CABINDA TELECOMMUNICATIONS
FEASIBILITY STUDY
PHASE I REPORT

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1.0 Introduction

1.1 General

This Phase I study addresses the communications needs for the Province of Cabinda. Consideration was given to the various transmission mediums, the state of the art switching systems and the all important subscriber networks. The resultants postulated within this report are a supplement to the previous traffic studies for both the commercial and government subscribers within the Province.

In section 2.0 of this report, the various types of communications networks are presented which could have some utility for Angola Telecom. Discussions center on the types of transmission paths including LOS Microwave, Satellite Applications employing VSAT technology, the utilization of fiber and the use of the old reliable HF, UHF and VHF systems that are synonymous with communications networks on the African Continent.

The use of the standard Class V digital exchange designed in a rural configuration is presented along with the new generation of soft switches, which are software controlled. These new switches will form the foundation for the telecommunications network over the next decade. In the future they will handle voice, VOIP, wideband data and internet service for the provincial subscribers.

From a local distribution standpoint, discussions center on the existing AMDS cellular system and the expansion thereof utilizing CDMA technology. These enhanced CDMA specifications are required for the transfer of wideband data.

It is recommended that these three mediums, i.e. VSAT Technology, Soft Switching Implementation and the extension of the existing cellular system form the basis for the telecommunications network design throughout the province and the whole of Angola. These three major elements will be the foundation for the Phase II design effort.

In section 3.0, an attempt was made to develop various design parameters or standards in which the planned new network will adhere to. Discussions center on the electro-mechanical details including the equipment operational parameters, grounding and the all important safety standards.

In section 4.0 we address the network description. Limitations and tradeoffs on bandwidth are presented along with the optimal sizing for the VSAT Stations. Traffic is projected, i.e. the number of VF Channels required based on our comprehensive traffic analysis.

Lastly the type of system is discussed coupled with a preliminary equipment design employing Hughes, STM or Gilat Equipment.

Power and alternative power sources are presented within section 5.0. The use of reciprocating engines, solar power panels, turbines, windmills and other alternative power sources are discussed. These alternative power sources will be further studied during the Phase II effort.

This paper is also complemented with three technical annexes. Annex A addresses the link budget calculations, traffic, equipment sizing, and traffic reports for both Government and Non-Government users. Annex B contains equipment brochures from the three primary VSAT suppliers, i.e. Hughes, STM and Gilat.

Annex C contains brochures from various solar power manufactures including gas turbines, windmills and diesel generator sets.

Annex D contains a List of Acronyms used throughout the Report and Annex E contains the Site Survey.

In Phase II, it is mandatory that ETS design a communications network that is highly reliable, inexpensive and has utility to the end user, the people of Cabinda. ETS is presently working on this Phase II design. It is hoped that our customer will review what has been done and is included herein, modify accordingly to best meet the needs of Angola and successfully implement the pending Phase II design effort.

2.0 Types of Communications Networks

2.1 Introduction

There are various types of communications networks that will have utility in Cabinda Province and within the other major provinces of Angola. We must first, however, address the three major elements or systems that constitute a viable telecommunications network. These constitute the transmission system, the switching network and the subscriber distribution network. Each of these elements along with the utility and the recommendations for each are presented within subsequent paragraphs of this report.

2.2 Transmission Network

The transmission or backbone network will interconnect the various towns, villages and plantations native to the province with Cabinda City and, in turn, Luanda and the outside world. HF networks, UHF/VHF systems, LOS microwave and satellite communications are the primary transmission mediums that can be implemented within the Province by Angola Telecom.

2.2.1 HF Systems

Long haul communications systems operating in the 3 to 30 Mhz band form the foundation for HF communications. Transceivers can be provided with a data modem for vehicle mount. Coverage or distance is a function of the antenna and the power output of the transceiver. This transmission medium is ideal for communications to remote areas such as a mining or remote lumbering operation within the province.

This mode of communication is not recommended for village type communications or telephony operation within Cabinda Province.

2.2.2 VHF/UHF Communications

Communication transceivers normally operating in the 118 to 174 Mhz bands for VHF operations. Data capacity is presently at 9600 baud.

UHF tranceivers operate in 450 to 470 Mhz bands and normally necessitate line of sight between the radios. This system is ideal for a private network within a mining complex. Other more efficient mediums should be used for telephony applications.

2.2.3 LOS Applications

Microwave Line-of-Site (LOS) is an ideal system for long haul telephony. New digital microwave sets can now handle over 3,000 equivalent voice grade circuits. A much smaller capacity system presently links Cabinda City with Luanda.

LOS is ideal for transmission between major cities and to backhaul cellular traffic to a central switch. It is an extremely expensive medium to interconnect rural areas with small regional villages in Cabinda Province. It should be used, however, to interconnect all the municipalities with Cabinda City so that the cellular coverage can be extended throughout the province.

2.2.4 Fiber Optic Networks

Fiber optics is perhaps the ideal transmission medium. It is a very expensive system to install. It is a system that can be upgraded as the needs for bandwidth increase. Angola Telecom could initially provide an OC-12 (622 Mbs) system throughout the province carrying voice, data, internet and video service.

In five years as the demand for wideband data increases, the terminal equipment could easily be changed out to carry OC-48 or 2.5 Gbs of data.

This is the recommended medium in places where it can be used, but often from a practical or cost standpoint it cannot be implemented.

2.2.5 Satellite Systems

There are two types of Satcom systems that can be utilized in the Province. These constitute the handsets that operate from the LEO family of satellites and those ground stations that operate with the geostationary satellites.

2.2.5.1 LEO Satcom

There are presently two and maybe three potential operational systems available in the Low Elliptical Orbital (LEO) planes. Two of these are the Iridium and the ICO system, both of which are in receivership. The third system i.e. Globalstar is struggling. The problem is the cost of the handheld unit and the cost per minute of usage. The cost to operate is not designed for use in the developing nations. Often in developed nations, these systems can not compete with cellular telephone.

Angola Telecom should consider having a small number of handhelds available for short-term lease by foreign nationals.

2.2.5.2 VSAT Applications

VSAT applications are perhaps the ideal approach to providing communications to the remote areas of the province. They can be designed in a single point-to-point mode, with DAMA in a point-to-multi-point configuration and expanded to up to twenty channels or more by adding plug-in modules without changing out the RF electronic equipment.

Subsequent sections of this report address the design and the implementation of a VSAT network throughout the province.

2.3 Switching Systems

The all important network control and billing system for the various types of subscribers resides in the switching network. There are two types of exchanges or central office switches that can be provided in Cabinda Province and throughout Angola. These constitute the standard telephony Class V digital switch and the new broadband soft switch design, which is software controlled.

Another all-important factor to consider is the initial number of subscribers in the various towns and villages within Angola. The expandability factor is of equal importance coupled with the type of power system required to energize each rural switch.

Lastly is the all important maintenance factor. The complexity of the switches and ease in which cards can be replaced or tested are of utmost importance.

The standard Class V digital exchange for the rural areas should initially be equipped for fifty lines and expandable to 100 lines. For certain applications these new switches may be provided with 250 lines easily expandable to 500 lines. These larger switches will be slated for the provincial capitals. Modified R-2 signaling which is the national signaling scheme for Angola Telecom, will be included along with all pertinent features homogenous to a Class V Exchange.

The soft switch design will incorporate features to handle both digital and analog voice traffic, frame relay with VOIP capability, hopefully cellular applications and if the need exists, international trunks via satellite.

During Phase II, it is our intent to evaluate both the Class V rural office and the soft switch design for use in the provinces of Angola. Our preliminary recommendations however, are to go with the soft switch approach because of flexibility, price and future INTERNET usage.

2.4 Local Loop Systems

Design efforts in Phase II must be expended on the selection and then the proper design for a local loop radio system to interconnect the subscribers with the existing switch or satellite ground station. Naturally the equipment selection must be a function of the transmission mode, e.g. rural radios, point-to-multi-point radios operating in the MMDS bands or utilizing cellular radios in both the fixed station or portable handheld design.

Selection must be based on the utilization of voice or Internet service, coverage and area topology. In many applications it is also envisioned that a debit or credit card could be used outside the local Post Office or grocery store for use by the Angolan people.

Point-to-point or point-to-multi-point radio applications definitely have specific utility. For the former, it is the ideal way to communicate with one subscriber such as the village store or the local dispensary. Multi-point applications are ideal for a mining complex, or a community of multiple subscribers

Perhaps the best way to provide coverage for local subscribers is to extend the cellular radio system for nationwide or provincial coverage. This would entail building out the new AMPS system throughout the province.

Restricted Internet usage is the problem in utilizing the future INTERNET system for data transmission. Although, with the new CDMA extended bandwidth design, cellular operators will have the connectivity that supports e-commerce and internet activity. Cost of course would be the deciding criteria for the short term.

The ideal wireless system for Angola should be device independent. It should be friendly, easy to operate and flexible in nature. The base stations, control activities and the billing features should be easy to install and maintain by Angola Telecom. Perhaps the most important feature, considering the dynamics of today's telecommunications demands, is the incorporation of the asset of Extensibility. The Angola Telecom wireless system must be compatible with future technologies. This asset presently exists via the existing AMPS network in Angola. ETS recommends extending the AMPS system throughout the province. In the future consider the enhanced CDMA system.

3.0 Design Parameters

3.1 Introduction

This section of the report addresses the various design parameters that are pertinent to the design specifications for Angola Telecom. Discussions center on the design standards, reliability and maintainability data, the environmental conditions, wire, cable, and connectors and the safety features.

The foundation for a viable telecommunications network is good traffic projections coupled with comprehensive system calculations for a VSAT Network. Discussions on each of these important elements are presented within this section of the paper.

3.2 Standards

The resultant system design proposed for Cabinda will be fully responsive to the technical parameters of INTELSAT, CCITT, and CCIR recommendations.

The philosophy utilized by ETS will be to achieve the most cost-effective design while optimizing the performance, operational and reliability objectives for the new communications equipment. The equipment will be designed for continuous 24-hour operation in the customer's environment.

3.3 Reliability

The equipment will be designed for continuous operation with a high reliability factor through the use of long life components and best workmanship

3.4 Accessibility

All electronic, electrical and mechanical equipment will be designed and constructed to provide easy access for operational adjustment, calibration, monitoring, repair, replacement and overhaul. Essential test points and controls will be accessible during operation.

Access or maintenance will not require more than nominal disassembly of the specific equipment shelf. Appropriate extender boards and/or extension cables for each different type of unit will be provided in sufficient quantity.

3.5 Ergonomics Design

Ergonomics considerations will be applied in the design of all equipment, controls, indicators, packaging, monitors, operation and maintenance of the systems.

3.5.1 Indoor Equipment

The equipment is designed to work in a normal air-conditioned environment. The equipment will operate without degradation in an ambient temperature range between 10°C to 35°C with a relative humidity between 0% to 95%. The acceptable range for barometric pressure is between 700mB and 1,100mB.

The equipment will continue to operate over a further 10°C above and below the specified range but some degradation will occur.

3.5.2 Outdoor Equipment

Outdoor equipment will operate under the environmental conditions that can be expected on the site, i.e. outside temperatures between 0°C and +45°C. Relative humidity and barometric pressure will be as for indoor equipment.

Non-operating conditions:

- Storage Temperature: -10°C to 55°C
- Relative Humidity: 5% to 99%
- Seismic Conditions: All designs and mountings will be suitable for local seismic conditions.

3.6 Connectors and Impedances

Interface connectors will be of good workmanship and long-lasting plating. Standardization of accessories will be used throughout the design.

Impedances and interface points will be in accordance with the latest CCITT/CCIR recommendations.

3.7 Components

Components used in the design will be of good commercial manufacture. All components will be of rugged construction and will be designed with adequate margins to withstand the rigors of continuous service with a minimum of maintenance.

Semiconductors, resistors, capacitors, etc. will have nominal values according to internationally recognized standards and be of types which can be purchased on the general market.

All specially selected components will be separately listed. All components will be suitably designated on their PC. board, sub-assembly or main chassis, with their circuit component number. Components will in general be up-rated as regards to both voltage and power to ensure a high degree of reliability over the equipment lifetime. Component value, tolerance and working voltage will be clearly marked.

3.8 Fire Resistance Material

In the design, fire resistant materials will be used wherever possible in the ETS proposed equipment.

No part of the equipment will liberate noxious fumes, vapors or gases under normal operation or by overheating.

3.9 Modular Construction

Modular construction will be employed to the maximum extent to facilitate maintenance, repair and extension capabilities.

Electrically identical units, assemblies or parts will be physically interchangeable without modification of the unit or part thereof.

3.10 Cabling

Cable and wires will carry an identification number at each end. This number will be the same as given in the installation drawings and manuals.

3.11 Controls

The type and layout of controls will be such as to avoid an interruption of service or change of operational mode as a result of accidental bumping, touching or catching of clothing.

3.12 Power Supply

The AC power supply is 240V +/-10%, single phase, or 240/415V, 3Φ, 50 Hz nominal
The electronic equipment will operate within the specified performance under the above mentioned variation of power supply.

The equipment will be protected from permanent damage via the use of circuit breakers.

Nominal DC voltage is –47.5 VDC. The range of variation of DC voltage over which the equipment will operate satisfactorily is –44 to –54 VDC.

3.13 Electro Static Protection

Equipment/plug-in units containing Electrostatic Sensitive Devices (ESD) will be identified by a "Warning Label."

The packaging of E.S.D. will offer protection against static electricity, e. g., the use of static shielding bags/material.

3.14 Dust Proofing

All critical parts of the ETS equipment including electrical components, enclosures and shelves accommodating plug in units will be protected against ingress of dust.

3.15 Personnel Safety

Special emphasis will be placed on safeguarding personnel from hazards. Safety measures will be undertaken in accordance with the latest internationally recognized standards. ETS will adhere to both the American UL Standards and ISO-9000.

In the design of the equipment, special emphasis will be placed on safeguarding personnel from high voltages. Any voltage of 60V or more will be considered as hazardous.

ETS will provide Safety Regulations and Procedures to safeguard personnel, working on the system maintenance and repairs, from the hazard of high voltages present on the system during the normal operation.

3.15.1 Earthing

The outside of all cabinets and racks and the chassis of all enclosed components, and all external parts, meter cases, control shafts and knobs will be securely grounded. Their length will be as short as possible in order not to create earth loops.

3.15.2 Terminal Strip Protection

All strips containing hazardous voltages will be equipped with covers. The design of the covers will be such that sufficient mechanical rigidity and clearance is provided to prevent short circuits and other failures.

3.15.3 Warning Notices

All equipment which will be connected to AC mains or to DC voltages in excess of 60 volts will have warning notice in a conspicuous position on the front face.

The notice will read: - DANGER, HIGH VOLTAGE and will be in red characters on a white background.

3.15.4 Connector Withdrawal

Normal withdrawal of a connector will not enable accidental access to hazardous voltage

3.16 Equipment Practice: Mechanical

Cable interconnections between different units will be run with particular care to neatness and will be provided with adequate length so as to avoid cable damage under stress. All cables will be clearly labeled or color-coded so that they can be readily identified from drawings.

All units will be adequately sealed against the ingress of dust and moisture.

The equipment design, fabrication and mounting will be based on sound engineering practices to ensure that microphony and vibration effects do not degrade the performance of the system.

3.17 Printed Circuit Boards

All circuits will, where practicable, be mounted on plug-in printed wiring boards. Preferably they should be of a reliable plug-in type, of a standard size, and will be suitable for use in the climatic conditions specified. The boards will be on an approved non-hygroscopic base material, having high insulation resistance, of self-extinguishing grade, and be of adequate strength. The printed wiring side of the board will be given a suitable finish to avoid accumulation of dust, moisture and fungus.

The equipment design will be based on the principle of built-in self-diagnostic subsystems such as to ensure that the operation of all units within their performance specification can be readily verified.

All controls will provide sufficient adjustment such that optimum specification settings are approximately midrange, and there is adequate contingency of component aging during the lifetime of the system.

3.18 Radio Interference

All motors used in the equipment will either be of a type which does not produce radio frequency interference or will be equipped with interference filters. All contacts which open and close will be equipped with interference suppression devices. Only interference-free gaseous-discharge devices will be employed. Means will be employed

to reduce static-electricity and the consequent RF noise generated in any rotating machinery.

All items of equipment supplied under this contract will be properly grounded and shielded to preclude any interference to or by other equipment installed at the station.

3.19 Configuration of Equipment

ETS will use standard racks (defined as those approximately 2 feet (61 cm) wide and 8.5 feet (260 cm) high to the maximum extent feasible for uniform appearance and minimization of interface and maintenance requirements. If some equipment is to be mounted on other size racks, the size will be clearly specified. All jack fields and controls will be located no lower than the average man's waist.

All racks which require patch cords will have a drawer for storage. In any rack where blowers are required for cooling, low noise blowers will be used. All blowers will be equipped with washable-type filters.

3.20 Finish

All equipment will be finished in accordance with good commercial practice. It will be cleaned, primed and finished with at least two coats of finish paint.

3.21 Monitoring Points

1) Sufficient test points will be provided in the equipment assemblies to facilitate servicing and alignment of the equipment and in-service measurements of all functions of operation.

2) Color-coding of test points will be employed to distinguish circuit function and to identify the type of measuring instrument required for reading the level at the test point.

3) Test points will not be considered as a substitute for self-contained meters.

3.22 Earth Station Design

The ground stations and the resultant systems designs proposed for the Cabinda Satellite Network will be fully responsive to the operational satellite specifications for digital transmission within the Atlantic Ocean Community including those for the future INTELSAT family of satellites or those by PanAmSat or New Skies.

It is envisioned that new VSAT Stations in Cabinda and in the other provinces in Angola will receive wideband signals from INTELSAT and be designed to operate at "C" band frequencies.

The philosophy utilized by ETS will be to achieve the most cost effective design while optimizing the performance and reliability objectives for the new VSAT Terminals. The new VSAT terminals will be designed for continuous 24-hour operation in the Angolan environment. The operational lifetime will be for fifteen years having a guaranteed equipment availability in the up and down link chains of 99.9% for hub and gateway sites.

3.23 System analysis

Link budgets were undertaken for various VSAT configurations in Cabinda Province. Point-to-point and point-to-multi-point calculations employing DAMA are included. The effects of Rain Attenuation on the operational earth stations were also projected. These comprehensive analysis along with others, such as Intermodulation Interference, Optimization of Transponders, maximizing bandwidth et al are included with Annex A of this document.

3.24 Traffic Models

Contained within Annex A of this document are comprehensive Traffic Models that formed the foundation for both the Government and Commercial Subscriber Traffic Projections that have been included within Annex A.

4.0 Equipment Architecture

The Cabinda Province Single Channel Per Carrier (SCPC) network consists of a gateway hub at Cabinda City and ten remote sites. Six of the remote sites have eight channels each and four remote sites have four channels each. The VSAT SCPC equipment is the Hughes TES Quantum product line, and has Demand Assigned Multiple Access (DAMA) capabilities. The network uses the INTELSAT 801 satellite at 328.5 E longitude (31.5 W).

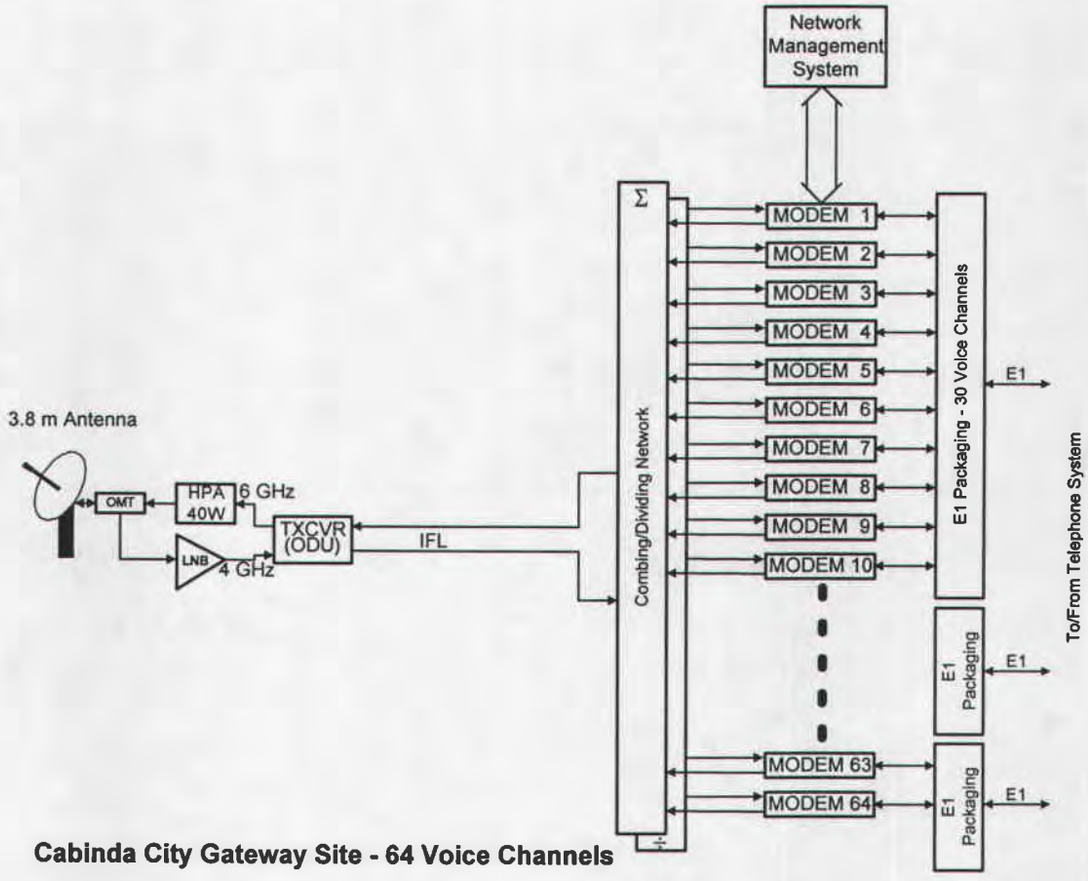
ETS has studied several different manufacturers of VSAT DAMA equipment. We have looked especially close at the Hughes Network Systems, STM Wireless, and Gilat equipment. The same basic block diagram applies to all three manufacturers. The Hughes and the STM equipment are very similar in configuration and function, however, the Gilat equipment configuration and functioning is quite different to do the same job.

4.1 Block Diagrams

Basic block diagrams of the Cabinda City Gateway hub and of a remote site with eight voice channels are given in Figure 4.1-1. At the hub the VSAT equipment is divided into indoor equipment and outdoor equipment. Telephone traffic comes into the gateway hub earth station as E1s. They are broken down into individual voice channels and sent to modems. Each modem handles only one voice channel at a time. When the modem is not handling a call, it is tuned to a supervisory frequency band. There are 64 modems at the hub. The modem compresses the 64 kbps voice signal from the E1 to either 4.8 or 6.4 kbps, adds Forward Error Correction (FEC) to the data stream and modulates it using Quadrature Phase Shift Keying (QPSK) to an intermediate frequency (IF) carrier. The IF carriers from all of the modems are combined and sent to the Outdoor Unit (ODU) via an interfacility link (IFL) cable. The ODU is mounted on the earth station antenna. The outbound signal is upconverted to the 6 GHz band, is amplified in a 40-Watt Solid State Power Amplifier (SSPA) and transmitted out of the gateway's 3.8-meter antenna.

The signal goes through the satellite, is converted to 4 GHz, and retransmitted to the destination remote site's 3.8-meter antenna. It is amplified by a low noise block downconverter (LNB) and downconverted to an intermediate frequency in the ODU. The signal goes through an IFL to the indoor equipment, where it goes through a power divider and is distributed to several different modems. One modem is tuned to the frequency of the call and demodulates the voice signal. The voice signal is uncompressed and converted to analog for use by a PBX or telephone hand set.

The return signal follows the reverse path.



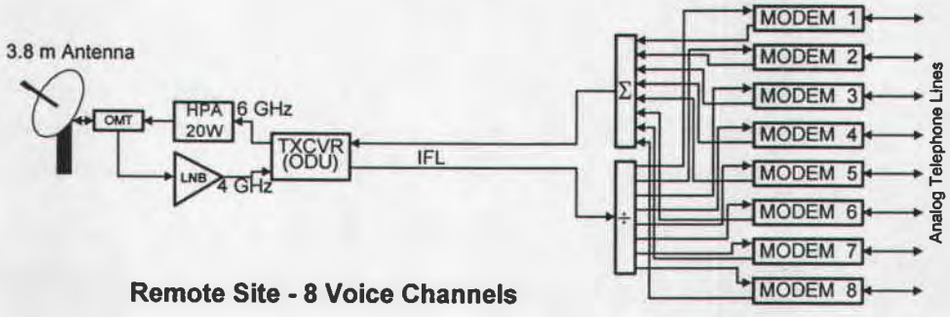


Figure 4.1-1 Cabinda Gateway and Remote Block Diagram

4.2 Satellite Access Architecture

A call coming to the hub from the telephone system is packaged in an E1. The indoor equipment breaks the E1 down into its thirty voice circuits. Different VSAT manufacturers have different methods for sending multiple channels of voice traffic between sites. The most common architecture is Frequency Division Multiple Access where the outbound carrier from the hub is Time Division Multiplex (TDM) and the inbound carrier from the remotes to the hub is a burst TDMA carrier. This architecture could be called TDM/TDMA.

4.2.1 FDMA Architecture

In the Frequency Division Multiple Access Architecture, each voice channel is sent on a separate frequency (single channel per carrier or SCPC). More bandwidth can be added as a system grows, without disturbing traffic of the existing network. Bandwidth can be added in any increment of size consistent with satellite transponder leasing policies.

Minimum Required Bandwidth and Carrier Spacing

With modern compression techniques, the bandwidth occupied by a single voice channel may be as low as 10 kHz. A 64 kbps voice channel is typically compressed to either 4.8 or 6.4 kbps, or sometimes 8 kbps. Bandwidths required for these compression rates are shown in Table 4.2-1. Occupied bandwidth is the actual bandwidth of the signal spectrum. Allocated bandwidth is the bandwidth that must be provided and must be large enough so that the spectrum tails do not overlap into an adjacent frequency slot and interfere with an adjacent signal.

Table 4.2-1 Minimum Bandwidth Requirements for FDMA Carrier

				Units
Compression	4.8	6.4	8	kbps
Modulation factor (QPSK)	1/2	1/2	1/2	
FEC	1/2	1/2	1/2	
Symbol rate	4.8	6.4	8	ksps
Bandwidth factor	1.2	1.2	1.2	
Occupied bandwidth	5.76	7.68	9.6	kHz
Carrier spacing	1.4	1.4	1.4	
Minimum allocated bandwidth	6.72	8.96	11.2	kHz

For an FEC of rate 1/2, one error correction bit is added for each user bit. With QPSK modulation there are two bits per symbol. The symbol rate is shown for each of the three compression rates given in the table. The actual occupied bandwidth is usually considered 1.2 times the symbol rate. However, there must be some guard band between each carrier to keep the tails at the bandwidth edges of one carrier from interfering with the adjacent carrier. This guard band should be large enough to prevent degradation between carriers, yet small enough to permit as many carriers as possible to be placed in the available bandwidth. At 1.5 times the symbol rate there is no degradation between carriers. At 1.25 times the symbol rate the interference between carriers causes a noticeable decrease in Eb/No versus Bit Error Rate (BER) performance. At a carrier spacing of 1.4 times the bit error rate, the degradation between carriers is negligible.

There is a practical limit in the closeness of carrier spacing. Note in Table 4.2-1 above that for compression rates of 4.8 kbps and 6.4 kbps and a carrier spacing of 1.4, the minimum allocated bandwidth required is less than 10 kHz. However, when assigning frequencies, one must also consider the frequency uncertainty in the frequency generation and conversion stages of the system. Due to oscillator stability there is some uncertainty in the IF frequency output of the modulator. There is also uncertainty in the frequency conversion of the upconversion stages of the transmitting station's upconverters, the frequency conversion from 6 GHz to 4 GHz in the satellite, and the down conversion stages of the receive earth station's downconverter. And finally, there is the frequency uncertainty in the tuning stage of the receiving demodulator. All of these uncertainties can add up to several kilohertz for the end-to-end system. If the frequency uncertainty is large and the carrier spacing is small, there is the risk that the receiving demodulator will acquire and lock on to a carrier adjacent to the desired carrier. A practical lower limit to the assigned bandwidth of an SCPC voice carrier is 15 kHz, although some manufacturers claim good results down to 10 kHz. If 15 kHz is used as the lower bandwidth limit, there is no bandwidth advantage for using 4.8 or 6.4 kbps compression as compared to 8 kbps compression.

Often there will be more than one SCPC channel out of each remote. This is the case with the Cabinda network, where some remotes have 8 channels and others have 4 channels. When multiple carriers go through an SSPA, they generate spurious sum and difference frequency products that are a source of interference. The level of these intermodulation products (IMP) becomes higher as the total power at the SSPA output approaches the saturation level of the SSPA. In order to keep the IMP interference at an acceptable level, the total output power due to all carriers in the high power amplifier (HPA) must be kept to at least 6 to 7 dB below saturation for traveling wavetube amplifiers (TWTA) or about 5 dB for SSPA's. Thus adding a second and third carrier to a remote site requires disproportionate increases in the size of the SSPA. Past the third carrier, the SSPA size can be scaled to that required for three carriers.

Voice Operated Carriers

Some manufacturers offer voice operated transmission (VOX). During a conversation between two people, one person listens while the other talks. Even the person talking will have pauses within his sentences. Statistically, any one talker will actually speak only about 40% of the time. VOX will shut down the carrier during periods, even short periods, when there is no audio. The advantage of this is that if the number of carriers going through an HPA is large enough to make a good statistical sample, the probability of all active carriers actually transmitting at the same time is small. So the HPA may be sized for a smaller number of carriers. The number of carriers required to get the full statistical advantage of VOX is 60. In the case of the Cabinda network, the remote sites do not have enough carriers to benefit from VOX. But the gateway hub, with 64 modems, does have enough carriers to benefit from VOX.

The biggest benefit of VOX is in the satellite. Satellite transponder spectrum is leased by MHz of bandwidth of a transponder. However, the leased bandwidth does not include unlimited bandwidth. The lease agreement provides only an amount of transponder power proportional to the leased bandwidth. A quarter transponder lease comes with a quarter of the transponder's bandwidth and a quarter of the transponders output power. We desire to make the remote sites as economical as possible. This means the designer must use the smallest antenna at the remotes that is consistent with reliable links. For an SCPC network with VOX'ed carriers, at any instant of time many of the active carriers are shut off because a talker is listening. The transponder transmitter power is less if only 40% of the active carriers are actually turned on than if all carriers are turned on. This gives a 4-dB advantage in transponder power, 4 dB than can be used to purchase remote site antennas that are 4 dB smaller in area. For example a remote antenna could be reduced in size from 3.8 meters to 2.4 meters in diameter if the SCPC carriers are VOXed.

The Cabinda network uses 3.8-meter antennas for both the remote sites and the Cabinda City gateway hub. When used with the INTELSAT 801 satellite, the 3.8-meter antennas are large enough that the links are reliable without using VOX. But it may be advantageous for future expansion of the network by permitting the use of 2.4-meter antennas at small remote sites. Alternately, the use of VOX could provide the existing system with additional rain margin.

A downside of VOX is that receiver (demodulator) acquisition time must be faster than without VOX. Without VOX a site must acquire a carrier when a call is first set up. Once the call is set up, the carrier stays up and the demodulator stays locked to it for the duration of the call. If acquisition takes half a second, this is just part of the normal setup time of a call. In the case of VOX, however, after

initial acquisition, the carrier is constantly going up and down during the call as the speaker talks, pauses, and listens. Each time the carrier comes back up, the demodulator must re-acquire the signal. The acquisition time must be fast in order to prevent clipping of the first syllable of the speech. The required faster acquisition time requires higher frequency stability in the equipment to reduce frequency uncertainty of the carrier. The receive equipment must remember the last frequency that it receiver to a greater degree of accuracy.

Mesh

The preceding discussions related to a star network where all of the remotes talk directly to the hub. However, there is no basic change in equipment for a mesh connection, in which one remote connects directly to another remote. The frequencies are still assigned by the Network Control System at the hub. But once the call is set up, there is no more involvement of the hub. In an FDMA system, the modems at the hub are functionally identical to those at the remote. Therefore, one remote can talk directly to another without a change in functionality of equipment, so long as both remotes have a large enough antenna and large enough SSPA for remote-to-remote communication.

4.2.2 TDM/TDMA Architecture

In an alternative architecture to the FDMA, the outbound carrier from the hub to the remotes is continuously on. All remotes are tuned to this carrier all of the time. Each active channel is assigned a time slot within the carrier, depending on the destination of the call, resulting in a Time Division Multiplex (TDM) carrier. Remotes are assigned to specific time slots. In the case of DAMA, the time slots are assigned to remotes on an as needed basis. The bit rate of the TDM carrier is large enough to accommodate all channels of all remotes. Where an FDMA system has many small bandwidth outbound carriers, a TDM/TDMA system has one large bandwidth outbound carrier.

On the inbound link, each remote sends a short duration burst of energy to the hub on an assigned time slot. Each remote site bursts on the same frequency, but in a different time slot. There must be guard time between bursts to accommodate the clock uncertainties of the various remotes and prevent the trailing end of a burst from one remote from overlapping the beginning of a burst from another remote. The bit rate of the bursts will be at a high enough rate to accommodate all channels of all remotes. Because of the larger bit rate of the burst, the bandwidth of the inbound burst carriers is much larger than the bandwidth of the individual inbound carriers of an FDMA system. When a call is set up, the hub tells the remote what time slot to use for its inbound burst and which time slot to listen to on the outbound TDM carrier.

When the network outgrows the system, the TDM outbound carrier must be enlarged to accommodate additional channels. Adding additional channels to the inbound TDMA bursts requires increasing the bit rate of the bursts and reducing the length of the bursts. Increasing the system capacity requires shutting down the system and interrupting the traffic for a short period of time while activating a new configuration. To circumvent this, manufacturers of this type of equipment have gone to a hybrid FDMA-TDM/TDMA system. The system is still basically a TDM/TDMA architecture. But instead of being one large TDM/TDMA system, it is broken into a number of small TDM/TDMA systems. For example, instead of a single 10 MHz TDM carrier, a large system may have 10 TDM carriers, of 1 MHz bandwidth each. The inbound bursts are assigned both a frequency slot and a time slot within the frequency slot. With this change, the network can be grown incrementally without interrupting the existing traffic.

The TDM/TDMA system architecture has some advantages and disadvantages when compared to the FDMA system. The larger bandwidth carriers, both inbound and outbound, reduce the frequency uncertainty requirements for the system. The demodulators don't need as much frequency precision. In a star network, the remotes need only a single modulator and demodulator for several channels, provided all of its traffic is assigned to a single carrier frequency. A hub needs a modulator and demodulator for each frequency carrier, not one for each channel of each remote. Thus there can be a significant reduction in equipment. For a small system, even a remote with several channels will have only a single modem and a single carrier. With only one carrier going through the SSPA there is no need for output backoff. However, the strength of the carrier must be sized for the instantaneous bit rate of the burst, not the average bit rate. Consider a system with three active 8 kbps voice channels in a system with 500 kbps for the bit rate of the bursts. The average bit rate is 24 kbps. However, the carrier strength must be sized for the peak 500 kbps data rate of the bursts, which is equivalent to a 13.2 dB SSPA output backoff for an FDMA system.

For a small network with a single outbound carrier and single inbound burst frequency, the remote demodulators have to acquire the outbound carrier only once. Then they stay locked to it indefinitely (unless for some reason, such as a prime power failure, the entire site comes down). There is no need for a remote demodulator to reacquire a hub carrier for each call. However, the hub must acquire each burst of each remote. And the bursts are much shorter than a transmission in the FDMA case, even if VOX is implemented. If the beginning of a burst is missed, the whole burst is missed, resulting in a problem larger than just clipping.

The timing of the remotes is critical. The start of each burst from each remote must be very precise, and must take into consideration the difference in path length between the hub and the various remotes. The more uncertainty in the

timing of the start of burst, the larger the guard time required between to prevent partial overlapping of bursts. And the larger the guard time, the more wasted bandwidth.

Because the outbound carrier is TDM with a fairly wide bandwidth, there is no limit on the compression of the voice. A 4.8 kbps voice channel takes less bandwidth than an 8 kbps compressed voice channel. The same is true to an extent on the inbound burst channel. But if the greater compression results in a burst length that is too short, the guard time between each burst may take up an appreciable amount of the inbound bandwidth. The payload data stream in each burst is preceded by a stream of synchronization bits. The length of this stream is independent of the length of the payload. For extremely short bursts the synchronization bit overhead may become an appreciable amount of the total burst, resulting in a reduction of bandwidth goals desired from using greater compression. Thus the inbound TDMA system has similar practical compression constraints as the FDMA system.

One final disadvantage of the TDM/FDMA system is that it is not readily convertible to a mesh network. The outbound carrier is a continuous TDM carrier and the inbound carrier is burst. If two remotes try to talk to each other, both are transmitting bursts and trying to receive a continuous signal. To convert a TDM/TDMA system to mesh, the remote receiver/demodulators must have a hardware addition that permits them to be used as TDM receivers when talking to the hub and as burst receivers when talking to remotes. If a remote has a capacity for several channels and is to be used in a mesh network, it must have at least two receiver/demodulators so it may listen to the hub and another remote simultaneously.

4.2.3 Supervisory and Call Setup

Just about all VSAT system have the same call setup scheme. Certain frequencies are reserved for supervisory and call setup. Even in FDMA systems, the control and call setup frequencies are TDM outbound and burst inbound.

The inbound burst is a contention, Slotted Aloha configuration. The contention means that there are no specific time slots assigned for any remote burst. A remote bursts whenever it has a need. If the bursts from two remotes overlap (a collision of bursts through the satellite) both bursts are lost. If a remote has not received a response from the hub to its burst before a timeout, the remote bursts again. Because of collisions and the resulting retransmissions, the statistical throughput of a pure contention system is less than 10% of the bandwidth capacity. As the attempted throughput increases, there are more collisions, and for each collision there are two retries.

It is possible that a burst from one site could wipe out the end of the burst from a second site and the beginning of the burst from a third site, resulting in three retries. Slotted Aloha is a scheme where time is broken up into structured segments. A remote that needs to communicate with the hub bursts at the beginning of a segment. Thus if a remote bursts, and a second remote bursts at the same time, those two will be wiped out but there is no chance of a third burst in the following time slot being destroyed. With Slotted Aloha throughput is increased to between 15% and 20%. Because of the low amount of traffic for call setup, throughput of the NMS channels is usually not critical. If a system grows to the point that single NMS outbound and inbound frequency slots are not adequate, one or more sets of NMS frequency slots can be added. The total NMS bandwidth is a small part of the bandwidth required by the entire system.

The remote receivers are tuned to the TDM carrier when they are not involved in a call. When a call originates at a remote, the remote sends a burst to the Network Management System (NMS) at the hub with the called telephone number and a request for a frequency (or time slot in the case of a TDM/TDMA system) assignment. The NMS selects an unused frequency from its frequency pool and sends back the frequency assignment (or time slot assignment). If this is a mesh network and the call is to another remote, the hub sends frequency (time slot) assignments to both remotes. Then the remote retunes its receiver to the assigned frequency. At the end of the call, the remote retunes its transmitter and receiver to the NMS frequencies and notifies the hub that the call is complete.

