# CHAPTER 8 PRELIMINARY DESIGN FOR AIRPORT FACILITIES

## CHAPTER 8 PRELIMINARY DESIGN FOR AIRPORT FACILITIES

### 8.1 Runway, Taxiway and Apron

(1) Taxiway Separation from Runway Centerline

The separation between runway and taxiway centerlines is planned to be 184m based on the following considerations:

a. ICAO minimum separation for aircraft category E when the wing span is less than 60m is 180m based on total of 1/2 runway strip width (300m/2 = 150m) and 1/2 wing span (60m/2 = 30m).

b. The wing span of the design aircraft, B-747-400 is approx. 65m. Minimum separation can therefore be calculated to be 182.5m (300m/2 + 65m/2). This figure may be rounded to 184m, which is the JCAB minimum separation.

c. Although the preliminary design adopted 184m for the taxiway separation from the runway centerline, further study may be required in the detailed engineering design taking into account ICAO's requirements on this matter.

(2) Separation between Taxiway Centerlines

The separation between centerlines of parallel taxiways is planned to be 85m based on the following considerations:

a. ICAO minimum separation for aircraft category E is 76.5m for aircraft with a wing span up to 60m. This based on a total of wing span (60m), 2 times maximum lateral deviation (2 x 4.5m = 9m) and an increment of (7.5m).

b. For B-747-400, aircraft the separation becomes 81.5m (65m + 9m + 7.5m). This figure may be rounded to 85m which is the JCAB minimum separation. The turning radius of the cross over taxiway will be 42.5m, which allows B-747 to turn with less than a 40 degree steering angle.

(3) Stormwater Drainage

The planning criteria employed for the drainage facility requirements are summarized as follows:

a. Run off

Rational formula is utilized to estimate the run off.

$$Q = 1/360 \times C \times I \times A$$

Where, Q: Run off ($m^3$/sec)
C: Run off coefficient
I: Rainfall intensity (mm/hr)
A: Catchment area (ha)

b. Run off coefficient

Pavement area : 0.95
Building area : 0.90
Sodded area : 0.30

c. Rainfall intensity

The rainfall intensity for a 10 year return period at El Alto airport is given by the following formula:

$$I_{10} = 718.6 \times t^{-0.802}$$

where, $I_{10}$ : Average rainfall intensity for 10 year return period
t : Inlet time (min)

(4) Pavement

Design of the aircraft pavement is carried out based on the airport pavement design manual of JCAB. Design load and design coverage of the pavement are based on B-747 class aircraft and 3,000 times/year respectively. The subgrade conditions are assumed as follows based on the results of the soil investigation undertaken at the site.

Design CBR : More than 20% for cut and fill portion
Design K-value : More than 7.0 kg/cu.cm

The detailed conditions for the respective pavement areas are summarized below:

| Pavement Type No. | Place | Design Aircraft | JCAB Design Load Classification | Remarks |
|---|---|---|---|---|
| Type-1 | Runway Overlay | B-747 Class | LA-1 | |
| Type-2 | Taxiway | B-747 Class | LA-1 | |
| Type-3 | Taxiway | B-747 Class | LA-1 | Reduced Thickness of Type-2 by 10% |
| Type-4 | Taxiway | C-141 Class | LA-12 | |
| Type-5 | Meat Carrier's Taxiway and Apron | C-54 Class | LA-4 | |
| Type-6 | Passenger and Cargo Apron | B-747 Class | LA-1 | |
| Type-7 | Isolated Apron | B-747 Class | LA-1 | Reduced Thickness of Type-2 by 20% |
| Type-8 | General Aviation Apron | COMMANDER-690 Class | LA-5 | |
| Type-9 | Shoulder | - | - | |
| Type-10 | Blast Pad | - | - | |
| Type-11 | GSE Service Road | - | LT-1 | Towing Tractor Load |
| Type-12 | GSE Service Road and Parking | - | LT-1 | Towing Tractor Load |

## 8.2 Access Road

The cross section of the underpass box-culvert designed for the aircraft load of L-144 is shown in Figure 8.2.1.

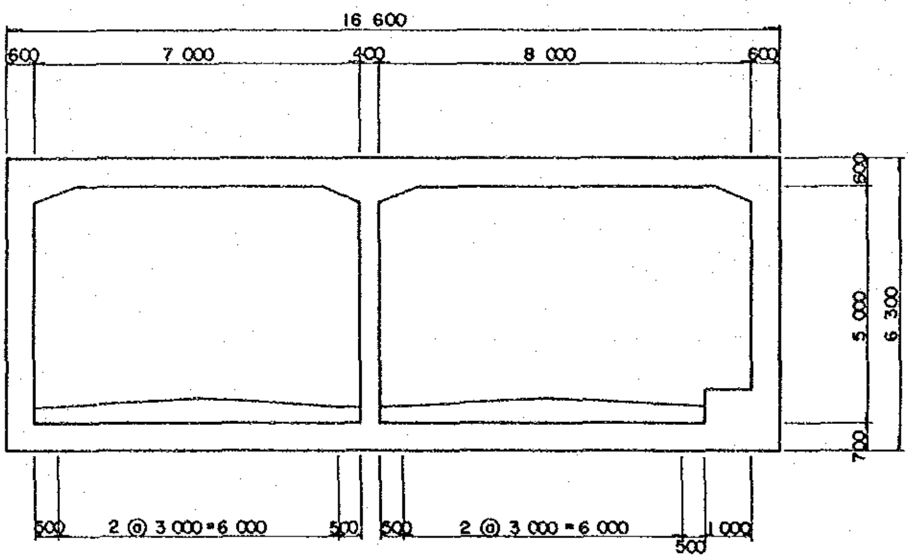



Figure 8.2.1 Cross Section of Box Culvert

## 8.3 Air Navigation Systems

The air navigation systems for the Phase-I development were planned based on the facility requirements indicated in Subsection 3.4 and the evaluation of the existing equipment and systems discussed in Subsection 4.5.

Table 8.3.1 shows the development items and their outlines in the Phase-I development.

Table 8.3.1 Outline of Air Navigation Systems for Phase-I Development

| Equipment | Outline of Equipment | Quantity |
|---|---|---|
| A. RADIO NAVIGATIONAL AIDS | | |
| A-1 Replacement of CVOR/DME | -Conventional VOR, 100 watt, 115.7 MHZ, dual equipment<br>-DME, 1 Kwatt, Channel 104X, dual equipment<br>-Pre-fabricated shelter<br>-Non breaking DC power supply equipment<br>-Remote control and monitor | 1 set |
| A-2 Replacement of Locator | -Locator, 330 KHz, 100 Watt, dual equipment, solid state<br>-Antenna with tower<br>-Pre-fabricated shelter<br>-Non breaking DC power supply equipment | 1 set |
| A-3 Installation of Microwave Landing System | -Approach azimuth with basic data transmission<br>-Approach elevation<br>-Precision DME<br>-Remote control and display equipment<br>-Non breaking DC power supply equipment | 1 set |
| A-4 Provision of Spare Parts and Maintenance Tools for Items A-1 through A-3 | | 1 lot |
| A-5 Provision of Test Equipment for Items A-1 through A-3 | | 1 lot |
| A-6 Installation of Telecommunication Cables for Navaids | | 1 lot |

| Equipment | Outline of Equipment | Quantity |
|---|---|---|
| A-7 Installation of External Power Supply Cables and Airfield Substations | | Lump sum |
| B. AIR TRAFFIC CONTROL AND AERONAUTICAL TELECOMMUNICATIONS SYSTEMS | | |
| B-1 Replacement of VHF Air-Ground Transmitters | -FIC, TMA(1), TMA(2), TMA(3), APP, TWR, SMC, EMERG/eight frequencies<br>-Solid state 50 Watt transmitter<br>-High gain antenna with change-over switch<br>-VHF antenna support tower<br>-Pre-fabricated shelter | 16 sets |
| B-2 Replacement of VHF Air-Ground Receivers | -Frequencies: same as B-1<br>-High gain antenna with changeover switch<br>-VHF antenna support tower<br>-Pre-fabricated shelter | 16 sets |
| B-3 Replacement of Multi-channel Transceivers | -Multi-channel transceiver complete with antenna<br>-Two sets for control tower and approach control office | 2 sets |
| B-4 Replacement of VHF FM Transceiver for Vehicle Control | -VHF FM transceiver with antenna to be installed at control tower | 1 set |
| B-5 Replacement of VHF Links by UHF Links | -Three links: Achachicala - Huaricollo - Tapacari - Juno<br>-UHF transmitter/receiver, Dual and hot-stand-by configulation, 50W, 6 sets<br>-UHF Link Multiplexer, 24 channel, 2 sets<br>-Parabolic antenna and tower, 6 sets<br>-Solar cells with battery for TAPACARI Relay Station | Lump sum |

| Equipment | Outline of Equipment | Quantity |
|---|---|---|
| B-6 Replacement of HF/SSB/ISB Air-Ground Transmitters | -For SAM-1, SAM-2 and National Circuit HF/SSB/ISB transmitter, 1 Kwatt,<br>-TX antenna: Existing<br>-Antenna changer | 7 sets |
| B-7 Replacement of SSB/ISB/Air-Ground Receivers | -HF/SSB/ISB receiver<br>-RX omni-directional receiver antenna with change over, 4 sets<br>-Remote controller | 7 sets |
| B-8 Replacement of Control Consoles | -Control tower console and communications control unit, 3 control positions<br>-ACC console, 3 sectors without radar<br>-Console for VFR aircraft, 2 positions with HF radio controls | 3 sets |
| B-9 Installation of ATIS | -Console<br>-Tape-recorder and reproducer<br>-VHF transmitter (dual) and antenna | 1 set |
| B-10 Replacement of Magnetic-Taperecorder | -Tape recorder, 24 channels<br>-Reproducer | 1 set |
| B-11 Replacement of Traffic Light Gun | | 2 sets |
| B-12 Provision of Spare Parts and Mainten-ance Tools for B-1 through B-10 | | 1 lot |
| B-13 Provision of Test Equipment for B-1 through B-10 | | 1 lot |
| C. ATC RADAR SYSTEM | | |
| C-1 Relocation of the Existing SSR | IRS-10/CESELSA | Lump sum |

