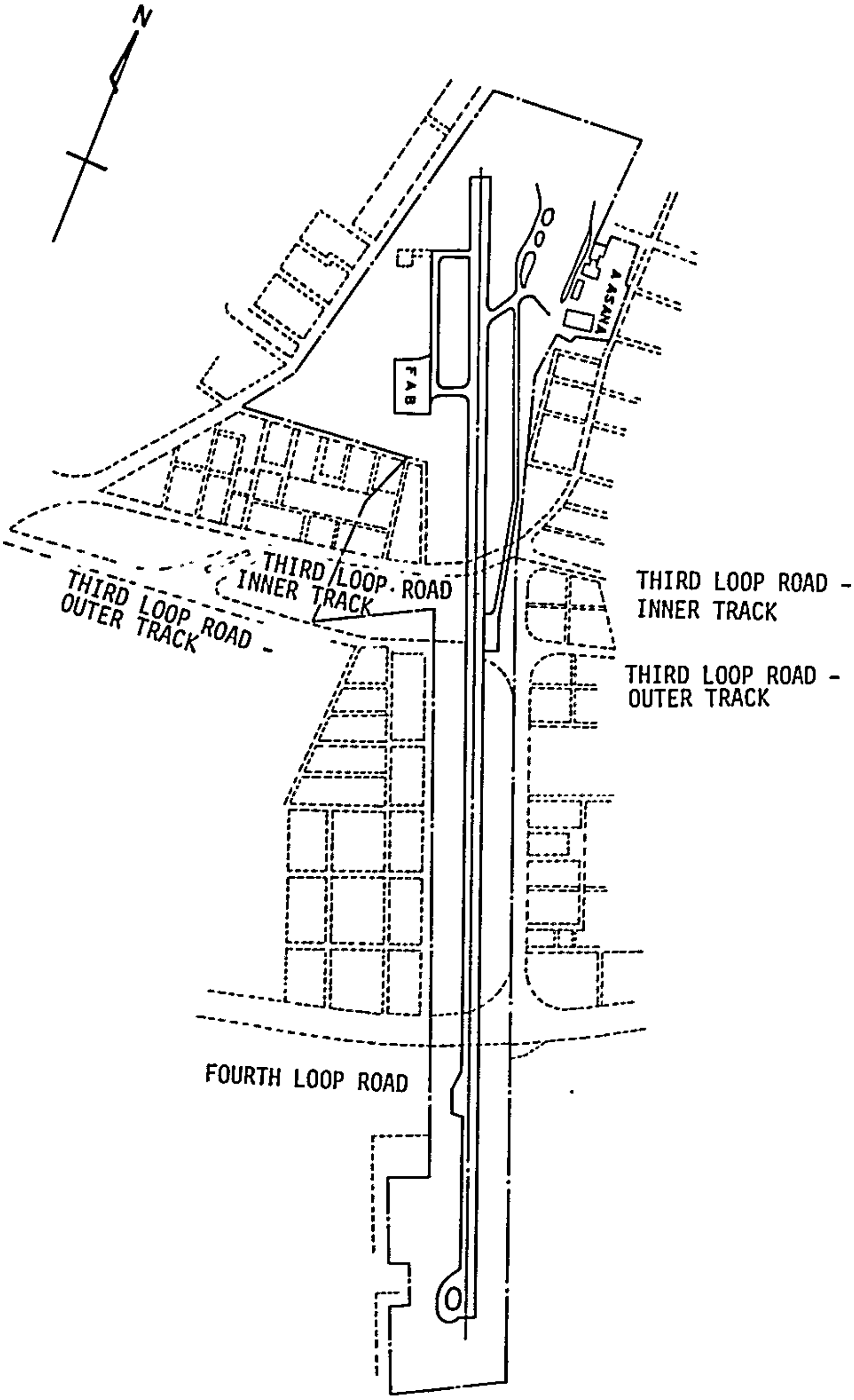



Fig. 3.3-4 Planned Loop Roads in the Vicinity of El Trompillo Airport

Though, as stated earlier, implementation of the said road plan is considerably behind schedule, it is assumed under the present plan that, judging from the population density in the surrounding areas of the planned roads, inner and outer tracks of the 3rd Loop will be completed by early 1980 and early 1985 respectively, and the 4th Loop by early 1990.

Re-routing of these planned roads is, of course, not impossible theoretically at least, but in reality it is highly impracticable since good part of the said road plan is actually in progress. Consequently, it is planned to construct the tunnels for the roads at places where they cross the existing airport premises. The number and the width of the lanes planned for the road tunnels are shown in Table 3-3-3.

Table 3-3-3 Width and Number of Lanes of the Road Tunnels under the Runway

| | Number of Lanes | Width of Lane (m) |
|---|---|---|
| Third Loop - Inner Track | 2 | 3.50 |
| Third Loop - Outer Track | 2 | 3.50 |
| Fouth Loop | 4 | 3.50 |

Shield driving method is used in the construction of the part of the tunnels directly under the existing runway so that the work may be carried out without interrupting the use of the runway. The part of the tunnels falling under the parallel taxiway is to be constructed by an open-cut method prior to the construction of the taxiway under the expansion plan.

The part of the tunnels under the parallel taxiway will be of the reinforced concrete box culvert structure, and the sloping open-cut approach section will have retaining walls of reinforced concrete.

2) Re-routing of the Railroad

The existing railroad that connects Santa Cruz with Villamontes runs across the extension of the runway at a point 700 m to the south off its south end. To extend the runway to 3,500 m as envisaged under the present expansion plan, would, therefore, mean that it will have to cross the existing railroad. To solve the problem it is planned to have the railroad re-routed to make room for the extention, involving a total of about 3000 m of the detour route.

### 3-3-3 Staging and Timing of Construction

The staging and timing of construction for the expansion of the existing airport of El Trompillo have been planned on a similar concept to that of the new airport construction, resulting in an identical time schedules to what is presented in Fig. 3-2-5 in the preceding section.

### 3-3-4 Project Cost

The project cost of the expansion plan was estimated in a similar manner as in the case of the new airport construction plan. The estimated total cost includes the cost involved in the re-routing of the railroad but not that of the construction of the road tunnels, nor that of the acquisition of the land necessary for the expansion work. Tables 3-3-4 and 3-3-5 show the project cost in the cases of 2-stage and 4-stage construction respectively.

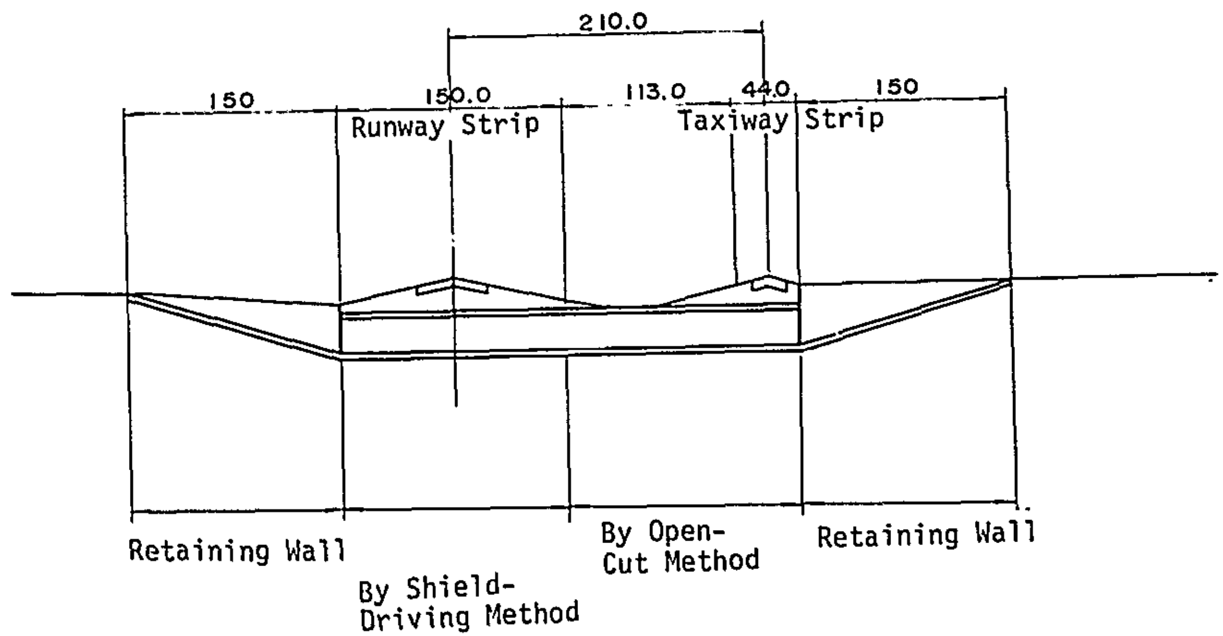



Fig. 3-3-5 Longitudinal Section of Road Tunnel under El Trompillo Airport Premises

Table 3-3-4 Project Cost of El Trompillo Airport Expansion in 2 Stages

(In Thousand US Dollars)

| Cost Items / Cost Distribution / Design Year | 1990 | | | 2000 | | |
|---|---|---|---|---|---|---|
| | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total |
| Civil Engineering Work | 10,625 | 17,335 | 27,960 | 2,963 | 5,502 | 8,465 |
| Building Work | 6,813 | 9,031 | 15,844 | 4,576 | 6,065 | 10,641 |
| Radio Navigational Aids, Telecommunications and Meteorological Service Facilities | 617 | 5,554 | 6,171 | 0 | 0 | 0 |
| Electric Power and Airfield Lighting | 1,295 | 5,178 | 6,473 | 167 | 670 | 837 |
| Utilities, Fuel and Lubricant Supply Facilities | 376 | 1,503 | 1,879 | 145 | 582 | 727 |
| Subtotal | 18,665 | 39,662 | 58,327 | 7,442 | 13,231 | 20,673 |
| Engineering Cost (6% of subtotal) | 1,120 | 2,380 | 3,500 | 447 | 794 | 1,241 |
| Total w/o Contingencies | 19,785 | 42,042 | 61,827 | 7,889 | 14,025 | 21,914 |
| Physical Contingency (10%) | 1,979 | 4,204 | 6,183 | 789 | 1,403 | 2,192 |
| Price Contingency (6% per annum) | 2,764 | 5,874 | 8,638 | 8,544 | 15,189 | 23,733 |
| Grand Total | 24,527 | 52,121 | 76,648 | 17,222 | 30,617 | 47,839 |