4.2.4 Architecture Comparison

A comparison of some of the key features of FDMA and TDM/TDMA are given in Table 4.2.4-1 on the next page.

4.3 Future Studies

In the second phase of this study we will investigate closely how the equipment of various manufacturers fits into the different architectures and which best fits the Angolan requirements. We will suggest recommendations for expansion of the current Cabinda network and how best to implement additional networks in Angola. At this point in time, the vendors with the best prices and the best chance of fitting into a solar power scheme are Hughes Network Systems, STM Wireless, and Gilat. We will focus on the products of these three manufacturers, but we will not exclude consideration of other manufacturers.

Table 4.2.4-1 Comparison of FDMA and TDM/TDMA Architecture

Architecture	FDMA	TDM/TDMA
Access method	Frequency division	Time division: TDM outbound, TDMA inbound
Bandwidth addition	Small increments (15 kHz)	Larger increments (100 kHz minimum)
Protection from adjacent channel interference	Guard bandwidth	Guard time (inbound only)
Minimum practical voice compression	6.4 kbps	4.8 kbps outbound, 6.4 kbps inbound
Transmission bit rate of carriers	8 kbps or less	100 kbps and up
Impact of oscillator frequency uncertainty	Large	Small
Acquisitions	Without VOX: once per call With VOX: every few seconds	Outbound: once during station setup Outbound: once each burst, hundreds of times per second
VOX advantage	4 dB	?. Probably none
Hub HPA backoff	5 dB	Pure TDM/TDMA system: 0 dB Hybrid TDM/TDMA system: 5 dB
Remote HPA backoff	0 dB for single channel remotes 5 dB for multiple channel remotes	Pure TDM/TDMA system: 0 dB Hybrid TDM/TDMA system: usually 0 dB
Remote HPA sizing	Size for required number of 15 kbps channels plus 5 dB output backoff	Size for a minimum 100 kbps carrier
Remote site timing for start of burst	No requirement	Critical
Conversion to mesh	In general no hardware impact. May not be possible with some super-economical single channel systems.	Requires addition of hardware to enable remote demodulators to receive both TDM and burst carriers.

5.0 Power Systems

5.1 General

The most important element in a communications network is the provision and the utilization of a viable power source. Often overlooked by telecom engineers, reliable power packets are key to operations. Subsequent paragraphs within this section of the report, address the various power sources and their utility to Angola Telecom.

5.2 Alternative Power Sources

Alternate energy sources generate power independent of the electrical grid. These sources can act independently or be tied directly into the Power Grid. Unfortunately in Cabinda Province, extensive planning and expansion to the existing power grid is still in the development or the planning stage. This has resulted in large geographic sections of the province not being served with electricity.

To overcome this lack of a primary power source, telco engineers are forced to evaluate alternative sources of energy within the province. Electrical energy is required to activate their cellular, satellite, and their Internet equipment.

These alternative power sources are diesel generators, microturbines, windmills, and solar panels. Each of these primary energy sources will be discussed within the following sections of this paper. Preliminary brochures associated with these potential alternatives are included within Annex C.

Recommendations for each of these alternative power sources will be further discussed within the Phase II Report.

5.2.1 Diesel Generators

The primary alternate power source is the provision of diesel generator (DG) sets at the remote sites within the province. The DG package consists of redundant diesel generators, starting battery, transfer switch, a fuel tank and a day tank. Depending on capacity and operating in the primary mode, a DG package can operate for 7 to 10 days. Capacity, i.e. KVA size will be a function of the telecom load.

The weakness, of course, in employing DG sets are the fuel costs, considering storage, transport and the cost of the petroleum by-product (DG fuel). Reciprocating engines are expensive and inefficient to operate. They have high O & M costs with an efficiency of not greater than 35%.

From a positive standpoint, they require the lowest capital cost.

5.2.2 Microturbines

Microturbines are ideal power sources for telecommunications networks. They are of a versatile design and can use a variety of fuels such as natural gas, propane, diesel, kerosene and even methane. When combined with air, compressed and ignited, the fuel spins the only moving part. This is a shaft with a turbine wheel. The turbine drives a permanent magnet or generator at full load of say up to 90,000 rps. This results in the production of AC Power. This jet engine, depending on size, can have 5 to 25 kW of power available for the remote site.

5.2.3 Windmills

Perhaps one of the primary considerations for prime power is the utilization of wind turbines. Cabinda has sustaining winds in excess of 10 mph. It involves a 25m guyed tower, wind turbine, a battery bank, and a sine wave inverter. It produces about 25 kWh/day or 1 kW per hour of energy.

It requires minimal maintenance and is ideal in locals in which there is a wind speed in excess of 15 mph. This technique will be further investigated during the Phase II Study.

5.2.4 Solar Power

Solar Power is ideal for low powered VSAT applications. Our preliminary analysis on solar power utility is presented in Par 5.3.

5.2.5 Fuel Cells

The application of fuel cells was originally developed for the space program some forty years ago. The fuel cell uses a highly efficient electo/mechanical process to convert hydrocarbon fuel or hydrogen into DC Power with minimal emission. It simply converts the fuel to hydrogen, which is combined with air (oxygen) resulting in a by-product of DC electricity. It is an expensive process, considering delivery of fuel cost and has a price range in the magnitude of $120 US per Watt.

5.2.6 Other Sources of Energy

There are two other sources of energy. The first is the new FlyWheel design which has a large flywheel continually spinning or in motion. Failure of the commercial power source results in the Flywheel assembly assuming the load for

a 90-second period or until the standby generators can assume full load. Ideal for a data center but for Cabinda, "No".

Lastly is the provision of large battery banks storing electricity. This system commonly referred to as an AC No Break (ACNB) System assumes the station load at time of commercial power failure. It involves the conversion of DC to AC energy via an inverter. Ideal for a large central office or an international gateway station, but not for rural Cabinda.

5.3 Power, Remote VSATs

A preliminary review was done to investigate the possibility of using solar power for remote VSAT sites. Items required by a solar power system are solar panels, batteries, and a charger/regulator to protect the batteries from over charging. Generally, the small VSATs are available in a DC prime power version so that an AC inverter with its inherent electrical inefficiencies is not necessary. The batteries must be sized to handle nighttime operation and also to handle a number of consecutive days of no sunshine.

It was found that for remote sites with a single voice channel, there are some VSATs that take only 35 Watts for the entire station. For these, solar power is available for between $1000 and $1500 US, depending on the number of hours per day that operation is desired and depending on the desired protection for consecutive days of cloudy/rainy weather. However, for sites with multiple voice channels, the power consumption is several hundred Watts, and the cost of solar power is prohibitive. We have obtained quotes varying from $10,000 US to $30,000 US for a few hundred Watts.

The Hughes TES Quantum Direct single channel VSAT requires 70 Watts of DC power. The STM Wireless Subscriber Earth Station single channel VSAT requires a mere 35 Watts, and the Gilat DialAw@y IP VSAT claims less than 35 Watts. All of these could run on solar power. The existing Cabinda VSATs with four and eight channel remotes is not a candidate for solar power. However, future expansion of the Angola VSAT system may have single channel sites. These could be designed for solar power.

5.4 Power-Handheld Units

The critical element in the wireless communications arena is the ability to easily recharge the Handheld Units. Present day cellular communications design necessitates that the handheld GSM Units are recharged after 2.5 to 3.0 hours of continuous usage. For fixed station application within the Province, a power source must be available to recharge the lithium batteries. If no commercial source is available, the subscribers must resort to solar power for the energy required. Realistically, this probably would require two units per subscriber. One is for telephony conversation and the other is in the recharge mode.

The lithium-ion cell presently used in most handhelds is the most rechargeable battery with today's technology. It can charge up to 75 W-hours per pound. Unfortunately the operations time is less than a half of day.

Unfortunately, this won't be enough energy to power the high-resolution color displays required with their new 3G phones. Current mobile phones consume 1.0 to 3.0 Watts of power. Color displays employing 3G technology require 4.5 to 8.0 Watts of power.

Software based on MI/S (Million Instructions/Second) requires additional power for message service, gaming and e-mail. Subscribers worldwide are demanding more features homogeneous to their mobile units. All require Watts to operate.

It is ETS's intent to evaluate power packets and energy sources for the fixed station subscriber and the mobile phone units in Phase II of the study project.

Angola Cabinda Province VSAT Network

Annex A
System Analysis

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A.0 System Analysis

Link analyses were performed for several configurations of the Cabinda Network. In order to perform the link analysis, the results of several other analyses were required. These analyses are described in the Sections of this Annex under A.1. The link budget analysis is described here also. The actual link budgets are given in the section under A.2.

A.1 Description of Analyses

A.1.1 Analysis Objective

A link analysis was performed to determine the bandwidth required for the entire network and the suitability of the selected equipment. This analysis was performed for several configurations. Where the equipment, such as antenna or HPA, is not adequate, then equipment upgrades are suggested.

A.1.2 Network Description

Extensive network analysis was performed on the Cabinda VSAT network. The network was modeled as a 12 node network. There are 10 remote sites in the province of Cabinda, a gateway site at Cabinda City, and a hub site in Luanda. A network diagram is given in Figure A.1.2-1

In the network modeled, there are 10 remote sites. The number of channels of SCPC installed at each remote site varies from 2 channels to 11 channels. The system is a Demand Assigned Multiple Access (DAMA) configuration, which means that bandwidth and frequency assignments are made as they are needed. It is assumed that the system has a full mesh capability. Channels are assigned for direct remote-to-remote connections on an "as needed basis". Some channels going to the gateway and hub are dedicated pre-assigned channels and others are demand assigned.

In the first analysis, it was assumed that this network is 0% call blocking at the Cabinda City hub. There is one modem at the Cabinda City hub for each channel of each remote. With this configuration, there would never be a time when a voice line at a remote would get a busy signal at the hub. However, in later studies, it is assumed that the hub and the gateway each have 14 equipped voice channels and that call blocking could occur if enough calls to either the hub or the gateway are initiated at the same time. Later in this report, call blocking probabilities will be addressed.

In the analysis, we assumed connections between the Cabinda VSAT network and the hub at Luanda. It was assumed that the Luanda hub would be provided with SCPC equipment that provides for direct connection to each remote site. The remotes would be configured for full mesh operation so that channels connecting to Luanda would use some of the same channel cards that are used to connect to Cabinda. The Luanda antenna is much larger than the antenna at the Cabinda gateway, so a channel going from a remote to Luanda would use less transmitter power than it requires when the channel goes to Cabinda. Therefore, no additional transmitter power had to be allocated to the remotes for connections with Luanda.

Several different studies of various configurations were performed. Link studies were performed for a model in which six remotes were assumed to have eight voice channels each and four remotes were assumed to have four voice channels each, for a total of 64 SCPC voice channels. In addition, in this study sixty voice channels were assumed to go between Luanda and the

Cabinda gateway. Analysis was done for three different configurations of these Cabinda City to Luanda channels. In one configuration, it was assumed that the these sixty voice channels would be transmitted as uncompressed E1's in two separate, 2048 kbps carriers. In another configuration, a single 512 kbps carrier uses two E1's compressed 8:1. In the third configuration, it was assumed that the SCPC system would be expanded to include 60 channels of SCPC between Luanda and Cabinda City.

In another study, the bandwidth was calculated for an initial system as shown in the connection diagram of Figure A.1.2-1. It was assumed that the Luanda hub and the Cabinda City gateway each have 14 voice channels. A few of these voice channels are dedicated pre-assigned, but most are demand assigned and can go to any site, and include channels going between Cabinda City and Luanda. In this calculation the 60 voice channels between Cabinda City and Luanda were assume to go via terrestrial microwave rather than by satellite.

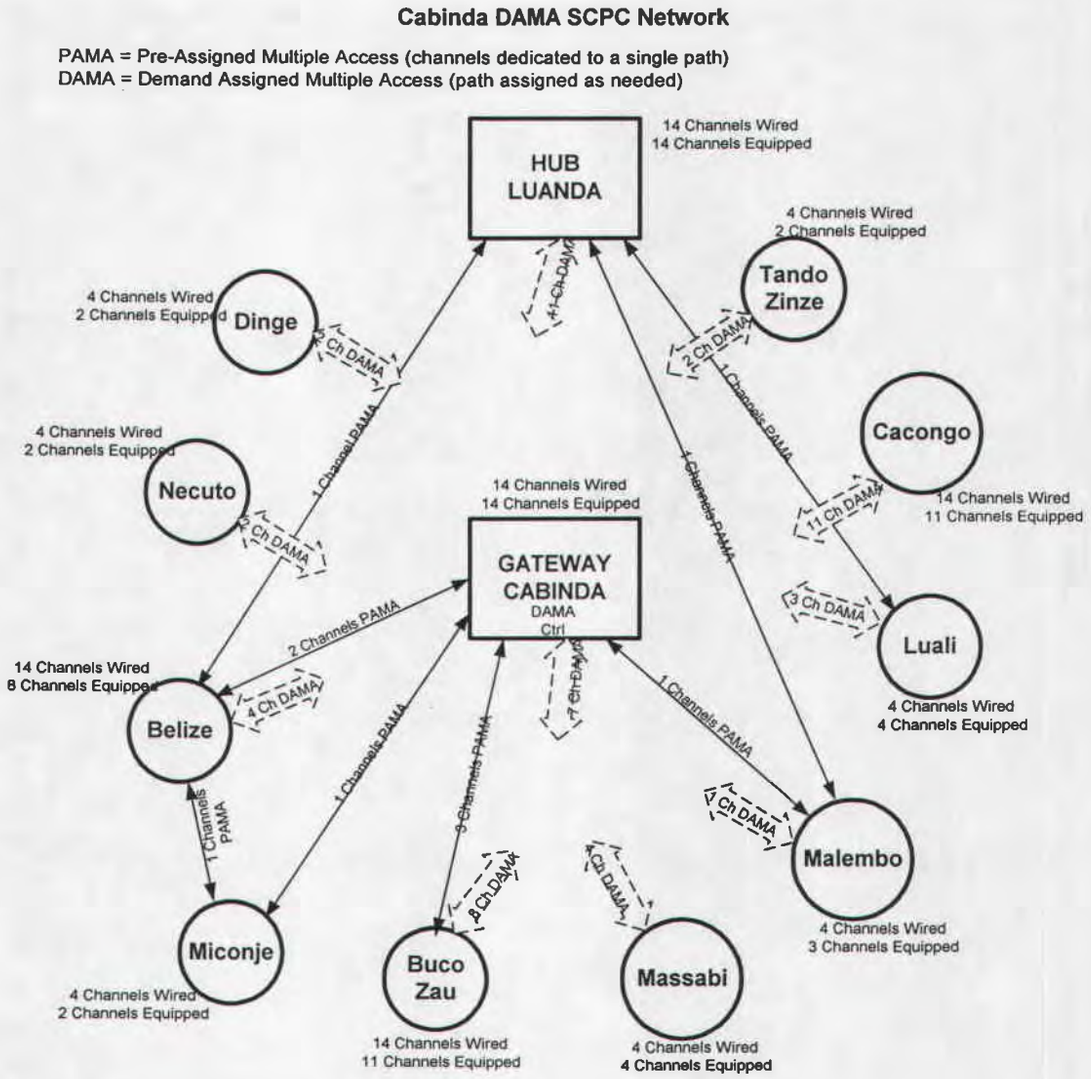


Figure A.1.2-1 Cabinda VSAT Network Connectivity

A.1.3 Link Budget Analysis

A.1.3.1 Analysis Discussion

Link budgets were calculated for a C-band satellite link for a VSAT in Angola with Cabinda City as the hub of a star network. These links were calculated using the INTELSAT 801 satellite located at 31.5° west longitude. An east hemispheric beam was assumed, with a transponder bandwidth of 72 MHz and centered at 6.050 GHz. Calculations were done for remote-to-Cabinda City links, remote-to-remote links, remote-to-Luanda links, and Cabinda City-to-Luanda links. The links were calculated for the following earth station hardware parameters:

Gateway – Cabinda City
3.8 meter antenna
40 Watt SSPA

Remote – Cabinda Province
3.8 meter antenna
20 Watt SSPA

Hub – Luanda
15 meter antenna
125 Watt (100 Watts at the output flange) TWTA

The Link Analysis was done for three conditions in each direction. The conditions were 1) clear sky with no pointing error, 2) clear sky with maximum expected pointing error due to wind and satellite drift, and 3) simultaneous rain fade and maximum expected pointing error. The ITU-R (CCIR) rain fade model was used, with rain fade allocations for rain fade probabilities of 0.4%. A 0.4% rain fade means that the assumed rain rate and resulting rain attenuation will not be exceeded by more than 0.4% of the time. It was assumed that the 0.4% rain fade occurs simultaneously at both ends of the link on both uplink and downlink.

A major consideration in the design of a satellite communication system is the ratio of available satellite transponder power to transponder bandwidth. A satellite transponder has a specific bandwidth (72 MHz in the case of IS 801 hemi beam) and a specific amount of transmit power. Power is evenly allocated per unit of bandwidth. If a tenth of the transponder bandwidth is leased, then a tenth of the power can be used. If a system requires more power than the amount allocated for the bandwidth required, a penalty must be paid in that extra bandwidth must be leased in order to get the extra power. This can happen if one of the receive antennas is very small or at the edge of the satellite coverage area, or if two small antennas are communicating with each other. The ratio of percent of transponder power required to the percent of bandwidth required is called the "power/bandwidth ratio". If possible, the power/bandwidth ratio should be kept to not greater than one. If the power/bandwidth ratio is greater than one, the system is power limited. If the power/bandwidth ratio is less than one, the system is bandwidth limited. If the power/bandwidth ratio is much less than one, the carriers may be run at a higher level than necessary, providing additional margin. If a site with large antenna communicates with a site with a small antenna, the power of the carrier being received by the larger antenna may be reduced and given to the carrier going to the smaller antenna. In Cabinda VSAT system, the 3.8 meter antennas at the Cabinda City hub and Cabinda Province remote sites result in a slightly

bandwidth limited condition. This applies to the star remote-to-hub network and the mesh remote-to-remote system. This permits operation of the system with link margins greater than 1 dB. Because of the large 15 meter antenna at the Luanda hub, the links between the Cabinda VSAT and the Luanda hub are somewhat more bandwidth limited and can be operated at more link margin.

The calculations for the SCPC DAMA network were done for QPSK modulation with rate ½ FEC (Forward Error Correction) encoding and Viterbi decoding. A bit error rate of 10^{-8} was assumed as the criteria for clear sky - no wind, 10^{-7} for clear sky - maximum wind,. and 10^{-6} for 0.4% rain fade simultaneous with maximum wind. A digital rate of 8 kbps was assumed for voice channels. A 1.4 channel spacing factor times symbol rate rounded up to the next 5 kHz gives a 15 kHz allocated channel bandwidth. An overhead of 10% over system calculated bandwidth was assumed for DAMA control channels. Lower bandwidth could possibly be achieved using rate ¾ FEC rather than rate ½. However, there is a limit to the minimum bandwidth that is usable. If the bandwidth gets much lower than 15 kHz, the frequency uncertainty in the earth station and satellite converters becomes nearly as large as the bandwidth. If the frequency uncertainty is great enough, there is the danger that a receiver will lock on to a carrier adjacent to the desired carrier.

Part of the link analysis addressed E1 circuits going between Cabinda City and Luanda. For these circuits, larger carriers were assumed. Modulation parameters assumed for these carriers were QPSK, rate ¾ FEC, and convolutional coding with Viterbi decoding and a concatenated Reed Solomon code.

A link budget is a calculation of carrier-to-noise ratio (C/N), energy per bit-to-noise density ratio (Eb/No), and the resulting bit error rate (BER). A number of noise and interference sources were considered in the C/N calculations. Uplink and downlink noise are the most straight forward to calculate. However, there are a number of other sources that, though small, can add up to a significant portion of the total noise. Occasionally some of these additional noise sources are individually large. The noise sources considered for these link budgets are as follows:

- Uplink noise
- Downlink noise
- Earth station uplink intermodulation
- Earth station uplink adjacent carrier interference
- Satellite intermodulation
- Adjacent co-polarized transponder interference
- Uplink cross polarization interference
- Downlink cross polarization interference
- Adjacent satellite interference
- Satellite adjacent carrier interference

Typical numbers were allocated for many of these noise budget items. Some, such as intermodulation and adjacent satellite interference, were calculated.

A.1.3.2 Rain Attenuation

Any communications link that sends signals through the atmosphere is subject to signal loss during periods of heavy rain. A communications system must be designed with link margins so that the communications link doesn't fail as soon as a little rain falls. On the other hand, if the system is designed so robust that it will withstand all rains, the system will be very expensive. It is the normal practice to design a communications system with enough margin to withstand most rainfalls, but with a link margin that will be exceeded an acceptable duration throughout the year. How much time the system is allowed to be out during the year due to rain is a decision made by the owners of a communications system that are familiar with the users of the system and the user needs. For purposes of the analysis in this report, a total outage time due to rain of 0.4% was used.

The branch of the International Telecommunications Union (ITU) that deals with standards and recommendations for radio communications has divided the world up into different rain regions, or zones, based on the 0.01% annual rain rate of an area. These rain regions, along with recommendations of how to calculate attenuation due to the rain are given in the ITU-R series of publications (formerly CCIR). These publications also give methods of extrapolating from the 0.01% rain rate to other rain rate probabilities. Each rain region is give a letter designation (A, D, J, etc.) depending on the rain rate in millimeters per hour that is exceeded 0.01% of the time. The province of Cabinda is in ITU-R rain zone N, which statically has a 0.01% rain probability of 95 mm/hour. This includes Cabinda City and all remotes. Luanda is right at the boarder of the ITU-R rain zones J and K. These rain zones have statistical 0.01% rain probabilities of 35 mm/hour and 42 mm/hour, respectively. The K region was used in the analysis. A plot of the rain rate regions for Africa is shown in Figure A.1.3-1. This figure is taken from ITU-R Report 563-3, Figure A.13.

The attenuation due to rain is dependent on the rate at which rain is falling, the frequency of the radio signals going through the rain, and the length of path that the signal travels through the rain. Attenuation also depends on the earth station latitude. Moisture in the atmosphere tends to crystallize out at lower altitudes in the higher latitudes. For satellite communications, the path length through the rain depends on the elevation angle of the earth station. An antenna pointed at zenith looks through only a few thousand meters at most before the signal is through the rain and in free space. If an antenna is pointed near horizon the path through the rain may be several kilometers.

At low frequencies, a few hundred megahertz, there is very little attenuation due to rain. As the frequency gets up into the gigahertz range, attenuation becomes significant. At 10 GHz attenuation can be quite high. Figure A.1.3-2 shows the dependence of rain attenuation with frequency.

The CCIR rain region data is based on the rain rate probability of 0.01%. This is the rain rate that is exceeded only 0.01% of the time in an average year. A probability of 0.01% corresponds to 53 minutes in a year. A probability of 0.4% corresponds to 35 hours in a year. As the rain rate probability increases, the rain rate decreases and so does attenuation due to rain. The CCIR publications give a procedure for extrapolating rain attenuation for different rain rate probabilities. Figure A.1.3-3 shows the variation of path attenuation with rain rate probability for several different antenna elevation angles above horizon at a frequency of 6 GHz. For a 40° elevation angle, the 0.01% probability attenuation is about 3 dB. For 0.4% probability the attenuation drops to between 0.5 and 0.6 dB at 6 GHz. A system designed to give link margin at

low rain rate probabilities is robust and has little link outage due to rain, but is also expensive. Antennas have to be larger, and High Power Amplifiers (HPA's) have to be more powerful. Therefore systems are designed for an acceptable amount of link outage due to rain fade. The value 0.4% rain rate probability is used in the analysis presented in this report.

Rain attenuation is also dependent on the earth station's antenna's pointing angle above horizon, called elevation angle. Heavy rain typically occurs in cells. Heavy rains usually occur in cells several kilometers in horizontal diameter and maybe one or two kilometers in vertical height. Of course, the longer the path of a radio signal through rain, the more attenuation there is. For low elevation angles, the path through rain may include the entire rain cell, and possibly even part of an adjacent rain cell. However, if the antenna is pointed straight up, the path through the rain is only the vertical height of the rain cell. The dependence of path attenuation (rain fade) on elevation angle is show in Figure A.1.3-4 for the Cabinda earth station transmit frequency. The Figure shows that here is very little additional drop in attenuation once the elevation increases above 40°.

Path attenuation due to rain fade is shown as a function of elevation angle in Figure A.1.3-5 for Cabinda and Luanda. This is shown for a rain rate probability of 0.4% for both the transmit and the receive frequency. Elevation angles to the satellite INTELSAT 801 at 31.5° west longitude are approximately 38° for Cabinda City, all sites in Cabinda Province, and Luanda. The chart shows that rain attenuation is relatively small, exceeding 0.5 dB for no more than 0.4% of the time, or 35 hours a year.

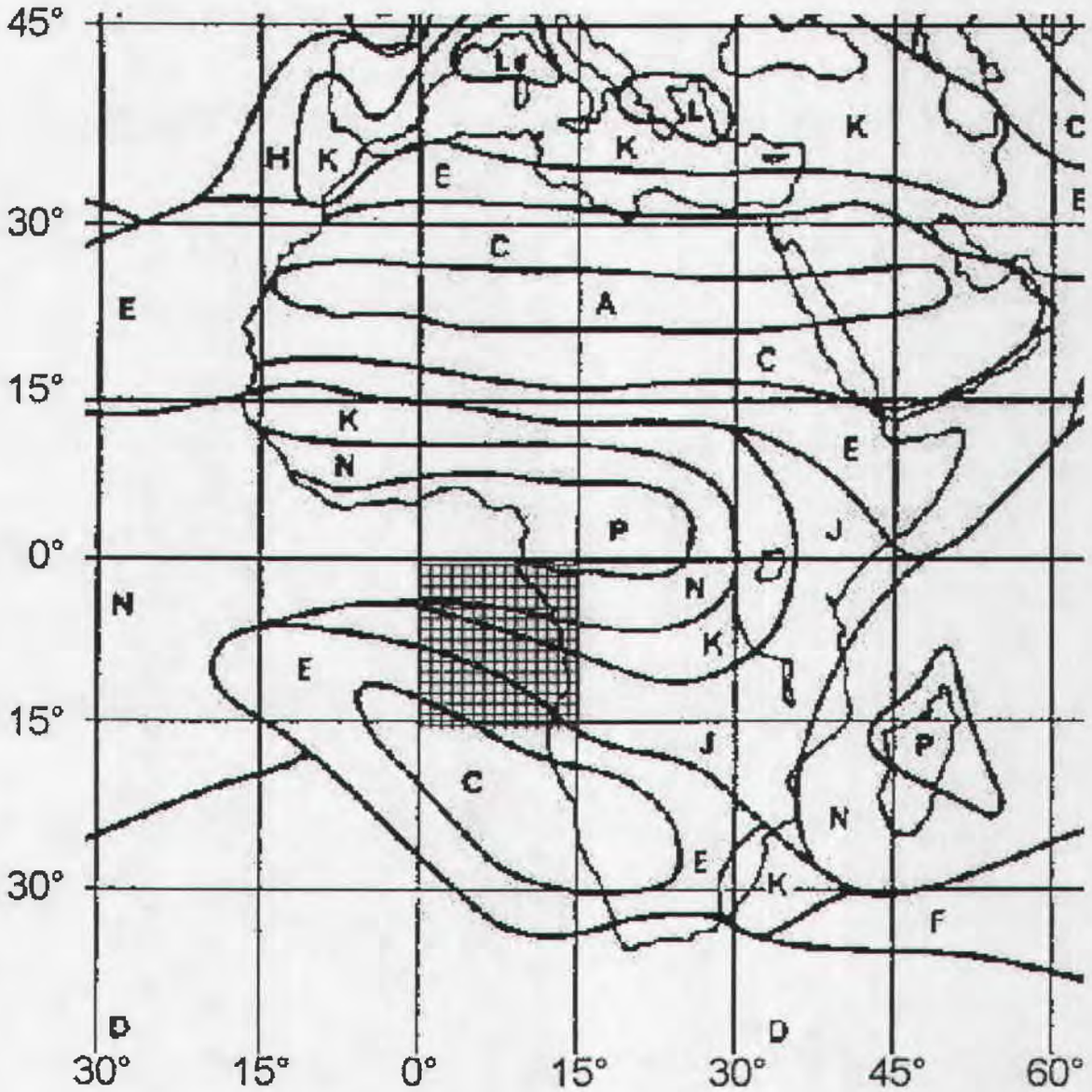


Figure A.1.3-1 CCIR (ITU-R) Rain Regions for Africa

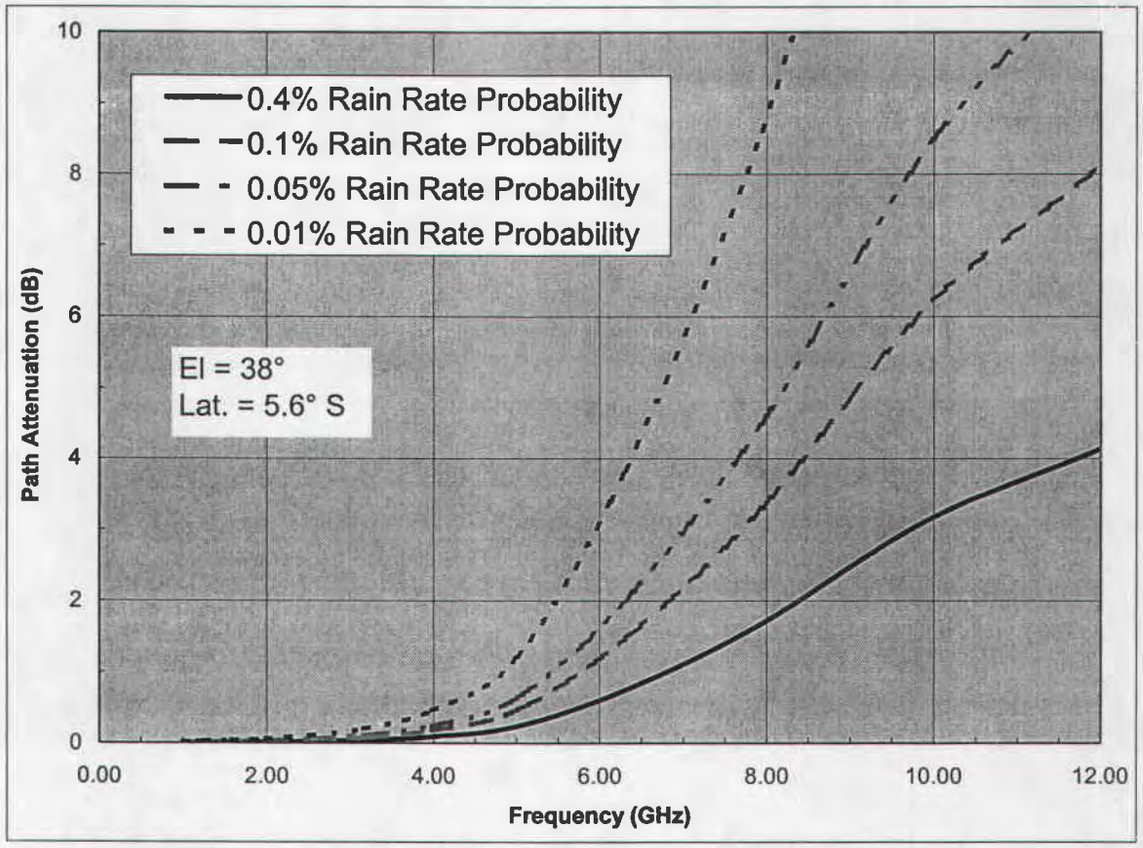


Figure A.1.3-2 Region N (Cabinda) Rain Attenuation vs Frequency for Various Rain Probabilities

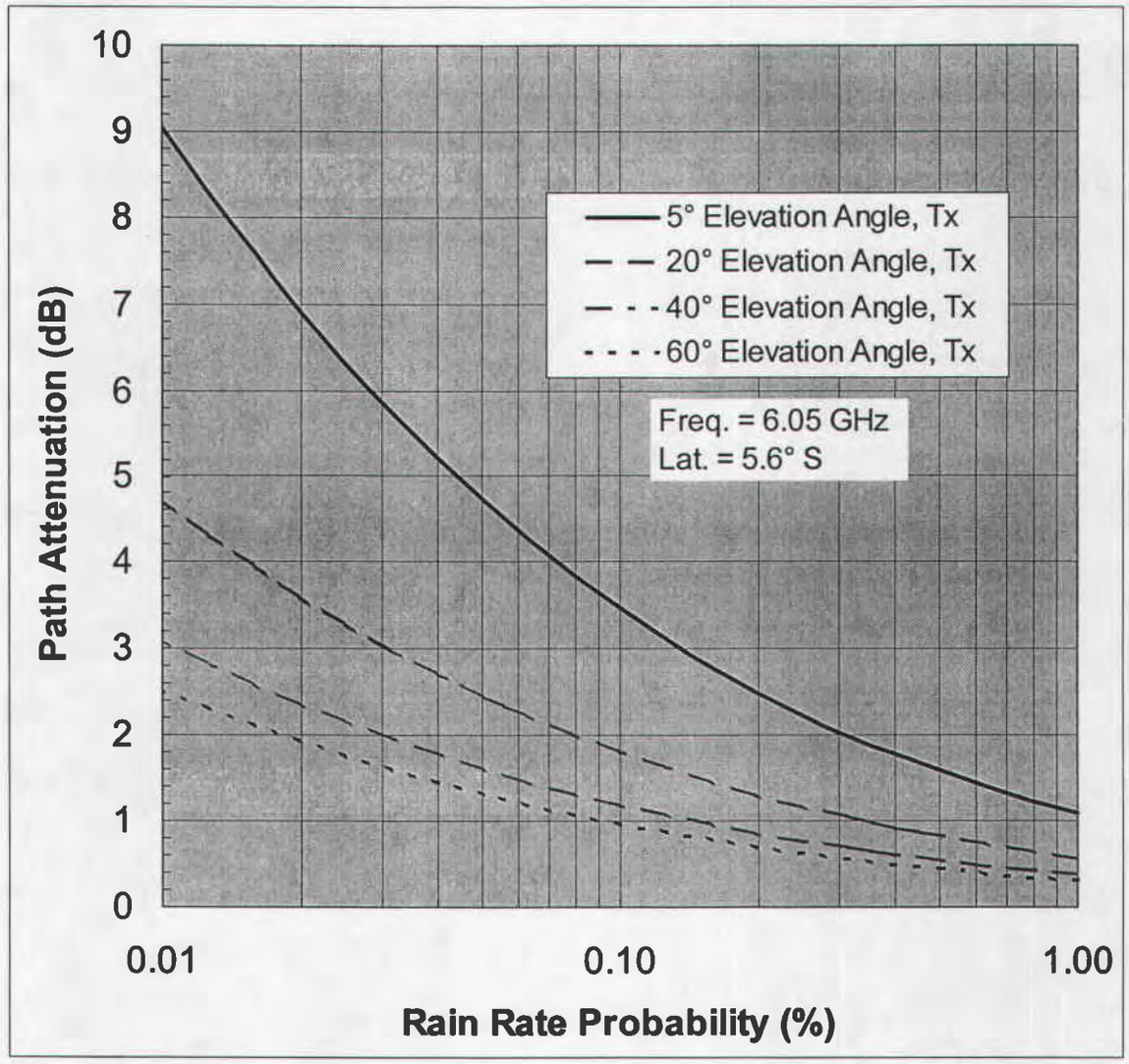


Figure A.1.3-3 Region N (Cabinda) Rain Attenuation for Various Elevations

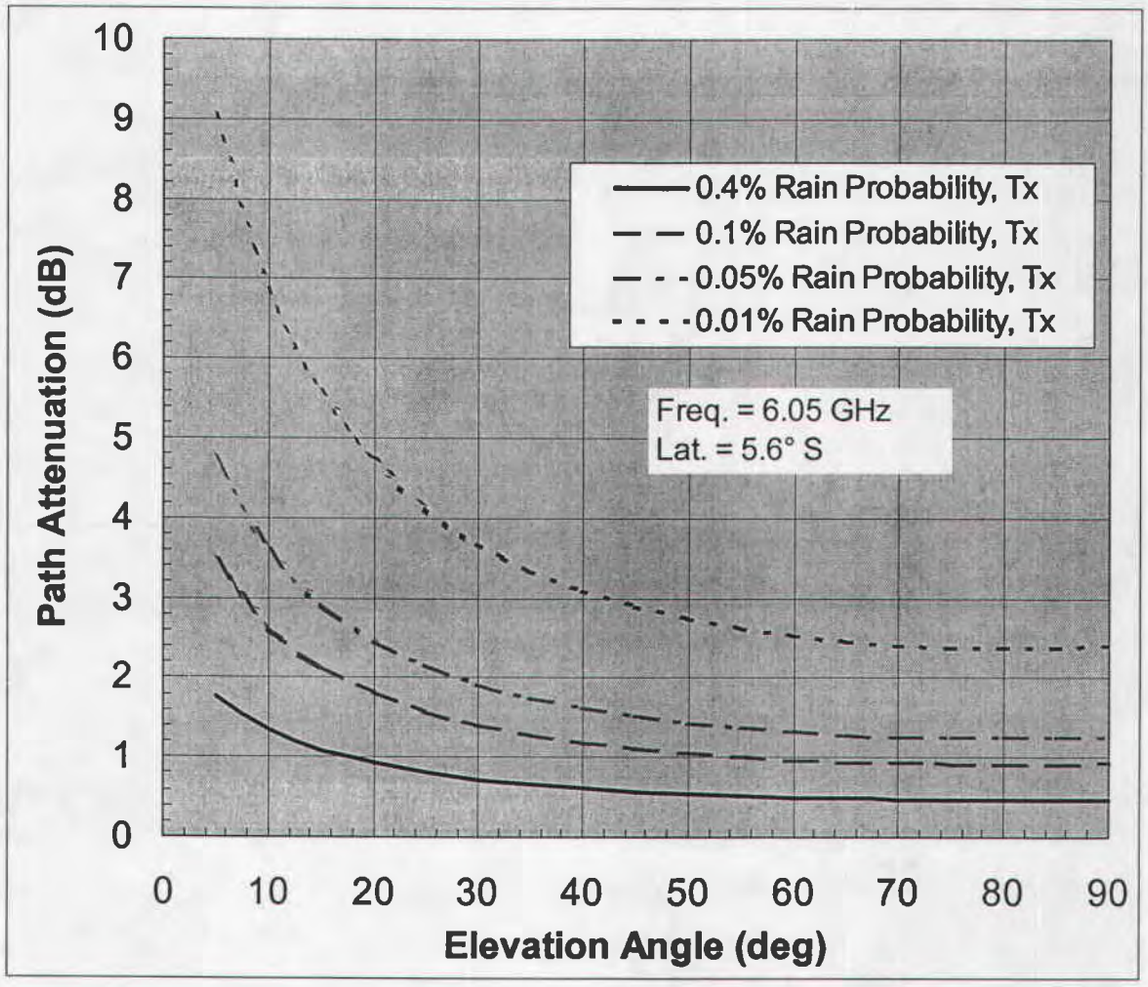


Figure A.1.3-4 Region N (Cabinda) Rain Attenuation for Various Rain Rate Probabilities

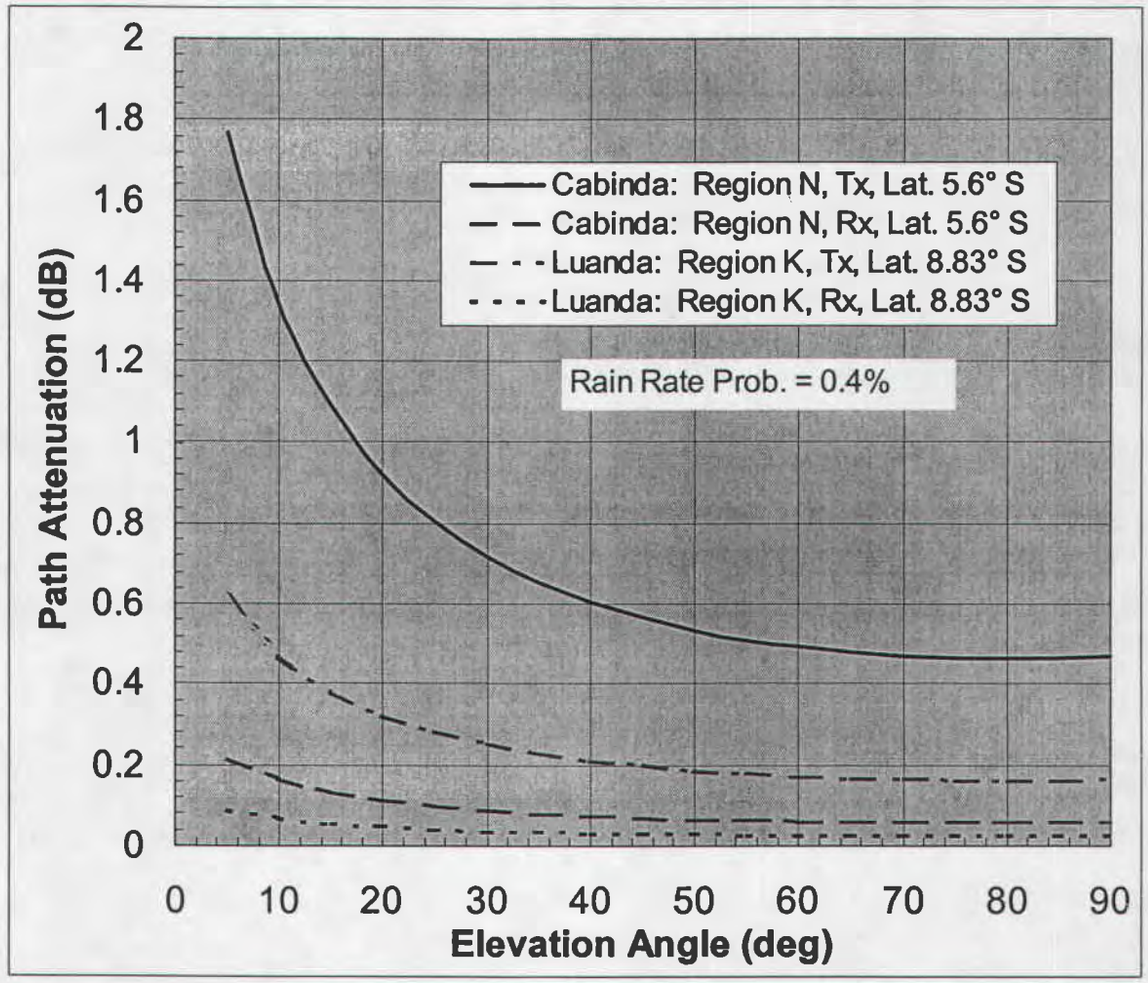


Figure A.1.3-5 Rain Attenuation as a Function of Elevation Angle

A.1.3.3 Intermodulation Interference

Intermodulation occurs when two or more carriers go through a non-linear device, such as an amplifier, especially an amplifier operating near saturation. Non-linear transfer characteristics of the amplifier create new frequencies which are combination sum and difference frequencies of the incident frequencies. These intermodulation products (IMP) are the result of the non-linear device's transfer function squaring (or higher power) a voltage that consists of more than one frequency. The math involved shows that this squaring produces new frequencies related to the input frequencies. The amplitude of an intermodulation product is proportional to the product of the amplitudes of the component frequencies. The frequency of the intermodulation product is a combination of the sums and differences of the component frequencies. The "order" of an intermodulation product is determined by the number of mixing frequencies involved. If a single frequency is involved twice, it gets counted twice when determining the order. If there are three frequencies, A, B, and C, then the intermodulation product frequency A+B-C is a third order product. The intermodulation frequency 2xA-B is also a third order product. Intermodulation products of higher order than 3rd order are generally not of concern. The level of higher order intermodulation products are enough lower than the level of 3rd order products that they are not of concern if the 3rd order products are acceptable.