| Equipment | Outline of Equipment | Quantity |
|---|---|---|
| D. AIRONAUTICAL GROUND LIGHTS | | |
| D-1 Installation of a Simple Approach Lighting System | -Installation of change-over switch of CCR, high tension cables, lighting fitting and bulbs with frames | Lump sum |
| D-2 Replacement of Runway Edge Lights | -Replacement of CCRs, cables lighting fittings and bulbs<br>-Demolition of the existing cables and lights | Lump sum |
| D-3 Replacement of Runway Threshold and End Lights for both Thresholds and Ends | -Category-I Layout<br>-Replacement of cables and lighting fittings and bulbs<br>-Demolition of the existing cables and lights | Lump sum |
| D-4 Replacement of Runway Wing-bar Lights | -Runway 09 only<br>-Replacement of cables and lighting fixtures and bulbs<br>-Demolition of the existing cables and lights | Lump sum |
| D-5 Replacement and Addition of Taxiway Edge Lights | -Installation and replacement of cables and lighting fixtures and bulbs<br>-Demolition of the existing cables and lights | Lump sum |
| D-6 Installation of Taxiing Guidance System | -Installation of 3 sets of a taxiing guidance boards and cables | Lump sum |
| D-7 Installation of Apron Flood lights | -Installation of a high luminous lighting fixtures with poles for the passsenger terminal apron and the cargo apron | Lump sum |
| D-8 Replacement of Illuminated Wind Direction Indicator Lights | -Runway 09 and 27 touch-down areas<br>-Replacement of cables and demolition of the existing cables | 2 sets |
| D-9 Replacement of Aerodrome Beacon | -Replacement of new aerodrome beacon top on new control tower | 1 set |

| Equipment | Outline of Equipment | Quantity |
|---|---|---|
| D-10 Replacement of Power Distribution and Control System | -Replacement of CCRs for ground lights, power distribution boards and cables<br>-Installation of new control desk for ground lights<br>-Demolition of the existing CCRs, power distribution boards and cables | Lump sum |
| D-11 Construction of Ducts and Manholes under Runway and Taxiways | -Installation of a suitable number of pipe under runway and taxiway | Lump sum |
| D-12 Construction of Substation for Lights | Installation of one set of cubicle type's substation in the administration building | Lump sum |
| D-13 Provision of Spare Parts and Mainten-ance Tools for D-1 through D-12 | | 1 lot |
| D-14 Provision of Test Equipment for D-1 through D-12 | | 1 lot |
| E. METEOROLOGICAL SYSTEM | | |
| E-1 Installation of Field Weather Observation Equipment | -Field weather equipment<br>. Wind sensor (2 sets)<br>. Thermo-hydro meter (2 sets)<br>. Precipitation guage (1 set)<br>. Transmissometer (2 sets)<br>. Ceilometer (1 set)<br>. Field junction converter (2 sets)<br>. Barometer (1 set)<br>-Automatic data collection and recording equipment | Lump sum |

| Equipment | Outline of Equipment | Quantity |
|---|---|---|
| (E-1 cont'd) | -Weather report desk<br>-Branch LED display (QNH, Wind speed/ direction, RVR), 3 units<br>-Branch video display (composite WX data display), 4 units | |
| E-2 Provision of Conventional Altimeter and Barometer | | 1 set |
| E-3 Replacement of HF receiver, Facsimile and Teletypewriter | -HF receiver complete with RX antenna<br>-HF facsimile equipment (dual)<br>-Teletypewriters (2 sets) | 1 lot |
| E-4 Replacement of APT Receiver | -Multi-frequencies receiver with antennas and printers | 1 lot |
| E-5 Installation of Radiosonde Receiver and Hydrogen Generator | -Radiosonde receivers (dual)<br>-Hydrogen generator for radiosonde<br>-Radiosonde (800 sets for two year operation) | 1 lot |
| E-6 Provision of Spare Parts E-1 through E-5 | | 1 lot |
| E-7 Provision of Test Equipment for E-1 through E-5 | | 1 lot |
| E-8 Provision of Consuming Materials | | 1 lot |
| F. OTHERS | | |
| F-1 Factory Training | | Lump sum |
| F-2 Site Training | | Lump sum |
| F-3 Ground Assistance for Flight calibration | | Lump sum |

### 8.3.1 Radio Navigational Aids

#### (1) ILS and MLS

The existing instrument landing system (ILS) and distance measuring equipment (DME) co-located with the glide path of the ILS which were installed in 1983, will require equipment replacement by around 1995. However, ILS will be replaced by a microwave landing system (MLS) by the year 1997 as shown in Table 8.3.2.

After a two (2) year transition period from ILS to MLS, ILS will no longer be considered standard landing guidance system of ICAO. Accordingly, the introduction of MLS in the Phase-I development was planned. The existing ILS must be well maintained in order to be operational up to the year 1997.

#### (2) NDB

AASANA has a plan to replace the existing non-directional beacon (NDB) with new equipment at the existing location in 1988. Accordingly, no replacement will be required in the Phase-I development.

#### (3) VOR/DME

The conventional VHF omni-directional range (VOR) and DME were replaced in 1982 and 1975, respectively. Replacement of this equipment will be necessary in Phase-I development at the same location. Although the existing VOR/DME are operated with AC power, a non breaking DC power supply of charger and batteries were planned in order to meet the ICAO requirements for power supply to navaids.

#### (4) Locator

The locator is an old piece of equipment installed in 1968. Although a locator is not mandatory for regular civil air transport, it will be replaced for guidance to small propellar-driven aircraft at El Alto airport.

| Year | 86 | 87 | 88 | 89 | 1990 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 2000 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ILS | Primary System | | | | | | | | | | | | Optional | | | | | | | | | | | | |
| MLS | Optional | | | | Recommended | | | | | | | | TRANSITION → Primary System | | | | | | | | | | | | |
| Status | Dual Standards exist. ILS ICAO primary system, use of MLS optional. | | | | Dual standards exist. ILS ICAO primary system, increased use of MLSis recommended. | | | | | | | | MLS is the ICAO primary system. Conti-nued use of ILS is optio-nal. | | MLS is a sole ICAO Standard approach and landing guidance system. | | | | | | | | | | |

(Source; Communications/Operations Division Meeting, 1985, ICAO)

Table 8.3.2 ILS/MLS Transition Plan

### 8.3.2 Air Traffic Control and Aeronautical Telecommunications systems

#### (1) Radar

The construction of a secondary surveillance radar (SSR) is underway at present and the radar operation will start in early 1988. The SSR is designated for terminal use for La Paz Terminal. Since the location of the SSR is to be developed as a cargo terminal area in Phase-I development, the re-location of the SSR will be required prior to the start of Phase-I construction work. The relocation of control consoles from the existing ACC room to the new Administration Building will also be required after completion of the Administration Building. The SSR will require replacement in Phase-II, preferably, by ASR/SSR.

#### (2) VHF Air-Ground Radios

Since there are communications problems on the existing VHF air-ground radios as explained in Subsection 4.5, transmitter and receiver antennas should be relocated to airside where an un-obstructed line of sight between airborne and/or parked aircraft can be obtained.

The following VHF air-ground radios will be replaced by complete-dual configuration equipment.

| | | | | |
|---|---|---|---|---|
| 1) | FIC | "La Paz Information" | 127.1 | MHz |
| 2) | TMA | "La Paz Control" - (1) | 123.9 | MHz |
| 3) | TMA | "La Paz Control" - (2) | 128.205 | MHz |
| 4) | TMA | "La Paz Control" - (3) | 128.195 | MHz |
| 5) | APP | "La Paz Approach" | 119.5 | MHz |
| 6) | TWR | "La Paz Tower" | 118.3 | MHz |
| 7) | SMC | | 121.9 | MHz |
| 8) | Emergency | | 121.5 | MHz |

#### (3) HF Radios

The world wide tendency is for HF ground-ground radio to be replaced by common carrier systems such as UHF link, microwave link, satellite communications, etc., due to the low reliability of HF propagation characteristics. The same tendency is observed in Bolivia, thus all the HF ground-ground radios are considered to be replaced by AASANA UHF links or ENTEL public network.

With respect to HF air-ground communications, the aeronautical satellite which is under development is the only alternative. HF air-ground communications is considered to be used for a while in South America, thus international (SAM-1* and SAM-2) and domestic circuits are planned with HF/SSB/ISB radios.

| * : Frequencies | | |
|---|---|---|
| SAM-1 | 6,649 | KHz |
| | 10,024 | KHz |
| SAM-2 | 3,479 | KHz |
| | 5,526 | KHz |
| | 8,855 | KHz |
| | 10,096 | KHz |
| La Paz National | 3,425 | KHz |
| | 6,622 | KHz |
| | 8,912 | KHz |
| | 10,082 | KHz |

The HF transmitter site is planned to remain unchanged whereas the HF receiver site is planned at the same location as the VHF receiver site for easy maintenance.

Replacement of three HF/SSB/ISB transmitters and three receivers will be required for SAM-1 and SAM-2 in Phase-I. Replacement of two transmitters and two receivers will be required for domestic circuits, i.e., "La Paz National". No replacement of transmitter antennas will be necessary.

(4) Control Consoles

All the control consoles will be installed new at the administration building and control tower, except that the SSR radar control consoles being installed are to be relocated from the existing ACC room. The console will include the following:

1) Aerodrome control console
2) Area control console
3) VFR aircraft control console

(5) UHF Links

The existing VHF links connecting El Alto airport to the Juno relay station, where La Paz Control radio is located, will be replaced by UHF links in order to solve the radio interference from taxi radios and to ensure high reliability for the fixed telecommunications. At least four links will be required between El Alto airport and the Juno relay station based on the condition that the line of sight between each relay station is obtained.

Each transmitter/receiver will require two parabolic antennas of space diversity due to the relatively long link distance.

(6) AFTN Exchange and Teletypewriters

The equipment at El Alto airport provides an international and domestic AFTN network in and outside Bolivia. Accordingly, the replacement of AFTN exchange and teletypewriters are to be planned by AASANA for a national network.

### 8.3.3 Aeronautical Ground Lights

Replacement and/or installation of additional aeronautical ground lights will be required as listed in Table 8.5.1 of Main Report in Phase-I development.

The existing precision approach category-II lighting system on runway 09 and PAPI can be utilized during Phase-I.

The other lights will require replacement of all components of the lighting system, i.e., replacement of constant current regulators, lighting fixtures and bulbs, sealed transformers, re-wiring of high and low tension cables, etc.

All the power supply systems including CCRs and control equipment for lights will be accommodated in the control tower and administration building for easy maintenance and operations.

### 8.3.4 Meteorological System

All equipment and office space for the meteorological services will require drastic renovation for the reasons described in Subsection 4.5.