## Table 3-3-5 Project Cost of El Trompillo Airport Expansion in 4 Stages

(In Thousand US Dollars)

| Cost Items \ Design Year / Cost of Distribution | 1985 | | | 1990 | | | 1995 | | | 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total | Local Portion | Foreign Portion | Total |
| Civil Engineering Work | 9,231 | 15,062 | 24,293 | 1,357 | 2,310 | 3,668 | 1,415 | 2,627 | 4,042 | 1,548 | 2,875 | 4,423 |
| Construction Work | 5,001 | 6,629 | 11,630 | 1,812 | 2,401 | 4,213 | 2,415 | 3,201 | 5,616 | 2,162 | 2,867 | 5,029 |
| Radio Navigational Aids, Telecommunications and Meteorological Service Facilities | 617 | 5,554 | 6,171 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Electric Power and Airfield Lighting | 1,253 | 5,011 | 6,264 | 42 | 167 | 209 | 103 | 411 | 514 | 65 | 258 | 323 |
| Utilities, Fuel and Lubricant Supply Facilities | 314 | 1,254 | 1,568 | 62 | 249 | 311 | 62 | 250 | 312 | 83 | 332 | 415 |
| Subtotal | 15,976 | 33,950 | 49,926 | 3,276 | 5,125 | 8,401 | 3,774 | 6,710 | 10,484 | 3,668 | 6,522 | 10,190 |
| Engineering Cost (6% of Subtotal) | 958 | 2,037 | 2,995 | 197 | 307 | 504 | 226 | 403 | 629 | 220 | 391 | 611 |
| Total (w/o Contingencies) | 16,634 | 35,987 | 52,921 | 3,473 | 5,432 | 8,905 | 4,001 | 7,112 | 11,113 | 3,888 | 6,913 | 10,801 |
| Physical Contingency (10%) | 1,693 | 3,599 | 5,292 | 347 | 544 | 811 | 400 | 711 | 1,111 | 389 | 691 | 1,080 |
| Price Contingency (6% per annual) | 2,350 | 4,994 | 7,344 | 1,982 | 3,101 | 5,083 | 4,401 | 7,824 | 12,225 | 7,054 | 12,542 | 19,596 |
| Grand Total | 20,978 | 44,579 | 65,557 | 5,803 | 9,076 | 14,879 | 8,802 | 15,647 | 24,449 | 7,055 | 24,422 | 31,477 |

# 4. ECONOMIC ANALYSIS

# 4. ECONOMIC ANALYSIS

## 4-1 BASIC APPROACH

The purpose of the economic analysis presented in this Chapter is to examine, in the first place, whether or not the construction of a new airport in Santa Cruz is really worthwhile and significant enough from the view point of the national economy, and subsequently, as a second step, to ascertain if the proposed construction plan is the optimum choice involving the least costs. Outlined in the following is the basic thinking of the present analysis.

(1) To determine whether or not a new airport construction project is economically feasible, it is necessary first to assess the economic significance of the construction of the new airport, that is to say, to find out what economic benefits are derived from the project as compared with its costs.

In the present analysis, such benefits are defined to be those identifiable through comparison of the case of the new airport construction for one, and the case "without project" for the other. Calculation of the benefits so defined, however, were limited only to those that are measurable.

(2) To ascertain whether the proposed New Airport Construction Plan is truly an optimum plan with minimal cost, comparison was made between the two development alternatives, i.e., the New Airport Construction Plan and the Existing Airport Expansion Plan, both envisaged to provide an equal service level.

(3) The project life is set at 20 years, and the Economic Internal Rate of Return is to be the evaluation criteria for the first step study described in (1) above, and the conclusion of the second step study was drawn by comparing the net costs of the two alternative plans calculated at a discount rate of 12% per annum.

(4) The official exchange rates in Bolivia has been stable for the last few years at 20 Bolivian pesos to One US Dollar, and there is no discrepancy between the official and the prevailing rates.

Furthermore, the rate of unemployment, both actual and latent, is relatively low in the Department of Santa Cruz, and the demand-supply situation of labor is fairly well balanced. It is, therefore, understood that the prevailing wage rates well reflect the marginal productivity of labor, and consequently shadow prices are not used in the present economic analysis.

(5) By policy of the Bolivian government, construction materials to be imported from abroad for the Project are exempt from customs duty. Furthermore, the excise taxes imposed on locally procured raw materials are considered negligible. Consequently, in calculating the project costs, no consideration is made for the taxes and duties that are interpreted as the values transferred.

## 4-2 DETERMINATION OF BASE PLAN

The case "without project" referred to above is defined as the Base Plan in which utilization of the existing airport of El Trompillo is continued at the present facility level as described in Subsection 1-2-1 of Chapter 1. It is assumed, however, that minimum replacement or renewal will be made of the facilities as required from time to time to keep the airport functioning properly.

The air transport demand of the Santa Cruz Airport as projected in Chapter 2 above represents the potential demand which would be realized only when the corresponding infrastructures are developed to a comparable level.

The existing passenger terminal building has a floor area of 2,500 $m^2$. During the peak hour, with a concentration of two B727s, terminal space per passenger is 12.5 $m^2$ which is below the standard area requirements.

In other words, the passenger handling capacity at the existing terminal has reached its limit. The terminal, however, may continue to be usable at the present level of congestion up to a point where the peaking pattern is evenly leveled throughout the year by flight schedule adjustments. At such a time, the total annual passengers including transit passengers will reach 876,000, and according to the figures in Table 4-2-1, the corresponding year falls on 1984. This means that, from the year 1985 on, the projected demand will not be fully met, resulting in overflow of passengers.

Table 4-2-1 Projected Annual Passengers at Santa Cruze Airport

(In thousands)

| | Arriving and Departing | | | Transit | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | International | Domestic | Total | International | Domestic | Total | International | Domestic | Total |
| 1980 | 98 | 350 | 403 | 65 | 76 | 141 | 163 | 381 | 544 |
| 1981 | 115 | 337 | 452 | 76 | 84 | 160 | 191 | 421 | 612 |
| 1982 | 134 | 373 | 507 | 88 | 93 | 181 | 222 | 466 | 688 |
| 1983 | 157 | 413 | 570 | 104 | 103 | 207 | 261 | 516 | 777 |
| 1984 | 183 | 456 | 639 | 121 | 114 | 235 | 304 | 570 | 874 |
| 1985 | 214 | 505 | 719 | 141 | 126 | 267 | 355 | 631 | 986 |
| 1986 | 244 | 554 | 798 | 161 | 139 | 300 | 405 | 693 | 1,098 |
| 1987 | 277 | 608 | 885 | 183 | 152 | 335 | 460 | 760 | 1,220 |
| 1988 | 315 | 667 | 982 | 208 | 167 | 375 | 523 | 834 | 1,357 |
| 1989 | 359 | 731 | 1,090 | 237 | 183 | 420 | 596 | 914 | 1,510 |
| 1990 | 408 | 803 | 1,216 | 269 | 201 | 470 | 677 | 1,004 | 1,681 |
| 1991 | 464 | 879 | 1,343 | 306 | 220 | 526 | 770 | 1,099 | 1,869 |
| 1992 | 527 | 965 | 1,492 | 348 | 241 | 589 | 875 | 1,206 | 2,081 |
| 1993 | 600 | 1,058 | 1,658 | 396 | 265 | 661 | 996 | 1,323 | 2,319 |
| 1994 | 682 | 1,161 | 1,843 | 450 | 290 | 740 | 1,132 | 1,451 | 2,583 |
| 1995 | 776 | 1,263 | 2,039 | 512 | 316 | 828 | 1,288 | 1,579 | 2,867 |
| 1996 | 854 | 1,351 | 2,205 | 564 | 338 | 902 | 1,418 | 1,689 | 3,107 |
| 1997 | 939 | 1,446 | 2,385 | 620 | 362 | 982 | 1,559 | 1,808 | 3,367 |
| 1998 | 1,033 | 1,547 | 2,580 | 682 | 387 | 1,069 | 1,715 | 1,934 | 3,649 |
| 1999 | 1,136 | 1,656 | 2,792 | 750 | 414 | 1,164 | 1,886 | 2,070 | 3,956 |
| 2000 | 1,250 | 1,771 | 3,021 | 825 | 442 | 1,268 | 2,075 | 2,214 | 4,289 |

## 4-3 ECONOMIC EVALUATION OF NEW AIRPORT CONSTRUCTION PLAN

In this section a cost-benefit analysis is made from the view point of the national economy of Bolivia to determine whether the construction of the new airport in Viru Viru is economically justified.

### 4-3-1 Calculation of Costs

The cost involved in the New Airport Construction Plan was calculated in 1977 prices as follows:

(1) Airport Construction Cost

Annual investment costs of the new airport construction including the physical contingency are as shown in Table 4-3-1.

Table 4-3-1 Annual Investment Cost of Viru Viru International Airport Construction

(In Thousand US Dollars)

| Year \ Construction | In 2 stages | In 4 stages |
|---|---|---|
| 1978 | 13,517 | 11,601 |
| 1979 | 28,717 | 25,430 |
| 1980 | 30,231 | 25,746 |
| 1981 | - | - |
| 1982 | - | - |
| 1983 | - | - |
| 1984 | - | 2,519 |
| 1985 | - | 7,168 |
| 1986 | - | - |
| 1987 | - | - |
| 1988 | - | - |
| 1989 | 13,608 | 3,359 |
| 1990 | 19,544 | 14,050 |
| 1991 | - | - |
| 1992 | - | - |
| 1993 | - | - |
| 1994 | - | 3,031 |
| 1995 | - | 12,711 |
| Total | 105,617 | 105,615 |

(2) Airport Maintenance and Operation Cost

Table 4-3-2 shows the expected annual cost of maintenance and operation of the new airport calculated on the following basis:

1) The cost of maintenance and operation of the civil engineering, building, utility, and fuel supply facilities is estimated at 1% of their respective construction cost.

2) As for the radio navigational aids, airfield lighting, and electric power supply facilities, 5% of their respective construction cost is estimated.

3) Calculation of the personnel cost is based on the 1976 records of the existing airport of El Trompillo, with 2% annual cost increase to cover the increasing number of personnel required to satisfy the future air transport demand.

