INTERNATIONAL SATELLITE EARTH STATION SYSTEM AND SERVICES FOR THE REPUBLIC OF RWANDA TECHNICAL PROPOSAL

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20 June 1978

Prepared for

MINISTRY OF POSTS AND COMMUNICATIONS
REPUBLIC OF RWANDA

Prepared by

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PROPRIETARY NOTICE

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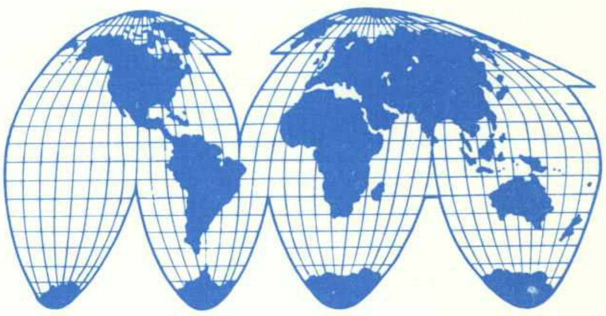

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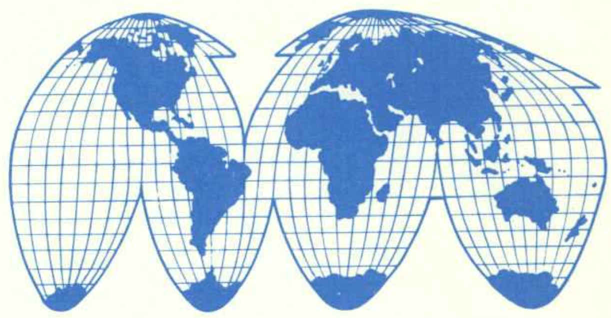

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SECTION 1

INTRODUCTION

Page Communications Engineers, Inc. hereafter referred to as Page in this document, is pleased to submit this proposal to engineer, furnish, install and commission the International Satellite Earth Station System (hereafter referred to as the "Satellite Earth Station"), and provide support services, for the Republic of Rwanda.

This proposal will furnish, for a firm price, the Satellite Earth Station including a telex switch, international telephone switchboards, training, and operation and maintenance (O&M) services.

The Satellite Earth Station is designed to meet all INTELSAT Standard "B" requirements and will pass the mandatory INTELSAT tests. The Satellite Earth Station will take advantage of the latest developments in earth station technology.

The configuration offered is based upon the results of the Page site survey team with the cooperation of the representatives of the Republic of Rwanda.

Succeeding sections of this proposal define the requirements and then describe in detail the proposed Satellite Earth Station and how Page will implement the program.

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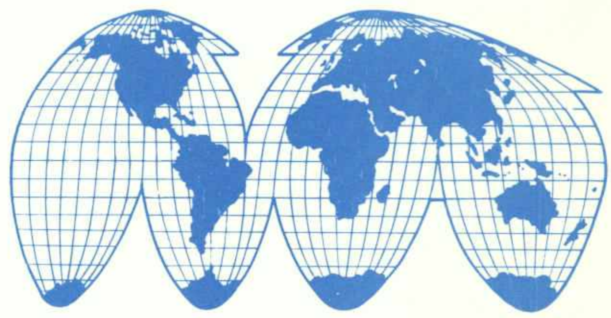

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SECTION 2

UNDERSTANDING THE PROBLEM

2.1 INTRODUCTION

In a study of the communications needs of various countries, Page Communications identified the Republic of Rwanda as a country whose economic growth is severely inhibited by its present limited international communications facilities.

Representatives from Page Communications visited Rwanda in early May 1978 and discussed with Government representatives, the present national and international communications capability and the need for a satellite earth station.

From the information obtained, Page has developed an Economic Traffic Analysis and International Network Requirements for Communication via Satellite.

2.2 SURVEY DATA

The survey obtained existing communications traffic and tariff data for analysis. The criteria for engineering and furnishing an INTELSAT Standard "B" satellite earth station were determined. Also defined were the interfaces between the local facilities. Suitable sites for the earth station were chosen, evaluated, and the selected site was identified for recommendation to the Ministry of Posts and Communications for approval. Survey data has been reviewed and analyzed for the purpose of forecasting circuit quantities, correspondent countries and the associated revenues from telephone, telex and telegraph operations.

Logistics data were gathered for use in preparing a personnel and material handling plan for the installation of the earth station and terminal facilities.

The site selected for an earth station operating in the INTELSAT system must meet a number of criteria, both for compatibility with the worldwide satellite system as well as for operational and economic requirements. The main criteria are:

a. A clear view of all satellites of interest. Table 2-1 lists the INTELSAT satellites that could be used and the look angles from Kigali.

b. Low radiated electromagnetic interference. This consideration minimizes the noise introduced into the satellite radio system by terrestrial emitters. To be avoided are:

   - high voltage power lines (at least 1 kilometer (Km) away)
   - television transmitters
   - radio transmitters
   - radar
   - electric rail systems

c. Convenient interconnection to the International Toll Center. Not only must the interconnection be practical, it must meet international transmission standards.

d. Adequate water supply for site personnel and for site preparation.

e. Ability to dispose of on-site sewage adequately.

f. Ability of site to accommodate up to two antennas either of which can work with the Indian and Atlantic Ocean satellites separately or simultaneously i.e., the antennas do not block one another.

2.2.1 Initial Site Selection

From these criteria, three sites appeared to possess most of the characteristics necessary.

2.2.1.1 Existing Telecommunications Site

This site is the location for the National and International Telephone Center. The site faces East and is clear of obstruction in this direction. A satellite earth station on this site will have an excellent look angle to the Indian Ocean but will not be able to see the Atlantic Ocean satellite. The site is sufficiently large to locate the earth station and allow for the future expansion of the present facilities.

Table 2-1. Satellite Look Angles
(From Kigali Area, Rwanda)

Kigali 30° 4'E Longitude, 1° 57'S Latitude

Satellite	AZ(°)	EL(°)
Atlantic Primary	271.38	27.72
Atlantic Major Path	271.14	22.38
Indian Primary	86.81	53.44

INTELSAT has stated that all pre-assigned single channel per carrier (SCPC) operation in the Atlantic Ocean region, will be through the Atlantic Major Path Satellite.

Locating the satellite earth station on this site will obviate the need for an interconnecting microwave link as the satellite earth station and new telephone and telex facilities would be colocated with the existing facilities.

A high-frequency aircraft warning beacon is presently located on this site and would have to be removed due to its physical and electrical interference. Commercial power is subject to instability and severe transients which would impose severe and potentially damaging conditions on the satellite earth station equipment.

2.2.1.2 Kacyira Site

This site is located on flat terrain on the north end of the ridge east of the telecommunication site and behind the Gendarmerie facility. The latter would ensure security of the site. This site affords unobstructed visibility to the Atlantic Ocean and Indian Ocean satellites. An interconnecting line-of-sight microwave link would be required to the telecommunication site. A 70 kV overhead power line is approximately 1 KM from the site. A well would be required for water for personnel use; soil conditions appeared suitable for sewage disposal.

2.2.1.3 Sugar Factory Site

This site is located on a low hill to the east of the Sugar Factory which is approximately 7 KM's north of Kigali. The site is entered through the factory facility across low lying and wet marshland. Observations indicated that there is unobstructed visibility to the satellites; there are two high voltage power lines about 1 KM away and an intervening hill between the site and Kigali. A microwave link with a passive repeater on this hill, would be required to interconnect to the telecommunications site.

2.2.2 Final Site Selection

The telecommunications site and the Kacyira site meet the principal criteria. The Sugar Factory site was not considered suitable due to the added passive repeater.

The telecommunications site has been picked by Page and is recommended to the Ministry of Posts and Communications. The principal reasons for the Page recommendations are:

a. The traffic study proves that the Indian Ocean satellite is preferred because traffic predictions to East Africa and the Far East are higher than those to the American Continent. The latter can be served by transiting through Europe and using the North Atlantic underseas cables to prevent double satellite hops with their inherent long delays.

b. The satellite earth station operating with the Atlantic Ocean Satellite would require a larger diameter antenna and more sensitive receiving equipment to provide the same performance that could be obtained with an earth station looking at the Indian Ocean satellite. For purposes of preparing this proposal, Page has assumed that the site recommended will be acceptable to the Ministry.

c. An interconnecting microwave link is not required.

d. From an operation and maintenance viewpoint, colocating the satellite earth station and new telephone and telex facilities along with the present facilities reduces manpower and overhead expenses.

2.3 SYSTEM REQUIREMENTS

As a result of the survey and the analysis performed by Page of the existing national and international traffic patterns, Page has developed the satellite earth station system and communications network scheme for Rwanda.

The proposed communications network scheme is depicted in Figure 2-1. This scheme is tentative until formal agreements have been concluded with the corresponding countries. The following are the major requirements.

a. The earth station will be an INTELSAT Standard "B" type.

b. The earth station will operate through the Indian Ocean satellite.

c. The earth station will be located on the telecommunications site.

d. A total of ten communications channels to be transmitted initially via the satellite. Their destinations and voice, telex, telegraph circuits are shown in Figure 2-1.

e. Telex and telegraph circuits to Europe to be carried on separate voice grade bearers.

f. Speech plus three telex and telegraph circuits will be satisfactory for communications with Kenya and Tanzania.

g. Communications to India and Japan can be added economically as needed later. There was insufficient historical data to determine traffic projections to these countries.

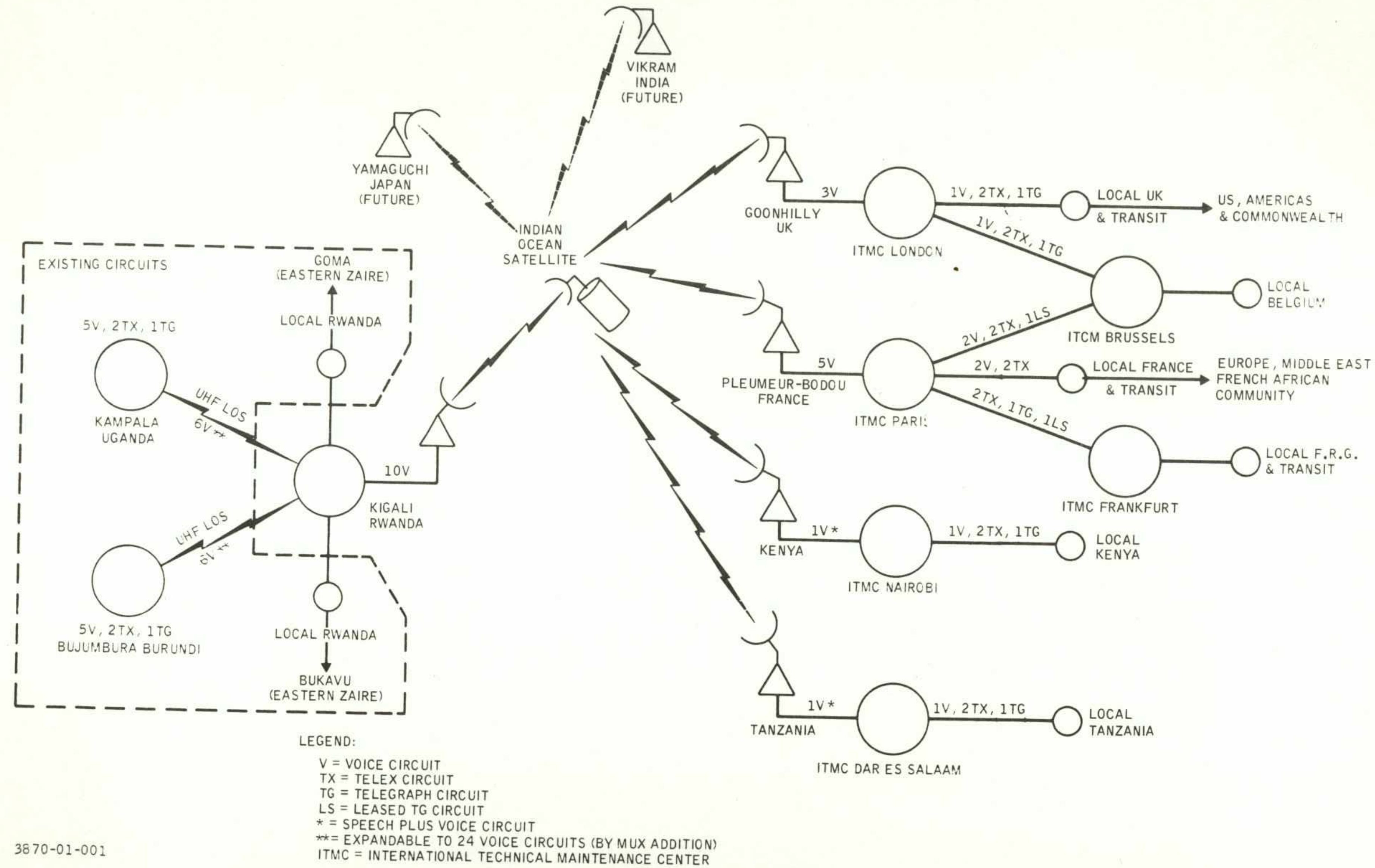

Figure 2-1. Rwanda Satellite Communications Network

h. The pre-assigned single channel per carrier (SCPC) PCM/PSK 4 Ø terminal will be equipped for the ten channels mentioned above, two engineering service circuit channels, and two channels for spare or future expansion.

i. Five one hundred and forty-two (142) line international telephone switchboards, expandable to 284 lines will be provided and interfaced with the existing telephone network.

j. A one-hundred line international telex switch to be provided and interfaced with the new Siemens switch to be installed by Rwanda this year.

k. Provide a new terminal building for the new telephone and telex switch equipments and the associated operator positions.

l. Operate the complete earth station from diesel generators supported by uninterruptible power supplies for the critical equipment, as the commercial power is unstable and subject to severe transients or surges.

m. Provide a one-year maintenance and operation service during which time, Rwanda engineers and technicians would be trained to continue the maintenance and operation at the end of the one year period.

n. Offer an option for reception of television from the satellite.

o. Provide spares for support of the operational and test equipment for the first year after system acceptance.

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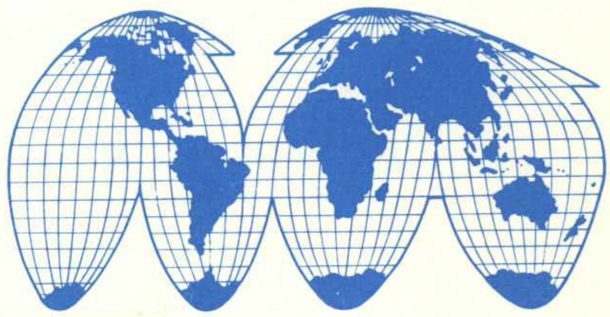

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SECTION 3

PROGRAM OVERVIEW

3.1 INTRODUCTION

This overview of the program is intended to show how Page has solved the problem in accordance with the requirements stated in Section 2.

This section describes the earth station and facilities being provided, the methods to implement the program, support services furnished, options offered, and technical assumptions.

3.2 SYSTEM SPECIFICATIONS

The program provides an INTELSAT Standard "B" satellite earth station system in full compliance with current INTELSAT specifications:

a. INTELSAT BG-28-74E M/6/77, 27 July 1977. Performance Characteristics of Earth Stations in the INTELSAT IV, IVA and V Systems having a G/T of 31.7 dB/K.

b. INTELSAT BG-9-21E H/5/74 (Rev 2) 20 October 1976, SCPC/PSK 4 Phase and SCPC/PCM/PSK 4 Phase System Specifications.

Further, the system is designed for convenient and economic modification to meet future requirements of INTELSAT (as of this date), particularly as they relate to INTELSAT V operation.

Applicable performance recommendations of the CCIR and CCITT are met.

The objective of the program is to construct a system to provide voice, telex and telegraph service between its users and its correspondents in the INTELSAT network. The system has been designed to meet this objective in a cost effective manner.

The system provides:

For Transmission -

a. Fourteen pre-assigned single channel per carrier (SCPC) PCM/PSK/4 Ø carriers. Future expansion to sixty channels is possible.

For Reception -

a. Fourteen pre-assigned SCPC PCM/PSK 4 Ø carriers. Future expansion to sixty channels is possible.

b. One television video carrier (see Section 9), as an option.

Five international telephone switchboards with 42 international trunks are proposed. An international 100 line telex switch with two operator positions and 25 international trunks is also proposed.

The entire system has been designed for better than 99.9 percent reliability and low maintenance. Only solid state components with the sole exception of the power amplifier tubes have been used. In addition, only equipments proven in use in satellite earth terminals or similar telecommunications applications have been included.

Complete redundancy is offered in the following equipments.

a. Redundant power amplifiers
b. Redundant low noise amplifiers
c. Redundant frequency conversion equipment
d. Redundant SCPC Common Equipment
e. Redundant international telex switch processors.

The equipment provided by Page shall meet INTELSAT requirements and shall be selected on the basis of Page's extensive experience in satellite earth station design, implementation, operation, and maintenance.

3.3 FUNCTIONAL DESCRIPTION

The proposed Rwanda Satellite Earth Station and terminal system is functionally described in Figure 3-1, Rwanda Satellite Earth Station Functional Block Diagram. The

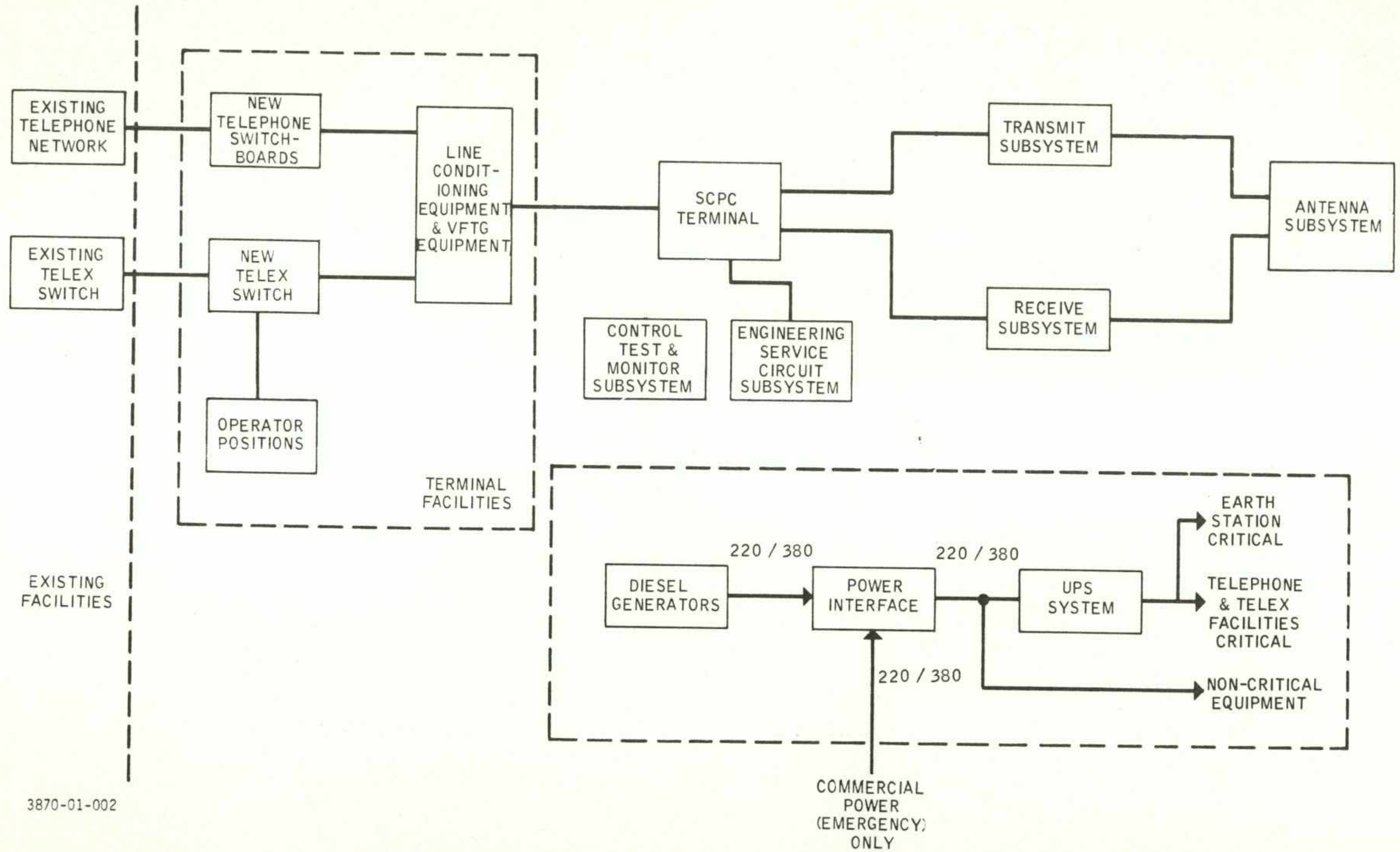

Figure 3-1. Rwanda Earth Station Functional Block Diagram

earth station is comprised of several subsystems and discrete equipments which interface with each other. The antenna subsystem includes an 11-meter diameter antenna, with single polarization cassegrain feed and a step-track tracking system for antenna pointing and control. This subsystem interfaces with the power amplifiers through an interfacility link in the transmit subsystem in the 5.925 to 6.425 GHz frequency range and with the low noise amplifiers in the receive subsystem in the 3.700 to 4.200 GHz range.

The single channel per carrier (SCPC) subsystem consists of the preassigned SCPC terminal and the frequency conversion equipment to interface the SCPC terminal at IF with the transmit and receive subsystems at RF.

The SCPC terminal interfaces with the line conditioning equipment and VFTG equipment which in turn is connected to the new 142 line telephone switchboard and 100 line telex switch which are all part of the terminal facilities. The new international terminal facilities are then interfaced and interconnected with the existing national telephone and telex switches.

The engineering service circuit subsystem interfaces with the SCPC terminal and provides for voice and telegraph orderwire communication with the INTELSAT Manager and with the correspondent administrations.

The control test and monitor subsystem provides for switch selection of equipment, patching of equipment for test and operational purposes, monitoring by instruments of important operating parameters and alarming of out-of-tolerance equipment performance. Test equipment for in-service and general testing as well as maintenance is provided. The power subsystem provides for ac critical and non-critical loads. Redundant diesel generators will provide primary power with one generator on-line at a time. The in-service critical equipment will be fed from an uninterruptible power supply. It is not intended to use commercial power because of its instability. A protective ac contactor with sensing and disconnect capability will be provided to enable commercial power to be used in case of an emergency. However, the stability of the commercial power must be improved by the Government to within the limits given elsewhere in this proposal.

3.4 PROGRAM IMPLEMENTATION

The Page Project team will be mobilized in Vienna, Virginia, USA, immediately upon the effective date of contract. As members are assigned their specific area of responsibility the first priority will be to place all major equipment on order to assure early delivery as this is a major factor in completing the program in the shortest possible time, as shown in later sections.

