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AIRPORT FEASIBILITY STUDIES
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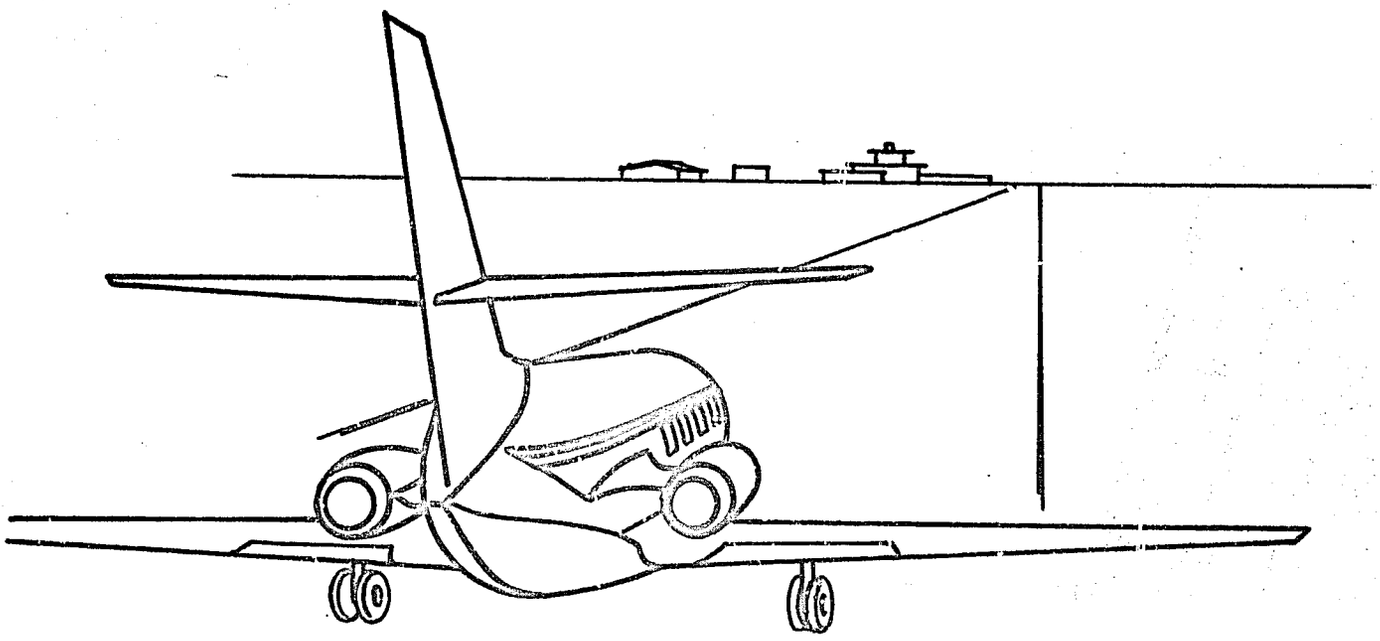

THE GOVERNMENT OF THE REPUBLIC OF BOLIVIA
MINISTRY OF ECONOMY
MINISTRY OF PUBLIC WORKS AND COMMUNICATIONS
DEPARTMENT OF CIVIL AERONAUTICS

AID LOAN NO 511-L-010

DANIEL, MANN, JOHNSON, & MENDENHALL
5900 WILSHIRE BLVD • LOS ANGELES, CALIF. 90036 • TEL. [illegible]

ENGINEERING - ECONOMIC FEASIBILITY REPORT

AIRPORTS

TRINIDAD - COMMUNICATIONS - NAVAID

(Special Supplement)

FOR

Republic of Bolivia — Department of Civil Aeronautics

Ministry of Economy - Ministry of Public Works and Communications

By

Daniel, Mann, Johnson & Mendenhall
3325 Wilshire Blvd., Los Angeles, California

LA PAZ, BOLIVIA

April, 1968

DMJM

DANIEL, MANN, JOHNSON, & MENDENHALL

APR 30 1968

PRESIDENT
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T. K. KUTAY, A.I.A.

The Honorable Alberto Larrea Humérez
Minister of Economy
Republic of Bolivia
La Paz, Bolivia

Dear Sir:

We are pleased to submit herewith the final report, Special Supplement "Engineering Economic Feasibility Report for Trinidad Airport, Communications and NAVAID". This supplement is in addition to the final report covering the first three airports, 25 April 1968. It covers only those items contained in the contract amendment dated 15 November, 1967.

The report was prepared in La Paz, Bolivia and Los Angeles, California and complies with the outlined requirements of USAID as set forth in that Agency's publication "Feasibility Studies, Economic and Technical Soundness Analysis, Capital Projects".

We gratefully acknowledge the assistance of personnel of Direccion Nacional de Aeronautica Civil and United States Agency for International Development stationed in La Paz in furnishing information and reference data.

Our association with Bolivia has been extremely pleasant and we desire to express our sincere gratitude for the courtesies and friendly assistance accorded our personnel by the people of Bolivia, particularly those most intimately associated with this project.

We appreciate the privilege of carrying out this assignment, and we hope that we may be of further assistance to the Republic of Bolivia.

Very truly yours,

DANIEL, MANN, JOHNSON, & MENDENHALL

Stanley Walsh
Project Manager

Bill Shope
Vice President and Manager
International Operations

SW/ed

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APPENDIX E (Revised)

CHAPTER I

INTRODUCTION

This is the final special supplement reporting study findings for Trinidad and Communications/NAVAID items added to the initial contract scope of work. Only data applicable to Trinidad and Communications/NAVAIDS is contained in this supplement. This part of the study was programmed over a period of two months starting November 1, 1967.

The initial preliminary special supplement was submitted on 20 December 1967. Requested changes have been included in this final report. All appendices are contained in the final report covering the first three airports, 25 April 1968.

CHAPTER II

OBJECTIVES AND SCOPE

The objective of this study is to provide an analysis of benefits and costs of proposed improvements. This study also provides engineering guidelines for the design of proposed improvements at Trinidad.

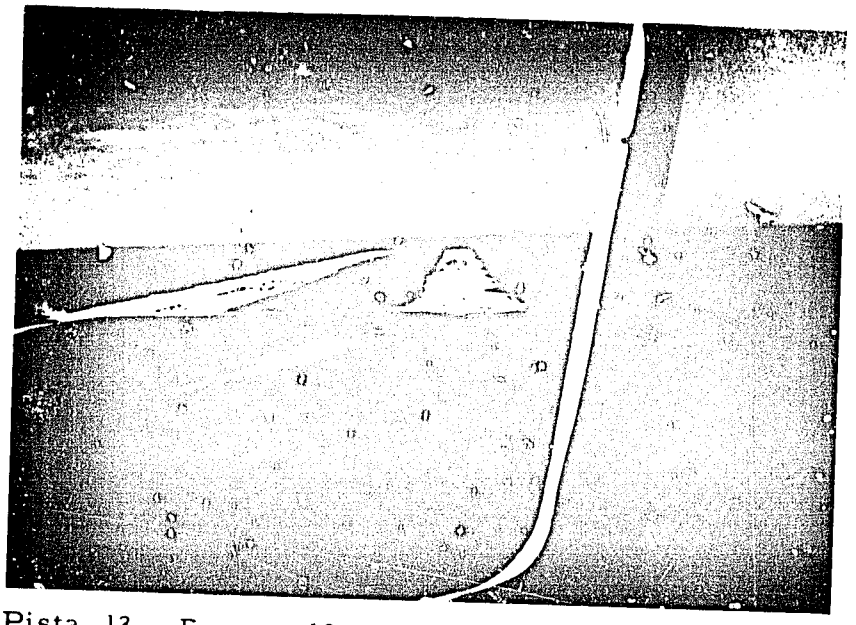
The scope of work is an follows:

Trinidad Airport

Provide paved runway, taxiway and parking apron. Provide medium intensity runway and taxiway lighting and parking apron lighting.

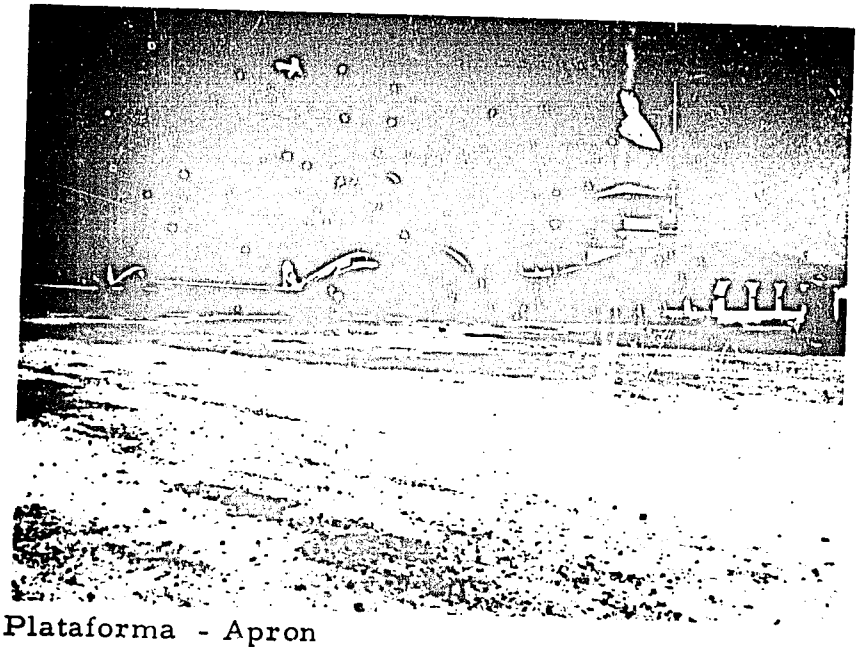
Communications/NAVAID

Economic study and analysis to show feasibility or non-feasibility of improvement to communications equipment at La Paz, Cochabamba, Santa Cruz and Trinidad. Installation of a VOR at Trinidad. Procurement and installation of equipment to be accomplished by the Bolivian Government. No engineering feasibility study is required.

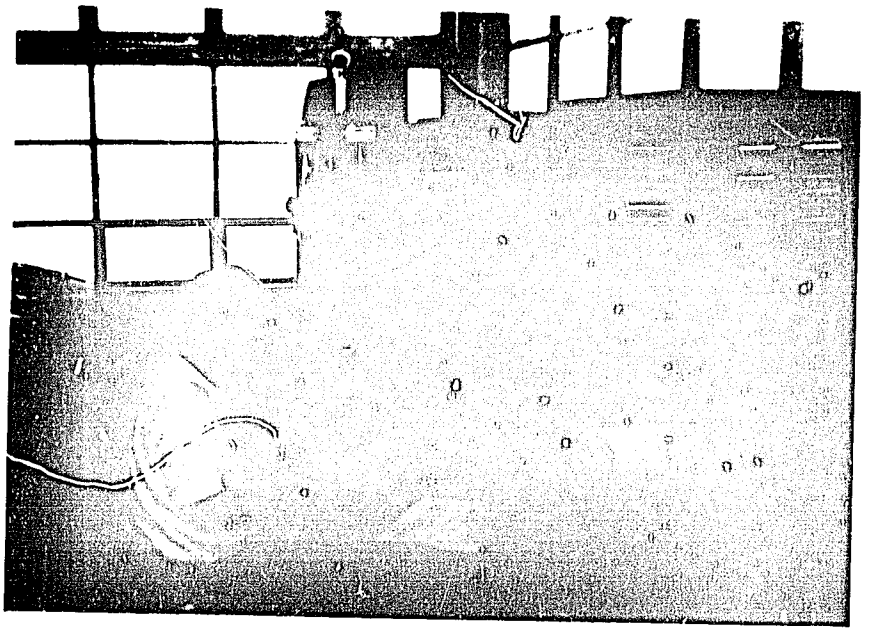


Pista 13 - Runway 13

TRINIDAD AIRPORT

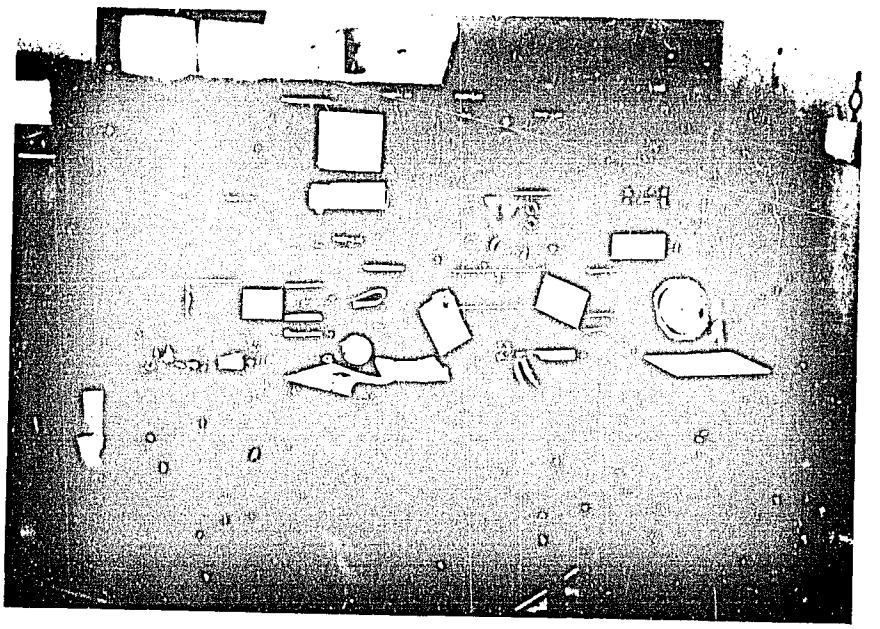


Plataforma - Apron



EQUIPO TIPICO DE COMUNICACION DE AEROPUERTOS

TYPICAL AIRPORT COMMUNICATIONS EQUIPMENT



CHAPTER III

SUMMARY AND RECOMMENDATIONS

The benefit/cost findings for proposed improvements at Trinidad Airport and for Communications/NAVAID installations are summarized below. Methods to determine feasibility used are in accordance with the standards of Agency for International Development Manual, M.O. 1221.2, October 1, 1964.

Alternate designs for proposed improvements were developed and subjected to economic evaluation. Designs with the highest net benefits and benefit/cost ratios are recommended for implementation.

Trinidad - Pave Runway, Taxiway and Apron

Alternate I provides a jet airport suitable for Boeing 727 operations. A 2,600 meter (8,600 feet) soil cement stabilized runway with runway turnarounds, taxiways and a rigid pavement parking apron was proposed. The high cost of this alternative is due to surface transportation difficulties and lack of construction materials. Construction cost less interest during construction are: pavement $4,026,268; fencing $108,669. The benefit/cost ratio using 12% interest is 0.29 to 1.00 and using 15% interest is 0.26 to 1.00. Alternate I is not recommended for implementation.

Alternate II provides a paved airport suitable for turbo-prop all wet weather operation. Aircraft such as F27K as well as existing piston powered aircraft could operate at this airport. The existing 1,600 meter (5,248 feet) runway has been improved and surfaced. Suitable taxiways and an aircraft terminal apron are provided. Construction cost less interest during construction are: pavement $846,478; fencing $86,886. The resulting benefit/cost ratio at 12% is 1.22 to 1.00 and at 15% is 1.04 to 1.00. This alternate is recommended for implementation.

Trinidad - Lighting

A medium intensity runway and taxiway lighting system is recommended with apron flood lighting. Installation of a new generator is also recommended. Reliable commercial power is not available. The existing airport power plant is inadequate to serve the proposed system. Installation cost, less interest during construction for Alternate I is $91,044. This alternate is not recommended. Installation cost less interest during construction of lighting Alternate II is $84,722. Alternate II benefit/cost ratio at 12% interest is 3.72 to 1.00 and 3.14 to 1.00 at 15% interest.

Trinidad - Fencing

Perimeter fence has been included at all airports in the study. This is consistent with adequate ground safety planning. The present animal fencing at all locations has proven inadequate. Night operations would be unsafe without proper airport security provided by a fence. For costing and economic evaluation, fencing has been tabulated with pavement improvements.

Communications/NAVAID

The program to install selected communications equipment at all airports in the study and to install a VOR at Trinidad was estimated as follows: total capital cost $1,314,966. The resulting benefit cost ratio at 12% interest is 4.37 to 1.00 and 3.88 to 1.00 at 15% interest.

Capital Costs

The cost estimates, less interest during construction, of all recommended improvements are as follows:

El Alto Airport-La Paz	
Water Supply (Alt #3)	$ 34,100
Cargo Terminal	705,936
Cargo Apron	276,423
Apron Lights	8,932
	$1,025,391
Cochabamba Airport	
Pavement	$562,855
Fencing	101,270
Lights	64,718
Lights (Terrain)	70,224
	$ 799,067
Santa Cruz Airport	
Pavement	$1,511,171
Fencing	75,152
Lights	95,634
	$1,681,957
Trinidad Airport	
Pavement	$ 846,478
Fencing	86,886
Lights	84,722
	$1,018,086
Communication/Navaid	
La Paz	$ 718,080
Santa Cruz	175,200
Cochabamba	198,516
Trinidad	223,200
	$1,314,996

Total --- $5,839,497

TABLE I

COMBINED BENEFIT/COST RATIO PROPOSED AIRPORT AND COMMUNICATIONS IMPROVEMENTS
BOLIVIA

	@ 12%			@ 15%		
	Present Value Total Annual:			Present Value Total Annual:		
PROJECT	Benefits	Costs	B/C	Benefits	Costs	B/C
EL ALTO AIRPORT:						
Water Supply (Alt. #1)	$ 153,081	$ 120,127	1.27	$ 139,658	$ 106,333	1.31
(Alt. #2)	120,127	153,081	0.78	106,333	139,658	0.76
(Alt. #3)*	120,127	74,371	1.62	106,333	68,064	1.56
Cargo Terminal/Apron/Lights*	2,591,040	1,329,704	1.95	2,228,341	1,264,066	1.76
COCHABAMBA AIRPORT:						
Pavement*	1,786,632	1,019,337	1.75	1,460,198	975,596	1.50
Lights*	771,275	214,746	3.59	661,015	202,914	3.26
SANTA CRUZ AIRPORT:						
Pavement:						
Alt. I - With Fencing*	2,891,655	2,573,900	1.12	2,277,990	2,450,810	0.93
Alt. II - Without Fencing	2,891,655	2,392,676	1.21	2,277,990	2,285,458	0.99
Lights*	664,341	133,325	4.98	524,408	127,940	4.10
TRINIDAD AIRPORT:						
Pavement:						
Alt. I - Jet	1,868,534	6,369,820	0.29	1,520,476	6,186,505	0.26
Alt. II - Turbo-Prop/Propeller*	1,868,534	1,526,958	1.22	1,520,476	1,466,153	1.04
Lights:						
Alt. II - Turbo-Prop/Propeller*	439,296	118,110	3.72	356,131	113,337	3.14
Communications/NAVAIDS*	15,103,002	3,459,660	4.37	12,062,009	3,112,405	3.88
Totals	$26,235,902	$10,450,111	2.51	$21,196,901	$ 9,781,285	2.17

Note: Items with (*) included in totals

CHAPTER IV

DESIGN PARAMETERS

AIRPORT CAPACITY

The capacity of an airport is expressed as the number of operations that can be accommodated within a given time period and within acceptable limits of delay. Extensive tests of mathematical models against actual airport operating experience was carried out by FAA to arrive at basic development criteria. The methodology and criteria can be applied to all airports regardless of location and thus have been applied to the airports of this study.

Runway Capacity Criteria

The annual capacity of a single runway airport will exceed 150,000 operations with suitable taxiway facilities. The demand forecast for the study airports is expected to reach but a small percentage of this criteria in the next five years.

Taxiway Capacity Criteria

The criteria for taxiways to allow a runway to realize its maximum capacity are as follows:

(a) Turnarounds at runway ends are recommended as a minimum operational pavement facility.

(b) Stub taxiways to aircraft aprons are recommended minimum operational pavement facilities.

(c) Parallel taxiways may be justified if one of the following criteria is forecast to be reached within the next five years:

1. There are four instrument approaches during the normal peak hour;

2. The annual operations total 50,000;

3. The normal peak hour itinerant operations total 20; or

4. The hourly total operations are 20 for runways serving 40% to 100% large aircraft.

The statistics required for a rigid application of the above criteria were not available, however, from data available and an analysis of airport operations during the study period plus data obtained by interrogation, it was determined that neither Cochabamba nor Santa Cruz airports exceeds the above operational limits. Peak hour statistics and differentiation between local and itinerant operations is not recorded.

Annual operations based on recorded landings during 1966 are:

La Paz	15,062	Annual Operations
Cochabamba	10,302	Annual Operations
Santa Cruz	5,970	Annual Operations
Trinidad	13,890	Annual Operations

An aircraft operation is defined as an arrival or departure from an airport.

CRITICAL AIRCRAFT

The frequency of airport use by various types of aircraft and their operating characteristics influence runway length and apron configuration. Airline aircraft are the most demanding.

For initial design purposes discussions were held with FAA/USAID representatives to select critical aircraft criteria. The general guidance of the 1966 SARC report was considered. The more specific 1967 SARC report became available late in the study. Initially, DC-9 and Boeing 737 aircraft were assumed. The loading of 97,500 pounds was increased to 110,000 pounds (50,000 kilos) for design purposes. The later SARC report indicates that the Boeing 727 trijet could be the most critical aircraft on primary trunk routes in Bolivia. Maximum gross weight is 161,000 pounds. Final design for Santa Cruz pavement is based on this criteria.

The design load of 110,000 pounds is the maximum allowable 727 load at Cochabamba when payload restrictions are applied; i.e. high altitude, takeoff climb limitations and nonextendible runway. At Santa Cruz runway length and apron design will permit maximum gross weight 727 operations.

AIRLINE SERVICE DEMAND

The Hub Structure is a classification of communities in terms of their percentage share of scheduled domestic enplaned passengers. This structure is a useful tool in relating airport development to airline service requirements and in forecasting traffic activity. Communities have been classified as Large, Medium, Small and Nonhub according to their respective percentages of total enplaned airline passengers. For planning purposes in Bolivia we have further correlated the percentages to passengers generated per day.

HUB STRUCTURE BASED ON 1966 LAB DATA

Hub Structure	Percentage of Total Passenger Traffic	Passengers per Day
Large	4.39 or more	20 or more
Medium	1.08 to 4.38	5 to 19
Small	0.21 to 1.07	1 to 4
Nonhubs	less than 0.21	less than 1

City	Hub Structure	Annual No. of Passengers	Percentage of Total Passenger Traffic
La Paz	Large	46,057	26.3 %
Cochabamba	Large	44,678	25.5
Santa Cruz	Large	28,198	16.7
Trinidad	Large	9,483	5.6

NAVIGABLE AIRSPACE

Standards for determining obstructions to air navigation are based on the U. S. Code of Federal Regulation, Part 77 of the Federal Aviation Regulations entitled "Objects Affecting Navigable Airspace". This part applies to existing and proposed man-made objects, objects of natural growth and terrain.

Cochabamba

Civil airport imaginary surfaces have been plotted for Cochabamba and are shown on drawing FS-CBB-2 and 2A. The transitional, horizontal and conical surfaces are penetrated by existing terrain. Only the approach area to secondary runway 13 is clear of obstructions. It should be noted that the pavement on this runway has deteriorated and the runway is normally unused. All other runway approaches are violated by mountainous terrain. The terrain obstructions will adversely effect establishment of instrument approach procedures and severely restrict night operations.

R/W 13-31 - Cochabamba

An analysis of the use of unimproved runway 13-31 is beyond the scope of this feasibility study. However, because of terrain obstructions the question of possible development of this runway is raised. A comment on requirements and cost is appropriate.

Using the present runway alignment approximately 30 hectares of additional land would be required to accommodate a 2700 meter runway. This is the minimum recommended length for new runway development. Present airport property would limit the length to 1700 meters. The new area would also accommodate a centrally located terminal building aircraft apron and parallel taxiways with adequate clearance.

Construction of runway 13-31 would cost approximately 1.5 million dollars. A minimum layout of stub taxiways and turnarounds are estimated at $500,000. Total estimated cost not including new terminal and access road would be 2.5 to 3 million dollars.

Santa Cruz and Trinidad

The terrain in the vicinity of both airports is flat. The Andes are approximately 40 miles west of Santa Cruz and 200 miles southwest of Trinidad. A plot of the airport imaginary surfaces was not necessary. Man-made obstructions are shown on the Airport Layout Plans with obstruction penetration shown as + meters.

ENVIRONMENTAL DATA

The following geographic and climatic conditions influence airport design and aircraft performance:

Average Annual Rainfall - Source: LAB Meteorological Office

La Paz	574.0 mm	22.[illegible]0 inches
Cochabamba	478.3 mm	18.83 inches
Santa Cruz	1,224.9 mm	48.22 inches
Trinidad	1,840.9 mm	72.47 inches

Temperature - Source: Servicio Meteorológico de Bolivia
Average daily maximum temperature of the hottest month.

La Paz	16.6° C	61.9° F
Cochabamba	30.3° C	86.5° F
Santa Cruz	31.1° C	87.8° F
Trinidad	34.6° C	94.3° F

Airport Elevation - Source: Instituto Geográfico Militar

La Paz - West end	4,033 mts	13,228 feet
- East end	4,057 mts	13,307 feet
Cochabamba	2,544 mts	8,345 feet
Santa Cruz	416 mts	1,365 feet
Trinidad	154 mts	505 feet

ASSUMPTIONS

As a basis for costing, the following assumptions have been made: 1) all material and equipment will be free of Bolivian taxes, 2) because special equipment and techniques will be needed to accomplish the projects, a non-Bolivian contractor will be the prime contractor, 3) local material costs were used where appropriate, 4) equipment costs were considered as rental.

CHAPTER V

AIR TRAFFIC ANALYSIS

Estimated future air traffic volumes at El Alto, Cochabamba and Santa Cruz airports establish a means for determining the correct scale of proposed airport improvements and for measuring future benefits from these improvements. Economic trends, historical air traffic patterns, and intermodal transport relationships were analyzed to provide background for projecting air traffic trends.