Only the intermodulation products that fall in-band are of concern. The third order intermodulation product A+B+C is at a frequency roughly three times the operating frequency. A frequency this high will probably not be propagated through the subsequent components, and if it is, it will not be received on the other end of the link. A look at the possible frequency combinations of even order intermodulation products will show that these also are always out-of-band and not of concern.

The third order intermodulation products of concern are the A+B-C products and the 2xA-B products. It can be shown from the math governing the process that the 2xA-B product is 6 dB lower than the A+B-C product.

In a satellite communication earth station, the high power amplifier (HPA) is the component that contributes most to intermodulation products. If an HPA is operated close to saturation, its transfer characteristic becomes more non-linear. This increases the power level of the intermodulation products. Further, a Traveling Wave Tube Amplifier (TWTA) tends to be more non-linear than a Solid State Power Amplifier (SSPA) and consequently has higher intermodulation products. If a single carrier goes through an HPA, there are no intermodulation products and the HPA can be operated close to saturation. But if there are multiple carriers going through the HPA, the HPA must be operated far enough below saturation to get into a fairly linear region of the HPA. This will insure that the intermodulation products generated do not cause significant interference to the system.

How far the amplifier is operated below saturation is called "backoff", Designers speak of "input backoff" (BOi) and "output backoff" (BOo). A plot of a typical HPA transfer curve is shown in Figure A.1.3-6. This plot shows input and output levels referenced to the saturation point. A straight line on the plot shows the extension of the linear portion of the HPA curve. Note that the gain of the HPA is less at saturation than in the linear region. In this plot, if saturation (0 dB input and output backoff) is taken as the gain reference, then at 8 dB input backoff, the output backoff is only 5 dB.

An analysis of intermodulation will give the level of a single IMP. If there are many carriers, the level of an individual intermodulation product is reduced somewhat. As the number of carriers increases, the level of each individual IMP decreases. However, if there are many carriers, there will be many IMP's falling on top of each other, causing an increase in the total IMP interference level at a particular frequency. If the carriers are equally spaced over a bandwidth, the number of superimposed IMP's at the edge of the band will be small, but will increase to many superimposed IMP's at the center of the band. For a very large number of carriers, the two opposing phenomena, IMP reduction vs. superimposing of multiple IMP's, will even each other out. This leads to a constant level in intermodulation interference as the number of carriers increases. For a system with many carriers, a worst case IMP interference level can be calculated from the output backoff of the HPA. This worst case IMP level is independent of the number of carriers and can be estimated from typical HPA characteristics.

A plot of carrier-to-interference ratio with many carriers for a typical TWTA and a typical SSPA is shown in Figure A.1.3-7 As shown in the plot, SSPA intermod performance is usually better than TWTA performance. When calculating link budgets, it is desired that the component of noise-interference due to intermodulation is small compared to the total noise. In order to obtain a bit error rate (BER) of 10^{-8} with QPSK modulation and rate ½ FEC, the Eb/No should be 7.6 dB, corresponding to a 6.8 dB C/N. For rate ¾ FEC, the Eb/No should be 9.2 dB, corresponding to a 10.2 dB C/N. The intermodulation plot shows that at 6 dB output backoff, a TWTA will have a 16 dB carrier-to-interference (C/I) ratio, which would have a small but noticeable affect on the total system C/N. When used for multicarrier operation, a TWTA should not have less than about 6 to 7 dB of output backoff. For an SSPA used in multicarrier operation, the output backoff should not be less than 4.5 to 5 dB.

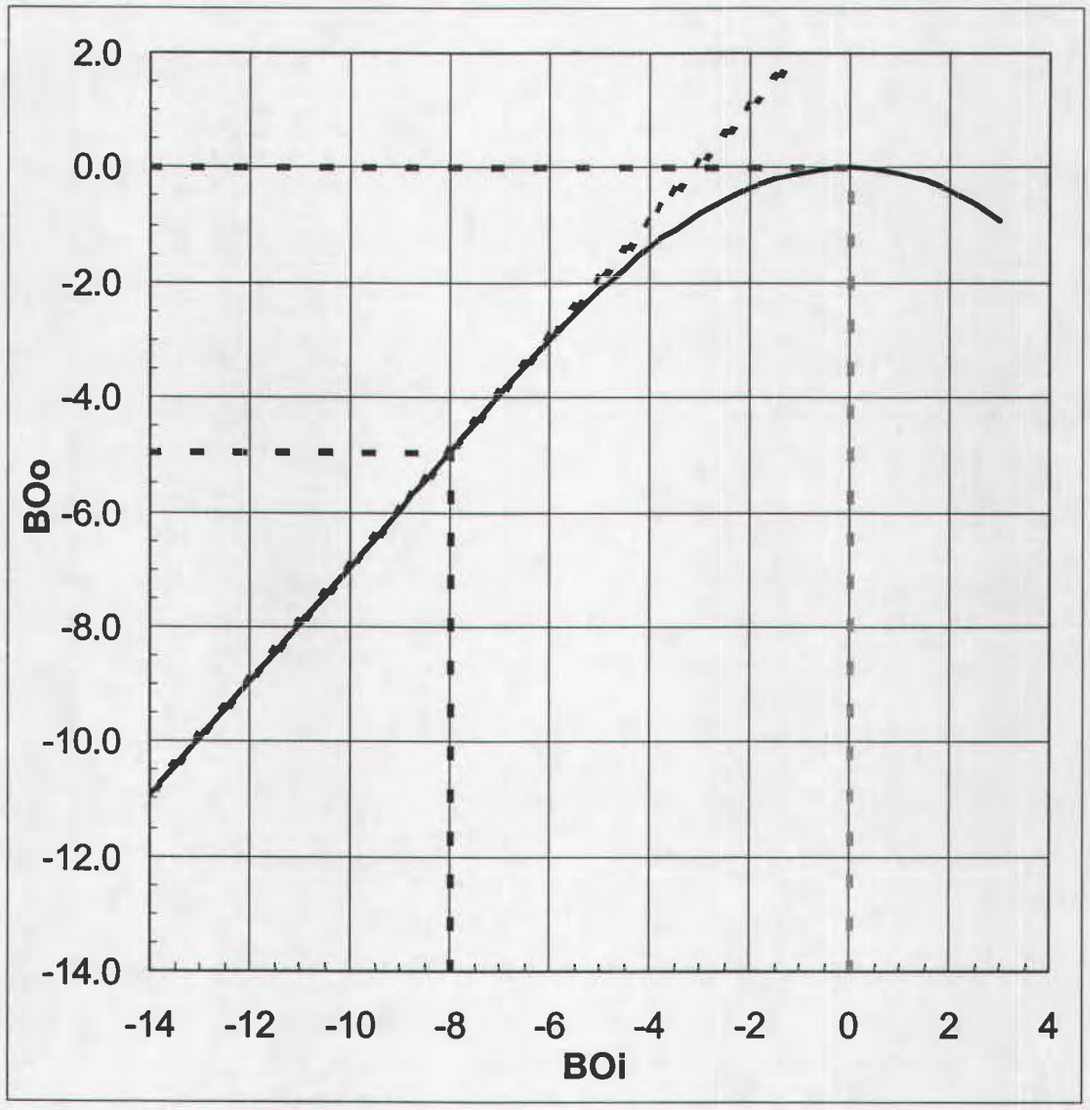


Figure A.1.3-6 Typical HPA Transfer Curve

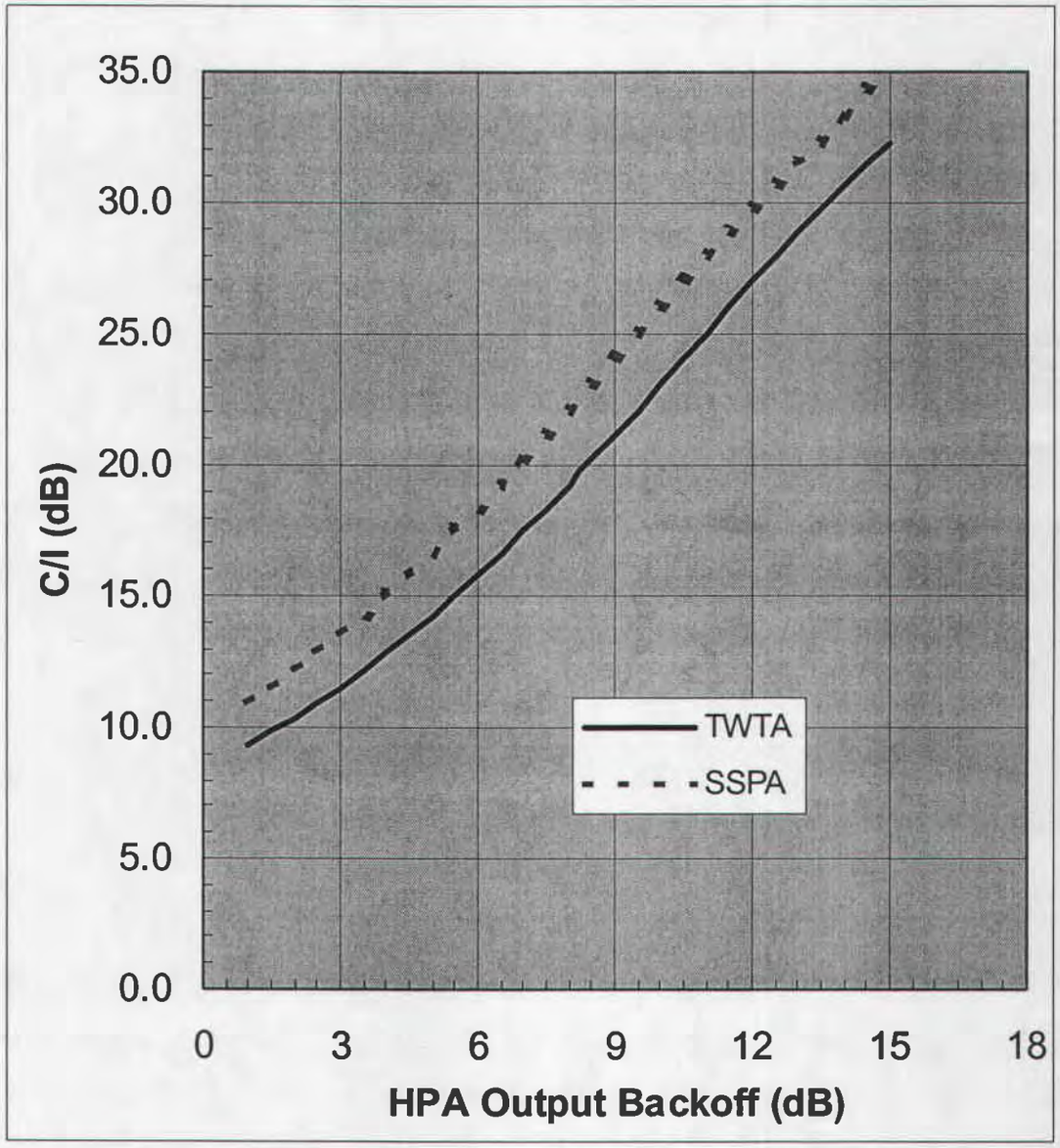


Figure A.1.3-7 Typical Intermodulation as a Function of HPA Output Backoff

A.1.3.4 Voice Activated Carrier and Activity Factor

In a Single Channel per Carrier (SCPC) Demand Assigned Multiple Access (DAMA) system, the modulators may be on continuously after a connection is made between two earth terminals. In this case a carrier is up continuously through the satellite in each direction. In this case, during a telephone conversation, a carrier is up continuously, through the satellite, from the time the user goes off hook until he goes back on hook. For example if there is a connection between Remote A and Cabinda City, there is a carrier going from Cabinda City through the satellite to Remote A and a carrier going from Remote A through the satellite to Cabinda City. These carriers are up continuously, taking satellite power and earth station HPA power from the time the talkers go off hook to the time they hang up (go on hook).

In an actual telephone conversation, there are many pauses during which information is not being sent in one direction or the other. The main example of this is that one person talks while the other listens. There are also pauses between sentences, between speakers, and during thinking moments. Statistically, each person talks only about 40% of the time that he is on the telephone. If, instead of the carrier being up continuously, it is on only during the time that a person is actually talking, then there is no satellite power being used for that carrier when the person is listening. An earth station modulator can be built such that it will activate the carrier when it detects the presence of voice. This is called voice activation or VOX. With VOX, during the periods of time when a user is listening to the person at the other end of the conversation, the carrier comes down. If there are only a few voice circuits in a system, there is no assurance that there will not be times of peak satellite power usage, when all speakers are talking at the same time. However, in a system with a large enough number of voice circuits to make a good statistical sample, it is a good statistical bet that there will never be a time when 100% of the people talk simultaneously. A parameter called "activity factor" is the maximum percent of people that are likely to be talking at the worst case end of the statistical curve. The statistical activity factor depends on the size of the system. For a 12 channel system, it is unlikely that more than 85% of the talkers will ever speak simultaneously. For systems with more than 60 voice channels, it is unlikely that more than 40% of the talkers will be speaking simultaneously. In a VOX system, this activity factor can be used to calculate the actual transmit power required by a satellite (this also applies to earth station HPA's).

In a large system with over 60 trunks, the activity factor resulting from VOX saves a lot of satellite power, making some power limited systems become bandwidth limited. If a system uses 2.4 meter antennas at one end of the link, or if some sites are in a poor part of the satellite footprint, a system may be power limited and extra power is needed to close the link. In these systems extra bandwidth must be leased to provide this extra power. If the modulators have VOX capabilities, the extra power requirement is reduced because when any given talker is listening, his carrier is not up, taking satellite power. Table A.1.3-1 below applies to a large, 1000 remote site VSAT system that we analyzed recently. This system uses 2.4 meter antennas at the remote sites. The table shows the number of trunks required for various call blocking probabilities and the bandwidth required with and without VOX. In this example, VOX reduced the required satellite power by about 40% and turned a power limited system into a bandwidth limited system.

Table A.1.3-1 Bandwidth for Various Call Blocking Probabilities for 2.4 Meter Antenna With and Without VOX

Call Blocking Probably	Required Trunks	Transponder Bandwidth required	
		Without VOX.	With VOX
3.6%	620	34.92 MHz	20.46 MHz
10%	571	32.16 MHz	18.84 MHz
20%	504	28.39 MHz	16.63 MHz
35%	408	22.98 MHz	13.46 MHz

If a system is bandwidth limited, there is no help from the activity factor, because bandwidth must be allocated for each talker, even while he is listening. Because of the 3.8 meter antennas at both ends of the links, the power/bandwidth ratio of the Cabinda VSAT is unity, and there is no bandwidth reduction that can be accomplished by implementing VOX. However, the use of VOX will permit running the links at a higher transmitted power, which will increase the link margin.

A.1.4 Explanation of Link Budget Tables

The detailed link budget calculations are given in tables in Appendix A.2. Six sets of link budgets are given, one for each of the following cases

- Cabinda to Remote
- Remote to Remote
- Luanda to Remote
- Cabinda to Luanda – 60 Channels DAMA
- Cabinda to Luanda – 60 Channels 2 E1's compressed, 1 carrier
- Cabinda to Luanda – 60 Channels 2 E1's uncompressed, 2 carriers

As stated in Section A.1.3.1, the effects of a number of potential interference sources were considered, including adjacent channel interference for satellites at 2° spacing and satellite intermodulation. Calculations were done for clear sky with no pointing error, clear sky with maximum expected pointing error, and simultaneous uplink and downlink ITU-R rain fades with maximum pointing error. The BER threshold for these conditions was assumed to be 10^{-8}, 10^{-7}, and 10^{-6}, respectively.

Each link budget contains five pages and gives the budget for both outbound and inbound carriers. The first page gives system parameters (such as bit rate, modulation parameters, and bandwidths) and space segment parameters (such as satellite saturated and operating EIRP, satellite saturated and operating flux density, satellite G/T, etc.). The second page gives typical satellite interference values, including an estimate of the adjacent satellite interference caused by satellites located ±2° and ±4° on each side of operating satellite. The adjacent satellites are assumed to have the same EIRP capability as the desired satellite and the same operating backoff. The third page gives the earth station parameters, including look angles, antenna parameters, pointing errors, and LNA and HPA characteristics. The fourth page shows the actual link budget calculations, and includes the interference assumptions. The last page shows a summary of calculated C/N values for each contributor to the total C/N.

A.1.5 Transponder Utilization

There were two types of systems analyzed. The first was a system with eight voice channels at six remotes, four voice channels at four remotes, and 60 voice channels dedicated between Cabinda City and Luanda. There variations of this system were analyzed. A second system analyzed was a system with from two to eleven voice channels at the remotes, 14 voice channels at Cabinda City and Luanda, and no dedicated satellite traffic between Cabinda City and Luanda. This network was shown in Figure A.1.2-1.

A summary of the link analysis of the first type of system, including the 60 dedicated satellite channels between Cabinda City and Luanda, is shown in the three transponder utilization tables below. All three tables show analyses results for the Cabinda VSAT with additional DAMA links between Luanda and the Cabinda Province remotes and 60 channels of voice between Cabinda City and Luanda. The tables only differ in the way the 60 voice channels between Cabinda City and Luanda are configured. Table A.1.5 –1 shows these channels as SCPC DAMA channels. Table A.1.5-2 shows these channels in the form a single 512 kbps carrier containing two E1's compressed 8:1. Table A.1.5-3 shows these channels as two 2048 kbps, uncompressed E1 carriers.

These tables are broken up into four sections: per carrier bandwidth requirement, system bandwidth requirements, key parameters, and link margins. Each of the link types are shown; Cabinda City-to-remote, remote-to-remote, etc. The Cabinda City-to-remote Configuration 1 refers to the remote sites with 8 channels of voice. The Configuration 2 remotes are those with 4 channels. The link budgets for these two configurations are essentially the same link budgets, but overall bandwidth requirements are different and SSPA loading is different.

The Per Carrier Bandwidth Requirements section shows percent of transponder bandwidth and power required by each carrier, the actual occupied bandwidth including a 1.4 factor for bandwidth spacing, and the required bandwidth in terms of satellite power. The bandwidths are rounded up to the next 5 kilohertz increment. The last column in this section gives the power bandwidth ratio.

The second section in these tables shows the System Bandwidth Requirements. This includes bandwidth for all carriers of all sites. The number of carriers of each type at each site and the number of sites with each type of carrier are shown. The required bandwidth (occupied bandwidth plus guardband between carriers based on a 1.4 carrier spacing factor) is shown. The activity factor and the required power in terms of bandwidth is also shown. Required leased bandwidth is the largest of the columns "Required Bandwidth" and "Required Power in Terms of Bandwidth". A 10% bandwidth overhead is added on for control and call setup channels for the SCPC DAMA system.

The third section gives key parameters. This shows modulation parameters, antenna size, and HPA size and output backoff. The last column in this key parameter section shows HPA output backoff. The Cabinda City hub has a 40 Watt SSPA. For a system with 60 DAMA channels going between Cabinda City and Luanda, the output backoff is 6.3 dB (Table A.1.5-1). This is acceptable for an SSPA, but it shouldn't go much lower. Table A.1.5-2 is for a system with a single carrier between Cabinda City and Luanda carrying two 8:1 compressed E1's. For this configuration, the Cabinda City 40 Watt SSPA has a 5.4 dB output backoff. That output is marginally acceptable. Table A.1.5-3 covers the case with two uncompressed E1's between Cabinda City and Luanda. In this configuration, the Cabinda City SSPA had to be increased to

150 Watts power at the SSPA output waveguide flange. Even with the 150 Watt SSPA at Cabinda City, the output backoff was still only 5.7 dB.

The Luanda gateway terminal HPA output backoff does not include HPA power required for uses other than the Cabinda VSAT system.

The last section of the Transponder Utilization Tables show link margins for each link. Clear sky ideal conditions, Clear sky with maximum expended wind at both ends of the link, and 0.4% rain fade with maximum expected winds at both ends of the link are shown. It can be seen that all margins are greater than 1 dB.

The link margins shown were calculated without taking advantage of VOX and activity factor. The System Bandwidth Requirements section of Tables 1.5-1 through 1.5-3 show that link power could be increased without increasing required leased bandwidth. For example, for the Cabinda City-to-Remote case, required bandwidth for the six Configuration 1 sites is 1.44 MHz. The required satellite power in terms of bandwidth is only 0.576 MHz. The satellite power for these links could be increased by 0.576/1.44 or 4 dB, without increasing the power/bandwidth ratio beyond unity. This allows for an increase in link margin of up to 4 dB, which is a significant increase. However, increasing the link margins would mean increasing HPA power output. The HPA output backoff for the Cabinda City hub was shown to be at the low end of the acceptable. The link margins can not be increased without increasing the size of the Cabinda City HPA.

Bandwidth required for a network with the connection capacity shown in Figure A.1.2-1 was also calculated. This is shown in Table A.1.5-4. For this configuration it is assumed that there is no large number of dedicated channels between Cabinda City and Luanda that go over the satellite. Satellite bandwidth required for the network connections shown in Figure A.1.2-1 is 1.27 MHz.

Table A.1.5-1 Transponder Utilization for the Angola Domsat - 60 Channels SCPC DAMA between Cabinda City and Luanda

Satellite INTELSAT 801 Hemi 3-4

	Based on Full Transponder Bandwidth (MHz): 72													Key Parameters					Link Margin		
	Per Carrier BW Requirements					System BW Requirements															
Link	Percent BW	Percent Power	Required BW (MHz)	Required Power in Terms of BW (MHz)	Power - BW Ratio	Number Carriers	Number Sites Trans. Simultaneously	Required BW (MHz)	Carrier Activity Factor	Required Power in Terms of BW (MHz)	Required Leased BW (MHz)	Overhead for Call Setup and M&C (%)	Total Required Bandwidth (MHz)	FEC	Decoder	Antenna Diameter (m)	HPA Flange Power (W)	HPA Output Backoff (dB)	Clear Sky (dB)	Clear Sky, Wind (dB)	Rain, Wind (dB)
Cabinda City, Angola - Remote Link - Cfg 1							**Carrier Data Rate = 8 kbps**														
CBC to REM	0.021%	0.021%	0.015	0.015	1.00	48	1	0.720	0.40	0.288	0.720			1/2	Viterbi	3.8	40	6.34	1.9	1.6	1.4
REM to CBC	0.021%	0.021%	0.015	0.015	1.00	8	6	0.720	0.40	0.288	0.720			1/2	Viterbi	3.8	20	10.17	2.2	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**1.440**		**0.576**	**1.440**	10%	**1.584**								
Cabinda City, Angola - Remote Link - Cfg 2							**Carrier Data Rate = 8 kbps**														
CBC to REM	0.021%	0.021%	0.015	0.015	1.00	16	1	0.240	0.40	0.096	0.240			1/2	Viterbi	3.8	40	6.34	1.9	1.6	1.4
REM to CBC	0.021%	0.021%	0.015	0.015	1.00	4	4	0.240	0.40	0.096	0.240			1/2	Viterbi	3.8	20	13.31	2.3	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**0.480**		**0.192**	**0.480**	10%	**0.528**								
								1.920		**0.768**	**1.920**		**2.112**								
Remote (Angola, Cabinda) - Remote (Angola, Cabinda) Link							**Carrier Data Rate = 8 kbps**														
REM to REM	0.021%	0.021%	0.015	0.015	1.00	8	1	0.120	0.40	0.048	0.120			1/2	Viterbi	3.8	20	10.30	2.2	1.9	1.6
REM to REM	0.021%	0.021%	0.015	0.015	1.00	4	1	0.060	0.40	0.024	0.060			1/2	Viterbi	3.8	20	13.31	2.3	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**0.180**		**0.072**	**0.180**	10%	**0.198**								
Luanda, Angola - Remote (Angola, Cabinda) Link							**Carrier Data Rate = 8 kbps**														
LUA to REM	0.021%	0.021%	0.015	0.015	1.00	10	1	0.150	0.40	0.060	0.150			1/2	Viterbi	15.0	100	21.51	2.3	1.5	1.6
REM to LUA	0.021%	0.005%	0.015	0.004	0.25	1	10	0.150	0.40	0.015	0.150			1/2	Viterbi	3.8	20	10.17	4.2	3.8	3.7
Duplex Link	**0.042%**	**0.026%**	**0.030**	**0.019**	**0.63**			**0.300**		**0.075**	**0.300**	10%	**0.330**								
Luanda, Angola - Cabinda City, Angola Link							**Carrier Data Rate = 8 kbps**														
LUA to CBC	0.021%	0.021%	0.015	0.015	1.00	60	1	0.900	0.40	0.360	0.900			1/2	Viterbi	15.0	100	21.51	2.3	1.5	1.6
CBC to LUA	0.021%	0.005%	0.015	0.004	0.25	60	1	0.900	0.40	0.090	0.900			1/2	Viterbi	3.8	40	6.34	3.5	3.3	3.3
Duplex Link	**0.042%**	**0.026%**	**0.030**	**0.019**	**0.63**			**1.800**		**0.450**	**1.800**	10%	**1.980**								
												Total Network Bandwidth	**4.422**								

Table A.1.5-2 Transponder Utilization for the Angola Domsat – Two Compressed E1's as a Single Carrier between Cabinda City and Luanda

Satellite INTELSAT 801 Hemi 3-4

	Based on Full Transponder Bandwidth (MHz): 72																				
	Per Carrier BW Requirements					System BW Requirements								Key Parameters					Link Margin		
Link	Percent BW	Percent Power	Required BW (MHz)	Required Power in Terms of BW (MHz)	Power - BW Ratio	Number Carriers	Number Sites Trans. Simultaneously	Required BW (MHz)	Carrier Activity Factor	Required Power in Terms of BW (MHz)	Required Leased BW (MHz)	Overhead for Call Setup and M&C (%)	Total Required Bandwidth (MHz)	FEC	Decoder	Antenna Diameter (m)	HPA Flange Power (W)	HPA Output Backoff (dB)	Clear Sky (dB)	Clear Sky, Wind (dB)	Rain, Wind (dB)
Cabinda City, Angola - Remote Link - Cfg 1							**Carrier Data Rate = 8 kbps**														
CBC to REM	0.021%	0.021%	0.015	0.015	1.00	48	1	0.720	0.40	0.288	0.720			1/2	Viterbi	3.8	40	5.36	1.7	1.4	1.2
REM to CBC	0.021%	0.021%	0.015	0.015	1.00	8	6	0.720	0.40	0.288	0.720			1/2	Viterbi	3.8	20	10.17	2.2	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**1.440**		**0.576**	**1.440**	10%	**1.584**								
Cabinda City, Angola - Remote Link - Cfg 2							**Carrier Data Rate = 8 kbps**														
CBC to REM	0.021%	0.021%	0.015	0.015	1.00	16	1	0.240	0.40	0.096	0.240			1/2	Viterbi	3.8	40	5.36	1.7	1.4	1.2
REM to CBC	0.021%	0.021%	0.015	0.015	1.00	4	4	0.240	0.40	0.096	0.240			1/2	Viterbi	3.8	20	13.31	2.3	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**0.480**		**0.192**	**0.480**	10%	**0.528**								
								1.920		**0.768**	**1.920**		**2.112**								
Remote (Angola, Cabinda) - Remote (Angola, Cabinda) Link							**Carrier Data Rate = 8 kbps**														
REM to REM	0.021%	0.021%	0.015	0.015	1.00	8	1	0.120	0.40	0.048	0.120			1/2	Viterbi	3.8	20	10.30	2.2	1.9	1.6
REM to REM	0.021%	0.021%	0.015	0.015	1.00	4	1	0.060	0.40	0.024	0.060			1/2	Viterbi	3.8	20	13.31	2.3	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**0.180**		**0.072**	**0.180**	10%	**0.198**								
Luanda, Angola - Remote (Angola, Cabinda) Link							**Carrier Data Rate = 8 kbps**														
LUA to REM	0.021%	0.021%	0.015	0.015	1.00	10	1	0.150	0.40	0.060	0.150			1/2	Viterbi	15.0	100	18.63	2.3	1.5	1.6
REM to LUA	0.021%	0.005%	0.015	0.004	0.25	1	10	0.150	0.40	0.015	0.150			1/2	Viterbi	3.8	20	10.17	4.2	3.8	3.7
Duplex Link	**0.042%**	**0.026%**	**0.030**	**0.019**	**0.63**			**0.300**		**0.075**	**0.300**	10%	**0.330**								
Cabinda City, Angola - Luanda, Angola Link -							**Carrier Data Rate = 512 kbps**														
CBC to LUA	0.736%	0.293%	0.530	0.211	0.40	1	1	0.530	1.00	0.211	0.530			3/4	RS	3.8	40	5.36	4.8	4.1	3.7
LUA to CBC	0.736%	1.167%	0.530	0.840	1.58	1	1	0.530	1.00	0.840	0.530			3/4	RS	15.0	100	18.63	2.9	1.8	1.6
Duplex Link	**1.472%**	**1.460%**	**1.060**	**1.051**	**0.99**			**1.060**		**1.051**	**1.060**	0%	**1.060**								
												Total Network Bandwidth	**3.502**								

Table A.1.5-3 Transponder Utilization for the Angola Domsat - Two Uncompressed E1's between Cabinda City and Luanda
Satellite INTELSAT 801 Hemi 3-4

	Based on Full Transponder Bandwidth (MHz): 72																				
	Per Carrier BW Requirements					System BW Requirements								Key Parameters					Link Margin		
Link	Percent BW	Percent Power	Required BW (MHz)	Required Power in Terms of BW (MHz)	Power - BW Ratio	Number Carriers	Number Sites Trans. Simultaneously	Required BW (MHz)	Carrier Activity Factor	Required Power in Terms of BW (MHz)	Required Leased BW (MHz)	Overhead for Call Setup and M&C (%)	Total Required Bandwidth (MHz)	FEC	Decoder	Antenna Diameter (m)	HPA Flange Power (W)	HPA Output Backoff (dB)	Clear Sky (dB)	Clear Sky, Wind (dB)	Rain, Wind (dB)
Cabinda City, Angola - Remote Link - Cfg 1							**Carrier Data Rate = 8 kbps**														
CBC to REM	0.021%	0.021%	0.015	0.015	1.00	48	1	0.720	0.40	0.288	0.720			1/2	Viterbi	3.8	150	5.71	1.8	1.5	1.3
REM to CBC	0.021%	0.021%	0.015	0.015	1.00	8	6	0.720	0.40	0.288	0.720			1/2	Viterbi	3.8	20	10.17	2.2	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**1.440**		**0.576**	**1.440**	10%	**1.584**								
Cabinda City, Angola - Remote Link - Cfg 2							**Carrier Data Rate = 8 kbps**														
CBC to REM	0.021%	0.021%	0.015	0.015	1.00	16	1	0.240	0.40	0.096	0.240			1/2	Viterbi	3.8	150	5.71	1.8	1.5	1.3
REM to CBC	0.021%	0.021%	0.015	0.015	1.00	4	4	0.240	0.40	0.096	0.240			1/2	Viterbi	3.8	20	13.31	2.3	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**0.480**		**0.192**	**0.480**	10%	**0.528**								
								1.920		**0.768**	**1.920**		**2.112**								
Remote (Angola, Cabinda) - Remote (Angola, Cabinda) Link							**Carrier Data Rate = 8 kbps**														
REM to REM	0.021%	0.021%	0.015	0.015	1.00	8	1	0.120	0.40	0.048	0.120			1/2	Viterbi	3.8	20	10.30	2.2	1.9	1.6
REM to REM	0.021%	0.021%	0.015	0.015	1.00	4	1	0.060	0.40	0.024	0.060			1/2	Viterbi	3.8	20	13.31	2.3	1.9	1.6
Duplex Link	**0.042%**	**0.042%**	**0.030**	**0.030**	**1.00**			**0.180**		**0.072**	**0.180**	10%	**0.198**								
Luanda, Angola - Remote (Angola, Cabinda) Link							**Carrier Data Rate = 8 kbps**														
LUA to REM	0.021%	0.021%	0.015	0.015	1.00	10	1	0.150	0.40	0.060	0.150			1/2	Viterbi	15.0	100	10.24	2.2	1.4	1.5
REM to LUA	0.021%	0.005%	0.015	0.004	0.25	1	10	0.150	0.40	0.015	0.150			1/2	Viterbi	3.8	20	10.17	4.2	3.8	3.7
Duplex Link	**0.042%**	**0.026%**	**0.030**	**0.019**	**0.63**			**0.300**		**0.075**	**0.300**	10%	**0.330**								
Cabinda City, Angola - Luanda, Angola Link -							**Carrier Data Rate = 2048 kbps**														
CBC to LUA	2.924%	1.164%	2.105	0.838	0.40	2	1	4.210	1.00	1.676	4.210			3/4	RS	3.8	150	5.71	4.5	3.9	3.4
LUA to CBC	2.924%	4.634%	2.105	3.336	1.58	2	1	4.210	1.00	6.672	4.210			3/4	RS	15.0	100	10.24	2.9	1.8	1.5
Duplex Link	**5.847%**	**5.798%**	**4.210**	**4.174**	**0.99**			**8.420**		**8.348**	**8.420**	0%	**8.420**								
												Total Network Bandwidth	**10.86**								

Table A.1.5-4 Angolan Network Connection Capacity

Earth Station	Bandwidth per Carrier (MHz)	Initial Capacity: Channels	Full Load User Bandwidth (MHz)	Overhead for Call Setup and M&C	Total Required Bandwidth (MHz) - Initial System
Dinge	0.015	2	0.030	10%	0.033
Necuto	0.015	2	0.030	10%	0.033
Belize	0.015	8	0.120	10%	0.132
Miconje	0.015	2	0.030	10%	0.033
Buco Zau	0.015	11	0.165	10%	0.182
Massabi	0.015	4	0.060	10%	0.066
Malembo	0.015	3	0.045	10%	0.050
Luali	0.015	4	0.060	10%	0.066
Cacongo	0.015	11	0.165	10%	0.182
Tando Zinze	0.015	2	0.030	10%	0.033
Gateway Cabinda	0.015	14	0.210	10%	0.231
Hub Luanda	0.015	14	0.210	10%	0.231
System Total		77	1.155		1.271

A.1.6 Traffic Models

The design of an inter-city communications system must take into account the amount of traffic it will carry and how this traffic will vary throughout the day. The offered traffic may be very heavy in the middle of the day but very light in the middle of the night. If a system is designed to handle all offered traffic during the busiest hour of the day, there will be much equipment that is not used during the slack times. If a system is designed for a moderately active time of day, it will be overloaded during the busy hour and many offered calls will be blocked due to insufficient trunks to carry the traffic. The system design and hardware complexity depends on the amount of traffic and the acceptable rate of blocked calls during the busy hour. Because of the DAMA in the Cabinda VSAT, a system with a hundred remotes does not require a hundred trunks to the satellite. In a star system, one modem is required at the hub for each trunk through the satellite. The number of satellite trunks required depends on the acceptable rate of blocked calls during the busy hour. Alternately, for a given number of trunks through the satellite (and the number of modems at the hub) the number of subscribers the system can serve depends on the acceptable rate of blocked calls during the busy hour.