A project office will be established in Rwanda during the 6th month of the program. When the detailed design effort is complete, the program responsibility and personnel will move to Rwanda to implement construction, installation, test, and operations and maintenance.

Civil construction of the antenna foundation, power amplifier shelter pad, power building slab, and terminal building slab will be the first construction task. This will allow all structures to be completed early in the program, thus allowing equipment to be stored in the buildings as it is received. As the hardware is delivered to Rwanda, installation teams will be available for equipment installation and checkout.

3.5 SUPPORT SERVICES

Four categories of support services are planned for the Rwanda earth station to provide the operational and logistic capability until the cadre of Rwandan technical personnel has assumed full system operational responsibility. Classroom instruction and hands-on equipment, on-the-job-training (OJT) will impart a degree of technical expertise to Ministry technicians. The objective is to furnish sufficient training that Ministry communications personnel may be capable of O&M and training other Rwanda communications personnel when required. Operation and Maintenance (O&M) will be accomplished by Page for a one-year period. Spare parts availability will enhance system O&M failure problem correction since these manufacturer and Page-developed spares will be on hand for ready use by maintenance personnel during this period. System and equipment documentation is mandatory for successful operations, maintenance and training. All of these services are described further in Section 8 of this proposal.

3.5.1 Spares

The spare parts required to support the operational hardware and test equipment for the first year after acceptance will be provided by Page. In addition, a spares control system for recording the spare parts used and initiating procurement of additional repair spare parts is required to insure a continuously and fully-operational system.

3.5.2 Documentation

The standard commercial English-language documentation package is furnished to complement the satellite earth station. The following types of data will be supplied with the satellite earth station:

a. System O&M Manual

b. Equipment Manuals

c. Spare Parts List

d. Installation and As-Built Drawings

3.6 TECHNICAL ASSUMPTIONS

Page Communications has made the following assumptions upon which all work and the associated price is based.

a. Acceptance of the satellite earth station system by INTELSAT in accordance with the INTELSAT test requirements will constitute technical acceptance of the earth station system by the Ministry of Posts and Communications, whose representatives are invited to witness all tests.

b. The Ministry will make necessary circuit correspondent arrangements with other countries within four months after contract award to Page. Page will assist in every possible manner technically, but the final correspondent arrangements, technical, financial and legal, are the responsibility of the Government of Rwanda.

c. The Ministry will grant Page free access to the Telecommunications site, its buildings and equipment at all times.

d. The Ministry will remove the present HF airport beacon facilities from the Telecommunications site within four months after effective date of contract.

e. The Ministry will supply diesel fuel and lubricants for the prime power plant upon installation of this plant.

f. For emergency use, the commercial power shall be capable of supplying 225 kVA at 220/380 Vac ±7%, 50 Hz ±5%, 3 phase, 4 wire. The Ministry will provide all necessary regulation and protection equipment to ensure that normal variations of voltage and frequency remain within the stated tolerances.

g. All technical documentation on the present Telecommunications site and facilities including floor plans, cabling diagrams and equipment details shall be made available to Page at award of contract.

h. The Ministry does not have plans for expansion of the present facilities into the recommended satellite earth station site and does not plan the installation of any interference emitter on the site.

i. Authorization to transmit on the required radio frequencies in the 5.925-6.425 GHz band will be given prior to the beginning of the site test program.

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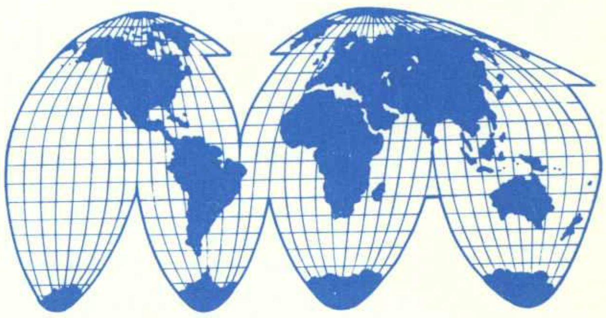

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SECTION 4

TECHNICAL DESCRIPTION

4.1 GENERAL

This section is the detailed technical description of the satellite earth station and terminal facilities.

4.2 SATELLITE EARTH STATION SYSTEM

4.2.1 System Description

The block diagram of the Rwanda satellite earth station system is presented in Figure 4-1. The system concept is for a SCPC communication capability together with an optional single FM television video receiver. The system will operate well within its capacity and at a high degree of reliability.

The SCPC terminal accepts single voice channels from the line conditioning and VFTG equipment and pulse code modulates (PCM) phase shift keys (PSK) carriers at the IF of 70 MHz on the basis of a single voice channel per carrier. The redundant IF outputs from the SCPC terminal are frequency converted to RF by redundant frequency up converters. The RF output from each up converter drives a two-stage power amplifier. The RF output from each amplifier is selected by a waveguide switch, one output of which is routed to the antenna feed via the interfacility link, and the other output to a dummy load. Switching of the redundant transmit chains is performed automatically or manually from the local control on the power amplifiers. A directional coupler to provide monitoring of the transmitted carriers is provided at the output from the power amplifier waveguide switch. A directional coupler is also provided at the input to the feed for initial check-out, line-up and test.

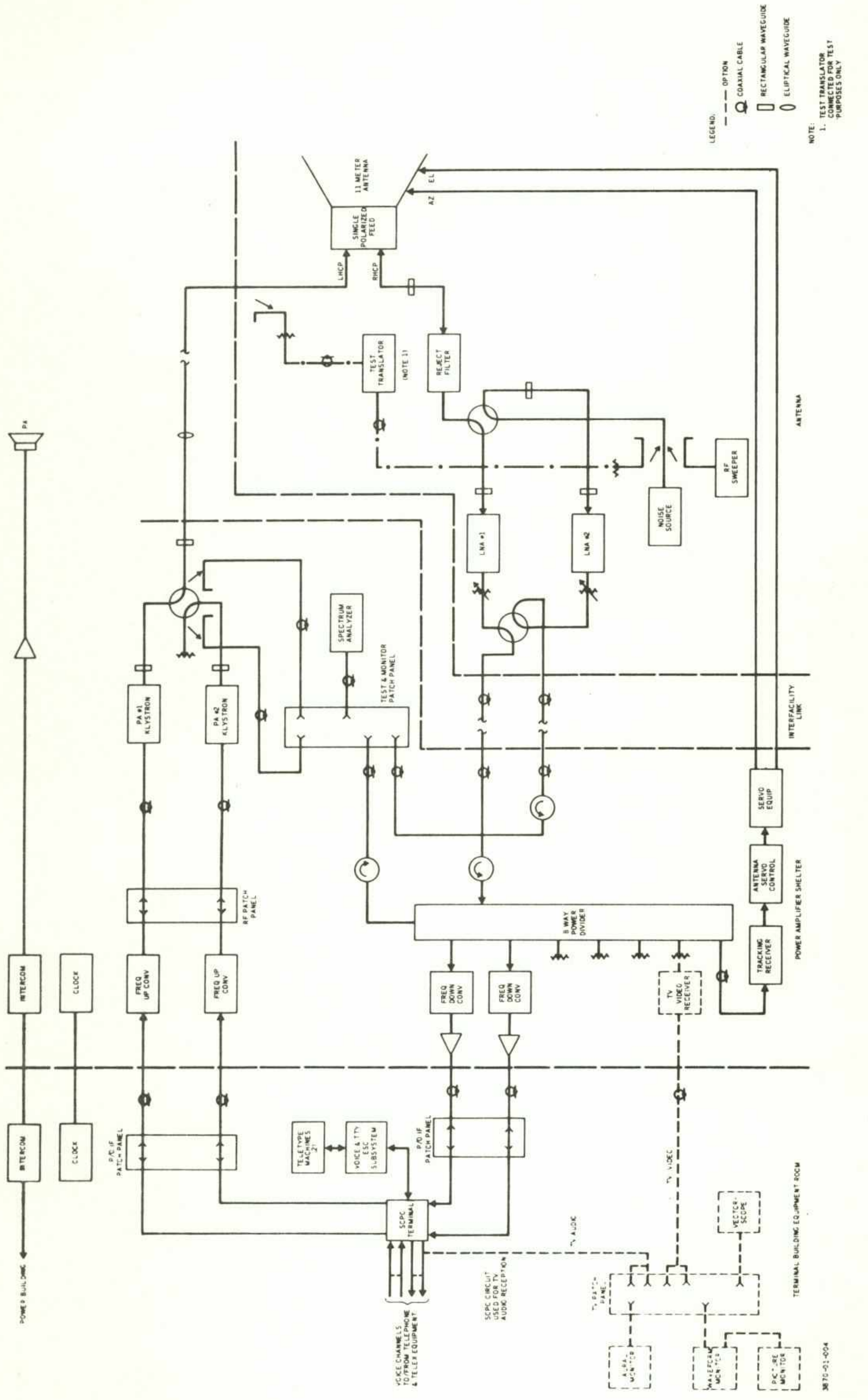

Figure 4-1. Standard "B" Earth Station Block Diagram

Thermoelectrically cooled low noise amplifiers coupled to the antenna feed receive output port, amplify the low level signals in the satellite receive frequency range. Redundant automatically switched amplifiers are provided with the capability to remotely operate the selector switches manually. Means are provided to terminate the input to the standby amplifier in a hot load, signal source for frequency response measurements and the output from a test translator. The receive power divider is driven from the low noise amplifier subsystem through air-dielectric coaxial cable and an isolator to improve the VSWR on the interfacility link.

RF outputs from the power divider drive the redundant SCPC frequency down converters, the television video FM receiver, and the step-track receiver. A separate RF output is terminated on the test patch panel and is available for test and monitoring purposes.

The 70 MHz IF output from the redundant SCPC frequency down converters drives the SCPC terminal. Switching within the SCPC terminal will select between the two inputs. The output from the SCPC terminal receive channels, interfaces with the line conditioning and VFTG equipment at voice level on a per channel basis. If the television option is selected, one SCPC receive channel will be allocated for the reception of the television audio program.

The optional television video receiver would be provided with the necessary crystals, IF filters and de-emphasis units for reception of 625/50 and 525/60 color television signals in accordance with INTELSAT requirements for Standard "B" reception of television video.

In service monitoring is provided by the RF spectrum analyzer which can be patched via the test patch panel to points in both the transmit and receive chains. Carrier power monitoring of the transmitted SCPC carriers will be performed using the RF spectrum analyzer. Monitoring is also provided by integral metering within the equipments.

The antenna tracking system uses a step track technique which deliberately steps the antenna a known amount both in azimuth and elevation from the nominal pointing direction and measures the offset error which is translated into a controlled operation of the antenna drive motors to move the antenna to a position of zero offset error. The step track receiver measures the level of the received satellite RF beacon signal and provides the antenna control with a dc voltage in proportion to offset angle. The antenna control unit interfaces with the servo equipment which drives the motors.

The voice plus telegraph engineering service circuit equipment is fully compliant with INTELSAT requirements and provides for two separate speech plus single teletype circuits. Each of the two units has dial up means for voice and a teletype machine for transmission and reception of telegraph messages. One teletype machine will be automatic send and receive and the other will be a keyboard send and receive.

A master clock driving three slave clocks will provide GMT and local time displays in the equipment room and operations room of the terminal building. An HF receiver with a whip antenna will enable reception of standard time and frequency signals.

An intercom will be provided between the equipment room, power amplifier shelter and power building. An external public address loudspeaker will also be included for warning personnel near the antenna prior to any major movement of the antenna.

The low noise amplifier subsystem is located in the hub section of the 11 meter antenna. It is connected directly to the feed. The test directional coupler is also located at the feed. The transmit and receive interfacility links interconnect the antenna located equipment with the equipment located in the power amplifier shelter.

Flexible sections will be provided to transverse the azimuth and elevation axis of the antenna.

4.2.2 Antenna Subsystem

The antenna subsystem consists of an 11-meter diameter shaped reflector, receive-transmit feed, subreflector, mount with motor drives, servo system and a remote antenna control panel. The antenna has been engineered specifically for satellite communications, and its performance satisfies the INTELSAT mandatory requirements for an INTELSAT Standard "B" satellite earth station.

The antenna mount is an elevation over azimuth type with tripod supporting structure. Motorized drives are provided. The motors are automatically or manually controlled from the antenna control panel in the power amplifier shelter. The antenna control panel also provides digital readout of elevation and azimuth positions of the antenna.

The main reflector is manufactured from aluminum and is specially shaped to improve the efficiency. The construction is of truss-type ribs and precision panels surrounding a central hub.

To meet the INTELSAT Standard "B" requirements for high aperture efficiency in the receive band, and very low sidelobes in the transmit band, a corrugated conical horn feed and shaped subreflector are used. The subreflector is a fiberglass unit. A tripod holds the subreflector in place.

The feed will be supplied for single polarization operation, that is, left-hand circular for transmit and right hand circular for receive. The polarization voltage axial ratio will be 1.4 maximum. This meets the INTELSAT requirement for operation with an INTELSAT IV A satellite with which Rwanda will be operating. An option is offered to improve the polarization voltage axial ratio to the INTELSAT requirement of 1.06 for operation with future satellites of the INTELSAT V type.

4.2.3 Power Amplifier Subsystem

The proposed power amplifier subsystem consists of redundant amplifiers, an output waveguide change over switch, dummy load and harmonic filter. Each power amplifier is a two stage amplifier employing a VA936 final tube klystron. The amplifier and power supply unit are contained within one cabinet. The complete assembly is air-cooled.

The power amplifier is tuneable over the entire 5.925 to 6.425 GHz frequency range. The klystron is equipped with a channel tuner which permits the rapid manual selection of any one of six pre-set tuning conditions.

The power amplifier is adjustable over a 20 dB range down from 3.0 kW. It is capable of maintaining the RF output level constant within ± 0.25 dB in any 24-hour period with constant drive.

Each power amplifier is equipped with a complete set of operating controls, meters and protective interlocks to provide ease of operation, safety to personnel and equipment.

The dummy load is suitably rated to dissipate the maximum power output capability of the power amplifier. A harmonic filter will reduce the harmonic components at the output from the system to at least 60 dB below carrier level.

A control and monitoring panel is provided for each power amplifier. Status and fault indicators are provided on the panel. A control panel for manual selection of the output waveguide switch is provided.

4.2.4 Low Noise Amplifier Subsystem

The low noise amplifier (LNA) subsystem is designed to amplify radio frequency signals, with a minimum of degradation to the signal to noise ratio in the 3.7 to 4.2 GHz band.

Each low noise amplifier consists of a thermoelectrically cooled parametric amplifier followed by a transistor amplifier to obtain a passband gain of 55 dB. Each low noise amplifier is contained in a compact gasketed enclosure, is fully solid state, and utilizes modular construction.

The proposed redundant low noise amplifier subsystem will consist of two LNA's, input and output switches, input transmit band reject-filter and test equipment for connection to the standby LNA. Control and monitor functions as well as LNA selection will be from remote control panels located in the power amplifier shelter.

4.2.5 Interfacility Links

4.2.5.1 Transmit

The transmit interfacility link between the power amplifier subsystem in the shelter and the transmit feed port on the antenna will be comprised of eliptical waveguides such as Andrew EW56 with suitable connectors to WR137/CPR 137 flanges. A flexible section will be provided to traverse the antenna axis.

4.2.5.2 Receive

Air-dielectric coaxial cable such as Andrew HJ5-50 heliax will be used to interconnect the low noise amplifiers in the antenna hub and the isolator at the input to the receive power divider in the shelter. Sections of RG214 will be used to traverse the antenna axis.

4.2.5.3 Pressurization

A pressurization system comprising an automatic dehydrator will be provided to supply dry air to the waveguide and heliax interfacility links.

4.2.6 Frequency Conversion Equipment

The SCPC frequency up and down converters are highly stable dual conversion units. The second local oscillator in the up converter and the first local oscillator in the down converter employ cavity oscillators phase locked to crystal controlled sources.

The intercept point of the frequency up converter has been chosen such that the contribution to the total intermodulation due to multiple SCPC operation is negligible. The up converter accepts multiple carriers in the 52 to 88 MHz range and converts them to a 36 MHz band in the 5.925 to 6.425 GHz range with a power gain of 10 dB. The down converter converts any 36 MHz band in the 3.7 to 4.2 GHz band to 52 to 88 MHz with a minimum power gain of 30 dB.

4.2.7 SCPC Terminal

An SCPC terminal, equipped with 14 duplex channels, and meeting the INTELSAT requirements for operation in a Standard "B" satellite earth station will be provided. The terminal provides channel assignment flexibility for traffic patterns differing from those projected.

The SCPC terminal will meet the requirements of INTELSAT documents BG 9-21 (Rev. 2) and BG-19-48E (Rev. 1). All common active modules of the SCPC terminal are redundant. This consists of the IF subsystem, timing and frequency unit and power supply. Fully redundant common equipment provides the terminal with extremely high reliability. Channel units are not redundant. The terminal is suitable for PCM/PSK 4 Ø transmission of voice, low speed data, telex and telegraph.

The SCPC terminal is equipped for 14 message channels. Two of these are assigned for engineering service circuits. Two of the channels will be unused initially and will be available as spares, future expansion and reception of television audio.

4.2.8 Engineering Service Circuits (ESC) Subsystem

In conformance with INTELSAT requirements for Engineering service circuits from earth stations equipped only with SCPC capability, two speech plus telegraph orderwire circuits will be provided. The satellite earth station to the INTELSAT Manager orderwire will use an assigned SCPC channel. To make an outgoing call from the satellite earth station, the operator dial selects for voice or keyboard selects for telegraph. The manager will place a call to the earth station in a similar manner. The Manager's ESC Terminal will forward the called number over the dedicated SCPC channel. Code recognizers in the satellite earth station will recognize the call and cut it through to the called telephone or teleprinter.

The station to station engineering service circuit provides both voice and telegraph communications over an SCPC frequency pair that has been assigned by INTELSAT. Selective calling is used for outgoing calls. Code recognition equipment at the satellite earth station will recognize the called address and cut the call through as required. Circuit busy indication will be provided.

Two teletypewriters will be provided at the satellite earth station. One will be assigned to the INTELSAT Manager's telegraph circuit and the other to the Station-to-Station telegraph circuit.

4.2.9 Control Test and Monitoring

The control test and monitoring subsystem includes controls for selection of the transmit and receive chains, and antenna positioning; on-line test equipment; and monitoring and alarm equipments.

Major controls are the remote antenna control panel, the local power amplifier control panels and the remote low noise amplifier control panel.

A status and alarm panel will be used to centrally monitor the operational status of the earth station equipments. It provides a continuous visual display with an audible alarm.

An RF spectrum analyzer is provided for monitoring and measurement of the transmit and receive spectrums. A noise figure indicator enables measurement of the noise temperature of the standby low noise amplifier to be determined.

A clock system consisting of a quartz crystal clock driver and three clocks for display of local and Greenwich mean time are provided. To provide a time source for setting the clock system, a solid state HF receiver with whip antenna is provided.

A wind speed and direction indicator system will be provided with readouts in the shelter.

4.3 TELEPHONE AND TELEX TERMINAL SYSTEM

4.3.1 System Description

Page proposes to integrate the new telex and telephone systems between the existing Rwanda national telex and telephone systems, and the new Page installed satellite earth station. As described in paragraph 2.3, direct voice grade circuits will be provided to London, England; Paris, France; Brussels, Belgium; Nairobi, Kenya; and Dar Es Salaam, Tanzania.

Page assumes that, after satisfactory coordination and negotiation of operating agreements, these circuits will be provided.

The circuits to Kenya and Tanzania will be equipped with Speech Plus terminals. These terminals permit transmission of a voice circuit, two telex circuits and one telegraph circuit over a single voice grade channel.

Two of the voice circuits to Europe (one to the U.K. and one to France) will be terminated in a telegraph carrier system (VFTG). Twelve channels will be available for telex, telegraph and leased channel service to each of these two countries where some channels will terminate, and some will be extended to other countries.

The circuit flow block diagram, Figure 4-2, shows the traffic flow through the Page provided equipment.

4.3.1.1 Telex Circuits

The new international telex exchange will be connected via interswitch trunk circuits to the Rwanda Siemens TWK N telex exchange. High usage subscribers can be directly connected to the switch bypassing the TWK N. The international trunks from the new telex exchange will pass through a new dc circuit patch/test board, then to a new VFTG system (in the case of circuits going to Europe). The VF portion of the VFTG system will connect through a new VF patch/test board, and then on to the Earth Station equipment. Return signals from European countries will follow a reverse signal flow.

Telex circuits to Uganda and Burundi will also pass from the international telex switch, through the dc test/patch board, then to the existing multiplex equipment for on-passage to either of these countries.

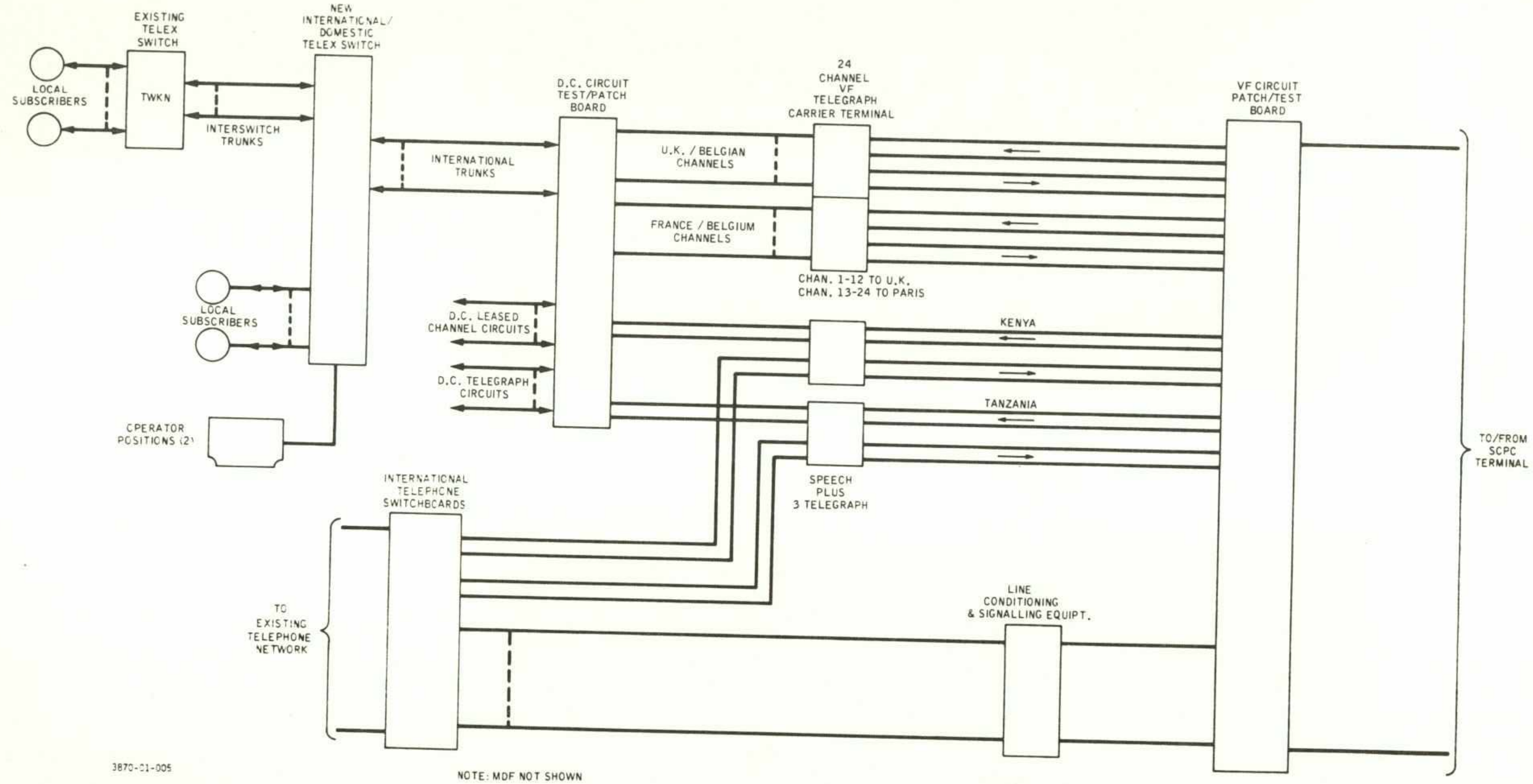

Figure 4-2. Rwanda Telephone and Telex Circuit Flow Block Diagram

Telex circuits for Kenya and Tanzania pass through the dc patch/test board to the Speech Plus multiplex equipment. The VF aggregate from the Speech Plus equipment passes through the VF patch/test board and then on to the Earth Station equipment.