Air Route Structure

La Paz, Cochabamba, Santa Cruz and Trinidad are the four major air traffic hubs of Bolivia.

Internationally, six foreign cities are served from Bolivia: Lima, Arica (Chile), and Buenos Aires from La Paz; Buenos Aires, Sao Paulo and Corumbá from Santa Cruz; and Salta (Argentina) from Tarija. Cochabamba is not a port of entry for international flights. See Figure 2.

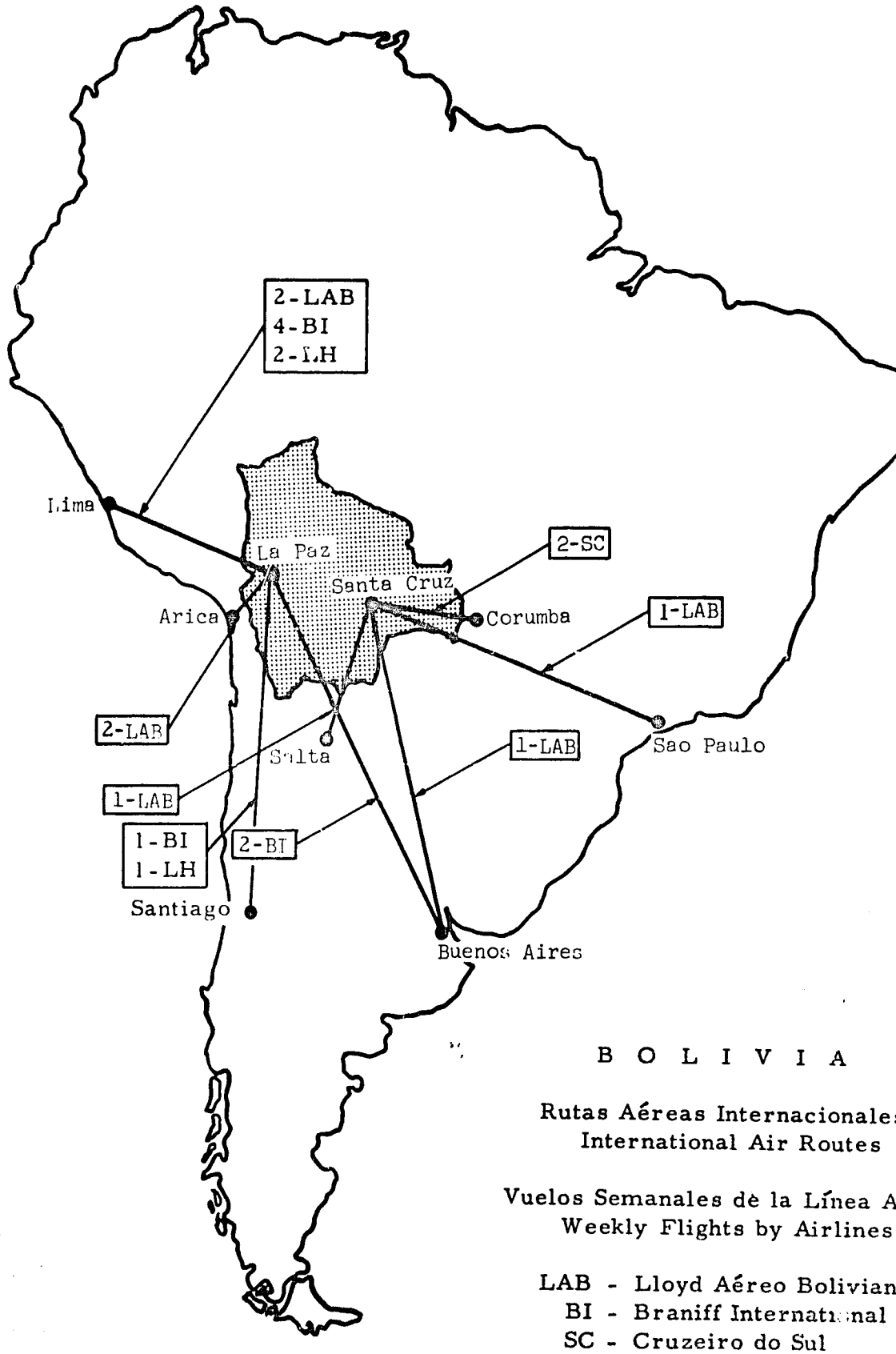
Domestically, 35 cities are served over 63 scheduled route segments by Lloyd Aéreo Boliviano (LAB) and Transportes Aéreos Militares (TAM). See Figure 4. Additional cities are served on a charter flight basis by non-scheduled airlines. Scheduled domestic route development in Bolivia is still in a formative stage of development. Existing domestic routes comprise 5% of all possible route segments between cities presently being served.

$$\frac{y}{n^2 - n} \times 100 = \frac{63}{35^2 - 35} \times 100 = 5\%$$

n = number of cities served
y = number of existing routes

Origin and Destination

The airlines covered and O&D data obtained is shown in Appendix A.(1st. volume) Braniff International and Cruzeiro do Sul data was not available. The volume of traffic would increase with the inclusion of these carriers. Traffic volume data necessary to establish building space requirements was based on DNAC traffic statistics reported by all scheduled air carriers. Commodity and intermodal traffic data in this chapter covers all air carriers. La Paz, Cochabamba and Santa Cruz are the principal points of origin and destination. See Figure 5. Total passenger traffic volume in 1966 at these major air hubs is shown below. Air routes connecting La Paz, Cochabamba and Santa Cruz account for the largest portion of passenger volume.



B O L I V I A

Rutas Aéreas Internacionales
International Air Routes

Vuelos Semanales de la Línea Aérea
Weekly Flights by Airlines

LAB - Lloyd Aéreo Boliviano
BI - Braniff International
SC - Cruzeiro do Sul
LH - Lufthansa

April 1968

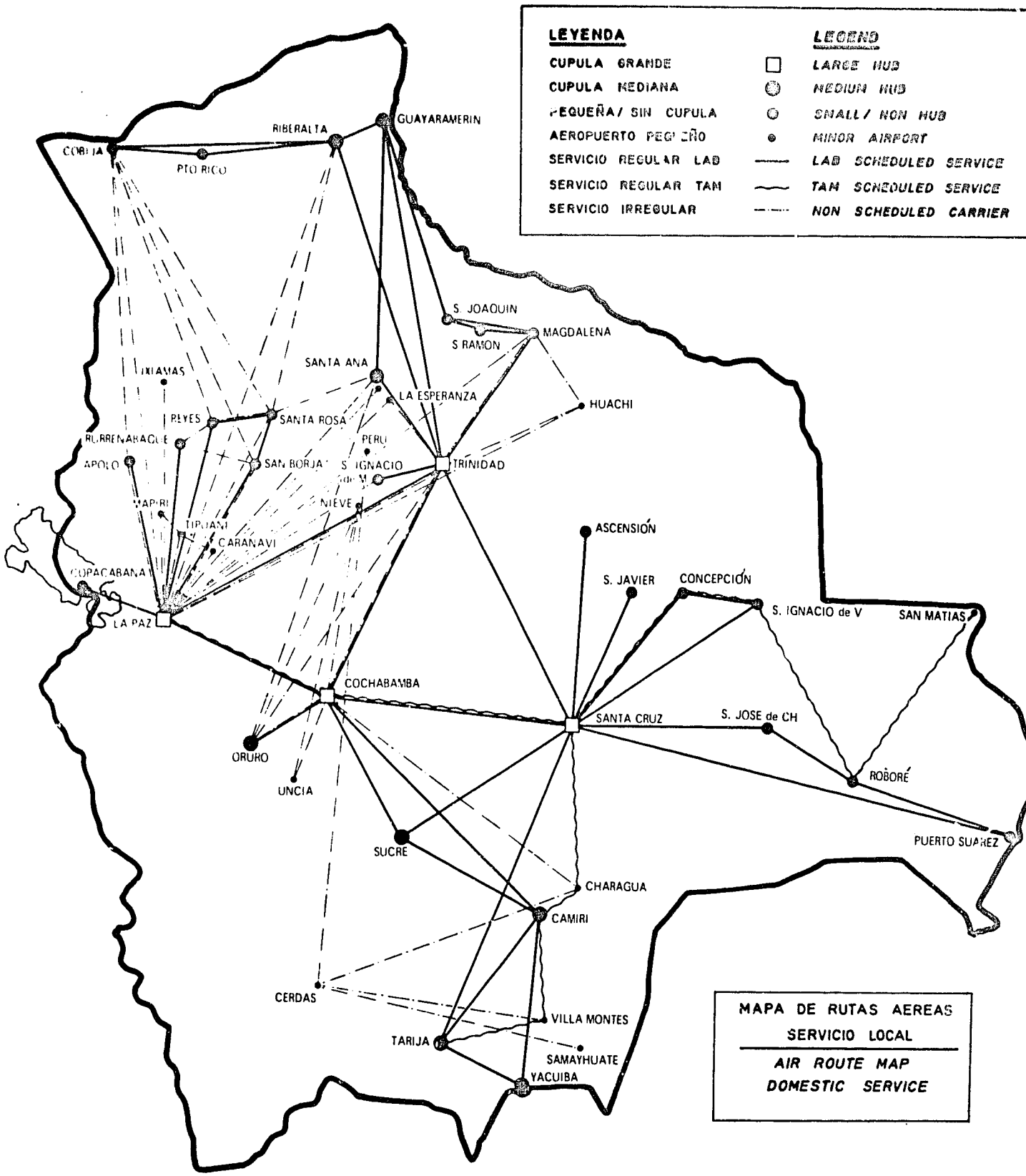
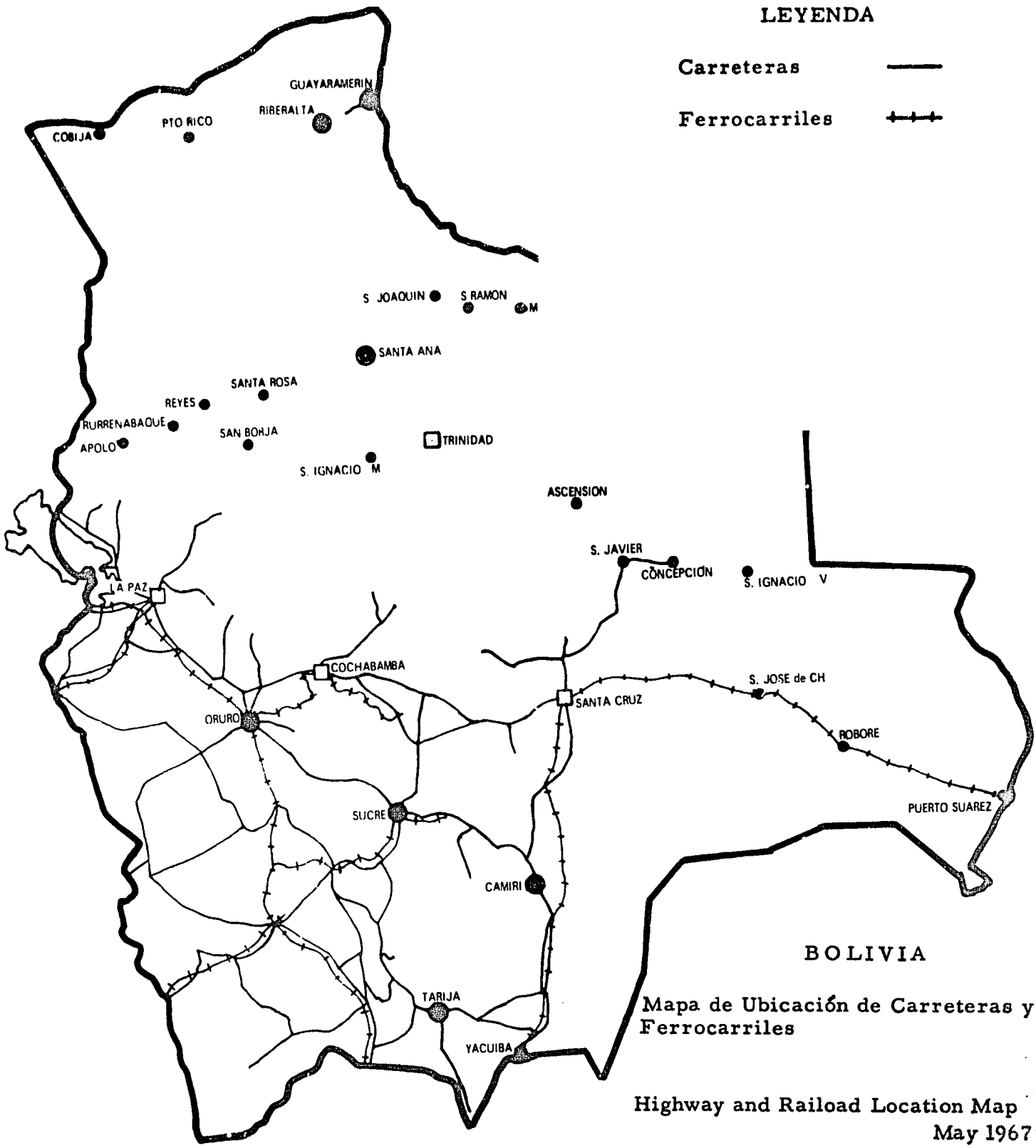

LEYENDA
LEGEND
CUPULA GRANDE
LARGE HUB
CUPULA MEDIANA
MEDIUM HUB
PEQUEÑA / SIN CUPULA
SMALL / NON HUB
AEROPUERTO PEQUEÑO
MINOR AIRPORT
SERVICIO REGULAR LAB
LAB SCHEDULED SERVICE
SERVICIO REGULAR TAM
TAM SCHEDULED SERVICE
SERVICIO IRREGULAR
NON SCHEDULED CARRIER
GUAYARAMERIN
RIBERALTA
COBIJA
PTO RICO
S. JOAQUIN
MAGDALENA
S RAMON
SANTA ANA
LA ESPERANZA
HUACHI
IXIAMAS
REYES
SANTA ROSA
RURRENABAQUE
PERU
APOLO
SAN BORJA
S. IGNACIO
TRINIDAD
NIEVE
TIPUANI
CARANAVI
COPACABANA
LA PAZ
ASCENSIÓN
S. JAVIER
CONCEPCIÓN
S. IGNACIO de V
SAN MATIAS
COCHABAMBA
SANTA CRUZ
S. JOSE de CH
ORURO
UNCIA
ROBORÉ
PUERTO SUAREZ
SUCRE
CHARAGUA
CAMIRI
CERDAS
VILLA MONTES
TARIJA
SAMAYHUATE
YACUIBA
MAPA DE RUTAS AEREAS
SERVICIO LOCAL
AIR ROUTE MAP
DOMESTIC SERVICE

Figura No. 2



BOLIVIA

Mapa de Ubicación de Carreteras y Ferrocarriles

Highway and Raiload Location Map
May 1967

Figura No. 3

La Paz, Cochabamba and Santa Cruz are the principal points of origin and destination for domestic air passenger traffic. Air routes connecting these three cities carry the heaviest passenger volumes. Trinidad is a considerably smaller air hub in terms of total number of passengers, but has importance as the principal air hub serving the Beni region. See Figure 5. Total passenger traffic volume in 1966 at these major air hubs is shown in the table below.

Domestic Air Passenger Traffic - 1966
(Number of Passengers)

	La Paz	Cochabamba	Santa Cruz	Trinidad
Origin	45,692	40,996	24,829	10,703
Destination	47,158	41,082	24,777	7,648
Totals	92,850	82,078	49,606	18,351

Source: Appendix A.

La Paz is the dominant hub for domestic air cargo traffic, as shown in Figure 6. Air cargo traffic between La Paz, Cochabamba, and Santa Cruz is relatively light because of highway and rail connections between La Paz and Cochabamba and a paved highway connecting Cochabamba with Santa Cruz. Trinidad, on the other hand, is without rail or highway access and relies heavily on air transport to ship beef to La Paz and meet other cargo transport requirements.

Domestic Air Cargo Traffic - 1966
(Kilograms)

	La Paz	Cochabamba	Santa Cruz	Trinidad
Origin	12,291,407	2,797,588	820,434	3,622,986
Destination	14,495,999	1,597,132	716,261	3,170,211
Totals	26,787,406	4,394,720	1,536,695	6,793,197

Source: Appendix A.

La Paz is also the principal hub for international air passenger traffic, being the point of origin or destination for 8,373 international air travellers in 1966. Cochabamba and Santa Cruz are also important international passenger traffic centers. Trinidad is not significant as a point of origin or destination for international air passenger traffic. See Figure 7.

International Air Passenger Traffic - 1966
(Number of Passengers)

	La Paz	Cochabamba	Santa Cruz	Trinidad
Origin	4,407	2,593	2,251	2
Destination	3,966	2,600	2,061	0
Totals	8,373	5,193	4,312	2

Source: Appendix A.

International air cargo traffic is focused on La Paz, with lesser cargo hubs at several other cities in Bolivia. Cochabamba and Trinidad are not ports of entry, hence have a limited air cargo traffic volume. See Figure 8.

International Air Cargo Traffic - 1966
(Kilograms)

	La Paz	Cochabamba	Santa Cruz	Trinidad
Origin	11,943	13,613	53,294	3,000
Destination	130,240	25,169	57,123	0
Totals	142,183	38,782	110,417	3,000

Source: Appendix A.

Air Cargo Commodity Composition

Inbound and outbound domestic air cargo, classified by type of commodity, is presented in Tables 2 and 3 for La Paz, Cochabamba, Santa Cruz and Trinidad airports.

TABLE 2

COMMODITY CLASSIFICATION OF CARGO ARRIVALS
LA PAZ, COCHABAMBA, SANTA CRUZ, AND TRINIDAD
1966

	LA PAZ		COCHABAMBA		SANTA CRUZ		TRINIDAD	
	Kilograms	Percent of Total	Kilograms	Percent of Total	Kilograms	Percent of Total	Kilograms	Percent Of Total
A. FOOD PRODUCTS								
1. Fresh Fruits and Vegetables	49,639		0		23,438		165,581	
2. Conserves and Sweets	0		809		1,892		132,207	
3. Grains and Grain Products	185		0		0		33,578	
4. Beer, Wines, Liquors, Alcohol, Soft Drinks	0		5,347		4,861		177,336	
5. Dairy Products	14,437		627		67,653		0	
6. Sugar	0		0		0		0	
7. Meats, Fish, Poultry	973,316		20,009		1,917		0	
8. Salt	0		0		0		0	
9. Cacao Seed	168,877		68,747		10,137		8,813	
10. Almonds, Brazil Nuts, Peanuts	154,021		183,731		172,620		7,711	
11. Coffee	104,328		0		0		0	
12. Misc. Food Products	0		9,386		0		11,313	
	1,464,803	44.7	288,656	31.7	282,318	58.9	536,539	49.3
B. SKINS, HIDES AND LEATHER PRODUCTS								
1. Hides and Leather Goods	644,797		402,171		10,997		3,260	
2. Shoes	0		0		0		0	
	644,797	19.7	402,171	44.2	10,997	2.3	3,260	0.3
C. TEXTILES AND DRY GOODS								
1. Textiles and Dry Goods	28,645	0.9	28,628	3.2	17,401	3.6	7,934	0.7
D. FOREST PRODUCTS								
1. Lumber	114,313		0		0		0	
2. Rubber	59,188		61,267		10,928		4,654	
3. Quinine	273,996		0		0		0	
4. Misc. Forest Products	5,687		0		0		0	
	453,184	13.8	61,267	6.7	10,928	2.3	4,654	0.4
E. PETROLEUM PRODUCTS								
1. Gasoline, Kerosene, Lubricants	0	0	1,010	0.1	0	0	38,207	3.5
F. METAL PRODUCTS, MACHINERY, ELECT. EQUIPT.								
1. Metal Products, Plumbing Supplies	0		12,971		0		168,995	
2. Motors, Machinery and Auto Parts	41,745		24,625		0		63,092	
3. Electrical Equipment	16,414		8,295		42,029		63,178	
	58,159	1.8	45,891	5.0	42,029	8.5	295,265	27.1
G. MISCELLANEOUS PRODUCTS								
1. Published Materials and Stationery	2,560		4,816		1,869		10,805	
2. Pharmaceutical, Veterinarian Products	1,614		2,362		5,289		15,066	
3. Miscellaneous Non-edible Agricultural Products	57,481		0		62,956		29,067	
4. Empty Bottles	436,152		20,809		6,487		525	
5. Miscellaneous	127,416		55,047		38,808		148,172	
	625,223	19.1	83,034	9.1	115,409	24.1	203,635	18.7
TOTAL	3,274,819	100.0%	910,657	100.0%	479,282	100.0%	1,089,494	100.0%

Source: Lloyd Aereo Boliviano, S.A., Seccion Estadistica. Data compiled from airport cargo receipts records.

TABLE 3

COMMODITY CLASSIFICATION OF AIR CARGO DISPATCHED LA PAZ, COCHABAMBA, SANTA CRUZ, AND TRINIDAD 1966

	LA PAZ		COCHABAMBA		SANTA CRUZ		TRINIDAD	
	Kilograms	Percent of Total	Kilograms	Percent of Total	Kilograms	Percent of Total	Kilograms	Percent Of Total
A. FOOD PRODUCTS								
1. Fresh Fruits and Vegetables	19,949		426,934		5,138		1,891	
2. Conserves and Sweets	86,750		59,651		3,103		3,592	
3. Grains and Grain Products	611,582		48,188		27,988		13,718	
4. Beer, Wines, Liquors, Alcohol, Soft Drinks	248,991		22,872		27,549		10,412	
5. Dairy Products	24,051		10,253		304		27,282	
6. Sugar	283,851		5,352		30,296		11,037	
7. Meats, Fish, Poultry	148,370		1,120		45,691		831,377	
8. Salt	189,905		0		28,104		6,605	
9. Cacao Seed	0		0		0		106,333	
10. Almonds, Brazil Nuts, Peanuts	0		0		136		0	
11. Coffee	0		0		0		0	
12. Misc. Food Products	0		0		0		24,555	
	1,613,449	63.3	574,370	64.2	168,309	34.5	1,036,802	71.0
B. SKINS, HIDES AND LEATHER PRODUCTS								
1. Hides and Leather Goods	0		37,793		0		262,004	
2. Shoes	8,275		12,529		0		0	
	8,275	0.3	50,322	5.6	0	0	262,004	17.9
C. TEXTILES AND DRY GOODS								
1. Textiles and Dry Goods	77,872	3.1	38,117	4.3	20,401	4.2	7,674	0.5
D. FOREST PRODUCTS								
1. Lumber	0		0		1,016		0	
2. Rubber	0		0		0		3,507	
3. Quinine	0		0		0		0	
4. Misc. Forest Products	0		0		0		0	
	0	0	0	0	1,016	0.2	3,507	0.2
E. PETROLEUM PRODUCTS								
1. Gasoline, Kerosene, Lubricants	240,942	9.4	24,969	2.8	51,785	10.6	12,913	0.9
F. METAL PRODUCTS, MACHINERY, ELECT. EQUIPT.								
1. Metal Products, Plumbing Supplies	274,598		72,829		14,437		7,964	
2. Motors, Machinery and Auto Parts	49,673		36,413		16,504		3,689	
3. Electrical Equipment	21,138		10,815		5,067		1,023	
	345,409	13.5	120,057	13.4	36,008	7.3	12,676	0.9
G. MISCELLANEOUS PRODUCTS								
1. Published Materials and Stationery	20,747		8,820		0		0	
2. Pharmaceutical, Veterinarian Products	5,562		1,394		5,000		4,175	
3. Miscellaneous Non-edible Agricultural Products	0		0		0		0	
4. Empty Bottles	0		0		6,216		97,376	
5. Miscellaneous	238,756		76,507		199,471		24,382	
	265,065	10.4	86,721	9.7	210,687	43.2	125,933	8.6
TOTAL	2,551,012	100.0%	894,556	100.0%	488,206	100.0%	1,461,059	100.0%

Source: Lloyd Aereo Boliviano, S.A., Seccion Estadistica. Data compiled from air cargo waybills.

Domestic air cargo is predominantly composed of foodstuff and raw materials, reflecting the limited industrial base of the Bolivian economy. For instance, foodstuffs with limited or no processing constitute almost two-thirds of air cargoes outbound from La Paz, while metal products, machinery and electrical equipment consitute only 13% of the total. In the case of Trinidad, meats and hides comprise 74% of outbound air cargo.

Monthly variations in air cargo caused by the seasonal nature of agricultural production are exhibited in Figure 5. On the whole, however, domestic air cargo shipments are free of marked monthly or seasonal variations.

Airport Traffic by Type of Aircraft

Two and four-motor aircraft in commercial or public service create the greater part of aircraft operations at La Paz, Cochabamba and Santa Cruz airports. However, at Trinidad airport light aircraft account for 75% of all aircraft operations. See Table 4. Light aircraft are almost entirely operated by air-taxi companies and private firms or organizations; private flying for non-commercial purposes is not an important form of aircraft use in Bolivia.

Intermodal Transport Relationships

The broken terrain of the Andes Mountains and jungle areas of the eastern lowlands create formidable problems for the development and operation of surface transportation systems in Bolivia. See Figure 3. The high cost of constructing rail lines and highways has to date prevented the linking of the eastern and western rail systems which are divided by the Andes Mountains, and limited road networks to that part of Bolivia south of 16 degree latitude.

The La Paz, Cochabamba and Santa Cruz areas account for three-quarters of all motor vehicles in the nation; other areas have very limited motor vehicle resources for road transport of passengers and cargo. See Figures on Page 30. Inasmuch as La Paz, Cochabamba, and Santa Cruz are linked by surface transport, future development plans to further develop surface transport systems between these major cities will not have a substantial impact on inter-city air traffic between these cities.

The relative importance of air, highway and rail passenger and cargo traffic volumes in Bolivia during the period 1963-65 is shown in figures on pages 31 and 32. Air transport has a potentially larger share of transportation volume, especially passenger travel, that can be realized through further penetration of the domestic travel market by improved service and competitive prices.