A sample traffic model was developed for this system. It was assumed for the Cabinda VSAT that there are 64 modems (and satellite trunks) at the Cabinda City hub. There are 10 remote sites. In one model it was assumed that six of them have eight modems each and four remote sites have four modems each. These total 64 lines. If the hub has 64 modems, then there are 64 trunks through the satellite. From the hub's perspective, there could be more than 64 users (sources) connected to the switch serving the Cabinda City hub. These users could be telephones, but more likely would be PBX's or other switches. Each trunk has the capacity of 60 call minutes during an hour. An Erlang is a call hour or 60 call minutes. If during the busy hour, an average of five calls originate (or terminate) from each of the user (source) lines, and each call lasts an average of six minutes, then there are 30 call minutes or 0.5 Erlangs from that user.

If each remote-to-hub channel is treated as a trunk serving remote subscribers, there are 64 trunks into Cabinda City. If remote sites are connected to PBX's, Then there are more than 64 users (or sources) with access to the satellite trunks. The probability of call blocking for various numbers of calls per hour can be calculated. In telephone traffic theory, there are statistical formulas that relate the probability that a call will be blocked based to the number of sources, total traffic in Erlangs and number of servers (trunks, or in this case modems). One traffic formula is the Erlang B. The Erlang B formula was derived with the assumption that there are infinite sources, equal traffic density per source, and that lost calls are cleared, not held. Another traffic formula, the Engset uses the same assumptions, except that a finite number of sources are assumed. Call blocking probabilities are shown plotted against the number of sources in Figure A.1.6-1. These are for 7, 5, and 3 calls per hour per source. Both the Erlang B and the Engset calculations are shown. Actually the Erlang B calculations are not a function of the number of sources; an infinite number of sources are assumed for the equations. For the purpose of these plots, Erlangs were calculated from the number of sources, the number of calls per hour per source, and assuming an average length of six minutes per call. Then the Erlang B probabilities were calculated from the Erlangs of traffic. From the plots, it can be seen that the Erlang B calculations and the Engset calculations converge for larger number of sources. With the 64 modems at the Cabinda hub, almost 200 sources can be supported with a 5% call blocking probability at the rate of 3 calls per source per hour and 6 minutes per call. At 7 calls per source, only 88 sources can be supported during the busy hour, with 5% probability of call blocking.

A similar analysis was done, treating a remote site with eight modems (and satellite trunks) as a network node with eight trunks to Cabinda City. The results are shown in Figure A.1.6-2. Both Engset and Erlang B calculations were used. The Erlang B formula assumes that there are an infinite number of sources; it's inputs are Erlangs and the number of trunks. The call blocking probabilities are plotted against a finite number of sources. For the Erlang B formula, this was done by assuming an average call length of 6 minutes, calculating Erlangs for various numbers of sources and various busy hour calls per hour per source. The Engset formula, which assumes a finite number of sources, is more appropriate for these assumptions. Consider a case where 15 sources are connected to a switch serving the eight trunks. The chart shows that if there are three calls per hour, the call blocking probability is 2.5%. If there are 5 calls per hour for the 15 sources, then the call blocking probability increases to 17.5%.

This analysis was repeated for the hubs in the model presented in Figure A.1.2-1. In this case it was assumed that both hubs have 14 modems and 14 trunks. The results are given in Figure A.1.6-3. This chart shows that if there are three calls per hour and 30 sources, the call blocking probability is between 2%. If there are 5 calls per hour for 31 sources, then the call blocking probability increases to 20%.

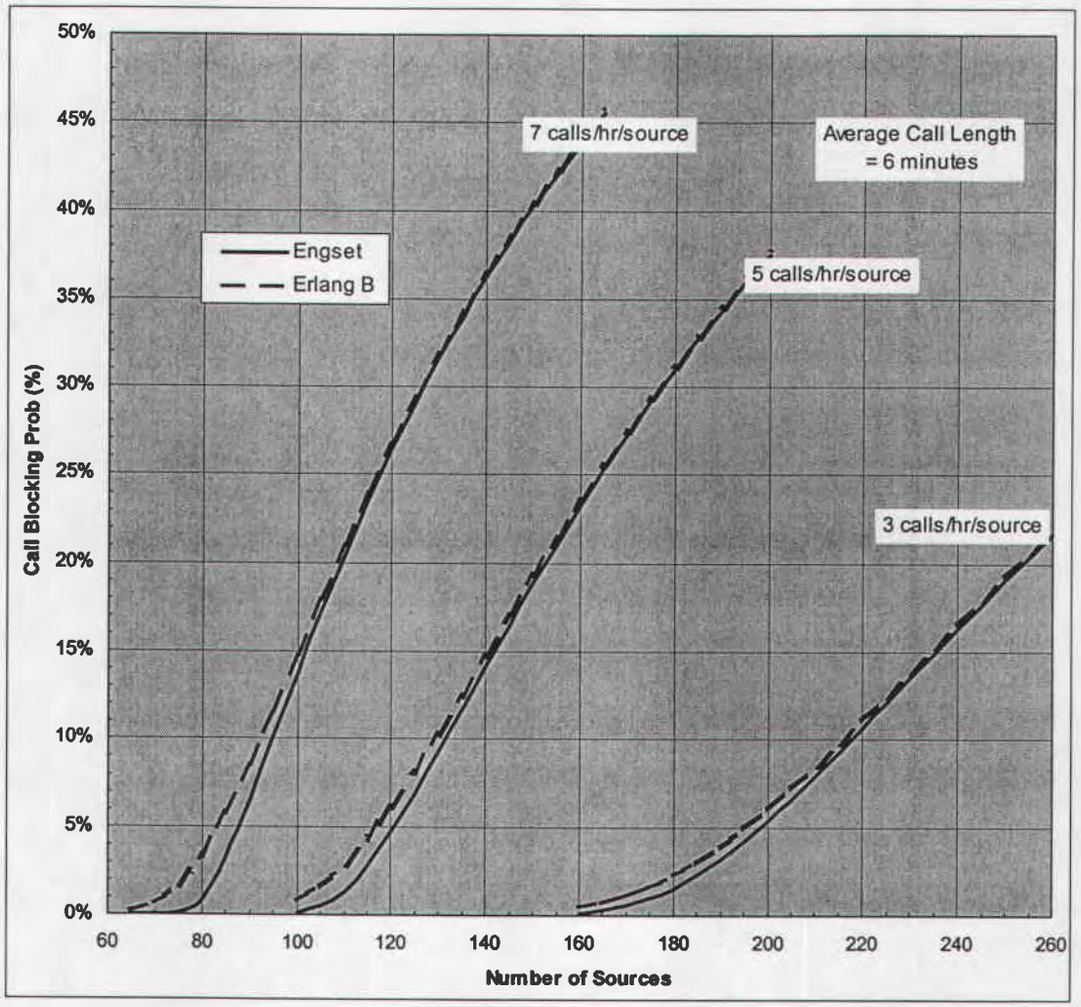


Figure A.1.6-1 Call Blocking Probability

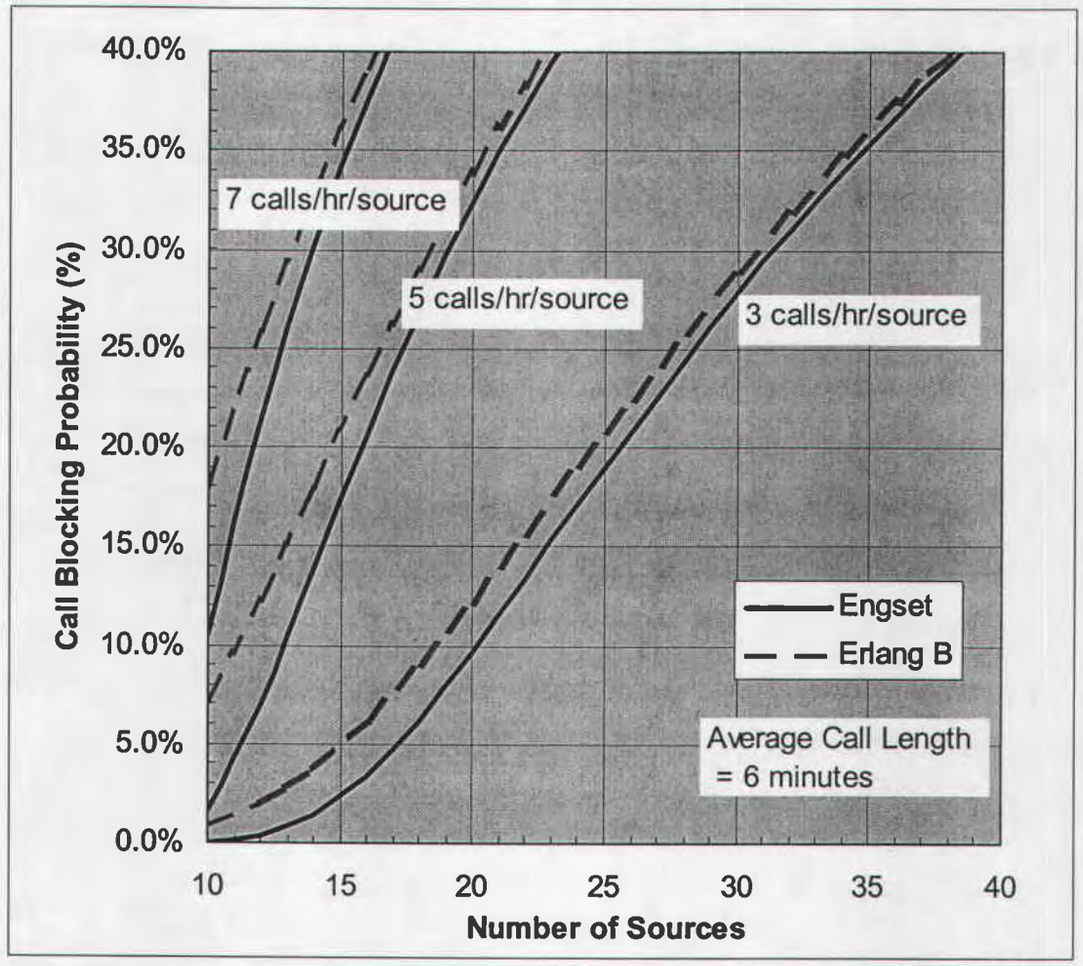


Figure A.1.6-2 Call Blocking Probabilities for Remotes with Eight Trunks

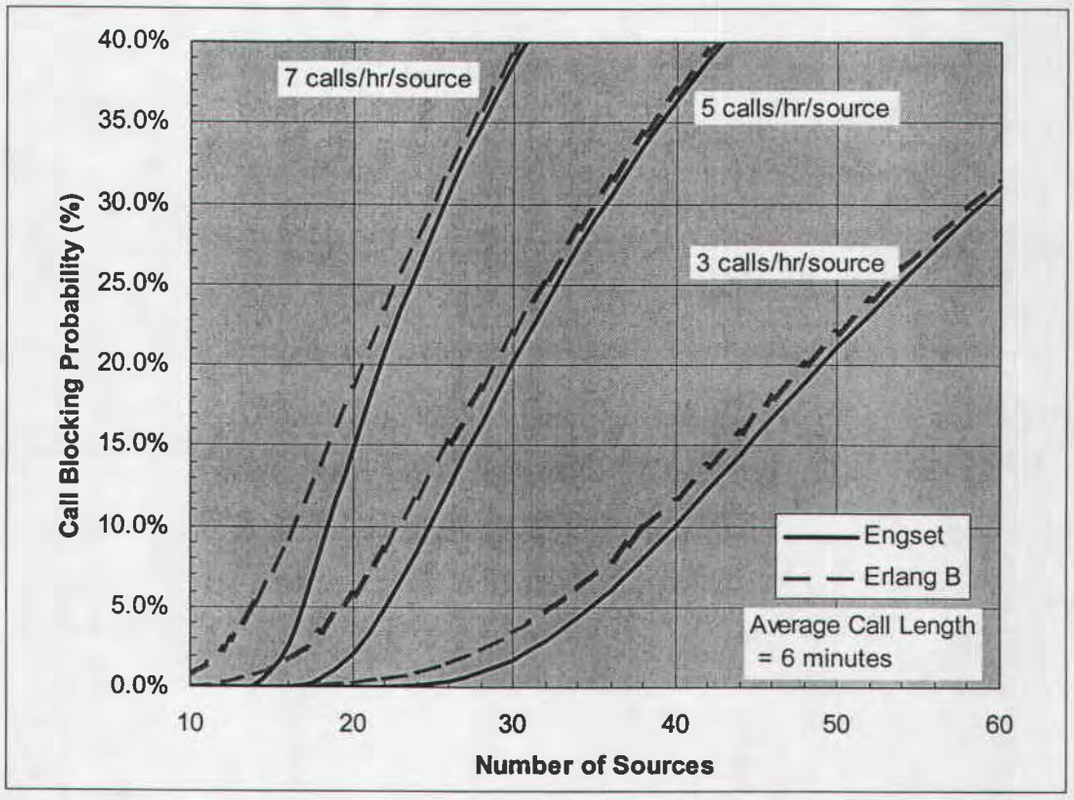


Figure A.1.6-3 Call Blocking Probabilities for Hubs with Fourteen Trunks

A.2 Link Budgets

Link budgets are given in the following Tables. The following link budgets are provided:

Section A.2.1	Cabinda City to Remote
Section A.2.2	Remote to Remote
Section A.2.3	Luanda to Remote
Section A.2.4	Cabinda City to Luanda – 60 Channels DAMA
Section A.2.5	Cabinda City to Luanda – 60 Channels, 2 E1's Compressed, 1 Carrier
Section A.2.6	Cabinda City to Luanda – 60 Channels, 2 E1's Uncompressed, 2 Carriers

A.2.1 Link Budgets, Cabinda City to Remote

Link Budgets
Cabinda City to Remote
C-Band
INTELSAT 801 Satellite

1.01	**LINK BUDGET CALCULATION**							Ant (M)
1.02			**Site 1**	**Cabinda City, Angola**				3.80
1.03	**INTELSAT 801 Hemi 3-4**			CBC				
1.04	**Angola - Cabinda Domsat**		**Site 2**	**Remote (Angola, Cabinda)**				3.80
1.05	**8/8 kbps Carriers**			REM-AC				
1.06	**0.4% Rain Fade Probability**		Satellite Longitude: -31.5			Band: C		
1.07	Originating Site		Cabinda City, Angola			Remote (Angola, Cabinda)		
1.08	Originating Site Abbreviation		CBC			REM-AC		
1.09	Destination Site		Remote (Angola, Cabinda)			Cabinda City, Angola		
1.10	Destination Site Abbreviation		REM-AC			CBC		
1.11			Clear	Clear	0.4%	Clear	Clear	0.4%
1.12	**SYSTEM PARAMETERS:**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
1.13	Uplink Freq	GHz	6.050			6.050		
1.14	Downlink Freq	GHz	3.825			3.825		
1.15	Information bit rate	kbps	8			8		
1.16	Information bit rate + overhead	kbps	8.0			8.0		
1.17	Coding rate		1/2			1/2		
1.18	Modulation type (BPSK/QPSK)		QPSK			QPSK		
1.19	Demodulator decoder type		Viterbi			Viterbi		
1.20	Carrier spacing factor (x SR)		1.40			1.40		
1.21	Necessary bandwidth factor (x SR)		1.20			1.20		
1.22	Modulation bit/symbol		2.0			2.0		
1.23	Transmission symbol rate	ksps	8.0			8.0		
1.24	Allocated Bandwidth	MHz	0.015			0.015		
1.25	Occupied Bandwidth	MHz	0.010			0.010		
1.26		dB-Hz	39.8			39.8		
1.27	Desired BER		1.0E-8	1.0E-7	1.0E-6	1.0E-8	1.0E-7	1.0E-6
1.28	Req Eb/No w coding	dB	7.6	7.1	6.5	7.6	7.1	6.5
1.29	Required C/No with coding	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
1.30	Required C/N with coding	dB	6.8	6.3	5.7	6.8	6.3	5.7
1.31	**SATELLITE PARAMETERS:**							
1.32	Satellite Longitude (+ = E, - = W)	deg	-31.5			-31.5		
1.33	Transponder Number		Hemi 3-4			Hemi 3-4		
1.34	Transponder BW	MHz	72.0			72.0		
1.35	Saturated EIRP toward Destination	dBW	36.5			36.5		
1.36	Gain Step above Nominal	dB	-11.1			-11.1		
1.37	Nom Sat. Flux Density toward Orig. Site	dBW/sq M	-91.0			-91.0		
1.38	G/T toward Origination Site	dB/K	-6.0			-6.0		
1.39			Available:			Available:		
1.40	Available Transponder Bandwidth	MHz	72.0			72.0		
1.41	Carrier Allocated Bandwidth	MHz	0.02			0.02		
1.42	Dest. EIRP Power Above Even Distribution	dB	0.0			0.0		
1.43	Available Saturated EIRP	dBW	-0.3			-0.3		
1.44	Available Saturated Flux Density	dBW/sq M	-116.7			-116.7		
1.45	Transponder Multicarrier Output Backoff	dB	5.5			5.5		
1.46	Transponder Multicarrier Input Backoff	dB	7.4			7.4		
1.47	Available Operating EIRP	dBW	-5.8			-5.8		
1.48	Available Operating Flux Density	dBW/sq M	-124.1			-124.1		
1.49	G/T	dB/K	-6.0			-6.0		
1.50	Transponder Gain	dB	155.4			155.4		
1.51	Station Keeping (NS & EW)	deg	0.05			0.05		

2.01	**SATELLITE INTERFERENCE BUDGETS**							
2.02								
2.03	Originating Site		Cabinda City, Angola			Remote (Angola, Cabinda)		
2.04	Originating Site Abbreviation		CBC			REM-AC		
2.05	Destination Site		Remote (Angola, Cabinda)			Cabinda City, Angola		
2.06	Destination Site Abbreviation		REM-AC			CBC		
2.07	**INTERFERENCE AT SATELLITE**		Clear	Clear	0.4%	Clear	Clear	0.4%
2.08	**INTELSAT 801 Hemi 3-4**		Sky	Pt error	Rain	Sky	Pt error	Rain
2.09	IMo	dB/Hz	-71.6			-71.6		
2.10	Io adj co-pol xpndr	dB/Hz	-80.6			-80.6		
2.11	Io xpol up	dB/Hz	-77.6			-77.6		
2.12	Io xpol down	dB/Hz	-77.6			-77.6		
2.13	Total Io (at satellite)	dBW/Hz	-69.5			-69.5		
2.14	**Adjacent Satellite Interference**							
2.15	Satellite Spacing	deg	2.00					
2.16	Adjacent Satellite BOo	dB	5.00					
2.17	Adjacent Satellite #1							
2.18	Satellite							
2.19	Satellite Longitude (+ = E, - = W)	deg	-29.50			-29.50		
2.20	El to Satellite #1	deg	41.46			41.51		
2.21	Az to Satellite #1	deg	275.56			276.24		
2.22	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.23	Bandwidth	MHz	72.00			72.00		
2.24	Output Backoff	dB	5.00			5.00		
2.25	Angular distance	deg	2.22			2.22		
2.26	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.35			20.35		
2.27	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.6	-222.9	-222.9	-222.6	-222.9	-222.9
2.28	Adjacent Satellite #2							
2.29	Satellite							
2.30	Satellite Longitude (+ = E, - = W)	deg	-27.50			-27.50		
2.31	El to Satellite #2	deg	43.67			43.71		
2.32	Az to Satellite #2	deg	275.96			276.70		
2.33	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.34	Bandwidth	MHz	72.00			72.00		
2.35	Output Backoff	dB	5.00			5.00		
2.36	Angular distance	deg	4.45			4.45		
2.37	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.80			12.80		
2.38	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.1	-230.4	-230.5	-230.1	-230.4	-230.5
2.39	Adjacent Satellite #3							
2.40	Satellite							
2.41	Satellite Longitude (+ = E, - = W)	deg	-33.50			-33.50		
2.42	El to Satellite #3	deg	37.08			37.13		
2.43	Az to Satellite #3	deg	274.84			275.43		
2.44	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.45	Bandwidth	MHz	72.00			72.00		
2.46	Output Backoff	dB	5.00			5.00		
2.47	Angular distance	deg	2.21			2.21		
2.48	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.41			20.41		
2.49	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.5	-222.8	-222.9	-222.5	-222.8	-222.9
2.50	Adjacent Satellite #4							
2.51	Satellite							
2.52	Satellite Longitude (+ = E, - = W)	deg	-35.50			-35.50		
2.53	El to Satellite #4	deg	34.90			34.95		
2.54	Az to Satellite #4	deg	274.51			275.07		
2.55	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.56	Bandwidth	MHz	72.00			72.00		
2.57	Output Backoff	dB	5.00			5.00		
2.58	Angular distance	deg	4.40			4.40		
2.59	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.91			12.91		
2.60	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.0	-230.3	-230.4	-230.0	-230.3	-230.4
2.61	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.1	-219.2

3.01	**EARTH STATION PARAMETERS:**							
3.02	**Angola - Cabinda Domsat Cfg 1**	Band: C	INTELSAT 801 Hemi 3-4					
3.03	**8/8 kbps Carriers**		Clear	Clear	0.4%	Clear	Clear	0.4%
3.04	**0.4% Rain Fade Probability**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
3.05			Site 1			Site 2		
3.06	Site Location		Cabinda City, Angola			Remote (Angola, Cabinda)		
3.07	Site Abbreviation		CBC			REM-AC		
3.08	ES Latitude	deg	-5.60			-5.00		
3.09	ES Longitude	deg	12.20			12.30		
3.10	Elevation	deg	39.31			39.27		
3.11	Azimuth	deg	275.82			275.19		
3.12	Slant Range	km	37835			37839		
3.13	Antenna Type		P-3.8			P-3.8		
3.14	Antenna Diameter	M	3.80			3.80		
3.15	Antenna Transmit Gain	dBi	45.83			45.83		
3.16	Antenna Receive Gain	dBi	41.86			41.86		
3.17	Antenna Noise Temperature	dB-K	22.07			22.07		
3.18	Antenna Transmit Beamwidth	deg	0.89			0.89		
3.19	Antenna Receive Beamwidth	deg	1.40			1.40		
3.20	Antenna Tracking		no			no		
3.21	Satellite Drift Error (or Tracking Error)	deg	0.071			0.071		
3.22	Wind Pointing Error (30 mph gust to 45)	deg	0.140			0.140		
3.23	Total Pointing Error	deg	0.211			0.211		
3.24	Transmit Pointing Loss due to Sat. Drift	dB	0.08			0.08		
3.25	Transmit Pointing Loss due to Wind	dB	0.60			0.60		
3.26	Transmit Pointing Loss	dB	0.67			0.67		
3.27	Receive Pointing Loss	dB	0.27			0.27		
3.28	Uplink Power Control		no			no		
3.29	Max UPC	dB	0.00			0.00		
3.30	Rain Model		CCIR			CCIR		
3.31	Rain Zone		N			N		
3.32	Rain Probability	%	0.40			0.40		
3.33	Uplink Rain Attenuation	dB	0.61			0.61		
3.34	Downlink Rain Attenuation	dB	0.07			0.07		
3.35	Loss Antenna to LNA	dB	0.15			0.15		
3.36	Noise due to Ant/LNA Loss	K	10.18			10.18		
3.37	LNC Noise Temperature	K	45.00			45.00		
3.38	Electronics Noise Temperature	K	1.00			1.00		
3.39	Rain Contribution to Sys Temp	K	0.00	0.00	4.54	0.00	0.00	4.54
3.40	System Noise Temperature	K	77.50	77.50	81.89	77.51	77.51	81.90
3.41		dB-K	18.89	18.89	19.13	18.89	18.89	19.13
3.42	G/T	dB/K	22.81	22.81	22.57	22.81	22.81	22.57
3.43	Required C/kT	dB-Hz	46.63	46.13	45.53	46.63	46.13	45.53
3.44	HPA Type (TWTA or SSPA)		SSPA			SSPA		
3.45	Saturated TWTA Output Power	dBW	16.02			13.01		
3.46	(SSPA @ 1 dB Gain Comp)	Watts	40.00			20.00		
3.47	Loss HPA to Antenna	dB	2.00			1.00		

4.01	**LINK BUDGET CALCULATION**		**Satellite Longitude: -31.5**					
4.02	**INTELSAT 801 Hemi 3-4**	Band: C	Carrier Size:			Carrier Size:		
4.03	**Angola - Cabinda Domsat Cfg 1**		8 kbps			8 kbps		
4.04	**8/8 kbps Carriers**	From	CBC Cabinda City, Angola			Remote (Angola, Cabinda)		
4.05	**0.4% Rain Fade Probability**	To	Remote (Angola, Cabinda)			CBC Cabinda City, Angola		
4.06			Clear	Clear	0.4%	Clear	Clear	0.4%
4.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
4.08	HPA Saturated Output Power	dBW	16.0			13.0		
4.09		Watts	40.0			20.0		
4.10	HPA output backoff	dB	5.4	5.4	5.4	10.2	10.2	10.2
4.11	Total Power out of HPA	dBW	10.7	10.7	10.7	2.8	2.8	2.8
4.12	Total number of carriers	#	48.0			8.0		
4.13	Activity Factor	#	0.4			1.0		
4.14	Number of active carriers	#	19.2			8.0		
4.15	Power per Carrier out of HPA	Watts	0.29	0.29	0.29	0.23	0.23	0.23
4.16		dBW	-5.3	-5.3	-5.3	-6.3	-6.3	-6.3
4.17	Loss to antenna	dB	2.0	2.0	2.0	1.0	1.0	1.0
4.18	Power per Carrier into Antenna	dBW	-7.3	-7.3	-7.3	-7.3	-7.3	-7.3
4.19	Antenna Transmit Gain	dBi	45.8	45.8	45.8	45.8	45.8	45.8
4.20	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	38.5	38.5	38.5
4.21	Earth Station C/IMo	dB-Hz	57.0	57.0	57.0	66.2	66.2	66.2
4.22	ES Adja. Ch Interference C/Ia	dB	43.0	43.0	43.0	56.5	56.5	56.5
4.23	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.24	ES C/Io (adj carrier)	dB-Hz	82.8	82.8	82.8	96.3	96.3	96.3
4.25	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	38.5	38.5	38.5
4.26	Uplink Free Space Loss	dB	199.6	199.6	199.6	199.6	199.64	199.64
4.27	Uplink Pointing Loss due to Sat. Drift	dB	0.0	0.1	0.1	0.0	0.1	0.1
4.28	Uplink Pointing Loss due to Wind	dB	0.0	0.6	0.6	0.0	0.6	0.6
4.29	Uplink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.30	Uplink Rain Attenuation	dB	0.0	0.0	0.6	0.0	0.0	0.6
4.31	Receive Isotropic Pwr/Carrier	dBW	-161.2	-161.9	-162.5	-161.2	-161.9	-162.5
4.32	Satellite G/T	dB/K	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
4.33	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.34	Uplink C/kT (C/No)	dB-Hz	61.4	60.7	60.1	61.4	60.7	60.1
4.35	Transponder EIRP/Carrier	dBW	-5.8	-6.5	-7.09	-5.8	-6.49	-7.09
4.36	Satellite Output Io	dB/Hz	-69.5	-69.5	-69.5	-69.5	-69.5	-69.5
4.37	Satellite C/Io	dB-Hz	63.6	63.0	62.4	63.6	63.0	62.4
4.38	Sat. Adja. Ch Interference C/Ia	dB	34.0	34.0	34.0	34.0	34.0	34.0
4.39	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.40	Satellite C/Io (adj carrier)	dB-Hz	73.8	73.8	73.8	73.8	73.8	73.8
4.41	Receive Isotropic Pwr/Carrier	dBW	-161.2	-161.9	-162.5	-161.2	-161.9	-162.5
4.42	Transponder Gain	dB	155.4	155.4	155.4	155.4	155.4	155.4
4.43	Transponder EIRP/Carrier	dBW	-5.8	-6.5	-7.1	-5.8	-6.5	-7.1
4.44	Downlink Rain Attenuation	dB	0.0	0.0	0.1	0.0	0.0	0.1
4.45	Downlink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.46	Downlink Pointing Loss	dB	0.0	0.3	0.3	0.0	0.3	0.3
4.47	Downlink Free space Loss	dB	195.7	195.7	195.7	195.7	195.7	195.7
4.48	ES Ant Rx Gain at LNA Input	dB	41.7	41.7	41.7	41.7	41.7	41.7
4.49	Receive Level (LNA Input)	dBW	-159.8	-160.8	-161.5	-159.8	-160.8	-161.5
4.50	ES System Noise Temp.	dB-K	18.9	18.9	19.1	18.9	18.9	19.1
4.51	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.52	Downlink C/kT	dB-Hz	49.9	48.9	48.0	49.9	48.9	48.0
4.53	Receive Level (Antenna Port)	dBW	-159.8	-160.8	-161.5	-159.8	-160.8	-161.5
4.54	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.1	-219.2
4.55	Adjacent Satellite C/Io	dB/Hz	59.0	58.3	57.7	59.0	58.3	57.7
4.56	Total Link C/kT	dB-Hz	48.3	47.5	46.8	48.9	48.0	47.1
4.57	Required C/kT	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
4.58	**System Link Margin**	**dB**	**1.7**	**1.4**	**1.2**	**2.2**	**1.9**	**1.6**

5.01	**LINK BUDGET SUMMARY**		**Satellite Longitude: -31.5**					
5.02	**Angola - Cabinda Domsat Cfg 1**	Band: C	Carrier Size:			Carrier Size:		
5.03	**8/8 kbps Carriers**	INTELSAT	8 kbps			8 kbps		
5.04	**0.4% Rain Fade Probability**	From	CBC Cabinda City, Angola			Remote (Angola, Cabinda)		
5.05		To	Remote (Angola, Cabinda)			CBC Cabinda City, Angola		
5.06			Clear	Clear	0.4%	Clear	Clear	0.4%
5.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
5.08	SUMMARY OF CARRIER/NOISE							
5.09	Earth Station C/IM	dB	17.2	17.2	17.2	26.4	26.4	26.4
5.10	ES C/I (adj carrier)	dB	43.0	43.0	43.0	56.5	56.5	56.5
5.11	Uplink C/N	dB	21.6	20.9	20.3	21.6	20.9	20.3
5.12	C/Sat IM	dB	25.9	25.3	24.7	25.9	25.3	24.7
5.13	C/I adj co-pol xpndr	dB	34.9	34.3	33.7	34.9	34.3	33.7
5.14	C/I xpol up	dB	31.9	31.3	30.7	31.9	31.3	30.7
5.15	C/I xpol down	dB	31.9	31.3	30.7	31.9	31.3	30.7
5.16	C/I adjacent satellite	dB	19.2	18.5	17.9	19.2	18.5	17.9
5.17	Sat C/I (adj carrier)	dB	34.0	34.0	34.0	34.0	34.0	34.0
5.18	Downlink C/N	dB	10.1	9.1	8.2	10.1	9.1	8.2
5.19	Total Link C/N	dB	8.5	7.7	6.9	9.0	8.2	7.3
5.20	Required Link C/N	dB	6.8	6.3	5.7	6.8	6.3	5.7
5.21	Total Link C/kT	dB-Hz	48.3	47.5	46.8	48.9	48.0	47.1
5.22	Total Link Eb/No	dB	9.3	8.5	7.7	9.8	9.0	8.1
5.23	Required Link Eb/No	dB	7.6	7.1	6.5	7.6	7.1	6.5
5.24	**System Link Margin**	**dB**	**1.7**	**1.4**	**1.2**	**2.2**	**1.9**	**1.6**
	U/L + D/L C/N	dB	9.8	8.8	7.9	9.8	8.8	7.9
		Total (%)						
	Fraction of Bandwidth	0.042%	0.021%			0.021%		
	Fraction of Power	0.04167%	0.021%			0.021%		
	Pwr/BW Ratio	1.00	1.00			1.00		
	BW based on BW (MHz)	0.0300	0.0150			0.0150		
	BW based on Power (MHz)	0.0300	0.0150			0.0150		

A.2.2 Link Budgets, Remote to Remote

Link Budgets
Remote to Remote
C-Band
INTELSAT 801 Satellite

1.01	**LINK BUDGET CALCULATION**							Ant (M)
1.02			**Site 1**	**Remote (Angola, Cabinda)**				3.80
1.03	**INTELSAT 801 Hemi 3-4**			REM-AC				
1.04	**Angola - Cabinda Domsat**		**Site 2**	**Remote (Angola, Cabinda)**				3.80
1.05	**8/8 kbps Carriers**			REM-AC				
1.06	**0.4% Rain Fade Probability**		Satellite Longitude: -31.5			Band:	C	
1.07	Originating Site		Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
1.08	Originating Site Abbreviation		REM-AC			REM-AC		
1.09	Destination Site		Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
1.10	Destination Site Abbreviation		REM-AC			REM-AC		
1.11			Clear	Clear	0.4%	Clear	Clear	0.4%
1.12	**SYSTEM PARAMETERS:**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
1.13	Uplink Freq	GHz	6.050			6.050		
1.14	Downlink Freq	GHz	3.825			3.825		
1.15	Information bit rate	kbps	8			8		
1.16	Information bit rate + overhead	kbps	8.0			8.0		
1.17	Coding rate		1/2			1/2		
1.18	Modulation type (BPSK/QPSK)		QPSK			QPSK		
1.19	Demodulator decoder type		Viterbi			Viterbi		
1.20	Carrier spacing factor (x SR)		1.40			1.40		
1.21	Necessary bandwidth factor (x SR)		1.20			1.20		
1.22	Modulation bit/symbol		2.0			2.0		
1.23	Transmission symbol rate	ksps	8.0			8.0		
1.24	Allocated Bandwidth	MHz	0.015			0.015		
1.25	Occupied Bandwidth	MHz	0.010			0.010		
1.26		dB-Hz	39.8			39.8		
1.27	Desired BER		1.0E-8	1.0E-7	1.0E-6	1.0E-8	1.0E-7	1.0E-6
1.28	Req Eb/No w coding	dB	7.6	7.1	6.5	7.6	7.1	6.5
1.29	Required C/No with coding	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
1.30	Required C/N with coding	dB	6.8	6.3	5.7	6.8	6.3	5.7
1.31	**SATELLITE PARAMETERS:**							
1.32	Satellite Longitude (+ = E, - = W)	deg	-31.5			-31.5		
1.33	Transponder Number		Hemi 3-4			Hemi 3-4		
1.34	Transponder BW	MHz	72.0			72.0		
1.35	Saturated EIRP toward Destination	dBW	36.5			36.5		
1.36	Gain Step above Nominal	dB	-11.1			-11.1		
1.37	Nom Sat. Flux Density toward Orig. Site	dBW/sq M	-91.0			-91.0		
1.38	G/T toward Origination Site	dB/K	-6.0			-6.0		
1.39			Available:			Available:		
1.40	Available Transponder Bandwidth	MHz	72.0			72.0		
1.41	Carrier Allocated Bandwidth	MHz	0.02			0.02		
1.42	Dest. EIRP Power Above Even Distribution	dB	0.0			0.0		
1.43	Available Saturated EIRP	dBW	-0.3			-0.3		
1.44	Available Saturated Flux Density	dBW/sq M	-116.7			-116.7		
1.45	Transponder Multicarrier Output Backoff	dB	5.5			5.5		
1.46	Transponder Multicarrier Input Backoff	dB	7.4			7.4		
1.47	Available Operating EIRP	dBW	-5.8			-5.8		
1.48	Available Operating Flux Density	dBW/sq M	-124.1			-124.1		
1.49	G/T	dB/K	-6.0			-6.0		
1.50	Transponder Gain	dB	155.4			155.4		
1.51	Station Keeping (NS & EW)	deg	0.05			0.05		

2.01	**SATELLITE INTERFERENCE BUDGETS**							
2.02								
2.03	Originating Site		Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
2.04	Originating Site Abbreviation		REM-AC			REM-AC		
2.05	Destination Site		Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
2.06	Destination Site Abbreviation		REM-AC			REM-AC		
2.07	**INTERFERENCE AT SATELLITE**		Clear	Clear	0.4%	Clear	Clear	0.4%
2.08	**INTELSAT 801 Hemi 3-4**		Sky	Pt error	Rain	Sky	Pt error	Rain
2.09	IMo	dB/Hz	-71.6			-71.6		
2.10	Io adj co-pol xpndr	dB/Hz	-80.6			-80.6		
2.11	Io xpol up	dB/Hz	-77.6			-77.6		
2.12	Io xpol down	dB/Hz	-77.6			-77.6		
2.13	Total Io (at satellite)	dBW/Hz	-69.5			-69.5		
2.14	**Adjacent Satellite Interference**							
2.15	Satellite Spacing	deg	2.00					
2.16	Adjacent Satellite BOo	dB	5.00					
2.17	Adjacent Satellite #1							
2.18	Satellite							
2.19	Satellite Longitude (+ = E, - = W)	deg	-29.50			-29.50		
2.20	El to Satellite #1	deg	41.46			41.46		
2.21	Az to Satellite #1	deg	275.56			275.56		
2.22	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.23	Bandwidth	MHz	72.00			72.00		
2.24	Output Backoff	dB	5.00			5.00		
2.25	Angular distance	deg	2.22			2.22		
2.26	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.35			20.35		
2.27	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.6	-222.9	-222.9	-222.6	-222.9	-222.9
2.28	Adjacent Satellite #2							
2.29	Satellite							
2.30	Satellite Longitude (+ = E, - = W)	deg	-27.50			-27.50		
2.31	El to Satellite #2	deg	43.67			43.67		
2.32	Az to Satellite #2	deg	275.96			275.96		
2.33	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.34	Bandwidth	MHz	72.00			72.00		
2.35	Output Backoff	dB	5.00			5.00		
2.36	Angular distance	deg	4.45			4.45		
2.37	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.80			12.80		
2.38	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.1	-230.4	-230.5	-230.1	-230.4	-230.5
2.39	Adjacent Satellite #3							
2.40	Satellite							
2.41	Satellite Longitude (+ = E, - = W)	deg	-33.50			-33.50		
2.42	El to Satellite #3	deg	37.08			37.08		
2.43	Az to Satellite #3	deg	274.84			274.84		
2.44	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.45	Bandwidth	MHz	72.00			72.00		
2.46	Output Backoff	dB	5.00			5.00		
2.47	Angular distance	deg	2.21			2.21		
2.48	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.41			20.41		
2.49	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.5	-222.8	-222.9	-222.5	-222.8	-222.9
2.50	Adjacent Satellite #4							
2.51	Satellite							
2.52	Satellite Longitude (+ = E, - = W)	deg	-35.50			-35.50		
2.53	El to Satellite #4	deg	34.90			34.90		
2.54	Az to Satellite #4	deg	274.51			274.51		
2.55	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.56	Bandwidth	MHz	72.00			72.00		
2.57	Output Backoff	dB	5.00			5.00		
2.58	Angular distance	deg	4.40			4.40		
2.59	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.91			12.91		
2.60	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.0	-230.3	-230.4	-230.0	-230.3	-230.4
2.61	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.1	-219.2