4.3.1.2 Telephone Circuits

Five new international telephone switchboards will interconnect the Rwanda national telephone network as shown on Figure 4-2. The international circuits of the new telephone switchboards will connect through the line conditioning and signalling equipment, then pass through the VF patch/test board, then on to the Earth Station equipment.

The circuits to Burundi and Uganda will also pass through the line conditioning and equipment cabinet, through the VF patch/test board, then to existing Rwanda equipment for connection to either of these countries.

The circuits for Kenya and Tanzania will pass from the switchboards to the Speech Plus equipment. The Speech Plus equipment will contain all necessary signalling equipment for the telephone circuits. From this Speech Plus equipment, the combined speech and telegraph (telex) VF aggregate signal will pass to the VF patch/test board, then on to the Earth Station equipment.

4.3.1.3 Telegraph and Leased Channel Circuits

Telegraph and dc leased channel circuits which will be multiplexed on the earth station equipment will pass through the dc patch/test board. From there the circuit will connect to the appropriate VFTG equipment or the speech plus equipment where it will be multiplexed as were the telex circuits, then passed on a VF basis through the VF patch/test board to the earth station equipment.

4.3.2 Telephone Switch

Page will provide five new international gateway manual telephone switchboards for Rwanda. The switchboards will be of modern design, flexible, and compact.

The switchboards will have capacity for 100 two way national circuits and 42 two way international circuits. Five positions will be equipped. The system shall be capable of expanding to a maximum of 200 national circuits and 84 international circuits.

Billing information will be recorded by the operator on toll tickets for each call. A calculagraph will be provided at each position for time stamping the start and stop times of the call. Ticket slots will be provided adjacent to each cord circuit for storing active call toll tickets.

In-country and international circuits will be multipled on boards to the maximum extent feasible. Every effort will be made to distribute calls evenly to all manned boards during peak hour operations, but allow for board concentration of circuits to minimize the number of operators during slack operating hours.

Switchboard features will include:

a. Interposition circuit transfer capability
b. Busy lamps per international trunk circuit
c. Idle indicators per group of 20 national circuits
d. Ticket bins
e. Area for writing and routing information
f. Night alarm lamp and buzzer with cut-off key

National and international signalling schemes will be provided, to enable the Rwanda international operator to dial through to the called party, if possible. This scheme will, of course, require the concurrence of the connecting countries.

4.3.3 Telex Switch

Page will provide a 100 line international telex switch for Rwanda. The telex switch will be of the most modern design utilizing a maximum of solid state components. The switch will be computer controlled. The system architecture and modular design permit expansion of the system in small or large steps to the maximum capacity of 512 terminations.

The system will be configured such that 50 terminations will be programmed for trunk service while the other 50 will be programmed for subscriber service. The trunks will be arranged to interface Rwanda's new Siemens TWK N domestic switch, as well as the international trunks. It is contemplated that Rwanda will wish to terminate some subscribers directly on the new international switch — particularly some in-house teleprinters as may be used for administrative purposes. Further, as the domestic switch reaches its capacity of subscribers, new subscribers can be terminated on the international switch.

The system will be able to interface trunk signalling requirements of CCITT Type A, B, and C as well as manual signalling protocols (dial pulse, or Baudot keyboard). The system will work with manual, semi-automatic and automatic exchanges. Subscriber lines will operate either on a loop basis (60 ma operate current, 5 ma idle current) or 60 ma ground return double current.

Chargeable minutes for each call will be accumulated automatically. At the completion of a call, the chargeable minutes will be printed on a "billing printer". The billing printer readout will print the calling party's number, the time and date, the called party's number, and the chargeable minutes. A "reason for disconnect" code will also be printed so that disconnects due to equipment faults can be readily detected.

An alarm printer will be provided. This printer will advise the maintenance staff of any system problems such as a failure of any system equipment, a failure of a trunk group, an open subscriber line, etc.

Routing of international traffic will be by CCITT F.69 destination codes. Tables will be established within the switch memory to accomplish the traffic routing. Up to two alternate routing paths can be set up in the tables. The alternate paths would be used in case of failure of the primary path or, if desired, when all primary trunk paths are busy. An "executive" printer will be supplied with the system to enable up-dating or altering of the tables.

The software program for the system will be provided by the switch manufacturer. With the exception of table changes, all programming changes requested by Rwanda will be made by the manufacturer. The manufacturer will keep on file all original programs as well as modifications, and will be able to provide rapid response to Rwanda in providing requested changes.

The system can be expanded to 512 terminations by adding terminator cards and associated mounting hardware. Expansion beyond this point will necessitate changing system processors and adding additional memory. Expansion typically requires a maximum of four (4) hours system down time.

Additional features of the system include:

Call transaction number - every valid call attempt recognized by the system will initially be assigned a unique six digit call transaction number.

Line grouping - the exchange will allow for assigning any termination to any line group.

System messages - the system can output various messages as required such as "OCC, NP, NA" etc.

Auto retry/camp-on - For selected input line groups, area codes and routes, instead of clearing a connection attempt when unsuccessful, the system will go into an automatic retry mode under the control of a "Camp-on" table. This table will indicate to the program how many times a call will be attempted and the frequency of each attempt.

Subscriber Line Testing - a test message generator, in accordance with CCITT R.52 is provided for testing subscriber teleprinters. This test generator can be initiated by field maintenance personnel by dialing a 2 or 3 digit address.

4.3.4 Telex Operator Positions

Two telex operator positions will be provided by Page. These positions can be accessed directly by the subscriber or by another international operator requesting assistance. Rwanda can also arrange for the operator to be called in under some trouble conditions (such as all trunks out to a destination) or for special purpose conditions. It is expected, however, that calls to as many destinations as possible will pass on a fully automatic basis.

Each operator position will consist of a teleprinter. The operator will be able to talk to the calling party only, called party only, couple calls and monitor the connection, as desired.

4.3.5 Line Conditioning and Signalling Equipment

Page will provide all line conditioning equipment as required to interface the international telephone trunks. Assuming that connections can be established on a semi-automatic basis, the signalling equipment for each telephone trunk will consist of a signalling unit and an echo suppressor suitable for satellite transmission. Amplifiers, pads and equipment housing will be provided as required for the equipment.

Because of the excellent transmission quality of the Page proposed equipment, and the satellite and associated equipment, no line conditioning equipment is expected to be required. However, Page will provide line amplifiers which are capable of amplitude equalizing the high end (above 2600 Hz) of each international telephone trunk circuit.

Page assumes the Rwanda in-country signalling to be the CCITT R2 type, and that the signalling can be directly interfaced between the new international telephone switch and the existing Kigali switches. Accordingly, no additional equipment specifically for domestic signalling is contemplated.

4.3.6 VFTG Equipment

Page will provide a 24 channel Voice Frequency Telegraph Carrier system for Rwanda. The telegraph channels will be compatible with the CCITT R35 frequency spacing for 50 baud telegraph. It is contemplated that 12 of the 24 channels will operate over a VF circuit to the United Kingdom, while the other 12 channels will operate over a VF circuit to France. The channel frequency assignments will be determined in agreements with the connecting countries. For example, the UK may utilize channels 1 through 12, while France may utilize channels 13 through 24. Alternatively, both countries may wish to operate channels 1 through 12. Page will provide these channels in accordance with Rwanda's correspondent technical agreements.

The VFTG system will contain a power supply capable of supplying loop battery for each channel. Loop current adjust potentiometers will also be provided. The channel units will be strappable for either full-duplex or half-duplex operation. Single current or double current working can be provided by a strap option. A meter panel for checking either dc loop current or ac output power will be provided.

4.3.7 Speech Plus Equipment

Speech plus equipment (two sets) will be provided for Rwanda to operate with both Tanzania and Kenya. The speech plus equipment will permit the multiplexing of the voice path with three 50 baud teleprinter circuits.

The voice path will have a bandwidth of from 300 to 2700 Hz. The teleprinter channels will be in accordance with CCITT recommendations R35. Page proposes to supply channels 121, 122 and 123 for these circuits.

The speech plus equipment will contain all necessary speech filters and amplifeirs to ensure a good quality voice signal. The teletype channel signals will be filtered to such low level as to be non discernable to the voice channel user. By the same token, the teletype channels will operate with quality equal to that of the VFTG. The filtering is such that the speech signals will not affect the teletype channels.

The proper inter-switch signalling equipment will be provided with the speech plus equipment. This may consist of 2600 Hz inband signalling or other as required. The equipment will contain an echo suppressor, line amplifier and pads as required to provide satisfactory service.

4.3.8 Existing Terminal Interface and Integration

4.3.8.1 Telephone

As stated in earlier portions of section 4.3, Page will directly interface the local Rwanda telephone network at Kigali with the new international telephone switchboards. Page presently contemplates initial testing by interconnecting the new switchboards to unused trunk circuits of the interurban switch, the Kigali local exchange and the Kigali manual operator positions. The exact method and approach for the interconnect will be defined by a detailed study of the specifications of the present switching equipment and with discussions between Page engineer's and Rwanda engineering and supervisory personnel. Tests will be made to ensure the equipment works in accordance with specifications. The exact timing and values of interface signals will be studied and Page will ensure that matching signalling criteria is available on the new equipment.

In addition to obtaining agreements with connecting countries, interface signalling schemes must be obtained. These signalling criteria will be studied by Page engineers to ensure compatible signalling.

4.3.8.2 Telex

Because of the nature of its operation, the telex network is easier to interface than is the telephone exchange. Page foresees no problem in interfacing Rwanda's new Siemens TWK N exchange nor in interfacing its subscriber terminals. The flexibility of the exchange permits it to meet virtually all signalling to be found on international links except the new type D signalling. This complicated signalling scheme is not being provided, but could be added at a later date if needed by Rwanda.

4.3.8.3 Systems Integration

During the testing phase of the new switches and associated equipment, Page will make every effort to minimize the disruption of normal Rwanda telephone and telex services. Before cutover, a complete plan will be developed by Page. This cutover plan will be reviewed with the Rwanda supervisory staff and concurrence will be obtained to the schedule prior to Page cutting over any service. To the extent possible, Page will arrange for "fall-back" circuit patching to enable Rwanda to return to the original communication media in the event of catastrophic equipment failure during the cutover phase. Again, these plans will be thoroughly reviewed with Rwandan telecommunications supervisory personnel.

4.4 SATELLITE EARTH STATION FACILITIES

4.4.1 General

This section describes the site plan and the earth station buildings.

4.4.2 Site Layout and Description

The site selection for the Rwanda satellite earth station is in Kigali next to the existing Post and Telecommunications Building on Avenue De L'Armee Rwandaise. Advantages of this selection include greatly improved access for employees and a more secure location, together with excellent visibility of the Indian Ocean satellite. The site has adequate drainage for this installation. A site plan is shown in Figure 4-3.

4.4.3 Buildings

4.4.3.1 Terminal Building

In developing the optimum building layouts, Page has made a detailed study of the electronic and human factors requirements.

The building housing the telex switch, telephone switchboards, earth station electronics equipment and uninterruptible power systems will be a pre-fabricated steel frame building 32 feet x 36 feet erected on a reinforced concrete slab foundation. The service areas will incorporate an electronics equipment room, uninterruptible power supplies (UPS) and batteries area, and an operators room. The structure is designed in accordance with the applicable provisions of the Metal Building Systems Manual, American Institute of Steel Construction Manual, and American Concrete Institute (ACI-318-71), Building Code Requirements for Reinforced Concrete.

The building is designed to withstand a vertical live load of 20 Pounds per square foot (PSF) applied to the roof plus a horizontal wind load of 25 PSF. The building will withstand each load applied independently and also both loads applied in full combination.

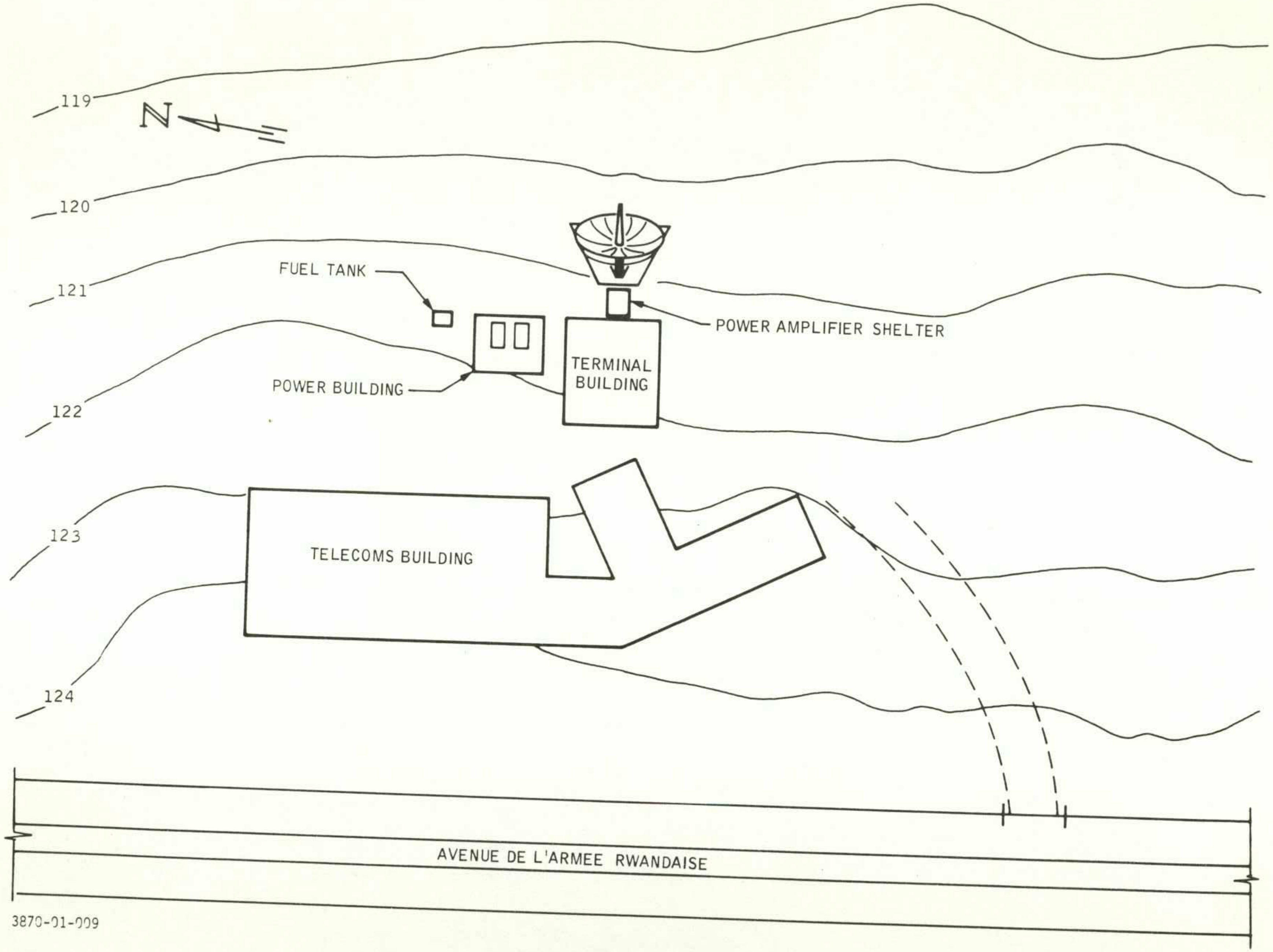

Figure 4-3. Earth Station Facilities Site Plan

The building will be environmentally controlled so that the supplied electronic equipment will be operating within the ambient temperature and humidity conditions required by the equipment specifications.

4.4.3.2 Power Building

The facility which will house the prime power system will be a pre-fabricated steel frame building 20 feet x 24 feet erected on a concrete slab foundation with isolated engine foundations. The building will have a ventilation system consisting of louvers and an exhaust fan.

4.4.3.3 Power Amplifier Shelter

The unit housing the power amplifiers will be an 8 feet x 12 feet fiber glass/foam sandwich construction shelter. This unit is extremely rugged, with good insulating qualitites, requires no maintenance or painting other than normal housekeeping, and it is readily transportable. The shelter walls and roof are designed to withstand 150 mph wind loading. The communications equipment will be installed in the shelter at Page's Vienna, Virginia facilities and will be shipped direct within the shelters for rapid installation in Rwanda.

The shelter will be environmentally controlled to meet the operating requirements of the electronic equipment.

4.4.4 Equipment Layout and Floor Plans

Figure 4-4 shows the terminal building and power amplifier shelter in relation to each other. The terminal building is divided into two rooms, the equipment room and the operators room. The dimensions shown are typical and Page reserves the right to change them during the final detailed design stage. The equipment layouts in the power amplifier shelter, equipment room and operators room are discussed in the following paragraphs.

4.4.4.1 Power Amplifier Shelter

Figure 4-5 shows the floor plan and the intended equipment layout for the shelter. The power amplifiers will be located in the end nearest to the antenna to shorten the length of the interfacility link. Except for the low noise amplifiers which will be located within the hub of the antenna, the remainder of the RF equipment will be located in the shelter. This includes the frequency conversion equipment, RF test and monitoring and antenna control and servo equipment.

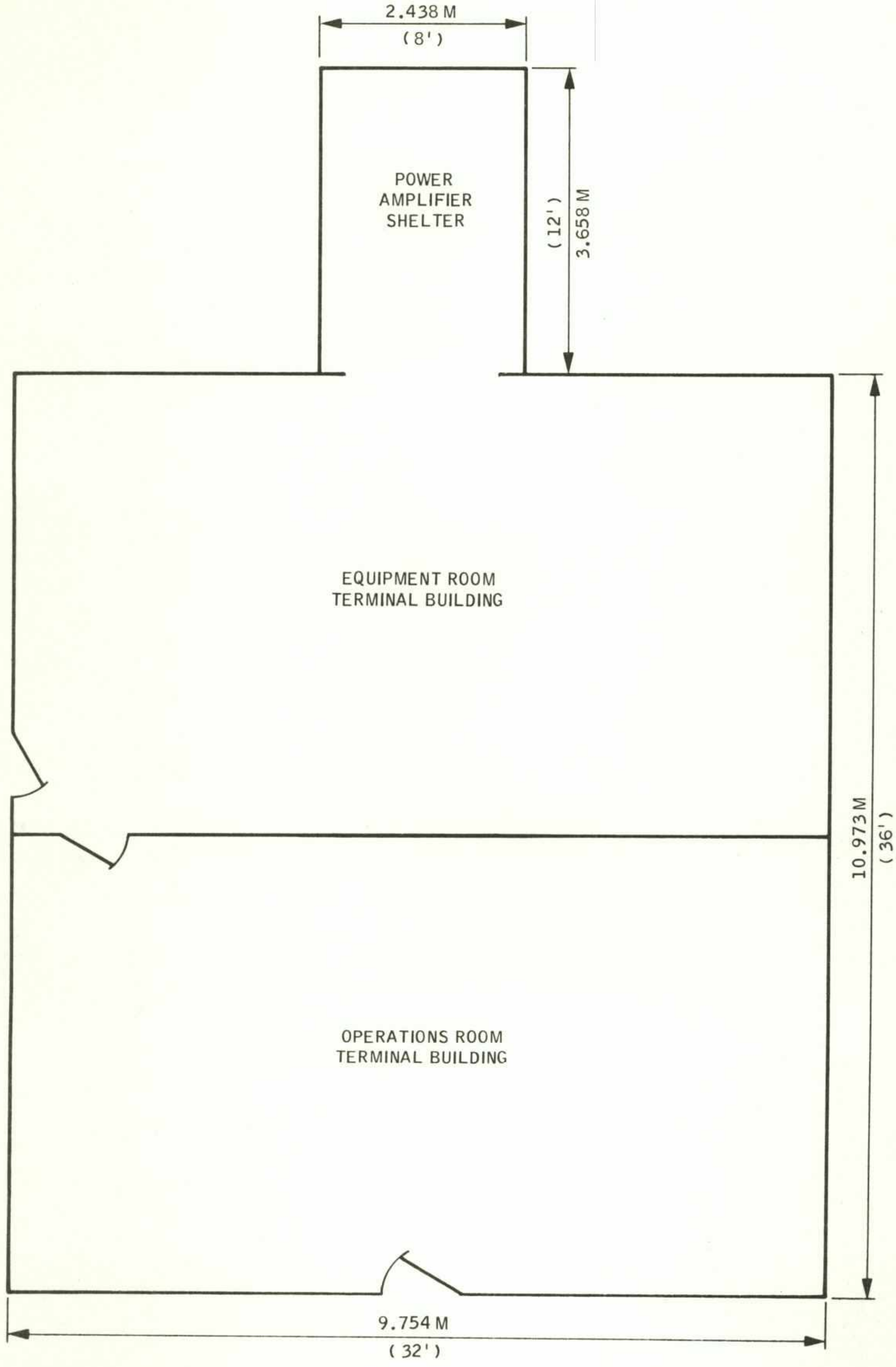

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Figure 4-4. Terminal Building and Shelter Outline