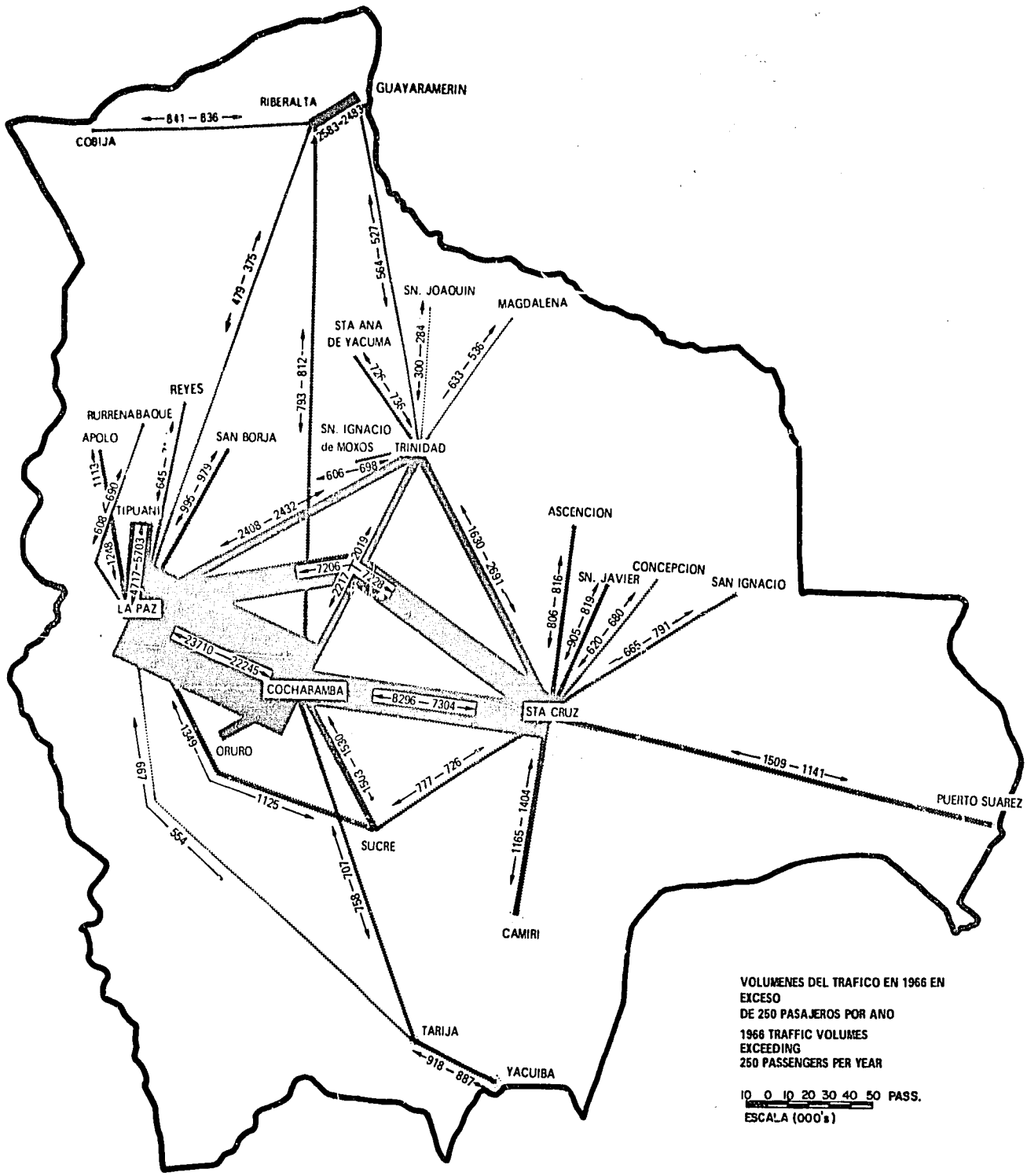
TABLE 4

NUMBER OF LANDINGS BY TYPE OF AIRCRAFT

1966

	La Paz	Cochabamba	Santa Cruz	Trinidad
Four-Motor Jet Aircraft				
DC-8	234	0	0	0
B-707	50	0	0	0
Subtotal	284	0	0	0
Four-Motors Piston Aircraft				
C-54	108	30	89	5
C-87	218	1	0	128
C-130	50	1	5	3
C-118	26	0	0	0
DC-6	904	1,250	579	21
DC-7	86	0	0	0
B-17	921	169	1	379
Constellation	1	1	0	0
Subtotal	2,314	1,452	674	536
Two-Motor Piston Aircraft				
C-46	1,116	444	24	176
C-47	3,067	773	909	609
DC-3	151	623	345	440
B-25	32	0	0	3
Convair	0	0	3	0
Subtotal	4,366	1,840	1,281	1,228
One - Two Motor Light Aircraft	565	1,856	1,030	5,178
Special Type Aircraft				
Military Sabre Jet	2	0	0	0
Helicopter	0	3	0	3
Subtotal	2	3	0	3
TOTAL	7,531	5,151	2,985	6,945

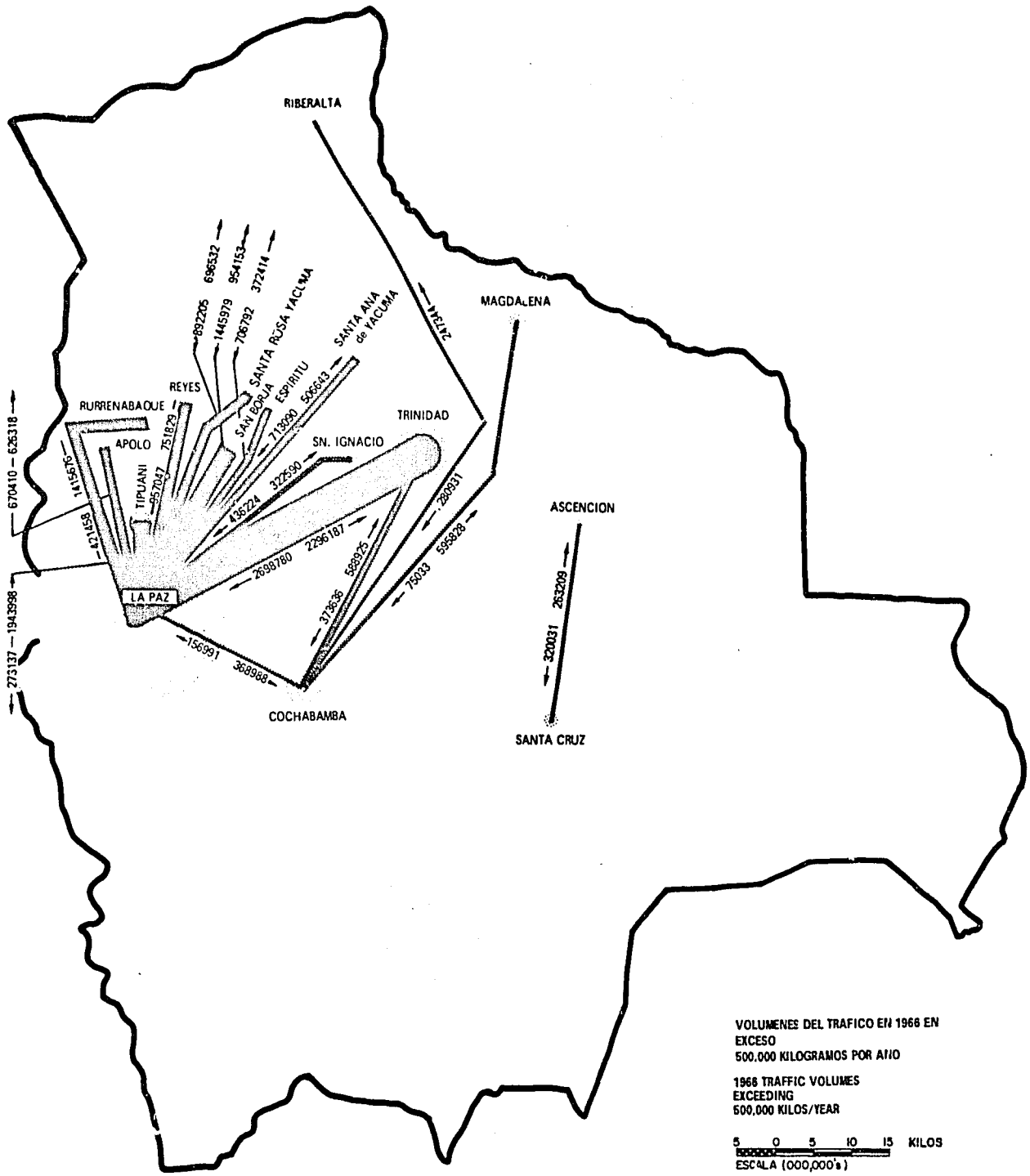
Source: Government of Bolivia, Dirección Nacional de Aeronáutica Civil, Boletín Estadístico No. 5, (La Paz, Bolivia), April 1967.



REPUBLICA DE BOLIVIA

PASAJEROS DOMESTICOS
ORIGEN Y DESTINIOS
DOMESTIC AIR PASSENGERS

DRAWN BY: DIB POR:	DATE: FECHA:	Fig 5
DATA BY: DATOS POR:	SCALE-ESCALA	



REPUBLICA DE BOLIVIA

CARGA DOMESTICA
ORIGEN Y DESTINO
DOMESTIC AIR CARGO

DRAWN BY: DIB. POR:	DATE: FECHA:	Fig 6
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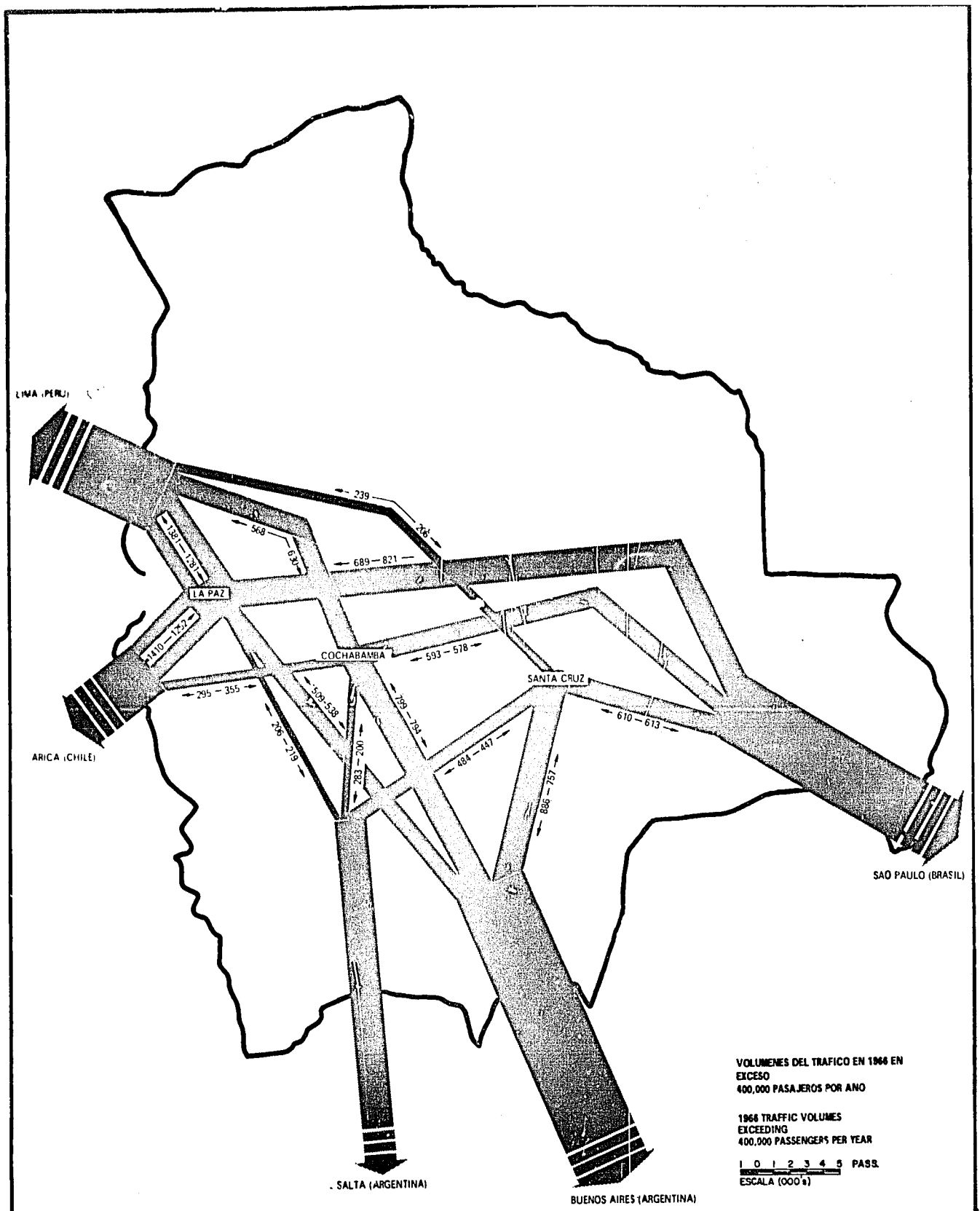
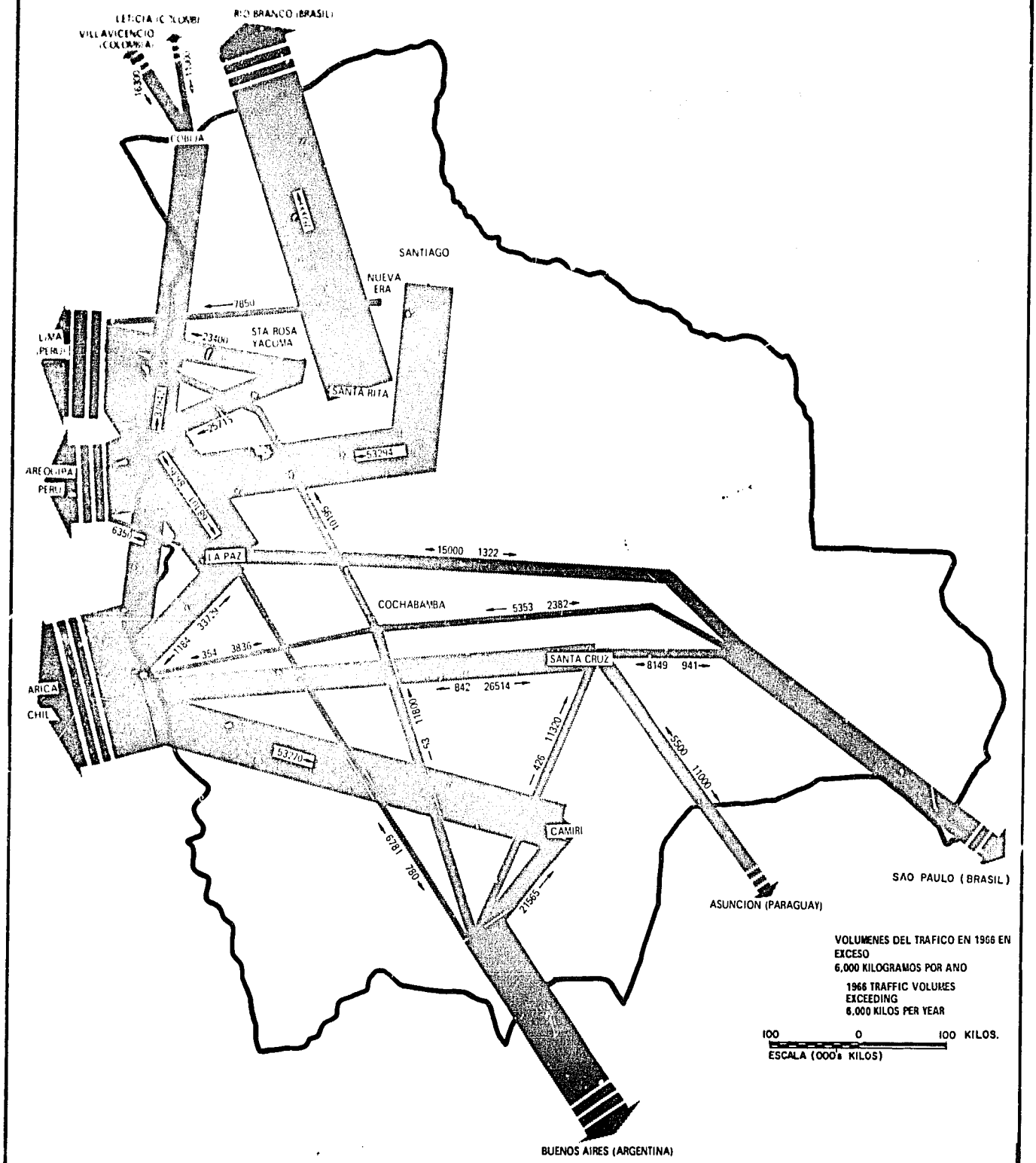


REPUBLICA DE BOLIVIA

PASAJEROS INTERNACIONALES
ORIGEN Y DESTINO
INTERNATIONAL AIR PASSENGERS

DRAWN BY: DIB. POR: | DATE: FECHA: | DATA BY: DATOS POR: | SCALE-ESCALA | Fig 7

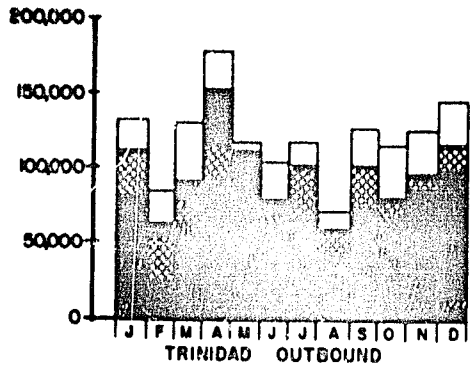


REPUBLICA DE BOLIVIA

CARGA INTERNACIONAL
ORIGEN Y DESTINOS
INTERNATIONAL AIR CARGO

DRAWN BY: DIB POR: DATA BY: DATOS POR: DATE: FECHA: SCALE-ESCALA

Fig 8



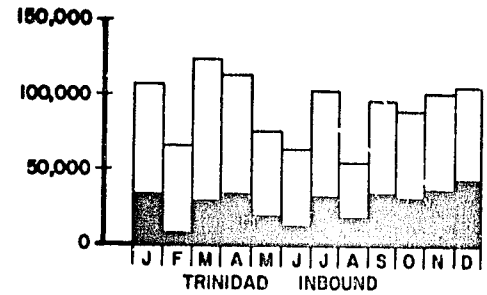


FIGURE V-1

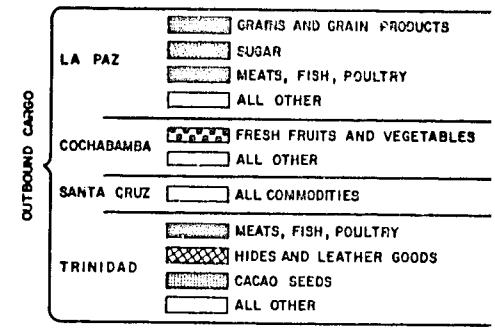
COMMODITY CLASSIFICATION OF MONTHLY AIR CARGO

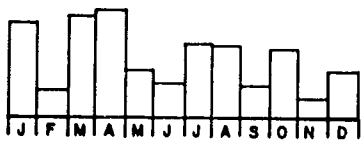
INBOUND AND OUTBOUND CARGO

LA PAZ, COCHABAMBA, SANTA CRUZ, AND TRINIDAD AIRPORTS

1966

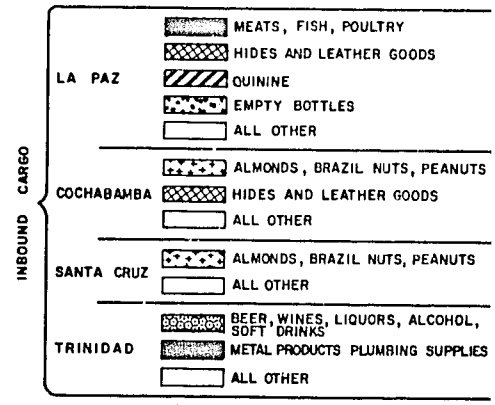
(KILOGRAMS)





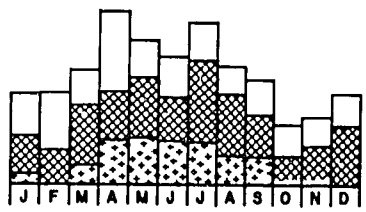
SANTA CRUZ OUTBOUND

SANTA CRUZ INBOUND

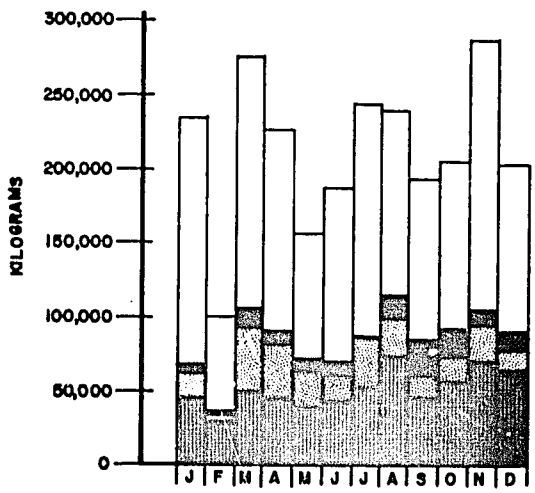


SOURCE: LLOYD AERO BOLIVIANO, S.A., SECCION ESTADISTICA

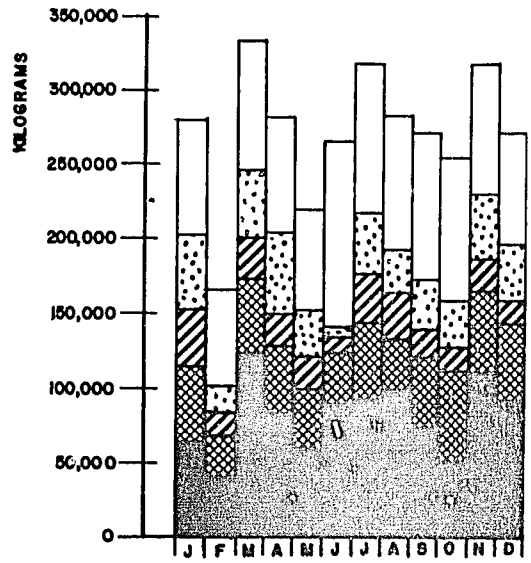
COCHABAMBA OUTBOUND



COCHABAMBA INBOUND



LA PAZ OUTBOUND



LA PAZ INBOUND

Air transport is without competition on many inter-city routes because of the complete absence of highway or rail connections. This is particularly true in cities located north of the 16 degree latitude, as noted above. River transport in the Beni is of local importance for the movement of cargo and passengers, but is slow and with a degree of hazard because of the uncertainties of navigation in unimproved river channels.

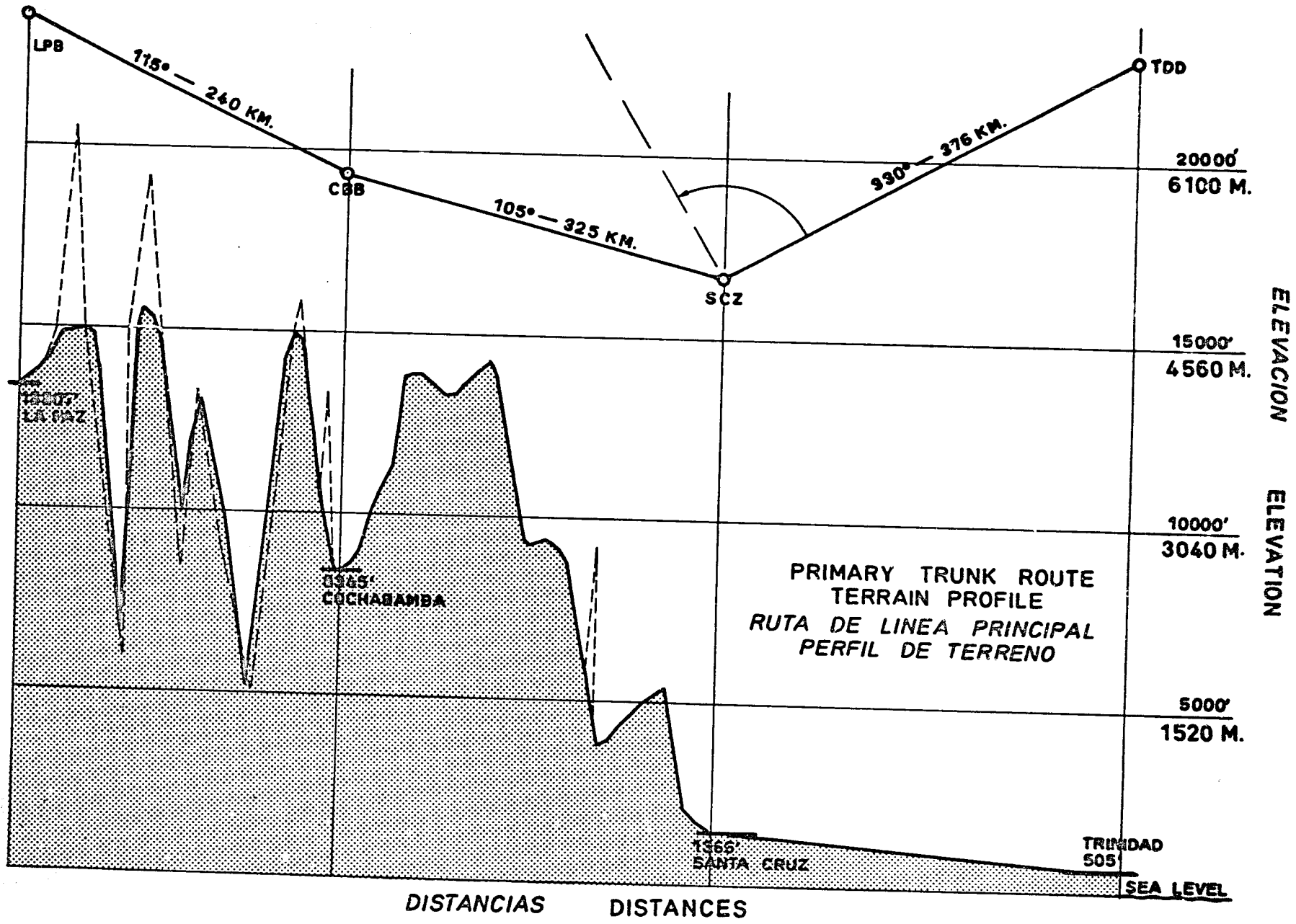
The relatively high cost of air passenger travel, from two to eight or more times expensive than surface travel, limits air travel to a small segment of the population of Bolivia. The higher cost of air travel is partly offset by the generally higher frequency of service per week on many routes, and shorter travel time.