3.01	**EARTH STATION PARAMETERS:**							
3.02	**Angola - Cabinda Domsat Cfg 1**	Band: C	INTELSAT 801 Hemi 3-4					
3.03	**8/8 kbps Carriers**		Clear	Clear	0.4%	Clear	Clear	0.4%
3.04	**0.4% Rain Fade Probability**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
3.05			Site 1			Site 2		
3.06	Site Location		Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
3.07	Site Abbreviation		REM-AC			REM-AC		
3.08	ES Latitude	deg	-5.00			-5.00		
3.09	ES Longitude	deg	12.30			12.30		
3.10	Elevation	deg	39.27			39.27		
3.11	Azimuth	deg	275.19			275.19		
3.12	Slant Range	km	37839			37839		
3.13	Antenna Type		P-3.8			P-3.8		
3.14	Antenna Diameter	M	3.80			3.80		
3.15	Antenna Transmit Gain	dBi	45.83			45.83		
3.16	Antenna Receive Gain	dBi	41.86			41.86		
3.17	Antenna Noise Temperature	dB-K	22.07			22.07		
3.18	Antenna Transmit Beamwidth	deg	0.89			0.89		
3.19	Antenna Receive Beamwidth	deg	1.40			1.40		
3.20	Antenna Tracking		no			no		
3.21	Satellite Drift Error (or Tracking Error)	deg	0.071			0.071		
3.22	Wind Pointing Error (30 mph gust to 45)	deg	0.140			0.140		
3.23	Total Pointing Error	deg	0.211			0.211		
3.24	Transmit Pointing Loss due to Sat. Drift	dB	0.08			0.08		
3.25	Transmit Pointing Loss due to Wind	dB	0.60			0.60		
3.26	Transmit Pointing Loss	dB	0.67			0.67		
3.27	Receive Pointing Loss	dB	0.27			0.27		
3.28	Uplink Power Control		no			no		
3.29	Max UPC	dB	0.00			0.00		
3.30	Rain Model		CCIR			CCIR		
3.31	Rain Zone		N			N		
3.32	Rain Probability	%	0.40			0.40		
3.33	Uplink Rain Attenuation	dB	0.61			0.61		
3.34	Downlink Rain Attenuation	dB	0.07			0.07		
3.35	Loss Antenna to LNA	dB	0.15			0.15		
3.36	Noise due to Ant/LNA Loss	K	10.18			10.18		
3.37	LNC Noise Temperature	K	45.00			45.00		
3.38	Electronics Noise Temperature	K	1.00			1.00		
3.39	Rain Contribution to Sys Temp	K	0.00	0.00	4.54	0.00	0.00	4.54
3.40	System Noise Temperature	K	77.51	77.51	81.90	77.51	77.51	81.90
3.41		dB-K	18.89	18.89	19.13	18.89	18.89	19.13
3.42	G/T	dB/K	22.81	22.81	22.57	22.81	22.81	22.57
3.43	Required C/kT	dB-Hz	46.63	46.13	45.53	46.63	46.13	45.53
3.44	HPA Type (TWTA or SSPA)		SSPA			SSPA		
3.45	Saturated TWTA Output Power	dBW	13.01			13.01		
3.46	(SSPA @ 1 dB Gain Comp)	Watts	20.00			20.00		
3.47	Loss HPA to Antenna	dB	1.00			1.00		

4.01	**LINK BUDGET CALCULATION**		**Satellite Longitude: -31.5**					
4.02	**INTELSAT 801 Hemi 3-4**	Band: C	Carrier Size:			Carrier Size:		
4.03	**Angola - Cabinda Domsat Cfg 1**		8 kbps			8 kbps		
4.04	**8/8 kbps Carriers**	From	Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
4.05	**0.4% Rain Fade Probability**	To	Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
4.06			Clear	Clear	0.4%	Clear	Clear	0.4%
4.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
4.08	HPA Saturated Output Power	dBW	13.0			13.0		
4.09		Watts	20.0			20.0		
4.10	HPA output backoff	dB	10.3	10.3	10.3	13.3	13.3	13.3
4.11	Total Power out of HPA	dBW	2.7	2.7	2.7	-0.3	-0.3	-0.3
4.12	Total number of carriers	#	8.0			4.0		
4.13	Activity Factor	#	1.0			1.0		
4.14	Number of active carriers	#	8.0			4.0		
4.15	Power per Carrier out of HPA	Watts	0.23	0.23	0.23	0.23	0.23	0.23
4.16		dBW	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3
4.17	Loss to antenna	dB	1.0	1.0	1.0	1.0	1.0	1.0
4.18	Power per Carrier into Antenna	dBW	-7.3	-7.3	-7.3	-7.3	-7.3	-7.3
4.19	Antenna Transmit Gain	dBi	45.8	45.8	45.8	45.8	45.8	45.8
4.20	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	38.5	38.5	38.5
4.21	Earth Station C/IMo	dB-Hz	66.4	66.4	66.4	71.8	71.8	71.8
4.22	ES Adja. Ch Interference C/Ia	dB	56.8	56.8	56.8	65.3	65.3	65.3
4.23	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.24	ES C/Io (adj carrier)	dB-Hz	96.7	96.7	96.7	105.1	105.1	105.1
4.25	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	38.5	38.5	38.5
4.26	Uplink Free Space Loss	dB	199.6	199.6	199.6	199.6	199.64	199.64
4.27	Uplink Pointing Loss due to Sat. Drift	dB	0.0	0.1	0.1	0.0	0.1	0.1
4.28	Uplink Pointing Loss due to Wind	dB	0.0	0.6	0.6	0.0	0.6	0.6
4.29	Uplink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.30	Uplink Rain Attenuation	dB	0.0	0.0	0.6	0.0	0.0	0.6
4.31	Receive Isotropic Pwr/Carrier	dBW	-161.2	-161.9	-162.5	-161.2	-161.9	-162.5
4.32	Satellite G/T	dB/K	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
4.33	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.34	Uplink C/kT (C/No)	dB-Hz	61.4	60.7	60.1	61.4	60.7	60.1
4.35	Transponder EIRP/Carrier	dBW	-5.8	-6.5	-7.09	-5.8	-6.49	-7.09
4.36	Satellite Output Io	dB/Hz	-69.5	-69.5	-69.5	-69.5	-69.5	-69.5
4.37	Satellite C/Io	dB-Hz	63.6	63.0	62.4	63.6	63.0	62.4
4.38	Sat. Adja. Ch Interference C/Ia	dB	34.0	34.0	34.0	34.0	34.0	34.0
4.39	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.40	Satellite C/Io (adj carrier)	dB-Hz	73.8	73.8	73.8	73.8	73.8	73.8
4.41	Receive Isotropic Pwr/Carrier	dBW	-161.2	-161.9	-162.5	-161.2	-161.9	-162.5
4.42	Transponder Gain	dB	155.4	155.4	155.4	155.4	155.4	155.4
4.43	Transponder EIRP/Carrier	dBW	-5.8	-6.5	-7.1	-5.8	-6.5	-7.1
4.44	Downlink Rain Attenuation	dB	0.0	0.0	0.1	0.0	0.0	0.1
4.45	Downlink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.46	Downlink Pointing Loss	dB	0.0	0.3	0.3	0.0	0.3	0.3
4.47	Downlink Free space Loss	dB	195.7	195.7	195.7	195.7	195.7	195.7
4.48	ES Ant Rx Gain at LNA Input	dB	41.7	41.7	41.7	41.7	41.7	41.7
4.49	Receive Level (LNA Input)	dBW	-159.8	-160.8	-161.5	-159.8	-160.8	-161.5
4.50	ES System Noise Temp.	dB-K	18.9	18.9	19.1	18.9	18.9	19.1
4.51	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.52	Downlink C/kT	dB-Hz	49.9	48.9	48.0	49.9	48.9	48.0
4.53	Receive Level (Antenna Port)	dBW	-159.8	-160.8	-161.5	-159.8	-160.8	-161.5
4.54	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.1	-219.2
4.55	Adjacent Satellite C/Io	dB/Hz	59.0	58.3	57.7	59.0	58.3	57.7
4.56	Total Link C/kT	dB-Hz	48.9	48.0	47.1	48.9	48.0	47.2
4.57	Required C/kT	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
4.58	**System Link Margin**	**dB**	**2.2**	**1.9**	**1.6**	**2.3**	**1.9**	**1.6**

5.01	**LINK BUDGET SUMMARY**		**Satellite Longitude: -31.5**					
5.02	**Angola - Cabinda Domsat Cfg 1**	Band: C	Carrier Size:			Carrier Size:		
5.03	**8/8 kbps Carriers**		8 kbps			8 kbps		
5.04	**0.4% Rain Fade Probability**	From	Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
5.05	**INTELSAT 801 Hemi 3-4**	To	Remote (Angola, Cabinda)			Remote (Angola, Cabinda)		
5.06			Clear	Clear	0.4%	Clear	Clear	0.4%
5.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
5.08	SUMMARY OF CARRIER/NOISE							
5.09	Earth Station C/IM	dB	26.6	26.6	26.6	32.0	32.0	32.0
5.10	ES C/I (adj carrier)	dB	56.8	56.8	56.8	65.3	65.3	65.3
5.11	Uplink C/N	dB	21.6	20.9	20.3	21.6	20.9	20.3
5.12	C/Sat IM	dB	25.9	25.3	24.7	25.9	25.3	24.7
5.13	C/I adj co-pol xpndr	dB	34.9	34.3	33.7	34.9	34.3	33.7
5.14	C/I xpol up	dB	31.9	31.3	30.7	31.9	31.3	30.7
5.15	C/I xpol down	dB	31.9	31.3	30.7	31.9	31.3	30.7
5.16	C/I adjacent satellite	dB	19.2	18.5	17.9	19.2	18.5	17.9
5.17	Sat C/I (adj carrier)	dB	34.0	34.0	34.0	34.0	34.0	34.0
5.18	Downlink C/N	dB	10.1	9.1	8.2	10.1	9.1	8.2
5.19	Total Link C/N	dB	9.1	8.2	7.3	9.1	8.2	7.4
5.20	Required Link C/N	dB	6.8	6.3	5.7	6.8	6.3	5.7
5.21	Total Link C/kT	dB-Hz	48.9	48.0	47.1	48.9	48.0	47.2
5.22	Total Link Eb/No	dB	9.8	9.0	8.1	9.9	9.0	8.1
5.23	Required Link Eb/No	dB	7.6	7.1	6.5	7.6	7.1	6.5
5.24	**System Link Margin**	**dB**	**2.2**	**1.9**	**1.6**	**2.3**	**1.9**	**1.6**
	U/L + D/L C/N	dB	9.8	8.8	7.9	9.8	8.8	7.9
		Total (%)						
	Fraction of Bandwidth	0.042%	0.021%			0.021%		
	Fraction of Power	0.04167%	0.021%			0.021%		
	Pwr/BW Ratio	1.00	1.00			1.00		
	BW based on BW (MHz)	0.0300	0.0150			0.0150		
	BW based on Power (MHz)	0.0300	0.0150			0.0150		

A.2.3 Link Budgets, Luanda to Remote

Link Budgets
Luanda to Remote
C-Band
INTELSAT 801 Satellite

1.01	**LINK BUDGET CALCULATION**							Ant (M)
1.02			**Site 1**	**Luanda, Angola**				15.00
1.03	**INTELSAT 801 Hemi 3-4**			LUA				
1.04	**Angola - Cabinda Domsat Cfg 1**		**Site 2**	**Remote (Angola, Cabinda)**				3.80
1.05	**8/8 kbps Carriers**			REM-AC				
1.06	**0.4% Rain Fade Probability**		Satellite Longitude: -31.5			Band: C		
1.07	Originating Site		Luanda, Angola			Remote (Angola, Cabinda)		
1.08	Originating Site Abbreviation		LUA			REM-AC		
1.09	Destination Site		Remote (Angola, Cabinda)			Luanda, Angola		
1.10	Destination Site Abbreviation		REM-AC			LUA		
1.11			Clear	Clear	0.4%	Clear	Clear	0.4%
1.12	**SYSTEM PARAMETERS:**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
1.13	Uplink Freq	GHz	6.050			6.050		
1.14	Downlink Freq	GHz	3.825			3.825		
1.15	Information bit rate	kbps	8			8		
1.16	Information bit rate + overhead	kbps	8.0			8.0		
1.17	Coding rate		1/2			1/2		
1.18	Modulation type (BPSK/QPSK)		QPSK			QPSK		
1.19	Demodulator decoder type		Viterbi			Viterbi		
1.20	Carrier spacing factor (x SR)		1.40			1.40		
1.21	Necessary bandwidth factor (x SR)		1.20			1.20		
1.22	Modulation bit/symbol		2.0			2.0		
1.23	Transmission symbol rate	ksps	8.0			8.0		
1.24	Allocated Bandwidth	MHz	0.015			0.015		
1.25	Occupied Bandwidth	MHz	0.010			0.010		
1.26		dB-Hz	39.8			39.8		
1.27	Desired BER		1.0E-8	1.0E-7	1.0E-6	1.0E-8	1.0E-7	1.0E-6
1.28	Req Eb/No w coding	dB	7.6	7.1	6.5	7.6	7.1	6.5
1.29	Required C/No with coding	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
1.30	Required C/N with coding	dB	6.8	6.3	5.7	6.8	6.3	5.7
1.31	**SATELLITE PARAMETERS:**							
1.32	Satellite Longitude (+ = E, - = W)	deg	-31.5			-31.5		
1.33	Transponder Number		Hemi 3-4			Hemi 3-4		
1.34	Transponder BW	MHz	72.0			72.0		
1.35	Saturated EIRP toward Destination	dBW	36.5			36.5		
1.36	Gain Step above Nominal	dB	-11.1			-11.1		
1.37	Nom Sat. Flux Density toward Orig. Site	dBW/sq M	-91.0			-91.0		
1.38	G/T toward Origination Site	dB/K	-6.0			-6.0		
1.39			Available:			Available:		
1.40	Available Transponder Bandwidth	MHz	72.0			72.0		
1.41	Carrier Allocated Bandwidth	MHz	0.02			0.02		
1.42	Dest. EIRP Power Above Even Distribution	dB	0.0			-6.0		
1.43	Available Saturated EIRP	dBW	-0.3			-6.3		
1.44	Available Saturated Flux Density	dBW/sq M	-116.7			-122.7		
1.45	Transponder Multicarrier Output Backoff	dB	5.5			5.5		
1.46	Transponder Multicarrier Input Backoff	dB	7.4			7.4		
1.47	Available Operating EIRP	dBW	-5.8			-11.8		
1.48	Available Operating Flux Density	dBW/sq M	-124.1			-130.1		
1.49	G/T	dB/K	-6.0			-6.0		
1.50	Transponder Gain	dB	155.4			155.4		
1.51	Station Keeping (NS & EW)	deg	0.05			0.05		

2.01	**SATELLITE INTERFERENCE BUDGETS**							
2.02								
2.03	Originating Site		Luanda, Angola			Remote (Angola, Cabinda)		
2.04	Originating Site Abbreviation		LUA			REM-AC		
2.05	Destination Site		Remote (Angola, Cabinda)			Luanda, Angola		
2.06	Destination Site Abbreviation		REM-AC			LUA		
2.07	**INTERFERENCE AT SATELLITE**		Clear	Clear	0.4%	Clear	Clear	0.4%
2.08	**INTELSAT 801 Hemi 3-4**		Sky	Pt error	Rain	Sky	Pt error	Rain
2.09	IMo	dB/Hz	-71.6			-71.6		
2.10	Io adj co-pol xpndr	dB/Hz	-80.6			-80.6		
2.11	Io xpol up	dB/Hz	-77.6			-77.6		
2.12	Io xpol down	dB/Hz	-77.6			-77.6		
2.13	Total Io (at satellite)	dBW/Hz	-69.5			-69.5		
2.14	**Adjacent Satellite Interference**							
2.15	Satellite Spacing	deg	2.00					
2.16	Adjacent Satellite BOo	dB	5.00					
2.17	Adjacent Satellite #1							
2.18	Satellite							
2.19	Satellite Longitude (+ = E, - = W)	deg	-29.50			-29.50		
2.20	El to Satellite #1	deg	41.46			39.87		
2.21	Az to Satellite #1	deg	275.56			279.42		
2.22	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.23	Bandwidth	MHz	72.00			72.00		
2.24	Output Backoff	dB	5.00			5.00		
2.25	Angular distance	deg	2.22			2.21		
2.26	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.35			20.39		
2.27	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.6	-222.9	-222.9	-222.6	-223.1	-223.1
2.28	Adjacent Satellite #2							
2.29	Satellite							
2.30	Satellite Longitude (+ = E, - = W)	deg	-27.50			-27.50		
2.31	El to Satellite #2	deg	43.67			42.03		
2.32	Az to Satellite #2	deg	275.96			280.09		
2.33	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.34	Bandwidth	MHz	72.00			72.00		
2.35	Output Backoff	dB	5.00			5.00		
2.36	Angular distance	deg	4.45			4.43		
2.37	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.80			12.84		
2.38	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.1	-230.4	-230.5	-230.1	-230.6	-230.6
2.39	Adjacent Satellite #3							
2.40	Satellite							
2.41	Satellite Longitude (+ = E, - = W)	deg	-33.50			-33.50		
2.42	El to Satellite #3	deg	37.08			35.57		
2.43	Az to Satellite #3	deg	274.84			278.20		
2.44	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.45	Bandwidth	MHz	72.00			72.00		
2.46	Output Backoff	dB	5.00			5.00		
2.47	Angular distance	deg	2.21			2.20		
2.48	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.41			20.44		
2.49	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.5	-222.8	-222.9	-222.5	-223.0	-223.0
2.50	Adjacent Satellite #4							
2.51	Satellite							
2.52	Satellite Longitude (+ = E, - = W)	deg	-35.50			-35.50		
2.53	El to Satellite #4	deg	34.90			33.43		
2.54	Az to Satellite #4	deg	274.51			277.66		
2.55	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.56	Bandwidth	MHz	72.00			72.00		
2.57	Output Backoff	dB	5.00			5.00		
2.58	Angular distance	deg	4.40			4.39		
2.59	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.91			12.95		
2.60	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.0	-230.3	-230.4	-230.0	-230.5	-230.5
2.61	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.3	-219.4

3.01	**EARTH STATION PARAMETERS:**		**INTELSAT 801 Hemi 3-4**					
3.02	**Angola - Cabinda Domsat Cfg 1**	Band: C						
3.03	**8/8 kbps Carriers**		Clear	Clear	0.4%	Clear	Clear	0.4%
3.04	**0.4% Rain Fade Probability**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
3.05			Site 1			Site 2		
3.06	Site Location		Luanda, Angola			Remote (Angola, Cabinda)		
3.07	Site Abbreviation		LUA			REM-AC		
3.08	ES Latitude	deg	-8.83			-5.00		
3.09	ES Longitude	deg	13.25			12.30		
3.10	Elevation	deg	37.72			39.27		
3.11	Azimuth	deg	278.79			275.19		
3.12	Slant Range	km	37961			37839		
3.13	Antenna Type		15.00			P-3.8		
3.14	Antenna Diameter	M	15.00			3.80		
3.15	Antenna Transmit Gain	dBi	57.36			45.83		
3.16	Antenna Receive Gain	dBi	53.45			41.86		
3.17	Antenna Noise Temperature	dB-K	35.00			22.07		
3.18	Antenna Transmit Beamwidth	deg	0.23			0.89		
3.19	Antenna Receive Beamwidth	deg	0.34			1.40		
3.20	Antenna Tracking		yes			no		
3.21	Satellite Drift Error (or Tracking Error)	deg	0.034			0.071		
3.22	Wind Pointing Error (30 mph gust to 45)	deg	0.034			0.140		
3.23	Total Pointing Error	deg	0.068			0.211		
3.24	Transmit Pointing Loss due to Sat. Drift	dB	0.27			0.08		
3.25	Transmit Pointing Loss due to Wind	dB	0.81			0.60		
3.26	Transmit Pointing Loss	dB	1.09			0.67		
3.27	Receive Pointing Loss	dB	0.48			0.27		
3.28	Uplink Power Control		no			no		
3.29	Max UPC	dB	0.00			0.00		
3.30	Rain Model		CCIR			CCIR		
3.31	Rain Zone		K			N		
3.32	Rain Probability	%	0.40			0.40		
3.33	Uplink Rain Attenuation	dB	0.22			0.61		
3.34	Downlink Rain Attenuation	dB	0.03			0.07		
3.35	Loss Antenna to LNA	dB	0.15			0.15		
3.36	Noise due to Ant/LNA Loss	K	10.18			10.18		
3.37	LNC Noise Temperature	K	45.00			45.00		
3.38	Electronics Noise Temperature	K	1.00			1.00		
3.39	Rain Contribution to Sys Temp	K	0.00	0.00	1.84	0.00	0.00	4.54
3.40	System Noise Temperature	K	90.00	90.00	91.77	77.51	77.51	81.90
3.41		dB-K	19.54	19.54	19.63	18.89	18.89	19.13
3.42	G/T	dB/K	33.76	33.76	33.67	22.81	22.81	22.57
3.43	Required C/kT	dB-Hz	46.63	46.13	45.53	46.63	46.13	45.53
3.44	HPA Type (TWTA or SSPA)		TWTA			SSPA		
3.45	Saturated TWTA Output Power	dBW	20.00			13.01		
3.46	(SSPA @ 1 dB Gain Comp)	Watts	100.00			20.00		
3.47	Loss HPA to Antenna	dB	2.00			1.00		

4.01	**LINK BUDGET CALCULATION**		**Satellite Longitude: -31.5**					
4.02	**INTELSAT 801 Hemi 3-4**	Band: C	Carrier Size:			Carrier Size:		
4.03	**Angola - Cabinda Domsat Cfg 1**		8 kbps			8 kbps		
4.04	**8/8 kbps Carriers**	From	Luanda, Angola			Remote (Angola, Cabinda)		
4.05	**0.4% Rain Fade Probability**	To	Remote (Angola, Cabinda)			Luanda, Angola		
4.06			Clear	Clear	0.4%	Clear	Clear	0.4%
4.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
4.08	HPA Saturated Output Power	dBW	20.0			13.0		
4.09		Watts	100.0			20.0		
4.10	HPA output backoff	dB	18.6	18.6	18.6	10.2	10.2	10.2
4.11	Total Power out of HPA	dBW	1.4	1.4	1.4	2.8	2.8	2.8
4.12	Total number of carriers	#	10.0			1.0		
4.13	Activity Factor	#	1.0			1.0		
4.14	Number of active carriers	#	10.0			1.0		
4.15	Power per Carrier out of HPA	Watts	0.02	0.02	0.02	0.06	0.06	0.06
4.16		dBW	-16.8	-16.8	-16.8	-12.3	-12.3	-12.3
4.17	Loss to antenna	dB	2.0	2.0	2.0	1.0	1.0	1.0
4.18	Power per Carrier into Antenna	dBW	-18.8	-18.8	-18.8	-13.3	-13.3	-13.3
4.19	Antenna Transmit Gain	dBi	57.4	57.4	57.4	45.8	45.8	45.8
4.20	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	32.5	32.5	32.5
4.21	Earth Station C/IMo	dB-Hz	79.3	79.3	79.3	500.0	500.0	500.0
4.22	ES Adja. Ch Interference C/Ia	dB	60.3	60.3	60.3	500.0	500.0	500.0
4.23	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.24	ES C/Io (adj carrier)	dB-Hz	100.1	100.1	100.1	539.8	539.8	539.8
4.25	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	32.5	32.5	32.5
4.26	Uplink Free Space Loss	dB	199.7	199.7	199.7	199.6	199.64	199.64
4.27	Uplink Pointing Loss due to Sat. Drift	dB	0.0	0.3	0.3	0.0	0.1	0.1
4.28	Uplink Pointing Loss due to Wind	dB	0.0	0.8	0.8	0.0	0.6	0.6
4.29	Uplink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.30	Uplink Rain Attenuation	dB	0.0	0.0	0.2	0.0	0.0	0.6
4.31	Receive Isotropic Pwr/Carrier	dBW	-161.2	-162.3	-162.5	-167.2	-167.9	-168.5
4.32	Satellite G/T	dB/K	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
4.33	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.34	Uplink C/kT (C/No)	dB-Hz	61.4	60.3	60.1	55.4	54.7	54.1
4.35	Transponder EIRP/Carrier	dBW	-5.8	-6.9	-7.12	-11.8	-12.49	-13.09
4.36	Satellite Output Io	dB/Hz	-69.5	-69.5	-69.5	-69.5	-69.5	-69.5
4.37	Satellite C/Io	dB-Hz	63.6	62.6	62.3	57.6	57.0	56.4
4.38	Sat. Adja. Ch Interference C/Ia	dB	34.0	34.0	34.0	34.0	34.0	34.0
4.39	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.40	Satellite C/Io (adj carrier)	dB-Hz	73.8	73.8	73.8	73.8	73.8	73.8
4.41	Receive Isotropic Pwr/Carrier	dBW	-161.2	-162.3	-162.5	-167.2	-167.9	-168.5
4.42	Transponder Gain	dB	155.4	155.4	155.4	155.4	155.4	155.4
4.43	Transponder EIRP/Carrier	dBW	-5.8	-6.9	-7.1	-11.8	-12.5	-13.1
4.44	Downlink Rain Attenuation	dB	0.0	0.0	0.1	0.0	0.0	0.0
4.45	Downlink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.46	Downlink Pointing Loss	dB	0.0	0.3	0.3	0.0	0.5	0.5
4.47	Downlink Free space Loss	dB	195.7	195.7	195.7	195.7	195.7	195.7
4.48	ES Ant Rx Gain at LNA Input	dB	41.7	41.7	41.7	53.3	53.3	53.3
4.49	Receive Level (LNA Input)	dBW	-159.8	-161.2	-161.5	-154.3	-155.4	-156.1
4.50	ES System Noise Temp.	dB-K	18.9	18.9	19.1	19.5	19.5	19.6
4.51	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.52	Downlink C/kT	dB-Hz	49.9	48.5	48.0	54.8	53.6	52.9
4.53	Receive Level (Antenna Port)	dBW	-159.8	-161.2	-161.5	-154.3	-155.4	-156.1
4.54	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.3	-219.4
4.55	Adjacent Satellite C/Io	dB/Hz	59.0	57.9	57.7	64.6	63.9	63.3
4.56	Total Link C/kT	dB-Hz	48.9	47.6	47.2	50.8	49.9	49.3
4.57	Required C/kT	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
4.58	**System Link Margin**	**dB**	**2.3**	**1.5**	**1.6**	**4.2**	**3.8**	**3.7**

5.01	**LINK BUDGET SUMMARY**		**Satellite Longitude: -31.5**					
5.02	**Angola - Cabinda Domsat**	Band: C	Carrier Size:			Carrier Size:		
5.03	**8/8 kbps Carriers**		8 kbps			8 kbps		
5.04	**0.4% Rain Fade Probability**	From	LUA Luanda, Angola			Remote (Angola, Cabinda)		
5.05	INTELSAT 801 Hemi 3-4	To	Remote (Angola, Cabinda)			LUA Luanda, Angola		
5.06			Clear	Clear	0.4%	Clear	Clear	0.4%
5.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
5.08	SUMMARY OF CARRIER/NOISE							
5.09	Earth Station C/IM	dB	39.5	39.5	39.5	460.2	460.2	460.2
5.10	ES C/I (adj carrier)	dB	60.3	60.3	60.3	500.0	500.0	500.0
5.11	Uplink C/N	dB	21.6	20.5	20.3	15.6	14.9	14.3
5.12	C/Sat IM	dB	25.9	24.9	24.6	19.9	19.3	18.7
5.13	C/I adj co-pol xpndr	dB	34.9	33.9	33.6	28.9	28.3	27.7
5.14	C/I xpol up	dB	31.9	30.9	30.6	25.9	25.3	24.7
5.15	C/I xpol down	dB	31.9	30.9	30.6	25.9	25.3	24.7
5.16	C/I adjacent satellite	dB	19.2	18.1	17.9	24.8	24.1	23.5
5.17	Sat C/I (adj carrier)	dB	34.0	34.0	34.0	34.0	34.0	34.0
5.18	Downlink C/N	dB	10.1	8.7	8.2	15.0	13.8	13.1
5.19	Total Link C/N	dB	9.1	7.8	7.3	11.0	10.1	9.5
5.20	Required Link C/N	dB	6.8	6.3	5.7	6.8	6.3	5.7
5.21	Total Link C/kT	dB-Hz	48.9	47.6	47.2	50.8	49.9	49.3
5.22	Total Link Eb/No	dB	9.9	8.6	8.1	11.8	10.9	10.2
5.23	Required Link Eb/No	dB	7.6	7.1	6.5	7.6	7.1	6.5
5.24	**System Link Margin**	**dB**	**2.3**	**1.5**	**1.6**	**4.2**	**3.8**	**3.7**
	U/L + D/L C/N	dB	9.8	8.4	7.9	12.3	11.3	10.6

	Total (%)		
Fraction of Bandwidth	0.04%	0.02%	0.02%
Fraction of Power	0.03%	0.02%	0.01%
Pwr/BW Ratio	0.63	1.00	0.25
BW based on BW (MHz)	0.03	0.02	0.02
BW based on Power (MHz)	0.019	0.02	0.00

A.2.4 Link Budgets, Cabinda to Luanda, 60 Channels, DAMA

Link Budgets
Cabinda to Luanda
60 Channels
DAMA
C-Band
INTELSAT 801 Satellite

1.01	**LINK BUDGET CALCULATION**							Ant (M)
1.02			**Site 1**	**Luanda, Angola**				15.00
1.03	**INTELSAT 801 Hemi 3-4**			LUA				
1.04	**Angola - Cabinda Domsat**		**Site 2**	**Cabinda City, Angola**				3.80
1.05	**8/8 kbps Carriers**			CBC				
1.06	**0.4% Rain Fade Probability**		Satellite Longitude: -31.5			Band: C		
1.07	Originating Site		Luanda, Angola			Cabinda City, Angola		
1.08	Originating Site Abbreviation		LUA			CBC		
1.09	Destination Site		Cabinda City, Angola			Luanda, Angola		
1.10	Destination Site Abbreviation		CBC			LUA		
1.11			Clear	Clear	0.4%	Clear	Clear	0.4%
1.12	**SYSTEM PARAMETERS:**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
1.13	Uplink Freq	GHz	6.050			6.050		
1.14	Downlink Freq	GHz	3.825			3.825		
1.15	Information bit rate	kbps	8			8		
1.16	Information bit rate + overhead	kbps	8.0			8.0		
1.17	Coding rate		1/2			1/2		
1.18	Modulation type (BPSK/QPSK)		QPSK			QPSK		
1.19	Demodulator decoder type		Viterbi			Viterbi		
1.20	Carrier spacing factor (x SR)		1.40			1.40		
1.21	Necessary bandwidth factor (x SR)		1.20			1.20		
1.22	Modulation bit/symbol		2.0			2.0		
1.23	Transmission symbol rate	ksps	8.0			8.0		
1.24	Allocated Bandwidth	MHz	0.015			0.015		
1.25	Occupied Bandwidth	MHz	0.010			0.010		
1.26		dB-Hz	39.8			39.8		
1.27	Desired BER		1.0E-8	1.0E-7	1.0E-6	1.0E-8	1.0E-7	1.0E-6
1.28	Req Eb/No w coding	dB	7.6	7.1	6.5	7.6	7.1	6.5
1.29	Required C/No with coding	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
1.30	Required C/N with coding	dB	6.8	6.3	5.7	6.8	6.3	5.7
1.31	**SATELLITE PARAMETERS:**							
1.32	Satellite Longitude (+ = E, - = W)	deg	-31.5			-31.5		
1.33	Transponder Number		Hemi 3-4			Hemi 3-4		
1.34	Transponder BW	MHz	72.0			72.0		
1.35	Saturated EIRP toward Destination	dBW	36.5			36.5		
1.36	Gain Step above Nominal	dB	-11.1			-11.1		
1.37	Nom Sat. Flux Density toward Orig. Site	dBW/sq M	-91.0			-91.0		
1.38	G/T toward Origination Site	dB/K	-6.0			-6.0		
1.39			Available:			Available:		
1.40	Available Transponder Bandwidth	MHz	72.0			72.0		
1.41	Carrier Allocated Bandwidth	MHz	0.02			0.02		
1.42	Dest. EIRP Power Above Even Distribution	dB	0.0			-6.0		
1.43	Available Saturated EIRP	dBW	-0.3			-6.3		
1.44	Available Saturated Flux Density	dBW/sq M	-116.7			-122.7		
1.45	Transponder Multicarrier Output Backoff	dB	5.5			5.5		
1.46	Transponder Multicarrier Input Backoff	dB	7.4			7.4		
1.47	Available Operating EIRP	dBW	-5.8			-11.8		
1.48	Available Operating Flux Density	dBW/sq M	-124.1			-130.1		
1.49	G/T	dB/K	-6.0			-6.0		
1.50	Transponder Gain	dB	155.4			155.4		
1.51	Station Keeping (NS & EW)	deg	0.05			0.05		

2.01	**SATELLITE INTERFERENCE BUDGETS**							
2.02								
2.03	Originating Site		Luanda, Angola			Cabinda City, Angola		
2.04	Originating Site Abbreviation		LUA			CBC		
2.05	Destination Site		Cabinda City, Angola			Luanda, Angola		
2.06	Destination Site Abbreviation		CBC			LUA		
2.07	**INTERFERENCE AT SATELLITE**		Clear	Clear	0.4%	Clear	Clear	0.4%
2.08	**INTELSAT 801 Hemi 3-4**		Sky	Pt error	Rain	Sky	Pt error	Rain
2.09	IMo	dB/Hz	-71.6			-71.6		
2.10	Io adj co-pol xpndr	dB/Hz	-80.6			-80.6		
2.11	Io xpol up	dB/Hz	-77.6			-77.6		
2.12	Io xpol down	dB/Hz	-77.6			-77.6		
2.13	Total Io (at satellite)	dBW/Hz	-69.5			-69.5		
2.14	**Adjacent Satellite Interference**							
2.15	Satellite Spacing	deg	2.00					
2.16	Adjacent Satellite BOo	dB	5.00					
2.17	Adjacent Satellite #1							
2.18	Satellite							
2.19	Satellite Longitude (+ = E, - = W)	deg	-29.50			-29.50		
2.20	El to Satellite #1	deg	41.51			39.87		
2.21	Az to Satellite #1	deg	276.24			279.42		
2.22	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.23	Bandwidth	MHz	72.00			72.00		
2.24	Output Backoff	dB	5.00			5.00		
2.25	Angular distance	deg	2.22			2.21		
2.26	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.35			20.39		
2.27	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.6	-222.9	-222.9	-222.6	-223.1	-223.1
2.28	Adjacent Satellite #2							
2.29	Satellite							
2.30	Satellite Longitude (+ = E, - = W)	deg	-27.50			-27.50		
2.31	El to Satellite #2	deg	43.71			42.03		
2.32	Az to Satellite #2	deg	276.70			280.09		
2.33	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.34	Bandwidth	MHz	72.00			72.00		
2.35	Output Backoff	dB	5.00			5.00		
2.36	Angular distance	deg	4.45			4.43		
2.37	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.80			12.84		
2.38	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.1	-230.4	-230.5	-230.1	-230.6	-230.6
2.39	Adjacent Satellite #3							
2.40	Satellite							
2.41	Satellite Longitude (+ = E, - = W)	deg	-33.50			-33.50		
2.42	El to Satellite #3	deg	37.13			35.57		
2.43	Az to Satellite #3	deg	275.43			278.20		
2.44	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.45	Bandwidth	MHz	72.00			72.00		
2.46	Output Backoff	dB	5.00			5.00		
2.47	Angular distance	deg	2.21			2.20		
2.48	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.41			20.44		
2.49	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.5	-222.8	-222.9	-222.5	-223.0	-223.0
2.50	Adjacent Satellite #4							
2.51	Satellite							
2.52	Satellite Longitude (+ = E, - = W)	deg	-35.50			-35.50		
2.53	El to Satellite #4	deg	34.95			33.43		
2.54	Az to Satellite #4	deg	275.07			277.66		
2.55	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.56	Bandwidth	MHz	72.00			72.00		
2.57	Output Backoff	dB	5.00			5.00		
2.58	Angular distance	deg	4.40			4.39		
2.59	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.91			12.95		
2.60	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.0	-230.3	-230.4	-230.0	-230.5	-230.5
2.61	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.3	-219.4

3.01	**EARTH STATION PARAMETERS:**							
3.02	**Angola - Cabinda Domsat**	Band: C	INTELSAT 801 Hemi 3-4					
3.03	**8/8 kbps Carriers**		Clear	Clear	0.4%	Clear	Clear	0.4%
3.04	**0.4% Rain Fade Probability**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
3.05			Site 1			Site 2		
3.06	Site Location		Luanda, Angola			Cabinda City, Angola		
3.07	Site Abbreviation		LUA			CBC		
3.08	ES Latitude	deg	-8.83			-5.60		
3.09	ES Longitude	deg	13.25			12.20		
3.10	Elevation	deg	37.72			39.31		
3.11	Azimuth	deg	278.79			275.82		
3.12	Slant Range	km	37961			37835		
3.13	Antenna Type		15.00			P-3.8		
3.14	Antenna Diameter	M	15.00			3.80		
3.15	Antenna Transmit Gain	dBi	57.36			45.83		
3.16	Antenna Receive Gain	dBi	53.45			41.86		
3.17	Antenna Noise Temperature	dB-K	35.00			22.07		
3.18	Antenna Transmit Beamwidth	deg	0.23			0.89		
3.19	Antenna Receive Beamwidth	deg	0.34			1.40		
3.20	Antenna Tracking		yes			no		
3.21	Satellite Drift Error (or Tracking Error)	deg	0.034			0.071		
3.22	Wind Pointing Error (30 mph gust to 45)	deg	0.034			0.140		
3.23	Total Pointing Error	deg	0.068			0.211		
3.24	Transmit Pointing Loss due to Sat. Drift	dB	0.27			0.08		
3.25	Transmit Pointing Loss due to Wind	dB	0.81			0.60		
3.26	Transmit Pointing Loss	dB	1.09			0.67		
3.27	Receive Pointing Loss	dB	0.48			0.27		
3.28	Uplink Power Control		no			no		
3.29	Max UPC	dB	0.00			0.00		
3.30	Rain Model		CCIR			CCIR		
3.31	Rain Zone		K			N		
3.32	Rain Probability	%	0.40			0.40		
3.33	Uplink Rain Attenuation	dB	0.22			0.61		
3.34	Downlink Rain Attenuation	dB	0.03			0.07		
3.35	Loss Antenna to LNA	dB	0.15			0.15		
3.36	Noise due to Ant/LNA Loss	K	10.18			10.18		
3.37	LNC Noise Temperature	K	45.00			45.00		
3.38	Electronics Noise Temperature	K	1.00			1.00		
3.39	Rain Contribution to Sys Temp	K	0.00	0.00	1.84	0.00	0.00	4.54
3.40	System Noise Temperature	K	90.00	90.00	91.77	77.50	77.50	81.89
3.41		dB-K	19.54	19.54	19.63	18.89	18.89	19.13
3.42	G/T	dB/K	33.76	33.76	33.67	22.81	22.81	22.57
3.43	Required C/kT	dB-Hz	46.63	46.13	45.53	46.63	46.13	45.53
3.44	HPA Type (TWTA or SSPA)		TWTA			SSPA		
3.45	Saturated TWTA Output Power	dBW	20.00			16.02		
3.46	(SSPA @ 1 dB Gain Comp)	Watts	100.00			40.00		
3.47	Loss HPA to Antenna	dB	2.00			2.00		