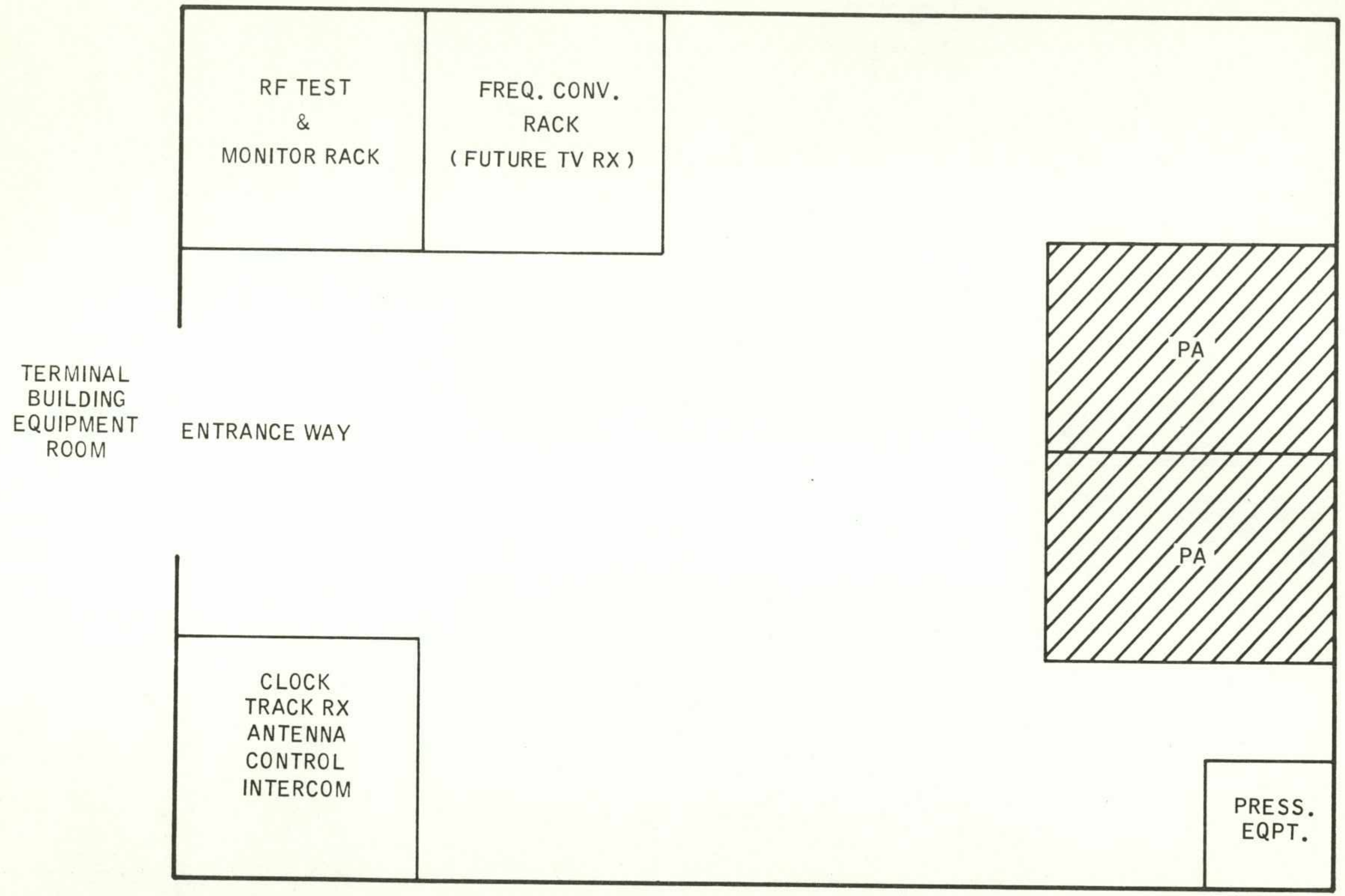

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Figure 4-5. Power Amplifier Shelter Floor Layout

4.4.4.2 Equipment Room

Figure 4-6 shows the floor plan and equipment layout for this room. The uninterruptible power supply equipment will be located within a walled-in area in a corner of this room. The battery systems will be vented to the outside of the building.

The telex switch as well as the VFTG, line conditioning, and signalling equipment will be mounted in racks and located as shown in the Figure. The SCPC terminal, ESC orderwire, clocks and central status and alarm equipment will also be rack mounted and located as shown. There is ample space for growth in each of the equipments.

When the optional television is added the television video monitor would be located in the rack facing the operators desk.

The two ESC orderwire teletype machines are in close proximity to the central operating area surrounding the operators desk. From the desk the operator will be able to monitor all important functions. This central area will also enable him to perform any patching or circuit testing required.

An entry door leads into the parts storage set aside within the operators room, as shown in Figure 4-7.

4.4.4.3 Operators Room

The floor plan and equipment layout for this room is shown in Figure 4-7. A maximun of eight operator positions are possible for international telephone operation. Initially five of these positions will be provided leaving three positions for expansion. Four operator positions are possible for international telex operation. Initially two of these positions will be provided leaving two positions for expansion. Two supervisor desks with chairs will be provided. Page will also provide the file cabinets, bookcases and operator position desks and chairs shown in the floor plan.

4.4.5 Earth Station Power

4.4.5.1 System Description

The proposed power system consists of the following major components.

a. One prime power system, consisting of two 150 kW diesel engine generators equipped for automatic operation.

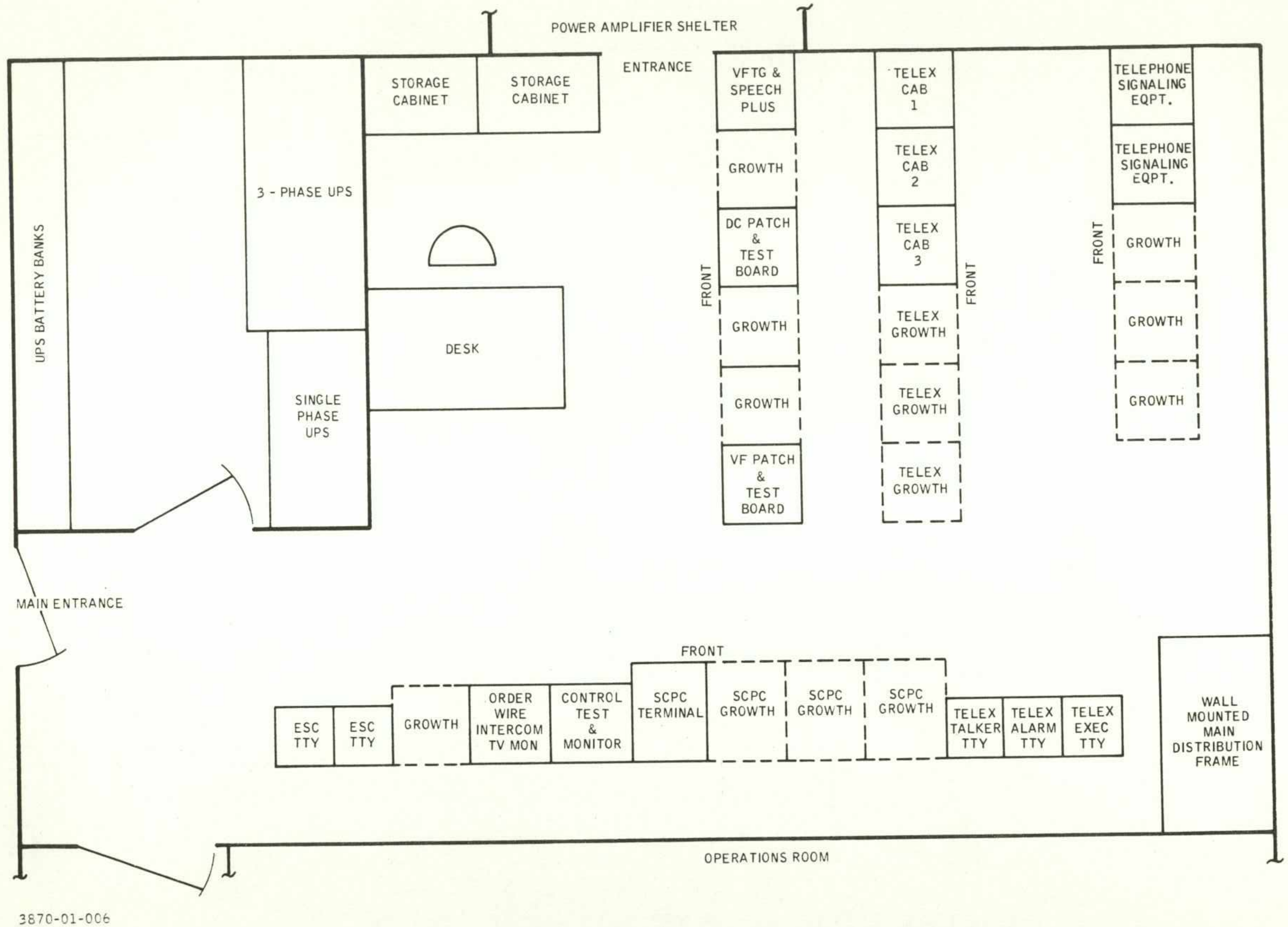

Figure 4-6. Terminal Building Equipment Room Floor Plan

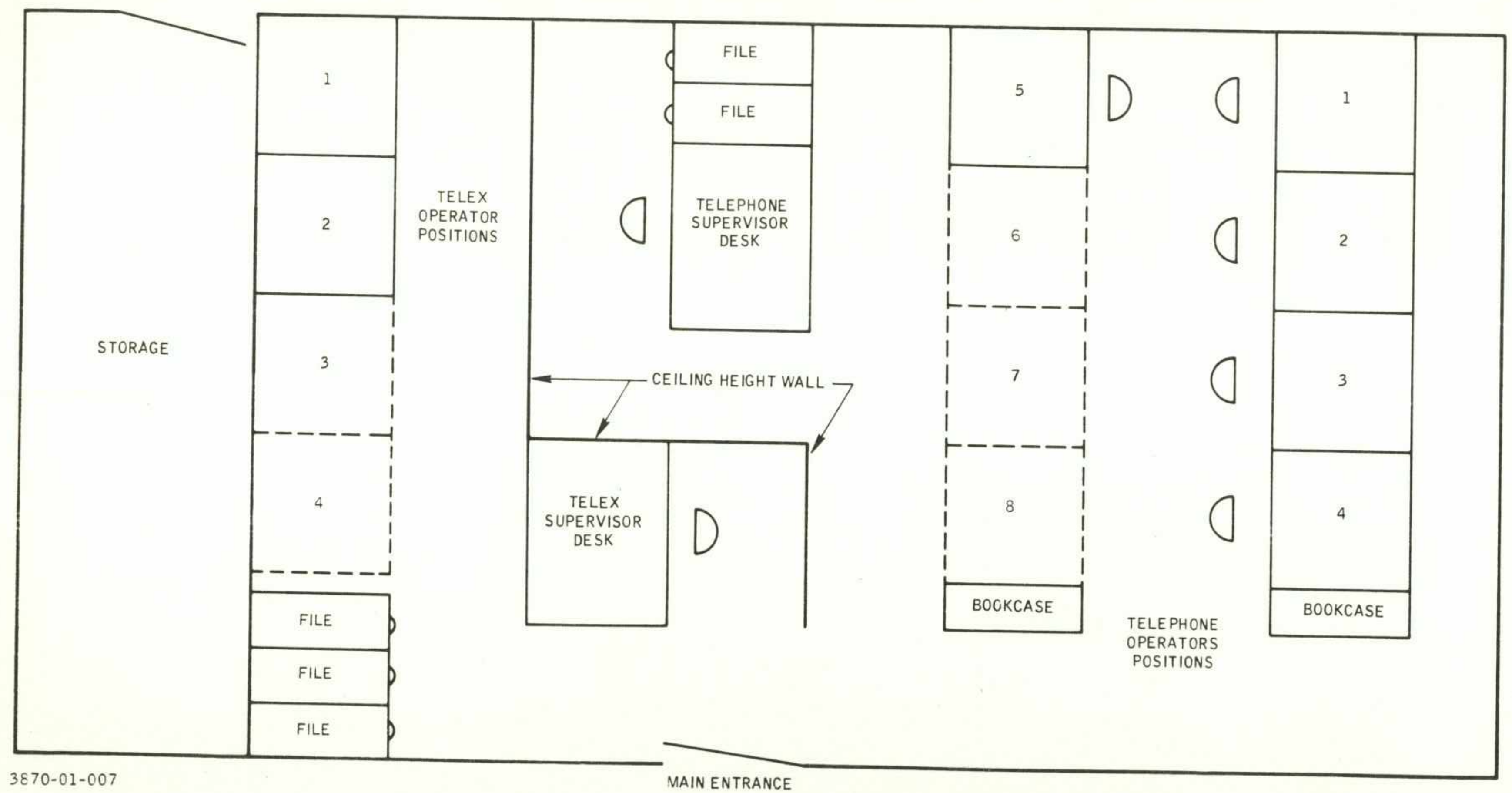

Figure 4-7. Terminal Building Operations Room Floor Plan

b. One 25 kVA uninterruptible power system designed to provide up to 10 minutes of support for the telephone and telex equipment.

c. One 45 kVA uninterruptible power system designed to provide up to 10 minutes of support for the earth station electronics equipment.

d. Power distribution panels, cables, conduit, lighting, and ancillary items. All of the power subsystems proposed are of the latest, proven, state-of-the-art design, and wherever feasible, use solid state components.

The Ministry of Posts and Communications shall provide a commercial power interface at an ac contactor provided by Page. In the event of a total prime power shut down, regulated commercial power shall thus be available for operation. A line voltage regulator shall be provided by the Ministry to maintain input voltage to the communications equipment within a $\pm7\%$ band. If the voltage excursions of the incoming power are outside the capacity of the regulator, the over/under voltage sensing and disconnect provided by Page shall disconnect the system.

4.4.5.2 Performance Summary

The simplified one line electrical diagram (Figure 4-8) shows the major electrical components and the plans for protection and distribution to the essential ac loads and to those non-essential ac loads which will tolerate short interruptions. The short interruptions to the non-essential loads will occur only upon shut down of one of the diesel generators. If such power interruption should occur, the period of interruption to the non-essential load is limited to the starting time of the second diesel engine (approximately 20 seconds). The essential loads will be unaffected by ac power outages because of the reservoir of stored energy supplied by the uninterruptible power systems. All electrical equipment for a complete and operational earth station facility will be provided.

4.4.5.3 Prime Power System

Normal electrical service for the earth station will be from a prime stationary diesel electric generator system. Each individual diesel engine generator will provide a rated output of 150 kW, 50 Hz, 220/380 volts, 3 phase, 4 wire.

The equipment supplied will be designed to operate as a semi-automatic prime power plant. Normally, one engine generator will be supplying power to the load. In the event that the running engine generator fails or the output voltage rises 10% or more for an

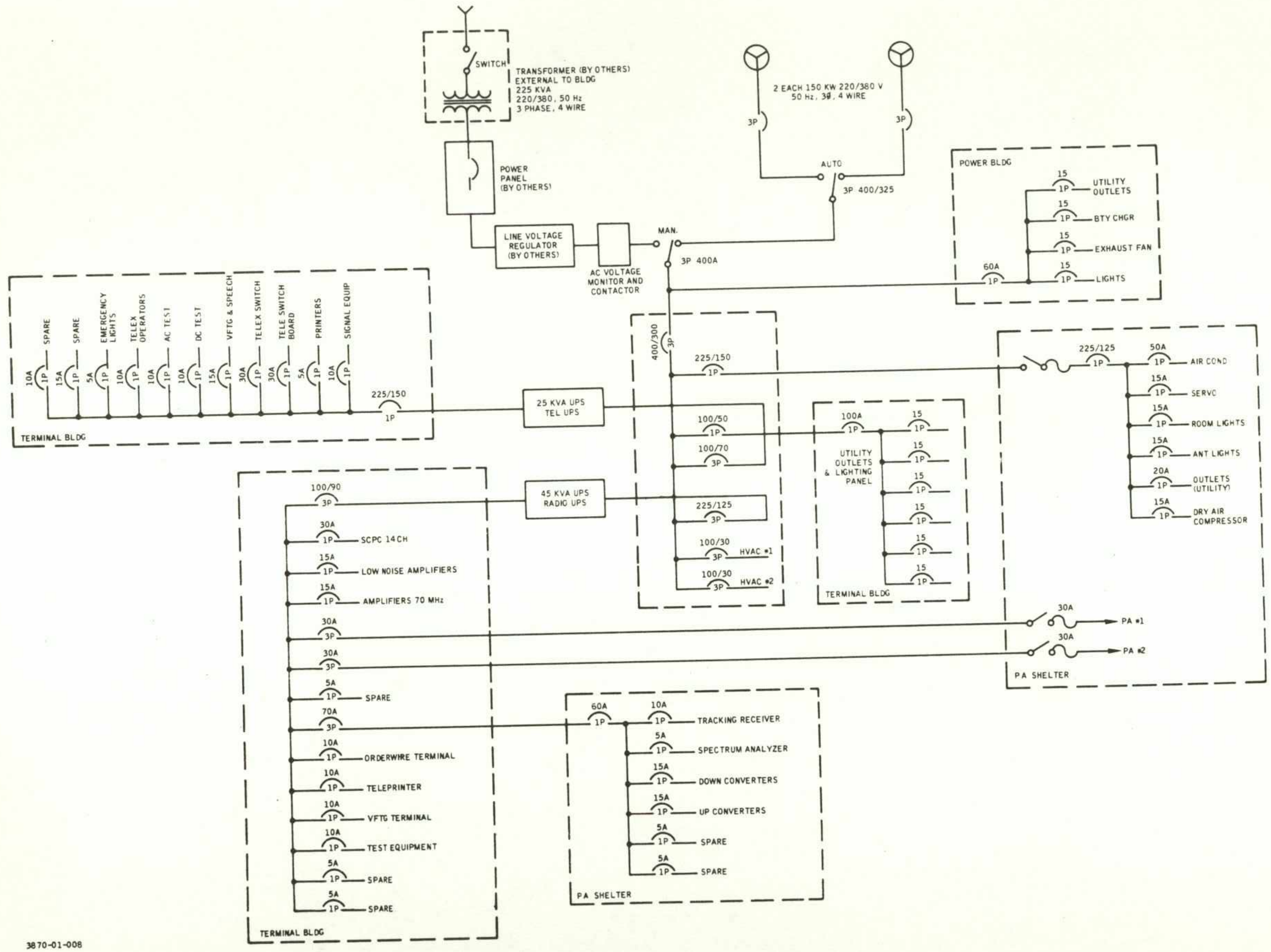

Figure 4-8. Power System Configuration

adjustable period, it shall automatically stop and lockout, and the circuit breaker will open. The standby generator will start and upon reaching voltage and speed, the generator circuit breaker will automatically close. The failed generator set will remain locked out until manually reset. Interlocks will be provided to ensure that the failed generator breaker is open before the incoming generator breaker is closed.

4.4.5.4 AC Uninterruptible Power Supply (AC-UPS)

Two UPS systems will be provided for the critical ac loads. The 45 kVA system will supply output power of 220/380 Vac, 3 phase, 50 Hz and the 25 kVA system will supply output power of 220 Vac, single phase, 50 Hz. Both will require input power of 220/380 VAC, 3 phase, 50 Hz. They will be continuous systems consisting of a constant-voltage, current-limited battery charger, a lead calcium storage battery, and a static inverter.

Normally, the ac input power will be rectified to both charge and float the battery bank and power the essential load through the static inverters. In the event that ac input power is interrupted, the essential loads are powered directly from the battery bank through the inverters. The battery bank has sufficient capacity to power the load for 10 minutes in complete absence of ac input to the rectifiers.

Worldwide Communications

NORTHROP PAGE

SECTION 5

SYSTEM PERFORMANCE

5.1 INTRODUCTION

This section provides the performance of the Page-designed satellite earth station for Rwanda. The system designed by Page will meet the mandatory requirements of INTELSAT for a Standard "B" satellite earth station and would be capable of operating with future INTELSAT satellites of the V type which may require a frequency re-use capability. The flexibility of the system, as well as the earth station site and elevation look angle, are discussed.

5.2 SPECIFICATIONS

The system will meet the performance specified in the documents given in Section 3.2.

5.3 OVERALL PERFORMANCE

The overall system performance is given in Table 5-1. The performance of each subsystem and equipment item has been calculated to provide this performance.

5.4 SATELLITE LOOK ANGLE

Page has computed the elevation look angle from the selected Rwanda Satellite Earth Station site to the Indian Ocean INTELSAT IVA primary satellite. A reproduction of the computer printout is presented in Table 5-2. From the table it can be seen that the elevation angle is at a very satisfactory 53°.

5.5 SITE DATA

Page recommends that the Rwanda Satellite Earth Station be located on the telecommunications site in Kigali. The elevation of the station will be at 1550 meters. The meteorological data and environmental conditions are the following:

Table 5-1

OVERALL SYSTEM PERFORMANCE

Frequency Range	Transmit 5925-6425 MHz Receive 3700-4200 MHz
Transponder for SCPC Operation	Transponder 10 Transmit 6300-6340 MHz Receive 4075-4115 MHz
G/T	31.7 + 20 LOG_{10} f/4 (dB/k) at operating elevation angle, where f is in GHz
Antenna Gain	Transmit 55.0 + 20 LOG_{10} f/6 (dB), where f is in GHz Receive 52.0 + 20 LOG_{10} f/4 (dB), where f is in GHz
Polarization	Circular: left hand transmit; right hand receive
Operating Elevation Angle to Indian Ocean Satellite	53^{o} approximately
EIRP (per SCPC) To Standard A station To Standard B station	 63.0 dBw* at 10^{o} elevation 69.8 dBw* at 10^{o} elevation *less 2.5 dB elevation angle correction for global transmission (0.06 (α -10) dB) where α is angle in degrees
EIRP spurious products	4 dBw/4 KHz maximum within transmit frequency range
EIRP Intermodulation products	(50-20 LOG_{10} N)* dBw where N is number of transmitted carriers ($>$ 7). *less 2.5 dB elevation angle correction for global transmission
EIRP Stability	$\pm$0.5 dB of nominal
Transmit SCPC carrier frequency tolerance	$\pm$250 Hz
Reliability	99.9%

TABLE 5-2

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ORBITAL CALCULATIONS FOR A SATELLITE INCLUDING INCLINED PARAMETERS

                      NAME              L A T I T U D E   L O N G I T U D E
EARTH STATION   RWANDA                    -1.  56.  45.    -30.   3.  50.
SATELLITE       INDIAN   PRIMARY           0.   0.   0.    -61.  24.   0.