Meteorological forecast and telecommunications offices will be accommodated in the administration building while a meteorological observation station will be located independently near the runway and between the sewage treatment plant and receiver site. A briefing room will be located in the new passenger terminal building so as to ensure easy access to the dispatcher.

The meteorological observation station will be a one storey building of about 160 sq.m and will have an observation room on the roof from which a clear and un-obstructed view of the runway and sky should be obtained. The meteorological station will also have a confined meteorological park where conventional observation sensors are to be installed.

Airport surface sensors will be located separately near the runway 09 and 27 touch-down areas and the observed surface data will automatically be transmitted to the meteorological observation station. The observed data will be collected and compiled at the meteorological station and distributed to branch displays in the aerodrome control tower, approach control office and meteorological office in the administration building.

A radiosonde launching pad and receiver together with a hydrogen generator will be installed in the meteorological observation station, while HF radio receiver, facsimile equipment, teletypewriters and multi-frequencies automatic picture transmitter (APT) receiver will be installed at the administration building for meteorological telecommunications and forecast.

## 8.4 Airport Utilities

### (1) Power Supply System

Power supply system is planned based on the facility capacity shown in Table 8.4.1.

Table 8.4.1 Facility Capacity for Electricity Power Supply

(Unit in KVA)

| Load | Commercial Electricity Only | With Stand-By Generator | Total Supply |
|---|---|---|---|
| Aeronautial Ground Lights | - | 120 | 120 |
| Navigational Aids and Telecommunications | - | 130 | 130 |
| Buildings etc. | 770 | 980 | 1,750 |
| Total | 770 | 1,230 | 2,000 |

Electrical power will be supplied from the Alto La Paz substation and Tarapaca substation of COBEE in order to provide a highly reliable source. The cost estimates include installation cost of these cables, but the transformer and distribution devices at these substations are not included.

Emergency power supply system consists of two generators. A new 1000 KVA 6.6 KV generator will be added to the existing 587 KVA (470 KW) 240 V generator.

(2) Sewer System

Wastewater treatment system is planned based on the following conditions:

a. Quality of Influent

$BOD_5$ : 200 mg/litre
SS : 250 mg/litre

b. Quality of Effluent

$BOD_5$ : Less than 20 mg/litre
SS : Less than 30 mg/litre

# CHAPTER 10  SUPPLEMENTARY CONSIDERATIONS

# CHAPTER 10 SUPPLEMENTARY CONSIDERATIONS

## 10.1 Calculation of Aircraft Noise Contours

Aircraft noise contours were calculated based on the following assumptions:

(1) Number of Daily Flights

| Aircraft | Year 1987 | Year 2005 |
|---|---|---|
| JJM (B-747M Class) | 1 | 2 |
| LJ (L-1011 Class) | - | 9 |
| NJ (B-727 Class) | 8 | 20 |
| SJ (B-737 Class) | 10 | 12 |
| P (F-27 Class) | 7 | 8 |
| Total | 27 | 51 |

(2) Time Distribution of Flights

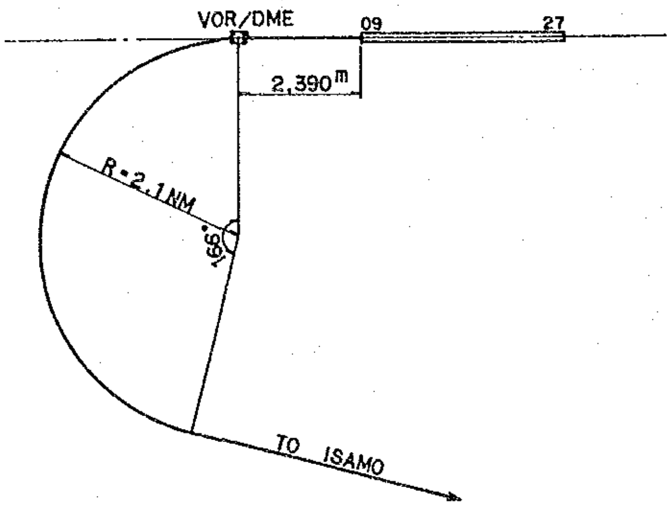
| | | | |
|---|---|---|---|
| Day Time | (7:00 - 19:00) | : | 80 % |
| Evening Time | (19:00 - 22:00) | : | 15 % |
| Night Time | (22:00 - 7:00) | : | 5 % |
| Total | | | 100 % |

(3) Ratio of Runway Use

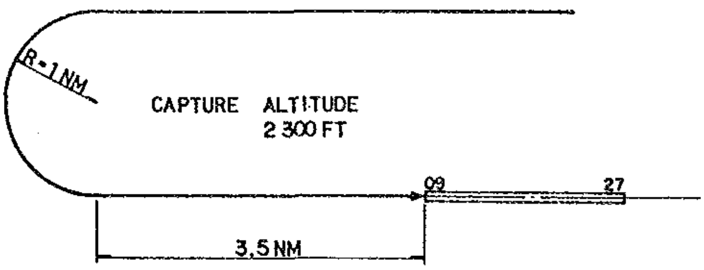
| | | | |
|---|---|---|---|
| Runway 09 | Take-off | : | 2 % |
| | Landing | : | 46 % |
| Runway 27 | Take-off | : | 48 % |
| | Landing | : | 4 % |
| Total | | | 100 % |

(4) Typical Traffic Patterns

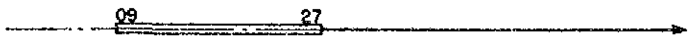
a. Runway 09 Takeoff



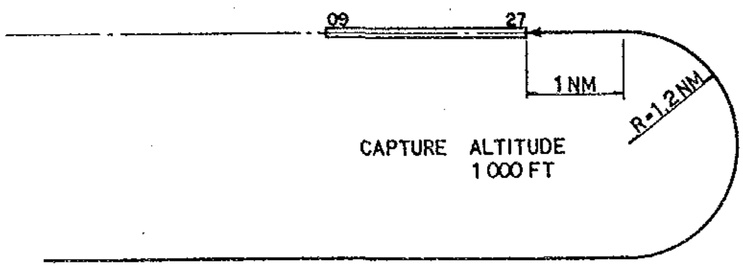

b. Runway 09 Landing



c. Runway 27 Take-off




d. Runway 27 Landing




(5) Takeoff Profile

The take-off profile at sea level was utilized for the calculation due to the lack of aircraft take-off performance data at high altitude. This approximation gives a smaller noize level under the take-off path because the actual take-off climb angle at high altitude is lower than that at sea level and also because the aircraft require a longer take-off run at higher altitude.

(6) Landing Profile

Landing profile is assumed to be the same as the actual glide path angle, i.e. $2.5^{o}$ for 09 landing and $3.0^{o}$ for 27 landing.

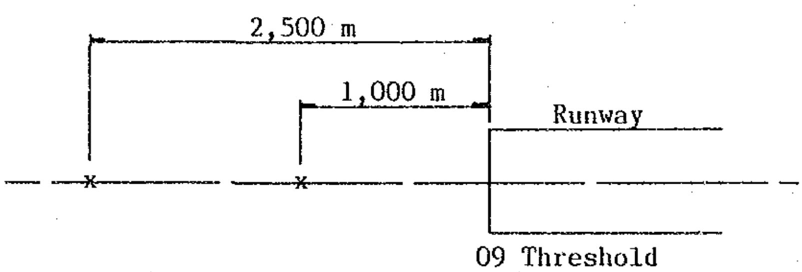
## Appendix 10.1 Result of Aircraft Noise Measurement

### 1. General

The measurement of the aircraft noise level at El Alto airport was carried out in accordance with the request by AASANA because there is no data on the aircraft noise level at an altitude of 4,000 m above mean sea level.

### 2. Outline of Measurement

| | | |
|---|---|---|
| Measurement Point | : | Shown in Figure A.10.1.1 |
| Date of Measurements | : | From 8th July to 14th August in 1987 |
| Atmospheric Pressure | : | 627 mb - 628 mb |
| Temperature | : | 12 - 16$^{o}$C |
| Objective Aircraft | : | B747, B727-200<br>B727-100, B737 |
| Instrument | : | Sound level meter |




x : Measurement point

Figure A.10.1.1

### 3. Result of Measurement

The data collected is shown on pages 10-6 through 12.

Based on the data collected, the following significant points on the aircraft noise level at the altitude of 4,000 m above mean sea level are noted:

- In the case of take-off, aircraft noise level is a little higher than level at a sea level. This may be caused by a lower take-off profile than that at sea level.

- In the case of landing, the aircraft noise level is a little lower than the level at sea level. Landing profiles were not different from those at sea level. Therefore, a lower level is assumed to be caused by an approximately 40 percent lower atmospheric pressure compared with sea level.

## Data Collected for Aircraft Noise Level

1.1 B747 Landing     Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| AUG 10 | 12:49 | 89 | 73 | LH 528 | LIM |
| (At sea level | | 102 | 57) | | |

1.2 B747 Landing     Location : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| JUL 13 | 12:43 | 91 | 136 | LH 528 | LIM |
| AUG 10 | 12:49 | 92 | 127 | LH 528 | LIM |
| (At sea level | | 95 | 122) | | |

1.3 B747 Take off     Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUL 22 | 14:35 | 96 | 204 | LH 529 | LIM |
| JUL 27 | 14:25 | 91 | - | LH 529 | LIM |
| AUG 10 | 14:39 | 82 | 190 | LH 529 | LIM |
| (At sea level | | 87 | 550) | | |

1.4 B747 Take off Location : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUL 8 | 14:50 | 77 | 806 | LH 529 | LIM |
| JUL 13 | 14:28 | 75 | - | LH 529 | LIM |
| JUL 22 | 14:35 | 87 | 308 | LH 529 | LIM |
| JUL 27 | 14:25 | 71 | - | LH 529 | LIM |
| JUL 29 | 14:38 | 90 | - | LH 529 | LIM |
| AUG 10 | 14:39 | 78 | - | LH 529 | LIM |
| (At sea level | | 83 | 800) | | |

2.1 B727-200 Landing Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| JUL 22 | 11:54 | 97 | 155 | LB 752 | SRE |
| JUL 30 | 10:10 | 95 | 58 | LB 918 | CBB |
| AUG 11 | 13:19 | 89 | 65 | EA 992 | LIM |
| AUG 12 | 11:31 | 88 | 62 | CB 752 | SRE |
| (At sea level | | 100 | 57) | | |

2.2 B727-200 Landing Location : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| JUL 30 | 10:10 | 97 | 110 | LB 918 | CBB |
| AUG 11 | 13:19 | 90 | 127 | EA 992 | LIM |
| AUG 12 | 11:31 | 93 | 126 | LB 752 | SRE |
| (At sea level | | 98 | 122) | | |