Higher frequency of service and shorter travel time are largely offset by the high cost of air cargo shipment, except in the case of high value cargoes and perishable products such as meat. However, air cargo forms an important part of the transportation infrastructure of Bolivia because it frequently is the only mode of transport connecting communities in the mountain and jungle areas of the country.

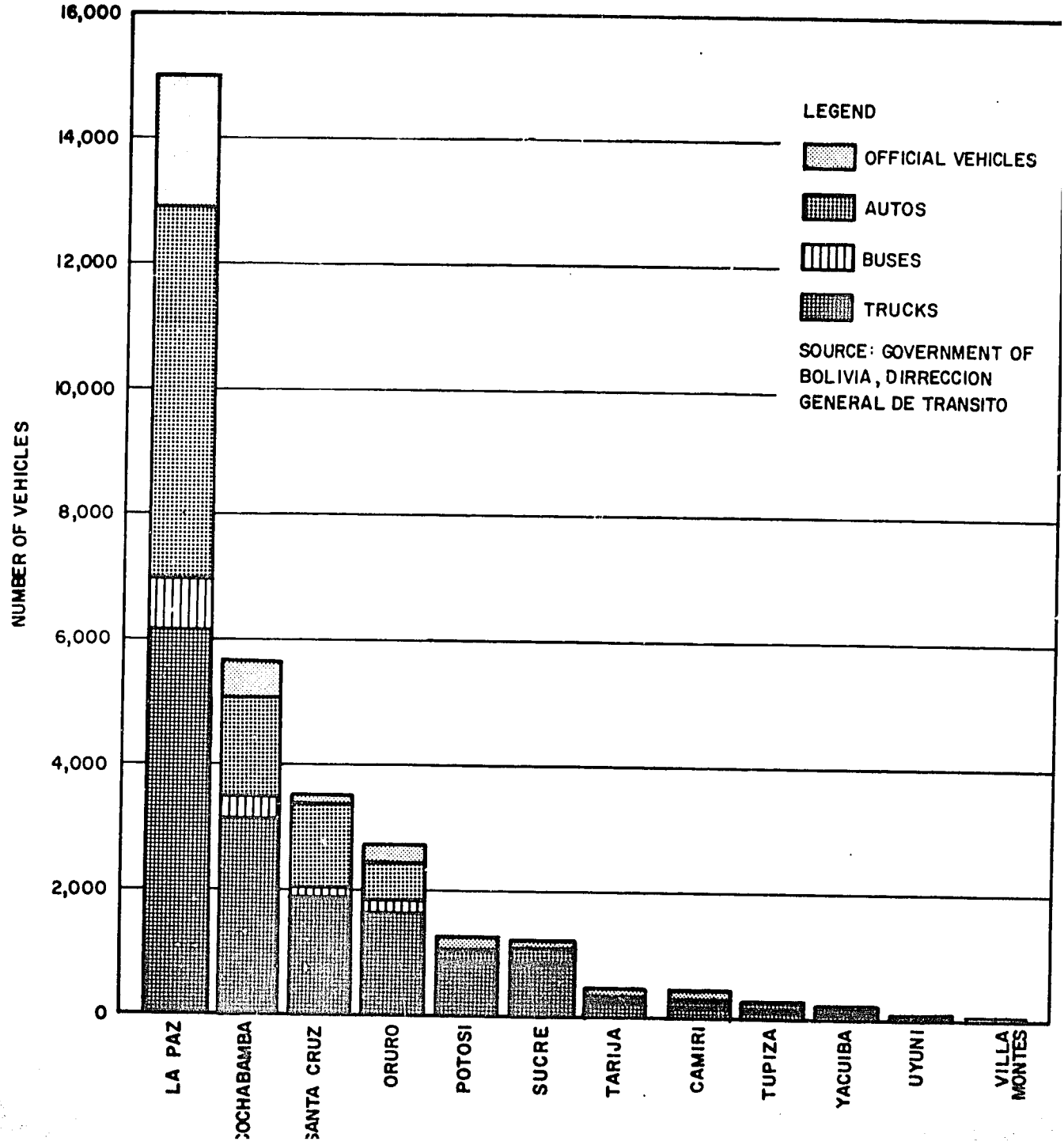
Population and Economic Trends

La Paz, Cochabamba and Santa Cruz are the three largest cities of Bolivia. Santa Cruz has been and will continue increasing in population at a more rapid rate than the other two large cities due to agricultural colonization programs, petroleum extraction and refining activity, and industrialization. Trinidad is expected to show a slower rate of increase than the major cities due to the absence of road or highway links with other parts of Bolivia. See Table

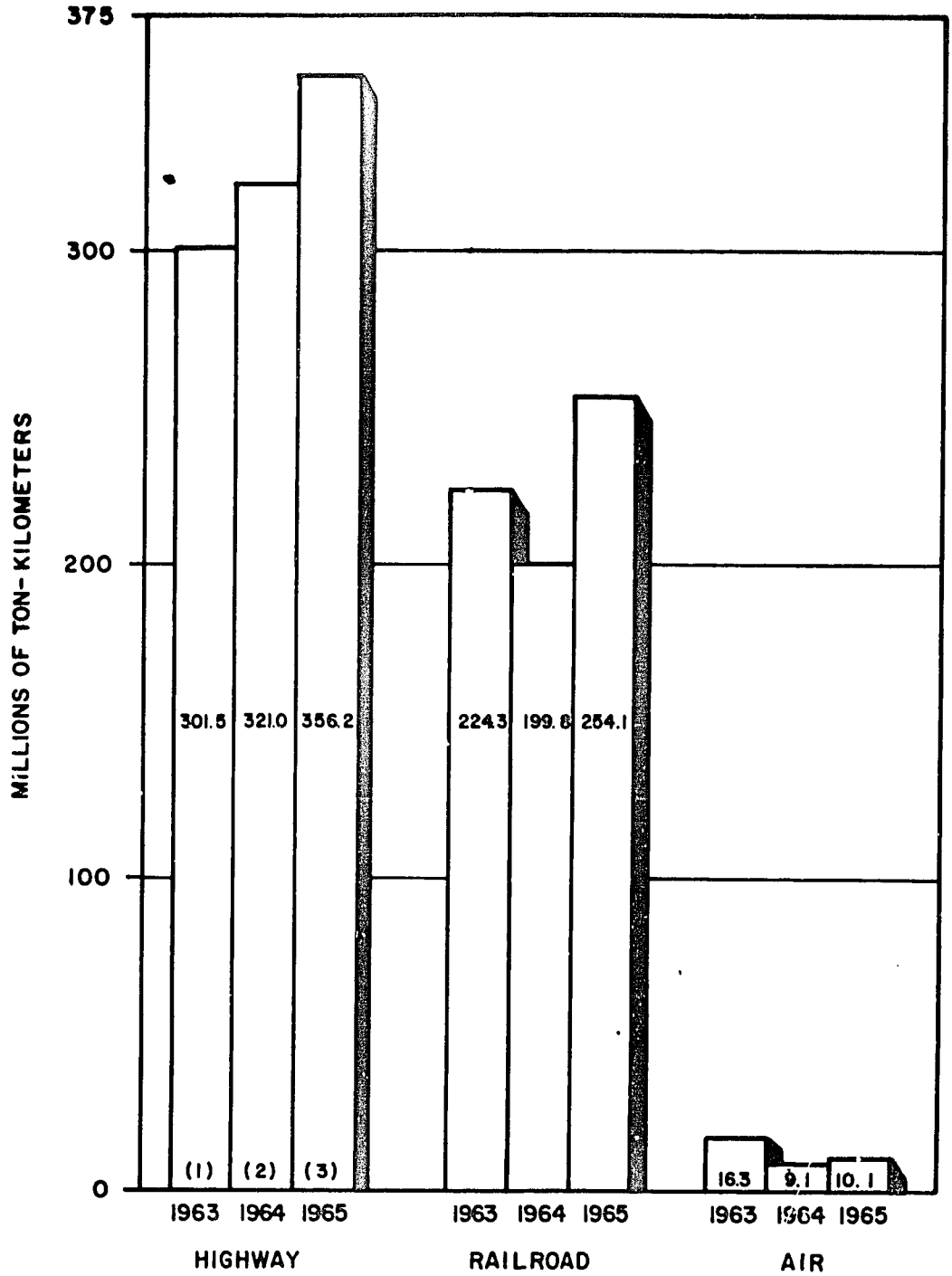
The experience of other countries shows that industrial activity is closely correlated to local air traffic volumes. Accurate industrial production statistics are not available for the above cities, however historical data of electric power production provides a good index of local industrial activity trends. See Table 6. Santa Cruz shows the highest rate of increase in electric power production, while the very limited increase of power production in Trinidad corresponds with a virtual absence of industry located there.


LPB
115° — 240 KM.
CBB
105° — 325 KM.
SCZ
330° — 376 KM.
TDD
20000'
6100 M.
15000'
4560 M.
10000'
3040 M.
5000'
1520 M.
ELEVACION
ELEVATION
LA PAZ
8345'
COCHABAMBA
1366'
SANTA CRUZ
TRINIDAD
505'
SEA LEVEL
PRIMARY TRUNK ROUTE
TERRAIN PROFILE
RUTA DE LINEA PRINCIPAL
PERFIL DE TERRENO
DISTANCIAS
DISTANCES

REGISTERED MOTOR VEHICLES BY DISTRICT
BOLIVIA
(AS OF MARCH 31,1966)



CARGO MOVEMENT BY TYPE OF TRANSPORT
BOLIVIA
1963-1965
(MILLIONS OF TON -KILOMETERS)



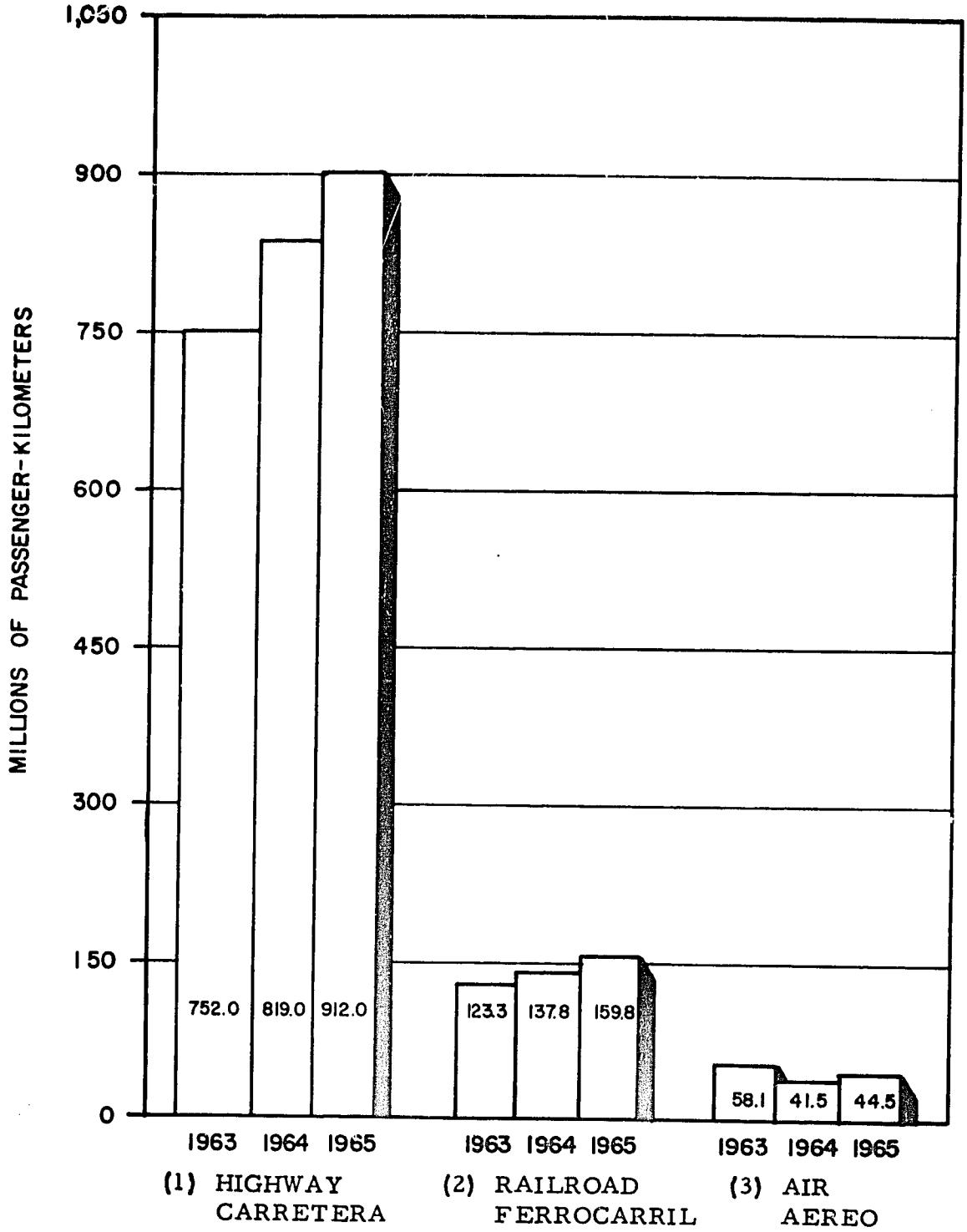
SOURCES:
(1) ESTIMATED
(2) ESTIMATE BASED ON COCHABAMBA-STA. CRUZ TRAFFIC TRANSPORT OF MINERALS TRAFFIC COUNTS AND ESTIMATED UTILIZED CAPACITY OF VEHICLES.
(3) ESTIMATE BASED ON COMISION PERMANENTE DE TRANSPORTE

SOURCE:
EMPRESA NACIONAL DE FERROCARRILES, ANNUAL REPORT, 1965.

SOURCES:
DNAC, BOLETINES ESTADISTICOS 1,2,3,4. (1) ESTIMATE BASED ON REPORT NO. 1 OF THE DEPTO. ECONOMICO, DGAC, DECEMBER 1963.

PASSENGER MOVEMENT BY TYPE OF TRANSPORT
BOLIVIA

1963 - 1965
(MILLIONS OF PASSENGER-KILOMETERS)



SOURCES: (1) COMISION PERMANENTE DEL TRANSPORTE.
(2) EMPRESA NACIONAL DE FERROCARRILES, ANNUAL REPORT , 1965.
(3) DNAC, BOLETINES ESTADISTICOS 1,2,3,4.

TABLE 5

HISTORICAL AND PROJECTED POPULATION
BOLIVIA
1950 – 1990
(Thousands of Persons)

Year	La Paz	Cochabamba	Santa Cruz	Trinidad
1990	1,375.0	400.0	300.0	
1985	1,080.0	320.0	232.0	27.1
1980	849.2	251.6	186.7	23.8
1975	664.9	201.1	146.0	20.5
1970	543.5	163.8	114.2	17.8
Annual Growth Rate 1970-90:	4.7%	4.6%	5.0%	2.8%
1965	466.2	135.3	89.3	15.6
1960	411.7	113.9	69.8	13.8
1950	321.1	80.8	42.8	10.8
Annual Growth Rate 1950-65	2.5%	3.5%	5.0%	2.5%

Sources: 1950-1980, Secretaria Nacional de Planificación y Coordinación.
1980-1990, Estimated by DMJM.

TABLE 6

ELECTRIC POWER PRODUCTION BY DEPARTMENT
BOLIVIA
1955 – 1964
(Thousands kilowatt-hours)

Year	La Paz	Cochabamba	Santa Cruz	Beni
1964	347.8	35.5	29.6	0.4
1963	342.5	33.3	27.5	0.4
1962	325.4	31.1	24.7	0.4
1961	314.1	31.2	18.5	0.4
1960	304.6	30.4	17.6	0.3
1959	286.6	28.0	14.6	0.3
1958	260.8	24.9	13.9	0.3
1957	230.0	24.0	12.4	0.3
1956	229.6	21.8	6.6	0.3
1955	231.2	22.8	2.6	0.3

Source: Republic of Bolivia, Dirección General de Estadística y Census, Boletín Estadístico, No. 91, La Paz, Bolivia, 1965, pp. 71-72.

Projected Rate of Air Traffic Increase

Route segment monthly traffic data provided by LAB for the period 1962-1966 was processed by an IBM 1620 computer in La Paz to yield growth trend information on the major airports of Bolivia. Trends indicated by this approach did not provide realistic guides for forecasting purposes due to serious aircraft accidents and other non-recurring adverse effects on traffic during the 1963-1965 period. Data quality may have been another element which distorted trend findings to unrealist levels.

Annual traffic volume at Cochabamba and Trinidad airports is estimated to increase at an annual rate of 12% to 1980 and thereafter at an 8% annual rate to 1990. Santa Cruz airport air traffic was projected at an annual growth rate of 15% from 1966 to 1980, and thereafter at 12% per year to 1990.

These estimates take into account the differential growth rates in population and economic growth between the cities noted above, future industrial development projects, and the size and character of their air trade areas. In the case of Trinidad, continuing development of the region as a major source of meat and hides in Bolivia will support further increases in the volume of air cargo.

Projections of domestic air passenger and international air cargo at El Alto International Airport are shown separately in the following chapter.

CHAPTER IX

TRINIDAD AIRPORT

PAVE RUNWAY, TAXIWAY AND APRON

The airport is located on the northeast side of the town of Trinidad. It is the principal air hub of the Beni. This jungle area is served only by air and river transport, no roads or rail lines penetrate the jungles of northeast Bolivia. There is a complete lack of direct surface transport to Trinidad. A deficiency of aggregate material makes the position of Trinidad unique when considering design and construction. For this reason our method of presentation will vary somewhat from the format used for the other airports.

Transport and Construction

Trinidad at an elevation of 505 feet lies in the flat flood plain of the Río Mamore. This river eventually flows to the Amazon and then to the Atlantic. The meandering rivers Ichilo, Grande and Chapare at their confluence at the Río Mamore dominate the soil structure in Trinidad. The river system has a considerable seasonal rise and fall.

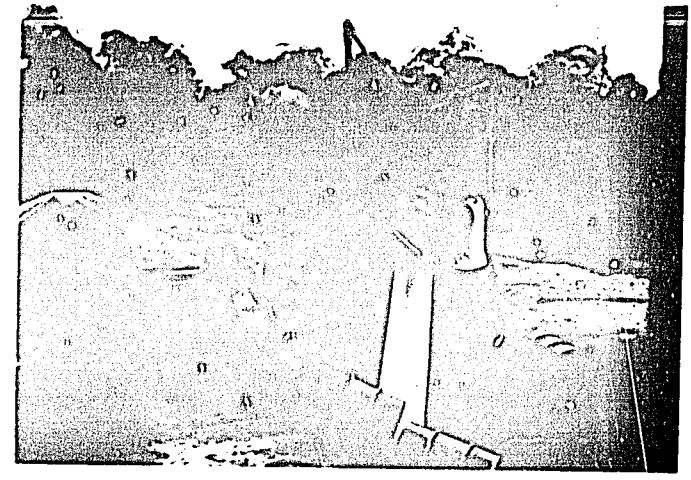
Pictures on pages 36 and 37 illustrate the problems of river transport. A reconnaissance journey from Cochabamba took eight days to complete. The road route to Villa Tunari is extremely hazardous. Narrow turns on mountain roads present formidable problems in the movement of larg immobile equipment. The present trucking system is limited to eight metric tons. The river crossing at Villa Tunari must be done on a pontoon of limited capacity.

Port facilities at San Francisco are inadequate and must be modified. Damp proof storage will be required at this location and at Trinidad. Loading will be by hand. Palletized loading is impossible because of the configuration of the river carriers.

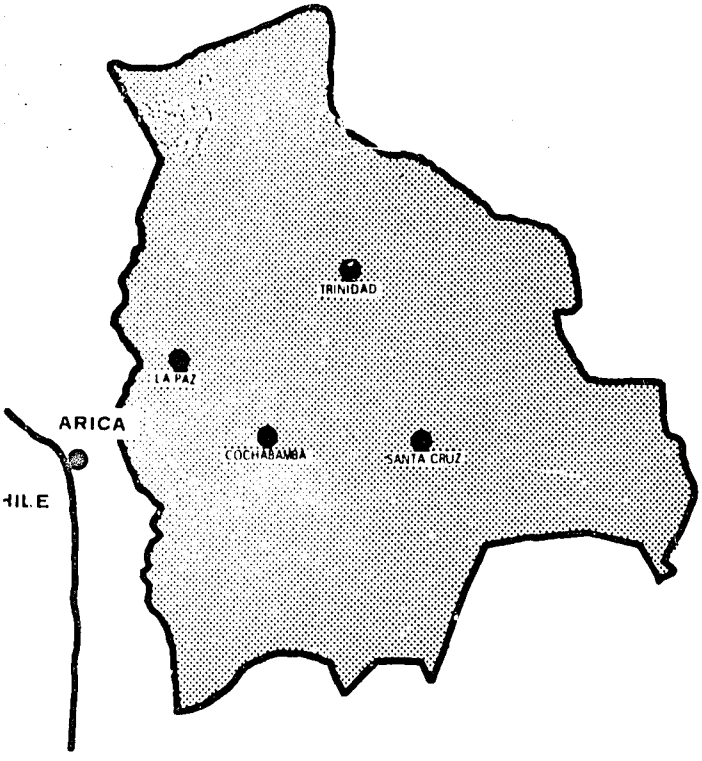
A heavy demand for truck and river transport will have an effect on the local economy. Conferences with agents and shippers indicated that stable prices can be maintained if planning and construction operations are coordinated and there is sufficient lead time.