EARTH RADIUS=3963.40 STAT. MILES. SATELLITE HEIGHT=22237.20 STAT. MILES

AZIMUTH   EAST OF NORTH FROM EARTH STATION TO SATELLITE    86.808 DEGREES
OFF-BEAM  FROM VERTICAL OF SATELLITE TO EARTH STATION       5.170 DEGREES
ELEVATION FROM HORIZONTAL AT EARTH STATION TO SATELLITE    53.440 DEGREES

                SLANT RANGE EARTH STATION TO SATELLITE
               STATUTE MILES   KILOMETERS  NAUTICAL MILES
                22910.484      36870.971      19908.706

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a.	Winds	Average velocity	55 km/hr.
		Velocity of Gusts	100 km/hr.
b.	Temperature	Maximum	$31^{o}C$
		Minimum	$10^{o}C$
c.	Rainfall	Maximum in 1 hour	46.4 mm
		Maximum in 24 hours	124.8 mm

5.6 CAPACITY AND EXPANSION

The satellite earth station is equipped for duplex transmission of 14 single voice channel per carrier (SCPC) carriers. Included in this total are two duplex SCPC carriers for engineering service circuits and one receive SCPC carrier for the future optional reception of the television audio program. Future expansion in the capacity of the SCPC terminal beyond the 14 equipped channels is possible by the addition of channel units and wired racks. Expansion in the telephone and telex terminal facilities is by addition of plug-in cards, operator positions, and signaling equipment.

5.7 FLEXIBILITY

To accommodate the flexibility required of operating in the INTELSAT network, the system is designed to enable operation at other than its initially assigned operational parameters of transponder, carrier frequency and power outputs.

A change in assigned transponder can be achieved by change of crystal in the frequency conversion equipment. The carrier frequency can be changed by synthesizer selection of the new frequency in the SCPC terminal. The per carrier output power can be adjusted by attenuator setting in the SCPC terminal. Total output power is adjustable to the limits of the final power amplifier stage, consistent with meeting the INTELSAT requirements for intermodulation products.

The antenna has sufficient travel capability in both the azimuth and elevation axes to enable the earth station to operate with the Indian Ocean primary path satellite and its backup.

5.8 SYSTEM COMPUTATIONS

Computations for the receive system G/T and transmit EIRP are discussed in the following paragraphs.

5.8.1 Receive System G/T (Gain to Noise Temperature Ratio)

The system has been designed using a thermoelectrically cooled low noise parametric amplifier. The calculations for the receive system performance have been made at the elevation look angle of 53^{o}, at the low, middle, and high ends of the 3.7 to 4.2 GHz frequency range.

Figure 5-1 shows the receive system in block format with the equation used to calculate the total receive system noise temperature. The total noise T_s has been subdivided in T^1 which is the antenna noise referenced to the receive output flange from the antenna feed modified by the VSWR of the interface and T_{REC} which is the receiving system noise temperature referenced to the same point.

Table 5-3 gives the calculated receive system G/T at 53^{o} elevation. The calculation shows that the INTELSAT mandatory requirement should be met with margin at the operating elevation look angle to the Indian Ocean primary satellite.

5.8.2 EIRP Calculation and Carrier Capacity

To determine the optimum rating of the power amplifier, it has been assumed that at least 50% of the transmitted carriers will be to Standard "A" receiving stations and not more than 50% of the transmitted carriers to Standard "B" receiving stations. The earth station power amplifier design is predicated upon this assumption.

Figure 5-2 shows the transmit interfacility link in block format with losses identified and total loss computed.

The elevation look angle for the earth station to the Indian Ocean INTELSAT IVA satellite is approximately 53 degrees. The EIRP elevation correction factor is given by the following equation for global beam transmission.

$0.06\ (\alpha - 10)$ dB where α is the elevation angle in degrees.

= 2.58 dB at 53 degrees elevation.

Using the calculated losses from figure 5-2, the elevation correction factor, and a final power tube rating of 3000 watts, the carrier capability of the power amplifier system has been calculated and is presented in Table 5-4. The calculation shows that the power amplifier subsystem has the capability for transmission of at least 60 SCPC carriers at an activity factor of 65%. This is in excess of the 14 SCPC carriers that the SCPC terminal is initially equipped to transmit.

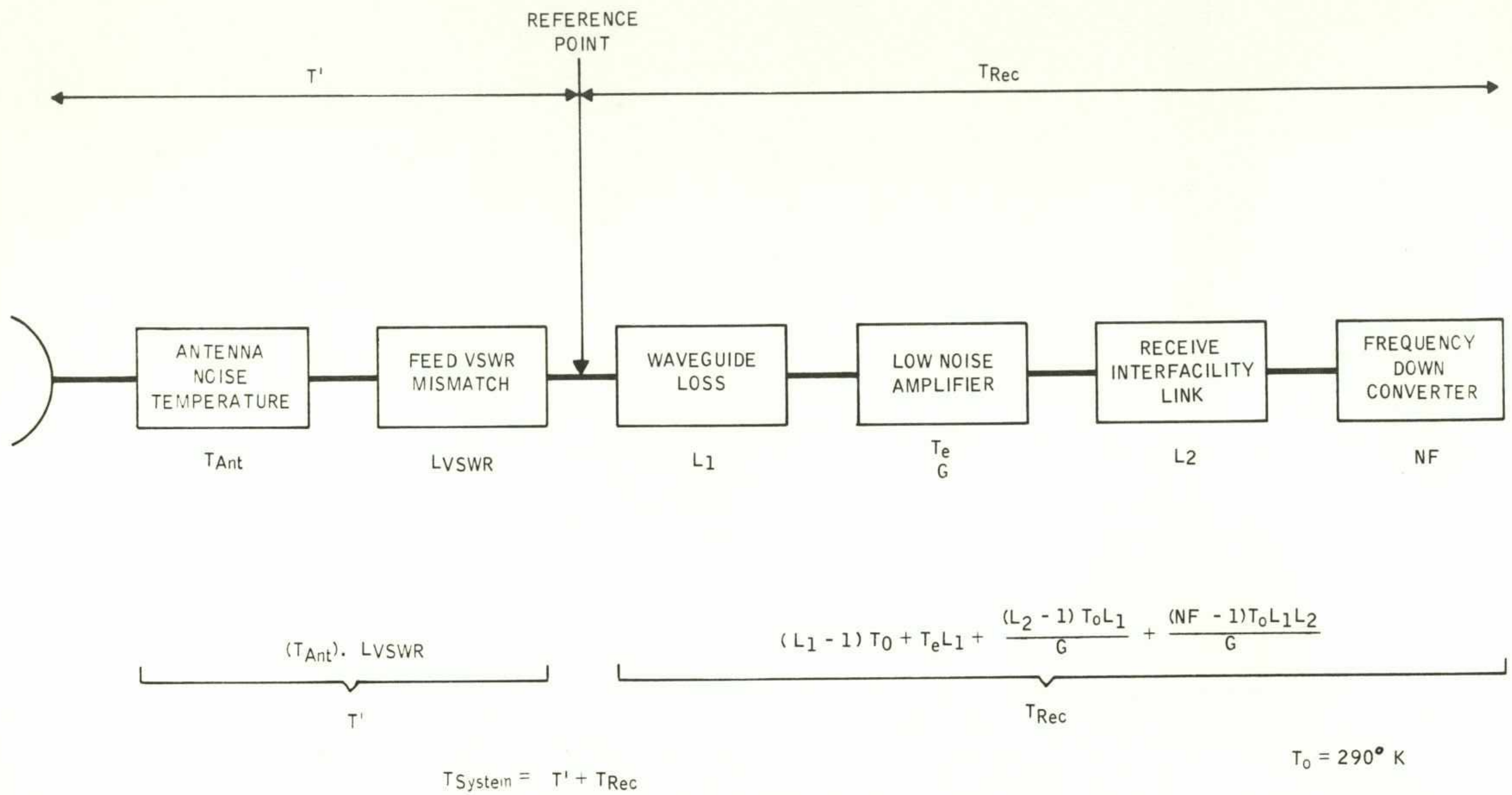

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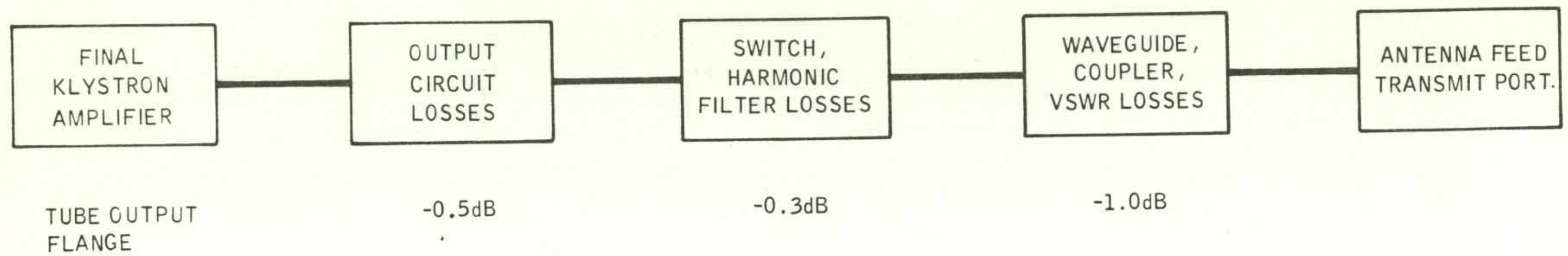
Figure 5-1. Receive System Equipment Parameter Design

TABLE 5-3. CALCULATED RECEIVE SYSTEM G/T

Frequency (GHZ)	3.7	3.95	4.2
T^1 (k)	23.52	23.52	23.52
T_{REC} (k)	56.53	56.53	56.53
System Temperature (k)	80.05	80.05	80.05
Antenna Gain (dB)	51.32	51.89	52.42
System G/T (dB/K)	32.29	32.86	33.39
Mandatory G/T (dB/K)	31.02	31.59	32.12
G/T Margin (dB)	1.27	1.27	1.27



TOTAL LOSSES FROM TUBE OUTPUT FLANGE TO ANTENNA FEED TRANSMIT
PORT INPUT =0.5 + 0.3 + 1.0 dB
=1.8dB

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Figure 5-2. Transmit Interfacility Link Loss

TABLE 5-4

POWER AMPLIFIER CARRIER CAPABILITY ANALYSIS

	TO STANDARD "A" STATION	TO STANDARD "B" STATION
EIRP/Carrier at Operation Elevation Angle of 53°	60.5 dBw	67.3 dBw
Antenna Gain at 6.32 GHz	55.45 dB	55.45 dB
Carrier Power at Feed Point	5.05 dBw	11.85 dBw
Transmit Interfacility Link Loss	-1.8 dB	-1.8 dB
Power Required/Carrier at Tube Output Flange	6.85 dBw	13.65 dBw
Output Tube Single Carrier Saturated Power (3000 W)	34.8 dBw	
Back-off From Single Carrier Saturation to Meet Intermodulation Products	7 dB	
Maximum Total Power Available for Multicarrier Operation	27.8 dBw (603 W)	
Assuming a 65% Activity Factor and 50%/50% Distribution Ratio the Number of Carriers that Can be Transmitted is	32	32
TOTAL NUMBER OF CARRIERS	64	
SCPC TERMINAL ULTIMATE CAPABILITY	60	

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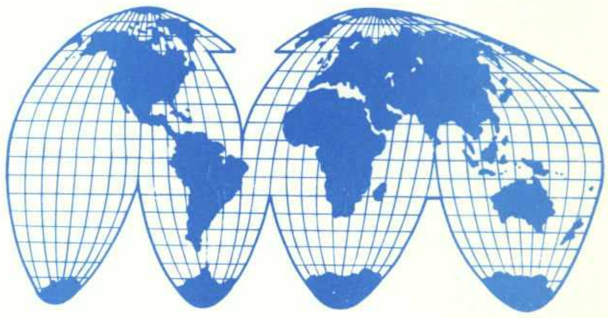

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SECTION 6

TEST AND ACCEPTANCE

6.1 INTRODUCTION

The satellite earth station and its supporting subsystems will be tested to ensure that the performance stated as well as the required INTELSAT performance is met. The test program will consist of the following:

a. Factory Tests
b. On-site subsystem tests
c. INTELSAT mandatory acceptance tests
d. INTELSAT line-up tests

Test procedures will be prepared for each test category other than the factory tests. Equipment suppliers will be required to provide the factory test procedures.

The INTELSAT mandatory acceptance tests will constitute the formal acceptance testing. The satellite earth station will be considered technically acceptable upon satisfactory completion and approval of the mandatory tests by INTELSAT.

Test equipment to be used in the on-site acceptance testing will become part of the satellite station equipment for station maintenance. A list of this equipment is provided in Table 6-1. This list may be supplemented by other Page owned equipment, necessary only during the site testing. The latter equipment will be removed from the site following completion of the tests and returned to Page facilities in the U.S.A.

Table 6-1. Test Equipment List

Description	Quantity
Power Meter and Sensor	2
Frequency Counter	1
Frequency Meter	1
RF Spectrum Analyzer	1
Test Translator	1
Oscilloscope	1
RMS Voltmeter	1
RF Signal Generator	1
Voltmeter	1
Picture Monitor, Color 625/50, 525/60 (TV Option)	1
Waveform Monitor 525/60 (TV Option)	1
Vectorscope 625/50 PAL (TV Option)	1
Transmission Test Set	1
Clamp-on Ammeter	1
PCM Multiplex Pseudo-Random Noise Test Set (or equivalent)	1
Audio Oscillator	1
Sweep Generator	1

6.2 ON-SITE SUBSYSTEM TESTS

These tests are to confirm that the equipment in a subsystem is performing in accordance with the design requirements. The following subsystems will be tested.

a. Antenna subsystem

b. Transmitting chain (power amplifier subsystem and frequency up converters)

c. Receiving chain (low noise amplifier subsystem and receive interfacility link)

d. SCPC terminal

e. Engineering service circuit subsystem

f. Power subsystem

g. Control and monitoring subsystem

6.3 INTELSAT MANDATORY TESTS

Following completion of the subsystem tests, the mandatory tests will be performed. Satisfactory completion of these tests will qualify the earth station as an INTELSAT Standard "B" satellite earth station.

The following tests will be performed:

a. Receiving system gain-to-noise temperature (G/T) ratio.

b. Transmit antenna gain and sidelobe pattern.

c. Feed polarization and axial ratio. (Factory data submitted as proof.)

d. Antenna steerability.

e. Feed system bandwidth (factory data submitted as proof).

f. Transmitting system bandwidth

g. Receiving system bandwidth.

h. Carrier EIRP.

i. EIRP stability.

j. RF out-of-band emission.

k. Intermodulation products.

l. Carrier frequency tolerance.

m. Phase noise.

6.4 INTELSAT LINE-UP TESTS

Following completion and preliminary approval by INTELSAT of the mandatory test data, the Satellite Systems Operation Guide (SSOG) line-up tests can commence with initially, an INTELSAT monitoring facility followed by the earth stations of the correspondent administrations. The line-up tests to be performed and the procedures to be used are described in the SSOG, Section 5, Volume II. Completion of the line-up tests enables International Telephone Center to International Telephone Center, telephone and telex exchange checkout and operation to commence.

6.5 TEST REPORT

A test report will be prepared for each of the categories of testing. The INTELSAT Mandatory and Line-up test reports will be submitted to INTELSAT within the permitted period following completion of the tests. Page will provide copies of all test reports to the Ministry of Posts and Communications.

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SECTION 7

PROGRAM MANAGEMENT

7.1 INTRODUCTION

Page, with more than 25 years of experience, has demonstrated capability in all facets of communications on a global scale. This includes system management, design, installation, test, maintenance and operations, and the training of personnel of many nationalities throughout the world. As a company with vast experience in the performance of turnkey programs, Page recognizes that each program has its own unique requirements which determine the structure and staffing of the management group. Major factors to be considered are:

a. System diversity and complexity
b. Location of the program
c. Program schedule, major milestones leading to the contractual completion date
d. Interdependencies of the operational phases
e. Area and degree of interface and overlays with the work of others; customer and other contractors
f. Nature and structure of the customer organization
g. Type of contract
h. Special contractual requirements

These major factors are scrutinized in minute detail during the bid stage and each addressed as applicable. The organization to manage, implement and attain the program objectives of the Rwanda Satellite Earth Station Program has been set up to conform to the structure which has proven effective on similar programs. Allowances have been made for all areas requiring special emphasis. To ensure the successful completion of the work, Page has assembled a team of proven individuals whose collective experience encompasses all the skills required by this program.

7.2 PROGRAM ORGANIZATION

The Page Team will be mobilized immediately upon effective date of contract award, with all members assigned their specific areas of responsibility. A functional organization chart depicting the Page Program Team for the Rwanda Satellite Earth Station Communications project, is provided in Figure 7-1.

The prime responsibility of the Rwanda Satellite Earth Station Program Team is to assure implementation of a smoothly coordinated program, in a timely and cost-effective manner, to anticipate potential problems and provide solutions before actual problems impair progress. To that end, the organization depicted will be composed of personnel experienced in management and implementation of similar programs throughout the world.

The responsibilities of the key individual team members and a description of the necessary actions and functions required to execute the program are discussed in the following paragraphs.

7.2.1 Program Manager

The key individual in this project management organization is the Rwanda Satellite Earth Station Program Manager. He is assigned total responsibility and authority for organizing, implementing, and completing the project. Further, the Program Manager is the authorized liaison officer to coordinate with the customer.

The Program Manager develops work plans and schedules, defines and issues task assignments, establishes budgets for all functional groups, sets priorities, monitors subcontracts, coordinates with the customer, evaluates work progress, schedules concept and design reviews, initiates corrective action when necessary, and ensures adherence to all contractual obligations. As required, the Program Manager may mobilize the expertise of any company department to resolve unforeseen problems and to assure that the project is completed in a totally satisfactory manner. The Program Manager reports directly to the Page Vice President of Program Management.

7.2.2 Project Engineer

The need for overall technical direction of the engineering effort required for the project is recognized by the assignment of a Project Engineer. Under the direction of the Rwanda Satellite Earth Station Program Manager, the Project Engineer defines specific

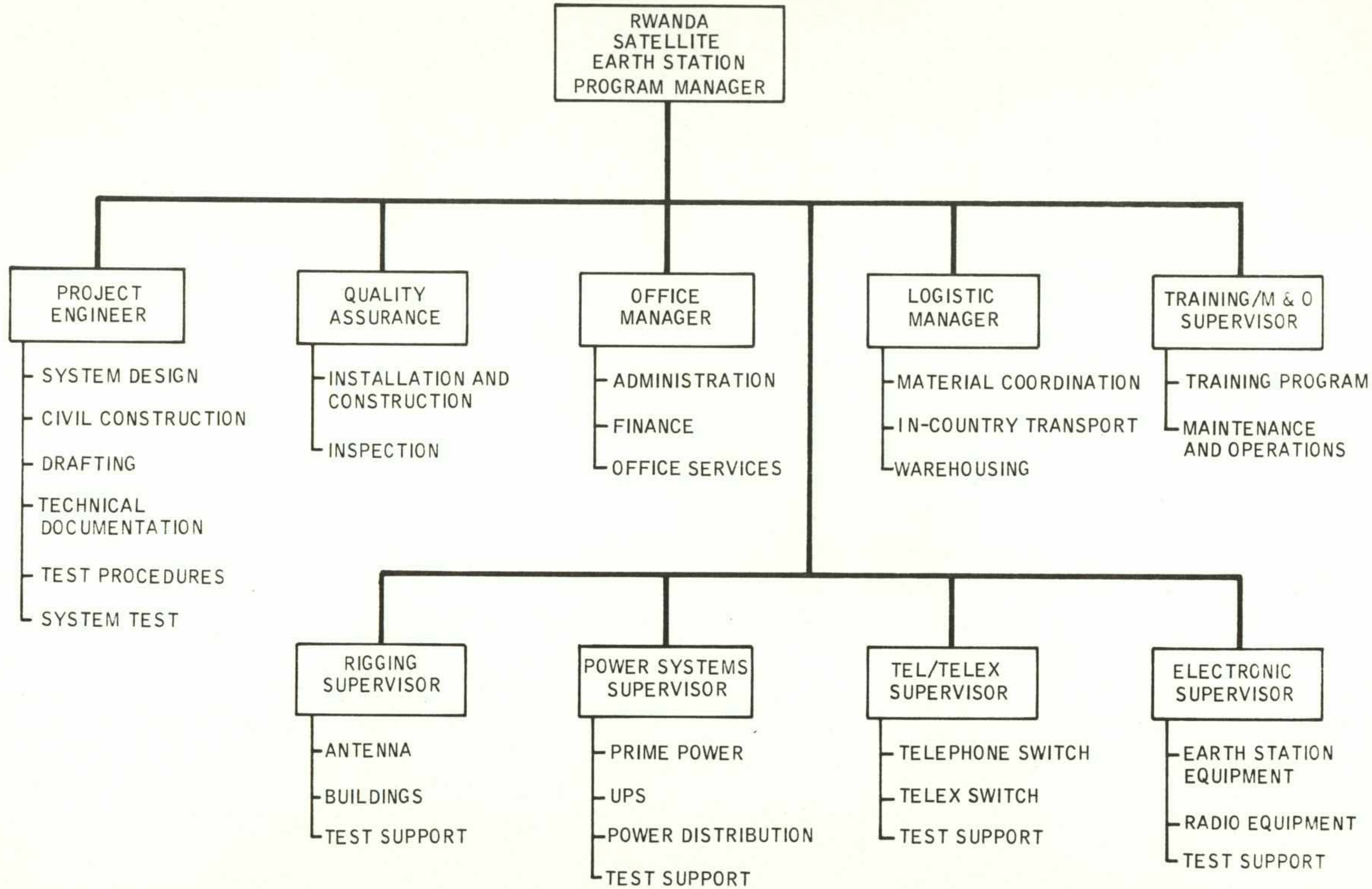

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Figure 7-1. Program Organization In-Country engineering tasks and is charged with the responsibility of assigning each task to the appropriate engineering group, monitoring its progress, and reviewing and approving the finished product for use on the project. In this manner, the Project Engineer exercises complete control of the technical content of the system configuration and ensures that all technical requirements of the program are accommodated. The following are typical of the tasks under his responsibility.

a. Reviews the technical specifications for the project and secures clarification, if required, to assure compliance.

b. Establishes design parameters and monitors the design effort for applicability, timeliness, and cost-effectiveness.

c. In the civil design area, he is responsible for ascertaining that all required site data is secured and for reviewing the design effort.

d. He is responsible for assuring that a detailed Bill of Material (BOM) is generated and that it is compliant with technical and procurement specifications.

e. He monitors and assists in the system installation and checkout, and is responsible for performance and acceptance tests in accordance with previously approved specifications.

f. The Project Engineer is also responsible for the correctness and completeness of all technical data and documentation.

7.3 IMPLEMENTATION PLAN

This section describes Page's organization and management approach to the Rwanda Satellite Earth Station and Telephone/Telex switching systems.

Page has all of the technical, managerial, administrative and support personnel experience necessary to design, install, test, and deliver the proposed communication system on time to meet the government's operational requirements.

The detailed plan and schedule for executing the program is summarized in this section. Analysis of the plan shows that the program can be completed, tested and placed in operation 12 months after effective date of contract.