2.3 B727-200 Take off     Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUL 22 | 13:07 | 106 | 103 | LB 775 | TJA |
| JUL 23 | 11:05 | 109 | - | LB 918 | LIM |
| JUL 24 | 10:59 | 104 | 130 | LB 771 | SRE |
| JUL 27 | 10:00 | 110 | - | LB 753 | SRE |
| JUL 28 | 10:43 | 95 | - | LB 907 | ARI |
| JUL 30 | 10:14 | 105 | 131 | LB 918 | SCL |
| JUL 30 | 11:05 | 104 | 132 | LB 918 | LIM |
| AUG 11 | 14:08 | 99 | 67 | EA 992 | ASU |
| AUG 12 | 12:07 | 96 | 181 | LB 775 | TJA |
| JUL 29 | 10:54 | 98 | 203 | LB 751 | |
| | (At sea level | 98 | 350) | | |

2.4 B727-200 Take off     Lacation : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUL 8 | 12:30 | 85 | 340 | LB 775 | TJA |
| JUL 22 | 13:07 | 94 | 177 | LB 775 | TJA |
| JUL 23 | 11:05 | 97 | 268 | LB 918 | LIM |
| JUL 24 | 10:59 | 103 | 153 | LB 771 | SRE |
| JUL 28 | 10:43 | 95 | - | LB 907 | ARI |
| JUL 29 | 10:54 | 98 | 149 | LB 751 | |
| JUL 30 | 10:14 | 103 | 143 | LB 907 | SCL |
| JUL 30 | 11:05 | 107 | 150 | LB 918 | |
| AUG 11 | 14:08 | 103 | 251 | EA 992 | ASU |
| AUG 12 | 12:07 | 94 | 135 | LB 775 | TJA |
| | (At sea level | 93 | 550) | | |

3.1 B727-100 Landing    Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| JUL 22 | 11:36 | 89 | 181 | LB 635 | |
| JUL 30 | 14:28 | 89 | 70 | SC 880 | SAO |
| JUL 30 | 15:31 | 96 | 67 | LB 917 | LIM |
| AUG 10 | 13:10 | 91 | 55 | LB 637 | TDD |
| AUG 11 | 10:07 | 93 | 64 | LB 801 | |
| AUG 12 | 11:42 | 92 | 68 | LB 635 | |
| AUG 13 | 12:38 | 96 | 61 | LB 918 | |
| AUG 13 | 13:22 | 90 | 75 | SC 880 | SAO |
| (At sea level | | 100 | 57) | | |

3.2 B727-100 Landing    Location : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| JUL 13 | 13:37 | 95 | 119 | LB 637 | TDD |
| JUL 30 | 14:28 | 91 | 125 | SC 880 | SAO |
| JUL 30 | 15:31 | 86 | 150 | LB 917 | LIM |
| AUG 10 | 13:10 | 98 | 109 | LB 637 | TDD |
| AUG 11 | 10:07 | 94 | 125 | LB 801 | |
| AUG 12 | 11:42 | 95 | 131 | LB 635 | |
| AUG 13 | 12:38 | 92 | 127 | LB 918 | |
| AUG 13 | 13:22 | 92 | 136 | SC 880 | |
| (At sea level | | 98 | 122) | | |

3.3 B727-100 Take off        Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUL 23 | 14:02 | 95 | 83 | LB 943 | ARI |
| JUL 27 | 11:22 | 98 | - | LB 636 | TDD |
| JUL 27 | 14:37 | 95 | - | LB 773 | TJA |
| JUL 28 | 10:18 | 95 | - | LB 801 | CBB |
| JUL 29 | 12:19 | 98 | 147 | LB 638 | TDD |
| JUL 30 | 14:40 | 92 | 168 | LB 943 | ARI |
| JUL 30 | 15:17 | 98 | 165 | SC 881 | SAO |
| AUG 10 | 11:10 | 91 | 211 | LB 636 | TDD |
| AUG 10 | 14:20 | 98 | 104 | LB 773 | TJA |
| AUG 11 | 10:25 | 94 | 153 | LB 907 | ARI |
| AUG 11 | 11:10 | 101 | 68 | LB 918 | LIM |
| AUG 12 | 13:02 | 91 | 96 | LB 638 | TDD |
| AUG 13 | 13:07 | 102 | 59 | LB 918 | LIM |
| AUG 13 | 14:21 | 97 | 105 | SC 881 | SAO |
| (At sea level | | 98 | 350) | | |

3.4 B727-100 Take off      Location : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUL 8 | 15:20 | 92 | 200 | LB 638 | TDD |
| JUL 9 | 14:09 | 86 | 111 | LB 943 | ARI |
| JUL 9 | 14:21 | 96 | 178 | SC 881 | SAO |
| JUL 13 | 9:37 | 97 | – | LB 753 | SRE |
| JUL 13 | 11:02 | 94 | 202 | LB 636 | TDD |
| JUL 22 | 12:12 | 87 | 130 | LB 638 | TDD |
| JUL 23 | 14:02 | 82 | 118 | LB 943 | ARI |
| JUL 27 | 11:22 | 71 | – | LB 636 | TDD |
| JUL 27 | 14:37 | 76 | – | LB 773 | TJA |
| JUL 28 | 10:18 | 94 | – | LB 801 | CBB |
| JUL 29 | 12:19 | 96 | 161 | LB 638 | TDD |
| JUL 30 | 15:17 | 98 | 240 | SC 881 | SAO |
| AUG 10 | 11:10 | 92 | 164 | LB 636 | TDD |
| AUG 10 | 14:20 | 84 | 80 | LB 773 | TJA |
| AUG 11 | 10:07 | 93 | – | LB 801 | CBB |
| AUG 11 | 10:25 | 96 | 169 | LB 907 | ARI |
| AUG 11 | 11:10 | 101 | 124 | LB 918 | LIM |
| AUG 13 | 13:07 | 103 | 151 | LB 918 | LIM |
| AUG 13 | 14:21 | 101 | 144 | SC 881 | SAO |
| AUG 14 | 11:16 | 104 | 149 | LB 775 | SRE |
| (At sea level | | 93 | 550) | | |

4.1 B737 Landing      Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| JUL 24 | 12:20 | 84 | – | LA 118 | ARI |
| JUL 31 | 12:35 | 95 | 61 | LA 118 | ARI |
| AUG 14 | 12:30 | 83 | 67 | LA 118 | ARI |
| (At sea level | | 100 | 57) | | |

4.2 B737 Landing Location : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Origin |
|---|---|---|---|---|---|
| JUL 13 | 12:53 | 82 | 156 | LA 118 | ARI |
| JUL 24 | 12:20 | 88 | 123 | LA 118 | ARI |
| JUL 31 | 12:35 | 77 | 125 | LA 118 | ARI |
| AUG 14 | 12:30 | 84 | 123 | LA 118 | ARI |
| | (At sea level | 98 | 122) | | |

4.3 B737 Take off Location : 1,000m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUL 24 | 13:16 | 97 | 115 | LA 119 | ARI |
| JUL 27 | 13:58 | 95 | - | LA 119 | ARI |
| JUL 31 | 13:30 | 99 | 189 | LA 119 | ARI |
| AUG 14 | 13:26 | 97 | 151 | LA 119 | ARI |
| | (At sea level | 93 | 550) | | |

4.4 B737 Take off Location : 2,500m from runway threshold 09

| Date | Time | Maximum Noise Level (dB(A)) | Slant Distance (m) | Flight Number | Destination |
|---|---|---|---|---|---|
| JUl 10 | 13:18 | 97 | - | LA 119 | ARI |
| JUL 13 | 13:42 | 91 | 232 | LA 119 | ARI |
| JUL 24 | 13:16 | 96 | 183 | LA 119 | ARI |
| JUL 27 | 13:58 | 83 | - | LA 119 | ARI |
| JUL 31 | 13:30 | 85 | 270 | LA 119 | ARI |
| AUG 14 | 13:26 | 96 | 185 | LA 119 | ARI |
| | (At sea level | 88 | 800) | | |

ABBREVIATIONS:

| | | |
|---|---|---|
| ARI : ARICA | ASU : ASUNSION | CBB : COCHABAMBA |
| LIM : LIMA | SAO : SAO PAULO | SCL : SANTIAGO |
| SRE : SUCRE | TDD : TRINIDAD | TJA : TARIJA |

# CHAPTER 11 IMMEDIATE IMPROVEMENT

# CHAPTER 11 IMMEDIATE IMPROVEMENT

## 11.1 Preliminary Design for Immediate Improvement

### 11.1.1 Improvement of Runway Pavement

The existing runway pavement located 1,740 m from runway 09R threshold is seriously deteriorated. This is assumed to be caused by the minimum pavement thickness as described in Chapter 4. The existing cement concrete pavement is therefore planned to be partially replaced with an asphalt concrete pavement with the required thickness.

The pavement thickness has been planned as follows based on the JCAB (Japan Civil Aviation Bureau) method.

| | | |
|---|---|---|
| Design aircraft | : | B-747 class |
| Repetition of design load | : | 3,000 times |
| Subgrade CBR value | : | 20% |

| Component | Thickness |
|---|---|
| Surface course | 4 cm |
| Binder course | 5 cm |
| Ditto | 5 cm |
| Base course | 25 cm |
| Sub-base course | 15 cm |
| Total | 54 cm |

At the interface between the proposed asphalt concrete pavement and the existing cement concrete pavement, an approach slab will be constructed in order to prevent the asphalt concrete pavement from causing any differential in level.

### 11.1.2 Construction of Runway Shoulders and Blast Pads

Based on the JCAB method, a 27 cm thick asphalt concrete pavement (5 cm thick surface course and 22 cm thick base course) is required for the runway shoulders and blast pads. The area required for runway shoulders and blast pads is estimated to be 57,500 sq.m and the estimated cost is high.

It is essential for the immediate improvement to be implemented by MDA/AASANA as soon as possible. The pavement of runway shoulders and blast pads for the immediate improvement has therefore been planned to be surface course of 3 cm thickness considering the economy and minimum thickness required for the construction.

### 11.1.3 Renovation of Existing Passenger Terminal Building

The renovation shown in Figure 11.2.3 of the Main Report has been planned considering the cost efficiency and minimum requirements to resolve the serious congestion in the existing passenger terminal building, particulary in the international arrival area.