Table 4-3-2 Expected Annual Maintenance and Operation Cost of Viru Viru International Airport

(In Thousand US Dollars)

| Year \ Construction | In 2 stages | In 4 stages |
|---|---|---|
| 1981 | 1,541 | 1,462 |
| 1982 | 1,547 | 1,468 |
| 1983 | 1,557 | 1,475 |
| 1984 | 1,561 | 1,482 |
| 1985 | 1,567 | 1,488 |
| 1986 | 1,575 | 1,575 |
| 1987 | 1,582 | 1,582 |
| 1988 | 1,589 | 1,589 |
| 1989 | 1,596 | 1,596 |
| 1990 | 1,605 | 1,605 |
| 1991 | 1,967 | 1,798 |
| 1992 | 1,975 | 1,806 |
| 1993 | 1,982 | 1,813 |
| 1994 | 1,990 | 1,822 |
| 1995 | 1,999 | 1,830 |
| 1996 | 2,008 | 2,008 |
| 1997 | 2,017 | 2,017 |
| 1998 | 2,026 | 2,026 |
| 1999 | 2,035 | 2,035 |
| 2000 | 2,044 | 2,044 |

(3) Cost of Access Transport

The new airport is sited at 17 km north of the center of the City of Santa Cruz, while the existing airport of El Trompillo is only 2 km to the south of the city center. The access distance for the new airport, therefore, is longer by 15 km as compared with the existing airport. The urban area of the City of Santa Cruz, however, tends to develop more and more toward the north, and furthermore, the proposed site of Viru Viru is conveniently located for the prospective users of the new airport residing in Montero where the population is growing remarkably.

Though the distribution of origin of the prospective users of the new airport is not fully identified, the present study envisages Viru Viru to occupy a position virtually of the center of gravity in the passenger origin distribution. Consequently, no increase in the cost of access time has been calculated.

On the other hand, in addition to the existing road linking Santa Cruz and Montero, a new expressway is planned apart from the airport project, and it is expected that road access requirements of the new airport up to the year 2000 will be satisfied by these two roads. Consequently, no cost of investment in access road is calculated.

4-3-2 Measurement of Benefits

As benefits resulting from the construction and utilization of the new airport, the following items are identified in the present analysis through comparison of the New Airport Construction Plan with the Base Plan, namely the plan to utilize the existing airport at the present service level.

a) Benefits resulting from the improved service level to be provided by the airport, comprising principally of the time saving benefits.

b) Benefits of increased utility resulting from satisfied trip demand.

Continued use of the existing airport without expansion will result in the future trip demand in excess of its supply capacity, causing an overflow of passenger traffic, which the new airport is intended to absorb. This excess demand to be satisfied by the new airport is regarded as an element of benefits attributable to the New Airport Construction Plan.

In actual calculation, this benefit is identified as the sum of the current air fare and of the current airport user charges per passenger, devoid of duplications, which is considered to be the minimum value each individual passenger is expected to have been willing to pay, and which in other words, is considered to represent the minimum amount of benefit enjoyed by each passenger.

The total benefit under this item is calculated solely in respect of the projected number of resident air passengers, in both international and domestic services, whose trip demand would not have been satisfied by the Base Plan. Benefits of the same nature enjoyed by foreign passengers are excluded from the calculation, since they are regarded as benefits that "spill over." It is to be noted further that "consumer's surplus" is not accounted for in this calculation, and that, therefore, true benefits accruing from the new airport construction may well be expected to be greater than the value calculated herein.

c) Benefits represented by the maintenance and operation cost of the existing airport that would have been incurred in case the new airport is not constructed.

d) Benefits represented by the social cost such as that of road tunnel construction, counter noise and accident, etc., that would have been incurred in El Trompillo in case the new airport is not constructed.

In addition to the above, conceivable benefits accruing from the new airport construction include, for one thing, those represented by the net values and their multiplier effects of foreign currency payments in tourism, etc. to be made by the projected air passengers of foreign origin, as well as the foreign currency payments for aviation fuel, etc. made by foreign airlines, and for the other, the intangible benefits of direct and indirect contribution to the Bolivian economy (such as promoted international trade, information obtained, etc.) made by the "overflowing" passengers whose trip demand is satisfied by the construction of the new airport, and lastly the secondary and induced effects of the construction and operation of the new airport on the development of the regional economy. These benefits, however, were not calculated in the present analysis as they are difficult to quantify with reasonable degree of accuracy.

Of all the conceivable benefits of the new airport as discussed above, only the measurables are described item by item in further details hereunder.

(1) Benefits Resulting from the Imporved Service Level

The new airport, with its completely new and improved facilities as compared with those of the existing airport, will give its users the following benefits.

i) Better and faster baggage service resulting from the new and improved baggage handling facility

ii) Reduced travel time resulting from the establishment of new direct air routes.

iii) Increased aviation safety resulting from the new and improved navigational aid facilities

iv) Reduction in flight cost due to introduction of larger aircraft

v) Increase in comfort to passengers resulting from the relatively more comfortable accommodations in the passenger terminal, and elimination of inconvenience that are being experienced at the existing airport due to increasing flight movements and congestion in the passenger terminal.

Out of the quantifiable items of i), ii), and iv) above, calculation is made only on items i) and ii) that are considered to be the time saving benefits, with the following results.

1) Time saving benefit resulting from the new and improved baggage handling facility.

   At the existing airport of El Trompillo, domestic baggage claim is being conducted outdoors, requiring an average of 45 minutes after arrival of passengers at the airport. As the congestion increases, so does the average time required in baggage claim. At the new airport, on the other hand, baggage claim requires only 15 minutes on an average, representing a saving in time of at least 30 minutes. With the average time value of resident passenger estimated at US$2.00 per hour, total benefits for the projected resident air passengers under this item are calculated as shown in Table 4-3-3.

2) Benefit of reduced travel time brought by the direct air routes to be newly established.

   The 3,500 m runway of the new airport will permit establishment of direct routes and corresponding reduction in flight time as shown below.

| Direct Routes | Reduced Flight Time (hours) |
|---|---|
| Santa Cruz - Miami | 0.83 |
| Santa Cruz - Montevideo | 0.67 |
| Santa Cruz - New York | 4.58 |

   Total time saving benefits related to the projected resident passengers expected to fly on these direct routes are calculated as shown in Table 3-4-4.

(2) Benefits of Satisfied Trip Demand

As discussed in Section 4-2 above, the new airport is able to satisfy the potential trip demand of passengers expected to overflow from the existing airport in future.

Table 4-3-3 Benefits Resulting from Improved Service Level

(In Thousand US Dollars)

| Description of Benefits / Year | Time Saving in Baggage Claim | Reduced Flight Time Attributable to Direct Routes | Total |
|---|---|---|---|
| 1981 | 174 | 12 | 186 |
| 1982 | 194 | 13 | 207 |
| 1983 | 216 | 16 | 232 |
| 1984 | 240 | 18 | 258 |
| 1985 | 268 | 21 | 289 |
| 1986 | 296 | 25 | 321 |
| 1987 | 326 | 28 | 354 |
| 1988 | 360 | 32 | 392 |
| 1989 | 397 | 36 | 433 |
| 1990 | 439 | 41 | 480 |
| 1991 | 484 | 46 | 530 |
| 1992 | 534 | 53 | 587 |
| 1993 | 590 | 60 | 650 |
| 1994 | 652 | 68 | 720 |
| 1995 | 716 | 78 | 794 |
| 1996 | 771 | 86 | 857 |
| 1997 | 829 | 94 | 923 |
| 1998 | 873 | 104 | 997 |
| 1999 | 961 | 113 | 1,074 |
| 2000 | 1,035 | 125 | 1,160 |

It is considered appropriate to express the minimum value of the utility of satisfied trip demand, which would have been lost never being satisfied, in terms of the sum of the air fare and the airport user charges that individual passenger is thought to have been willing to pay for his potential trip. The said sum is considered to be an equivalent of the sum of the total operational revenues of the airport and of the total air fares collected by the airlines concerned, minus the airport user charges paid by the airlines to avoid double counting. The total value of the utility lost in the trip demand unsatisfied, of course, should be greater if the consumer's surplus is taken into account.

The component of this benefit represented by air fare amounts to US$106.00 and US$22.00 respectively for each resident international and domestic passenger.

The total benefits calculated under this item, including those represented by the airport user charges, are shown in Table 4-3-4. If consumer's surplus and benefits for foreign passengers were to be included in the calculation, the total benefits under this item would amount to more than double the figures shown in Table 4-3-4.

(3) Benefits Represented by the Saving in the Maintenance and Operation Cost of the Existing Airport

When the new airport is opened to traffic, there will be a saving in the maintenance and operation cost of the existing airport. Even if it is kept at the present service level, the existing airport will require minimum necessary enforcement and repair work on the runway and aprons as well as renewal of the obsolete navaids and lighting facilities in order to be able to continue functioning as an airport. Table 4-3-7 shows the expected annual expenditures of this nature calculated on the basis of the 1975 records of the existing airport of El Trompillo.