This proposal demonstrates our full understanding of the system requirements. We have formed an organization, built around a successful team, which is completely capable of anticipating and surmounting those problems which are frequently encountered in complex turnkey systems. We are confident this proposal offers the Government of Rwanda assured ultimate success.

7.3.1 Schedule

In planning the implementation of the Rwanda Satellite Earth Station and Terminal Facilities, Page has attempted to achieve an operational communication network at the earliest date possible. A summary implementation schedule for the Rwanda communications network, Figure 7-2, depicts major milestone activities start and completion dates. A Work Breakdown Structure, Figure 7-3, indicates major task descriptions and sub-tasks.

7.3.2 Site Survey

A preliminary site survey was performed in Kigali during the month of May. Additional data that may be required to accomplish this program will be obtained during the proposal delivery. This information will allow Page to detail and finalize the design.

7.3.3 Long Lead Procurement

Immediately after effective date of contract, the Page Materiel organization, assisted by Page Systems Engineering, will develop long-lead equipment procurement packages.

These packages will be forwarded to selected equipment suppliers which have been evaluated during proposal preparation, requesting best delivery, and, using definitized performance specifications, developed by Page System Engineering.

Because these equipment suppliers are knowledgeable of the system requirements, a minimum of response time will be required. Supplier responses will be technically evaluated, final selections made, and subcontracts awarded.

7.3.4 Equipment Shelterizing and Pre-Assembly

In order to minimize on-site installation time and in-country logistics support requirements, the communications equipment will be installed in the power amplifier shelter at the Page fabrication warehouse facility in Vienna, Virginia, U.S.A. Prior to shipment, the pre-assembled shelter will be checked out and tested to the extent possible.

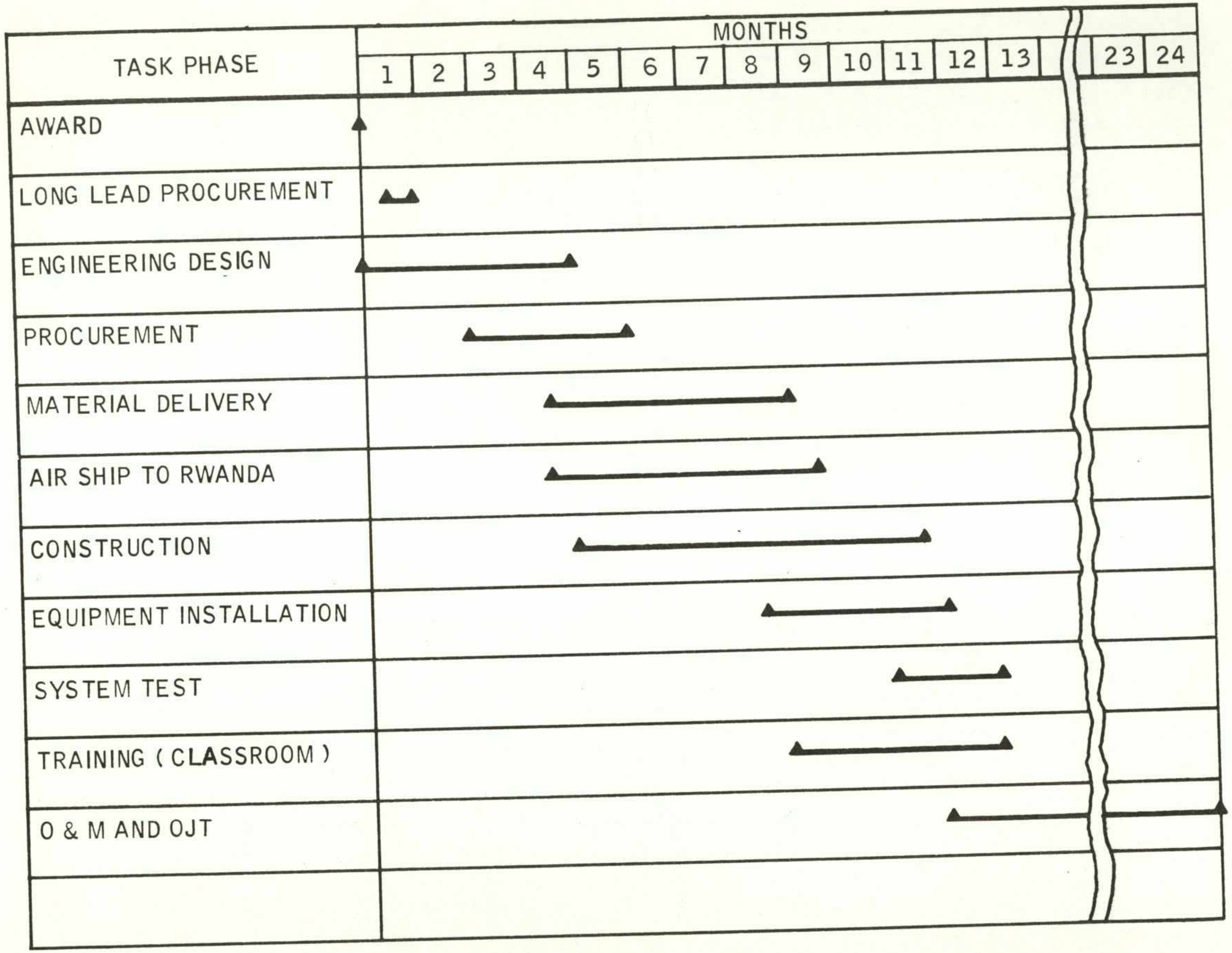

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Figure 7-2. Project Schedule

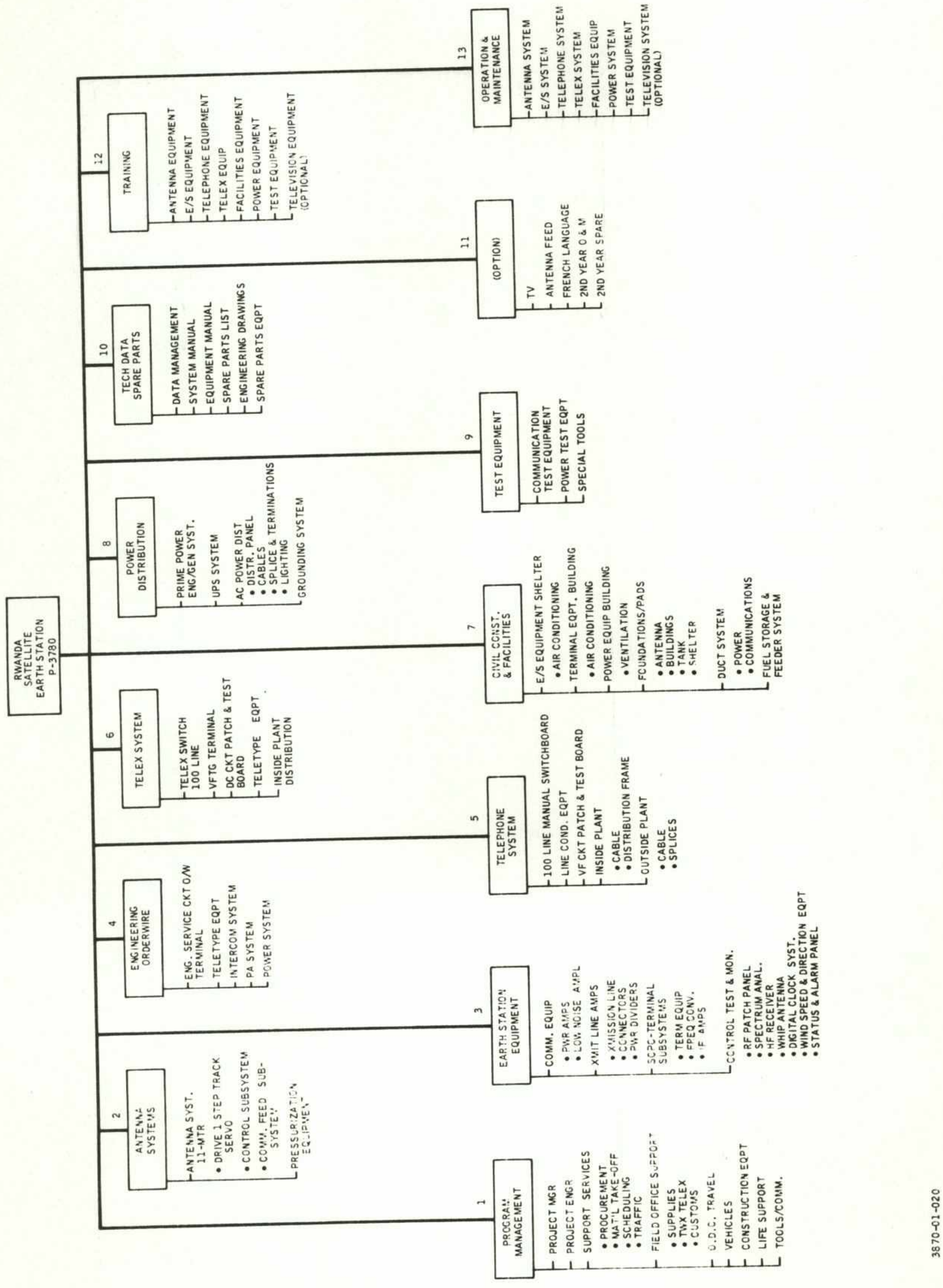

Figure 7-3. Work Breakdown Structure

7.3.5 Transportation and Logistics

Page will provide expediting, staging, transport, material handling and control of all material from our Vienna, Virginia, U.S.A. warehousing and export packing facilities to Kigali, Rwanda. Transportation of all equipment and materials will be made by air freight to assure its timely delivery and undamaged condition. Transportation, control and handling of the material to the site location will be the responsibility of Page Communications Engineers, Inc.. Page will provide in-country material coordinators and logistics control to assure scheduled on-site arrivals and physical security of the material.

7.3.6 Installation and Check-out

Major on-site installation tasks to be performed by Page:

a. Construct antenna foundation.

b. Erect 11 meter antenna system.

c. Construct a 20 foot wide by 24 foot long prefabricated metal, prime power generating building.

d. Construct a 32 foot wide by 36 foot long prefabricated metal communications center building.

e. Construct a shelter pad.

f. Install a 5000 gallon fuel tank above ground.

g. Install a dual 150 kW prime power system including a 25 kVA and 45 kVA continuous UPS system.

h. Install an international telephone switchboard

i. Install a telex switch.

j. Place the power amplifier shelter on its pad and install transmission lines.

k. Interconnect the new terminal building equipment with existing equipment with underground cabling.

Page construction personnel will be responsible for excavation of foundations pads, construction of forms, installation of rebar, pouring concrete and allowing sufficient curing time for all concrete.

Page will construct the buildings, antenna system, grounding systems, power generating and distribution. The communications and related support systems will be installed. Upon completion of site installation, Page will perform site checkout and test.

7.3.7 Quality Assurance

Page quality assurance personnel will monitor the equipment suppliers' equipment qualification program and perform in-plant/in-process inspection to assure compliance with specifications. All construction and installation will be monitored by Page quality assurance field personnel to assure compliance with the drawings and procedures.

7.3.8 Testing

Page will perform tests of the communication and power systems in accordance with the test procedures. (see Section 6)

7.3.9 System Turnover

Page will prepare and submit as-built drawings and technical documentation. Site inventories will be performed and turnover documentation will be submitted to the Rwanda Ministry of Posts and Communication for acceptance and signature. (see paragraph 6.5)

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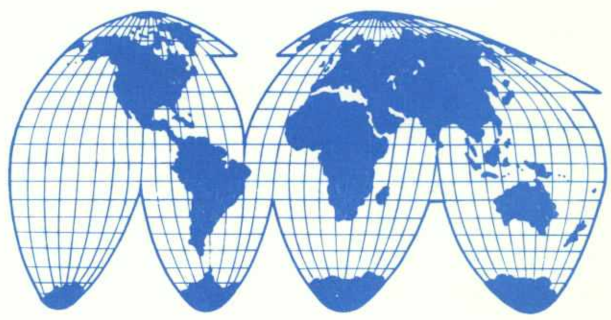

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SECTION 8

SUPPORT SERVICES

Page will provide specific logistics services required for support of the Rwanda Satellite Earth Station and the associated Telex and telephone switching centers. Included in the services are training, operation and maintenance (O&M), spare parts provisioning, and documentation support.

Support services to be accomplished by Page are described in the following paragraphs.

8.1 TRAINING

Page will provide an in-country training program for the Rwanda Ministry of Posts and Communications personnel assigned to the satellite earth station. The program will consist of three elements:

a. System operation and maintenance
b. Guided on-the-job training (OJT)
c. On-the-job advisor service

The number of trainees to be enrolled in the program is flexible, but should not exceed eight trainees per class. Page will train eight Posts and Communications personnel: four in power and radio and four in switching and ancillary equipment.

The training program will commence in the 9th month after effective date of contract with the Ministry's assignment of four power trainees and four telecommunications trainees.

8.1.1 Formal Classroom Training

Formal training will be provided for one class in the specific basic areas of power generation, radio, switching, ancillary equipment and maintenance and operation concepts. Each trainee will receive familarization in the entire station equipment.

General electronics theory training will not be provided. The period of training will be three months.

Training provided by Page will not include OJT on teletypewriter or telephone instruments or Telex or telephone operator positions.

8.1.2 Class Schedule

Page will conduct classes for six hours a day, five days a week. The classes will consist of 50 minutes of instruction and participation, and 10 minutes break.

8.1.3 Training Staff

The Page training staff will consist of one senior power technician and two senior telecommunications technicians.

8.1.4 Course Content

The subject material to be presented will use Page prepared material, commercial material, and manufacturers manuals.

8.1.5 Trainee Prerequisites

The trainees should be fluent in spoken and written English, as the program of instruction will be conducted in English. Page plans to provide at least one instructor bilingual in English and French.

The power trainees should possess a basic knowledge of electricity, and the communications and electronics trainees should have a basic understanding of electronics.

8.1.6 Training Logistics Requirements

The formal classes will be taught at a classroom facility to be provided by the Ministry of Posts and Communications. The facility must be fully equipped for teaching purposes with instructional items such as blackboards, podium, desks, chairs and other required furniture. Page will furnish sufficient manuals, drawings, and other technical matter for use by the trainees during the program.

The students (Ministry) will be responsible for the supply of personal items such as pens, pencils, pads, etc.

8.2 OPERATION AND MAINTENANCE

Page will furnish a qualified staff of management and technical personnel to provide operations and maintenance of the Rwanda satellite earth station for a period of one year. The period of service will commence with the commission of the system and will consist of full-time (24 hours per day, 7 days per week), full manning for each shift.

8.2.1 Operations

The assignment of a Page Telecommunications Technician and a Power Generation Technician to each shift will provide sufficient manpower to meet initial operational requirements. In addition, OJT will be provided for Ministry technicians and trainees who have completed the formal classroom instruction. As Ministry trainees complete their course of instruction, they are expected to work with the satellite earth station contractor technicians. As the program develops, the point (month 21 after effective date of contract) should be reached when Ministry technicians can assume necessary operations.

The following tasks are included as operational duties:

a. Maintaining the daily log of station activity.

b. Maintaining the records of equipment performance (meter readings, etc.,) and operational checklists.

c. Transmitting and receiving teletype messages and reports as required or scheduled for earth station operation.

d. Assisting the local message center and distant terminals, as required, in the testing, performance evaluation and fault correction of individual circuits or channels.

8.2.2 Maintenance

The maintenance to be performed will include routine, preventive and emergency maintenance. Maintenance will be performed in accordance with manufacturer or Page-developed procedures and INTELSAT recommendations. Maintenance will be performed initially by Page technicians who will be assisted by Ministry technicians as they complete their course of instruction. OJT will be provided by Page in system equipment maintenance. Page anticipates that as the O&M and OJT program develop, Ministry personnel should be capable of fully maintaining the satellite earth station system at the end of 24 months after effective date of contract.

8.2.2.1 Preventive Maintenance

Preventive maintenance will be performed by each operating shift in accordance with a master schedule. This schedule will be based upon manufacturer's recommendations and field experience on similar systems. The preventive maintenance will consist of two categories:

a. Inspection, cleaning and normal physical adjustments, such as tightening loose knobs, as required.

b. Performance testing of the equipment to ensure its full operational capability.

All discrepancies found during the performance of preventive maintenance will be cleared immediately unless parts are not available. If parts required are not on hand, one of the following actions will occur:

a. If the equipment does not meet specifications in the normal operating configuration, the equipment will be listed as deadlined until repaired. It will not be placed on-line unless an emergency occurs which would interrupt service.

b. If the defective part of the equipment is not required in the normal operating mode (i.e., multiplex group), the equipment will be listed as degraded until repaired. It will be placed on standby but may be used at any time without service interruption or degradation.

8.2.2.2 Emergency Maintenance

Emergency maintenance will be performed as required and will commence immediately upon detecting a failure. After the failure is diagnosed, the problem will normally be remedied by replacement of an equipment subassembly such as a module, circuit board or similar item. This type of repair concept will provide rapid restoration of equipment to operating status with minimum effort.

8.2.2.3 Maintenance Management

Page will organize and maintain a complete maintenance record system for the station. Such a system will provide a complete history of equipment performance and will allow for future planning such as logistics requirements. A record system will be prepared for major equipment items and will consist of the following forms:

a. Equipment Service Record - All maintenance performed on the equipment will be recorded.

b. Parts Usage Record - All parts replaced in the equipment will be recorded.

c. Modification Record - Any modifications or alterations made to the equipment will be entered.

d. Deadlined Equipment Record - This form will be used to record the time and reason the equipment was nonoperational for lack of parts.

e. Degraded Equipment Record - This form will be used to record the time and reason for equipment degradation due to lack of parts.

Upon completion of the contractual O&M period, all maintenance data will remain as part of the Rwanda satellite earth station.

8.3 SPARES

8.3.1 Introduction

Page will supply spare parts and will initiate a spare parts control system that will help to insure that the Rwanda Satellite Earth Station and the International Telephone Switchboard and Telex switch are kept in a fully operational status.

8.3.2 Maintenance Concept

The maintenance concept for the Satellite Earth Station and the terminal equipment is the repair or replacement of failed circuit boards, modules, subassemblies, and assemblies. The failed units that cannot be repaired by technicians, will be sent to the equipment manufacturer for repair or replacement and will then be returned to the sites as spares. Spare fuses, lamps, and other minor replaceable components for each equipment will be stocked at the site for the correction of minor failures.

8.3.3 One-Year Spare Parts

Page will supply the initial stock of spare parts, based on Page's assessment of the equipment density and maintenance philosophy, to support the operational and test equipment for the first year after acceptance.

8.3.4 Spares Control System

Page will establish a spares control system to keep a record of the spare parts used and to initiate reprocurement of spare parts used to repair equipment. In addition, the control system will provide a record and control for the ordering of parts that must be acquired by the government for the first time. As time passes, a visible record will be developed to indicate what equipment is failing; from that record, the reasons for failures can be analyzed and long-term corrective actions can be taken to eliminate common, repetitive equipment failures.

8.4. DOCUMENTATION

8.4.1 Introduction

Page will provide a documentation package in the English language to support the Rwanda Satellite Earth System Station. The technical data will include the following:

a. System Operation and Maintenance (O&M) Manual

b. Equipment O&M Manuals

c. Spare Parts List

d. Installation and As-Built Drawings

The documentation will be prepared to standard commercial practices.

8.4.2 System O&M Manual

Page will prepare one system O&M manual to cover the Satellite Earth Station System. The system manual, along with the associated equipment level manuals, will give an understanding of the station and its many functions. As applicable, the following types of system-level information (text, tables and illustrations) will be included: General Information, Operation, Principles of Functional Operation, Maintenance, Engineering Drawing List, Equipment List, List of Abbreviations and an Equipment Publications List.

Page will deliver 25 copies of the system O&M manual by 90 days after final acceptance of the Satellite Earth Station System; delivery then insures that final as-built details will be included.

8.4.3 Equipment O&M Manuals

Page will provide manufacturer's existing commercial O&M manuals, or catalog specification data, as applicable, to support the different equipment items comprising the Satellite Earth Station System. Page will deliver one copy of the manufacturer's data, packed with the equipment, required to support each applicable equipment at each location. In addition, Page will deliver two extra sets of each different manual/catalog specification data sheet to the Minister of Post and Communications by 60 days after final acceptance of the Rwanda Earth Station and the Exchanges.

8.4.4 Spare Parts List

Page will prepare a list of the spare parts that will be procured by Page to support the Rwanda Satellite Earth Station System for the first year of operation. The spare parts list will consist of those assemblies, subassemblies, modules, circuit boards, and minor replaceable components that are necessary to support the operational and test equipment. The list will be organized in alphabetical sequence by vendor and equipment, and will provide the part number, description, manufacturer's or vendor's name and address, and quantity purchased for each item.

Page will deliver 10 copies of the one-year spare parts list concurrently with final acceptance of the Satellite Earth Station System.

8.4.5 Installation and As-Built Drawings

Page will prepare an engineering drawing package that will include all project drawings and documents in the engineering index.

Sixty days after acceptance of the Rwanda Satellite Earth Station System Page will deliver one reproducible sepia and two blackline copies of each as-built drawing.

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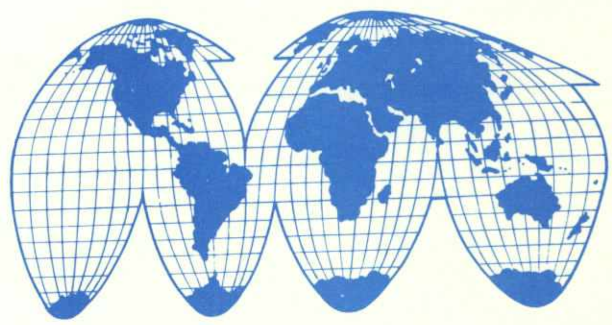

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SECTION 9

OPTIONS

9.1 TV RECEIVE OPTION

For the reception of television video and audio from the satellite, Page will provide the following equipments:

a. TV video receiver

b. Rack mounted color picture monitor to display 625/50 PAL or 525/60 NTSC color signals

c. Waveform monitor

d. Vectorscope for 625/50 PAL standard

e. Baseband patchfield

f. Aural monitor to monitor the audio program received by way of an SCPC carrier.

The above equipment will be rack mounted. The television receiver consists of a dual conversion frequency converter to 70 MHz, IF filter, demodulator and baseband unit. The receiver will be frequency selectable for reception of full transponder or half transponder transmissions in transponder 12. The de-emphasis characteristic will be in accordance with CCIR recommendation 405-1.

The receiver will be suitable for demodulation and conditioning of 625/50 PAL and 525/60 NTSC standard color television signals to INTELSAT Standard "B" parameters.

The patchfield would be the interface point, provided by Page.