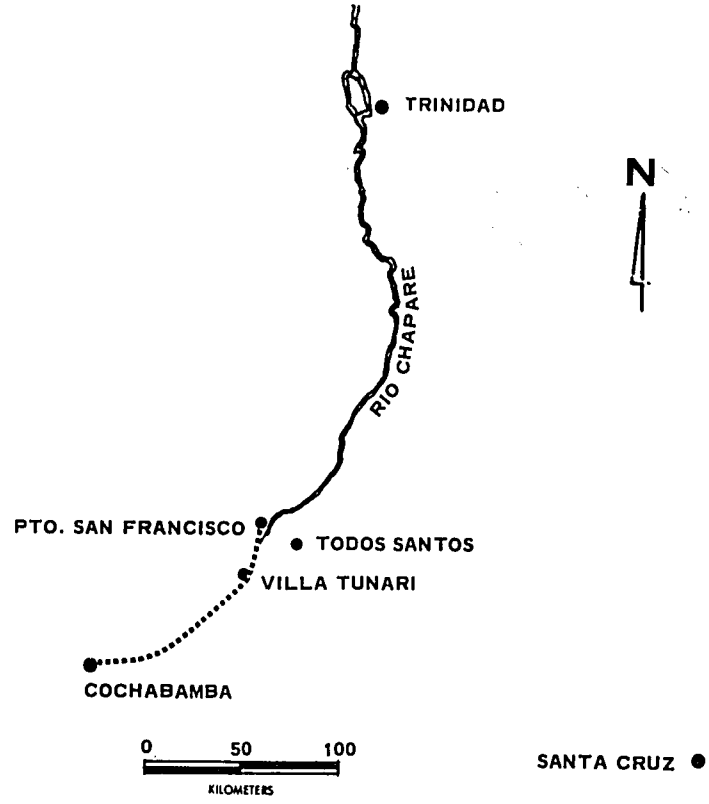
The snag infested river system and constant sandbar shifting will produce some cargo loss. Port facility at Almacen near Trinidad will require modification similar to that at San Francisco. The

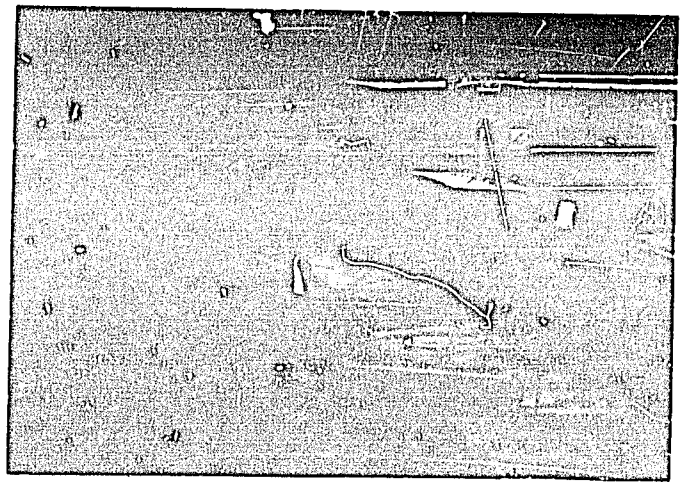
Pto. San Francisco



Pto. San Francisco







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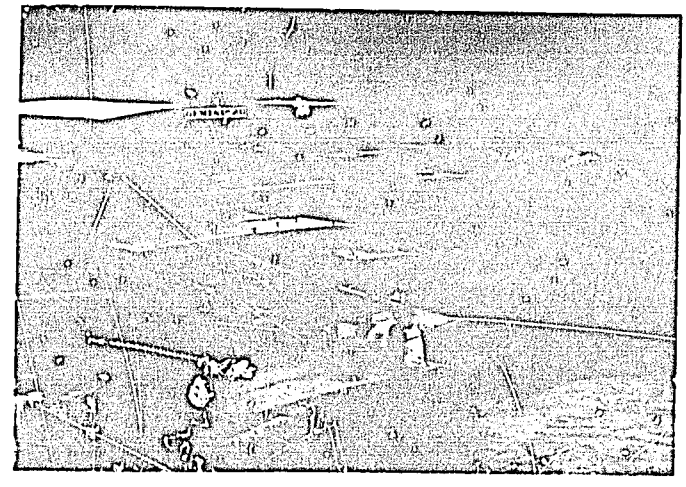

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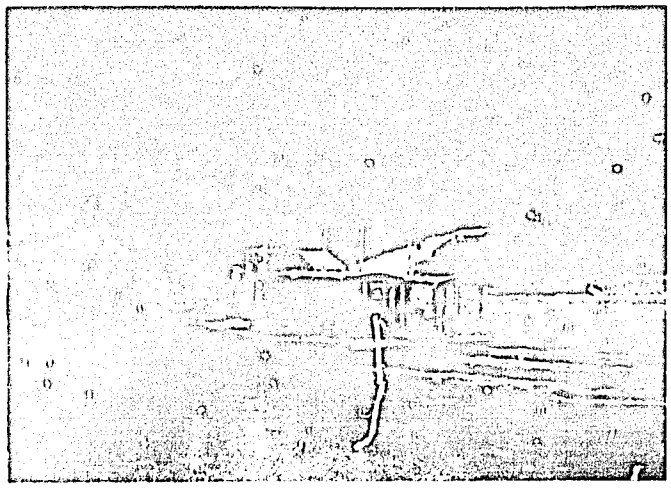
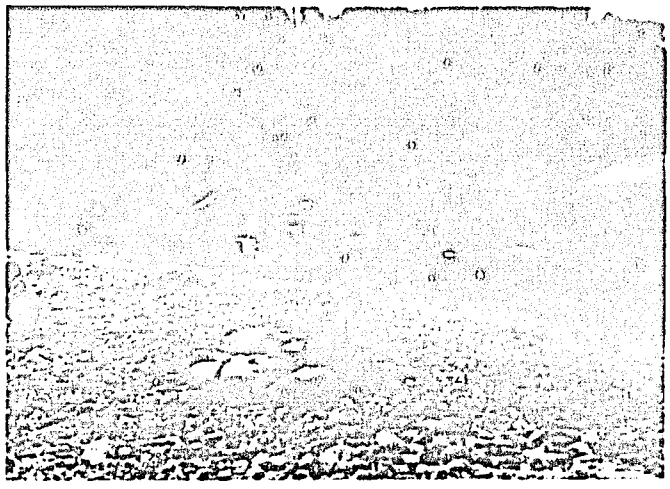
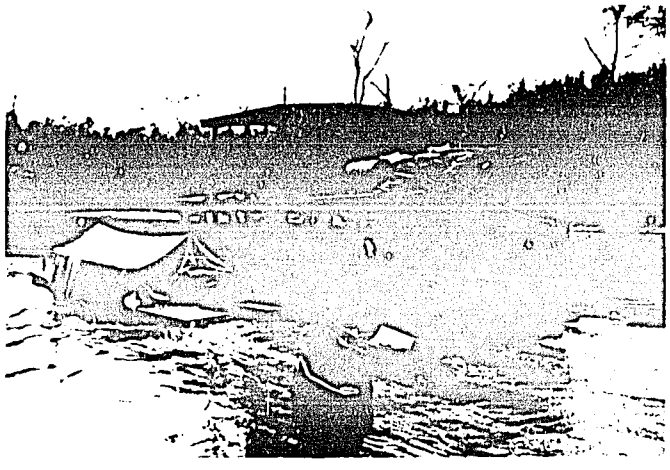
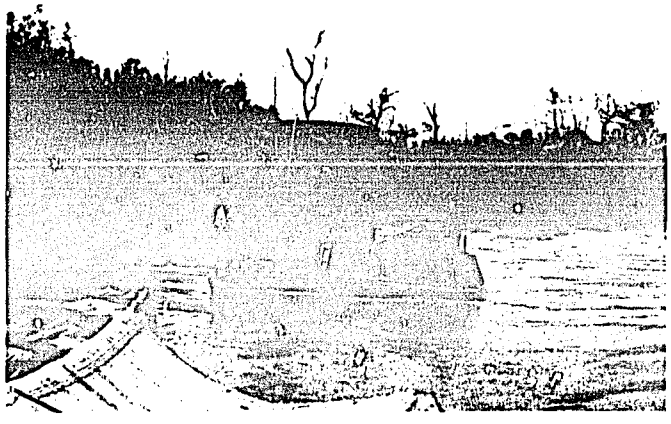


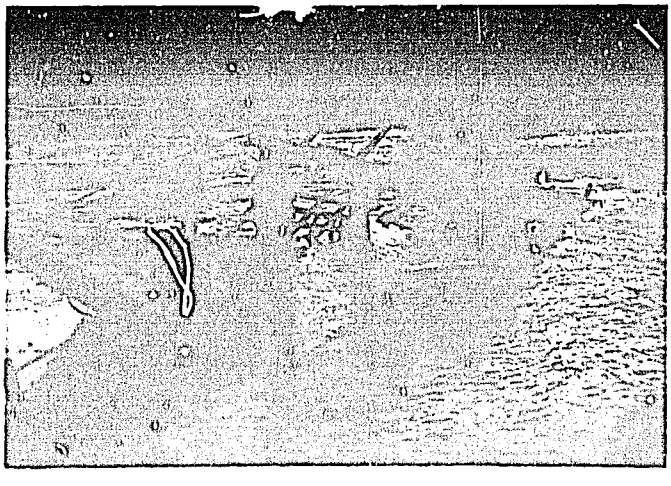
Villa Tunari

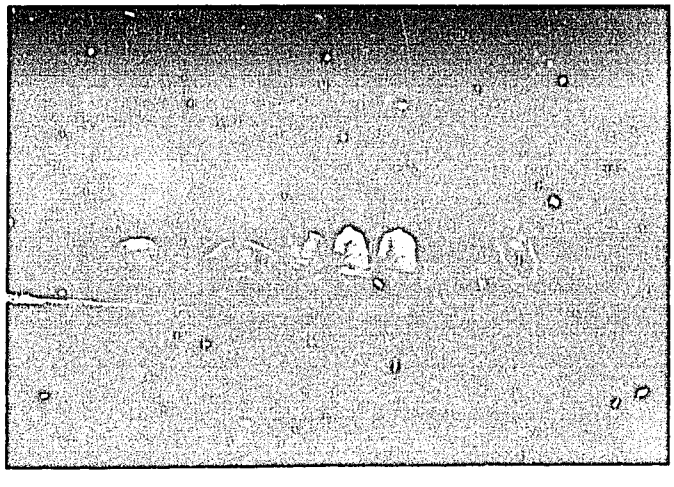


Villa Tunari









road between Almacen and Trinidad (approximately 10 kms.) must be reconstructed and maintained during the life of the airport project.

No aggregate is available in Trinidad. The closest known source is Villa Tunari approximately 310 kms. upstream. Aggregate is also available in the Guayaramerin-Riberalta area approximately 490 kms. downstream from Trinidad. This source was discounted because of the greater distance and the slowness and higher cost of hauling against the river current.

Soils Survey

The soil at Trinidad is water deposited with a minor amount being relocated by aeolian action. The entire area, to a feasible economic depth, is characterized as homogeneous clayey sands of medium plasticity, CL by the unified classification system. The complete lack of aggregate has a direct influence on design and construction.

The airport was sampled at nine sites to a depth of five feet. The results of these tests are displayed in Table IX-I.

Soil Stabilization

The lack of aggregate ballast in the soil accounts in part for the relatively low stability (low CBR value) of the soil in the natural state. The only possibility of using these soils for a moderately high wheel loading airport is by soil stabilization. Consequently, a representative portion of the Trinidad samples were subjected to a series of laboratory controlled stabilization tests using cement in one case and hydrated lime in the other. The soils were completely mixed into a representative homogeneous mixture. One portion was designated as a "Control" with no additive. Remaining portions were given 3%, 5%, 7% and 9% by weight additives of Class A Portland cement, cured for seven days and subjected to a CBR penetration. The results are given below.

	Sample No.	LL	PL	PI	MD*	CBR
1.	"Control (no additive)	29	16	14	125.6	11
2.	3% Cement	34	21	13	-Do-	65
3.	5% Cement	31	22	9	-Do-	82

4.	7% Cement	30	23	7	-Do-	93
5.	9% Cement	30	24	6	-Do-	133

*Maximum Density

The results of these tests indicate that approximately 6% by weight of cement would be required allowing for field conditions and possible minor variations in soil.

Trinidad Airport Design Alternate I

Design conditions for Alternate I are as follows:

(a) Airport improvements to accommodate Boeing 727-100 series aircraft. This is equivalent to the criteria established for Santa Cruz and Cochabamba.

(b) Maximum gross takeoff weight 161,000 pounds (73,000 kgs.); elevation 505 feet (164 meters) average daily maximum temperature hottest nonth 94°F (34.5°C).

Runway length required 8,600 feet (2,600 meters) width 150 feet (46 meters) with a loop turnaround taxiway at the northwest end and two access taxiways to the parking apron at the southeast end. Projected operations for the next five years are below 50,000 annually, therefore no improvement is planned for the existing parallel taxiway. In the pavement structural design, maximum advantage will be taken of the existing stabilized areas of the runway (station 0+00 to 16+00) two apron access taxiways and the terminal apron area.

Semi-rigid Pavement Design Section

(a) Runway Station: 0+000 to 1+600 and Taxiways "A" and "B" 3 inch sand asphalt surface applied in 2 inch and 1 inch separate lifts over base 8 inch cement stabilized soil to 100% Mod. Proctor density.

(b) Runway Station: 1+600 to 2+600 and Loop Taxiway "C" 3 inch sand asphalt surface applied in 2 inch and 1 inch separate lifts over base 8 inch cement stabilized soil to

TABLE IX-I

TRINIDAD AIRPORT SOILS EXPLORATION

Sample No.	Station (metric)	R/L	Gradation #10	% #40	Passing #200	Liquid Limit	Plastic Limit	Plastic Index	Maximum Density (lbs/cu. ft.)	Optimum Moisture	CBR Value 95% Proctor	CBR Value 100%	Classificatio Unified/FA
1	0-010	℄	100%	99%	96	44	18	26	121.1	13.4	4	7	CL/E-7
2	0+040	110L	100	99	95	45	19	26	120.9	12.1	6	9	CL/E-7
3	0+920	37R	100	99	96	44	18	26	121.9	13.2	9	12	CL/E-7
4	1+400	48L	100	94	94	37	17	20	127.3	10.8	5	8	CL/E-7
5	1+650	30R	100	99	98	47	20	27	123.6	12.7	4	7	CL/E-7
6	1+180	150L	100	97	95	40	22	18	119.6	12.9	5	9	CL/E-7
7	0+590	145L	100	98	94	42	18	24	122.7	14.1	11	17	CL/E-7
8	2+110	℄	100	98	92	29	16	13	125.6	11.1	9	12	CL/E-7
9	2+540	℄	100	99	96	36	21	15	124.7	13.6	6	9	CL/E-7

100% Mod. Proctor density over subbase 6 inch cement stabilized soil to 95% Mod. Proctor density.

Assumptions:

1. All materials for base course soils will be pulverized to pass No. 4 screen.
2. No more than four hours will pass between the union of soil and the final compaction and curing.
3. Construction joints will be used between separate days' work.
4. Hand placing of cement will not be allowed.
5. In the case of the sand asphalt wearing surface, maximum stability and flow (disregarding percentage of voids filled) will be determined by accepted laboratory methods i. e. Marshall system.
6. FAA subgrade reaction classification of F-5 with only moderate conditions of drainage with no frost possibility.

Rigid Pavement Design

(a) Parking: terminal apron only, 11 inches of Class A, unreinforced concrete. Over base 6 inch soil-cement stabilization.

Assumptions:

1. FAA subgrade reaction classification of RB with moderate drainage and no frost condition.
2. Design strength of concrete is 550 psi in flex (minimum 3,500 psi in compression) at 28 days.
3. No reinforcement or temperature steel employed.
4. Metallic load transfer devices used on all lateral and longitudinal joints.
5. "Snap" (contraction) joints to be formed rather than sawn.
6. Joint pattern established on a 15 feet module.
7. Curing compound applied no later than 45 minutes after union of water and cement.

Quantities

Semi-rigid soil cement pavement area:

R/W=2,600 M x 46 M = 119,600 SM (square meters)
T/W "A"=100 M x 23 M = 2,300 SM

T/W "B" = 110 M x 23 M	=	2,530 SM
T/W "C" = 300 M x 23 M	=	6,900 SM
		131,330 SM

Concrete rigid pavement area:

Apron = 170 M x 85 M	=	14,450 SM
Total Area		145,780 SM

Material Quantities

Semi-rigid pavement, soils/cement

R/W - 119,600 SM x 0.21 M	=	25,116 CM (cubic meters)
R/W - 1,000 M (new subbase) 46,000 SM x 0.15 M	=	6,900 CM
T/W "A" 2,300 SM x 0.21 M	=	485 CM
T/W "B" 2,530 SM x 0.21 M	=	530 CM
T/W "C" 6,900 SM x 0.21 M	=	1,450 CM
"C" (new subbase) 6,900 SM x 0.15 M	=	1,035 CM

Semi-rigid pavement, asphalt surfacing

131,330 SM x 0.078 M	=	10,245 CM
Rigid pavement, concrete apron: 14,450 SM x 0.28 M	=	4,050 CM
Rigid pavement, soils cement base apron: 14,450 SM x 0.153 M	=	2,210 CM

Excavation Quantities

Most of the excavated soils will be utilized in reworking the material into the soil/cement mixture.

Station 1 + 600 to 2 + 60 (Extended R/W)	
1,000 M x 50 M x 0.43	21,500 CM
Shoulder Areas	
2,900 M x 50 M x 0.46 M x 2	133,400 CM
	154,900 CM
Approximately 30% will be organic soils and will be wasted	- 46,470 CM
	108,430 CM

Construction Assumptions

The lack of readily available aggregate and direct surface transportation impose restrictions on both design and construction. Project time phasing is shown in Figure . The type of construction envisaged and construction plant required is as follows:

Step 1:

The top 6 inches (15 cms.) of soil will be removed between station 1 + 600 and 2 + 600, plus both sides of the runway station 0 + 000 to 2 + 600.

This estimated 46,000 ± CM will be removed and spoiled in a suitable area. The remaining material to the specified depth will be stockpiled along both sides of the runway in an attempt to air dry it in preparation for the cement additive. This action will have the dual purpose of immediately creating a negative shoulder gradient and providing material for soil stabilization.

Equipment:
6 each 5-6 yd. trucks
2 each D-7 size dozer with blade, one tire and one on tracks.
3 each front end loaders, two on tires and one on tracks.
2 each M-12 size road graders with blades and rooters

Time: 3-1/2 months

Step 2:

(occurring concurrently with Step 1 but with a two month time lag)

The airdried earth stockpiled in Step 1 adjacent to the runway will either be moved onto the runway in windrows or carried directly to a mixer-compactor, preferably to a mixer-compactor where quality control will be infinitely superior. The soil cement mixture with water added will be placed in a uniform thickness (8 inches maximum depth) and receive initial compaction with a grid or sheepsfoot vibratory compactor. Following this initial compaction, a

pneumatic compactor, self powered will continue rolling until 95% or 100% of modified Proctor density has been achieved. Finally, a steel wheel tandem roller of 8-10 tons will bring the surface to approximately 1/4 inch in 10 foot tolerance. Immediately afterwards, a coating of MC-3 will be applied at the rate of 0.25 gals./sq. yd. This application will serve as a curing compound and tack coat for subsequent sand asphalt surface.

Equipment:

1 each soil cement mixer with bulker, tamper-leveler miscellaneous metal forms
1 each grid-sheepsfoot (2 drum width) vibratory compactor
2 each pneumatic wheeled compactors, preferably self-propelled
2 each 8-10 ton tandem steel wheeled rollers
1 each asphaltic heater-spreader with 10 foot spray bore and hand spray attachments, minimum of 600 gallons capacity
3 each 5 c.y. trucks (previously mentioned)
1 rubber type front end loader (previously mentioned)

Time: 8 months

Step 3:

(Starting 2-1/2 months after beginning of Step 2)

A selected local sand will be dried and mixed with a penetration grade (120-150) asphalt in an amount determined by laboratory analysis for maximum stability and minimum flow. Approximately 9% AC. The hot mix will be placed over the soil/cement stabilization in 2 inch and 1 inch thicknesses respectively. Both of these hot mix applications will receive initial compaction with a three wheel tractor roller followed immediately with light load pneumatic roller and final application of an 8 ton tandem roller to maximum density.

Equipment:

1 each 25 ton/hr. continuous mix asphalt plant with dryer and gradation unit.
1 each track type asphalt lay down machine with heater bar and tampers.

1 each three-wheel roller
2 each pneumatic roller of eight tire width, tractor hauled.
2 each 8 ton tandem rollers steel wheel
3 each 5 c. y. trucks with covers and wood insulation for short haul.

Time: 7 months

Step 4:

Apron concrete (beginning 3 months after beginning R/W soils/cement operation)

A base course of soils cement using parent soils will be placed 6 inches in depth and cured similar to the runway process. Using steel forms placed to line and grade, unreinforced concrete will be placed to required thickness in a 15 foot module. The concrete will be compacted by hand vibrators and wooden vibratory float. Finishing will be done manually with final "striking" done with a burlap broom drag. Curing compound will be pressure applied by hand. Contraction joints will be formed by manual means.

Equipment:
4 each weigh batch, 1/3 c. y. mixer
- miscellaneous forms
- miscellaneous hand tools, vibrators
3 each powered "Georgia buggies"
1 pressure during compound applicator
1 joint seal applicator w/heater

Time: 3-1/2 months

Step 5:

Shoulder grading

Shoulders of all paved areas to be given a negative fall of 2-3% with water lead away to suitable area.

Equipment:
2 each M-12 type graders (previously mentioned)
1 front end loader (previously mentioned)
2 five c. y. trucks (previously mentioned)

Paving Costs - Trinidad Alternate I

Because of the unique problems presented at Trinidad this cost estimate has been developed in a manner that reflects the effect of location and transport difficulties on project costs. Further, it is established that the type of equipment required for this project is not available in Bolivia. The depreciation of the equipment is therefore based on the U.S. rental price and reasonable market value for used equipment at Cochabamba.

Transportation constitutes a considerable portion of the airfield cost. Transport prices are firm as of November 1967. Prices between Cochabamba, Porto de San Francisco, down river to Porto de Almacen and to Trinidad have been verified by a personal reconnaissance of the route to determine the condition of the roadways, port and dock facilities, and actual water carrier availability and capability.

Material Costs (at job site)

Cement Assumed compacted density 122.9 lbs./cu. ft. specific gravity 1.97. Six percent by weight additive.

Basic requirement 130,100 bags	5,725 MT (metric tons)	
Loss Allowance 10%	573 MT	
Total cement 143,110 bags	6,298 MT	
Source Viacha, Bolivia F.O.B. @ $2.16/bag		
143,110 bags @ $2.16		$309,117

Asphalt Hot mix sand asphalt assumed compacted density of 155.3 lbs./cu. ft. bulk specific gravity 2.49. Nine percent weight asphaltic cement added as binder. 10,245 CM.

Basic requirement	2,295 MT	
Loss Allowance 8%	185 MT	
	2,480 MT	
MC-3 curing/tack	140 MT	
Total Asphalt	2,620 MT	
2,620 MT @ $105/MT F.O.B. Arica, Chile		$275,100

Aggregate Apron only.

Basic requirement 5,600 CM (14,000 MT)	
2 inch size F.O.B. Villa Tunari $2.80/CM 5,600 CM x $2.80	$ 15,680

Sand Apron only.	
Basic requirement 3,400 CM (5,200 MT)	
3,400 CM x $1.20/CM	$ 4,080
Subtotal Material Cost	$603,977
Insurance 1-1/2%	$ 9,059
Freight	
Cement. Rail Viacha-Cochabamba	
6,298 MT @ $10.38/T	$ 65,373
Road, Cochabamba-Porto San Francisco River to Trinidad. 6,298 MT @ $36.00/T	$226,728
Asphalt. Rail Arica-Cochabamba	
2,620 MT @ $22.67/T	$ 59,395
Road and river to Trinidad. 2,620 MT @ $36.00/T	$ 94,320
Aggregate. Road and river - Villa Tunari to Trinidad.	
14,000 MT @ $23.83/T	$333,620
Sand. Loca source	
5,200 MT @ $9.16/T	$ 47,632
Storage and Warehousing	$ 55,000
Subtotal Materials Transportation	$891,127
Equipment Costs	
Depreciation Chargeable to Trinidad project 35% of $865,000 initial cost	$302,750
Spare parts 12%	$ 36,330
Insurance 3% Cochabamba - Trinidad and return to Cochabamba 3% x 865,000	$ 25,900
Freight U.S. to Arica	$ 45,500

Arica to Cochabamba 615 MT @ $31.30	$ 19,250
Cochabamba - Trinidad and return charged by units - one way $13,000	$ 26,000
Subtotal Equipment Costs	$445,730

Other Costs

Fuel and Lubricants (POL) 600 days @ $280/day	$168,000
Miscellaneous - Runway marking	26,000
Labor 600 days @ $900/day	540,000
Subtotal Other Costs	$734,000
Subtotal	$2,684,834
4% Contractor Contingency	107,393
	$2,793,227
17% Contractor Overhead and Profit	474,848
	$3,268,075
12% Design and Supervision	392,169
	$3,660,244
10% Contingency	366,024
	$4,026,268
Interest during Construction	
(a) 600 days @ 12%	397,151
(b) 600 days @ 15%	496,438

Pavement Capital Costs Trinidad Alternate I

(a)	(b)
$4,423,419	$4,522,706

Fencing - Trinidad Alternate I

U.S. purchased cost in place @ $11/Linear Meter 8,019 meters required @ $11/LM	$ 88,205
12% Design and Supervision	10,585
	$ 98,790
10% Contingency	9,879
	$108,669

Interest during Construction	
(a) 90 days @ 12%	$ 1,630
(b) 90 days @ 15%	$ 2,037

Fencing Capital Costs	(a)	(b)
	$ 110,299	$ 110,706

Totals:

	(a)	(b)
Pavement Capital Cost	$4,423,419	$4,522,706
Fencing Capital Cost	110,299	110,706
	$4,533,718	$4,633,412

Lighting Costs - Trinidad Alternate I

L802 Stake Mounted R/W Lights incl. Lamps (85 @ $32)	$ 2,720
L822 Stake Mounted T/W Lights incl. Lamps (55 @ $35)	1,925
L833 Insulating Tranformer, Direct Burial (140 @ $25)	3,500
L823 Cable Connector Kits (140 @ $10)	1,400
L824 B Series Lighting Cable 14,500 M	7,400
#6 Bare Ground Wire 7,000 M (23,000 ft. @ 90/1,000 ft.)	1,920
Apron Lighting	
50 ft. Steel Poles (4 @ 300)	1,200
Mercury Floodlights incl. Lamps (4 @ 200)	800
Incandescent Floodlights incl. Lamps (16 @ 80)	1,280
Plus all other items listed under Alternate II	25,085
	$ 47,230
30% Transportation	14,170
	61,400
Contractors Labor and Profit	12,500
	73,900
12% Design and Supervision	8,868
	82,768
10% Contingency	8,276
	91,044
Interest during Construction	
(a) 90 days @ 12%	1,366
(b) 90 days @ 15%	1,707

Lighting Capital Costs	(a)	(b)
	$ 92,410	$ 92,751

Operating and Maintenance Costs - Trinidad Alternate I

	(a)	(b)
Pavement	$ 239,366	$ 244,629
Fencing	3,309	3,321
Lighting	4,620	4,637
Total Operating and Maintenance Costs	$ 247,295	$ 252,587

Trinidad Airport Design - Alternate II

Design conditions for Alternate II are as follows:

(a) Airport improvements to accommodate jet-prop aircraft similar to the Fairchild F-27K. This proposed minimum improvement will provide a usable runway under all wet weather conditions. It provides a paved surface and establishes positive surface drainage.

(b) Runway length, existing 5,248 feet (1,600 meters), width 150 feet (46 meters) with two access taxiways to a minimum parking apron.

(c) A 6 inch (15 cm.) soil cement base 100% Mod. Proctor density with a double bituminous surface treatment (DBST) is proposed. This asphalt surfacing will improve the running surface and protect the base and subbase. It is the most economically acceptable surfacing possible under existing transportation difficulties and lack of local building materials.

Construction Process

The construction process requires minimum time, equipment and material. Minor grade difficulties will be corrected where necessary before major construction begins. Placement of soil cement base will be in accordance with assumptions and methods described for Alternate I. DBST will be applied in the following manner: a spreader truck with 10 foot spray bar will make the initial application. A tail gate truck will make a "quick hitch" to a standard screw feed aggregate spreader backing over the hot applied asphalt cutback. A steel wheel 8 ton roller will immediately follow for full coverage. This will be followed by tractor draw wobble wheel 10 ton roller for a maximum number of passes.

Actual construction time 60 days. (Total contract period 180 days)

Paving Costs - Trinidad Alternate II

Apron	110 M x 50 M	=	5,500 SM (Square Meters)
T/W "A"	130 M x 20 M	=	2,600 SM

T/W "B"	105 M x 20 M	=	2,100 SM
R/W (existing)	1,600 M x 46 M	=	73,600 SM
			83,800 SM

Material Quantities

Semi-rigid pavement, soil/cement

Apron	5,500 SM x 0.15 M	=	825 CM (Cubic Meter)
T/W "A"	2,600 SM x 0.15 M	=	390 CM
T/W "B"	2,100 SM x 0.15 M	=	315 CM
R/W	73,600 SM x 0.15 M	=	11,040 CM
Total base	83,800 SM x 0.15 M	=	12,570 CM

Cement Assumed compacted density 122.9 lbs./cu.ft. Specific gravity 1.97. Six percent by weight added.