Table 4-3-4 Benefits of Satisfied Air Trip Demand

(In Thousand US Dollars)

| Year | Airport User Charges | Air Fares | | | Total |
|---|---|---|---|---|---|
| | | International | Domestic | Subtotal | |
| 1981 | - | - | - | - | - |
| 1982 | - | - | - | - | - |
| 1983 | - | - | - | - | - |
| 1984 | - | - | - | - | - |
| 1985 | 371 | 1,272 | 968 | 2,240 | 2,611 |
| 1986 | 741 | 2,438 | 1,936 | 4,374 | 5,115 |
| 1987 | 1,143 | 3,816 | 3,014 | 6,830 | 7,973 |
| 1988 | 1,592 | 5,300 | 4,180 | 9,480 | 11,072 |
| 1989 | 2,092 | 7,107 | 5,434 | 12,536 | 14,628 |
| 1990 | 2,676 | 9,010 | 6,864 | 15,858 | 18,534 |
| 1991 | 3,543 | 11,342 | 8,382 | 19,724 | 23,267 |
| 1992 | 4,265 | 13,886 | 10,076 | 23,962 | 28,227 |
| 1993 | 5,081 | 16,748 | 11,924 | 28,672 | 33,753 |
| 1994 | 5,994 | 20,140 | 13,948 | 34,088 | 40,082 |
| 1995 | 7,031 | 23,850 | 15,972 | 39,822 | 46,853 |
| 1996 | 7,858 | 27,030 | 17,710 | 44,740 | 52,5 8 |
| 1997 | 8,770 | 30,422 | 19,602 | 50,024 | 58,784 |
| 1998 | 9,759 | 34,238 | 21,604 | 58,842 | 68,601 |
| 1999 | 10,850 | 38,392 | 23,760 | 62,132 | 72,982 |
| 2000 | 12,035 | 42,930 | 26,026 | 68,956 | 80,991 |

Table 4-3-5 Projected Foreign and Resident Passengers at Viru Viru International Airport

(In thousands)

| Description / Year | International Services | | | Domestic Services | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Foreign Passengers | Resident Passengers | Total | Foreign Passengers | Resident Passengers | Total | Foreign Passengers | Resident Passengers | Total |
| 1981 | 79 | 44 | 115 | 34 | 303 | 337 | 105 | 347 | 452 |
| 1982 | 83 | 51 | 134 | 37 | 336 | 373 | 120 | 387 | 507 |
| 1983 | 97 | 60 | 157 | 41 | 372 | 413 | 138 | 432 | 570 |
| 1984 | 113 | 70 | 183 | 46 | 410 | 456 | 159 | 480 | 639 |
| 1985 | 133 | 81 | 214 | 51 | 454 | 505 | 184 | 535 | 719 |
| 1986 | 151 | 93 | 244 | 55 | 499 | 554 | 206 | 592 | 798 |
| 1987 | 172 | 105 | 277 | 61 | 547 | 608 | 233 | 652 | 885 |
| 1988 | 195 | 120 | 315 | 67 | 600 | 667 | 262 | 720 | 982 |
| 1989 | 223 | 136 | 359 | 73 | 658 | 731 | 296 | 794 | 1,090 |
| 1990 | 253 | 155 | 408 | 80 | 723 | 803 | 333 | 878 | 1,211 |
| 1991 | 288 | 176 | 464 | 88 | 791 | 879 | 376 | 967 | 1,343 |
| 1992 | 327 | 200 | 527 | 97 | 868 | 965 | 424 | 1,068 | 1,492 |
| 1993 | 372 | 228 | 600 | 106 | 952 | 1,058 | 478 | 1,180 | 1,658 |
| 1994 | 423 | 259 | 682 | 116 | 1,045 | 1,161 | 539 | 1,304 | 1,843 |
| 1995 | 481 | 295 | 776 | 126 | 1,137 | 1,263 | 607 | 1,432 | 2,039 |
| 1996 | 529 | 325 | 854 | 135 | 1,216 | 1,351 | 664 | 1,541 | 2,205 |
| 1997 | 582 | 357 | 939 | 145 | 1,301 | 1,446 | 727 | 1,658 | 2,385 |
| 1998 | 640 | 393 | 1,033 | 155 | 1,392 | 1,547 | 795 | 1,785 | 2,580 |
| 1999 | 704 | 432 | 1,136 | 166 | 1,490 | 1,656 | 870 | 1,922 | 2,792 |
| 2000 | 775 | 475 | 1,250 | 177 | 1,594 | 1,771 | 952 | 2,069 | 3,021 |

Table 4-3-6 Passengers Exceeding the Capacity of El Trompillo Airport

(In thousands)

| Description / Year | International Service | | | Domestic Services | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Foreign Passengers | Resident Passengers | Total | Foreign Passengers | Resident Passengers | Total | Foreign Passengers | Resident Passengers | Total |
| 1980 | - | - | - | - | - | - | - | - | - |
| 1981 | - | - | - | - | - | - | - | - | - |
| 1982 | - | - | - | - | - | - | - | - | - |
| 1983 | - | - | - | - | - | - | - | - | - |
| 1984 | - | - | - | - | - | - | - | - | - |
| 1985 | 19 | 12 | 31 | 5 | 44 | 49 | 24 | 56 | 80 |
| 1986 | 38 | 23 | 61 | 10 | 88 | 98 | 48 | 111 | 159 |
| 1987 | 58 | 36 | 94 | 15 | 137 | 152 | 73 | 173 | 246 |
| 1988 | 82 | 50 | 132 | 21 | 190 | 211 | 103 | 240 | 343 |
| 1989 | 109 | 67 | 176 | 28 | 247 | 275 | 137 | 314 | 451 |
| 1990 | 140 | 85 | 225 | 35 | 312 | 347 | 175 | 397 | 572 |
| 1991 | 174 | 107 | 281 | 42 | 381 | 423 | 216 | 488 | 704 |
| 1992 | 213 | 131 | 344 | 51 | 458 | 509 | 264 | 589 | 853 |
| 1993 | 259 | 158 | 417 | 60 | 542 | 602 | 319 | 700 | 1,019 |
| 1994 | 309 | 190 | 499 | 71 | 634 | 705 | 380 | 824 | 1,204 |
| 1995 | 368 | 225 | 593 | 81 | 726 | 807 | 449 | 951 | 1,400 |
| 1996 | 416 | 255 | 671 | 90 | 805 | 895 | 506 | 1,060 | 1,566 |
| 1997 | 469 | 287 | 756 | 99 | 891 | 990 | 568 | 1,178 | 1,746 |
| 1998 | 527 | 323 | 850 | 109 | 982 | 1,091 | 636 | 1,305 | 1,941 |
| 1999 | 591 | 362 | 953 | 120 | 1,080 | 1,200 | 711 | 1,442 | 2,153 |
| 2000 | 662 | 405 | 1,067 | 132 | 1,183 | 1,315 | 794 | 1,588 | 2,382 |

Table 4-3-1 Saving of Maintenance and Operation Cost of El Trompillo Airport

(In Thousand US Dollars)

| Year | Maintenance and Operation Cost | Cost of Investment in Reinforcement or Renewal of Facilities | Total |
|---|---|---|---|
| 1981 | 273 | 6,649 | 6,922 |
| 1982 | 278 | - | 278 |
| 1983 | 284 | - | 284 |
| 1984 | 290 | - | 290 |
| 1985 | 296 | - | 296 |
| 1986 | 301 | - | 301 |
| 1987 | 307 | - | 307 |
| 1988 | 314 | - | 314 |
| 1989 | 320 | - | 320 |
| 1990 | 326 | - | 326 |
| 1991 | 333 | 1,506 | 1,839 |
| 1992 | 339 | - | 339 |
| 1993 | 346 | - | 346 |
| 1994 | 353 | - | 353 |
| 1995 | 360 | - | 360 |
| 1996 | 367 | - | 367 |
| 1997 | 375 | - | 375 |
| 1998 | 382 | - | 382 |
| 1999 | 390 | - | 390 |
| 2000 | 398 | - | 398 |

(4) Benefits Represented by the Saving in the Cost of Constructing Road Tunnels

As stated in Subsection 1-2-2 of Chapter 1, the existing runway of El Trompillo Airport is intersected by the planned routes of the 3rd and the 4th Loop Roads.

In case of the continued use of the existing airport for scheduled commercial services, construction of the road tunnels as discussed in Section 3-3-2 of the preceding Chapter will be inevitable for the due accomplishment of the current urbanization program of the Santa Cruz City. On the other hand, in case the new airport is constructed, the existing runway at El Trompillo will be shortened to 1,000 m, and no construction of road tunnels will be required, resulting in a saving of the total cost as shown in Table 4-3-8.

Table 4-3-8 Road Tunnel Construction Cost

| Loop Roads | Construction Cost (Thousand US Dollars) | Expected Date of Completion |
|---|---|---|
| Third Loop-Inner Track (2 lanes) | 6,344 | 1980 |
| Third Loop-Outer Track (2 lanes) | 6,344 | 1985 |
| Fourth Loop (4 lanes) | 12,688 | 1990 |

(5) Benefits Represented by the Saving in the Cost of Countermeasures against Aircraft Noise

As stated in Subsection 1-2-2, in case of the continued use of the existing airport, countermeasures including compensation for the damages caused by aircraft noise will become necessary.

In accordance with the recommendations of ICAO Annex 16, the expected aircraft noise was calculated in terms of the WECPNL based on the future aircraft movements projected in Chapter 2 hereinabove. Fig. 4-3-1 shows the WECPNL contour expected in the year 2000.

In the absence of any established standards for aircraft noise-related compensation in Bolivia, the following statutory standards of compensation for damages caused by aircraft noise presently in effect in Japan have been applied in the present study.

| | |
|---|---|
| WECPNL 85-90 | Compensation of the costs of noise insulation work |
| WECPNL 90 and above | Compensation of the costs of house relocation |

Corresponding noise-affected areas are calculated using the city map in scale of 1/10,000, and the number of households existing in the respective areas is estimated based on the national census in 1976. Consequently, compensation for the households to be newly moving into the area is not taken into account in this calculation.

Table 4-3-9 shows the estimated cost of aircraft noise countermeasures calculated on the above basis. Since the Base Plan is unable to accommodate flight movement increases beyond the year 1984 as mentioned earlier, counter-noise costs will not be incurred beyond that year.