Television transmissions via satellite can occupy a full transponder or a half transponder. Due to the lower G/T of an INTELSAT Standard "B" satellite earth station as compared to a Standard "A" earth station, the signal-to-noise performance of the received video carrier will be degraded. The degradation is severe for half transponder reception of the video transmission. As a result, INTELSAT states that "the quality achieved with half transponder (17.5 MHz) TV reception at Standard "B" satellite earth stations is the responsibility of the earth station owner."

The calculated signal to noise performance to be expected at the operating elevation look angle, and including the margin in G/T, is as follows:

Satellite Earth Station	Std "A" or "B" to B	Std "A" to B	Std "B" to B
Television Standard	525/60 or 625/50	525/60 or 625/50	525/60 or 625/50
Signal to Weighted Noise* for			
Half Transponder	-	44.7 dB	42.2 dB
Full Transponder	51.3 dB	-	-

9.2 DOCUMENTATION IN THE FRENCH LANGUAGE

Page offers as an option the delivery of the documentation package in the French language. Under this option, the System Operation and Maintenance Manual, the Spare Parts List, and the Installation and As-Built Drawings will be prepared by Page in the English language and then translated into the French Language. The existing commercial English-language equipment operating and maintenance manuals and catalog specification data will be translated into the French language.

The French-language translations will be delivered to the customer on the following schedule:

- System Operation and Maintenance Manual - 120 days after final acceptance of the Satellite Earth Station.
- Equipment Operation and Maintenance Manuals - 120 days, after final acceptance of the Satellite Earth Station.
- Spare Parts List - 120 days after final acceptance of the Satellite Earth Station.
- As-Built Drawings - One reproducible sepia and two blackline copies of each as-built drawing by 90 days after acceptance of the Satellite Earth Station.

* As defined in CCIR Rec. 421-3 using Systems D, K and L weighting networks for 625/50 and System M for 525/60.

9.3 OPERATIONS AND MAINTENANCE - SECOND YEAR OPTION

Page proposes to provide, as an option, continued operations and maintenance support of the earth station and switching centers for an additional twelve month period beyond the initial year of service. During this second year of O&M, Page would provide daytime attendance advisors who would assist Ministry personnel, as necessary, in the management and technical operation of the satellite earth station, telephone switch, telex switch, and system support equipment .

9.4 EQUIPMENT SPARES - SECOND YEAR OPTION

Page offers as an option the furnishing of all spares required for support of the satellite earth station and associated equipment during the second year of system operation. The spares provided would be based on the initial spare parts list, modified by the actual parts usage during the initial year's operation.

9.5 ANTENNA FEED POLARIZATION OPTION

Page proposes to offer as an option, a diplexer to the antenna feed which would provide a polarization voltage axial ratio of 1.06 which is required when an INTELSAT V satellite is placed in operation in the Indian Ocean Region in the period 1980 - 1981.

At commencement of service Rwanda will operate through an INTELSAT IVA satellite in the Indian Ocean Region. The INTELSAT mandatory requirement for the voltage axial ratio of the transmitted carrier to the satellite is 1.4. The antenna feed that Page is providing meets this requirement.

In the period 1980 to 1981 INTELSAT plans to place into service in the Indian Ocean Region, an INTELSAT V satellite which employs a frequency re-use capability. Frequency re-use means that the same frequency will be used twice. Dual circular polarization is employed and in order to preserve a high isolation and minimum interference from one carrier to another carrier on the same frequency but different (orthogonal) polarization, the voltage axial ratio of the transmitted carrier must be improved to 1.06.

The option is to modify the 1.4 voltage axial ratio feed to a 1.06 axial ratio feed. This is achieved by addition of a diplexer to the feed which provides a frequency re-use capability as well as the 1.06 voltage axial ratio.

The diplexer can be provided with the feed initially or procured and added to the feed later when INTELSAT has more fully planned the transition to INTELSAT V. The option price is for the supply of the diplexer which would be incorporated into the antenna feed at commencement of service.

Modification of the feed at a later date would require the antenna system, and thus the earth station, to be taken out of service for several days while the feed is modified and performance tests on the antenna system are carried out.

Worldwide Communications

NORTHROP
PAGE

SECTION 10

BACKGROUND AND EXPERIENCE

10.1 EXPERIENCE

Page offers a unique capability in the engineering system design and development areas, in that it is a nonmanufacturing system house. In this capacity, Page offers complete objectivity in the selection of equipment for satisfying a given set of requirements. Page experience in system engineering runs the gamut from requirements analysis and basic feasibility studies to complete "turnkey" programs for a wide variety of communications business.

International telephone, telegraph, television, facsimile, and high-speed data are transmitted now by satellite. In conjunction with earth stations, satellites provide reliable, instant worldwide communications.

Page designs and builds high capacity and transportable earth stations to operate with any satellite through INTELSAT.

Page system engineering expertise in the study, analysis, design, and installation of international communication systems, such as earth station technology, telephone centers, and telex switches, has been gained through programs for a wide variety of customers and continuing in-house research and development. These programs provide extensive technical expertise in engineering, furnishing, installing, and operating satellite terminal, telephone, and telex communication equipment.

10.2 PROGRAM SUMMARIES

The following material directly represents portions of Page's contractual undertakings relevant to satellite earth stations, telephone and telex applications, and demonstrates Page expertise and experience with respect to satellite earth terminals and general communications.

10.2.1 Sudan Earth Station (Figures 10-1, 10-2, 10-3)

Page recently completed a turnkey contract to design, furnish and install a satellite communications earth station in the Republic of Sudan in the record time of only 12 months.

The site is located in the vicinity of Khartoum, and the station went into operation via INTELSAT-IV Atlantic Satellite in the fall of 1974.

The Sudan Earth Station incorporates a new and improved tracking antenna, 32 meters in diameter. The radio frequency feed system is a beam waveguide and the radio energy is transmitted and received through a series of RF mirrors, enabling the feed horn to be located in the ground-level equipment room immediately adjacent to the high-power amplifier transmitters and low-noise receivers. This new technique results in improved gain, eliminates the necessity of locating the feed horn and low-noise receivers at the vertex of the antenna and simplifies operation and maintenance.

The station is equipped with single-channel-per-carrier ground communication equipment. For the small user of satellite facilities this has significant advantages. It provides high-speed data service capability over a single-voice channel of 48 to 56 K bit-per-second streams, instead of using a bandwidth equivalent to 10 voice channels which is required at the present time.

A television-receive capability was provided initially with provisions for future expansion into television transmit functions, if required.

Page is also providing complete on-site facilities with uninterrupted ac and dc power supplies and modern fully air-conditioned, functional and administrative building facilities.

The complete system includes a microwave back-haul link to the International Traffic Center in Khartoum and a microwave link directly to the television station at Omdurman for TV program service.

Page is also upgrading the international switchboard at the Khartoum terminal and installing a telex solid state switchboard of the latest design.

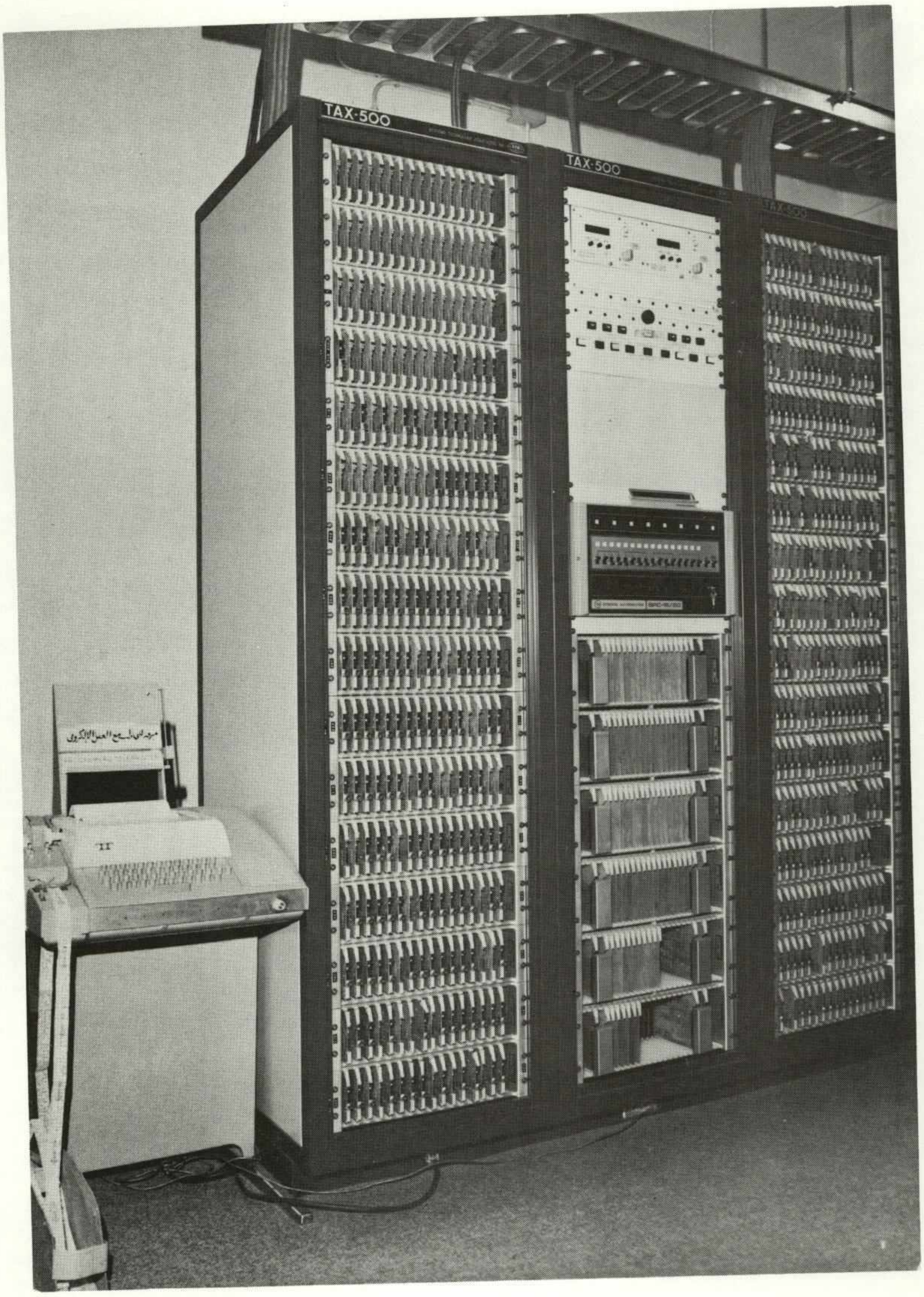

Figure 10-1. Sudan Telex Switch

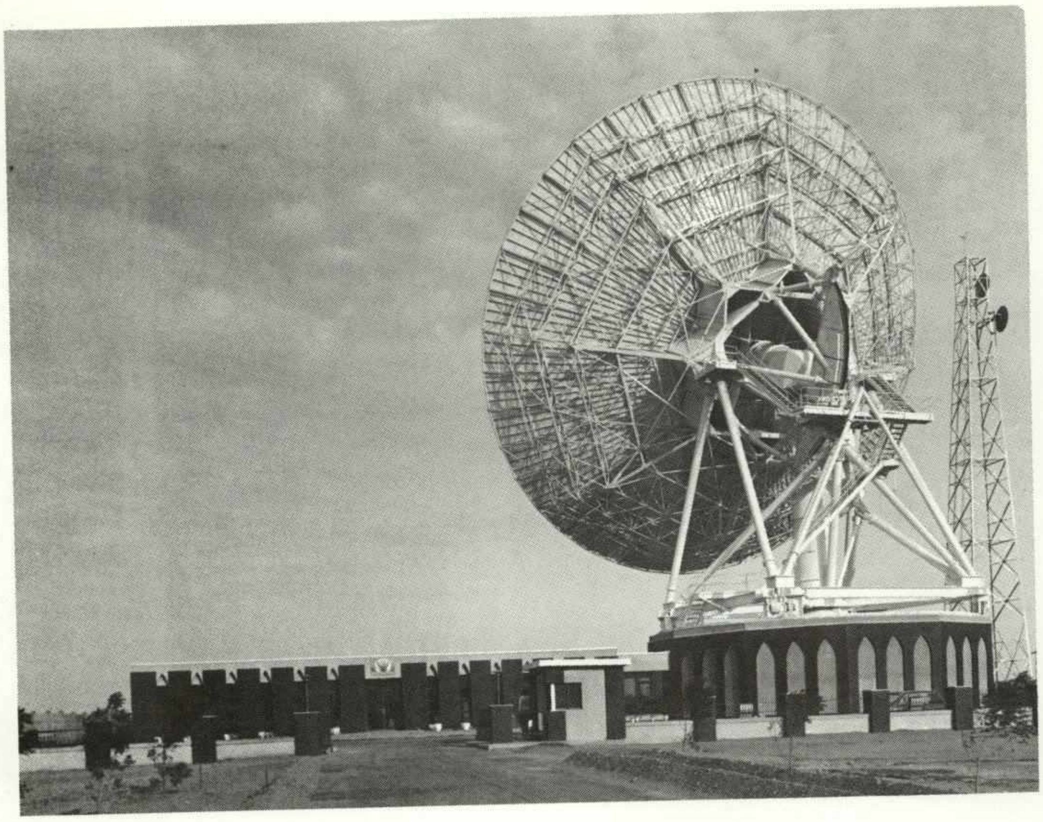

Figure 10-2. Sudan Earth Station

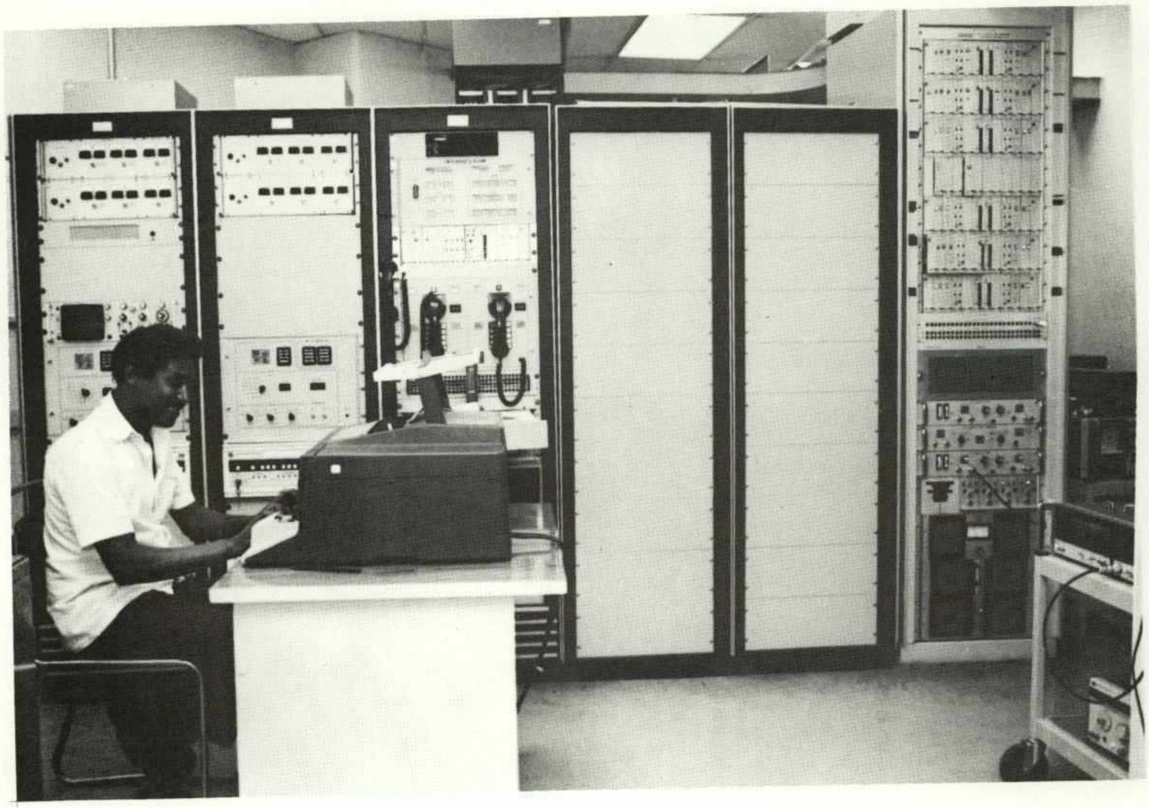

Figure 10-3. Sudan Earth Station SPADE

As always, the Page specialized system design provides essential redundancy in operating functions, complete reliability and easy maintainability.

Concurrently, with the installation of the Sudan Earth Station, Page-trained Sudanese technicians who have progressed to on-the-job training alongside Page operations and maintenance personnel.

10.2.2 Iran and Lebanon Earth Stations

The first satellite communications earth stations to be built in the Middle East were built by Page in Lebanon and Iran.

These high-capacity stations utilize 30-meter antennas for communications through INTELSAT satellites. The information-carrying capability includes telephony, telegraphy and telex, television, and wideband data.

Page performed the viability and the site selection studies and designed, engineered, constructed, and installed the stations--one near Hamadan in Western Iran and the other at Arbaniyeh, Lebanon. Page also provided training for Iranian and Lebanese personnel, as well as operation and maintenance services.

In Iran, a 300-kilometer microwave link was constructed by Page at the same time as the earth station. It is designed to transmit and receive 1200 telephone channel and a color or black and white television channel simultaneously.

10.2.3 COMSAT Transportable Satellite Communication Earth Stations (Figure 10-4)

Page designed and produced the first transportable satellite earth terminals for use in the INTELSAT system. The first two terminals (at Andover, Maine and Paumalu, Hawaii) were COMSAT's primary telemetry and command stations, and were successfully used to launch and position the first two INTELSAT II satellites. The third terminal (Brewster Flat, Washington) was used at the Paumalu terminal to carry the first Pacific commercial satellite telephone traffic. Later, terminals were used to send the first television transmission between Australia and the British Post Office Station.

The Page terminal, shown in figure 10-4, was contained in three vans, including an operations van, a power van and the antenna van. A total of five terminals were delivered to COMSAT.

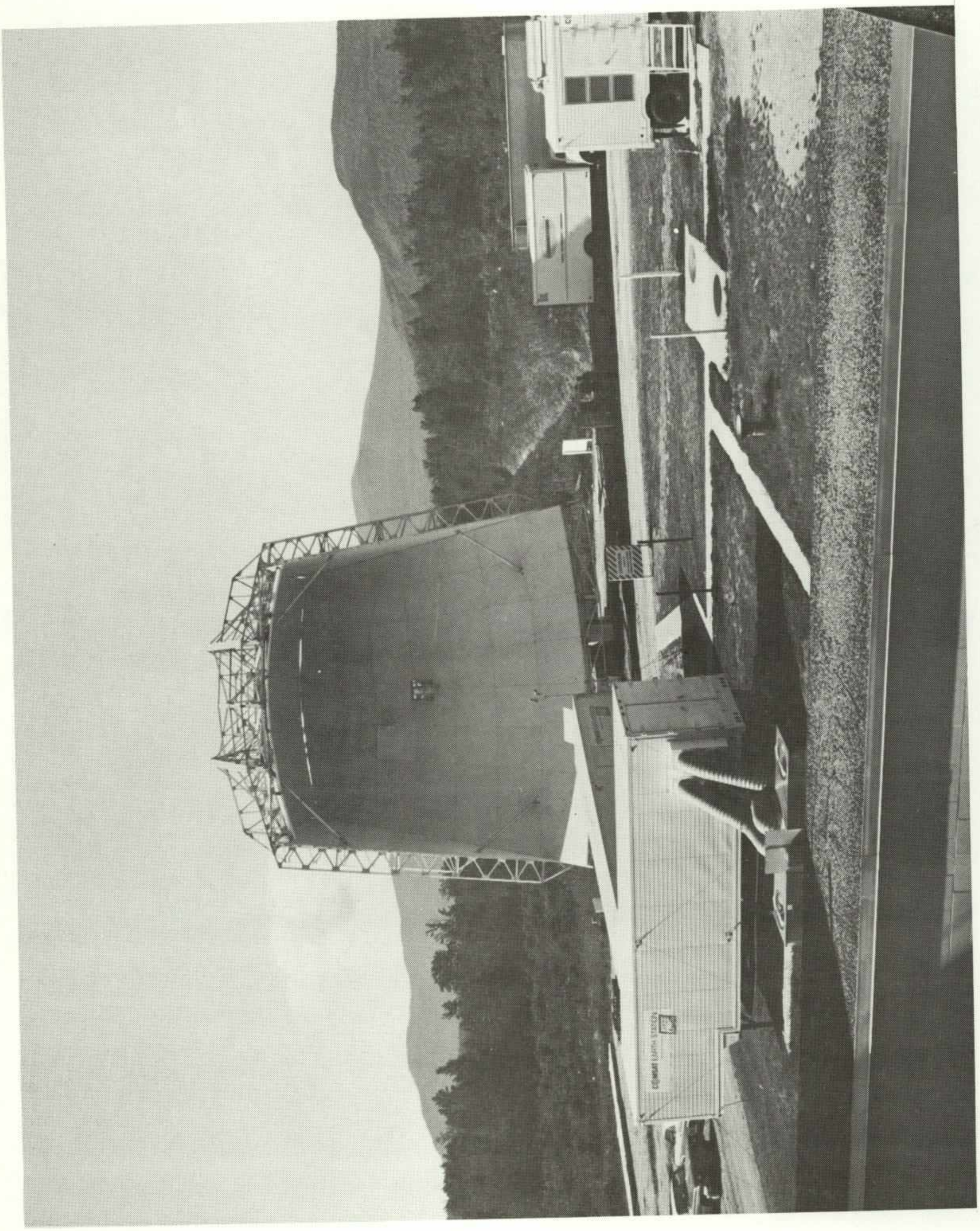

Figure 10-4. Page Transportable Satellite Communications Terminal

10.2.4 Panama Earth Station

Page provided the first satellite communication earth station to be built in Central and South America.

This high-capacity station, with a 30-meter, fully steerable antenna, was installed near Panama City under a contract with Intercontinental de Comunicaciones por Satelites, S.A. (INTERCOMSA).

Panama is linked with other Latin American countries, the United States and Canada, Europe and Africa by direct relay through INTELSAT's Atlantic satellites. The information-carrying capability includes telephone, telegraph, telex, television, and wideband data.

Page designed, furnished, and installed the station. They assisted INTERCOMSA in selecting the most suitable site, and with construction of all associated buildings, primary power plant, access roads, and interconnection with the Panamanian National Network. Other facilities needed for an international telecommunications gateway system capable of providing highly reliable and profitable commercial service were completed with Page assistance.

10.2.5 Brazil Earth Station

Engineering services for the design and acquisition of a satellite communications earth station were provided by Page to Empresa Brasileira de Telecomunicacoes (EMBRATEL). The objective of the Page contract was to assure EMBRATEL that its station would display optimum technical and performance characteristics at the lowest reasonable price.

In addition to the earth station itself, the program scope included all other aspects of the facility, such as power, civil works, terrestrial microwave link, station and system operation, and logistical support.