4.01	**LINK BUDGET CALCULATION**		**Satellite Longitude: -31.5**					
4.02	**INTELSAT 801 Hemi 3-4**	Band: C	Carrier Size:			Carrier Size:		
4.03	**Angola - Cabinda Domsat**		8 kbps			8 kbps		
4.04	**8/8 kbps Carriers**	From	Luanda, Angola			Cabinda City, Angola		
4.05	**0.4% Rain Fade Probability**	To	Cabinda City, Angola			Luanda, Angola		
4.06			Clear	Clear	0.4%	Clear	Clear	0.4%
4.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
4.08	HPA Saturated Output Power	dBW	20.0			16.0		
4.09		Watts	100.0			40.0		
4.10	HPA output backoff	dB	21.5	21.5	21.5	6.3	6.3	6.3
4.11	Total Power out of HPA	dBW	-1.5	-1.5	-1.5	9.7	9.7	9.7
4.12	Total number of carriers	#	60.0			60.0		
4.13	Activity Factor	#	0.4			0.4		
4.14	Number of active carriers	#	24.0			24.0		
4.15	Power per Carrier out of HPA	Watts	0.02	0.02	0.02	0.07	0.07	0.07
4.16		dBW	-16.8	-16.8	-16.8	-11.3	-11.3	-11.3
4.17	Loss to antenna	dB	2.0	2.0	2.0	2.0	2.0	2.0
4.18	Power per Carrier into Antenna	dBW	-18.8	-18.8	-18.8	-13.3	-13.3	-13.3
4.19	Antenna Transmit Gain	dBi	57.4	57.4	57.4	45.8	45.8	45.8
4.20	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	32.5	32.5	32.5
4.21	Earth Station C/IMo	dB-Hz	85.1	85.1	85.1	58.8	58.8	58.8
4.22	ES Adja. Ch Interference C/Ia	dB	66.0	66.0	66.0	45.8	45.8	45.8
4.23	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.24	ES C/Io (adj carrier)	dB-Hz	105.8	105.8	105.8	85.6	85.6	85.6
4.25	Earth Terminal EIRP/Carrier	dBW	38.5	38.5	38.5	32.5	32.5	32.5
4.26	Uplink Free Space Loss	dB	199.7	199.7	199.7	199.6	199.64	199.64
4.27	Uplink Pointing Loss due to Sat. Drift	dB	0.0	0.3	0.3	0.0	0.1	0.1
4.28	Uplink Pointing Loss due to Wind	dB	0.0	0.8	0.8	0.0	0.6	0.6
4.29	Uplink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.30	Uplink Rain Attenuation	dB	0.0	0.0	0.2	0.0	0.0	0.6
4.31	Receive Isotropic Pwr/Carrier	dBW	-161.2	-162.3	-162.5	-167.2	-167.9	-168.5
4.32	Satellite G/T	dB/K	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
4.33	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.34	Uplink C/kT (C/No)	dB-Hz	61.4	60.3	60.1	55.4	54.7	54.1
4.35	Transponder EIRP/Carrier	dBW	-5.8	-6.9	-7.12	-11.8	-12.49	-13.09
4.36	Satellite Output Io	dB/Hz	-69.5	-69.5	-69.5	-69.5	-69.5	-69.5
4.37	Satellite C/Io	dB-Hz	63.6	62.6	62.3	57.6	57.0	56.4
4.38	Sat. Adja. Ch Interference C/Ia	dB	34.0	34.0	34.0	34.0	34.0	34.0
4.39	Occupied Bandwidth	dB-Hz	39.8	39.8	39.8	39.8	39.8	39.8
4.40	Satellite C/Io (adj carrier)	dB-Hz	73.8	73.8	73.8	73.8	73.8	73.8
4.41	Receive Isotropic Pwr/Carrier	dBW	-161.2	-162.3	-162.5	-167.2	-167.9	-168.5
4.42	Transponder Gain	dB	155.4	155.4	155.4	155.4	155.4	155.4
4.43	Transponder EIRP/Carrier	dBW	-5.8	-6.9	-7.1	-11.8	-12.5	-13.1
4.44	Downlink Rain Attenuation	dB	0.0	0.0	0.1	0.0	0.0	0.0
4.45	Downlink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.46	Downlink Pointing Loss	dB	0.0	0.3	0.3	0.0	0.5	0.5
4.47	Downlink Free space Loss	dB	195.7	195.7	195.7	195.7	195.7	195.7
4.48	ES Ant Rx Gain at LNA Input	dB	41.7	41.7	41.7	53.3	53.3	53.3
4.49	Receive Level (LNA Input)	dBW	-159.8	-161.2	-161.5	-154.3	-155.4	-156.1
4.50	ES System Noise Temp.	dB-K	18.9	18.9	19.1	19.5	19.5	19.6
4.51	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.52	Downlink C/kT	dB-Hz	49.9	48.5	48.0	54.8	53.6	52.9
4.53	Receive Level (Antenna Port)	dBW	-159.8	-161.2	-161.5	-154.3	-155.4	-156.1
4.54	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.1	-219.2	-218.8	-219.3	-219.4
4.55	Adjacent Satellite C/Io	dB/Hz	59.0	57.9	57.7	64.6	63.9	63.3
4.56	Total Link C/kT	dB-Hz	49.0	47.6	47.2	50.2	49.4	48.8
4.57	Required C/kT	dB-Hz	46.6	46.1	45.5	46.6	46.1	45.5
4.58	**System Link Margin**	**dB**	**2.3**	**1.5**	**1.6**	**3.5**	**3.3**	**3.3**

5.01	**LINK BUDGET SUMMARY**		**Satellite Longitude: -31.5**					
5.02	**Angola - Cabinda Domsat**	Band: C	Carrier Size:			Carrier Size:		
5.03	**8/8 kbps Carriers**		8 kbps			8 kbps		
5.04	**0.4% Rain Fade Probability**	From	LUA Luanda, Angola			Cabinda City, Angola		
5.05	**INTELSAT 801 Hemi 3-4**	To	Cabinda City, Angola			LUA Luanda, Angola		
5.06			Clear	Clear	0.4%	Clear	Clear	0.4%
5.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
5.08	SUMMARY OF CARRIER/NOISE							
5.09	Earth Station C/IM	dB	45.3	45.3	45.3	19.0	19.0	19.0
5.10	ES C/I (adj carrier)	dB	66.0	66.0	66.0	45.8	45.8	45.8
5.11	Uplink C/N	dB	21.6	20.5	20.3	15.6	14.9	14.3
5.12	C/Sat IM	dB	25.9	24.9	24.6	19.9	19.3	18.7
5.13	C/I adj co-pol xpndr	dB	34.9	33.9	33.6	28.9	28.3	27.7
5.14	C/I xpol up	dB	31.9	30.9	30.6	25.9	25.3	24.7
5.15	C/I xpol down	dB	31.9	30.9	30.6	25.9	25.3	24.7
5.16	C/I adjacent satellite	dB	19.2	18.1	17.9	24.8	24.1	23.5
5.17	Sat C/I (adj carrier)	dB	34.0	34.0	34.0	34.0	34.0	34.0
5.18	Downlink C/N	dB	10.1	8.7	8.2	15.0	13.8	13.1
5.19	Total Link C/N	dB	9.1	7.8	7.4	10.3	9.6	9.0
5.20	Required Link C/N	dB	6.8	6.3	5.7	6.8	6.3	5.7
5.21	Total Link C/kT	dB-Hz	49.0	47.6	47.2	50.2	49.4	48.8
5.22	Total Link Eb/No	dB	9.9	8.6	8.1	11.1	10.4	9.8
5.23	Required Link Eb/No	dB	7.6	7.1	6.5	7.6	7.1	6.5
5.24	**System Link Margin**	**dB**	**2.3**	**1.5**	**1.6**	**3.5**	**3.3**	**3.3**
	U/L + D/L C/N	dB	9.8	8.4	7.9	12.3	11.3	10.6
		Total (%)						
	Fraction of Bandwidth	0.04%	0.02%			0.02%		
	Fraction of Power	0.03%	0.02%			0.01%		
	Pwr/BW Ratio	0.63	1.00			0.25		
	BW based on BW (MHz)	0.03	0.02			0.02		
	BW based on Power (MHz)	0.019	0.02			0.00		

A.2.5 Link Budgets, Cabinda to Luanda, 60 Channels, 2 E1's Compressed, 1 Carrier

Link Budgets
Cabinda to Luanda
60 Channels
2 E1's Compressed
1 Carrier
C-Band
INTELSAT 801 Satellite

1.01	**LINK BUDGET CALCULATION**							Ant (M)
1.02			**Site 1**	**Cabinda City, Angola**				3.80
1.03	**INTELSAT 801 Hemi 3-4**			CBC				
1.04	**Angola - Cabinda Domsat**		**Site 2**	**Luanda, Angola**				15.00
1.05	**512/512 kbps Carriers**			LUA				
1.06	**0.4% Rain Fade Probability**		Satellite Longitude: -31.5			Band:	C	
1.07	Originating Site		Cabinda City, Angola			Luanda, Angola		
1.08	Originating Site Abbreviation		CBC			LUA		
1.09	Destination Site		Luanda, Angola			Cabinda City, Angola		
1.10	Destination Site Abbreviation		LUA			CBC		
1.11			Clear	Clear	0.4%	Clear	Clear	0.4%
1.12	**SYSTEM PARAMETERS:**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
1.13	Uplink Freq	GHz	6.050			6.050		
1.14	Downlink Freq	GHz	3.825			3.825		
1.15	Information bit rate	kbps	512			512		
1.16	Information bit rate + overhead	kbps	512.0			512.0		
1.17	Coding rate		3/4			3/4		
1.18	Modulation type (BPSK/QPSK)		QPSK			QPSK		
1.19	Demodulator decoder type		RS			RS		
1.20	Carrier spacing factor (x SR)		1.40			1.40		
1.21	Necessary bandwidth factor (x SR)		1.20			1.20		
1.22	Modulation bit/symbol		2.0			2.0		
1.23	Transmission symbol rate	ksps	375.5			375.5		
1.24	Allocated Bandwidth	MHz	0.530			0.530		
1.25	Occupied Bandwidth	MHz	0.451			0.451		
1.26		dB-Hz	56.5			56.5		
1.27	Desired BER		1.0E-8	1.0E-7	1.0E-6	1.0E-8	1.0E-7	1.0E-6
1.28	Req Eb/No w coding	dB	6.4	6.2	6.0	6.4	6.2	6.0
1.29	Required C/No with coding	dB-Hz	63.5	63.3	63.1	63.5	63.3	63.1
1.30	Required C/N with coding	dB	7.0	6.8	6.6	7.0	6.8	6.6
1.31	**SATELLITE PARAMETERS:**							
1.32	Satellite Longitude (+ = E, - = W)	deg	-31.5			-31.5		
1.33	Transponder Number		Hemi 3-4			Hemi 3-4		
1.34	Transponder BW	MHz	72.0			72.0		
1.35	Saturated EIRP toward Destination	dBW	36.5			36.5		
1.36	Gain Step above Nominal	dB	-11.1			-11.1		
1.37	Nom Sat. Flux Density toward Orig. Site	dBW/sq M	-91.0			-91.0		
1.38	G/T toward Origination Site	dB/K	-6.0			-6.0		
1.39			Available:			Available:		
1.40	Available Transponder Bandwidth	MHz	72.0			72.0		
1.41	Carrier Allocated Bandwidth	MHz	0.53			0.53		
1.42	Dest. EIRP Power Above Even Distribution	dB	-4.0			2.0		
1.43	Available Saturated EIRP	dBW	11.2			17.2		
1.44	Available Saturated Flux Density	dBW/sq M	-105.2			-99.2		
1.45	Transponder Multicarrier Output Backoff	dB	5.5			5.5		
1.46	Transponder Multicarrier Input Backoff	dB	7.4			7.4		
1.47	Available Operating EIRP	dBW	5.7			11.7		
1.48	Available Operating Flux Density	dBW/sq M	-112.6			-106.6		
1.49	G/T	dB/K	-6.0			-6.0		
1.50	Transponder Gain	dB	155.4			155.4		
1.51	Station Keeping (NS & EW)	deg	0.05			0.05		

2.01	**SATELLITE INTERFERENCE BUDGETS**							
2.02								
2.03	Originating Site		Cabinda City, Angola			Luanda, Angola		
2.04	Originating Site Abbreviation		CBC			LUA		
2.05	Destination Site		Luanda, Angola			Cabinda City, Angola		
2.06	Destination Site Abbreviation		LUA			CBC		
2.07	**INTERFERENCE AT SATELLITE**		Clear	Clear	0.4%	Clear	Clear	0.4%
2.08	**INTELSAT 801 Hemi 3-4**		Sky	Pt error	Rain	Sky	Pt error	Rain
2.09	IMo	dB/Hz	-71.6			-71.6		
2.10	Io adj co-pol xpndr	dB/Hz	-80.6			-80.6		
2.11	Io xpol up	dB/Hz	-77.6			-77.6		
2.12	Io xpol down	dB/Hz	-77.6			-77.6		
2.13	Total Io (at satellite)	dBW/Hz	-69.5			-69.5		
2.14	**Adjacent Satellite Interference**							
2.15	Satellite Spacing	deg	2.00					
2.16	Adjacent Satellite BOo	dB	5.00					
2.17	Adjacent Satellite #1							
2.18	Satellite							
2.19	Satellite Longitude (+ = E, - = W)	deg	-29.50			-29.50		
2.20	El to Satellite #1	deg	39.87			41.51		
2.21	Az to Satellite #1	deg	279.42			276.24		
2.22	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.23	Bandwidth	MHz	72.00			72.00		
2.24	Output Backoff	dB	5.00			5.00		
2.25	Angular distance	deg	2.21			2.22		
2.26	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.39			20.35		
2.27	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.6	-223.1	-223.1	-222.6	-222.9	-222.9
2.28	Adjacent Satellite #2							
2.29	Satellite							
2.30	Satellite Longitude (+ = E, - = W)	deg	-27.50			-27.50		
2.31	El to Satellite #2	deg	42.03			43.71		
2.32	Az to Satellite #2	deg	280.09			276.70		
2.33	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.34	Bandwidth	MHz	72.00			72.00		
2.35	Output Backoff	dB	5.00			5.00		
2.36	Angular distance	deg	4.43			4.45		
2.37	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.84			12.80		
2.38	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.1	-230.6	-230.6	-230.1	-230.4	-230.5
2.39	Adjacent Satellite #3							
2.40	Satellite							
2.41	Satellite Longitude (+ = E, - = W)	deg	-33.50			-33.50		
2.42	El to Satellite #3	deg	35.57			37.13		
2.43	Az to Satellite #3	deg	278.20			275.43		
2.44	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.45	Bandwidth	MHz	72.00			72.00		
2.46	Output Backoff	dB	5.00			5.00		
2.47	Angular distance	deg	2.20			2.21		
2.48	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.44			20.41		
2.49	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.5	-223.0	-223.0	-222.5	-222.8	-222.9
2.50	Adjacent Satellite #4							
2.51	Satellite							
2.52	Satellite Longitude (+ = E, - = W)	deg	-35.50			-35.50		
2.53	El to Satellite #4	deg	33.43			34.95		
2.54	Az to Satellite #4	deg	277.66			275.07		
2.55	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.56	Bandwidth	MHz	72.00			72.00		
2.57	Output Backoff	dB	5.00			5.00		
2.58	Angular distance	deg	4.39			4.40		
2.59	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.95			12.91		
2.60	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.0	-230.5	-230.5	-230.0	-230.3	-230.4
2.61	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.3	-219.4	-218.8	-219.1	-219.2

3.01	**EARTH STATION PARAMETERS:**							
3.02	**Angola - Cabinda Domsat**	Band: C	INTELSAT 801 Hemi 3-4					
3.03	**512/512 kbps Carriers**		Clear	Clear	0.4%	Clear	Clear	0.4%
3.04	**0.4% Rain Fade Probability**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
3.05			Site 1			Site 2		
3.06	Site Location		Cabinda City, Angola			Luanda, Angola		
3.07	Site Abbreviation		CBC			LUA		
3.08	ES Latitude	deg	-5.60			-8.83		
3.09	ES Longitude	deg	12.20			13.25		
3.10	Elevation	deg	39.31			37.72		
3.11	Azimuth	deg	275.82			278.79		
3.12	Slant Range	km	37835			37961		
3.13	Antenna Type		P-3.8			15.00		
3.14	Antenna Diameter	M	3.80			15.00		
3.15	Antenna Transmit Gain	dBi	45.83			57.36		
3.16	Antenna Receive Gain	dBi	41.86			53.45		
3.17	Antenna Noise Temperature	dB-K	22.07			35.00		
3.18	Antenna Transmit Beamwidth	deg	0.89			0.23		
3.19	Antenna Receive Beamwidth	deg	1.40			0.34		
3.20	Antenna Tracking		no			yes		
3.21	Satellite Drift Error (or Tracking Error)	deg	0.071			0.034		
3.22	Wind Pointing Error (30 mph gust to 45)	deg	0.140			0.034		
3.23	Total Pointing Error	deg	0.211			0.068		
3.24	Transmit Pointing Loss due to Sat. Drift	dB	0.08			0.27		
3.25	Transmit Pointing Loss due to Wind	dB	0.60			0.81		
3.26	Transmit Pointing Loss	dB	0.67			1.09		
3.27	Receive Pointing Loss	dB	0.27			0.48		
3.28	Uplink Power Control		no			no		
3.29	Max UPC	dB	0.00			0.00		
3.30	Rain Model		CCIR			CCIR		
3.31	Rain Zone		N			K		
3.32	Rain Probability	%	0.40			0.40		
3.33	Uplink Rain Attenuation	dB	0.61			0.22		
3.34	Downlink Rain Attenuation	dB	0.07			0.03		
3.35	Loss Antenna to LNA	dB	0.15			0.15		
3.36	Noise due to Ant/LNA Loss	K	10.18			10.18		
3.37	LNC Noise Temperature	K	45.00			45.00		
3.38	Electronics Noise Temperature	K	1.00			1.00		
3.39	Rain Contribution to Sys Temp	K	0.00	0.00	4.54	0.00	0.00	1.84
3.40	System Noise Temperature	K	77.50	77.50	81.89	90.00	90.00	91.77
3.41		dB-K	18.89	18.89	19.13	19.54	19.54	19.63
3.42	G/T	dB/K	22.81	22.81	22.57	33.76	33.76	33.67
3.43	Required C/kT	dB-Hz	63.49	63.29	63.09	63.49	63.29	63.09
3.44	HPA Type (TWTA or SSPA)		SSPA			TWTA		
3.45	Saturated TWTA Output Power	dBW	16.02			20.00		
3.46	(SSPA @ 1 dB Gain Comp)	Watts	40.00			100.00		
3.47	Loss HPA to Antenna	dB	2.00			2.00		

4.01	**LINK BUDGET CALCULATION**		**Satellite Longitude: -31.5**					
4.02	**INTELSAT 801 Hemi 3-4**	Band: C	Carrier Size:			Carrier Size:		
4.03	**Angola - Cabinda Domsat**		512 kbps			512 kbps		
4.04	**512/512 kbps Carriers**	From	CBC Cabinda City, Angola			Luanda, Angola		
4.05	**0.4% Rain Fade Probability**	To	Luanda, Angola			CBC Cabinda City, Angola		
4.06			Clear	Clear	0.4%	Clear	Clear	0.4%
4.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
4.08	HPA Saturated Output Power	dBW	16.0			20.0		
4.09		Watts	40.0			100.0		
4.10	HPA output backoff	dB	5.4	5.4	5.4	18.6	18.6	18.6
4.11	Total Power out of HPA	dBW	10.7	10.7	10.7	1.4	1.4	1.4
4.12	Total number of carriers	#	1.0			1.0		
4.13	Activity Factor	#	1.0			1.0		
4.14	Number of active carriers	#	1.0			1.0		
4.15	Power per Carrier out of HPA	Watts	4.13	4.13	4.13	1.16	1.16	1.16
4.16		dBW	6.2	6.2	6.2	0.7	0.7	0.7
4.17	Loss to antenna	dB	2.0	2.0	2.0	2.0	2.0	2.0
4.18	Power per Carrier into Antenna	dBW	4.2	4.2	4.2	-1.3	-1.3	-1.3
4.19	Antenna Transmit Gain	dBi	45.8	45.8	45.8	57.4	57.4	57.4
4.20	Earth Terminal EIRP/Carrier	dBW	50.0	50.0	50.0	56.0	56.0	56.0
4.21	Earth Station C/IMo	dB-Hz	500.0	500.0	500.0	500.0	500.0	500.0
4.22	ES Adja. Ch Interference C/Ia	dB	500.0	500.0	500.0	500.0	500.0	500.0
4.23	Occupied Bandwidth	dB-Hz	56.5	56.5	56.5	56.5	56.5	56.5
4.24	ES C/Io (adj carrier)	dB-Hz	556.5	556.5	556.5	556.5	556.5	556.5
4.25	Earth Terminal EIRP/Carrier	dBW	50.0	50.0	50.0	56.0	56.0	56.0
4.26	Uplink Free Space Loss	dB	199.6	199.6	199.6	199.7	199.67	199.67
4.27	Uplink Pointing Loss due to Sat. Drift	dB	0.0	0.1	0.1	0.0	0.3	0.3
4.28	Uplink Pointing Loss due to Wind	dB	0.0	0.6	0.6	0.0	0.8	0.8
4.29	Uplink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.30	Uplink Rain Attenuation	dB	0.0	0.0	0.6	0.0	0.0	0.2
4.31	Receive Isotropic Pwr/Carrier	dBW	-149.7	-150.4	-151.0	-143.7	-144.8	-145.0
4.32	Satellite G/T	dB/K	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
4.33	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.34	Uplink C/kT (C/No)	dB-Hz	72.9	72.2	71.6	78.9	77.8	77.6
4.35	Transponder EIRP/Carrier	dBW	5.7	5.0	4.39	11.7	10.58	10.37
4.36	Satellite Output Io	dB/Hz	-69.5	-69.5	-69.5	-69.5	-69.5	-69.5
4.37	Satellite C/Io	dB-Hz	75.1	74.4	73.8	81.1	80.0	79.8
4.38	Sat. Adja. Ch Interference C/Ia	dB	34.0	34.0	34.0	34.0	34.0	34.0
4.39	Occupied Bandwidth	dB-Hz	56.5	56.5	56.5	56.5	56.5	56.5
4.40	Satellite C/Io (adj carrier)	dB-Hz	90.5	90.5	90.5	90.5	90.5	90.5
4.41	Receive Isotropic Pwr/Carrier	dBW	-149.7	-150.4	-151.0	-143.7	-144.8	-145.0
4.42	Transponder Gain	dB	155.4	155.4	155.4	155.4	155.4	155.4
4.43	Transponder EIRP/Carrier	dBW	5.7	5.0	4.4	11.7	10.6	10.4
4.44	Downlink Rain Attenuation	dB	0.0	0.0	0.0	0.0	0.0	0.1
4.45	Downlink Atmospheric Loss	dB	0.1	0.1	0.1	0.1	0.1	0.1
4.46	Downlink Pointing Loss	dB	0.0	0.5	0.5	0.0	0.3	0.3
4.47	Downlink Free space Loss	dB	195.7	195.7	195.7	195.7	195.7	195.7
4.48	ES Ant Rx Gain at LNA Input	dB	53.3	53.3	53.3	41.7	41.7	41.7
4.49	Receive Level (LNA Input)	dBW	-136.8	-137.9	-138.6	-142.3	-143.7	-144.0
4.50	ES System Noise Temp.	dB-K	19.5	19.5	19.6	18.9	18.9	19.1
4.51	Boltzmann's Constant	dBW/K-Hz	-228.6	-228.6	-228.6	-228.6	-228.6	-228.6
4.52	Downlink C/kT	dB-Hz	72.3	71.1	70.4	67.4	66.0	65.5
4.53	Receive Level (Antenna Port)	dBW	-136.8	-137.9	-138.6	-142.3	-143.7	-144.0
4.54	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.3	-219.4	-218.8	-219.1	-219.2
4.55	Adjacent Satellite C/Io	dB/Hz	82.1	81.4	80.8	76.5	75.4	75.2
4.56	Total Link C/kT	dB-Hz	68.3	67.4	66.8	66.4	65.1	64.7
4.57	Required C/kT	dB-Hz	63.5	63.3	63.1	63.5	63.3	63.1
4.58	**System Link Margin**	**dB**	**4.8**	**4.1**	**3.7**	**2.9**	**1.8**	**1.6**

5.01	**LINK BUDGET SUMMARY**		**Satellite Longitude: -31.5**					
5.02	**Angola - Cabinda Domsat**	Band: C	Carrier Size:			Carrier Size:		
5.03	**512/512 kbps Carriers**		512 kbps			512 kbps		
5.04	**0.4% Rain Fade Probability**	From	CBC Cabinda City, Angola			Luanda, Angola		
5.05	**INTELSAT 801 Hemi 3-4**	To	Luanda, Angola			CBC Cabinda City, Angola		
5.06			Clear	Clear	0.4%	Clear	Clear	0.4%
5.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
5.08	SUMMARY OF CARRIER/NOISE							
5.09	Earth Station C/IM	dB	443.5	443.5	443.5	443.5	443.5	443.5
5.10	ES C/I (adj carrier)	dB	500.0	500.0	500.0	500.0	500.0	500.0
5.11	Uplink C/N	dB	16.3	15.7	15.1	22.3	21.3	21.0
5.12	C/Sat IM	dB	20.7	20.0	19.4	26.7	25.6	25.4
5.13	C/I adj co-pol xpndr	dB	29.7	29.0	28.4	35.7	34.6	34.4
5.14	C/I xpol up	dB	26.7	26.0	25.4	32.7	31.6	31.4
5.15	C/I xpol down	dB	26.7	26.0	25.4	32.7	31.6	31.4
5.16	C/I adjacent satellite	dB	25.5	24.8	24.2	20.0	18.9	18.7
5.17	Sat C/I (adj carrier)	dB	34.0	34.0	34.0	34.0	34.0	34.0
5.18	Downlink C/N	dB	15.7	14.6	13.9	10.8	9.5	8.9
5.19	Total Link C/N	dB	11.7	10.9	10.2	9.9	8.6	8.1
5.20	Required Link C/N	dB	7.0	6.8	6.6	7.0	6.8	6.6
5.21	Total Link C/kT	dB-Hz	68.3	67.4	66.8	66.4	65.1	64.7
5.22	Total Link Eb/No	dB	11.2	10.3	9.7	9.3	8.0	7.6
5.23	Required Link Eb/No	dB	6.4	6.2	6.0	6.4	6.2	6.0
5.24	**System Link Margin**	**dB**	**4.8**	**4.1**	**3.7**	**2.9**	**1.8**	**1.6**
	U/L + D/L C/N	dB	13.0	12.1	11.4	10.5	9.2	8.7
		Total (%)						
	Fraction of Bandwidth	1.472%	0.736%			0.736%		
	Fraction of Power	1.45971%	0.293%			1.167%		
	Pwr/BW Ratio	0.99	0.40			1.58		
	BW based on BW (MHz)	1.0600	0.5300			0.5300		
	BW based on Power (MHz)	1.0510	0.2110			0.8400		

A.2.6 Link Budgets, Cabinda to Luanda, 60 Channels, 2 E1's Uncompressed, 2 Carriers

Link Budgets
Cabinda to Luanda
60 Channels
2 E1's Uncompressed
2 Carriers
C-Band
INTELSAT 801 Satellite

1.01	**LINK BUDGET CALCULATION**								Ant (M)
1.02			**Site 1**	**Cabinda City, Angola**					3.80
1.03	**INTELSAT 801 Hemi 3-4**			CBC					
1.04	**Angola - Cabinda Domsat Cfg 1**		**Site 2**	**Luanda, Angola**					15.00
1.05	**2048/2048 kbps Carriers**			LUA					
1.06	**0.4% Rain Fade Probability**		Satellite Longitude: -31.5				Band:	C	
1.07	Originating Site		Cabinda City, Angola			Luanda, Angola			
1.08	Originating Site Abbreviation		CBC			LUA			
1.09	Destination Site		Luanda, Angola			Cabinda City, Angola			
1.10	Destination Site Abbreviation		LUA			CBC			
1.11			Clear	Clear	0.4%	Clear	Clear	0.4%	
1.12	**SYSTEM PARAMETERS:**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain	
1.13	Uplink Freq	GHz	6.050			6.050			
1.14	Downlink Freq	GHz	3.825			3.825			
1.15	Information bit rate	kbps	2048			2048			
1.16	Information bit rate + overhead	kbps	2048.0			2048.0			
1.17	Coding rate		3/4			3/4			
1.18	Modulation type (BPSK/QPSK)		QPSK			QPSK			
1.19	Demodulator decoder type		RS			RS			
1.20	Carrier spacing factor (x SR)		1.40			1.40			
1.21	Necessary bandwidth factor (x SR)		1.20			1.20			
1.22	Modulation bit/symbol		2.0			2.0			
1.23	Transmission symbol rate	ksps	1501.9			1501.9			
1.24	Allocated Bandwidth	MHz	2.105			2.105			
1.25	Occupied Bandwidth	MHz	1.802			1.802			
1.26		dB-Hz	62.6			62.6			
1.27	Desired BER		1.0E-8	1.0E-7	1.0E-6	1.0E-8	1.0E-7	1.0E-6	
1.28	Req Eb/No w coding	dB	6.4	6.2	6.0	6.4	6.2	6.0	
1.29	Required C/No with coding	dB-Hz	69.5	69.3	69.1	69.5	69.3	69.1	
1.30	Required C/N with coding	dB	7.0	6.8	6.6	7.0	6.8	6.6	
1.31	**SATELLITE PARAMETERS:**								
1.32	Satellite Longitude (+ = E, - = W)	deg	-31.5			-31.5			
1.33	Transponder Number		Hemi 3-4			Hemi 3-4			
1.34	Transponder BW	MHz	72.0			72.0			
1.35	Saturated EIRP toward Destination	dBW	36.5			36.5			
1.36	Gain Step above Nominal	dB	-11.1			-11.1			
1.37	Nom Sat. Flux Density toward Orig. Site	dBW/sq M	-91.0			-91.0			
1.38	G/T toward Origination Site	dB/K	-6.0			-6.0			
1.39			Available:			Available:			
1.40	Available Transponder Bandwidth	MHz	72.0			72.0			
1.41	Carrier Allocated Bandwidth	MHz	2.11			2.11			
1.42	Dest. EIRP Power Above Even Distribution	dB	-4.0			2.0			
1.43	Available Saturated EIRP	dBW	17.2			23.2			
1.44	Available Saturated Flux Density	dBW/sq M	-99.2			-93.2			
1.45	Transponder Multicarrier Output Backoff	dB	5.5			5.5			
1.46	Transponder Multicarrier Input Backoff	dB	7.4			7.4			
1.47	Available Operating EIRP	dBW	11.7			17.7			
1.48	Available Operating Flux Density	dBW/sq M	-106.6			-100.6			
1.49	G/T	dB/K	-6.0			-6.0			
1.50	Transponder Gain	dB	155.4			155.4			
1.51	Station Keeping (NS & EW)	deg	0.05			0.05			

2.01	**SATELLITE INTERFERENCE BUDGETS**							
2.02								
2.03	Originating Site		Cabinda City, Angola			Luanda, Angola		
2.04	Originating Site Abbreviation		CBC			LUA		
2.05	Destination Site		Luanda, Angola			Cabinda City, Angola		
2.06	Destination Site Abbreviation	UNITS	LUA			CBC		
2.07	**INTERFERENCE AT SATELLITE**		Clear	Clear	0.4%	Clear	Clear	0.4%
2.08	**INTELSAT 801 Hemi 3-4**		Sky	Pt error	Rain	Sky	Pt error	Rain
2.09	IMo	dB/Hz	-71.6			-71.6		
2.10	Io adj co-pol xpndr	dB/Hz	-80.6			-80.6		
2.11	Io xpol up	dB/Hz	-77.6			-77.6		
2.12	Io xpol down	dB/Hz	-77.6			-77.6		
2.13	Total Io (at satellite)	dBW/Hz	-69.5			-69.5		
2.14	**Adjacent Satellite Interference**							
2.15	Satellite Spacing	deg	2.00					
2.16	Adjacent Satellite BOo	dB	5.00					
2.17	Adjacent Satellite #1							
2.18	Satellite							
2.19	Satellite Longitude (+ = E, - = W)	deg	-29.50			-29.50		
2.20	El to Satellite #1	deg	39.87			41.51		
2.21	Az to Satellite #1	deg	279.42			276.24		
2.22	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.23	Bandwidth	MHz	72.00			72.00		
2.24	Output Backoff	dB	5.00			5.00		
2.25	Angular distance	deg	2.21			2.22		
2.26	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.39			20.35		
2.27	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.6	-223.1	-223.1	-222.6	-222.9	-222.9
2.28	Adjacent Satellite #2							
2.29	Satellite							
2.30	Satellite Longitude (+ = E, - = W)	deg	-27.50			-27.50		
2.31	El to Satellite #2	deg	42.03			43.71		
2.32	Az to Satellite #2	deg	280.09			276.70		
2.33	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.34	Bandwidth	MHz	72.00			72.00		
2.35	Output Backoff	dB	5.00			5.00		
2.36	Angular distance	deg	4.43			4.45		
2.37	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.84			12.80		
2.38	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.1	-230.6	-230.6	-230.1	-230.4	-230.5
2.39	Adjacent Satellite #3							
2.40	Satellite							
2.41	Satellite Longitude (+ = E, - = W)	deg	-33.50			-33.50		
2.42	El to Satellite #3	deg	35.57			37.13		
2.43	Az to Satellite #3	deg	278.20			275.43		
2.44	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.45	Bandwidth	MHz	72.00			72.00		
2.46	Output Backoff	dB	5.00			5.00		
2.47	Angular distance	deg	2.20			2.21		
2.48	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	20.44			20.41		
2.49	Io Adjacent Satellite (at ES LNA input)	dB/Hz	-222.5	-223.0	-223.0	-222.5	-222.8	-222.9
2.50	Adjacent Satellite #4							
2.51	Satellite							
2.52	Satellite Longitude (+ = E, - = W)	deg	-35.50			-35.50		
2.53	El to Satellite #4	deg	33.43			34.95		
2.54	Az to Satellite #4	deg	277.66			275.07		
2.55	Saturated EIRP Toward Earth Station	dBW	36.50			36.50		
2.56	Bandwidth	MHz	72.00			72.00		
2.57	Output Backoff	dB	5.00			5.00		
2.58	Angular distance	deg	4.39			4.40		
2.59	ES Ant Gain to Adj Sat. (29-25 log ang)	dB	12.95			12.91		
2.60	Io Adjacent Satellite (at ES LNA input)	dBW/Hz	-230.0	-230.5	-230.5	-230.0	-230.3	-230.4
2.61	Total Io adjacent satellite (at ES)	dBW/Hz	-218.8	-219.3	-219.4	-218.8	-219.1	-219.2

3.01	**EARTH STATION PARAMETERS:**		INTELSAT 801 Hemi 3-4					
3.02	**Angola - Cabinda Domsat Cfg 1**	Band: C						
3.03	**2048/2048 kbps Carriers**		Clear	Clear	0.4%	Clear	Clear	0.4%
3.04	**0.4% Rain Fade Probability**	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
3.05			Site 1			Site 2		
3.06	Site Location		Cabinda City, Angola			Luanda, Angola		
3.07	Site Abbreviation		CBC			LUA		
3.08	ES Latitude	deg	-5.60			-8.83		
3.09	ES Longitude	deg	12.20			13.25		
3.10	Elevation	deg	39.31			37.72		
3.11	Azimuth	deg	275.82			278.79		
3.12	Slant Range	km	37835			37961		
3.13	Antenna Type		P-3.8			15.00		
3.14	Antenna Diameter	M	3.80			15.00		
3.15	Antenna Transmit Gain	dBi	45.83			57.36		
3.16	Antenna Receive Gain	dBi	41.86			53.45		
3.17	Antenna Noise Temperature	dB-K	22.07			35.00		
3.18	Antenna Transmit Beamwidth	deg	0.89			0.23		
3.19	Antenna Receive Beamwidth	deg	1.40			0.34		
3.20	Antenna Tracking		no			yes		
3.21	Satellite Drift Error (or Tracking Error)	deg	0.071			0.034		
3.22	Wind Pointing Error (30 mph gust to 45)	deg	0.140			0.034		
3.23	Total Pointing Error	deg	0.211			0.068		
3.24	Transmit Pointing Loss due to Sat. Drift	dB	0.08			0.27		
3.25	Transmit Pointing Loss due to Wind	dB	0.60			0.81		
3.26	Transmit Pointing Loss	dB	0.67			1.09		
3.27	Receive Pointing Loss	dB	0.27			0.48		
3.28	Uplink Power Control		no			no		
3.29	Max UPC	dB	0.00			0.00		
3.30	Rain Model		CCIR			CCIR		
3.31	Rain Zone		N			K		
3.32	Rain Probability	%	0.40			0.40		
3.33	Uplink Rain Attenuation	dB	0.61			0.22		
3.34	Downlink Rain Attenuation	dB	0.07			0.03		
3.35	Loss Antenna to LNA	dB	0.15			0.15		
3.36	Noise due to Ant/LNA Loss	K	10.18			10.18		
3.37	LNC Noise Temperature	K	45.00			45.00		
3.38	Electronics Noise Temperature	K	1.00			1.00		
3.39	Rain Contribution to Sys Temp	K	0.00	0.00	4.54	0.00	0.00	1.84
3.40	System Noise Temperature	K	77.50	77.50	81.89	90.00	90.00	91.77
3.41		dB-K	18.89	18.89	19.13	19.54	19.54	19.63
3.42	G/T	dB/K	22.81	22.81	22.57	33.76	33.76	33.67
3.43	Required C/kT	dB-Hz	69.51	69.31	69.11	69.51	69.31	69.11
3.44	HPA Type (TWTA or SSPA)		SSPA			TWTA		
3.45	Saturated TWTA Output Power	dBW	21.76			20.00		
3.46	(SSPA @ 1 dB Gain Comp)	Watts	150.00			100.00		
3.47	Loss HPA to Antenna	dB	2.00			2.00		

5.01	**LINK BUDGET SUMMARY**		**Satellite Longitude: -31.5**					
5.02	**Angola - Cabinda Domsat Cfg 1**	Band: C	Carrier Size:			Carrier Size:		
5.03	**2048/2048 kbps Carriers**		2048 kbps			2048 kbps		
5.04	**0.4% Rain Fade Probability**	From	CBC Cabinda City, Angola			Luanda, Angola		
5.05	INTELSAT 801 Hemi 3-4	To	Luanda, Angola			CBC Cabinda City, Angola		
5.06			Clear	Clear	0.4%	Clear	Clear	0.4%
5.07	PARAMETERS:	UNITS	Sky	Pt error	Rain	Sky	Pt error	Rain
5.08	SUMMARY OF CARRIER/NOISE							
5.09	Earth Station C/IM	dB	23.8	23.8	23.8	29.6	29.6	29.6
5.10	ES C/I (adj carrier)	dB	44.0	44.0	44.0	43.5	43.5	43.5
5.11	Uplink C/N	dB	16.3	15.6	15.0	22.3	21.2	21.0
5.12	C/Sat IM	dB	20.7	20.0	19.4	26.7	25.6	25.4
5.13	C/I adj co-pol xpndr	dB	29.7	29.0	28.4	35.7	34.6	34.4
5.14	C/I xpol up	dB	26.7	26.0	25.4	32.7	31.6	31.4
5.15	C/I xpol down	dB	26.7	26.0	25.4	32.7	31.6	31.4
5.16	C/I adjacent satellite	dB	25.5	24.8	24.2	19.9	18.8	18.6
5.17	Sat C/I (adj carrier)	dB	34.0	34.0	34.0	34.0	34.0	34.0
5.18	Downlink C/N	dB	15.7	14.6	13.8	10.8	9.4	8.9
5.19	Total Link C/N	dB	11.4	10.6	10.0	9.8	8.5	8.1
5.20	Required Link C/N	dB	7.0	6.8	6.6	7.0	6.8	6.6
5.21	Total Link C/kT	dB-Hz	74.0	73.2	72.6	72.4	71.1	70.6
5.22	Total Link Eb/No	dB	10.9	10.1	9.4	9.3	8.0	7.5
5.23	Required Link Eb/No	dB	6.4	6.2	6.0	6.4	6.2	6.0
5.24	**System Link Margin**	**dB**	**4.5**	**3.9**	**3.4**	**2.9**	**1.8**	**1.5**
	U/L + D/L C/N	dB	13.0	12.1	11.4	10.5	9.2	8.6
		Total (%)						
	Fraction of Bandwidth	5.847%	2.924%			2.924%		
	Fraction of Power	5.79752%	1.164%			4.634%		
	Pwr/BW Ratio	0.99	0.40			1.58		
	BW based on BW (MHz)	4.2100	2.1050			2.1050		
	BW based on Power (MHz)	4.1742	0.8380			3.3362		

A.3 Government User Traffic Report

A.3.1 Introduction

The purpose of this report is to develop a realistic traffic estimate for Government User Traffic in the province of Cabinda. The majority of the data collected, which forms the foundation of this report, was obtained from discussions with Angola Telecom Personnel and other government subscribers located within Cabinda City.