# CHAPTER 12 PROJECT IMPLEMENTATION SCHEDULE AND COST ESTIMATES

# CHAPTER 12 PROJECT IMPLEMENTATION SCHEDULE AND COST ESTIMATES

## 12.1 Project Cost Estimates

The estimated costs are based on the following assumptions:

a. Construction cost is estimated based on the unit construction prices existing in 1987.

b. Exchange rates are fixed at US$1.00 = Bs1.95 = ¥150

c. The following facilities which will be constructed and/or supplied by other related authorities are not included in the cost estimates.
- Fuel yard and fuel hydrant system
- Catering building
- Airlines' storage facilities
- Airlines' staff office to be located outside passenger terminal building
- Maintenance shop and gas station for airlines' ground service equipment
- Airlines' ground service equipment
- Building for cargo agents

d. Foreign currency portion of the project cost includes the following items:
- Procurement cost for the imported materials and equipment
- Procurement cost for the imported construction equipment
- The general expenses and profit for the foreign contractors and engineering firms
- Wages for foreign staff

e. Bolivian currency portion of the cost includes the following items:
- Operation cost of the construction equipment including fuel and lubricants
- Procurement costs of the construction materials which are available in Bolivia such as cement, aggregate and others
- Transportation costs for materials and laborers procured, employed in Bolivia
- The contractors' expenses and profits, for both foreign and local, for the amounts paid in Bolivian currency
- Wages for Bolivian laborers

Note: The cost shown in Appendix 12.1 which is based on the preliminary design is different from the cost of TC-3 shown in Table A.6.1.6 which was estimated for the evaluation comparison before the preliminary design.

## Appendix 12.1 Estimated Project Cost for the Phases I and II Development

Exchange Rate: US$1.00 - Bs1.95 = ¥150 (As of March 1987)
Cost estimate based on 1987 price

Unit: US$1,000

| Item | | Phase I | | | Phase II | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Bolivian Portion | Foreign Portion | Total | Bolivian Portion | Foreign Portion | Total | Bolivian Portion | Foreign Portion | Total |
| Civil Works | Runway Overlay and Turning Pad | 690 | 7,140 | 7,830 | 190 | 1,900 | 2,090 | 880 | 9,040 | 9,920 |
| | Taxiways | 1,550 | 6,260 | 7,810 | - | - | - | 1,550 | 6,260 | 7,810 |
| | Passenger Terminal Apron | 2,220 | 3,880 | 6,100 | 310 | 620 | 930 | 2,530 | 4,500 | 7,030 |
| | Road and Car Parking Area | 360 | 1,220 | 1,580 | 90 | 410 | 500 | 450 | 1,630 | 2,080 |
| | Security Fence and Perimeter/ Maintenance Road | 120 | 310 | 430 | 100 | 460 | 560 | 220 | 770 | 990 |
| | Cargo Terminal Apron | 790 | 1,290 | 2,080 | 160 | 330 | 490 | 950 | 1,620 | 2,570 |
| | General Aviation Apron, Cargo Apron for Small Carriers and Isolated Apron | 380 | 1,940 | 2,320 | 10 | 50 | 60 | 390 | 1,990 | 2,380 |
| | Sub Total | 6,110 | 22,040 | 28,150 | 860 | 3,770 | 4,630 | 6,970 | 25,810 | 32,780 |
| Architectural Works | Passenger Terminal Building including Flight Information System and Airport Security System | 8,470 | 20,660 | 29,130 | 4,260 | 10,390 | 14,650 | 12,730 | 31,050 | 43,780 |
| | Fire Station | 200 | 460 | 660 | 40 | 80 | 120 | 240 | 540 | 780 |
| | Administration Building and Control Tower | 1,870 | 4,370 | 6,240 | - | - | - | 1,870 | 4,370 | 6,240 |
| | Meteorological Observation Building | 130 | 290 | 420 | - | - | - | 130 | 290 | 420 |
| | Cargo Terminal Building | 1,650 | 4,040 | 5,690 | 1,120 | 2,750 | 3,870 | 2,770 | 6,790 | 9,560 |
| | Airport Maintenance Shop and Storage | 340 | 790 | 1,130 | - | - | - | 340 | 790 | 1,130 |
| | Sub Total | 12,660 | 30,610 | 43,270 | 5,420 | 13,220 | 18,640 | 18,080 | 43,830 | 61,910 |
| Air Navigation Systems | Aeronautical Ground Lights for Runway | 170 | 3,320 | 3,490 | 40 | 1,360 | 1,400 | 210 | 4,680 | 4,890 |
| | Secondary Surveillance Radar | 20 | 60 | 80 | 40 | 5,460 | 5,500 | 60 | 5,520 | 5,580 |
| | Aeronautical Ground Lights for Taxiway and Apron | 100 | 1,440 | 1,540 | 10 | 1,540 | 1,550 | 110 | 2,980 | 3,090 |
| | Radio Navigational Aids | 90 | 6,340 | 6,430 | 20 | 2,110 | 2,130 | 110 | 8,450 | 8,560 |
| | Air Traffic Control and Aeronautical Telecommunications System | 210 | 7,690 | 7,900 | 50 | 4,900 | 4,950 | 260 | 12,590 | 12,850 |
| | Meteorological System | 10 | 3,060 | 3,070 | 10 | 2,180 | 2,190 | 20 | 5,240 | 5,260 |
| | Sub Total | 600 | 21,910 | 22,510 | 170 | 17,550 | 17,720 | 770 | 39,460 | 40,230 |
| Airport Utilities | Power Supply System | 110 | 2,650 | 2,760 | 30 | 1,330 | 1,360 | 140 | 3,980 | 4,120 |
| | Water Supply System | 140 | 550 | 690 | - | - | - | 140 | 550 | 690 |
| | Telecommunications | 0 | 100 | 100 | 10 | 70 | 80 | 10 | 170 | 180 |
| | Sewage Treatment System | 490 | 1,950 | 2,440 | 340 | 1,370 | 1,710 | 830 | 3,320 | 4,150 |
| | Incinerator | 20 | 180 | 200 | 20 | 150 | 170 | 40 | 330 | 370 |
| | Sub Total | 760 | 5,430 | 6,190 | 400 | 2,920 | 3,320 | 1,160 | 8,350 | 9,510 |
| Rescue and Fire Fighting Vehicles | | 0 | 1,890 | 1,890 | - | 670 | 670 | 0 | 2,560 | 2,560 |
| Other Facilities | Boarding Bridges | 0 | 3,300 | 3,300 | - | 660 | 660 | 0 | 3,960 | 3,960 |
| | Lighting for Car Parking Area and Access Road | 30 | 660 | 690 | 20 | 480 | 500 | 50 | 1,140 | 1,190 |
| | Sub Total | 30 | 3,960 | 3,990 | 20 | 1,140 | 1,160 | 50 | 5,100 | 5,150 |
| Total of Construction Cost | | 20,160 | 85,840 | 106,000 | 6,870 | 39,270 | 46,140 | 27,030 | 125,110 | 152,140 |
| Soil Investigation and Topographical Survey | | 400 | 0 | 400 | 200 | 0 | 200 | 600 | 0 | 600 |
| Engineering Services | | 1,000 | 6,000 | 7,000 | 500 | 3,000 | 3,500 | 1,500 | 9,000 | 10,500 |
| Construction Supervision | | 2,000 | 10,000 | 12,000 | 1,000 | 5,000 | 6,000 | 3,000 | 15,000 | 18,000 |
| Sub Total | | 23,560 | 101,840 | 125,400 | 8,570 | 47,270 | 55,840 | 32,130 | 149,110 | 181,240 |
| Contingency (approximately 10%) | | 2,440 | 10,160 | 12,600 | 430 | 4,730 | 5,160 | 2,870 | 14,890 | 17,760 |
| Total of Project Cost | | 26,000 | 112,000 | 138,000 | 9,000 | 52,000 | 61,000 | 35,000 | 164,000 | 199,000 |

## Appendix 12.2 Principal Unit Prices of Construction Works

As of March 1987
Exchange Rate : US$1.00 = Bs1.95 = ¥150

### 1. Unit Price for Civil Works

(1) Unit Price of Materials

| Item | Unit | Unit Price in Bolivia | Producing Country | Unit Price in Japan |
|---|---|---|---|---|
| Straight asphalt | t | US$350 (¥53,000) | Brazil | US$270 (¥40,000) |
| Portland cement | t | US$120 (¥18,000) | Bolivia | US$93 (¥14,000) |
| Aggregate for asphalt concrete mix or cement concrete mix | $m^3$ | US$15*1 (¥2,300) | Bolivia | US$21 (¥3,200) |
| Aggregate for base course | $m^3$ | US$14*1 (¥2,000) | Bolivia | US$22 (¥3,300) |
| Aggregate for sub-base course | $m^3$ | US$11*1 (¥1,700) | Bolivia | US$18 (¥2,700) |
| Reinforcing steel | t | US$1,000 (¥150,000) | Argentine | US$240 (¥36,000) |
| Gasoline | liter | US$0.25 (¥88) | Bolivia | US$0.87 (¥130) |
| Asphalt concrete mix | t | US$43 (¥6,500) | | US$47 (¥7,000) |
| Cement concrete mix (flexural strength 45 kg per sq.cm) | $m^3$ | US$79 (¥12,000) | | US$93 (¥14,000) |

Note *1 : Unit price at the project site

(2) Labor

| Item | Unit | Rate in Bolivia | Rate in Japan |
|---|---|---|---|
| Skilled labor | day | | US$73 (¥11,000) |
| Common Labor | day | US$3.6 (¥540) | US$63 (¥9,400) |
| Operator of heavy machine | | US$9.7 (¥1,500) | US$87 (¥13,000) |
| Driver of truck | day | US$6.0 (¥900) | US$67 (¥10,000) |
| Foreman | day | | US$87 (¥13,000) |