The assistance provided by Page embraced the following areas:

a. Economic feasibility study.

b. Site selection.

c. Design specifications and request for proposals.

d. Proposal adjudication and contractor selection.

e. Contract preparation, including technical and financial negotiations with the selected bidder.

f. Training criteria for EMBRATEL personnel.

g. Contractor monitoring, to ensure successful accomplishment of the program.

h. Subsystem and system design reviews.

i. Updating specifications and requirements to accommodate any changes in ICSC criteria for operation with the INTELSAT global satellite communications system.

j. Subsystem and system testing at both factory and site locations, with recommendations concerning acceptance or rejection.

The contract designated Page as EMBRATEL's authorized representative for Items F through J, including both the technical and financial aspects.

10.2.6 Thailand Earth Station

The transportable satellite communications earth station installed at the Thailand earth station site to provide interim communication circuits to Thailand via the Pacific satellite launched by INTELSAT early in 1967 was designed and built by Page. It was installed by Page under a contract with RCA Communications (RCAC).

This station is similar to four other medium-capacity satellite communication earth stations designed and built by Page, all of which served with Atlantic or Pacific INTELSAT satellites as part of the commercial operation.

10.2.7 Satellite Communications Relay

Based on 1960 design studies, Page became prime contractor for upgrading and improving the operation of the passive satellite communications system for the Rome Air Development Center. The work encompassed the engineering and installation of a duplexed system which permitted simultaneous transmission at a 10-kW level and reception with low-noise receivers on a common antenna. Data recording, analysis, and evaluation were also provided.

The system provided a 12.5 dB signal-to-noise ratio with a margin of 14 dB for the ECHO II satellite in the most favorable position, and 9 dB in the least favorable position. Operating frequencies were in the 1800 to 2400 MHz range, with tracking provided either by the communications signal or by the Trinidad radar signal. Page-designed phase-locked receivers were used for communications signal demodulation, and for doppler shift measurements. Frequency synthesizers designed by Page controlled the transmitted frequency to 1 part in 10^9 using a National Atomichron primary frequency standard. Doppler investigations initiated the requirement for this highly stabilized equipment.

Page experience in the design of a high-power duplexed scatter installation aided in engineering this system, and the latest techniques and developments were used. For example, the use of extremely low noise-figure parametric preamplifiers, cryogenically cooled, enabled the system to operate at the required performance for nearly all satellite positions that were within the geometric bounds of mutual visibility.

10.2.8 PETROPERU Transportable Communications Facilities

Page supplied transportable shelterized communications equipment as part of its contract with Petroperu, the Peruvian agency responsible for petroleum production. The transportable units were part of a Page contract to provide a complete command and control network for the agency's new pipeline extending from the Amazon Jungles, over the Andes Mountains, to the Pacific Ocean terminal at Bayovar. The system is 776 kilometers long with 12 terminal stations and 11 repeater stations. The system was designed to carry 72 channels with the National Telephone System (ENTEL) using 36 channels. The other 36 channels are used for communications, control and supervision of a 856 kilometer long, 36 inch diameter pipeline.

Page designed the unique fiberglass shelters, which house the radio equipment, power generators and other supporting equipment. They were transported and emplaced in remote locations by means of standard military-type helicopters. The transportable shelters enabled vanizing to take place at the Page-Vienna facility and were then shipped by surface to Peru and airlifted to the remote sites. Although these sites are permanent, considerable cost savings were effected by utilizing the transportable approach thus negating the need for site access roads and extensive site preparation.

10.2.9 Peace Hawk V

This current project includes engineering, furnishing, installing and commissioning all communications towers, antennas, shelters, standby power equipment, radio equipment, telephone equipment, teletype equipment and miscellaneous communications equipment and systems, as well as other facilities and equipment which may be required to provide fully operational communications service within and between the Dhahran, Taif, and Khamis Mushayt Air Base Peace Hawk satellite facilities within Saudi Arabia.

A large PABX at each of the air bases in Saudi Arabia (Dhahran, Taif and Khamis Mushayt) interconnected by a trunking network whose capacity is responsive to the utilization of the telephone system will be provided. In addition, these PABX's will be responsive to the other on-base telephone systems and the public telephone network. The firing ranges will be equipped with small PABX's to support current communication requirements and provide for additional growth.

The new switching equipment installed at the air bases are to be common controlled PABX's and arranged to accommodate expansion beyond the capacity identified for the initial Peace Hawk V requirements. All Peace Hawk on-base telephone services are to be provided by means of a single switching facility in order to simplify intra-base calling procedures and telephone numbering plans. The switching equipment will provide access to inter-base circuits. Subscriber lines will be class-marked to respond to administrative directions.

The Peace Hawk V teletype system is to provide direct telegraph communication among the sites and headquarters.

10.2.10 Satellite System Monitor Group (SSMG) (Figure 10-5)

Page recently completed a contract to engineer, furnish, and install two new Satellite System Monitors (SSM) for INTELSAT at the Tangua, Brazil and Zamengoe, Cameroon earth stations. In addition, under the same contract, the SSM at four existing monitor stations (Andover, Maine; Fucino, Italy; Paumalu, Hawaii; and Carnarvon, Australia) were upgraded.

The Satellite System Monitor is a computer controlled system capable of measuring the parameters of a number of different carriers. It provides equipment for measuring pilot power, pilot frequency, channel power and common signal channel parameters on the Single Channel per Carrier transponder. It has the capability and the flexibility under computer control to adapt to the monitoring of new generations of satellites as they are placed in use and to monitor domestic satellite communications systems. Page was responsible for the total system design, and the implementation, which included among other items the development of all operational software for monitoring system control.

10.3 PAGE FACILITIES

Page resources encompass a base of operations with allocated space for assigned project personnel and includes office, engineering, laboratory, storage and other necessary facilities equipped with properly maintained, professional quality equipment.

The Page Vienna facilities were designed and built specifically for Page to support electronic and communications system development and implementation. Housed in this facility are the executive, administrative and engineering staffs, and program control

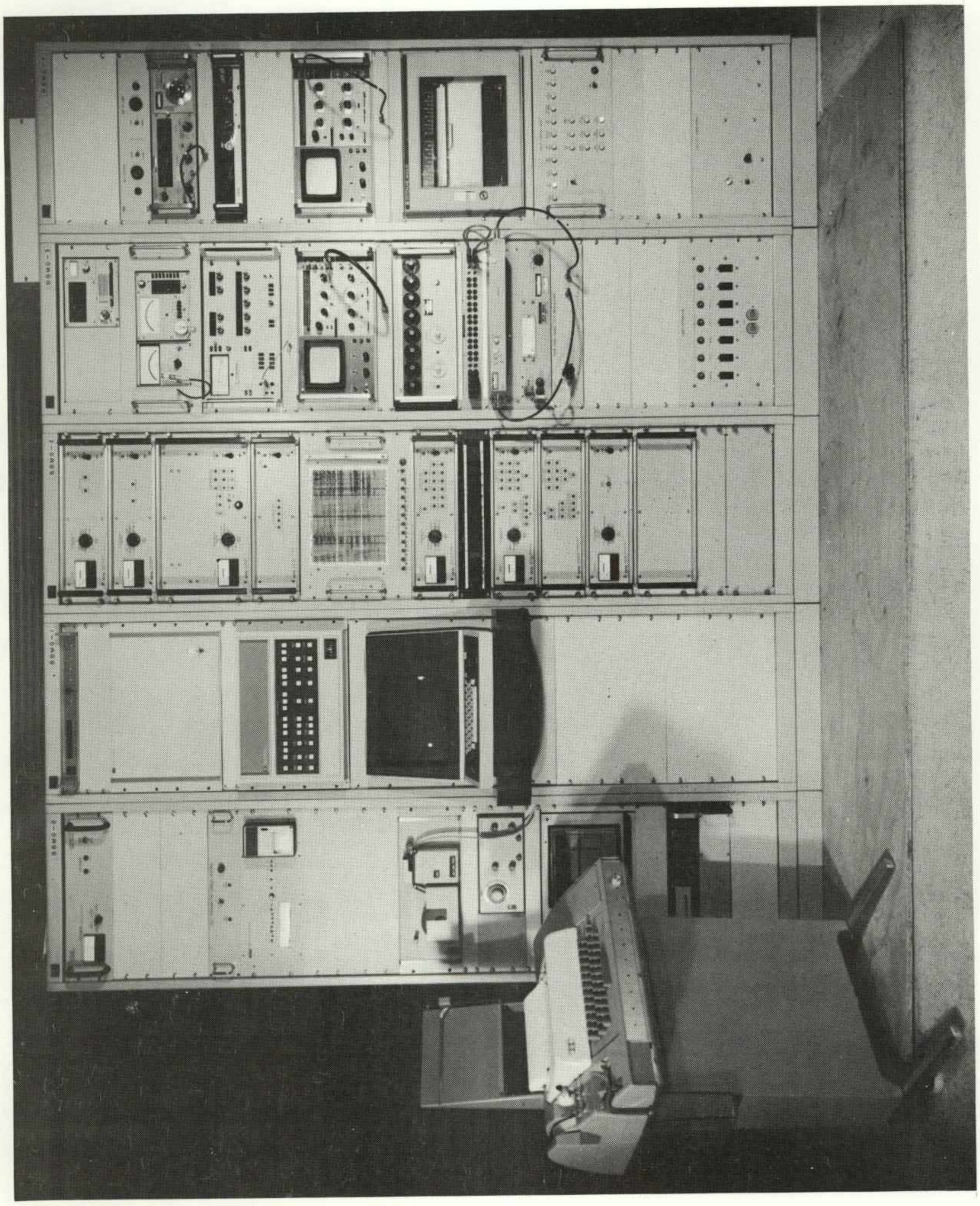

Figure 10-5. Satellite System Monitor Group (SSMG)

and management personnel. The main office complex is housed in two modern, air-conditioned, brick and steel buildings with a total of 235,000 square feet of floor space and contains the following facilities and equipment.

- Executive, administrative, engineering, procurement and program management offices
- Engineering and business systems computer and data processing center
- Engineering test and calibration laboratories
- Engineering research and development computer laboratory
- Prototype development machine shop
- Fully-equipped photo lab and reproduction facilities
- Complete engineering drafting facilities
- Graphic arts capabilities
- Technical and procurement data library
- System assembly, test and calibration facilities
- Mobile electronics measurement laboratory and 10 kW power system
- Logistics supply and bonded storage facilities

Page has its own IBM 360/Model 50 computer system on-site which is utilized for engineering design, research projects, simulation, test data processing, management information and control, and financial records of the Company. Peripheral equipment on the system includes 2401 Model V magnetic tape units with dual density and simultaneous read-while-write capability. On-line storage is provided by an 8-spindle 2314 disk module. Other input-output devices include a typewriter console, a 1403 line printer, a 2540 card reader and punch, and other data processing equipment including card sorter, key punches, print burster/imprinter, key tapes, decollator, paper tape converter and a card interpreter. Full-time programming and operator personnel are also available.

In addition to the IBM 360/50 computer, the following computational systems are available at this facility:

a. Hewlett-Packard calculator system consisting of a digital calculator model 9100A; extended memory model 9101A; X-Y plotter model 9107A; digitizer model 9107A; and a printer model 9120A.

b. Data General mini-computer system consisting of a CPU, model jumbo NOVA 1200, with 32k memory and teletype controller; dual Diablo disks; paper tape reader and punch; A/D and D/A subassemblies, with 16 channel multiplexer; and EIA-RS-232 communications interface multiplexer. Our NOVA system is interconnected with the IBM 360/50 computer system.

c. Datapoint Corporation terminal equipment consisting of a Datapoint 2200-118, version 2, with asynchronous communications adapter.

d. The Fairchild-F8 microprocessor system consisting of a single model 3850 CPU, one 3851 program storage unit, a 3852 Dynamic memory interface unit, one 3853 static memory interface and 2k bytes of random access memory. This unit has been configured into a communications interface controller with 14k bytes of random access memory. A brief description of this microcomputer configuration is provided in section 2.5 of this brochure.

e. The Motorola M6800 Microprocessor System consisting of a single model MC6800 MPU, one MCM 6830 ROM (1024 bytes), four MCM 6810 RAM (512 bytes), two MCM 6820 Peripheral Interface Adapters (PIA), one MC6850 Asynchronous Communications Interface Adapter (ACIA) and one MC6871B Clock Generator.

f. The Intel 8085 Microprocessor System consisting of a single model 8085 CPU, one 8205 Address Decoder, one 8355 ROM (2048 bytes), one 8155 RAM (256 bytes) with Input/Output ports, and one 8279 Programmable Keyboard/Display Interface.

g. Telenet computer communications network access is available from the Page, Vienna, Virginia office, providing direct access to to a nationwide network of computer facilities. Page, through its Telenet tie-in, has gained extensive experience in the use of the DOD nationwide packet switching digital data network (ARPANET).

10.4 IN-HOUSE RESEARCH AND DEVELOPMENT

The following in-house Research and Development efforts directly support Page capabilities in the satellite, telephone and telex communications area. These include:

- Network Analysis Simulation and Design Program
- Minicomputer/Microprocessor Applications Research

- Command, Control and Communications (C^3) Operations Analysis
- Digital Display Technology Research
- Signal Processing Technique Research (Delta Modulation/TDMA)
- Fiber Optics Research

10.4.1 Network Analysis Simulation and Design

It is impossible to analyze and design large scale data networks without the assistance of computerized programs. In recognizing this, Page has developed a set of programs for such purposes. Analysis programs are provided for evaluating the throughput, the response time and the network availability of an existing network, a candidate network and/or an intermediate network during the network design process. In addition, a network design program has been developed which determines the number and locations of Network Access Facilities (NAF's), i.e., multiplexers, concentrators, switches,and/or satellite earth terminals, the access network and the backbone network.

In the access circuitry area, a program for designing the connectivity of terminals to appropriate multiplexers, concentrators, switches or central host computers, usually either in a point-to-point fashion or in a multipoint fashion has been developed. A corresponding program for designing the backbone network interconnection of multiplexers, concentrators and/or host computers, or the interconnection of switches is also provided.

10.4.2 Minicomputer/Microprocessor Applications

Under this research project Page has acquired firsthand knowledge concerning microprocessors and has gained experience in their uses with regard to communications applications in general. A microprocessor selection process has been formulated based on user requirements.

Applying its background in microprocessors, Page has developed, using the Fairchild-F8 microprocessor, a digital communications controller which performs the functions of a mini switch and terminal interface controller. This small unit performs speed conversion (9600 baud/300 baud/75 baud) code conversion (8-level ASCII Code/5-level Baudot), and signal level conversion (MIL-STD-188-100/RS-232C) as required to permit various terminal types to communicate with each other. The device is transparent to the user. In addition, the controller provides the means for an operator to have real-time conversation between other connected terminals, and have displayed on the user's screen a vertical split-screen which depicts both the local and remote conversation data simultaneously. Hard copy printout, off-screen storage of message data with recall (Roll/Scroll/Page), and several other unique features useful in terminal conversation mode of operation are provided by the controller.

One of the functions of this controller device, which Page has now in operation, is to provide added reliability to normal communications networks by distributing the processing functions, normally performed by a larger computer, to the remote terminal areas. Efforts are continuing in this area of distributed processing design using microprocessors to support Page's many other varied digital communications systems development needs.

10.4.3 Command, Control and Communications Operations Analysis

Under this in-house research project, Page is addressing the operational requirements and constraints associated with generalized military oriented command and control systems. In many previously developed systems, Page has concluded that the comunications aspects of command and control have been "planned" as an afterthought, which in turn has led to serious deficiencies in service. Through this research effort Page is developing a set of guidelines, applying formal operations analysis techniques, which would be directed primarily at the specifications for communications, inclusive of digital communications areas such as high speed FAX, digitized voice, and other relatively recent innovations.

10.4.4 Digital Display Technology Research

Through this research effort Page is developing a library of presently available display systems which are categorized according to their communications applications and technological approach. Included within this data base are systems ranging from large screen CRT type projection display units, plasma devices, interactive graphic display devices, color terminals of all types and large screen real-time slide display systems such as Northrop's Vigicon display system. One of the objectives of this project is to compile a data base to support the ever growing need for state-of-the-art, input/output systems information required when designing total communications systems for Page's varied range of customer applications. One aspect of this research effort is to incorporate the results from parallel research efforts, such as microprocessor research, to enhance the capabilities of unintelligent display terminals.

Additionally, Page has demonstrated in several cases the feasibility of interfacing various types of terminal display devices which in combination improve system operational performance, (e.g., terminal devices have been interfaced directly with large screen color projection systems). This project supports Page needs when developing the best applicable system configuration based solely on a customer's requirements.

10.4.5 Signal Processing Techniques

Under this research effort, Page has explored the current economic advantages of Delta modulation techniques versus other commonly used modulation approaches (such as PCM). In addition to the Delta modulation subtask, Page is continuing to keep abreast of the latest technological advances being made in the multiple access techniques. This subtask has provided Page with firsthand experience in designing satellite communications networks using both FDMA and TDMA techniques, and has in turn proven beneficial to Page digital communications customers requiring the latest in design performance at minimal costs.

10.4.6 Fiber Optics Research

Under this project, Page is developing in-house expertise in implementing presently available, commercial fiber optic communications links. Information such as coupling problems which may occur, grades of commercially available fiber optics lines, technical trade-off factors for various applications, and other user oriented data are being compiled under this effort, both through surveys of available documentation and from firsthand experience by Page personnel applying fiber optics to communications problems.

10.5 SYSTEM DESIGN AND ENGINEERING

Page experience and capabilities in communications systems include feasibility studies, socio-economic surveys, traffic analysis consultation services, system design and engineering. Specific areas of application include:

- HF/VHF/UHF radio (broadcast and point-to-point)
- Active satellite systems
- Store and forward message processing

- Packet switching networks
- Telephone networks (switching and transmission)
- Telegraph and telex systems
- Telephone exchanges
- Teleprocessing systems
- Computer/control communications
- Common carrier systems
- Troposcatter systems
- Microwave radio systems

10.6 PAGE SYSTEM CAPABILITIES

Page provides "turnkey" systems, fixed plant or transportable, throughout the entire communications spectrum. Page is not a manufacturer, and can therefore, select the equipment best suited to the customer's need, without regard for proprietary products. The following systems related capabilities represent but a sample of that available from Page skilled personnel.

10.6.1 Earth Satellite Stations

Satellite communications has long been an area in which Page has excelled. Ground stations for communications and control have been supplied by Page in Sudan, Iran, Lebanon, Panama, Australia, Thailand, Philippines and the U.S.A. Numerous studies and plans concerning satellite communications have also been completed. Page built five transportable earth satellite terminals for COMSAT and OTC (Australia).

10.6.2 Telephone, Telex and Data Networks

Page has extensive capabilities in this area ranging from optimum network planning to engineering, furnishing and installing complete switched networks.

Modern computer programs developed by Page provide solutions for the analysis, design and optimization of switched networks. These programs take into consideration traffic volumes, changing traffic patterns, new switching and transmission equipment, costs, geographical constraints, existing plant, etc., in order to provide the most economical alternatives. To maintain a strong capability in the total communications system field, Page engineers continuously evaluate new techniques and equipment in order to be able to recommend the most suitable to meet the demands of customers. One example is the continuous evaluation of the new generation of Stored Program Control Switching Systems including their influence on the development of networks, new requirements and technical possibilities. New terminals for telex and data systems are also constantly being evaluated.

In the outside plant area, Page engineers rehabilitate existing plants and plan, design, engineer, furnish and install complete networks. Use of the state-of-the-art techniques and equipment is made, and complete familiarity with industry standards such as REA, USITA and CCITT is maintained. Computer programs are used for optional subscribers loop design in order to minimize the investments and make maximum use of existing plant.

10.6.3 Broadcast AM/FM/TV

Page maintains a capability to engineer, furnish and install AM/FM broadcast and television stations. Representative projects include Voice of America stations in Okinawa, Philippines, Greece, Liberia and Tangiers. Complete National Television networks for Greece and Sudan have been implemented by Page.

10.6.4 Power Systems

Under the INTS Contract in Tehran, Iran, Page engineered and installed power plants, both ac and dc, for approximately 280 stations. The engine generator sets range from 15 kVA to 165 kVA in one, two, and three-set configuration. The dc plants, with a reserve time of either four or eight hours, are engineered to provide a safety margin in the event of ac power failures, to allow the maintenance personnel time to travel to the station and repair the ac fault. The ac plants either provide standby power in the event of commercial power failure, or prime power where commercial power is not available. Similar power plants are being provided by Page under its Peace Hawk V contract, described earlier in paragraph 10.2.9.

10.6.5 NAVAIDS/Air Traffic Control

NAVAIDS have been provided by Page on projects such as the extended range antenna system in Massachusetts. Hawaii, Puerto Rico, Spain and Canary Islands. These systems provide reliable two-way voice communications over a 500 to 600 mile useful range, providing long-distance communications to incoming transoceanic jet aircraft. Page is presently under contract to provide an air traffic control communication system in Colombia. This contract calls for VHF ground/air radios, control consoles, HF radios and meteorology instruments at 44 airports and remote sites throughout the country. Page installed a similar system throughout Ethiopia.

10.7 SERVICES

In addition to providing "turnkey" systems covering the entire range of communications and engineering, Page also has the capability of providing technical services. The following paragraphs briefly describe the more significant services regularly provided by Page.

10.7.1 Advisory

- Competent field engineers and senior technicians to supervise system operation
- Assure knowledgeable troubleshooting and quick corrective action
- Provide follow-on instruction of customer operating personnel in on-the-job training programs
- Provide technical and administrative guidance to customer's system management organization

10.7.2 Configuration Management

- Technical discipline applied to all system changes and additions to protect integrity of system design and operation
- Engineering review of all work scope changes
- Assure maximum commonality of spare parts
- Maintain system technical documentation current and complete
- Minimize test equipment required to operate system
- Provide interface between customer and equipment suppliers
- Match customer operational capability and state-of-the-art employed
- Assure cost effective trade-offs

10.7.3 Construction

- Access roads
- Site preparation
- Buildings
- Heating-ventilating-air conditioning
- Antenna structures
- Power plants
- Fuel storage and distribution
- Performance by Page employees and/or supervision of local contractors

10.7.4 Data Processing

- Design and implement computer-assisted engineering, commercial operations, and business-management systems
- Automated data management and retrieval systems
- Provide engineers, system analysis, and programmers to design and operate custom tailored data processing systems
- Utilize existing proprietary software packages to perform such functions as national telephone network planning, antenna systems design, and logistics management and inventory control
- Assemble commercially available software packages to provide optimum requirement software/hardware match

10.7.5 Depot Repair

- Organize, man, and operate equipment repair depots
- Provide "turnkey" facilities-personnel-material repair depot support to operating systems
- Maintain stock of required components and equipment modules
- Produce equipment failure reports to assist in improving system design and operating methods
- Develop and maintain site and depot spares listings and logistic procedures
- Provide depot-level test equipment
- Provide test equipment calibration and repair.