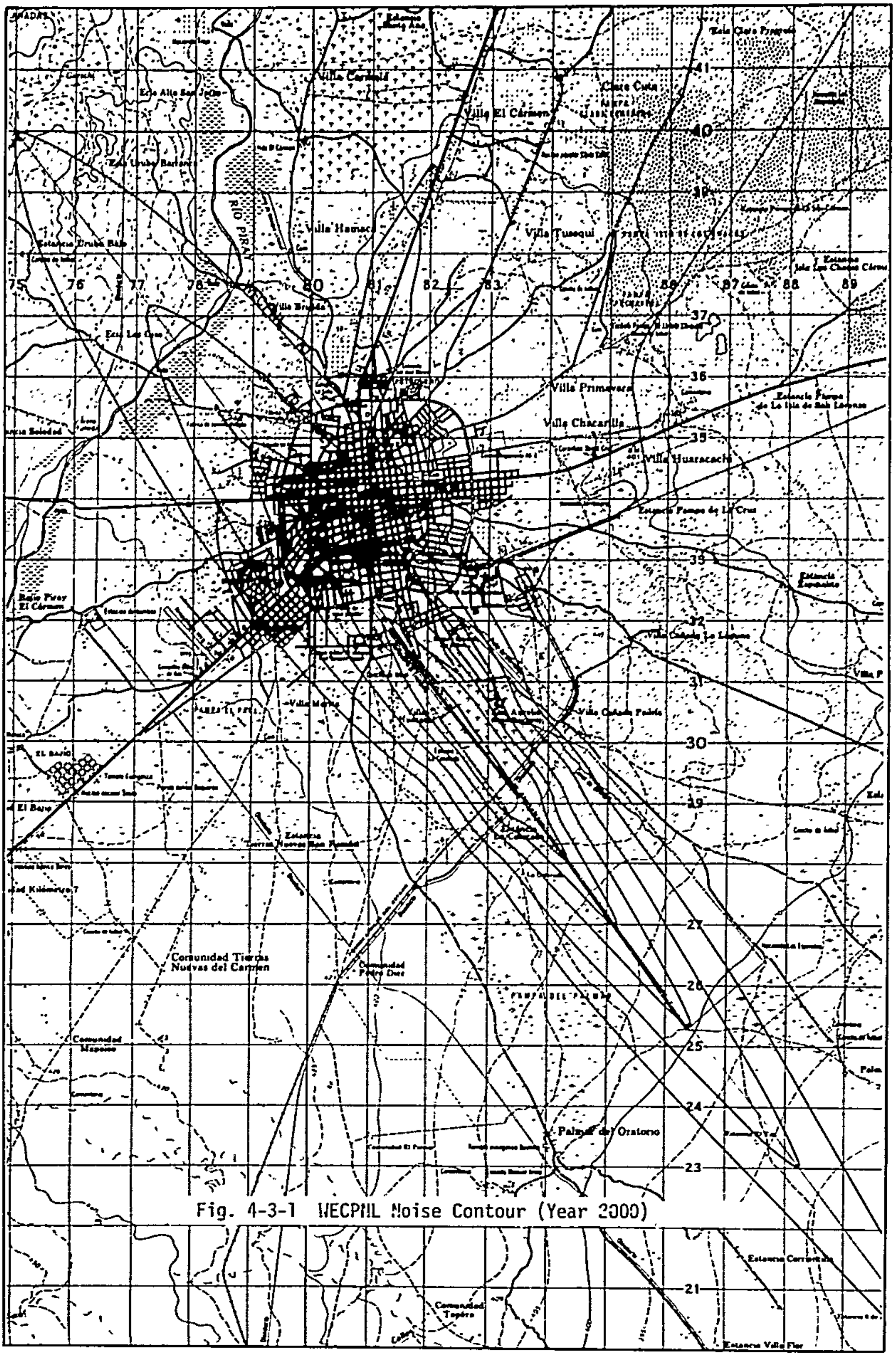


Fig. 4-3-1 WECPNL Noise Contour (Year 2000)

Table 4-3-9 Costs of Aircraft Noise Countermeasures

(In Thousand US Dollars)

| Costs \ Year | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Cost of Noise Insulation Work | 98,7000 | 143,350 | 781,900 | 1,650,700 |
| Cost of House Relocation | - | 296,050 | 895,950 | 1,801,500 |
| New Land Acquisition | - | 150,700 | 450,700 | 861,000 |
| House Construction | - | 70,000 | 220,000 | 510,000 |
| Rehabilitation of Lands after Relocation | - | 75,350 | 225,350 | 430,500 |
| Total | 98,700 | 439,400 | 1,677,850 | 3,452,200 |

Note 1 : In the Base Plan costs of countermeasures are calculated up to 1985.

Note 2 : The annual costs of countermeasures are calculated by equally distributing the cost estimated for each development stage over the 5 component years.

(6) Benefits Represented by the Saving in the Cost of Compensation for Damages Caused by Aircraft Accidents

As mentioned in Subsection 1-2-2 of Chapter 1, in case of the continued use of the existing airport which is completely surrounded by urban areas of Santa Cruz City, there always is a possibility of aircraft crashing into the densely populated area causing serious damages such as those mentioned earlier, and this was one of the major motives for the proposed construction of the new airport in Viru Viru to replace the existing El Trompillo Airport.

The cost of compensation for damages caused by aircraft accident varies according to the magnitude and the degree of seriousness of each accident. In the case of the above mentioned accident, the District Court of Miami, USA, in August 1977 ordered compensation payments of approximately US$5 million in total to the victims or their families. This decision will be referred to as precedent in future compensation claims of a similar nature.

It is difficult to estimate the probability of occurance of such a disastrous accident. However, considering the actual records showing 3 accidents in every 1,000 flight movements registered at El Trompillo for the recent three years as mentioned in Subsection 1-2-2, it may not be too much off the mark to assume that an accident of the magnitude as mentioned above would occur once in 10 years. Based on this thinking, the saving under this item is estimated as shown in Table 4-3-10.

### 4-3-3 Results of Cost-Benefit Calculation

Table 4-3-10 shows the results of the cost-benefit calculation made on the basis of the costs and benefits of the New Airport Construction Plan as calculated in 4-3-1 and 4-3-2 above. The resultant Economic Internal Rate of Return of 15.0% is considered large enough to assert that the New Airport Construction Plan will bring about sufficient economic benefit from the view point of the national economy of Bolivia.

Furthermore, it is well expected that the actual benefit would be even greater if such uncalculated benefits as mentioned in Subsection 4-3-2 were to be included in the calculation.

Table 4-3-10 Cost - Benefit Comparison of Viru Viru Airport Construction Plan (With Benefits Identified through Economic Comparison of New Airport Construction vs. Unexpanded Existing Airport)

(In Thousand US Dollars)

| Description / Year | Costs | | | Benefits | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | New Airport Construction Cost | New Airport Maintenance and Operation Cost | Total | Time Saving - Improved Service Level | Increased Passenger Benefit - Satisfied Trip Demand | Existing Airport Maintenance Cost Saved | Road Tunnel Construction Cost Saved | Counter Noise Cost Saved | Accident Compensation Cost Saved | Total |
| 1978 | 13,517 | - | 13,517 | - | - | - | - | - | - | - |
| 1979 | 28,717 | - | 28,717 | - | - | - | 6,344 | - | - | 6,344 |
| 1980 | 30,231 | - | 30,231 | - | - | - | - | - | - | - |
| 1981 | - | 1,541 | 1,541 | 186 | - | 6,922 | - | 20 | - | 7,128 |
| 1982 | - | 1,547 | 1,547 | 207 | - | 278 | - | 20 | - | 505 |
| 1983 | - | 1,557 | 1,557 | 232 | - | 284 | - | 20 | - | 536 |
| 1984 | - | 1,561 | 1,561 | 258 | - | 290 | 6,344 | 20 | - | 6,912 |
| 1985 | - | 1,567 | 1,567 | 289 | 2,611 | 296 | - | 20 | - | 3,216 |
| 1986 | - | 1,575 | 1,575 | 321 | 5,115 | 301 | - | - | 5,000 | 11,778 |
| 1987 | - | 1,582 | 1,582 | 354 | 7,973 | 307 | - | - | - | 8,634 |
| 1988 | - | 1,589 | 1,589 | 392 | 11,072 | 314 | - | - | - | 11,788 |
| 1989 | 13,608 | 1,596 | 15,204 | 433 | 14,628 | 320 | 6,344 | - | - | 21,725 |
| 1990 | 19,544 | 1,605 | 21,149 | 480 | 15,858 | 326 | 6,344 | - | - | 25,700 |
| 1991 | - | 1,967 | 1,967 | 530 | 18,534 | 1,839 | - | - | - | 25,636 |
| 1992 | - | 1,975 | 1,975 | 587 | 23,267 | 339 | - | - | - | 29,153 |
| 1993 | - | 1,982 | 1,982 | 650 | 28,227 | 346 | - | - | - | 34,749 |
| 1994 | - | 1,990 | 1,990 | 720 | 40,082 | 353 | - | - | - | 41,155 |
| 1995 | - | 1,999 | 1,999 | 794 | 46,853 | 360 | - | - | - | 48,007 |
| 1996 | - | 2,008 | 2,008 | 857 | 52,598 | 367 | - | - | 5,000 | 58,822 |
| 1997 | - | 2,017 | 2,017 | 923 | 58,794 | 375 | - | - | - | 60,092 |
| 1998 | - | 2,026 | 2,026 | 997 | 68,601 | 382 | - | - | - | 69,980 |
| 1999 | - | 2,035 | 2,035 | 1,074 | 72,982 | 390 | - | - | - | 74,446 |
| 2000 | - | 2,044 | 2,044 | 1,160 | 80,991 | 398 | - | - | - | 82,549 |
| Total | 105,617 | 35,763 | 141,380 | 11,444 | 566,071 | 14,787 | 25,376 | 100 | 10,000 | 624,804 |

## 4-4 DETERMINATION OF OPTIMUM DEVELOPMENT PLAN (ECONOMIC COMPARISON OF NEW AIRPORT CONSTRUCTION PLAN VERSUS EXISTING AIRPORT EXPANSION PLAN)

Having ascertained, in the preceding Section 4-3, the economic significance of the New Airport Construction in Viru Viru, the present economic analysis now proceeds to its second step to examine whether the proposed development plan is truly the best of all practicable alternatives. To that end, an economic comparison was made between the said Plan and the Existing Airport Expansion Plan which has been recognized in the present study to be the only practicable, and hence, the second best alternative. Since the two plans are assumed to provide services of an identical level as already established in the foregoing, the benefits to be brought about by these two plans are naturally regarded to be equal. As a consequence, the comparison of the two plans was made solely in respect of the costs involved in each, after discounting them to the present values.

### 4-4-1 Cost of the New Airport Construction Plan

(1) Airport Construction Cost

See Paragraph 4-3-1 (1).

(2) Airport Maintenance and Operation Cost

See Paragraph 4-3-1 (2).

### 4-4-2 Cost of the Existing Airport Expansion Plan

(1) Airport Construction Cost

Annual investment costs including physical contingency are as shown in Table 4-4-1.

Table 4-4-1 Annual Investment Costs of El Trompillo Airport Expansion Plan in 2-Stage Construction

(In Thousand US Dollars)

| Year | Cost |
|---|---|
| 1978 | 27,410 |
| 1979 | 28,281 |
| 1980 | 27,649 |
| 1981 | - |
| 1982 | - |
| 1983 | - |
| 1984 | - |
| 1985 | - |
| 1986 | - |
| 1987 | - |
| 1988 | - |
| 1989 | 9,961 |
| 1990 | 14,145 |
| 1991 | - |
| 1992 | - |
| 1993 | - |
| 1994 | - |
| 1995 | - |
| Total | 107,446 |

(2) Airport Maintenance and Operation Cost

Maintenance and operation costs of the El Trompillo Airport after expansion are estimated in the same manner as mentioned in Paragraph 4-3-1 (2), with the results as shown in Table 4-4-2.