Basic requirement 3,273,470 lbs.
or
1,485 MT (Metric Tons)
or
0.018 MT/SM

Asphalt MC-5 (MC-3000) based on a rate of application of 0.25 gal./SY first course and 0.35 gal./SY for second course. (SY = Square Yard).

Basic requirement	232 MT (metric tons)
Loss Allowance 10%	24 MT
Total Asphalt Required	256 MT

Aggregate Crushed and graded to 3/4 inch amount of minus #10 size must be kept to absolute minimum. Bulk specific gravity assumed 1.75. Rate of spread ratio of 1 CM (Cubic Meter) per 60 SM (Square Meters) for the first course and 1 CM per 100 SM for the second course.

Basic requirements		
1st course	3/4 in. size	1,400 CM
2nd course	3/4 in. size	840 CM
		2,240 CM
Loss Allowance 10%		224 CM
		2,464 CM

Material Costs (at job site)

52 (a) next . . .

Cement		
Basic requirement	1,485 MT	
Loss Allowance 10%	149 MT	
	1,634 MT	
Source - FANCESA, Sucre $b 27.80/50 kilo-bag at Cochabamba or $46.33/MT x 1,634		$ 75,703
Asphalt		
250 MT @ 105/Ton F.O.B. Arica		26,880
Aggregate		
2,500 CM @ $6/CM At source Villa Tunari		15,000
Subtotal Material Costs		$117,583
Insurance 1-1/2%		1,764
Freight		
Cement, Road Cochabamba-Porto San Francisco River to Trinidad 1,634 MT @ $36.00		$ 58,825
Asphalt. Railroad Arica-Cochabamba 256 MT @ $22.67/T		5,803
Road, Cochabamba-Porto San Francisco River to Trinidad. 256 MT @ $36.00/T		9,216
Aggregate. Road and river - Villa Tunari to San Francisco to Trinidad 4,875 MT @ $29.50/T		143,813
Subtotal Material Transport		$219,421
Equipment Costs		
Depreciation. Chargeable to Trinidad project 35% of $300,000 initial cost		105,000
Spare parts 12%		12,600

Insurance	3% Cochabamba-Trinidad return to Cochabamba	9,000
Freight	U.S. to Arica	10,000
	Arica to Cochabamba 105 MT @ $31.30/T	3,756
	Cochabamba - Trinidad and return charged by units - total $4,800 one way	10,000
	Subtotal Equipment Costs	$150,356
Other Costs		
Fuel and Lubricants (POL) 120 days @ $115/day		$ 13,800
Miscellaneous - Runway marking		9,500
Labor 25 Man force $450/day for 120 days		54,000
	Subtotal Other Costs	$ 77,300
	Subtotal	$564,660
4% Contractor Contingency		22,586
		$587,246
17% Contractor Overhead and Profit		99,831
		$687,077
12% Design and Supervision		82,449
		$769,526
10% Contingency		76,952
		$846,478

Unit Cost

1-1/2-inch (4 cm.) DBST	$ 5.80
Cement for base (0.018 metric ton/SM)	1.85
6-inch (15 cm.) soil-cement base construction	2.30
Miscellaneous work	0.15
Total per square meter	$10.10

Interest during Construction	
(a) 180 days @ 12%	$ 25,394
(b) 180 days @ 15%	$ 31,743
Pavement Capital Costs - Trinidad Alternate II Interest during construction excluded	$846,478

Pavement Capital Costs - Trinidad Alternate II	(a)	(b)
(a) 12% (b) 15%	$871,872	$888,221

Fencing - Trinidad

U.S. purchased cost in place @ $11/Linear Meter 6,411 meters required @ $11/LM	$ 70,525
12% Design and Supervision	8,463
	$ 78,988
10% Contingency	7,898
	$ 86,886
Interest during Construction	
(a) 90 days @ 12%	$ 1,304
(b) 90 days @ 15%	$ 1,630
Fencing Capital Costs Interest during construction excluded	$ 86,886

Fencing Capital Costs	(a)	(b)
(a) 12% (b) 15%	$ 88,190	$ 88,516

Totals:

	(a)	(b)
Pavement Capital Cost	$871,872	$888,221
Fencing Capital Cost	88,190	88,516
	$960,062	$976,737

Lighting - Trinidad Alternate II

A medium intensity lighting system is specified. Terrain warning lights are not required.

Electric Inventory

Power Source; Airport generators. The city power is unreliable with output characterized by extreme voltage variation. No plan exists to improve the city power system in the near future.

Generators: Primary

2-Kohler Model 10M61
8 KW 10 KVA
115-230 AC
60 cycle
1,200 RPM
Powered by Waukesha 4 cylinder motors FC186-G

Generator: Secondary

Ready Power Electric Plant Model RD14A
25 KVA
120-240 V
60 cycle
1,200 RPM
Powered by International Harvester 4 cylinder Diesel
This unit is inoperative because of maintenance needs.

Lighting Costs - Trinidad Alternate II

L802 Stake Mounted R/W Lights incl. Lamps (61 @ $32)	1,952
L822 Stake Mounted T/W Lights incl. Lamps (55 @ $35)	2,900
L833 Insulating Transformer, Direct Burial (116 @ $25)	2,900
L823 Cable Connector Kits (116 @ $10)	1,160
L824B Series Lighting Cable 12,000 M (39,500 ft. @ $155/1,000 ft.)	6,122
#6 Bare Ground Wire, 5,500 M (14,800 ft. @ $90/1,000 ft.)	1,329
L812 Regulator, 240 Volt Supply 7-1/2 KW (2 @ $1,500)	3,000
Circuit Breaker Panel (2 @ $85)	170
Relay in Cabinet (2 @ $50)	100
L816 Selector Switch (2 @ $850)	1,700
Power Transformer 15 KVA 2,400-120/240 Voltage (1 @ $225)	225
Feeder Circuits (2 @ $70)	140
2,400 Volt Service (1 @ 150)	150
L821 Tower Control Panel (1 @ $200)	200

Apron Lighting

50 ft. Steel Poles (3 @ $300)	$ 900
Mercury Floodlights incl. Lamps (3 @ $200)	600
Incandescent Floodlights incl. Lamps (12 @ $80)	960
Circuit Breakers, Contactors and Wiring	345
Subtotal	$ 25,153

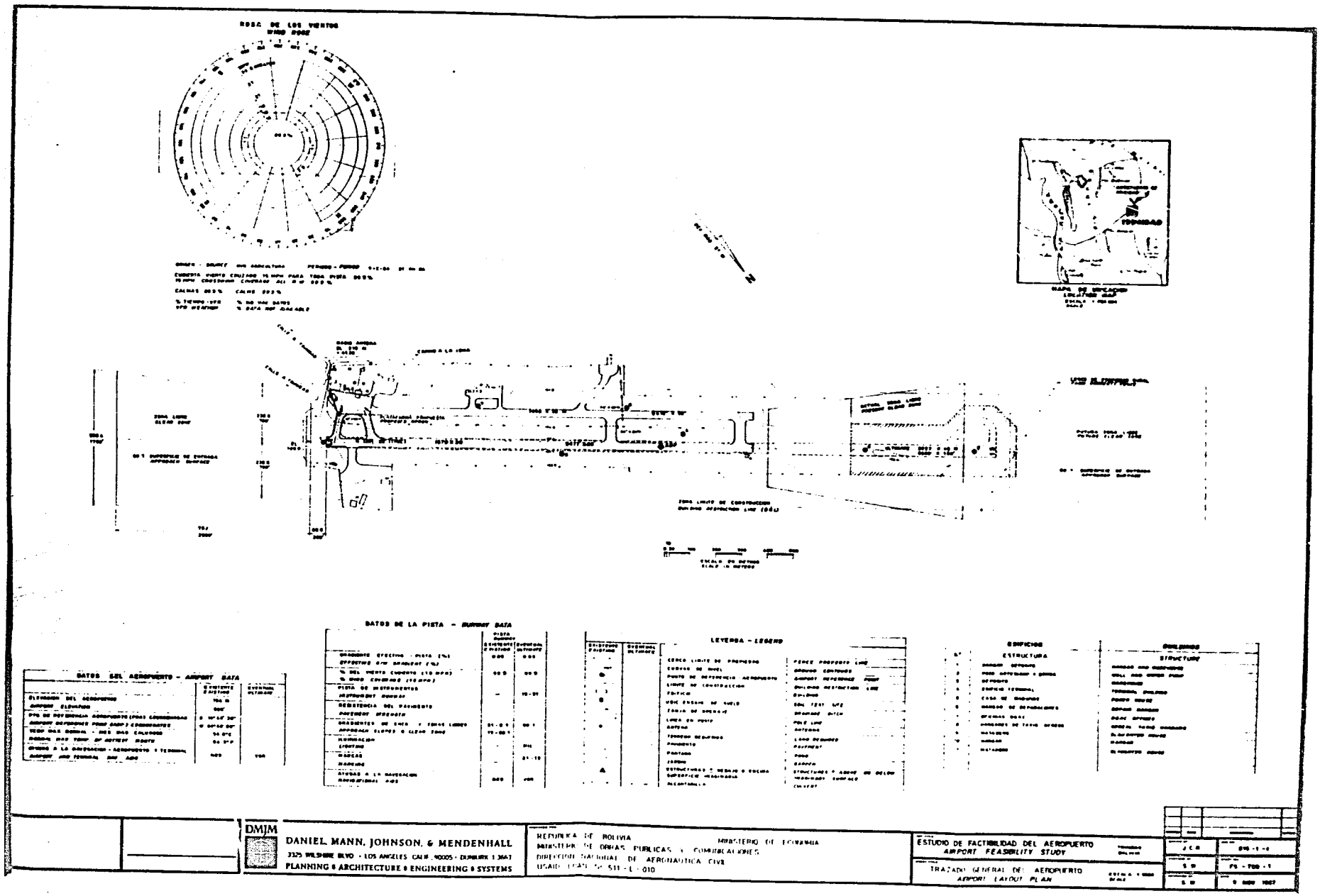
Standby Power and Beacon

Diesel-Generator 150 KW Complete	
Less Fuel Tanks (150 KW @ $100/KW)	15,000
	$ 40,153
Beacon - 36 inch Rotating	2,300
Tower - 51 foot Steel Tower	1,600
	$ 44,053
30% Transportation	13,215
	$ 57,268
Contractors Labor and Profit	11,500
	$ 68,768
12% Design and Supervision	8,252
	$ 77,020
10% Contingency	7,702
	$ 84,722
Interest during Construction	
(a) 90 days @ 12%	1,270
(b) 90 days @ 15%	1,588
Lighting Capital Costs Interest during construction excluded	$ 84,722

Lighting Capital Costs	(a)	(b)
(a) 12% (b) 15%	$ 85,992	$ 86,310

Operating and Maintenance Costs - Trinidad Alternate II

	(a)	(b)
Pavement	$ 73,237	$ 75,498
Fencing	2,645	2,655
Lighting	4,299	4,315
Total Operating and Maintenance Costs	$ 80,181	$ 82,468



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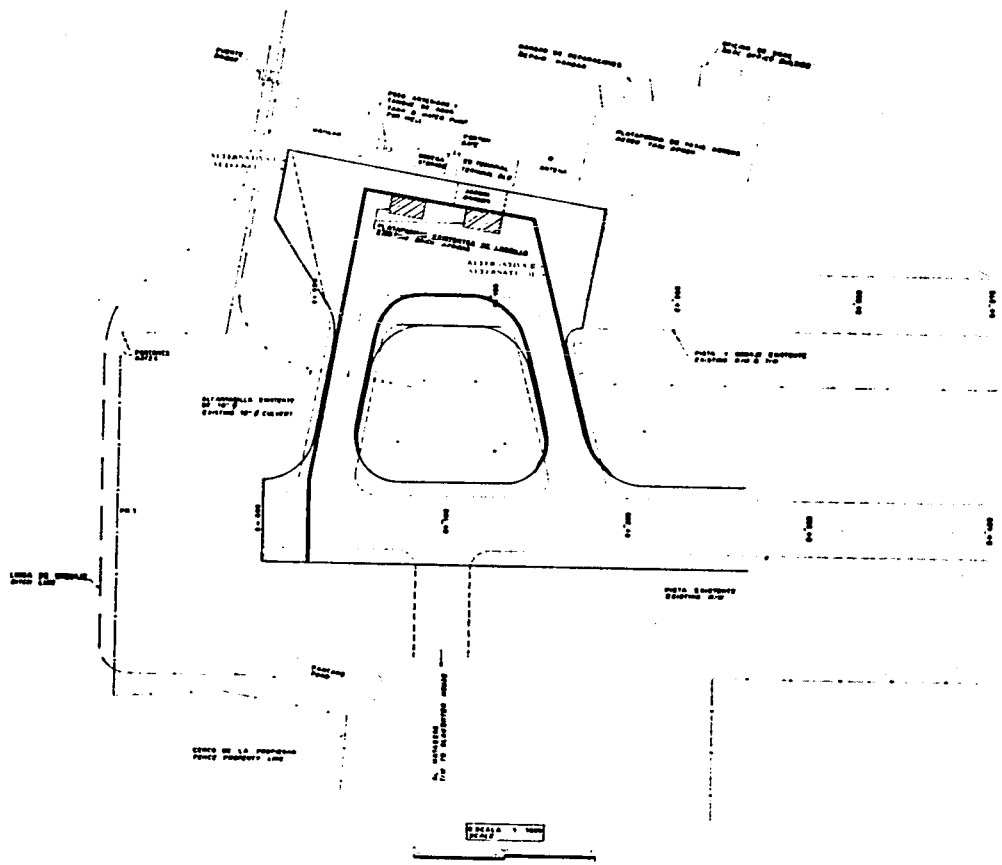

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REPUBLICA DE BOLIVIA — MINISTERIO DE ECONOMIA

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DIRECCION NACIONAL DE AERONAUTICA CIVIL

USAID LOAN Nº 511 - L - 010

ESTUDIO DE FACTIBILIDAD DEL AEROPUERTO

AIRPORT FEASIBILITY STUDY

PLATAFORMA DE AVION

AIRCRAFT APRON

J.C.B.

S.W.

S.W.

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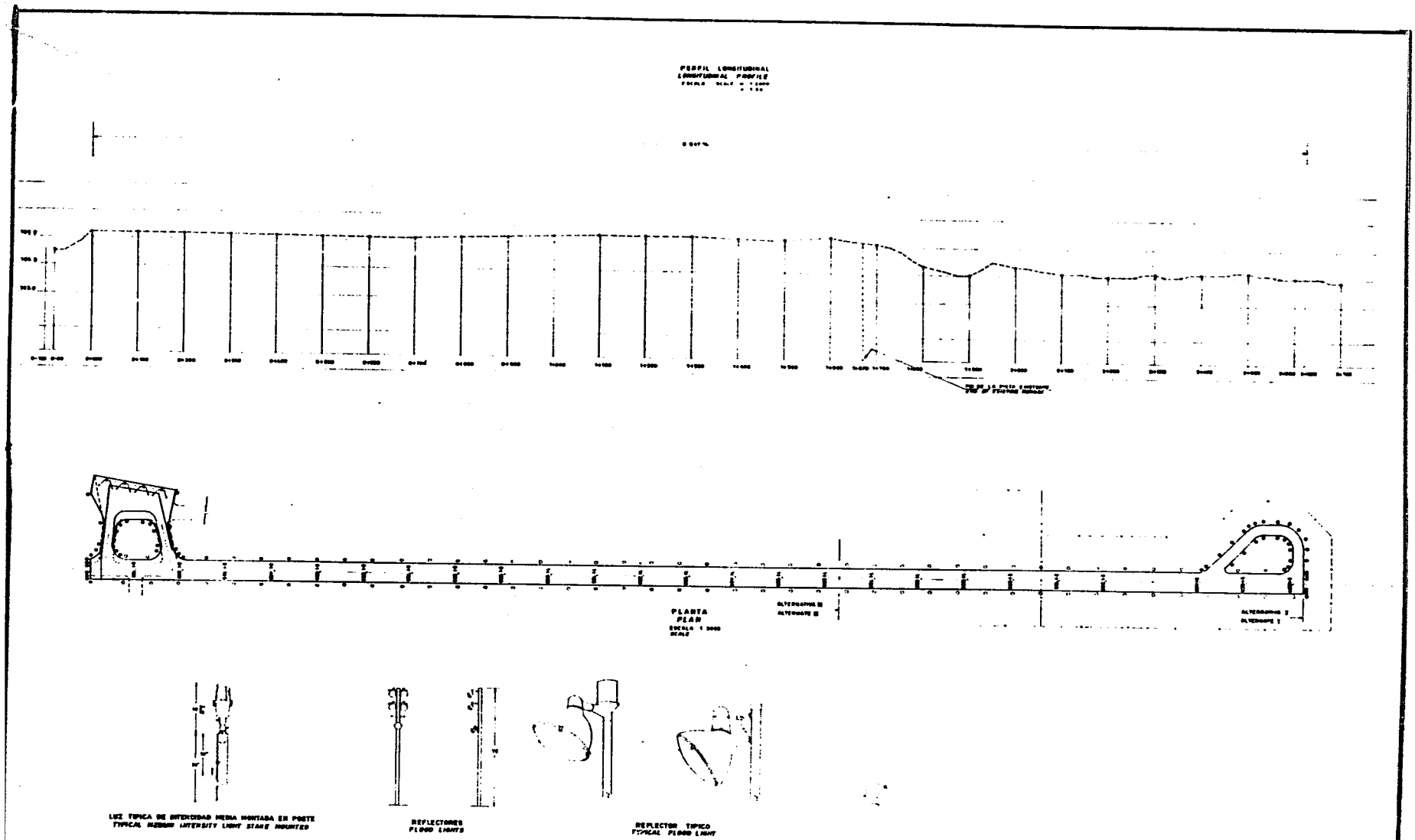

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ESTUDIO DE FACTIBILIDAD DEL AEROPUERTO
AIRPORT FEASIBILITY STUDY

PLANTA Y PERFIL — PLAN AND PROFILE

SISTEMA ELECTRICO — ELECTRICAL

J.C.R.

BYS - E - 3

S.W.

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S.W.

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ECONOMIC JUSTIFICATION - Trinidad Paving

Project Description

The proposed improvement consists of paving the following areas at Trinidad Airport:

1. runway
2. taxiway
3. aircraft parking apron.

Two alternate project designs were developed: Alternate I which is capable of serving jet aircraft, and Alternate II which cannot handle jet aircraft but which can accommodate the Fairchild F-27K turbo-prop and would also substantially improve the operating characteristics of the airport for conventional propeller aircraft.

Period of Analysis

The period of analysis for the proposed paving project is 20 years, based on the estimated service life of the pavement under the contemplated type and volume of air traffic, and local meteorological conditions.

Interest Rate

A 12 percent interest rate is used for project economic justification calculations. This rate is equal to the current rate for long-term investments in Bolivia. For purposes of sensitivity analysis a 15 percent rate is also employed.

Projected Growth of Air Traffic at Trinidad Airport

Air traffic volume is expected to increase at Trinidad Airport during the period 1966-1990 as shown below. Both Alternate I and II designs have a maximum capacity of 50,000 operations per year.

Traffic growth was projected at 12 percent per year during the period 1966-1980 and 8 percent thereafter. In 1980 the proposed runway improvement with stub taxiways will achieve its maximum capacity of 50,000 operations annually. Construction of a parallel taxiway in 1980 would increase runway capacity to in excess of 150,000 operations annually. No adjustment was made in the number of projected operations due to future replacement of present propeller aircraft used by LAB with jet and turbo-prop aircraft. The Boeing 727-100 has a maximum

payload capacity of 29,090 pounds and the Fairchild F-27K 10,445 pounds in comparison with the 23,360 pounds of the DC-6B seats up to 68 passengers and the Boeing 727-100, 119 passengers and the Fairchild F-27K, 44 passengers. Non-scheduled domestic airline and private aircraft are expected to continue to be predominantly propeller-driven types.

AIRCRAFT OPERATIONS

Year	Projected Annual Operations	Projected Operations Growth Index (1966 = 100)	Projected Actual Annual Operations With Proposed Improvement	Growth Index (1966 = 100)
1990	136,272	981	54,115	390
1985	92,742	668	54,115	390
1980	63,125	454	54,115	390
1978	54,115	390	54,115	390
1975	38,518	277	38,518	277
1970	21,856	157	21,856	157
1966	13,890	100	13,890	100

Project Costs

Capital Cost

Pavement and fence construction costs computed at a) 12% interest and b) 15% interest are as follows:

Alternate I - Jet Airport

	(a)	(b)
Pavement	$4,423,419	$4,522,706
Fencing	110,299	110,706
	$4,533,718	$4,633,412

Alternate II - Turbo Prop/Propeller Airport

	(a)	(b)
Pavement	$ 871,872	$ 888,221
Fencing	88,190	88,516
Total Capital Cost	$ 960,062	$ 976,737

Annual Cost

Alternate I - Jet Airport

Amortization of Capital Cost	(a)	(b)
20 years @ 12% (.1339 x $4,533,718)	$607,065	
20 years @ 15% (.1598 x $4,633,412)		$740,420
Maintenance Cost		
Pavement	$239,366	$244,629
Fencing	3,309	3,321
Total Annual Cost	$849,740	$988,370

Alternate II - Turbo Prop/Propeller Airport

Amortization of Capital Cost		
20 years @ 12% (.1339 x $960,062)	$128,552	
20 years @ 15% (.1598 x $976,737)		$156,083
Maintenance Cost		
Pavement	$ 73,237	$ 75,498
Fencing	2,645	2,655
Total Annual Cost	$204,434	$234,236

Project Benefits

The unpaved runway, taxiways, and aircraft parking area at Trinidad airport are in a state of deterioration as a result of weathering and the effects of heavy air traffic. Poor drainage of the runway frequently prevents aircraft operations due to flooding after rains. The present condition of the runway create an aircraft safety hazard for landings in wet weather and give rise to added aircraft maintenance and repair costs.

Economic benefits created by the proposed paving at Trinidad airport are derived from the following sources and valued at the 1966 traffic volume:

Increase in Net Revenues by addition of Turbo-Prop Aircraft Service:	$ 14,000
All-weather Airport Use Benefit	10,000

Reduction in Aircraft Accident Costs:

Aircraft Destroyed	$ 46,375
Aircraft Damaged	5,343
Accident Investigation Costs	2,100
Loss to Employer from Passenger or Crew Fatalities	500
	$ 54,318

Reduction in Aircraft Maintenance and Repair Costs:

Tire	$ 1,224
Propeller	1,700
Fuselage	1,200
	$ 4,124

Reduction in Economic Cost of Aircraft Accident Fatalities:

12%	$ 484
15%	$ 412

Total Benefits	(a)	(b)
	$ 82,926	$ 82,854

Paved runway, taxiway and parking areas will facilitate the introduction of turbo-prop aircraft service at Trinidad. Benefits from this source are estimated at $14,000 at 1966 traffic volume. The advent of jet service stimulates the volume of air traffic revenues 5 percent to 10 percent and reduces operating costs, as indicated by the experience of other countries. Turbo-prop aircraft are expected to show approximately the same results when they replace the Douglas DC-3 which is now the dominant type of passenger aircraft serving Trinidad.

Trinidad airport is frequently subject to heavy tropical rains during the summer season from December to February, causing flooding and slippery runway conditions that prevent aircraft departures and arrivals. The proposed pavement and drainage improvements will permit all wet weather airport utilization. The benefit from this increased airport use is estimated at $10,000 annually at 1966 traffic levels.

Benefits attributable to reduction of airport pavement-related accidents amount to $54,318 at 1966 air traffic levels. Accident reduction benefits were computed as shown in Appendix E.

Reduction in aircraft tire, propeller and fuselage repair costs amount to $4,124 at the 1966 traffic level. See Appendix E for method of computing these benefits for Trinidad Airport.

The computation of the present value total benefits over the service life of the proposed pavement improvement is shown on page 66. A maximum runway capacity of 50,000 aircraft operations annually, as designed without parallel taxiway, places an upper limit on attainable operations and benefits.

Economic Justification

Net Present Value

The net present values of Alternates I and II are shown as computed below.

Alternate I - Jet Airport

	(a)	(b)
Present Value Total Annual Benefits	$1,868,534	$1,520,476
Present Value Total Annual Costs		
(a) 20 years @ 12% (7.4692 x $849,740)	6,346,878	
(b) 20 years @ 15% (6.2593 x $988,370)		6,186,505

Negative net present values result from Alternate I, rendering the project not economically justifiable.

Alternate II - Turbo - Turbo-Prop/Propeller Airport

	(a)	(b)
Present Value Total Annual Benefits	$1,868,534	$1,520,476
Present Value Total Annual Costs		
(a) 20 years @ 12% (7.4692 x $204,434)	1,526,958	
(b) 20 years @ 15% (6.2593 x $234,236)		1,466,153
Net Present Value	$ 341,576	$ 54,323

The uniform series present worth factors 7.4692 and 6.2593 were derived using the formula shown on page 62 of initial report.

Benefit/Cost Ratio

Benefit/cost ratios for the two alternate Trinidad airport designs are shown below.

Alternate I - Jet Airport

Present Value Total Annual Benefits

(a) $\frac{\$1,868,534}{\$6,346,878} = 0.29/1.00$

(b) $\frac{\$1,520,476}{\$6,186,505} = 0.26/1.00$

Alternate II - Turbo Prop/Propeller Airport

Present Value Total Annual Benefits

(a) $\frac{\$1,868,534}{\$1,526,958} = 1.22/1.00$

(b) $\frac{\$1,520,476}{\$1,466,153} = 1.04/1.00$

65-A next...