Subsequent paragraphs present the Telephony Network that is both operational and planned. The names of the Central & Provisional Government Subscribers in Cabinda, the estimated amount of traffic presently being utilized by these subscribers and the five-year projections for traffic growth within the Province commencing with calendar year 2000 through 2004.

This report addresses the traffic projections for government subscribers. Subsequent reports will address the traffic projections for the business community.

A.3.2 The Telephone Network

The telephone network in Cabinda is multi functional. It is important to understand what is planned and what is operational by Angola Telecom. This information forms the foundation for the development of the circuit projections for the next five years. Each of these systems is discussed in the following paragraphs.

Long Haul Communications: A LOS Microwave networks ties the city of Cabinda with Luanda. This existing 2Ghz system employs the Harris Farinon Radios and FDM Multiplex Equipment. There is presently a spare E-1 on the Microwave Link to Luanda.

Cellular Expansion: It is Angola Telecom's intent to expand the cellular system for province wide coverage. The Motorola AMPs system is the vender of choice. This is an analog system presently operational in Luanda having over 5,000 subscribers. The existing equipment compliment at the Cabinda Central Office is 16 base station channels.

Business System: There is a business VSAT system presently operational in Angola with some of the remote terminals on line in Cabinda City. This network ties into a hub station in Luanda. The Hughes PES system is utilized for this network. Remote subscribers in Cabinda constitute the banking community, civil service offices including the police and shipping firms that handle freight for the oil companies.

Telco System: Angola Telecom is planning to implement a hub station with ten remote stations to carry telephony traffic. This system can also carry cellular traffic from the remote areas.

Internet: Although needed its implementation is now projected for mid 2002.

A.3.3 Government User Traffic, Province of Cabinda.

The number of Government Subscribers in Cabinda City can be subdivided into two major categories. The first is associated with the Government headquartered in the nation's capital, Luanda. We will refer to these agencies as the Central Government Offices. The second category is associated with the local government, more commonly referred to as the Provincial Government of Cabinda.

It should be noted that the total traffic fin use by the Governmental Organizations approaches fifty percent of the total traffic originating in Cabinda City. Chevron and other companies associated with the Petrol Chemical industry take up another 35% of the remaining traffic. The business and the residential community of the province makeup the last 15% of usage to Luanda.

A.3.3.1 The Central Government Offices

The Central Government has many branch offices in Cabinda City. This is primarily attributed to the Chevron Complex located at Malongo. Surprisingly, this Chevron liaison offices are primarily based within the town of Cabinda, which geographically is located some thirty kilometers south of the oil company complex.

For simplicity sake, these Central Government Liaison Offices are divided into four major classifications. These constitute:

The Angolan Oil Company: To include the local SONANGOL Offices, the Chevron Liaison Office, SONANGOL's and the transport facilities to the Chevron Complex.

Military & Police: To include the Military Barracks in Cabinda City, the two police stations, the customs office including immigration and the border patrol with the Congo Kinshasa and Congo Brazzaville.

Government Liaison Offices: To include all other federal liaison offices, such as education, mining, agriculture, fisheries and lumber.

Transportation: To include Angolan Airlines, the Port Authority of Cabinda, the Civil Aviation Authority and a branch office of the Meteorology Department of Angola.

A.3.4 Provincial Government

The Provincial Government of Cabinda has its own requirements for communications with both Luanda and on an international basis. As the microwave and the cellular networks are extended to the other municipalities in the Province, Cabinda will also be communicating with the towns in the municipalities of Belize, Buco-Zau and Landana.

The Provincial Government is also subdivided into four major categories. These constitute:

The Governor's Office: Including the entire executive branch of the Provincial Government of Cabinda.

Medical: Including both the Hospital and the Dispensary in Cabinda City.

Education: Including the local college, the high School and trade school and the four elementary schools located in metropolitan Cabinda.

Others: Including Public Transport, the administrative branch of the Cabinda government, the Department of Roads & Highways and the Electricity Department.

A.3.5 Trunk Usage

The primary purpose of this paper is to develop realistic traffic projections for Government subscribers in the Province of Cabinda. In order to project this estimated traffic; it is imperative to postulate the number of trunks that will be in service for a normal weekday for a twenty four-hour period. This realistic estimated is presented in the following Table A.3.5.1 entitled, "Trunk Usage Projections, Government of Cabinda".

A.3.5.1 Table A.3.5.1 Trunk Usage Projections Government of Cabinda

Time (Hrs.)	Trunk Usage	Time (Hrs.)	Trunk Usage
0100	1.0%	1300	22.0%
0200	0.5%	1400	25.0%
0300	0%	1500	30.0%
0400	0%	1600	45.0%
0500	0.5%	1700	49.0%
0600	4.0%	1800	52.0%
0700	14.0%	1900	41.0%
0800	30.0%	2000	31.0%
0900	39.0%	2100	19.0%
1000	45.0%	2200	6.0%
1100	*60.0%	2300	4.0%
1200	35.0%	2400	2.0%

* Denotes estimated Busy Hour.

To determine the average trunk usage, we must sum the total percentiles for each hour and divide by 24. This equates to 549/24 or 22.875% of the total circuits will be busy during the twenty four-hour day. This percentile is in the norm of telephone operating companies in that the average U.S. percentile is 25.7 % without Internet and the average European Rate is 28.7%.

It should be noted that the Busy Hour is between 11:00 and 12:00 hours. This conforms with Busy Hours of both Spain & Portugal on the Iberian Peninsula. A long lunch hour between 12:30 and in some cases 4:00 PM distorts the normal Bell shaped traffic curves. A great number of international calls to the USA including Cuba and Brazil also distorts this traffic curve over a normal eight-hour workday.

A.3.6 Circuit Count

The year 2000 finds Angola Telecom going into an expansion mode in the Province of Cabinda. Cellular is being added to Cabinda City and being extended northward to the Municipality of Landana. The Domestic satellite system is being installed for communications to the other towns within the province and the LOS System is being expanded to carry additional E-1's to Luanda.

The next step in this analysis is to determine the number of circuits originating and terminating in Cabinda Province. Care must be exercised in estimating this circuit count for government use only.

Subsequent paragraphs in this section address the number of projected government circuits from the year 2000 through a five-year period concluding in 2004.

A.3.6.1 Active Voice Circuit Count, Year 2000

Table A.3.6.2 reflects the number of active circuits for Government uses presently operational in the Province. A circuit count is presented along with the projected Erlangs. The latter is derived from the derived Busy Hour Usage.

Table A.3.6.2 presents a circuit count for calendar year 2000. Please note that the projections in this table for the year 2000 do not include any circuits to the rural towns or to the Municipalities.

A.3.6.2 Table A.3.6.2 Government Circuits Cabinda City, Year 2000

Organization	Circuit Count	Erlangs
Central Government		
Chevron Liaison & Support	6	3.6
Military & Police	5 (Note 1)	3.0
Transportation	4	2.4
Other Government Offices	2	1.2
Provincial Government of Cabinda		
Governor's Office	5	3.0
Medical	3	1.8
Education	2	1.2
Other	3	1.8

Note 1: Temporarily increased due to border uncertainties with both Congo Brazzaville & Kinshasa

A.3.7 Number of Voice Circuits, 2001

In the year 2001, the cellular system will be extended to Cacongo and six high-density remote satellite stations will be installed for voice communications with both Cabinda City and the capital of Luanda. Each high-density terminal will have up to ten equivalent voice grade circuits. There will be additional four low-density systems installed having a two-channel capacity in the remote villages of the interior. This ten station network will be fully operational by years end, 2001.

For government usage, it must be assumed that the government will utilize 50% of these satellite circuits. Angola Telecom and the business community of Angola will use the remainder for telephony service.

Table A.3.7.1 reflects the traffic growth during the year 2001.

A.3.7.1 Table A.3.7.1 Year 2001 Projected Government Circuits

Central Government	Year-2000 Circuits	Year-2001 Circuits
Chevron Liaison & Support	6	6
Military & Police	5	6 (Note 2)
Transportation	4	4
Other Government Offices	2	2
Six Large Satcom Terminals	-	6 (Note 3)
Four Small Satcom Terminals	-	1 (Note 3)
Provincial Government of Cabinda		
Governor's Office	5	5
Medical	3	3
Education	2	2
Other	3	3
Six Large Satcom Terminals	-	9 (Note 3)
Four Small Satcom Terminals	-	1 (Note 3)

Note 2: An increase of one military circuit is projected do to the uncertainty at the northern border.
Note 3: One half of the required number of circuits is shown because of the installation and test of the ten remote stations during 2001.

A.3.8 Number of Voice Circuits, 2002, & 2003

This year will be a full-fledged operational period with all the remote stations on line and the cellular network being expanded northeasterly toward the Congo borders. The Government circuits for both the Provincial and Federal subscribers will be fully operational for the twelve-month period.

This expansion is shown under table A.3.8.1.

The use of INTERNET service is projected to be available to both the government and commercial Cabinda subscribers by the beginning of calendar year 2003. These numbers are also presented within this same table.

A.3.8.1 Table A.3.8.1 Year 2002 & 2003 Projected Government Circuits

Central Government	**Year-2002 Circuits**	**Year-2003 Circuits**
Chevron Liaison & Support	8	10 (Note 4)
Military & Police	7	10 (Note 4)
Transportation	5	8 (Note 4)
Other Government Offices	4	8 (Note 4)
Six Large Satcom Terminals	12	14 (Note 4)
Four Small Satcom Terminals	2	2
Provincial Government of Cabinda		
Governor's Office	6	8 (Note 4)
Medical	3	6 (Note 4)
Education	3	6 (Note 4)
Other	3	6 (Note 4)
Six Large Satcom Terminals	12	14
Four Small Satcom Terminals	2	2

Note 4: Internet utilization by Government employees will increase the usage by 30 to 40 %.

A.3.9 Year 2004 Projections

It is estimated that there will be a thirty- percent increases by the year 2004 in the number of circuits required for government applications in Cabinda Province. A universal increase will result in all categories of subscribers. This increase primarily will be associated with an increase in Internet usage opposed to increased message service via government subscribers.

Table A.3.9.1 below reflects this increase.

A.3.9.1 Table A.3.9.1 Year 2004 Projected Government Circuits

Central Government	**Year-2004 Circuits**
Chevron Liaison & Support	14
Military & Police	14
Transportation	12
Other Government Offices	12
Six Large Satcom Terminals	18
Four Small Satcom Terminals	2
Provincial Government of Cabinda	
Governor's Office	12
Medical	10
Education	10
Other	10
Six Large Satcom Terminals	21
Four Small Satcom Terminals	2

A.3.10 Conclusion

This report addresses the government users in the Province. Our projections were based on both historical data and good traffic engineering practices. Traffic projections for the business community, the residential subscribers and the new cellular users will be included in a final composite report.

In essence Cabinda is growing and the need for more circuits and wide band data including INTERNET is mandatory. Angola Telecom is staying abreast of this accelerated growth and attempting to provide more and better circuits to all subscribers in the Province of Cabinda.

A.4 Non-Government User Traffic Report

A.4.1 Introduction

In the United States, it is understood that the demand for data communications will exceed the existing voice market within the next 36 months. All carriers are being forced to use an ATM based system in order to handle the demand for wideband data service. This demand for higher speed access results from the need of such services as streaming audio and video, teleconferencing, and telemetry. All require wider bandwidth and a higher speed on the existing Internet system.

Fortunately, Angola, e.g. Angola Telecom, does not have to address this problem yet. Two years from now when Internet is fully activated they will. Consequently this paper address primarily the voice needs for the business and residential subscribers in the Province of Cabinda. Traffic Projections are made for a five-year period commencing in 2001 for the business community. The provision of Internet Service in early 2002 will accelerate and increase the demand for additional voice circuits. These projections are discussed within the subsequent paragraphs of this report.

A.4.2 Potential Customer Base

The commercial customer base constitutes those subscribers in both the private sector and the business community using and requiring voice grade service within the Province of Cabinda. Consequently, the most important questions to be answered in projecting traffic for the business community are threefold. These are. "Who are the customers in Cabinda requiring new or existing voice grade service? Like wise, the same question can be asked for data applications. The last and most important question is "What type of data is planned for the Business community of Cabinda"? Once these questions are answered, realistic traffic projections can be postulated.

The business subscribers for additional voice grade service constitute, the Petroleum Sector excluding Chevron. These are primarily the support or ancillary companies working with Chevron at the Malonga Complex who have business offices in Cabinda City. The Transportation Industry which supports Chevron and the private sector needs within Cabinda Province is another user of Telecom Services. Another important sector is the Banking Community with circuits to up-country branches and to their headquarters bank in Luanda. The Banking community has over six commercial banks in Cabinda City.

Agriculture, Timber & Mining are other important sectors who will has an appreciable increase in both voice and data traffic within the Province. These major sectors will be complimented by the small business community of hotels, storekeepers, lawyers and medical practitioners who make up the remaining segment of commercial subscribers in Cabinda.

Last but not least, is the residential subscriber who presently has a telco or wireless set in their homes. These subscribers are primarily the wives and children of the business leaders.

Traffic estimates for each category of subscriber are postulated within the subsequent sections of this report.

A.4.3 Data Transmission.

Unfortunately, we here in the States, being the leading Internet User still do not fully understand how data communications traffic behaves. Researchers at Bell Labs and various Government sponsored "Think Tanks" are still struggling with how to develop accurate traffic models. The age old Voice Poisson Queuing Model is not the answer. The new packet train model appears to have some utility but leaves a lot to be desired from a traffic engineering standpoint. The fundamental problem is that predicted performance versus real time data do not agree.

Without Internet (although now planned for sometime in 2002) Angola Telecom really doesn't have to worry yet about the data traffic. If projections for Angola are similar to the rest of the world, Internet Traffic will surpass voice grade service during calendar year 2004.

Angola Telecom must remember that "Traffic means the movement of data across the Internet from one computer to another or from the web server to the users computer. Consequently, the amount of data traffic will be in direct proportion to the number of severs (computers) in use at any particular moment in Cabinda. Once the number of computers are determined in use by the residential, business and the government community, then and only then can realistic data traffic estimates be postulated.

A.4.4 Trunk Usage

The purpose of this report is to develop realistic traffic projections for commercial or business subscribers in the Province of Cabinda. Like the government users, we must first postulate the number of trunks that will be in service for a normal weekday over a twenty four-hour period for the business community. Our traffic estimate is presented in the following Table A.4.4.1 entitled, " Trunk Usage Projections, Commercial Subscribers, Cabinda.

A.4.4.1 Table A.4.4.1 Trunk Usage Projections Commercial Subscribers, Cabinda

Time (Hrs.)	Trunk Usage	Time (Hrs.)	Trunk Usage
0100	1.0%	1300	22.0%
0200	0.5%	1400	25.0%
0300	0%	1500	30.0%
0400	0%	1600	45.0%
0500	0.5%	1700	49.0%
0600	4.0%	1800	52.0%
0700	14.0%	1900	41.0%
0800	30.0%	2000	31.0%
0900	39.0%	2100	19.0%
1000	45.0%	2200	6.0%
1100	*60.0%	2300	4.0%
1200	35.0%	2400	2.0%

* Denotes estimated Busy Hour.

To determine the average trunk usage, we must sum the total percentiles for each hour and divide by 24. This equates to: 630/24 or 26.25 % of the total circuits will be busy during the twenty four-hour day. Again for commercial applications, this percentile is in the norm for telephone operating companies. The average U.S. percentile is 33.6.7 % without Internet and the average European Rate is 31.6 % for commercial subscribers.

It should be noted that the Busy Hour is between 11:00 and 12:00 hours. This conforms to the Busy Hour of Portugal. A long lunch hour between 12:30 and in some cases 4:00 PM will distort the normal Bell shaped traffic curve. The commercial community in Cabinda has a tendency to work during this long lunch period. The geographical location of Cabinda, with reference to Greenwich, will also distort the calling patterns. A great number of international calls are to the nations of Western Hemisphere including calls to the USA and Brazil.

A.4.5 Circuit Count

The next step in this analysis is to determine the number of circuits originating and terminating in Cabinda Province. Care was exercised in estimating this circuit count for the commercial sector versus the number of circuits used by the Government.

Subsequent paragraphs in this section address the number of projected commercial circuits from the year 2001 through a five-year period concluding in 2005.

A.4.5.1 4.2 Active Voice Circuit Count, Year 2001

The year 2001 finds Angola Telecom going into an expansion mode in the Province of Cabinda.

Table A.4.5.2 reflects the number of active circuits for the business community and the private sector in Cabinda. A circuit count is presented along with the projected Erlangs. The latter is derived from the Busy Hour Usage.

Table A.4.5.2 presents a circuit count for calendar year 2001. Please note that the projections in this table for the year 2001 do not include any circuits to the rural towns or to the Municipalities.

A.4.5.2 Table A.4.5.2 Private & Commercial Circuits Cabinda City, Year 2001

Organization	Circuit Count	Erlangs
Private Sector	6	3.8
Business Community c/o		
Petroleum Support	3	2.2
Transportation	2	1.4
Banks	5	3.2
Agriculture	2	1.2
Timber & Mining	2	1.3
Other	2	1.1

A.4.5.3 Number of Voice Circuits, 2002

In the year 2001 &2, the cellular system will be expanded. Internet will also be added to the Telecom Repertoire during the second year. The Internet usage automatically increases the demand for more data circuits.

Table A.4.5.4 reflects the traffic growth during the year 2001 & 2003

A.4.5.4 Table A.4.5.4 Years 2002 & 2003 Projected Commercial Circuits

	Year 2001 Circuits	Year 2002 Circuits
Commercial Sector	10	14
Business Community		
Chevron Laison & Support	8	9
Transportation	4	4
Banks	10	12
Agriculture	3	4
Timber & Mining	3	4
Other	2	2

A.4.5.5 Number of Equivalent Voice Circuits, 2004, & 2005

This expansion projected for years 2004 & 2005 are shown under Table A.4.5.6.

A.4.5.6 Table A.4.5.6 Year 2004 & 2005 Business & Commercial Circuits Traffic Projections

	Year 2004 Circuits	Year 2005 Circuits
Commercial Sector	20	24
Business Community		
Chevron Laison & Support	10	12
Transportation	10	12
Banks	14	15
Agriculture	4	4
Timber & Mining	5	5
Other	2	3

A.4.6 Conclusions

A realistic estimate is that the voice grade circuits for the commercial sector will increase 30 % in 2002 and an additional 20% in year 2003. In years 2004 and 2005, the voice grade traffic will increase an additional 30% and 20 % respectively.

Data due primarily to the Internet, will increase 55 to 60 % during the first year commencing in year 2002. From year 2003 through 2005, it is estimated that the data capacity will double per year, based on subscriber demand.

Angola Cabinda Province VSAT Network

Annex B
VSAT Brochures

B.0 VSAT BROCHURES

B.1 Hughes VSAT Equipment
- B.1.1 Hughes TES Quantum
- B.1.2 Hughes TES Quantum Direct
- B.1.3 Hughes TDMA 520
- B.1.4 Hughes HES Enterprise
- B.1.5 Hughes Acronyms

B.2 STM Wireless VSAT Equipment
- B.2.1 STM DAMA 10000 VSAT
- B.2.2 STM Subscriber Earth Station
- B.2.3 STM Space Loop

B.3 Gilat VSAT Equipment
- B.3.1 Gilat DialAw@y IP
- B.3.2 Gilat FaraWay VSAT
- B.3.3 Gilat Skystar Advantage

B.0 VSAT Brochures

Brochures are provided in the following pages for the VSAT equipment of three manufacturers:

Hughes Network Systems
STM Wireless, Inc.
Gilat

Brochures are included for several different product lines.

Annex B

B.1 Hughes VSAT Equipment

Annex B.1 Hughes VSAT Equipment

B.1.1 Hughes TES Quantum

HUGHES™
NETWORK SYSTEMS

TES Quantum

Advanced VSAT technology for high-speed digital applications

Hughes Network Systems offers VSAT technology that allows support for a new generation of high-speed digital applications: TES *Quantum*™.

FULL-MESH DEMAND-ASSIGNED SATELLITE CONNECTIVITY

Every VSAT in a TES *Quantum* network can communicate directly with any other VSAT. A single satellite hop means fast call setups, excellent quality voice, and fast-response data connections. Furthermore, TES *Quantum* is able to make intelligent routing decisions based upon traffic patterns using new Smart DAMA™ technology.

Connections are established using bandwidth-on-demand in order to conserve satellite space segment. International standard 16 Kbps LD-CELP voice encoding (ITU-T G.728) is used to further reduce space segment usage while providing the highest quality voice connections.

PSTN INTEROPERABILITY

TES *Quantum* operates within the public telephony network using ITU-T R1, R2, or No.5, DTMF and dial-pulse signaling. TES *Quantum's* Toll-Ready feature set includes automatic number identification, line testing, local emergency numbers, and pay phone operation.

DialWare™ software allows TES *Quantum* to connect to any numbering system in the world. Flexibility ranges from direct handset connections, to private branch exchanges, to gateway systems for an entire public calling office.

DIGITAL TRUNKING

TES *Quantum* is able to accept a T1 or E1 trunk without the need for external interface equipment. The VSAT looks at the individual 64 kbps channels on the trunk and routes them accordingly.

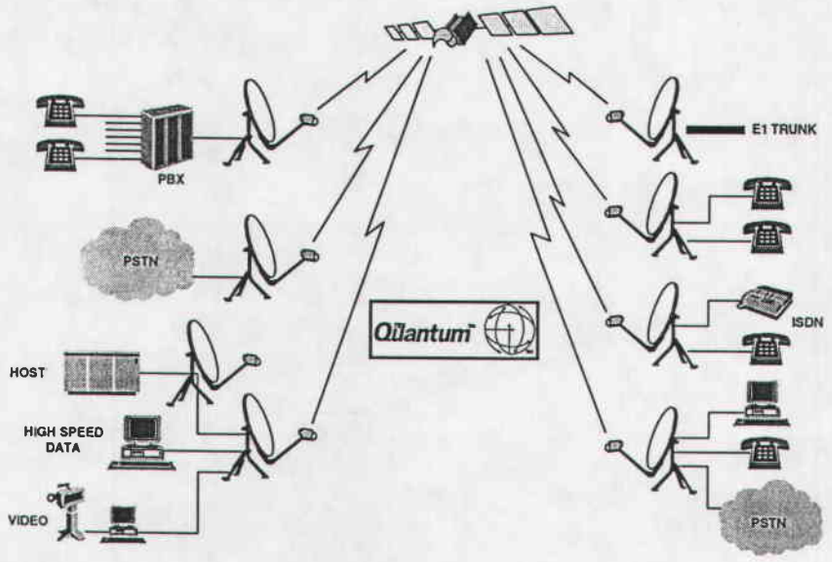
DigitalDirect technology allows TES *Quantum* to accept and process digital signals and deliver them to digital and analog locations.

VIRTUAL SWITCHING

TES *Quantum* is unique in its ability to interconnect dissimilar devices. Protocol processing is performed on telephony signals, and interfaces are provided for all common communications devices found in today's telecommunications environment. Interfaces include:

- PBX
- TouchTone handset
- Rotary handset
- Class-4 Exchange
- Class-5 Exchange
- Facsimile
- Data
- Video
- T1/E1 Trunks
- FXO/FXS

TES *QUANTUM* USES ADVANCED SATELLITE TECHNOLOGY TO PROVIDE HIGH-SPEED DIGITAL TELEPHONY SERVICES FOR BOTH PUBLIC AND PRIVATE NETWORKS.



FULL-MESH, DEMAND-ASSIGNED, DIGITAL SCPC

ADVANCED PRIVATE NETWORKING

The full range of features available for PSTN applications means TES *Quantum* can provide advanced telephony services for private users as well.

Business users will appreciate TES *Quantum's* graphical network management, which performs diagnostics to pinpoint trouble, optimize performance, and give complete visibility of network devices.

With Secure Skies operation, the network management system is both locally and geographically redundant in hot standby mode to provide the highest reliability.

Comprehensive billing statistics are provided by new Account-Manager software in a variety of formats, including ASCII and Bellcore BAF.

Technical expertise is just a mouse click away, because all VSAT documentation has been incorporated into an on-line hypertext help system.

SYSTEM EQUIPMENT

Indoor Unit

- Four-slot, 19 inch rackmountable
- Fourteen-slot, 19 inch rackmountable with load-sharing power supplies
- Universal channel unit for voice, data, fax, and video

Antennas

1.2 meter	2.4 meter	4.5 meter
1.8 meter	3.8 meter	6.1 meter

Radios

C-Band		Ku-Band	
5 Watt	40 Watt	2 Watt	16 Watt
20 Watt	125 Watt	8 Watt	

Interfaces

- Two-wire
- Four-wire
- RS-232, V.35
- E1 or T1
- ISDN

Network Control System

- Standard configuration using DEC VAX workstation
- Redundant configuration
- High-capacity redundant configuration
- Geographically redundant configuration

Voice Processing

- 32 kbps ADPCM (G.721)
- 16 kbps LD-CELP (G.728)
- 8 kbps A-CELP (G.729)
- Up to 14.4 kbps facsimile (V.17)
- Up to 14.4 kbps voiceband data (V.32bis)
- Voice activation
- Echo cancellation (G.164 and G.165)

HUGHES
NETWORK SYSTEMS

11717 Exploration Lane
Germantown, MD 20876 USA
Phone: 301-428-5765
Fax: 301-428-7099
Web: http://www.hns.com

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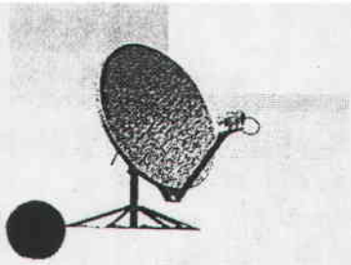
Information is subject to change.

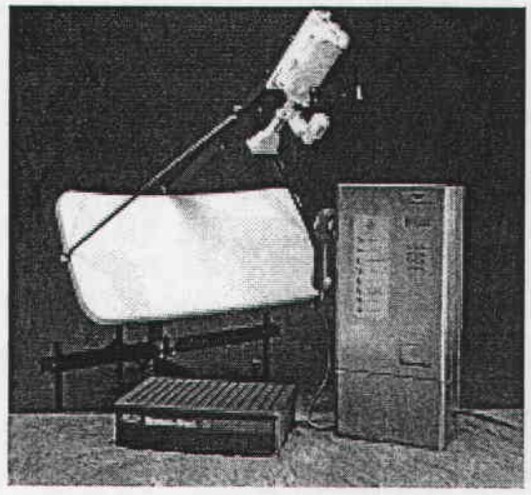
VSAT 334 FEB 99-4K

Annex B.1 Hughes VSAT Equipment

B.1.2 Hughes TES Quantum Direct



HUGHES
NETWORK SYSTEMS



TES Quantum-Direct™

Low-cost access for rural telephony

TES *Quantum-Direct*™, an extension of the Telephony Earth Station product family, is specifically designed to provide maximum economy for rural thin-route telephony applications.

RURAL TELEPHONY

Every aspect of the TES *Quantum-Direct* terminal is oriented towards providing low-cost access to the PSTN for rural telephony subscribers. The terminal provides a two-wire loop interface that can connect to a handset, public telephone, facsimile, modem, or multiple extensions. Each TES *Quantum-Direct* terminal communicates with a high-functionality TES *Quantum* Gateway Station to provide access to the PSTN, to other remote stations, or even to international trunks.

TES *QUANTUM-DIRECT* KEY FEATURES

- TES *Quantum* PSTN integration
- DialWare™ digit manipulation
- Autocommissioning
- Low power consumption

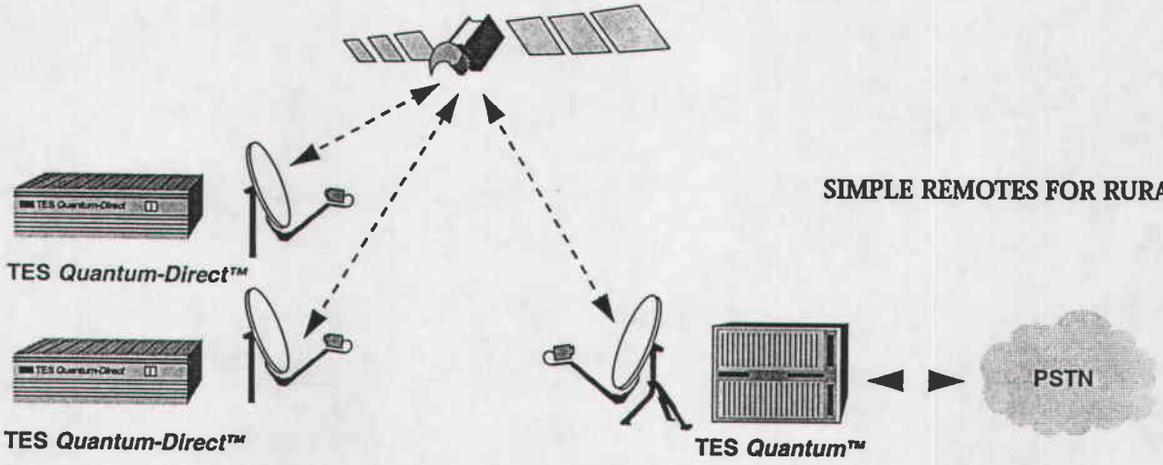
TES *Quantum-Direct* remote terminals operate within TES *Quantum* networks so that all of the advanced telephony features to which Telephony Earth Station users have grown accustomed remain available. For example, TES *Quantum* performs R1, R2, and SS #5 signaling internal to the VSAT network, providing a seamless transition from the end user to the PSTN. No external equipment is required.

DialWare™ software is resident in every TES *Quantum-Direct* terminal and allows the remote to intelligently interpret any local numbering plan. Thus, emergency and special service numbers may be routed in accordance with the site location.

Automatic Number Identification (ANI) allows for more advanced features such as caller identification. Least-cost routing ensures that local, long-distance, and international calls are handled appropriately.

From an overall network implementation standpoint, a vital feature of remote telephony terminals is that they be easy to install, maintain and operate. TES *Quantum-Direct* uses a unique autocommissioning procedure to simplify this process. The remote terminal is simply powered on, the dish is pointed using only a voltmeter, and everything else is handled automatically.

THE TES *QUANTUM-DIRECT* IS DESIGNED TO PROVIDE LOW-COST TELEPHONY ACCESS FOR RURAL, THIN-ROUTE APPLICATIONS.



SIMPLE REMOTES FOR RURAL TELEPHONY

Hughes Network Systems has been providing PTTs around the world with VSAT rural telephony solutions for many years. Telephony Earth Station VSATs are providing rural telephone connectivity throughout Canada and the Northwest Territory, to small villages in Africa, Asia, South America, and as far north as the Alaskan tundra. TES *Quantum* and TES *Quantum-Direct* have been chosen by PTTs around the world because of their ability to work within, instead of around, the existing telecommunications infrastructure.

It comes as no surprise, then, that INTELSAT has chosen the Telephony Earth Station as the demand-assigned standard for international telephony. TES *Quantum* and TES *Quantum-Direct* have established themselves worldwide as a cost-effective and reliable means to integrate remote telecommunications into the public telephone network.

TES *QUANTUM-DIRECT* SPECIFICATIONS

Frequencies:	Ext. C-Band, C-Band, Ku-Band
Voice Codec:	8 kbps G.729
Echo Cancellation:	ITU-T G.165
User Signaling Interface:	DTMF, Dialpulse
Gateway Signaling Interface:	R1, China #1, R2, SS#5
Dialing Plan:	Software Configurable
Facsimile:	Group III
Voiceband Data:	ITU-T Rec. V.32

Physical

Antenna:	1.2-2.4m
Dimensions:	38cm x 30cm x 9cm
Weight:	8.5 kg
User Physical Interface:	2-wire loop start Coin payphone Card payphone Keyset unit Line concentrator
Gateway Physical Interface:	4-wire E & M, T1/E1

Environmental

Operating Temperature	
■ ODU:	-30°C to + 55°C
■ IDU:	0°C to +50°C
Input Power:	90 to 240 VAC
Power Draw:	70 W (max)
Manufacturing:	ISO 9001 compliant

HUGHES™
NETWORK SYSTEMS

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Germantown, MD 20876 USA
Phone: (301) 428-5765
Fax: (301) 428-7099
Web: www.hns.com

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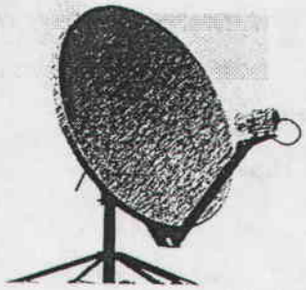
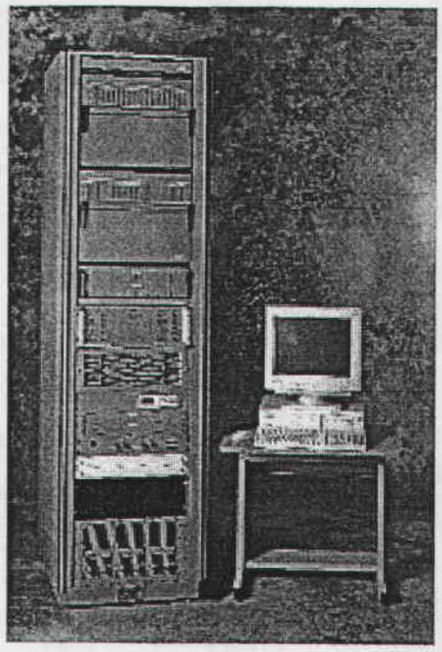
VSAT 395 JUN 99-5K

Annex B.1 Hughes VSAT Equipment

B.1.3 Hughes TDMA 520





HUGHES
NETWORK SYSTEMS

TDMA 520

LOW COST TRAFFIC TERMINAL

The HNS Model 520 low-cost TDMA (LCT) terminal is a simple, easy-to-use design providing superior performance and reliability. With state-of-the-art VLSI components and enhanced digital modulator/demodulator, the new, economical base-band equipment design contains these key modules: a TDMA processor, controller, and terrestrial interface port module, configured in a redundant operation mode.

HNS has supplied over 40 of our Model 1020 TDMA traffic terminals for the INTELSAT/EUTELSAT community, which have been, and still are, in continuous operation. Based on this field-proven design, the Model 520 takes full advantage of more than 12 years of operational experience with our Model 1020 TDMA terminal.

KEY FEATURES

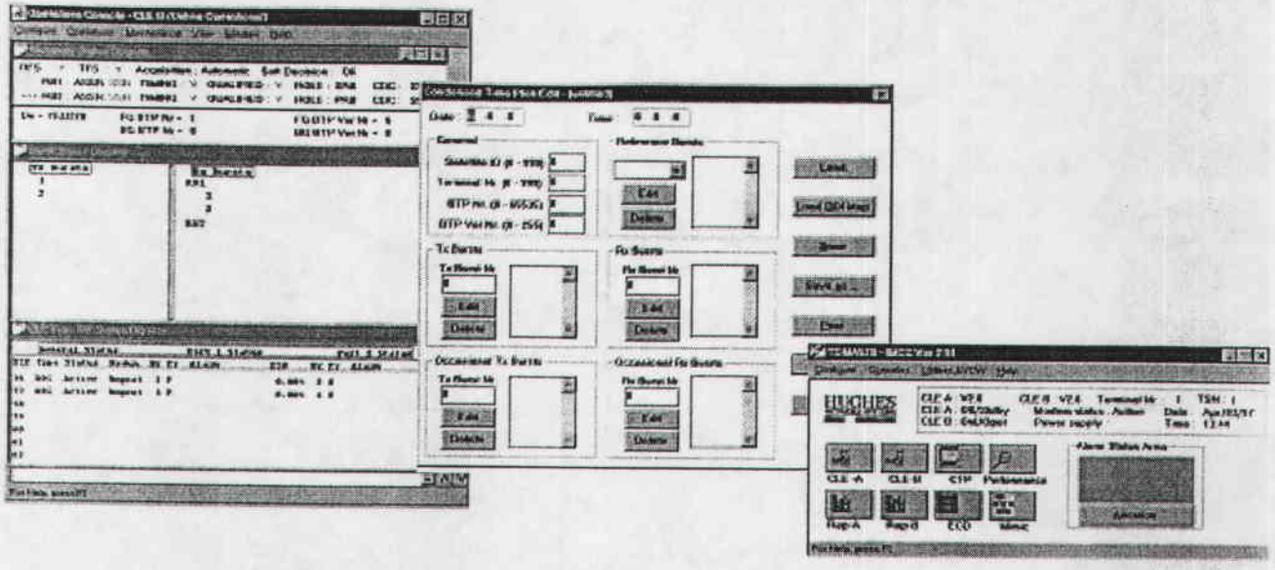
- Backward compatible with existing INTELSAT/EUTELSAT TDMA terminals
- Hot plug-in or removal of modules
- Outstanding modem performance
- Flexible direct digital interface (DDI) redundancy configurations
- Easy expansion for increased traffic requirements
- Remote diagnostics capability with HNS International Customer Support Center
- No traffic loss during operator-initiated common logic equipment (CLE) switchover
- Availability of 99.99% and MTTR of less than 2 hours
- Easy-to-use graphical user interface for monitor and control

DESIGN ADVANTAGES

The Model 520 TDMA terminal allows for "hitless" maintenance, terminal upgrades, module insertion, burst time plan switching, and reference burst switching. Traffic is not affected. In addition, a new, modular, state-of-the-art power supply increases system reliability.

One:N redundancy configuration of DDI modules results in maximum flexibility. For example, the base terminal provides eight DDI slots configurable anywhere from 1:1 up to 1:7. In fact, the eight slots can accommodate up to two redundancy groups (eg. a 1:2 and 1:4) for higher availability, if required. Each DDI module occupying a slot is capable of interfacing with one or two 2.048 Mbps (E1) terres-

THE 520 TDMA TERMINAL'S SIMPLE, EASY-TO-USE DESIGN PROVIDES SUPERIOR PERFORMANCE AND RELIABILITY.



trial interface(s). The terminal can easily be expanded to accommodate an additional 16 DDI modules within the same rack.