Table 4-4-2 Maintenance and Operation Costs of El Trompillo Airport Expansion Plan in 2-Stage Construction

(In Thousand US Dollars)

| Year | Cost |
|---|---|
| 1981 | 1,414 |
| 1982 | 1,420 |
| 1983 | 1,427 |
| 1984 | 1,434 |
| 1985 | 1,440 |
| 1986 | 1,448 |
| 1987 | 1,455 |
| 1988 | 1,462 |
| 1989 | 1,469 |
| 1990 | 1,478 |
| 1991 | 1,725 |
| 1992 | 1,733 |
| 1993 | 1,740 |
| 1994 | 1,749 |
| 1995 | 1,757 |
| 1996 | 1,766 |
| 1997 | 1,775 |
| 1998 | 1,784 |
| 1999 | 1,793 |
| 2000 | 1,802 |

(3) Road Tunnel Construction Cost

See 4-3-2 (4).

(4) Cost of Aircraft Noise Countermeasures

See 4-3-2 (5).

(5) Cost of Aircraft Accident Compensation

See 4-3-2 (6)

### 4-4-3 Comparison of Net Costs

The various costs involved in the two alternative plans as identified in the foregoing are discounted to the present value at an annual rate of 12% which is considered to represent the time preference rate of Bolivian economy. Table 4-4-3 shows the resultant net costs along with the corresponding annual costs for the 2 plans in the case of 2-stage construction.

Tabla 4-4-3 Table 4-4-3 Cost Comparison of Viru Viru Airport Construction Plan and El Trompillo Airport Expansion Plan

(In Thousand US Dollars)

| Description / Year | Costs of Viru Viru Airport Construction | | | Cost of El Trompillo Airport Expansion | | | | | | Net Cost Discounted at 12% per Annum | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Construction | Maintenance | Total | Construction | Maintenance | Tunnels | Countermeasures for Aircraft Noise | Countermeasures for Aircraft Accidents | Total | New Airport | Existing Airport Expansion |
| 1978 | 13,517 | | 37,217 | 12,080 | | | | | 27,410 | 13,517 | 12,080 |
| 1979 | 28,717 | | 28,717 | 28,281 | | 6,344 | | | 34,625 | 25,644 | 30,920 |
| 1980 | 30,231 | | 30,231 | 27,649 | | | | | 27,649 | 24,094 | 22,036 |
| 1981 | | 1,541 | 1,541 | | 1,414 | | 20 | | 1,434 | 1,097 | 1,021 |
| 1982 | | 1,547 | 1,547 | | 1,420 | | 20 | | 1,440 | 984 | 916 |
| 1983 | | 1,557 | 1,557 | | 1,427 | | 20 | | 1,447 | 883 | 820 |
| 1984 | | 1,561 | 1,561 | | 1,434 | 6,344 | 20 | | 7,798 | 791 | 3,953 |
| 1985 | | 1,567 | 1,567 | | 1,440 | | 20 | | 1,460 | 710 | 661 |
| 1986 | | 1,575 | 1,575 | | 1,448 | | 88 | 5,000 | 6,536 | 636 | 2,641 |
| 1987 | | 1,582 | 1,582 | | 1,455 | | 88 | | 1,543 | 571 | 557 |
| 1988 | | 1,589 | 1,589 | | 1,462 | | 88 | | 1,550 | 512 | 499 |
| 1989 | 13,608 | 1,596 | 15,204 | 9,961 | 1,469 | 6,344 | 88 | | 17,862 | 4,364 | 5,126 |
| 1990 | 19,544 | 1,605 | 21,149 | 14,145 | 1,478 | 6,344 | 88 | | 22,055 | 5,435 | 5,668 |
| 1991 | | 1,967 | 1,967 | | 1,725 | | 336 | | 2,061 | 450 | 472 |
| 1992 | | 1,975 | 1,975 | | 1,733 | | 336 | | 2,069 | 405 | 424 |
| 1993 | | 1,982 | 1,982 | | 1,740 | | 336 | | 2,076 | 363 | 380 |
| 1994 | | 1,990 | 1,990 | | 1,749 | | 336 | | 2,085 | 324 | 340 |
| 1995 | | 1,999 | 1,999 | | 1,757 | | 336 | | 2,093 | 292 | 306 |
| 1996 | | 2,008 | 2,008 | | 1,766 | | 691 | 5,000 | 7,457 | 261 | 969 |
| 1997 | | 2,017 | 2,017 | | 1,775 | | 691 | | 2,466 | 234 | 286 |
| 1998 | | 2,026 | 2,026 | | 1,784 | | 691 | | 2,475 | 211 | 257 |
| 1999 | | 2,035 | 2,035 | | 1,793 | | 691 | | 2,484 | 189 | 231 |
| 2000 | | 2,044 | 2,044 | | 1,802 | | 691 | | 2,493 | 170 | 207 |
| Total | 105,617 | 35,763 | 141,380 | 92,116 | 32,071 | 25,376 | 5,675 | 10,000 | 165,238 | 82,137 | 90,700 |

The results of the comparison of the net costs of the two plans are summarized as follows:

| | | |
|---|---|---|
| Net Cost of the Viru Viru Airport Construction in 2 Stages | (A) | US$82,310,000 |
| Net Cost of the El Trompillo Airport Expansion in 2 stages | (B) | US$90,700,000 |
| Difference in the Net Costs | (B - A) | US$8,390,000 |

As seen above, the difference between the total net costs of the two plans for the 20 year period of the project life amounts to more than US$8 million in favor of the New Airport Construction Plan, as compared with the Expansion Plan which is recognized to be the second best alternative. Consequently the New Airport Construction Plan may well be termed the most advantageous of all comparable alternatives that could provide services of an equal level.

In the foregoing economic calculation, the cost, or the value, of the land required for the airport development is not taken into account, since the acquisition of land is interpreted, from the view points of national economy, merely as a transfer of its ownership, without incurring any cost nor causing any variation in its value.

If, however, viewed from financial aspects, i.e., speaking in terms of actual expenditures, the acquisition of land does incur cost. Assuming on the unit prices of US$0.2/m$^2$(*) for the Viru Viru site and that of US$25/m$^2$(*) for the urban site of El Trompillo, the necessary land acquisition cost amounts to US$5,000,000 in the case of the new airport. As for the El Trompillo Airport, acquisition cost of the land needed for the expansion of the airport premises alone amounts to US$43,000,000, requiring US$38,000,000 more than in the case of the New Airport Construction Plan.

(*) Based on the results of land unit price survey by Comité Departamental de Obras Públicas de Santa Cruz (Public Work Committe of Santa Cruz)

In addition to the above, comparison is made between the costs incurred in the cases of implementation in 2 stages and 4 stages in respect of the New Airport Construction Plan. The net costs of both cases obtained with a discount rate of 12% per annum compare as follows:

| | | |
|---|---|---|
| Net Cost of 2-stage construction | (A) | US$82,310,000 |
| Net Cost of 4-stage construction | (B) | US$76,005,000 |
| Difference in the Net Costs | (B - A) | ∇US$6,305,000 |

# 5. FINANCIAL ANALYSIS

# 5. FINANCIAL ANALYSIS

In this Chapter an analysis is made to examine the financial viability of the proposed project for the construction of the new Santa Cruz- Viru Viru Airport, on the basis of the results of the review, also to be made herein, of the airport tariff structure currently in effect in Bolivia. For the purpose of the present analysis, the New Santa Cruz - Viru Viru Airport is regarded to be a financially autonomous public entity.

## 5-1 REVIEW OF CURRENT TARIFF STRUCTURE AND PROJECTION OF OPERATING REVENUE OF NEW AIRPORT

The current tariff structure of AASANA comprises as follows:

1. Charges for Landing, Airfield Lighting, and for Apron Parking
2. Charges for Navigational Aids and Enroute Service Facilities
3. Charges for Message Transmission
4. Passenger Head Tax
5. Airport Entrance and Automobile Parking Fees
6. Concession Fees

For quite some time in the past the AASANA's airport charges were kept at a low level due to the aviation promotion policy of the Government of Bolivia, until 1975 when a revision was made including a 60% raise in landing fee in international service, bringing the overall charges level of Bolivia close to that of the average in South American countries.

For example, the current landing fee of AASANA in international service compares with those of the neighboring countries as shown in Table 5-1-1.

Table 5-1-1 Comparison of Landing Fees in South American Countries

(In US Dollars)

| Country | DC-8-62 (152t) | B747-200 (352t) |
|---|---|---|
| Argentine | 570 | 1,590 |
| Colombia | 547 | 1,267 |
| Chile | 486 | 1,114 |
| Bolivia | 464 | 1,074 |
| Venezuela | 354 | 821 |
| Brasil | 322 | 732 |
| Ecuador | 291 | 528 |
| Average | 433 | 1,018 |

Note) Above figures show daytime landing fees at principal international airports of each country.

Source: International Civil Aviation Organization "Manual of Airport and Air Navigation Facility Tariffs, 1976 Edition".

Table 5-1-2 shows the expected annual operating revenues of the New Santa Cruz - Viru Viru Airport, calculated on the basis of the current airport charges and the projected air transport demand at the said airport.