TABLE

FREQUENCY AND ANNUAL COST OF AIRPORT-RELATED AIRCRAFT ACCIDENTS
TRINIDAD AIRPORT, BOLIVIA
1966

	Average Frequency Per 1000 Operations 1964-1966	Annual Number Operations 1966	Annual Number Accidents	Unit Cost Per Accident 1/	Total Cost Per Accident	Percent Accident Reduction Attributable Pavement 2/	Annual Accident Reduction Due Pavement
Passenger Fatalities	0.00477	13,890	0.066	a) $29,315 b) $24,957	a) $ 1,935 b) $ 1,647	25%	a) $484 b) $412
Injured Passengers	0	13,890	0	$ 2,700		25%	0
Aircraft Destroyed	0.03819	13,890	0.530	$350,000 3/	$185,500	25%	$46,375
Aircraft Damaged							
Major Damage	0.01910	13,890	0.265	$ 75,000 3/	$ 19,875	25%	$ 4,970
Light Damage	0.04297	13,890	0.597	$ 10,000 3/	$ 1,490	25%	$ 373

Sources: 1/ Appendix D.

2/ Estimated at 10%. Other 90% causes include inadequate navigation aids, faulty aircraft maintenance, pilot error, and other sources of airport-related accidents.

3/ Single engine light aircraft accounted for 75% of all operations at Trinidad in 1966; a lower unit cost per aircraft is used for Trinidad than for Cochabamba and Santa Cruz airports where multi-engine commercial aircraft predominate. See Table . The inability of multi-engine jet aircraft to utilize Trinidad airport also reduces the average unit value of aircraft below that of other airports covered by this study.

TABLE

PRESENT VALUE OF PAVEMENT BENEFITS
TRINIDAD AIRPORT

1970 - 1990

Projected Number of Aircraft Operations				Project Benefits (In U.S. Dollars)							Discounted Benefits (In U.S. Dollars)							
Year	Percent Annual Increase	Compound Factor	Number Aircraft Operations	Percent Annual Increase	Compound Factor	Turbo-prop Aircraft Benefit	Aircraft Accident Reduction Benefit	Aircraft Repair Savings Benefit	All Weather Airport Use Benefit	Total Benefit	Percent Discount	Discount Factor @ 12%	Present Value of Total Benefits @ 12%	Percent Discount	Discount Factor @ 15%	Present Value of Total Benefits @ 15%	Present Value of Fatality Reduction Benefit @ 12%	Present Value of Fatality Reduction Benefit @ 15%
1990			54,115							321,202		0.10367	33,299		0.06110	19,625	1,886	1,605
89												0.11611	37,295		0.07026	22,568		
88												0.13004	41,769		0.08081	25,956		
87												0.14565	46,783		0.09293	29,849		
86												0.16312	52,394		0.10686	34,324		
1985	8%											0.18270	52,683		0.12289	39,472		
84												0.20462	65,724		0.14133	45,395		
83												0.22917	73,610		0.16253	52,205		
82												0.25667	82,443		0.18691	60,036		
81												0.28747	92,336		0.21494	69,039		
1980												0.32198	103,421		0.24718	79,395		
79											12%	0.36061	115,829	15%	0.28426	91,305		
78		3.8960	54,115		3.8960					321,202		0.40388	129,727		0.32690	105,001	1,886	1,605
77					3.4786					286,790		0.45235	129,729		0.37594	107,816	1,684	1,433
76					3.1058					256,054		0.50664	129,727		0.43232	110,697	1,503	1,280
1975		2.7731	38,518		2.7731					228,625		0.56744	129,731		0.49717	113,665	1,342	1,143
74					2.4760					204,131		0.63553	129,731		0.57176	116,714	1,198	1,020
73					2.2107					182,259		0.71179	129,730		0.65751	119,837	1,070	911
72	12%			12%	1.9736					162,728		0.79719	129,725		0.75614	123,045	955	813
71					1.7623					145,291		0.89286	129,725		0.86957	126,341	853	726
1970		1.5735	21,856		1.5735					129,726		1.00000			1.00000		761	648
69																		
68																		
67																		
1966		1.0000	13,890			14,000	54,320	4,124	10,000	82,444							484	412
													$1,835,411			$1,492,285	$33,123	$28,191

SUMMARY	@ 12%	@ 15%
Present Value of Turbo-prop Aircraft Benefit, Aircraft Accident Reduction Benefit and Aircraft Repair Savings Benefits	$1,835,411	$1,492,285
Present Value of Fatality Reduction Benefit	33,123	28,191
TOTAL: Present Value of Pavement Benefits	a) $1,868,534	b) $1,520,476

ECONOMIC JUSTIFICATION - Trinidad Lighting

Description of Project

This project embraces the installation of runway, taxiway, aircraft apron lighting at Trinidad airport.

Period of Analysis

The period of analysis for the lighting project is 20 years, based on the estimated service life of proposed light fixtures.

Interest Rate

A 12% interest rate is used for the purpose of economic analysis. For purposes of sensitivity analysis, a 15% maximum rate is used.

Projected Growth of Air Traffic at Trinidad Airport

Air traffic volume is expected to increase at Trinidad Airport over the period 1966 - 1990 as shown on Trinidad Pavement Section page

Project Costs

Capital Cost

The total capital cost of the proposed lighting improvements are as follows:

12%	15%
$85,992	$86,310

Annual Cost

Amortization of Capital Cost:	(a)	(b)
(a) 20 years @ 12% (.1339 x $82,992)	$11,514	
(b) 20 years @ 15% (.1598 x $86,310)		$13,792
Operation and Maintenance Cost:	4,299	4,315
Total Annual Cost	$15,813	$18,107

Project Benefits

Annual economic benefits at 1966 air traffic levels provided by the proposed lighting installations at Trinidad Airport amount to $19,490, derived from the following sources.

Increase in Net Revenues from Night Flights	$15,000
Reduction in Aircraft Accident Costs - $29,930 x 15%	4,490
Total Benefits	$19,490

Trinidad has no airport lighting. In instances of emergency night landings at Trinidad, flares are set out to serve as runway lights.

The installation of airport lighting at Trinidad will prolong the airport operational day. The increment in net revenues to airlines and the airport is estimated to average $15,000 per year.

Accident reduction benefits are estimated at 15% of accident prevention benefits attributable to runway and taxiway paving improvements at Trinidad airport.

Economic Justification

Net Present Value

The net present value of the proposed lighting improvements are shown below:

	(a)	(b)
Present Value Total Annual Benefits	$439,296	$356,131
Present Value Total Annual Costs		
(a) 20 years @ 12% (7.4692 x $15,813)	118,110	
(b) 20 years @ 15% (6.2593 x $18,107)		113,337
Net Present Value	$321,186	$242,794

Benefit Cost Ratio

The proposed lighting project has the benefit/cost ratios shown below:

$$\frac{\text{Present Value Total Annual Benefits}}{\text{Present Value Total Annual Costs}} = \text{a)}\ \frac{\$439,296}{\$118,110} = 3.72/1.00$$

$$= \text{b)}\ \frac{\$356,131}{\$113,337} = 3.14/1.00$$

TABLE

PRESENT VALUE OF LIGHTING BENEFITS
TRINIDAD AIRPORT

1970 - 1990

Projected Number of Aircraft Operations				Projected Benefits (In U.S. Dollars)					Discounted Benefits (In U.S. Dollars)					
Year	Percent Annual Increase	Compound Factor	Number Aircraft Operations	Percent Annual Increase	Compound Factor	Night Flight Revenue Benefit	Aircraft Accident Reduction Benefit	Total Benefits	Percent Discount	Discount Factor @ 12%	Present Value of Total Benefits @ 12%	Percent Discount	Discount Factor @ 15%	Present Value of Total Benefits @ 15%
1990								75,933		0.10367	7,872		0.06110	4,639
1989										0.11611	8,817		0.07026	5,335
1988										0.13004	9,874		0.08081	6,136
1987										0.14565	11,060		0.09293	7,056
1986										0.16312	12,386		0.10686	8,114
1985										0.18270	13,873		0.12289	9,331
1984										0.20462	15,537		0.14133	10,732
1933										0.22917	17,402		0.16253	12,341
1982										0.25667	19,489		0.18691	14,19[illegible]
1981										0.28747	21,828		0.21494	16,321
1980										0.32198	24,449		0.24718	18,769
1979										0.36061	27,382		0.28426	21,585
1978		3.8960	54,115		3.8960			75,933	12%	0.40388	30,668	15%	0.32690	24,822
1977					3.4786			67,798		0.45235	30,668		0.37594	25,488
1976					3.1058			60,532		0.50664	30,668		0.43232	26,169
1975		2.7731	38,518		2.7731			54,048		0.56744	30,669		0.49717	26,871
1974					2.4760			48,257		0.63553	30,669		0.57176	27,591
1973					2.2107			43,086		0.71179	30,668		0.65751	28,329
1972	12%			12%	1.9738			38,469		0.79719	30,667		0.75614	29,088
1971					1.7623			34,347		0.89286	30,667		0.86957	29,833
1970		1.5735	21,856		1.5735			30,667		1.0000			1.0000	
1969														
1968														
1967														
1966		1.0000	13,890		1.0000	15,000	4,990	19,490						
											$435,313			$352,743

SUMMARY	@ 12%	@ 15%
Present value of night flight and accident reduction benefits	$435,313	$352,743
Present value of fatality reduction benefit (@ .15 of fatality reduction benefit from pavement)	3,983	3,388
TOTAL: Present Value of Lighting Benefit	$439,296	$356,131

CHAPTER X

AERONAUTICAL COMMUNICATIONS/NAVAID

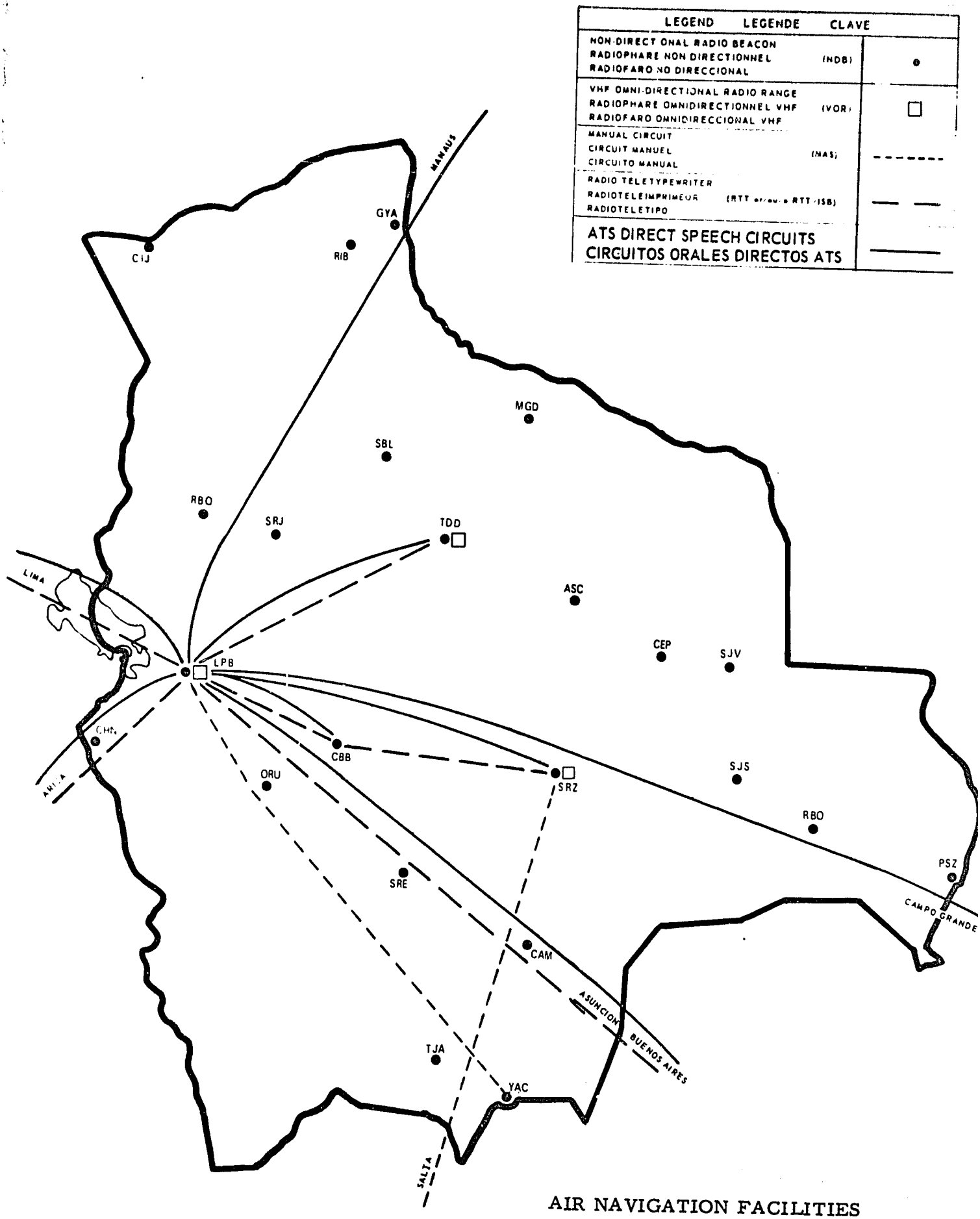
This proposed improvement includes installation of a VOR navigational aid at Trinidad and installation of communications equipment at La Paz, Cochabamba, Santa Cruz and Trinidad Airports.

Existing communications equipment at all airports is obsolete. Heat and humidity over the years has caused a general breakdown of components. Electronic leakage, frequency drift and high background noise is common. Components are out of tolerance causing poor reception and low power output. Garbled and distorted transmissions result with weak and noisy reception.

Proposed improvements conform to the ICAO Air Navigation Plan for South America/South Atlantic Region. All engineering and equipment selection has been done by FAA/USAID representatives in La Paz.

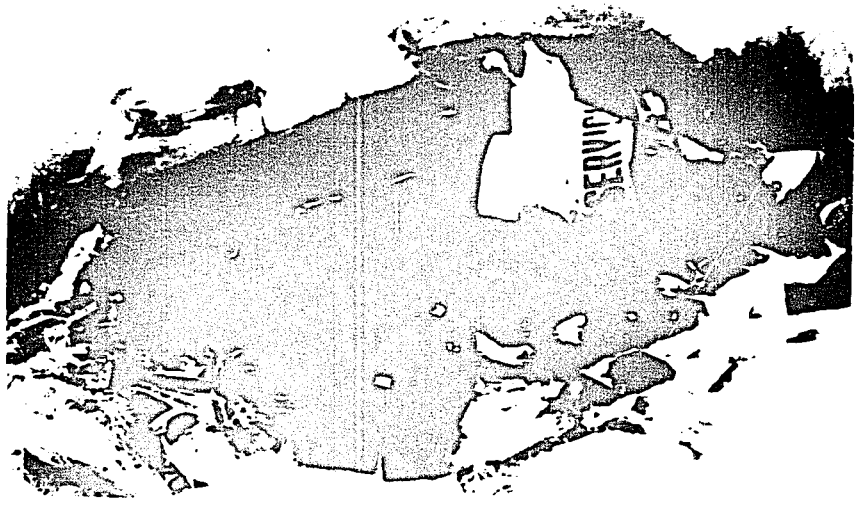
Communications/Navaid Costs

	Equipment Costs	Installation Costs	Total
La Paz	$598,400	$119,680	$718,080
Santa Cruz	146,000	29,200	175,200
Cochabamba	165,430	33,086	198,516
Trinidad	186,000	37,200	223,200
Total	$1,095,830	$219,166	$1,314,996



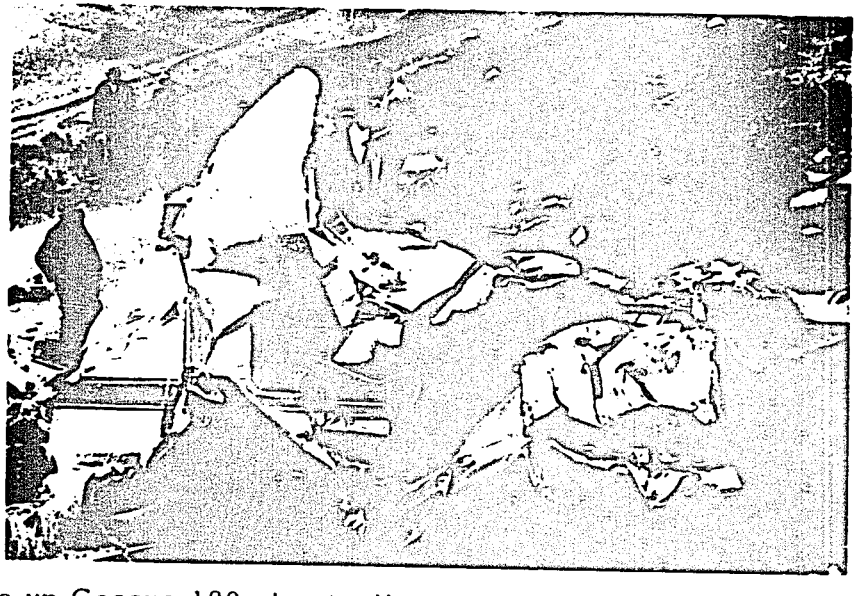
AIR NAVIGATION FACILITIES

FACILIDADES PARA LA NAVEGACION AEREA



Restos de un Douglas C-47 al estrellarse contra la montaña Huayna Potosí en ruta La Paz - Tipuani el 14 de Agosto de 1964. Resultaron cuatro fatalidades. Causado por mal tiempo.

Wreckage of Douglas C-47 crashed into Huayna Potosi mountain en route La Paz - Tipuani, August 14, 1964. Four fatalities resulted. Encountered bad weather.



Restos de un Cessna 180 al estrellarse en las montanas. El piloto se extravío en ruta La Paz - Cochabamba debido a poca visibilidad el 6 de Marzo de 1964. Resultaron cuatro fatalidades.

Cessna 180 crash wreckage in mountains. Pilot lost en route La Paz - Cochabamba due poor visibility weather March 6, 1964. Four fatalities resulted.

TABLE

INVENTORY OF EXISTING COMMUNICATIONS EQUIPMENT
LA PAZ, COCHABAMBA, SANTA CRUZ AND TRINIDAD AIRPORTS
BOLIVIA
December 1967

Number Pieces Equipment	Type and Manufacturer of Equipment	Year of Acquisition	Comments
	LA PAZ AIRPORT		
1	Transmitter, "Wilcox" 96C-4, 3 phase	1950	
1	Transmitter, "Federal" BC-447 B	1950	U.S. War Surplus
2	Transmitters, "Airaco" 500-AL	1943	
6	Transmitters, W. Electric, 4WTFA	1943	
1	Transmitter, Hallicrafters HT-9	1942	
2	Transmitters, "Collins"	1948	U.S. War Surplus
1	Transceiver, "RCA" SSB-1	1959	
4	Transmitters, "Aerocom"	1958	
3	Receivers, "Hammarlund" SP-400 & BC-779	1946	U.S. War Surplus
13	Receivers, "Wilcox" CW-3	1947	U.S. War Surplus

Number Pieces Equipment	Type and Manufacturer of Equipment	Year of Acquisition	Comments
	LA PAZ AIRPORT (Continued)		
4	Receivers, "Collins" 51-J-4	1958	
2	Teletypes, "Teletype" 15-B	1946	U.S. War Surplus
1	Teletype, "Siemens" FN-R-8	1954	
2	Motors, Kohler 10 Kw.	1947	
1	Motor, "Onan" 5 Kw.	1942	
	SANTA CRUZ AIRPORT		
2	Transmitters, "Airaco" 500-AL	1943	
2	Transmitters, "Collins" 32RB8	1944	
5	Transmitters, "W. Electric" 4WTFA	1943	
2	Transmitters, Localizer	1944	
3	Receivers, "Hammerlund" SP-400 & BC-779	1946	U.S. War Surplus
1	Receiver, "Collins" 51-J-4	1958	
1	Receiver, NC-2-40	1940	

Number Pieces Equipment	Type and Manufacturer of Equipment	Year of Acquisition	Comments
	SANTA CRUZ AIRPORT (Continued)		
16	Receivers, "Wilcox" CW-3 & F-3	1947	U.S. War Surplus
3	Receivers, "BC-348-Q"	1940	
2	Alarm Monitors, "AAM"	1943	
1	Motor, "Caterpillar" 50 Kv	1942	
2	Motors, Kohler, 10 Kw	1947	
2	Motors, "M AN", 60 Kv	1960	
	TRINIDAD AIRPORT		
1	Transmitter, "Federal" 446	1941	U.S. War Surplus
1	Transmitter, W. Electric 4WTFA	1942	
1	Transmitter, Wilcox 99-A	1950	U.S. War Surplus
1	Transmitter, Wilcox 96C4	1950	U.S. War Surplus
1	Transmitter, Wilcox 96-200	1950	U.S. War Surplus
2	Transmitters, Hallicrafters HT-9	1942	

Number Pieces Equipment	Type and Manufacturer of Equipment	Year of Acquisition	Comments
	TRINIDAD AIRPORT (Continued)		
1	Receiver, Wilcox CW-3	1947	U.S. War Surplus
2	Receivers, Hammarlund BC-779	1946	U.S. War Surplus
1	Receiver, Hallicrafter SX-25	1943	
1	Receiver, Collins 51-J-4	1958	
1	Motor, "Inter", diesel	1944	
2	Motors, Kohler, 10 Kw	1947	
	COCHABAMBA AIRPORT		
2	Transmitters, Wilcox 99-A	1950	U.S. War Surplus
2	Transmitters, Wilcox 96-C-4	1950	U.S. War Surplus
2	Transmitters, Wilcox 96-200	1950	U.S. War Surplus
3	Transmitters, W. Electric 4WTFA	1942	
2	Transmitters, Marino B-1000	1945	U.S. War Surplus

Number Pieces Equipment	Type and Manufacturer of Equipment	Year of Acquisition	Comments
	COCHABAMBA AIRPORT (Continued)		
1	Transmitter, Aerocom	1958	
12	Receivers, Hammarlund SP400	1946	U.S. War Surplus
1	Receiver, "Wilcox" CW-3	1947	U.S. War Surplus

ECONOMIC JUSTIFICATION - Aeronautical Communications/NAVAIDS

Project Description

The proposed project comprises the installation of aeronautical communications equipment at La Paz, Cochabamba, Santa Cruz and Trinidad. In addition, a VOR navigation aid is to be installed at Trinidad. Upon the completion of the proposed installations, La Paz would serve as a national aeronautical communications center, and Cochabamba, Santa Cruz and Trinidad would serve as regional aeronautical communications centers.

Period of Analysis

The period of analysis is the proposed telecommunications/NAVAID project is 20 years.

Interest Rate

Interest rates of 12% and 15% are used for purposes of project economic evaluation.

Projected Growth of Bolivian Air Traffic

Air traffic volume in Bolivia is projected for the period 1966-1990 as shown below. A 12% rate of increase was used for the period 1966-1980, and an 8% rate thereafter.

Year	Number of Flights	Growth Index (1966 = 100)
1990	374,636	1,055
1985	254,969	718
1980	173,531	489
1975	98,467	277
1970	55,872	157
1966	35,508	100

Project Costs

Capital Cost

The estimated cost of the proposed communications - NAVAID installations amounts to $1,314,996 distributed as follows:

La Paz	$ 718,080
Santa Cruz	175,200
Cochabamba	198,516
Trinidad	223,200
	$1,314,996

Annual Cost

	(a)	(b)
Amortization of Capital Cost		
20 years @ 12% (.1339 x $1,314,996)	$176,080	
20 years @ 15% (.1598 x $1,314,996)		$210,135
Operation and Maintenance Cost		
Operation	222,600	222,600
Maintenance	64,510	64,510
Total Annual Cost	$463,190	$497,245

Project Benefits

La Paz, Cochabamba, Santa Cruz and Trinidad airports are major air traffic hubs in Bolivia but are presently equipped with obsolete communications equipment ranging in age from 9 to 27 years. See table on page 74 for inventories of existing equipment at these airports.

Total annual economic benefits provided by the proposed aeronautical/NAVAID system amount to $381,375 at the 1966 air traffic volume in Bolivia. These were computed from reduction of losses due to aircraft accidents. Improved weather information availability prior to takeoff and enroute would substantially contribute to a reduced accident rate.

At present aircraft aloft frequently encounter unexpected weather below minimum VFR flying conditions, weather that greatly increases the risk of accidents through crashes in mountainous terrain, loss of geographical position, and forced landings. See photos page 73 and table page 84.

Additional benefits include the improvement of reliability of schedule airline service through improved weather information dissemination and air traffic control. Non-scheduled airline and general aviation also will benefit from a reduction in the number of flight cancellations; delays and diversions created by inadequate weather information. Insufficient statistical data is available in Bolivia to enable a quantification of benefits from these sources. Similarly, improved air traffic control will be possible with the proposed aeronautical communications systems, however, benefits from this source are also non-quantifiable due to the lack of statistical material.

Aircraft accident reports are available in Bolivia and provide a basis for determining the causes of accidents, frequency, extent of aircraft damage, and number of fatalities and injuries. Based on this information it was possible to develop estimates of economic loss due to accidents related to inadequate aeronautical communications.