(3) Unit Price of Works

| Item | Unit | Rate in Bolivia | Rate in Japan |
|---|---|---|---|
| Excavation | $m^3$ | US$0.4 (¥60) | US$1.7 (¥260) |
| Hauling of 10 km | $m^3$ | US$3.0 (¥450) | US$9.0 (¥1,300) |
| Spreading and grading for earth work | $m^2$ | US$0.06 (¥9) | US$0.07 (¥10) |
| Compaction of earthwork | $m^2$ | US$0.08 (¥12) | US$0.17 (¥25) |
| Distribution of pavement material (Layer of 20 cm thick) | $m^2$ | US$0.38 (¥57) | US$0.17 (¥25) |
| Compaction of pavement | $m^2$ | US$0.42 (¥63) | US$0.17 (¥25) |
| Grading and compaction of subgrade | $m^2$ | US$0.4 (¥60) | US0.5 (¥80) |
| Sub-base course (20 cm thick) | $m^2$ | US$3.0 (¥450) | US$5.9 (¥880) |
| Base course (15 cm thick) | $m^2$ | US$2.7 (¥410) | US$6.3 (¥940) |
| Asphalt concrete (5 cm thick) | $m^2$ | US$5.1 (¥770) | US$8.0 (¥1,200) |
| Prime coat (1.5 liter per sq.m) | $m^2$ | US$3.3 (¥500) | US$0.7 (¥100) |
| Tack coat (0.5 liter per sq.m) | $m^2$ | US$1.2 (¥180) | US$0.3 (¥80) |
| Cement concrete slab (38 cm thick including wire mesh and dowel bar) | $m^2$ | US$77 (¥12,000) | US$73 (¥11,000) |

(4) Unit Price of Asphalt Concrete Pavement

| Item | Unit | Unit Price in Bolivia | Rate Price in Japan |
|---|---|---|---|
| Grading and compaction of subgrade | $m^2$ | US$0.4 (¥60) | US$0.5 (¥80) |
| Sub-base course (15 cm thick) | $m^2$ | US$2.3 (¥350) | US$4.4 (¥660) |
| Base course (25 cm thick) | $m^2$ | US$4.5 (¥680) | US$10.7 (¥1,600) |
| Prime coat | $m^2$ | US$3.3 (¥500) | US$0.7 (¥100) |
| Asphalt concrete course (14 cm thick (3 layers)) | $m^2$ | US$24.0 (¥3,600) | US$22.7 (¥3,400) |
| Tack coat (2 layers) | $m^2$ | US$2.4 (¥360) | US$0.7 (¥100) |
| Total | $m^2$ | US$37 (¥5,600) | US$40 (¥5,900) |

(5) Unit Price of Cement Concrete Pavement

| Item | Unit | Unit Price in Bolivia | Rate Price in Japan |
|---|---|---|---|
| Grading and compaction of subgrade | $m^2$ | US$0.4 (¥60) | US$0.5 (¥80) |
| Base course (15 cm thick) | $m^2$ | US$2.7 (¥410) | US$6.3 (¥940) |
| Asphalt intermediate course (4 cm thick) | $m^2$ | US$4.1 (¥620) | US$6.4 (¥960) |
| Cement concrete slab (38 cm thick including wire mesh and dowel bars) | $m^2$ | US$77 (¥12,000) | US$73.3 (¥11,000) |
| Total | $m^2$ | US$84 (¥13,000) | US$87 (¥13,000) |

## 2. Unit Price for Architectural Works

Since useful information for estimating the cost of the architectural works in Bolivia has not been available, the following unit prices for this project have been assumed:

(1) Unit Prices of Structure including Electrical and Mechanical Facilities

| Item | Unit | Unit Price in Bolivia |
|---|---|---|
| Passenger terminal building | $m^2$ | US$1,470 (¥220,000) |
| Cargo terminal building | | |
| Handling area | $m^2$ | US$1,000 (¥150,000) |
| Office area | $m^2$ | US$1,330 (¥200,000) |
| Administration building | $m^2$ | US$1,400 (¥210,000) |
| Control tower | $m^2$ | US$3,000 (¥450,000) |
| Airport maintenance shop | $m^2$ | US$1,130 (¥170,000) |
| Fire station | $m^2$ | US$1,200 (¥180,000) |
| Meteorological station | $m^2$ | US$1,400 (¥210,000) |
| Energy center | $m^2$ | US$1,330 (¥200,000) |

(2) Unit Prices for Special Equipment for the Passenger Terminal Building

| Item | Unit | Unit Price in Bolivia |
|---|---|---|
| Visual sign | $m^2$ (Floor area) | US$31 (¥4,700) |
| Furniture | $m^2$ (Floor area) | US$20 (¥3,000) |
| Elevator | Unit | US$98,000 (¥15,000,000) |
| Escalator | Unit | US$130,000 (¥20,000,000) |
| Departure Conveyor L=60m | Unit | US$130,000 (¥20,000,000) |
| Arrival Conveyor | | |
| L = 70 m | Unit | US$150,000 (¥23,000,000) |
| L = 50 m | Unit | US$110,000 (¥17,000,000) |
| Check-in scale | Unit | US$9,150 (¥1,400,000) |
| X-ray explosive detector | Unit | US$190,000 (¥29,000,000) |

(3) Unit Prices for Special Equipment for the Cargo Terminal Building

| Item | Unit | Unit Price in Bolivia |
|---|---|---|
| Weighing scale, 5 ton | Unit | US$98,000 (¥15,000,000) |
| Cold storage | Unit | US$32,700 (¥4,900,000) |
| Freezer | Unit | US$45,800 (¥6,900,000) |

The unit prices shown in sections (1) through (3) above include the indirect cost, i.e. overhead of the contractor (supplier).

# CHAPTER 13 ECONOMIC AND FINANCIAL ANALYSES

# CHAPTER 13 ECONOMIC AND FINANCIAL ANALYSES

## 13.1 Economic Analysis

### 13.1.1 Methodology

The economic analysis evaluates all inputs and outputs for the project at economic prices as the existing price is considered to be influenced by things like import and export taxes and subsidies, minimum wage laws, and monopoly elements. One way to compute economic prices is Little and Mirrlees method. In this study, a simplified Little and Mirrlees method will be adopted, i.e. foreign currency portion of all benefits and costs will be dealt with as "tradeable goods" and be valued at the C.I.F. (cost, insurance and freight) price. The Bolivian currency portion will be considered as "non-traded goods" and a standard conversion factor (SCF) will be applied.

Standard Convertion Factor (SCF)

SCF was calculated by using the following formula and data:

$$SCF = \frac{M + X}{M(1 + tm) + X(1 - Tx)}$$

$$= \frac{27790 + 30928}{27790(1 + 0.334) + 30928(1 - 0.055)}$$

$$= 0.886$$

Where, M : Imports in 1986 expressed in million pesos at 1980 prices

X : Exports in 1986 expressed in million pesos at 1980 prices

tm: Import tariff at 33.4% as of July 1987

tx: Export tariff of 5.5% as of July 1987

By applying this formula as well as data collected during a field survey, the SCF has been calculated to be 0.886.

### 13.1.2 Project Costs

(1) Construction Cost

The construction cost for the Phase I development project is estimated to be disbursed as summarized in Table 13.1.1. SCF is applied to the Bolivian currency portion.

Table 13.1.1 Disbursement Schedule of Investment Costs

(Unit : 1,000 US$)

| Year | 1989 | 1990 | 1991 | 1992 | 1993 | Total |
|---|---|---|---|---|---|---|
| Foreign Currency | 3,420 | 6,120 | 16,070 | 45,840 | 40,550 | 112,000 |
| Bolivian Currency | 921 | 1,037 | 4,412 | 8,435 | 8,231 | 23,036 |

(2) Operation and Maintenance Costs

Operation and maintenance costs comprise personnel cost and materials and equipment costs.

a) Personnel Cost

Additional personnel cost for the Phase I development project has been calculated by multiplying the number of additional personnel by salary and social charges at 1987 prices for each department, as presented in Table 13.1.2. SCF has been applied to salary and social charges.

Table 13.1.2 Additional Personnel Cost

(Unit: 1,000 US$)

| Department | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|
| Personnel Regional El Alto | 26 | 28 | 28 | 28 |
| Administrative Dept. | 31 | 35 | 35 | 35 |
| Operating Tech. Dept. | | | | |
| Civil Work Section | 8 | 8 | 11 | 14 |
| Facilities Section | 35 | 38 | 42 | 46 |
| Electronics Section | 26 | 28 | 28 | 28 |
| Operation Section | 41 | 45 | 48 | 50 |
| Total | 167 | 182 | 192 | 201 |

b) The additional materials and equipment costs on an annual basis for the modernized facilities are estimated as follows:

Civil and Building Facilities : 1% of the construction cost of facilities
- Foreign currency US$518,000/year
- Local currency US$163,000/year

Equipment : 5% of the procurement cost of the equipment, to be fully replaced every 10 years
- Foreign currency US$1,700,000/year
- Local currency US$79,000/year

### 13.1.3 Project Benefits

#### (1) Accommodation of Overflowing Domestic Passengers

For the "Without Project" case, overflowing domestic passengers cannot satisfy their desire or necessity for air travel. The implementation of the project, therefore, will give benefit to the overflowing domestic Bolivian passengers. This benefit will be evaluated by their willingness to pay for their trip. It is considered reasonable that their willingness to pay for their trip is equivalent to the airfare and airport tax. SCF has, therefore, been applied to this benefit.

The accommodation of overflowing foreign passengers on domestic routes will lead to earning foreign exchange for the Bolivian economy. The earned foreign exchange is equivalent to the airfare and airport tax minus aircraft operation cost. Marginal operation cost of aircraft for gaining foreign exchange from foreign passengers is negligible however because the share of foreign passengers for all domestic passengers is very low (around 10%). The benefit was calculated by air route, multiplying the number of overflowing domestic passengers by airfare plus airport tax. SCF was applied to Bolivian passengers who were estimated at 90% of all domestic passengers. The benefit due to accommodation of overflowing domestic passengers is summarized in Table 13.1.3.

Table 13.1.3 Benefit due to accommodation of Overflowing Domestic Passengers

(Unit: 1,000 US$)

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| La Paz - Santa Cruz | 5,320 | 11,123 | 18,042 | 22,766 |
| - Cochabamba | 2,343 | 4,878 | 7,902 | 9,968 |
| - Trinidad | 508 | 1,067 | 1,727 | 2,159 |
| - Sucre | 635 | 1,321 | 2,134 | 2,692 |
| - Tarija | 978 | 2,054 | 3,293 | 4,140 |
| - Puerto Suarez | 422 | 928 | 1,435 | 1,857 |
| Total | 10,206 | 21,371 | 34,533 | 43,582 |
| At Economic Prices | 9,159 | 19,178 | 30,990 | 39,110 |

Year 1995

| Route | With-Without No. of Pax. (1,000 pass.) | Air fare Airport tax (US$) | Amount (1,000 US$) |
|---|---|---|---|
| La Paz - Santa Cruz | 143 | 37.2 | 5,320 |
| - Cochabamba | 110 | 21.3 | 2,343 |
| - Trinidad | 20 | 25.4 | 508 |
| - Sucre | 25 | 25.4 | 635 |
| - Tarija | 30 | 32.6 | 978 |
| - Puerto Suarez | 5 | 84.4 | 422 |
| Total | | | 10,206 |

At Economic Prices

10,206 x 0.9 (Share of Bolivian Pax.) x 0.886 (SCF) + 10,206 x 0.1 = 9,159

(2) Accommodation of Overflowing International Passengers

In the "With Project" case, the overflowing Bolivian international passengers will receive the same benefits as the overflowing Bolivian domestic passengers, which can be evaluated by their willingness to pay for their trip. It is also considered that their willingness to pay is equivalent to the airfare and airport tax. Except for LAB, however, the airfare paid by the overflowing Bolivian international passengers to foreign airlines leads to an outflow of foreign exchange from the Bolivian economy which is considered a disadvantage for the project. In this case, the benefit is offset by this disadvantage. SCF is applied to this benefit.