Table 5-1-2 Expected Operating Revenues of Viru Viru Airport
(Based on the Current Level of Airport Tariffs)

(In Thousand US Dollars)

| Year \ Tariffs | Landing | Airfield Lighting | Aircraft Parking | Passenger Head Tax | Airport Admis-sion | Conces-sionaire | Message Transmis-sion | Navi-gational Aids and En-Route Service | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 651 | 59 | 195 | 372 | 45 | 811 | 18 | 41 | 2,192 |
| 1982 | 747 | 67 | 224 | 428 | 51 | 811 | 19 | 45 | 2,392 |
| 1983 | 908 | 82 | 272 | 496 | 57 | 811 | 21 | 49 | 2,696 |
| 1984 | 1,061 | 95 | 318 | 572 | 64 | 811 | 23 | 55 | 2,999 |
| 1985 | 1,234 | 111 | 370 | 661 | 72 | 811 | 25 | 61 | 3,345 |
| 1986 | 1,434 | 129 | 430 | 749 | 80 | 811 | 25 | 64 | 3,722 |
| 1987 | 1,632 | 147 | 489 | 845 | 89 | 811 | 27 | 70 | 4,110 |
| 1988 | 1,863 | 168 | 559 | 954 | 98 | 811 | 30 | 78 | 4,561 |
| 1989 | 2,113 | 190 | 634 | 1,080 | 109 | 811 | 32 | 85 | 5,054 |
| 1990 | 2,436 | 219 | 731 | 1,221 | 121 | 811 | 36 | 94 | 5,669 |
| 1991 | 2,742 | 247 | 823 | 1,380 | 134 | 1,292 | 39 | 104 | 6,761 |
| 1992 | 3,094 | 278 | 928 | 1,559 | 149 | 1,292 | 43 | 114 | 7,457 |
| 1993 | 3,500 | 315 | 1,050 | 1,765 | 166 | 1,292 | 47 | 126 | 8,261 |
| 1994 | 3,967 | 357 | 1,190 | 1,998 | 184 | 1,292 | 52 | 139 | 9,179 |
| 1995 | 4,511 | 406 | 1,353 | 2,256 | 204 | 1,292 | 58 | 154 | 10,234 |
| 1996 | 4,931 | 444 | 1,479 | 2,473 | 221 | 1,292 | 62 | 166 | 11,068 |
| 1997 | 5,392 | 485 | 1,618 | 2,709 | 239 | 1,292 | 67 | 179 | 11,981 |
| 1998 | 5,894 | 530 | 1,768 | 2,969 | 258 | 1,292 | 73 | 193 | 12,977 |
| 1999 | 6,446 | 580 | 1,934 | 3,254 | 279 | 1,292 | 79 | 208 | 14,072 |
| 2000 | 7,051 | 635 | 2,115 | 3,568 | 302 | 1,292 | 85 | 225 | 15,273 |

## 5-2 CALCULATION OF FINANCIAL INTERNAL RATE OF RETURN

The Financial Internal Rate of Return of the subject project was calculated on the basis of the expected operating revenues of the new airport as projected in the preceding Section, as well as of the investment costs of construction and the maintenance and operation costs as calculated in Chapter 4.

Table 5-2-1 and 5-2-2 show the detailed cashflow in the cases of 2-stage and 4-stage construction respectively during the project life of 20 years along with the anticipated annual investments in the cases of: [I] excluding contingencies; [II] including physical contingency; and [III] including both physical and price contingencies. Financial Internal Rate of Return calculated with the investments including the physical contingency amounts to the very low figures as shown below:

| | Financial Internal Rate of Return |
|---|---|
| 2-stage construction | 0.15 % |
| 4-stage construction | 0.28 % |

It is almost impossible to predict at this time whether or not financial independence will be required of the New Santa Cruz Airport in Viru Viru, which is assumed to be established as a public entity, for it depends entirely on the policy of the national government. Generally speaking, however, it is desirable for any public entity to be financially independent to a certain extent at least, considering that to maintain sound financial status at all times helps ensure managerial efficiency. To that end, an upward adjustment of airport charges could certainly be an effective measure, and the current charges structure of AASANA is believed to leave some room for such adjustments.

In this connection, calculation has been made in an attempt to find out the rates of increase in airport tariffs that would yield sufficient revenue for achieving the Financial Internal Rate of Return in 20 years of 4% and 7% respectively, with the following results showing an example of possible tariff increase schemes for each case.

(1) To attain Financial IRR of 4% (Scheme A)

| | Annual Increase | Cumulative Increase |
|---|---|---|
| 1981 | 20 | 20 |
| 1983 | 10 | 32 |
| 1985 | 10 | 45 |

(2) To attain Financial IRR of 7% (Scheme B)

| | Annual Increase | Cumulative Increase |
|---|---|---|
| 1977 | 20 | 20 |
| 1979 | 20 | 44 |
| 1980 | 10 | 58 |
| 1982 | 10 | 74 |
| 1984 | 10 | 92 |

Summarized below are the results of calculation of the Financial Internal Rate of Return made on the basis of the total cashflow through the year 2000, with the initial as well as the additional investments including the physical contingency, and with the expected revenues under Schemes A and B above.

| | 2-Stage Construction | 4-Stage Construction |
|---|---|---|
| At Current Charges Level | 0.15% | 0.28% |
| At Charges Level under Scheme A | 4.13% | 4.62% |
| At Charges Level under Scheme B | 7.17% | 8.03% |

Actual scheme to be adopted for the revision of the AASANA's tariff structure will have to be decided taking into consideration all relevant factors, including, among other things, the interest rate of the available funds to finance the project, as well as the degree of financial self-sufficiency expected of the managerial organization of the New Santa Cruz-Viru Viru International Airport.

Table 5-2-1 Financial Analysis of New Santa Cruz - Viru Viru International Airport (Project in 2-stage Construction)

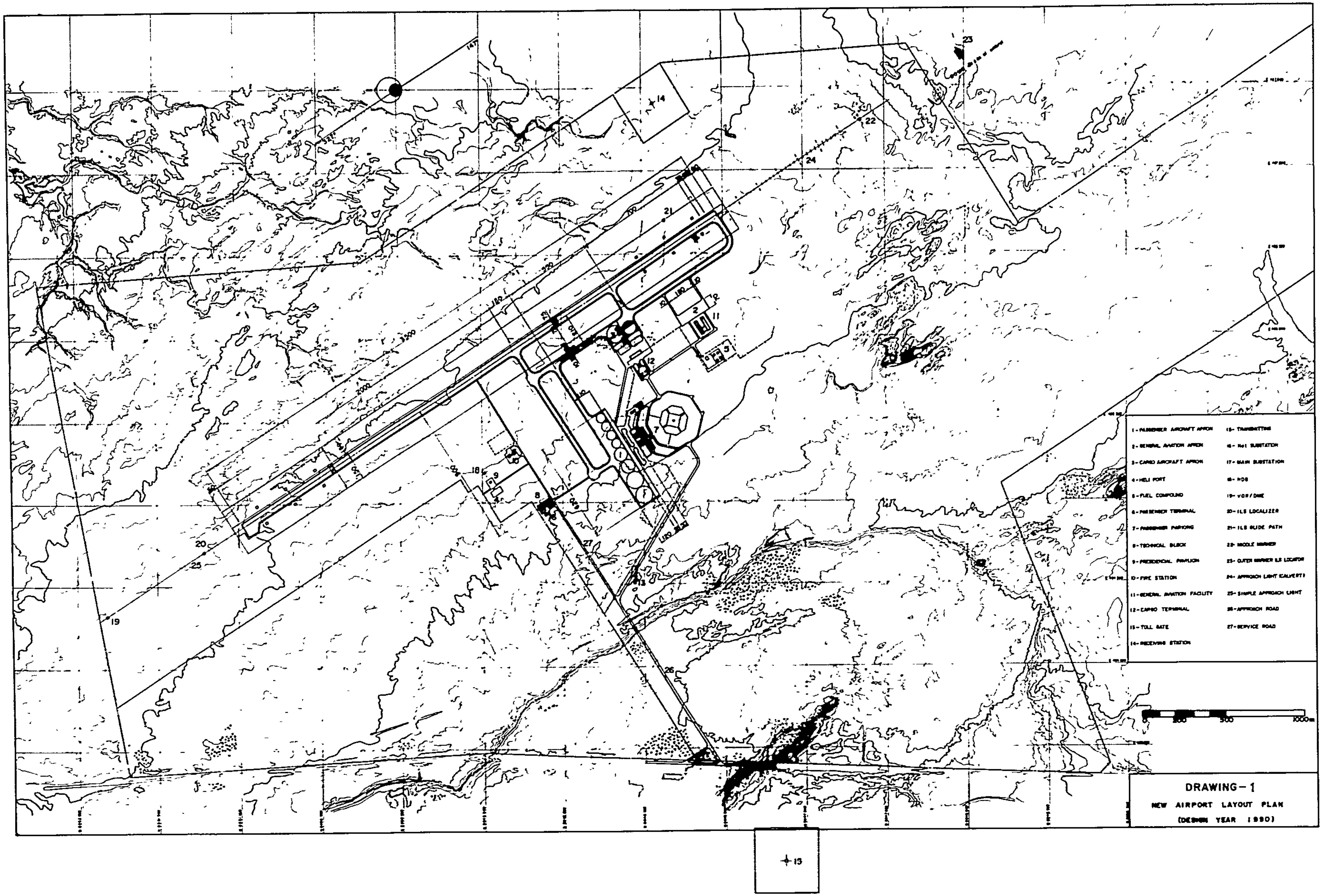
(In Thousand US Dollars)