Economic Justification

Net Present Value

The net present value of the proposed communications improvements are shown below:

	(a)	(b)
Present Value Total Annual Benefits	$15,103,002	$12,062,009
Present Value Total Annual Costs	3,459,650	3,112,405
(a) 20 years @ 12% (7.4692 x $463,190)		
(b) 20 years @ 15% (6.2593 x $497,245)		
Net Present Value	$11,643,352	$ 8,949,604

Benefit Cost Ratio

The proposed communication project has the benefit/cost ratios shown below:

$$\frac{\text{Present Value Total Annual Benefits}}{\text{Present Value Total Annual Costs}} = \text{(a)}\ \frac{\$15,103,002}{\$\ 3,459,660} = 4.37/1.00$$

$$= \text{(b)}\ \frac{\$12,062,009}{\$\ 3,112,405} = 3.88/1.00$$

TABLE

PRESENT VALUE OF COMMUNICATION/NAVAID BENEFITS
TRINIDAD AIRPORT

1970 - 1990

	Projected Number of Aircraft Flights			Projected Benefits (In U.S. Dollars)			Discounted Benefits (In U.S. Dollars)							
Year	Percent Annual Increase	Compound Factor	Number Aircraft Flights	Percent Annual Increase	Compound Factor	Aircraft Accident Reduction Benefits	Percent Discount	Discount Factor @ 12%	Present Value of Total Benefits @ 12%	Percent Discount	Discount Factor @ 15%	Present Value of Total Benefits @ 15%	12%	15%
1990		2.1589	374,636		2.1589	4,023,796		0.10367	$ 417,147		0.06110	$ 245,854	$ 408,915	$ 348,123
1989		1.9990	346,888		1.9990	3,725,772		0.11611	432,599		0.07026	261,773	378,426	322,339
1988		1.8509	321,188		1.8509	3,449,741		0.13004	448,604		0.08081	278,773	350,577	298,458
1987		1.7138	297,397		1.7138	3,194,211		0.14565	465,237		0.09293	296,938	324,609	276,350
1986	8%	1.5869	275,376	8%	1.5869	2,957,693		0.16312	482,459		0.10686	316,059	300,573	255,888
1985		1.4693	254,969		1.4693	2,738,507		0.18270	500,325		0.12289	336,535	278,299	236,925
1984		1.3605	236,009		1.3605	2,535,724		0.20462	518,860		0.14133	356,374	257,691	219,381
1983		1.2597	218,597		1.2597	2,347,851		0.22917	538,057		0.16253	381,599	238,599	203,127
1982		1.1664	202,407		1.1664	2,173,957		0.25667	557,989		0.18691	406,334	220,927	188,082
1981		1.0800	187,413		1.0800	2,012,923		0.28747	578,655		0.21494	432,657	204,561	174,150
1980		4.8871	173,531		4.8871	1,863,818		0.32198	600,112		0.24718	460,698	189,409	161,250
1979		4.3635	154,939		4.3635	1,664,130		0.36061	600,102		0.28426	473,045	169,116	143,974
1978		3.8960	138,339		3.8960	1,485,837	12%	0.40388	600,099	15%	0.32690	485,720	150,997	128,548
1977		3.4786	123,518		3.4786	1,326,651		0.45235	600,111		0.37594	498,741	134,820	114,776
1976		3.1058	110,281		3.1058	1,184,474		0.50664	600,102		0.43232	512,072	120,371	102,476
1975		2.7731	98,467		2.7731	1,057,591		0.56744	600,119		0.49717	525,806	107,477	91,498
1974		2.4760	87,918		2.4760	944,284		0.63553	600,121		0.57176	539,904	95,962	81,696
1973	12%	2.2107	78,498	12%	2.2107	843,105		0.71179	600,114		0.65751	554,350	85,680	72,942
1972		1.9738	70,086		1.9738	752,758		0.79719	600,091		0.75614	569,190	76,499	65,125
1971		1.7623	62,576		1.7623	672,097		0.89286	600,088		0.86957	584,435	68,301	58,147
1970		1.5735	55,872		1.5735	600,094		1.0000			1.0000		60,984	51,918
1969		1.4049												
1968		1.2544												
1967		1.1200												
1966		1.0000	35,508		1.0000	381,375							38,757	32,995
									$10,940,991			$8,518,754	$4,162,011	$3,543,255

SUMMARY	@ 12%	@ 15%
Present Value of Aircraft Accident Reduction Benefit	$10,940,991	$ 8,518,754
Present Value of Fatality Reduction Benefit	4,162,011	3,543,255
TOTAL: Present Value of Communication/NAVAID Benefits	$15,103,002	$12,062,009

TABLE

FREQUENCY AND ANNUAL COST OF COMMUNICATION/NAVAID-RELATED AIRCRAFT ACCIDENTS
BOLIVIA
1966

	Average Frequency Per 1000 Flights 1964-1966	Annual Number Flights 1966	Annual Number Accidents	Unit Cost Per Accident 1/	Total Cost Per Accident 1/	Percent Accident Reduction Attributable Proposed Improvement 2/	Annual Accident Reduction Due Proposed Improvement
Passenger Fatalities	0.12412	35,508	4.407	a) $29,315 b) $24,957	a) $129,191 b) $109,985	30% 30%	a) $38,757 b) $32,995
Injured Passengers	0	35,508	0	$ 2,700	0	30%	0
Aircraft Destroyed	0.04774	35,508	1.695	$750,000	$1,271,250	30%	$381,375
Aircraft Damaged							
Major Damage	0	35,508	0	$250,000	$ 0	30%	$ 0
Light Damage	0.04774	35,508	1.695	$ 25,000	$ 42,375	30%	$12,713

Sources: 1/ Appendix D.

2/ Estimated at 30%. Other 70% of causes include faulty aircraft maintenance, pilot error, and other sources of flight accidents.

APPENDIX E (Revised)

ECONOMIC BENEFITS OF AIRCRAFT ACCIDENT REDUCTION

Economic Cost of Fatalities and Injuries

Aircraft accidents are a serious and costly form of economic loss to the aviation industry of Bolivia and to the public. Injury and loss of human life, and damage or destruction of aircraft that result from airport-related aircraft accidents are quantifiable costs. The method for economic valuation of human life used in this report is similar to techniques employed in the literature listed in bibliography at end of this Appendix.

Accident Frequency

Accident rates were computed from data for the years 1964, 1965 and 1966. National frequency rates for airport-related accidents were used since aircraft operate at a number of airports over the year; tire damage from unpaved runways and other accident producing causes are frequently cumulative and not attributable to deficiencies at a single airport. National data was also used to develop aeronautical communications/NAVAID-related accident frequency rates inasmuch as El Alto has been proposed to serve as the national aeronautical communications center and Cochabamba, Santa Cruz, and Trinidad as major regional communications centers.

Airport-Related Accidents

Fatalities caused by airport-related aircraft accidents in Bolivia occur with a frequency of .00477 per thousand aircraft operations (landing or takeoff comprises an operation). Injuries do not occur at statistically significant levels.

Airport-related accidents resulting in destruction of aircraft occur at a rate of .03819/1,000 operations and damage to aircraft at .06206/1,000 operations. See Tables E-1 revised and E-2 revised.

Aeronautical Communications/NAVAID-Related Accidents

Fatalities caused by aeronautical communications/NAVAID-related accidents occur with a frequency of 0.12412 per 1,000 aircraft flights injuries occur at a rate of injuries/1,000 aircraft flight-

Accidents resulting in total loss of aircraft occur at loss rate of 0.04774 aircraft per 1,000 flights, and damage to aircraft at the same loss rate. See Tables E-1 revised and E-3 revised.

Fatalities and Injuries

The economic cost of an aircraft accident resulting in loss of human life is $29,315 when net earnings are discounted at 12 percent, and $24,957 at 15 percent. The cost per injury per passenger amounts to $2,700. These estimates were based on the unit costs presented in Table E-4, values given in Table E-5 and computations in Table E-6. International air carriers with landing rights in the United States of America are subject under law to a $75,000 maximum liability for death or injury per passenger.

TABLE E-1 Revised

FREQUENCY OF AIRCRAFT ACCIDENTS
BOLIVIA

1964-1966

	1964	1965	1966	Total	Accidents Per 1,000 Operations
All Accidents					
Total Accidents:	18	34	24	76	0.363
Aircraft Destroyed	10	12	9	31	0.148
Aircraft Damaged	8	22	15	45	0.215
Fatalities	12	5	3	20	0.095
Injuries	20	0	2	22	0.105
Airport - Related Accidents					
Total Accidents:	4	13	4	21	0.10025
Aircraft Destroyed	2	5	1	8	0.03819
Aircraft Damaged					
Major Damage	0	3	1	4	0.01910
Moderate Damage	2	5	2	9	0.04297
Fatalities	1	0	0	1	0.00477
Injuries	0	0	0	0	0
Communications/NAVAID Related Accidents					Accidents per 1,000 Aircraft Flights 2/
Total Accidents:	4	1	5	10	0.09548
Aircraft Destroyed	2	1	2	5	0.04774
Aircraft Damaged					
Major Damage	0	0	0	0	0
Light Damage	2	0	3	5	0.04774
Fatalities	8	2	3	13	0.12412
Injuries	0	0	0	0	0

Notes: 1/ Calculated from total of 209,472 operations in Bolivia, 1964-1966.
2/ Calculated from total of 104,736 aircraft flights in Bolivia, 1964-1966.
3/ Fatality and injury data excludes those caused by bomb planted in aircraft in flight and repair shop fires.

Source: Government of Bolivia, DNAC, Departamento de Seguridad Aérea, Registro de Accidentes, 1947-1967 (La Paz, Bolivia).
See Tables

TABLE E-2

AIRPORT-RELATED AIRCRAFT ACCIDENTS
BOLIVIA

1964-1966

	1964				1965						
	1	2	3	4	5	6	7	8	9	10	
1. Date/Hour	15 Jan/13:07	5 Feb/10:40	30 Oct/13:12	22 Nov/14:00	7 Feb/20:45	15 Feb/18:50	14 Mar/15:40	15 Mar/21:39	2 April/13:38	10 April/15:05	
2. Place	Potosí	Alacacia-Beni	San Borja	Trinidad	El Alto	Cobija	El Alto	Cobija	El Alto	Trinidad	
3. Aircraft Type/Reg No.	Douglas DC-3 CP-601	Helio-Courier 391-B CP-552	Boeing B-17G CP-741	Cessna 170 CP-592	Boeing B-17G CP-580	Boeing B-17G CP-742	North Am. B-25 CP-716	Boeing B-17G CP-753	Curtis C-46T1 CP-725	Piper PA 28-160 CP-736	
4. Owner	LAB	Jorge Lavadenz	COBRA	Aéreo Transportes Beni	LAB	COBRA	TABSA	BOA	A. San Lorenzo	Aero Taxi Beni	
5 Losses:											
a) Deaths/Injuries	1 Fatality	None	None	None	None	None	None	None	None	None	
b) Cargo Losses/Damage	None	None	None	None	None	None	None	None	None	None	
c) Aircraft Loss/Damage	Total Loss	Moderate Damage	Total Loss	Moderate Damage	Total Loss	Major Damage	Major Damage	Moderate Damage	Total Loss	Moderate Damage	
d) Time Aircraft Disabled	2-1/2 Months	2-1/2 Months		2-1/2 Months		3-1/2 Months	3-1/2 Months	2-1/2 Months		2-1/2 Months	
6. Pavement-Related Accident Cause	Tire blowout on takeoff.	Undercarriage collapse on landing due to metal fatigue.	Undercarriage malfunction on takeoff caused forced landing.	Brake failure on landing.	Tire blowout on takeoff.	Undercarriage collapse on landing.	Nosewheel puncture by stone on takeoff	Wet unpaved runway caused loss of control on landing.	Undercarriage malfunction prior to landing.	Undercarriage collapse on takeoff.	
7. DNAC Accident Folder No.	186	189	199	200	206	207	209	210	212	214	

	1965								1966		
	11	12	13	14	15	16	17	18	19	20	21
1. Date/Hour	27 Sept/19:50	1 Oct/21:45	4 Nov/12:29	7 Nov/17:30	9 Nov/17:30	10 Nov/15:30	3 Dec/14:42	20 Feb/14:55	16 Mar/16:30	20 Jun/19:15	15 Sept/21:33
2. Place	Trinidad	Cochabamba	Trinidad	Trinidad	Beni	San Pedro	El Alto	Reyes	Pista Baures, Beni	Trinidad	Apolo
3. Aircraft Type/Reg No.	Paulisthina 56C CP-685	Piper PA-28-235 CP-727	Boeing B-17G CP-686	Convair L-13 CP-629	Cessna 180 CP-602	Cessna 170 CP-586	Douglas C-47 CP-601	Curtis C-46F CP-760	Cessna 180	Boeing B-17G CP-640	Curtis C-46A CP-746
4. Owner	DNAC	R. Guzmán Hidalgo	LAB	FRIBAL	Aéreo Taxi Beni	Abraham Richard Ojopi	Aerol. Abaroa	TABSA	Mision Cristiana Evangelica	BOA	BAS
5. Losses:											
a) Deaths/Injuries	None	None	None	None	None	None	None	None	None	None	None
b) Cargo Losses/Damage	None	None	None	None	None	None	None	None	None	None	None
c) Aircraft Loss/Damage	Total Loss	Moderate Damage	Total Loss	Moderate Damage	Total Loss	Major Damage	Moderate Damage	Major Damage	Moderate Damage	Moderate Damage	Total Loss
d) Time Aircraft Disable		2-1/2 Months		2-1/2 Months		3-1/2 Months	2-1/2 Months	3-1/2 Months	2-1/2 Months		
6. Aircraft-Related Accident Cause	Inadequately moored aircraft destroyed by 60 knot wind.	Unmoored aircraft damaged by 60 knot wind.	Wet unpaved runway aggravated malfunctioning brake condition on landing.	Aircraft moored to earth with stakes, blown 9 meters by 60 knot wind.	Brake failure on landing and 60-80 knot wind.	Cattle on runway during landing.	Undercarriage malfunction prior to landing.	Undercarriage malfunction on landing.	Horses on runway during landing	Undercarriage collapse on landing due to metal fatigue.	Undercarriage malfunction on landing.
7. DNAC Accident Folder No.	222	227	232	233	234	235	236	239	243	248	258

TABLE E-3

TELECOMMUNICATION AND NAVAID - RELATED AIRCRAFT ACCIDENTS
BOLIVIA

1964-1966

	1964				1965	1966				
	1	2	3	4	5	6	7	8	9	10
1. Date/Hour	6 Mar./22:30	14 Aug./21:59	28 Aug./16:25	19 Oct./22:40	29 Oct./22:33	21 Feb./23:00	6 May/14:30	18 June/13:45	3 Aug./17:35	7 Nov./20:10
2. Place	Mountains in vicinity of Colquiri	Trinidad	Huayna Potosi Mountain	In vicinity of Santa Ana Yacuma	San Ramon	Santa Ana Yacuma	El Chorro	Bajic Florida, Beni	San Benito Mountains, Cochabamba	Cheeue Beni
3. Aircraft Type/Reg.No.	Cessna 180 CP-612	Cessna 172 CP-713	Douglas C-47 CP-680	Piper PA-22 CP-756	Douglas C-47 CP-645	Boeing B-17G CP-742	Piper PA-28-140 CP-774	Piper PA-12 CP-779	Curtis C-46 CP-730	Curtis C-46 CP-749
4. Owner	Walter Herron	Absalon Melgar	SAC	R. Montalvo	Trans. Acre	COBRA	Jose R. Montalvo	Antonio Murguia A.	Aerovias Condor	RAU
5. Losses:										
a) Deaths/Injuries	Four fatalities	None	Four fatalities	None	Two Fatalities	None	None	None	Three Fatalities	None
b) Cargo Losses/Damage	No cargo	None	Total Loss	No cargo	Total Loss	Moderate Loss	No Cargo	No Loss	Total Loss	No Loss
c) Aircraft Losses/Damage	Total Loss	Moderate Damage	Total Loss	Moderate Damage	Total Loss	Total Loss	Moderate Damage	Moderate Damage	Total Loss	Moderate Damage
d) Time Aircraft Disabled		2-1/2 Months		2-1/2 Months						2-1/2 Months
6. Communication and NAVAID-Related Accident Cause:	Adverse weather conditions encountered enroute for VFR flight with the possibility the pilot became lost. Route: La Paz - Cochabamba	Prop blast from B-17 taxiing after landing damaged Cessna 172 and endangered Super Curtis. Attributable to improper tower control.	Adverse weather conditions encountered while flying VFR. Route: La Paz - Tipuani	Bad weather conditions at destination and alternate airport caused forced landing in field. Route: Buena Hora-Santa Ana Yacuma	CP-645 crashed into CP-745 on landing under poor visibility condition. San Ramon airport has no radio. Neither aircraft under adequate traffic control from airport of flight origin. Route: CP-645, Cochabamba-San Ramon, CP-745, La Paz-San Ramon.	Crashed into tree during landing approach under poor visibility weather condition. No radio transmission of weather data from La Paz point of origin. Route: La Paz - Santa Ana Yacuma.	Motor failure. VHF equipped aircraft unable report condition on International VHF frequency 121.5 (emergency) to Cochabamba which has no VHF receiver. Route: Cochabamba-Cochabamba (training flight).	Pilot lost in bad weather caused forced landing after running out of gas. Route: Estancia Copacabana-Trinidad.	Crashed while on IFR with limited visibility weather. Inadequate radio-navigation assistance, a contributing factor. Route: Riberalta-Cochabamba	Hail damage. Pilot reported "communications over (61°.5 were deficient due to interference from radio Pekes." Use of VHF band would prevent above type radio interference. Route: Cerdas-Samaipata.
7. DNAC Accident Folder No.	191	196	197	198	231	240	246	250	254	260

TABLE E-4

AIRCRAFT PURCHASE COSTS IN BOLIVIA

1966

Type Aircraft	U.S. Dollars
In Service:	
DC-6B	$ 250,000
DC-3	$ 75,000
B-17	$ 45,000
Light Single-Engine	$ 12,000
Potential Future Service:	
Boeing 727-100	$5,025,000
Fairchild F-27K	$1,615,000
Otter Twin-Turbo-propeller	$ 328,000

Source: Superintendente Administrativo, Lloyd Aereo Boliviano S.A., Cochabamba, Bolivia.

Table E-5

Factors For Computing Net Lost Earnings Of Deceased Passenger

Numbered items are discussed in supplemental numbered notes appended to this section.

(1)	Life Expectancy at Time of Death	Age 60 yrs.
(1)	Work-Life Expectancy at Time of Death	Age 58 yrs.
(2)	Age at Death	38 yrs.
	Number of Work Years Lost	20 yrs.
	Number of Years Not in Labor Force	2 yrs.
(3)	Average Annual Earnings	$4,200
(4)	Annual Value of Home Services	$ 200
(5)	Personal Consumption Expenditures @ 20%	$ 840/yr.
(6)	Earnings Trend - % annual increase	8.6%
(6)	Cost of Living Trend - % annual increase	8.6%
(7)	Discount Rate	12%/15%

TABLE E-6

PRESENT VALUE OF LOST NET EARNINGS PER PASSENGER

Year	Earnings (+)	Value of Home Services (-)	Personal Consumption (=)	Net Earnings
1	$ 4,200	$ 200	$ 840	$ 3,560
2	↓	↓	↓	↓
3	↓	↓	↓	↓
4	↓	↓	↓	↓
5	↓	↓	↓	↓
6	↓	↓	↓	↓
7	↓	↓	↓	↓
8	↓	↓	↓	↓
9	↓	↓	↓	↓
10	↓	↓	↓	↓
11	↓	↓	↓	↓
12	↓	↓	↓	↓
13	↓	↓	↓	↓
14	↓	↓	↓	↓
15	↓	↓	↓	↓
16	↓	↓	↓	↓
17	↓	↓	↓	↓
18	↓	↓	↓	↓
19	↓	↓	↓	↓
20	↓	↓	↓	↓
21	1,400	↓	↓	760
22	1,400			760
Total	$86,800	$4,400	$18,480	$72,720
Present Value:				$22,494

Given:

Present Value of Uniform Series Payments @ 15% for 20 yrs. = 6.259 @ 12% = 7.467
Present Value of Single Payment @ 15% in 21 yrs. = 0.05313 @ 12% = 0.09256
Present Value of Single Payment @ 15% in 22 yrs. = 0.04620 @ 12% = 0.08264

Discounted Value:	@ 15%		@ 12%	
	$3,560 (6.259) =	$22,282	$3,560 (7.467) =	$26,583
	$ 760 (0.05313) =	40	$ 760 (0.09256) =	70
	$ 760 (0.04620) =	35	$ 760 (0.08264) =	62
	Total	$22,357	Total	$26,715

TABLE E-7

COSTS OF BOLIVIAN AIR CARRIER ACCIDENTS
1966
(U.S. Dollars)

Cost Per Fatality		Present Value @ 12%		Present Value @ 15%
Direct Costs				
Passenger Dependents		$26,715		$22,357
Employer		500		500
Government Accident Investigation		1,500		1,500
Airline Accident Investigation		600		600
Indirect Costs				
Community Services (not included)		0		0
Total Cost Per Fatality	a)	$29,315	b)	$24,957

Serious Injury	
Direct Costs	
Lost Wages (3 mos.)	$ 1,050
Medical Expense ($10 per day, 1 mo.)	300
Employer	150
Government Accident Investigation	600
Airline Accident Investigation	600
Indirect Costs	
Community Services (not included)	0
Total Cost Per Injury	$ 2,700

Aircraft Loss	
Destroyed (see Table)	$750,000
Substantially Damaged (1/3 cost)	$250,000

Source: Estimated by DMJM.

Supplemental Notes

(1) The combined average life expectancy at birth for males and females in Bolivia is 49.7 years.[1/] Airline passengers are estimated to have a life expectancy ten years longer than the general population due to superior living standards associated with higher incomes and educational attainment. The work-life expectancy of airline passengers is estimated to be two years less than life expectancy due to retirement and/or terminal illness.

(2) Age at time of death based on LAB management estimate of average age of air passenger in Bolivia.

(3) Average annual income estimate of airline passenger is based on market analysis of occupations of LAB passengers presented in the North Central Airlines, Inc. study: Final Report (on LAB Operations) Covering Period from August 27, 1963 Through August 11, 1965 in Accordance with Contract with the Government of the United States of America dated August 27, 1963.

(4) $20 \text{ hrs/mo} \times \frac{10 \text{ pesos/hr}}{12} \times 12 \text{ mos.} = \$200.$

(5) Personal consumption as percent of earnings based on personal expenses of head of family with two children. 20% estimate corresponds to U.S.A. experience cited by Cheit in Bibliography, item E.

(6) Earnings trend is assumed to equal cost of living trend. Combined cost of living trend for cities of La Paz, Cochabamba and Santa Cruz between 1957-1965 are shown in Table E-8. Trend is equal to an 8.6% increase annually based on a linear regression line fitted to data. A 9.5% annual increase trend using beginning and last year of same period was not used.

(7) Average opportunity cost of investment capital in Bolivia.

1/ Government of Bolivia, Secretaria Nacional de Planificacción y Coordinación, Proyección de la Población de Bolivia (La Paz, Bolivia, 1967), p. 6.

Table E-8

COST OF LIVING INDEX
LA PAZ, COCHABAMBA, SANTA CRUZ - BOLIVIA
1957 - 1965

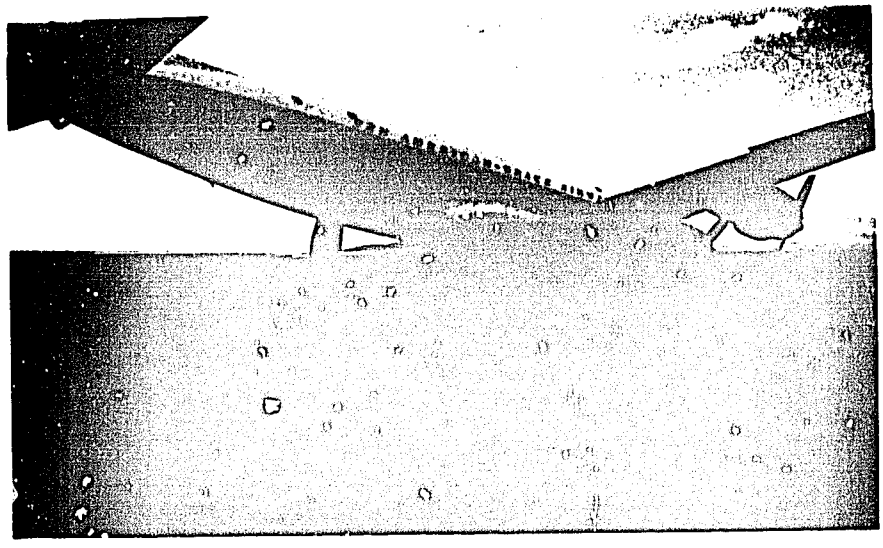
Year	La Paz		Cochabamba		Santa Cruz		Three-City Composite Growth Index (1957 = 100)
	Official Index	Growth Index (1957 = 100)	Official Index	Growth Index (1957 = 100)	Official Index	Growth Index (1957 = 100)	
1965	150.77	177	182.80	216	198.16	224	206
1964	146.52	172	168.87	194	201.84	228	199
1963	133.03	156	154.46	182	211.05	238	192
1962	133.98	158	152.84	180	212.67	240	193
1961	126.54	149	147.40	174	196.57	221	181
1960	117.65	138	138.95	164	174.09	197	166
1959	105.84	125	112.25	133	142.09	160	139
1958	87.68	103	84.20	99	111.98	126	
1957	85.04	100	84.79	100	88.56	100	

Source: Government of Bolivia, Ministerio de Hacienda, Dirección General de Estadística y Censos, Boletín Estadístico, No. 91 (La Paz, Bolivia) 1965.

Aircraft Damage

Airport-Related Accidents

Deficient airport facilities in Bolivia are an important cause of accidents leading to loss or damage of aircraft. High speed tire failures and collapse of undercarriages attributable to the rough condition of unpaved taxiways and deteriorated runways are the most common cause of airport-related accidents. See photograph below. Lack of adequate aircraft mooring facilities is also another source of aircraft damage. See Table E-2 for descriptions of airport-related accidents between 1964-1966.



Aeronautical Communication/NAVAID-Related Accidents

Accidents that occur enroute between points of departure and destination in Bolivia are characterized by a high incidence of fatalities and destruction of aircraft. Many of these accidents will be preventable through better weather information availability and air-traffic control measures when proposed communications equipment installations evaluated by this report became operational. See Table E-3 for description of communications-related aircraft accidents occurring between 1964-1966.

Cost of Destoyed and Damaged Aircraft

The average cost of a destroyed aircraft in Bolivia is estimated to be $750,000, taking into account the value of aircraft types currently in service and the purchase cost of jet aircraft being considered for service within the next several years. See Table E-4.

Repair costs for aircraft with major damage are estimated to be one-third of the cost of the aircraft, or $250,000; light damage repair costs are estimated to average $25,000.

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