The airfare paid by the overflowing foreign international passengers to LAB as well as airport tax will lead to an increase of foreign exchange for the Bolivian economy. The operation cost of LAB aircraft means consumption of the resources in the Bolivian economy. The net benefit, therefore, is the difference between the airfare paid to LAB as well as airport tax and the operation cost of LAB aircraft for carrying the overflowing foreign international passengers. The benefit was calculated by air route, multiplying the number of overflowing international passengers who will use LAB by airfare plus airport tax. Then, aircraft operating cost which was estimated to be 0.08 US$/pass-km on the basis of data provided by LAB was deducted from this benefit.

Airport tax to be paid by overflowing international foreign passengers who will use foreign airlines was included in this benefit as gain of foreign exchange to the Bolivian economy.

SCF was applied to Bolivian passengers who were estimated at 30% of all international passengers. Table 13.1.4 shows the benefit due to accommodation of overflowing international passengers.

Table 13.1.4 Benefit due to Overflowing International Passengers

(Unit: 1,000 US$)

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| La Paz - Miami | 242 | 2,902 | 6,047 | 9,675 |
| - Rio de Janeiro | 0 | 340 | 851 | 1,531 |
| - Buenos Aires | 0 | 554 | 1,247 | 2,078 |
| - Santiago | 0 | 264 | 594 | 989 |
| - Arica | 0 | 439 | 880 | 1,382 |
| - Lima | 95 | 1,435 | 2,870 | 4,593 |
| Airport Tax (except LAB) | 201 | 477 | 775 | 1,137 |
| Total | 538 | 6,411 | 13,264 | 21,385 |
| At Economic price | 516 | 6,039 | 12,479 | 20,111 |

Year 1995

| | With-Without No. of Pax(1,000 pass.) | Air fare & Airport Tax(US$) | Amount (1,000US$) | Aircraft Operation @0.08$/pass-km (km) | (1,000US$) | Net Benefit (1,000US$) |
|---|---|---|---|---|---|---|
| LPB - MIA | 1 | 486.2 | 486 | 3,054 | 244 | 242 |
| - RIO | 0 | 306.2 | 0 | 1,701 | 0 | 0 |
| - BUE | 0 | 250.2 | 0 | 1,396 | 0 | 0 |
| - SCL | 0 | 160.2 | 0 | 1,178 | 0 | 0 |
| - ARI | 0 | 78.2 | 0 | 192 | 0 | 0 |
| - LIM | 1 | 149.2 | 149 | 669 | 54 | 95 |
| Airport Tax (except LAB) | 35 | 8,205 | | 70% (Share of Foreign Pax.) | | 201 |
| Total | | | 635 | | 298 | 538 |

At Economic Prices

635 x 0.3 (Share of Bolivian Pax.) x 0.886 (SCF) + 635 x 0.7 + 201 - 298 = 516

(3) Accommodation of Overflowing Foreign Tourists

The implementation of the project can increase foreign exchange consumed by the overflowing foreign tourists in Bolivia. According to the information from AASANA, foreign exchange consumed by foreign tourists in Bolivia is, on average, US$160 per person. The estimated increase in foreign exchange from foreign tourtists is presented in Table 13.1.5.

Table 13.1.5 Benefit due to Accommodation of Overflowing Foreign Tourists

(Unit: 1,000 US$)

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| No. of Tourists (1,000 persons) | 13 | 44 | 79 | 121 |
| Foreign Exchange (1,000 US$) | 2,080 | 7,040 | 12,640 | 19,360 |

(4) Accommodation of Overflowing Aircraft of Foreign Airlines

a) Landing Charge, Navigation Services, etc.

By accommodating overflowing aircraft of foreign airlines, the Bolivian economy can increase its foreign exchange in terms of landing charge, night surcharge, navigation services, etc. Landing charge is calculated based on type of aircraft. Other revenues from foreign airlines such as navigation services and night surcharge were 95% of the landing charge in accordance with the 1985 profit and loss statement of AASANA. It is assumed that this tendency will continue in the future. Landing charge and other revenues from foreign airlines are summarized in Table 13.1.6.

Table 13.1.6 Landing Charge, Navigation Services, etc. Received from Foreign Airlines

(Unit: 1,000 US$)

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| JJM | 289 | 482 | 674 | 704 |
| LJ | 236 | 456 | 675 | 739 |
| SJ (SC) | 43 | 43 | 43 | 65 |
| NJ | 37 | 37 | 66 | 66 |
| SJ (AR) | 30 | 30 | 54 | 54 |
| SJ (LA) | 30 | 70 | 70 | 92 |
| Landing Charge | 665 | 1,118 | 1,582 | 1,720 |
| Total Revenues | 1,297 | 2,180 | 3,085 | 3,354 |

b) Selling of Jet Fuel to Foreign Airlines

Selling of jet fuel to foreign airlines leads to the gain of foreign exchange to the Bolivian economy. This benefit was estimated based on aircraft movement of overflowing aircrafts of foreign airlines and average fueling cost paid by each foreign airlines at El Alto airport. This estimation was made using the data in August 1987 as shown in Table 13.1.7.

Table 13.1.7 Selling of Jet Fuel to Foreign Airlines

(Unit: 1,000 US$)

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| JJM | 591 | 986 | 1,380 | 1,441 |
| LJ | 486 | 937 | 1,388 | 1,518 |
| SJ (SC) | 53 | 53 | 53 | 81 |
| NJ | 12 | 12 | 22 | 22 |
| SJ (AR) | 17 | 17 | 30 | 30 |
| SJ (LA) | 2 | 4 | 4 | 5 |
| Total | 1,161 | 2,009 | 2,877 | 3,097 |

Year 1995

| | With-Without No. of Landing | Fueling Volume (1,000G/Landing) | Fuel Cost (US$/G) | Amount (1,000US$) |
|---|---|---|---|---|
| JJM | 78 | 8.215 | 0.923 | 591 |
| LJ | 112 | 4.7 | | 486 |
| SJ (SC) | 56 | 1.031 | | 53 |
| NJ | 39 | 0.338 | | 12 |
| SJ (AR) | 39 | 0.462 | | 17 |
| SJ (LA) | 39 | 0.047 | | 2 |
| Total | | | | 1,161 |

(5) Reduction of Passenger Processing Time at Airport

For the "With Project" case, the passenger processing time at the airport is expected to be reduced by 0.5 hour per passenger compared with that in the "Without Project" case by introducing a more efficient check-in and baggage handling procedure and equipment. This benefit, however, will only be enjoyed by Bolivian passengers in the "Without Project" case and will not exit for the overflowing Bolivian passengers as they do not use air transport in the "Without Project" case.

The time value of the Bolivian passengers is estimated by using the AASANA payroll and the average number of working hours. Air passengers, in general, can be said to belong to a rather high income group. The estimated time value of Bolivian air passengers is US$2.4 per hour at 1987 constant prices. Increase in time value in the future is assumed to be the same as the real growth of GDP.
The purpose of trip by air is estimated according to the information and data gathered during the field survey, as presented in Table 13.1.8. Time value of non-business trip is assumed to be one third of that of business trip in line with World Bank practice.

The calculation of time benefit is presented in detail below. The number of Bolivian air passenger in the "Without Project" case was estimated as follows:

| | All Passengers | | Share of Bolivian | | Bolivian Passengers |
|---|---|---|---|---|---|
| Domestic (1000 pass.) | 554 | x | 0.9 | = | 499 |
| International ( " ) | 213 | X | 0.3 | = | 64 |
| Total ( " ) | | | | | 563 |

The value at 1987 prices was estimated by using the data on average monthly income, working hours and purpose of trip.

| | |
|---|---|
| Average Income of Air Passengers | US$ 460/m |
| Average Working Hours | 192 h/m |
| Time Value of Working Hours | US$ 2.4/h |
| Time Value for Non-business | US$ 0.8/h |

Accoridng to the assumption on trip purpose of air passengers, time value of Bolivian air passengers expressed at 1987 prices was estimated as follows:

1987 Time Value

| | | |
|---|---|---|
| | (Share of Business trip) | |
| Domestic | : 2.4 x 0.9 + 0.8 x 0.1 | = US$2.24/h |
| International | : 2.4 x 0.03 + 0.8 x 0.97 | = US$0.848/h |
| Average | | US$2.08/h |

2010 Time Value

| | | |
|---|---|---|
| | (Share of Business trip) | |
| Domestic | : 2.4 x 0.8 + 0.8 x 0.2 | = US$2.08/h |
| International | : 2.4 x 0.1 + 0.8 x 0.9 | = US$0.96/h |
| Average | | US$1.95/h |

Average Time Value 1994 - 2018

(2.04 + 1.89)/2 = US$1.965/h

1994 2018

Time value will raise in accordance with increase in real growth of GDP as estimated for traffic forecast.

| Year | Growth Rate |
|---|---|
| 1987 - 1990 | 3.0% |
| 1990 - 1995 | 4.0% |
| 1995 - 2018 | 3.5% |

Table 13.1.8 Purpose of Trip by Air

(Unit: %)

| Year | 1987 | | 2010 | |
|---|---|---|---|---|
| Purpose | Business | Other | Business | Other |
| Domestic | 90 | 10 | 80 | 20 |
| International | 3 | 97 | 10 | 90 |

The expected time reduction benefit to the Bolivian passengers in the "Without Project" case is calculated as summarized in Table 13.1.9.