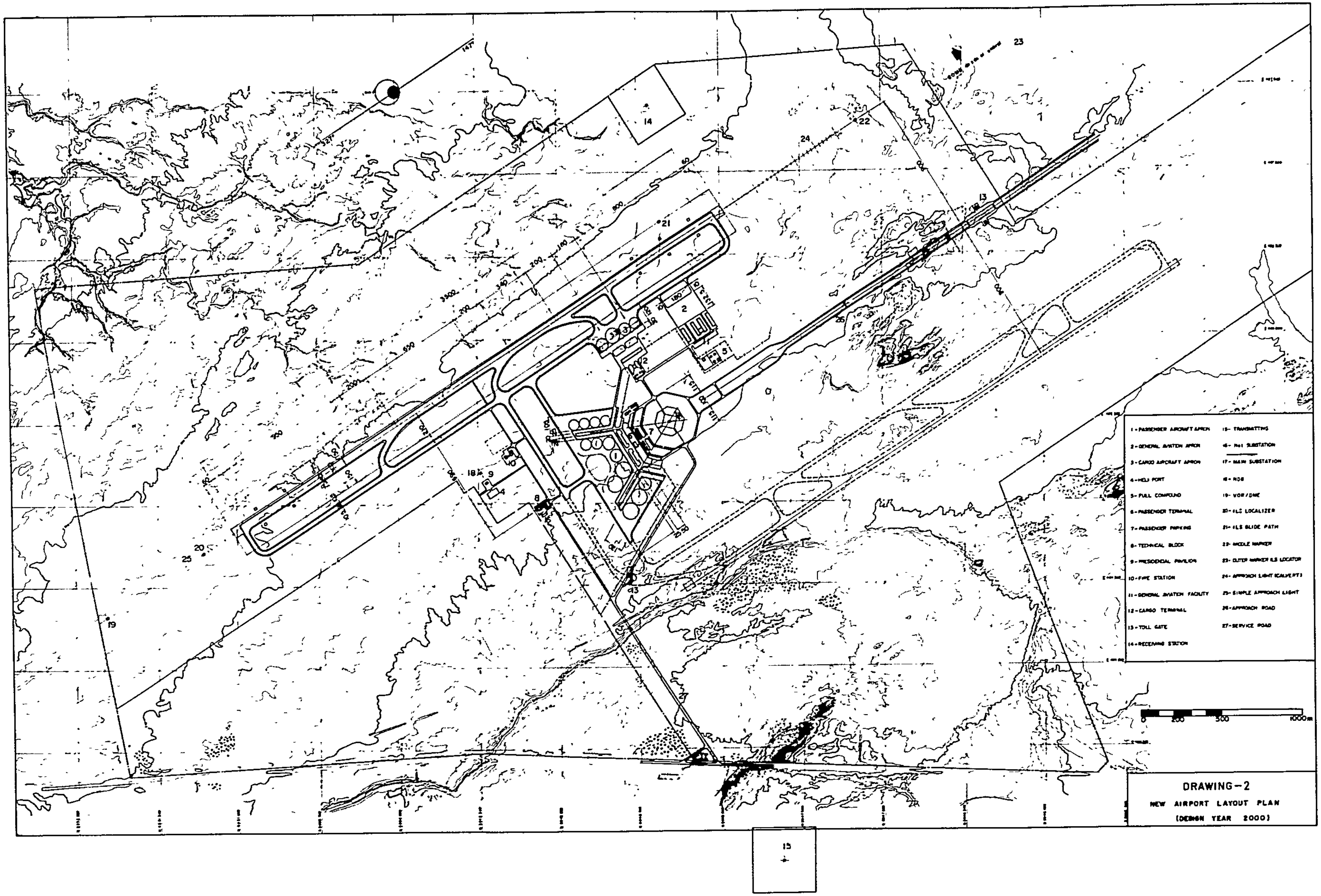
| Description / Year | Investment | | | Expenditure | Revenue | | | Revenue - Expenditure | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Contingencies not Included [I] | Physical Contingency Included [II] | Physical and Price Contingencies Included [III] | Maintenance and Operation Cost | Current Charges Level | Modified Charges Under Scheme A | Modified Charges Under Scheme B | Current Charges Level | Modified Charges Under Scheme A | Modified Charges Under Scheme B |
| 1978 | (12,288) | ( 13,517) | ( 14,328) | | | | | | | |
| 1979 | (26,106) | ( 28,717) | ( 32,266) | | | | | | | |
| 1980 | (27,483) | ( 30,234) | ( 36,005) | | | | | | | |
| 1981 | | | | 1,541 | 2,191 | 2,629 | 3,462 | 650 | 1,088 | 1,921 |
| 1982 | | | | 1,547 | 2,392 | 2,870 | 4,162 | 845 | 1,323 | 2,615 |
| 1983 | | | | 1,557 | 2,696 | 3,559 | 4,691 | 1,139 | 2,002 | 3,134 |
| 1984 | | | | 1,561 | 2,999 | 3,959 | 5,758 | 1,438 | 2,398 | 4,197 |
| 1985 | | | | 1,567 | 3,344 | 4,855 | 6,420 | 1,777 | 3,288 | 4,853 |
| 1986 | | | | 1,575 | 3,722 | 5,404 | 7,146 | 2,147 | 3,829 | 5,571 |
| 1987 | | | | 1,582 | 4,110 | 5,968 | 7,891 | 2,528 | 4,386 | 6,309 |
| 1988 | | | | 1,589 | 4,560 | 6,621 | 8,755 | 2,971 | 5,032 | 7,166 |
| 1989 | (12,371) | ( 13,608) | ( 26,130) | 1,596 | 5,055 | 7,340 | 9,706 | 3,459 | 5,744 | 8,110 |
| 1990 | (18,325) | ( 20,159) | ( 40,920) | 1,605 | 5,669 | 8,231 | 10,884 | 4,064 | 6,626 | 9,279 |
| 1991 | | | | 1,967 | 6,761 | 9,817 | 12,981 | 4,794 | 7,850 | 11,014 |
| 1992 | | | | 1,975 | 7,457 | 10,828 | 14,317 | 5,482 | 8,853 | 12,342 |
| 1993 | | | | 1,982 | 8,261 | 11,995 | 15,861 | 6,279 | 10,013 | 13,879 |
| 1994 | | | | 1,990 | 9,179 | 13,328 | 17,624 | 7,189 | 11,338 | 15,634 |
| 1995 | | | | 1,999 | 10,234 | 14,860 | 19,649 | 8,235 | 12,861 | 17,650 |
| 1996 | | | | 2,008 | 11,068 | 16,071 | 21,251 | 9,060 | 14,063 | 19,243 |
| 1997 | | | | 2,017 | 11,981 | 17,396 | 23,004 | 9,964 | 15,379 | 20,987 |
| 1998 | | | | 2,026 | 12,977 | 18,843 | 24,916 | 10,951 | 16,817 | 22,890 |
| 1999 | | | | 2,035 | 14,072 | 20,433 | 27,018 | 12,037 | 18,398 | 24,983 |
| 2000 | | | | 2,044 | 15,273 | 22,176 | 29,324 | 13,229 | 20,132 | 27,280 |
| Total | (96,590) | (106,251) | (148,751) | 35,763 | 144,001 | 207,183 | 274,820 | 108,238 | 171,420 | 239,057 |

Table 5-2-2 Financial Analysis of New Santa Cruz - Viru Viru International Airport (Project in 4-stage Construction)

(In Thousand US Dollars)

| Description / Year | Investment | | | Expenditure | Revenue | | | Revenue - Expenditure | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Contingencies not Included [I] | Physical Contingency Included [II] | Physical and Price Contingencies Included [III] | Maintenance and Operation Cost | Current Charges Level | Modified Charges Under Scheme A | Modified Charges Under Scheme B | Current Charges Level | Modified Charges Under Scheme A | Modified Charges Under Scheme B |
| 1978 | (10,546) | ( 11,601) | ( 12,234) | | | | | | | |
| 1979 | (23,118) | ( 25,430) | ( 28,274) | | | | | | | |
| 1980 | (23,406) | ( 25,746) | ( 31,025) | | | | | | | |
| 1981 | | | | 1,462 | 2,191 | 2,629 | 3,462 | 729 | 1,167 | 2,000 |
| 1982 | | | | 1,468 | 2,392 | 2,870 | 4,162 | 924 | 1,402 | 2,694 |
| 1983 | | | | 1,475 | 2,696 | 3,559 | 4,691 | 1,221 | 2,084 | 3,216 |
| 1984 | ( 2,290) | ( 2,519) | ( 3,673) | 1,482 | 2,999 | 3,959 | 5,758 | 1,517 | 2,477 | 4,276 |
| 1985 | ( 6,516) | ( 7,168) | ( 11,539) | 1,488 | 3,344 | 4,855 | 6,420 | 1,856 | 3,367 | 4,932 |
| 1986 | | | | 1,575 | 3,722 | 5,404 | 7,146 | 2,147 | 3,829 | 5,571 |
| 1987 | | | | 1,582 | 4,110 | 5,968 | 7,891 | 2,528 | 4,386 | 6,309 |
| 1988 | | | | 1,589 | 4,560 | 6,621 | 8,755 | 2,971 | 5,032 | 7,166 |
| 1989 | ( 3,054) | ( 3,359) | ( 6,450) | 1,596 | 5,055 | 7,340 | 9,706 | 3,459 | 5,744 | 8,110 |
| 1990 | (12,773) | ( 14,050) | ( 30,276) | 1,605 | 5,669 | 8,231 | 10,884 | 4,064 | 6,626 | 9,279 |
| 1991 | | | | 1,798 | 6,761 | 9,817 | 12,981 | 4,963 | 8,019 | 11,183 |
| 1992 | | | | 1,806 | 7,457 | 10,828 | 14,317 | 5,651 | 9,022 | 12,511 |
| 1993 | | | | 1,813 | 8,261 | 11,995 | 15,861 | 6,448 | 10,182 | 14,048 |
| 1994 | ( 2,755) | ( 3,031) | ( 7,695) | 1,822 | 9,179 | 13,328 | 17,624 | 7,357 | 11,506 | 15,802 |
| 1995 | (11,556) | ( 12,711) | ( 36,748) | 1,830 | 10,234 | 14,860 | 19,649 | 8,404 | 13,030 | 17,819 |
| 1996 | | | | 2,008 | 11,068 | 16,071 | 21,251 | 9,060 | 14,063 | 19,243 |
| 1997 | | | | 2,017 | 11,981 | 17,396 | 23,004 | 9,964 | 15,379 | 20,987 |
| 1998 | | | | 2,026 | 12,977 | 18,843 | 24,916 | 10,951 | 16,817 | 22,890 |
| 1999 | | | | 2,035 | 14,072 | 20,433 | 27,018 | 12,037 | 18,398 | 24,983 |
| 2000 | | | | 2,044 | 15,273 | 22,176 | 29,324 | 13,229 | 20,132 | 27,280 |
| Total | (96,014) | (105,615) | (167,914) | 34,521 | 144,001 | 207,183 | 274,820 | 109,480 | 172,662 | 240,299 |


1 - PASSENGER AIRCRAFT APRON
2 - GENERAL AVIATION APRON
3 - CARGO AIRCRAFT APRON
4 - HELI PORT
5 - FUEL COMPOUND
6 - PASSENGER TERMINAL
7 - PASSENGER PARKING
8 - TECHNICAL BLOCK
9 - PRESIDENTIAL PAVILION
10 - FIRE STATION
11 - GENERAL AVIATION FACILITY
12 - CARGO TERMINAL
13 - TOLL GATE
14 - RECEIVING STATION
15 - TRANSMITTING
16 - No1 SUBSTATION
17 - MAIN SUBSTATION
19 - VOR / DME
20 - ILS LOCALIZER
21 - ILS GLIDE PATH
22 - MIDDLE MARKER
23 - OUTER MARKER ILS LOCATOR
24 - APPROACH LIGHT (CALVERT)
25 - SIMPLE APPROACH LIGHT
26 - APPROACH ROAD
27 - SERVICE ROAD
200
500
1000m
DRAWING - 1
NEW AIRPORT LAYOUT PLAN
(DESIGN YEAR 1990)




DRAWING – 2
NEW AIRPORT LAYOUT PLAN
(DESIGN YEAR 2000)