Table 13.1.9 Benefit due to Reduction of Passenger Processing Time at Airport

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Time Value (US$/0.5h) | 1.306 | 1.551 | 1.842 | 2.188 |
| No. of Passengers (1,000) | 563 | 563 | 563 | 563 |
| Time Benefit (1,000 US$) | 735 | 873 | 1,037 | 1,232 |
| At Economic Prices (1,000 US$) | 651 | 773 | 919 | 1,092 |

## 13.2 Financial Analysis

### 13.2.1 Methodology

When carrying out a financial analysis, it is necessary to identify an entity that undertakes a project in question. In this study the Central Office and Regional El Alto, AASANA, is identified with the entity that will implement the Phase I development project.

The financial internal rate of return (FIRR) is calculated to see at what interest rate the project can yield financial profit. Income and funds statements are also prepared for 30 years from 1989 to 2018 in order to clarify the financial outcome of the project. All revenues and expenditures are valued at market prices. General inflation has not been taken into consideration in this study.

### 13.2.2 Evaluation of the Project by FIRR

(1) Expenditures

a) Investment Costs

The investment costs are disbursed in accordance with the disbursement schedule from 1989 to 1993. Equipment will be replaced every ten years.

b) Operation and Maintenance Costs

i) Personnel Cost

Personnel cost for El Alto airport including social charges is estimated to be US$650,400 per year in 1987 according to the data provided by AASANA. The personnel cost for the Central Office is estimated to be US$490,000 at 1987 constant prices based upon the 1985 profit and loss statement of AASANA.

With the implementation of this project, the number of personnel for El Alto airport will be increased in accordance with an airport organization plan. The future personnel cost for the Central Office and El Alto airport is estimated as shown in Table 13.2.1, assuming that the number of personnel for the Central Office is constant in the future.

Table 13.2.1 Estimated Personnel Cost

(Unit : 1,000US$)

| Year | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|
| Central Office | 490 | 490 | 490 | 490 |
| Personnel Regional El Alto | 83 | 85 | 85 | 85 |
| Administrative Dept. | 68 | 71 | 71 | 71 |
| Operations Technical Dept. Director | 9 | 9 | 9 | 9 |
| Civil Work Section | 85 | 85 | 89 | 92 |
| Facilities Section | 133 | 137 | 142 | 146 |
| Electronics Section | 168 | 170 | 170 | 170 |
| Operation Section | 286 | 290 | 293 | 296 |
| Total | 1,322 | 1,337 | 1,349 | 1,359 |

ii) Costs for Materials, Supplies and Equipment

The costs for materials, supplies and equipment for the Central Office was 55.7 percent of the personnel cost in 1985. Assuming that this tendency does not change in the future, the costs for materials and others for the Central Office are estimated to be US$273,000.

The annual costs for materials and others for the modernized El Alto airport are estimated as follows:

| | | |
|---|---|---|
| Civil and Architectural Facilities | : | 1% of the construction cost for facilities US$702,000/year |
| Equipment | : | 5% of the purchasing cost of the equipment US$1,789,000/year |

## (2) Revenues

### a) Air Passenger Service Charge

The revenue from air passenger service charges is calculated by multiplying the number of air passengers by US$0.769 for domestic passengers and US$8.205 for international ones. The results are summarized in Table 13.2.2.

Table 13.2.2 Revenue from Air Passenger Service Charges

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Domestic | | | | |
| No. of Passengers (1,000) | 444 | 625 | 840 | 987 |
| Revenue (1,000US$) | 341 | 481 | 646 | 759 |
| International | | | | |
| No. of Passengers (1,000) | 125 | 170 | 220 | 280 |
| Revenue (1,000US$) | 1,026 | 1,395 | 1,805 | 2,297 |
| Total | 1,367 | 1,876 | 2,451 | 3,056 |

### b) Aircraft Landing Charge

The revenue from air landing charge is calculated based on each type of aircraft using the unit charge published on July 8, 1986. The revenue from navigation services and night and holiday surcharge is estimated to be the same as that from aircraft landing charge considering the actual figures for El Alto airport in 1985. The estimated revenue from aircraft landing charge, navigation services, etc. is summarized in Table 13.2.3.

Table 13.2.3 Revenue from Aircraft Landing Charge, Navigation Services, etc.

(Unit : 1,000US$)

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Aircraft Landing Charge | | | | |
| Domestic | | | | |
| LJ | 0 | 0 | 275 | 902 |
| NJ | 0 | 285 | 505 | 203 |
| SJ | 633 | 568 | 307 | 337 |
| P | 5 | 5 | 7 | 9 |
| General Aviation | 77 | 97 | 102 | 117 |
| Meat Transport | 67 | 97 | 56 | 52 |
| International | | | | |
| JJM | 771 | 963 | 1,156 | 1,186 |
| LJ | 658 | 878 | 2,304 | 2,511 |
| NJ | 1,379 | 1,724 | 1,231 | 1,260 |
| SJ | 280 | 320 | 360 | 388 |
| Sub-total | 3,870 | 4,901 | 6,303 | 6,965 |
| Navigation, Surcharge | 3,870 | 4,901 | 6,303 | 6,965 |
| Grand Total | 7,740 | 9,802 | 12,606 | 13,930 |

c) Rent on Concessions in Terminal Building

The space for concessions in the new terminal building is estimated to be 1,500 sq. meters for shops and restaurants and 1,200 sq. meters for airlines. The annual rental charge is established to be US$360 per sq. meters for shops and restaurants and at US$300 per sq. meters for airlines totalling US$900,000, based on data available for rental charges at Viru-Viru Airport.

In addition, revenue is anticipated from vehicle parking charges, rental charge for VIP rooms, etc. The annual revenue in this category is assumed to be US$300,000.

### 13.2.3 Evaluation of the Project by Income and Funds Statements

#### (1) Income Statement

a) Revenues

Operating revenue is the same as that mentioned in section 13.2.2.

Other revenue will be from interest receivable as determined in this analysis. The interest rate is set at 0.5 percent based on a consideration of the rates for ordinary deposit.

b) Expenditures

Expenditures correspond to those mentioned in section 13.2.2.

c) Depreciation

Depreciation is calculated for the civil and architectural facilities as well as equipment procured for the Project, using a straight-line method. The useful life is established to be 45 years for the civil and architectural facilities and 10 years for the equipment. Scrap value is set at 5 percent of the asset values for both the civil and architectural facilites and the equipment.

#### (2) Funds Statement

a) Capital and Subsidy

In this analysis, it is assumed that capital and/or subsidy is available for 50 percent of the Bolivian currency portion of the investment cost of the project.

b) Long-term Debt

Long-term debt is appropriated for the shortage of the investment cost for the project.

c) Bank Loan

A bank loan is obtained for the shortage of funds for one year.

d) Repayment of Long-term Debt (1)

The long-term debt (1) will be repaid in 20-years with a 10-year grace period. The interest rate is set at 3.50 percent.

e) Repayment of Long-term Debt (2)

The long-term debt (2) will be repaid in 10-years with no grace period. The interest rate is set at 8.75 percent.

f) Repayment of Bank Loan

A bank loan is obtained for the shortage of funds for the year. This bank loan will be repaid in less than one year.

## Appendix 13.1 Definition of the Internal Rate of Return

1. Efficiency or adequateness of a project is measured or evaluated through the comparison of an outflow (costs) with an inflow (benefits). The outflow consists of costs for the construction of the facilities and management of the project, while the inflow consists of benefits which are acquired from the operation of the facilities.

   Benefit Cost Ratio (B/C Ratio), Net Present Value (NPV) and Internal Rate of Return (IRR) are used as indices for the economic assessment.

2. Timing of the outflow and inflow are different. The construction cost of the facilities are generated in the early stage of the project evaluation period, while the benefits are generated after the completion of the facilities.

   All costs and benefits should be discounted and compared at a fixed time, i.e., the present value of costs and the present value of benefits.

3. Definition of the indices (B/C Ratio, NPV and IRR) is as follows:
   B/C Ratio: Ratio of the present value of benefits to that of costs, i.e., B/C

   Present value of benefits $$B = \sum_{t=0}^{T} \frac{Yt}{(1 + ro)^t}$$

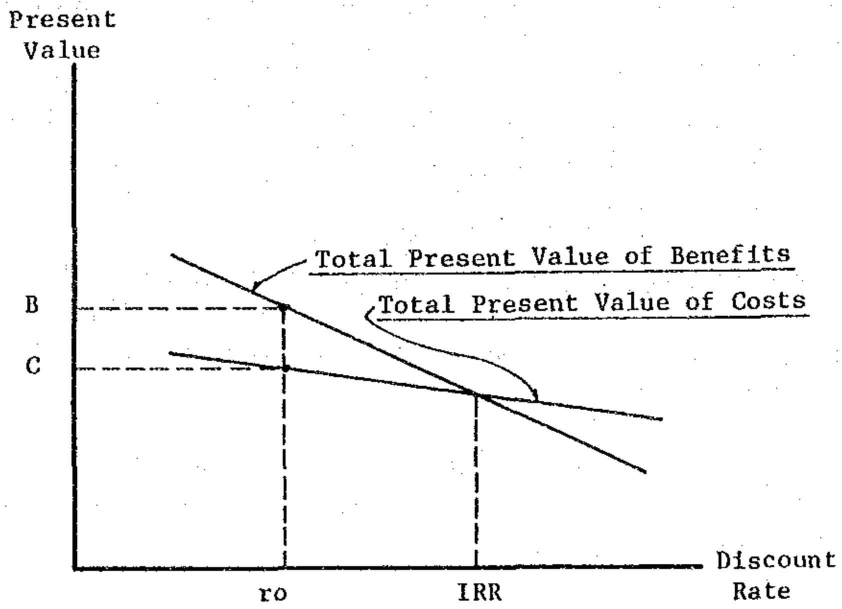
   Present value of costs $$C = \sum_{t=0}^{T} \frac{It + Ot}{(1 + ro)^t}$$

   Where;

   Yt: Benefits in year t
   It: Capital expenditure in year t
   Ot: Operation and maintenance costs in year t
   ro: Opportunity cost of capital of the country concerned (Maximum profit rate which would be anticipated when the fund is used for other projects)
   T : Project life

NPV: Difference between the present value of benefits and that of costs i.e., B-C. This represents the net contribution of the project to the national economy.

IRR: A discount rate to make a present value of the benefits equal to a present value of the cost. An iteration calculation method is used to calculate the discount rate, i.e., r on condition of B=C.




ro : Opportunity cost of capital
B : Present value of benefits
C : Present value of costs

NPV = B - C

B/C Ratio = B/C

4. Economic Assessment

(1) When NPV = 0 or B/C = 1, the project is judged to be economically feasible.

(2) When the IRR exceeds the opportunity cost of capital for the country concerned, the project is judged to be economically feasible.

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