The terminal's demodulator design uses the latest in ASIC development, providing fast acquisition time, increased tolerance for carrier frequency offsets, and lower implementation loss. The demodulator bit error rate (BER), a function of Eb/N0, typically has 1.5 dB of margin relative to the INTELSAT specification. Degradation testing for carrier and amplitude offsets also exceed INTELSAT specifications.

An optional, low-cost, soft-decision decoder allows for outstanding BER versus Eb/N0 performance. With the optional "soft-decision" BCH decoder, the TDMA terminal can now be operated from Standard B or, in certain cases, from smaller earth stations.

Lower implementation costs are due to easy installation, efficient training, and simpler documentation.

INTEGRATED MONITOR AND CONTROL CONSOLE (IMCC)

One of the obvious advantages of the Model 520 TDMA terminal is the enhanced operator interface, the IMCC. Due to the nature of INTELSAT network operations, the TDMA terminal is designed to operate with little or no operator interaction, making the IMCC design simple and inexpensive.

IMCC ADVANTAGES:

- In the event of an IMCC hardware failure, any standard, low-cost PC with minimal configuration uploads easily with the IMCC software for quick restoration of the operator interface. Downtime of the IMCC does not affect terminal operation.
- Less training is required for the MS Windows™ operating environment used with the IMCC because most technicians and engineers already have experience with this widely used application software. In addition, MS Windows™ can be run on the IMCC platform with other compatible software applications, such as the new Hollis BMLA test set.
- An elegant, concise picture of the terminal's configuration and operational state is available from a single window.
  - All alarms are managed in a single window
  - Log files can be captured and edited
- Wide flexibility is afforded for maintenance and test features with superior diagnostic, condensed time plan (CTP) editing and performance monitoring capabilities.
- An Ethernet LAN interfaces between the IMCC and the TDMA terminal. The terminal may also be monitored and operated remotely by simply using a standard telephone connection for a remote IMCC application.

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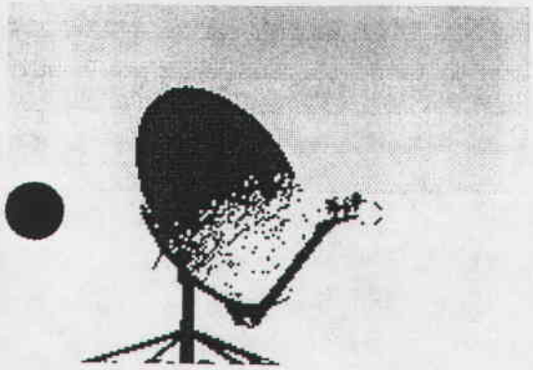
Annex B.1 Hughes VSAT Equipment

B.1.4 Hughes HES Enterprise



HUGHES™
NETWORK SYSTEMS

HES ENTERPRISE

Combining Internet and Telephony

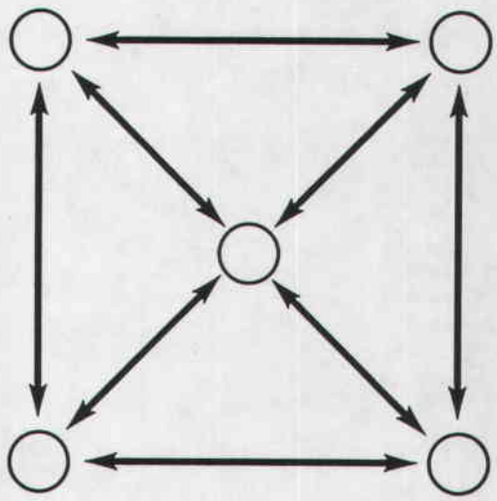
The Hybrid Earth Station (HES) Enterprise, by Hughes Network Systems, offers customers unprecedented flexibility, combining high-speed Internet and IP data applications together with mesh telephony. HES is an integrated remote platform that provides simultaneous support for different satellite access techniques. Supporting a variety of satellite access architectures on a single platform, HES Enterprise allows users to optimize the use of satellite resources and provide the best performance for each application – data or voice.

NOT ALL APPLICATIONS ARE THE SAME

Different applications require different satellite access techniques; HES Enterprise provides the flexibility for the right solution for each application. With HES Enterprise, you can use the Personal Earth Station™ (PES™) for IP and Internet applications and the TES *Quantum-Direct*™ for voice. The result is a platform that supports simultaneous single-hop mesh connections for voice and high-speed data and star topology data connections for efficient corporate intranetworking and Internet access.

COST EFFICIENCY

Minimizing satellite delay is key for voice applications – thus single-hop satellite connections provide the best performance. An added bonus is that the single hop connection minimizes the amount of bandwidth required for remote-to-remote traffic.



FLEXIBILITY AND PERFORMANCE

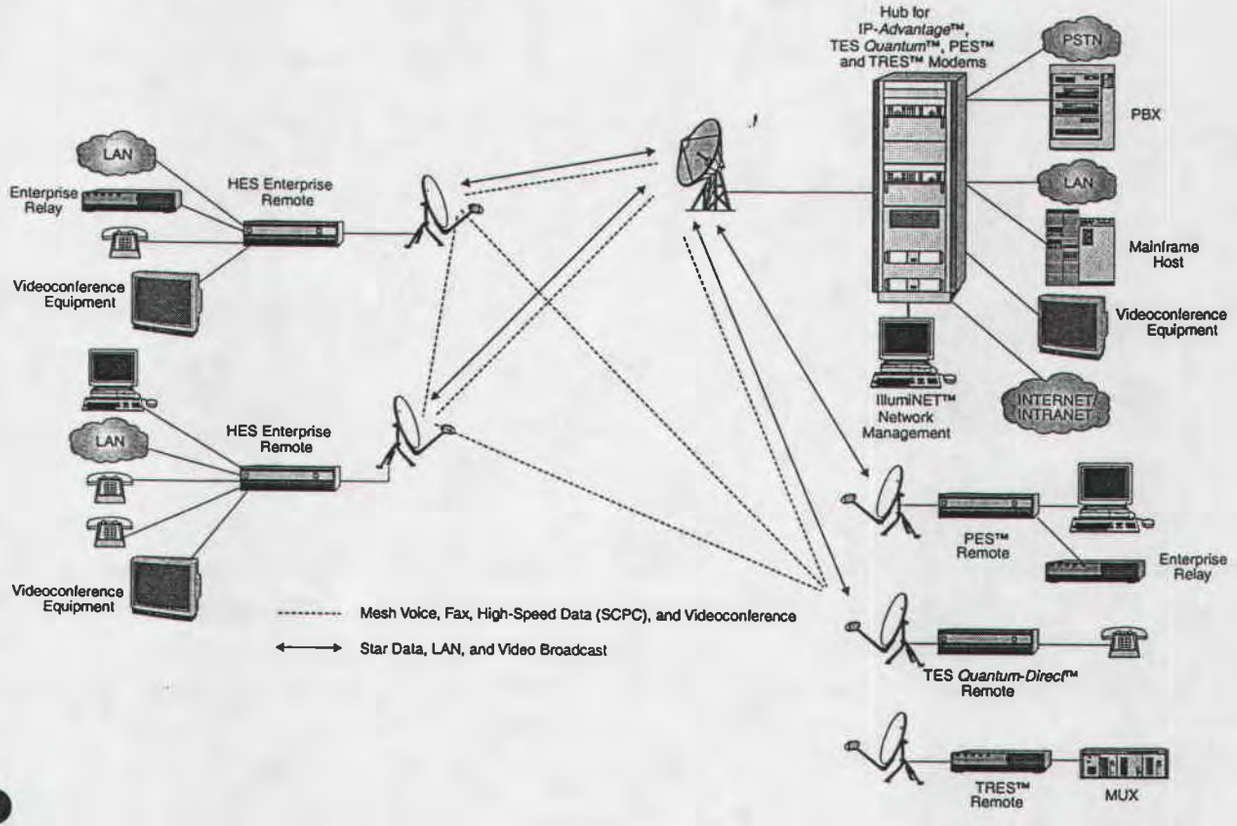
HES Enterprise supports any combination of the following:

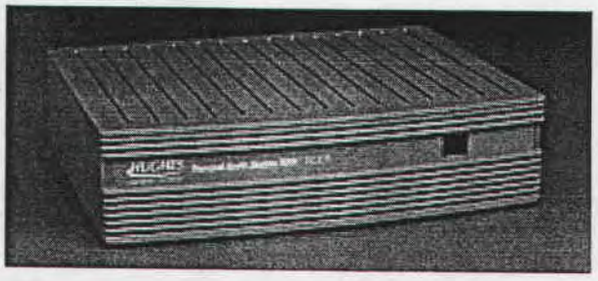
- PES 5000*Plus* – Ideal for interactive data applications such as retail POS, automated teller machines (ATM), inventory management, and intranet browsing
- DirecPC® Enterprise Edition – An Internet-ready, broadband IP system designed to support the high-bandwidth requirements of corporate networks
- TES *Quantum-Direct* – The industry standard for low-cost mesh telephony
- TRES™ – A cost-effective, bandwidth-efficient solution capable of supporting dedicated high-speed point-to-point data channels for video conferencing and LAN-to-LAN connections

THE HES ENTERPRISE COMBINES HIGH-SPEED INTERNET AND IP DATA APPLICATIONS WITH MESH TELEPHONY.

TES *QUANTUM-DIRECT*

This low-cost telephony channel unit provides a toll-quality 8 kbps G.729 voice channel to permit mesh voice, fax, or voice-band data connectivity to any remote within a network. This product features seamless integration with the public switched telephony network (PSTN) in the local area. A two-wire loop interface for connection to pay telephone or handset is provided, and options include 16 kbps G.728 voice compression as well as four-wire E&M interface connections to PBXs. This unit can communicate with existing TES *Quantum*™ gateway stations for connections to digital E1 trunks. In addition, the TES *Quantum-Direct* can support connections to a variety of rural telephony products such as wireless local loop and mobile cellular systems.

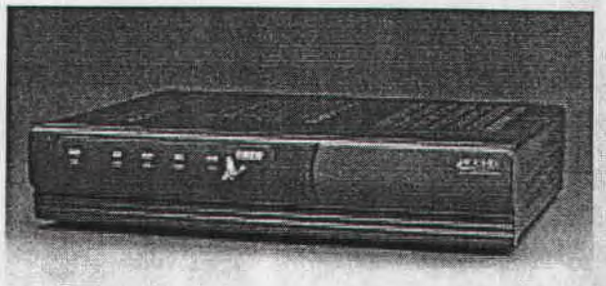




PERSONAL EARTH STATION (PES) 5000 *PLUS*

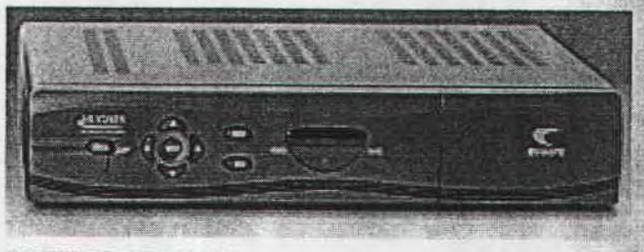
The PES 5000 *Plus*, the remote terminal component of HNS' Integrated Satellite Business Network, supports both toll-quality voice-over-IP solutions and data-intensive operations, both batch and interactive. The PES 5000 *Plus*' built-in router functions eliminate the need for any router for LAN/WAN connectivity. In addition, the PES 5000 *Plus* can support a variety of protocols, including the ubiquitous TCP/IP and PPP for both Ethernet and Token Ring, as well as X.25, SDLC, Telnet, BSC, and dozens of additional legacy protocols.

The PES 5000 *Plus* has been optimized for hundreds of end-user applications, including Internet access, point-of-sale, inventory control, automated teller machine (ATM) platforms, SCADA, file transfers, security monitoring, lottery ticketing, fax/image transmission, and email, to name a few. In addition, the PES can provide either two-wire interfaces for pay telephones or handsets, or 4-wire interfaces for connection to a telecom switch or a PBX. Other PES features include a file broadcast utility with guaranteed file delivery, fail-safe automatic dial backup, and parallel-path frame relay integration.



TRUNKING EARTH STATION (TRES)

The TRES is a versatile satellite modem, designed to provide high-speed transmission of data in an extremely cost-effective manner using efficient bandwidth-saving techniques. It is a very low-cost modem that supports data rates between 32 kbps and 2.048 Mbps.



ENTERPRISE RELAY

The IP-*Advantage*™ Enterprise Relay unit is the remote extension of the DirecPC Enterprise Edition system, providing high-speed Internet and IP data. It can provide up to two 10Base T LAN interfaces, a Channel 3/4 modulated output for video, composite video output capable of both PAL and NTSC video formats, and an S-Video output. The Enterprise Relay can connect to the PES or TES *Quantum-Direct* via their TVRO (L-band) outputs. The Relay provides the remote user with the capability to achieve extremely high data rates using an outroute carrier between 2 and 24 Mbps. This supports a myriad of applications including Internet, corporate intranet, multimedia, TCP/IP interactive traffic, MPEG-1 and MPEG-2 video, and huge file transfers.

HES ENTERPRISE SYSTEM EQUIPMENT

Indoor Equipment

- Single-channel TES *Quantum-Direct*
- PES 5000 *Plus* with one LAN port, serial ports, and voice ports
- TRES unit: serial port
- Enterprise Relay with LAN and video outputs

Antennas

- 1.0 meter, 1.2 meter, 1.8 meter, 2.4 meter, 3.7 meter, 3.8 meter
  (System compatible with a range of customer-provided antennas)

Radios

- **C-band:** 5 Watt, 20 Watt
- **Ku-band:** 2 Watt, 8 Watt

Physical Interfaces

- **Voice:** Two-wire, Four-wire, E1/T1
- **Data:** Ethernet, Token-Ring, RS-232, EIA-530, V.35, RS-422

For more information on the HES Enterprise satellite solution, contact Hughes Network Systems today.

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Annex B.1 Hughes VSAT Equipment

B.1.5 Hughes Acronyms

Acronyms

ADPCM - adaptive differential pulse code modulation

AIN - advanced intelligent network

AMPS - advanced mobile phone service

ANSI - American National Standards Institute

ASIC - application-specific integrated circuit

ASTN - Automotive Satellite Television Network

ATM - asynchronous transfer mode

ATM - automated teller machine

BECN - backward explicit congestion notification

BPSK - binary phase-shift keying

BSC - base station controller

BTS - base transceiver station

CAD - computer-aided design

CCITT - {Consultative Committee for International Telegraphy and Telephony (F. Comité Consultatif Internationale Téléphonique et Télégraphique)} See ITU

CDMA - code division multiple access

CDPD - cellular digital packet data

CEU - Continuing Education Unit

CIR - committed information rate

CMD-IS - circuit switched CDPD mobile data intermediate system

CMIP - common management information protocol

CMIS - customer management information service

CMOS - Complementary Metal Oxide Semiconductor

CS-CDPD - circuit switched cellular digital packet data

CO FRAD - Central Office FRAD

CSM - cell service module

CSU - channel service unit

CU - channel unit

DAMA - demand-assigned multiple access

DBS - Direct Broadcast Satellite

DCE - digital communications equipment

DCLI - data link correction identifier

DIU - digital indoor unit

DLS - data link switching

DSP - digital signal processing

DSU - data service unit

DTE - data terminal equipment

FCC - Federal Communications Commission

FECN - forward explicit congestion notification

FPGA - field programmable gate array

FRAD - frame relay assembler/disassembler

FSM - frame service module

FTP - file transfer protocol

GES - Gemini Earth Station

GMAC - General Motors Acceptance Corporation

GUI - graphic user interface

HDLC - high-level data link control

HES - Hybrid Earth Station

HLR - home location register

HNS - Hughes Network Systems, Inc.

HSS - Hughes Software Systems, India

HVAC - heating, ventilation, and air conditioning

IACET - International Association for Education and Training

IDF - intermediate distribution frame

IDS - Inventory Distribution System

IDU - indoor unit

IETF - Internet Engineering Task Force

IF - intermediate frequency

IFL - interfacility unit

IFU - internal framing unit

IMS - Installation Management system

IN - intelligent network

I/O - input/output

IP - internet protocol

IPX - internet packet exchange

ISBN - Integrated Satellite Business Network`

ISDN - integrated-services digital network

ITU - International Telecommunications Union {replaced CCITT)

LA - location area

LAN - local area network

LD-CELP - low delay code excited linear prediction

LEC - local exchange carrier

LNA - low noise amplifier

LNB - low noise block downconverter

M-ES - mobile-end systems

MBMP - modem bank management protocol

MDBS - mobile database station

MDF - main distribution frame

MD-IS - mobile data-intermediate system

MIB - management information base

MIPS - million instructions per second

MPOA - multiprotocol-over-ATM

MRP - materials requirements planning (system)

MSC - mobile switching center

MSU - multisubscriber unit

MTSO - mobile telephone switching office

NCC - network control center

NEI - network equipment identifier

NHRP - next hop resolution protocol

NFS - network file system

NMS - network management system

NNI - network-to-network interface

NRF - National Retail Federation

NSW - Nippon Systemware Co. Ltd., Japan

O&M - operations and maintenance

ODU - outdoor unit

OCC - operations control center

OLTP - online transaction process

OMC - operations and maintenance center

OSPF - open shortest path first

PABX - private automatic branch exchange

PACS - Personal Access Communications System

PAT - product assurance test

PBC - People's Bank of China

PBX - private branch exchange

PCMCIA - Personal Computer Memory Card Industry Association

PCS - Personal Communications Services

PES - Personal Earth Station`

PM - Program Manager

POS - point-of-sale

PSTN - public switched telephone network

PVC - permanent virtual circuit

QLLC - quality link layer control

QoS - Quality of Service

QPSK - quadrature phase-shift keying

RDBMS - Relational Database Management System

RES - Receive-Only Earth Station

RF - radio frequency

RFC - request for comment

ROM - read-only memory

RP - radio port

RPCU - radio port controller unit

RX - receive

SCADA - supervisory control and data acquisition

SCM - switch control module

SCPC - single channel per carrier

SDLC - synchronous data link control

SENA - Switched Enterprise Network Architecture

SMDS - switched megabit data services

SMT - surface mount technology

SMTP - simple mail transfer protocol

SNA - Systems Network Architecture

SNMP - simple network management protocol

SSU - single subscriber unit

SVC - switched virtual circuit

TCP/IP - transmission control protocol/internet protocol

TDM - time division multiplexing

TDMA - time division multiple access

TES - Telephony Earth Station

TRAI - Telecom Regulatory Authority of India

TWA - two-way alternating

TWS - two-way simultaneous

TX - transmit, transmission

UDP - user datagram protocol

UMOD - 9100 Universal Modem

UNI - user-to-network interface

USICA - US-India Commercial Alliance

VC - virtual circuit

VCI - virtual circuit identifier

VLR - visitor location register

VLSI - very large-scale integration

VPI - virtual path identifier

VSAT - very small aperture terminal

WAN - wide area network

WLL - wireless local loop

XID - exchange identification

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Annex B

B.2 STM Wireless VSAT Equipment

Annex B.2 STM Wireless VSAT Equipment

B.2.1 STM DAMA 10000 VSAT

Main Systems Features	
Switching/Capacity	18x18 DECT channels with up to 16 satellite channels
WLL/VSAT Configuration	Switch with internal DECT-DAMA interworking.
Maximum traffic per System	11.5 Erlangs @ 2% GOS – equates to 256 subscribers @ 0 .045 erlang/subscriber
Satellite Operating Frequency	C-band (Standard, INSAT), Ku-band
Satellite – TX Power	C-band: 1 W with optional 5 W booster amp
	Ku-band: 0.35 W with optional 1.2 W
Voice Coding	Toll quality, 32 Kbps ADPCM, per ITU-T G.726 – WLL
	16 kbps (G.728), 8 kbps (G.729), 4.8 kbps (AMBE) – Satellite
Satcom Connectivity	Full Mesh (single hop)
DECT Interface Unit (DIU)	
Interface with MHU	E1 (2.048 Mbps) + DC Power (48 V) on three twisted pair wires.
Power	1) -48 VDC
	2) 90-132/180-264, 50/60 Hz VAC.
	3) <200 Watts
Operating temperature	-30°C to +55°C.
Operating humidity	Up to 95%, non condensing.
Mast Head Unit (MHU)	
DECT air interface	Complies with ETS 300-175-2 (3 integrated blind-spot radios with 6 channels/sector).
Output Power	Standard DECT – 0.25 Watts (option for range extension with 1 Watt output power)
Frequency Range	1880-1900 MHz (standard)
	900-2500 MHz (configurable in any contiguous 20 MHz band)
Distance from DIU/VSAT	100 meters typical (up to 1.5 km with local power supply)
Enclosure construction	Weather-proof metal housing, suitable for both indoor and outdoor mounting.
Enclosure mounting	Pole or wall mounting.
Operating temperature	-10 ° C to +55 ° C.
Operating humidity	Up to 95% RH, non condensing.
Subscriber Wall Set	
Air interface	Complies with DECT specifications ETS 300-175 and CRT06.
Instruments	Regular telephone, Payphone, Fax and Modem data at 4.8 Kbps
Speech signal	1) Voice frequency band: 3.1 kHz.
	2) Input/Output impedance: 600 Ohms, balanced.
Payphone metering	1) Polarity reversal.
	2) 16 KHz metering pulse (12 KHz Optional)
Dialing	1) Pulse
	2) DTMF
Power	1) Voltage: nominal 12 V DC.
	2) Internal UPS Battery Backup up to 24 Hours
	3) Consumption: 2.5 watts (idle) / 5.25 watts (ring) / 3.9 watts(talk)
Enclosure mounting	1) Outdoor installation to frame or wall. (optional)
	2) Indoor installation:
	Wall mount.
	Table top.
Operating temperature	0° C to 50°C.
Operating humidity	To 95% RH, non condensing

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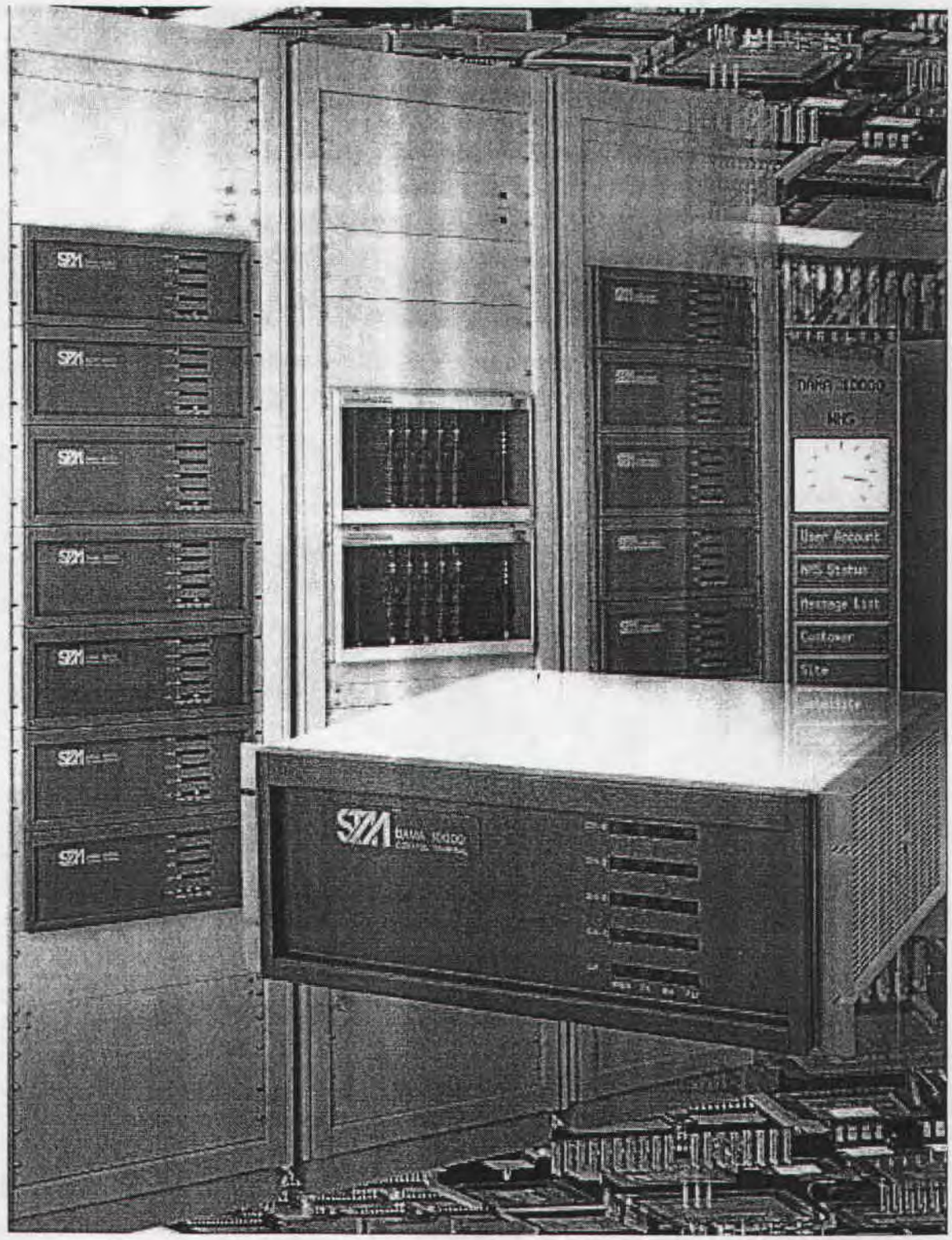
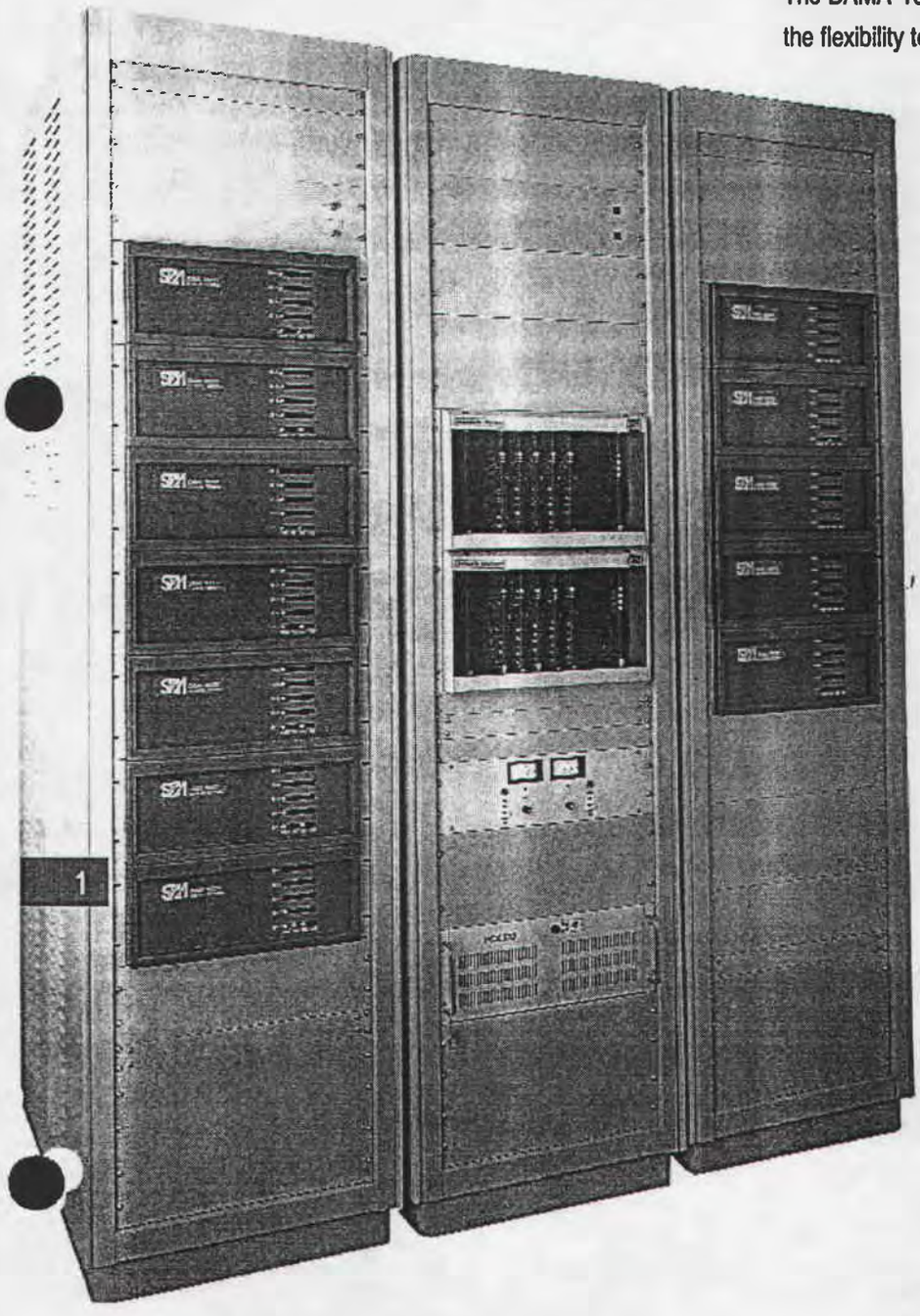
DAMA-10000 VSAT Network

The STM Wireless DAMA-10000 system is a full mesh, single hop satellite transmission network which allows direct connection between any two ports in the network.



The STM Wireless DAMA-10000 system is a full mesh, single hop satellite transmission network which allows direct connection between any two ports in the network. It provides real-time Demand Assigned Multiple Access (DAMA) communications solutions. The result is economical and flexible bandwidth sharing with any mix of voice, FAX, video and data traffic. The system optimizes the use of satellite capacity by automatically allocating satellite resources to each active circuit upon demand.



The DAMA-10000 is a fully integrated product that offers the flexibility to create and manage both large and small networks. With an expandable system architecture and highly configurable terminal equipment, the DAMA-10000 is a cost effective solution from small up to growing networks with 10,000 or more users. The system supports full mesh, point-to-point or point-to-multipoint communications circuits – any user can connect to any other user anywhere within the network.

Features

- Full Mesh, Single-Hop Transmission – Mesh interconnectivity is provided on a demand basis between any two ports within the network.
- Bandwidth-On-Demand – Transmission rate is configured to actual user requirements, utilizing satellite capacity only when needed.
- Small, Low Cost Remote Terminals – Antenna size and RF power requirements are determined based on the satellite chosen and the maximum data rate for the system applications.
- Expandable System Architecture – The DAMA-10000 is an integrated product designed for cost-effective applications in both small and large networks.

- System Integration Flexibility – System integrators can take advantage of the flexibility provided by industry standard interfaces.
- Gateway Station – Multiple gateway stations can be included for interconnection to a Public Switched Telephone Network (PSTN) central office.

Remote Terminal Equipment

SUBSCRIBER EARTH STATION (SES) is STM's newest generation telephony product designed to provide reliable, on-demand telecommunications service in remote and rural areas. SES is a small, light-weight and extremely low cost ultra-small aperture terminal (USAT) which is ideally suited for areas where telecommunications service is unavailable, unreliable or simply too expensive. The modem, radio, voice compression and subscriber interface are integrated into a single, ruggedized, weatherproof assembly. Since it is satellite based, a SES terminal can be installed virtually anywhere to allow immediate access to the DAMA network and the public switched telephone network (PSTN).

4-CHANNEL UNIT is designed for both low cost and maximum flexibility. This is the base indoor unit for all multi-channel remote terminals (RTs) in the DAMA-10000 satellite network. It can hold four independent channel units. A remote terminal is configurable to support combinations of SCPC mesh voice and data communications using a mix of plug-in voice or data channel units. Whether the application is full mesh voice, bandwidth-on-demand data, or a combination of both, each site can be tailored to meet specific communications needs. Sites can also be quickly and easily reconfigured as needs change. Several 4-Channel Units can be daisy chained to form larger remote units or gateway stations.

DAMA-10000 boards

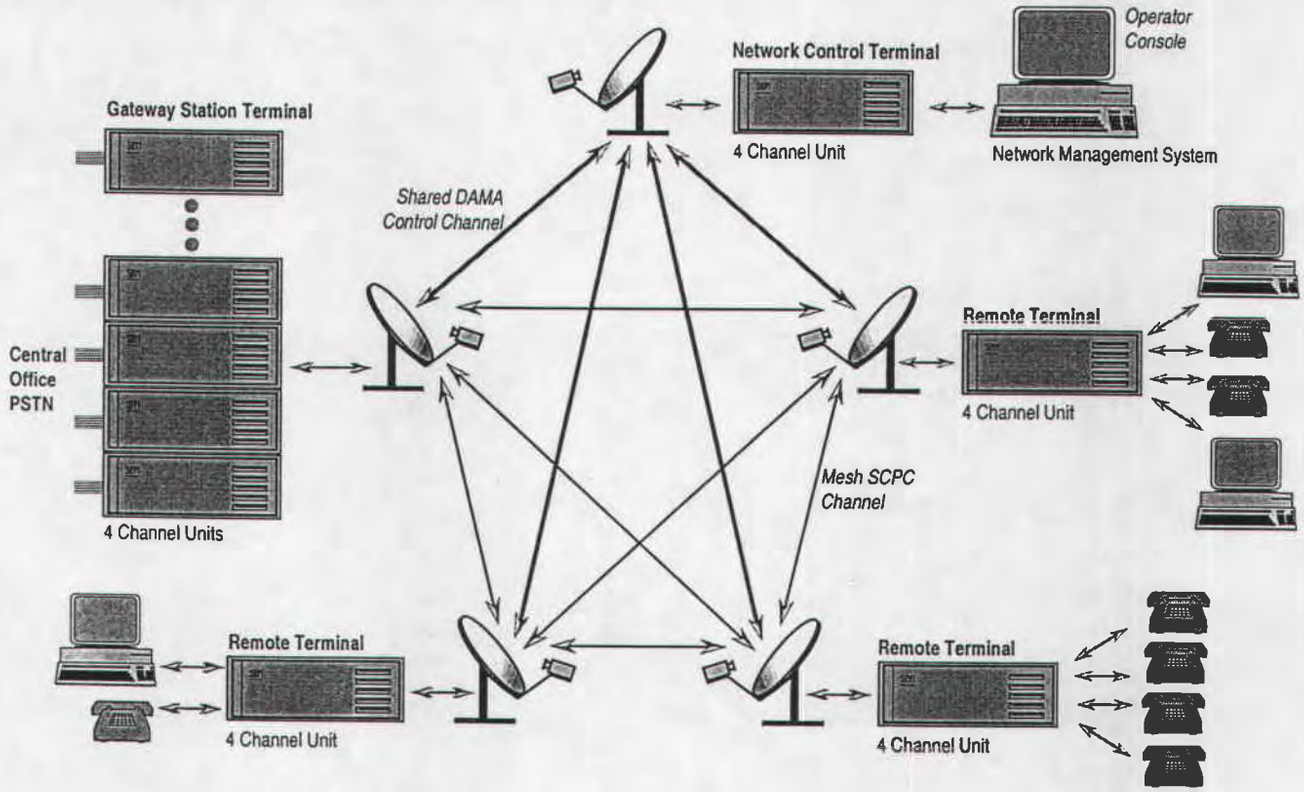
NETWORK CONTROL TERMINAL (NCT) – Any remote unit can be configured to perform as the NCT through the addition of a common signaling channel demodulator and the Network

Management System (NMS). The NCT hardware, together with the NMS, serves as the single focal point for system level control within the satellite communications network. The NCT contains the common signaling channel processors required to perform the following functions:

- Establish system timing to ensure fast call setup
- Process all call establishment and tear down requests
- Receive system status and performance
- Maintain a complete database of network information

VOICE CHANNEL UNIT (VCU) integrates a VOICE/FAX codec and BPSK/QPSK modem functions into a single module for reduced cost and improved channel control. The VCU provides variable voice and facsimile digitization rates that can be selected under NMS control. Voice compression rates of 4.8, 8, and 16Kbps are supported. Capabilities include:

DAMA-10000 Network Architecture



- Full CCITT Group III FAX send and receive
- Rotary pulse and touch tone dialing support
- All five E&M trunk signaling types and standard 2-wire interfaces supported
- Built-in echo cancellation

The latest advancement in digital voice compression algorithms has been incorporated into the design of the VCU. The result is a code that provides significantly improved voice quality, even at 4800 bps.

The VCU has an on-board Group III Facsimile modem. The VCU recognizes a facsimile call and transmits the information over a DAMA full duplex channel bypassing the compression algorithm. Fax transmissions are compatible with CCITT standard Group III Fax with send and receive at variable transmission rates. This affords maximum flexibility by ensuring operation with almost all fax machines.

DATA CHANNEL UNIT (DCU) is an advanced variable rate modem specifically designed for bandwidth-on-demand applications. Modulation and baseband processing functions are integrated into a single low-cost module. This provides excellent flexibility and reliability; no user adjustments are required. The design incorporates the latest in digital signal processing technology to produce a cost-effective, full capability unit. The unit supports both BPSK and QPSK operation with rates from up 384 Kbps. When inserted into a DAMA-10000 4-Channel Unit, the module's transmit/receive frequencies, transmit power level, scrambler, elastic buffer

length, data rate module and code rate are all configurable, either locally by the Control Processor module or remotely under NMS control.

Call Processing – Bandwidth-On-Demand

The DAMA-10000 features complete bandwidth-on-demand capability for efficient access by all users, regardless of their voice/data circuit needs. The system supports DAMA, pre-assignment (PAMA) and fixed assignments of all voice circuits and data circuits. When a caller at a remote terminal requests service (e.g. picks up telephone to make a call) the request is made to the NCT over the shared DAMA common signaling channel. This informs the NCT of the type of service being requested and who is being called. The NCT determines if the call is valid and if the called party is available, it then allocates the satellite bandwidth and power by which the two terminals can communicate. When the call is completed the NCT is informed by the remote terminals and the freed bandwidth is returned to the frequency pool.

The NMS maintains a directory of terminals in its network to facilitate routing of calls. This directory defines the capabilities of every remote terminal in terms of data rate, uplink power, terminal configuration and address. When a remote terminal requests a circuit, the NMS allocates an appropriate channel for use. The NCT then informs the calling and called remote terminals of the assigned frequencies, then blocks the assigned frequencies out of the pool. If capacity is not available and the requesting terminal is not of sufficiently high priority, a system busy signal is generated. Resources may be allocated on-demand (DAMA control) or as a fixed assignment (operator controlled). In the demand-assigned mode, the NCT controls a pool of transponder frequencies and allocates transmit and receive frequency pairs to each call on a demand-assigned basis. This frequency pool is managed as a group of available frequency division multiple access (FMDA) channels capable of being dynamically assigned as needed. Capability is also provided by the system for point-to-point and point-to-multipoint communications, with symmetric and asymmetric communication connections. With asymmetric channels different rates are assigned for

each direction (e.g. 128 Kbps digitized video link in one direction, and 16 Kbps control in the other). The system assigns bandwidth based on the total aggregate rate of the circuit for best satellite resource utilization.

Bandwidth Partitioning

DAMA-10000 performs frequency pool management using both partitioned and shared pool techniques for maximum flexibility and improved DAMA performance. Portions of the

available pool can be designated for voice or data, with the remainder designated as a common pool capable of being used by any service type. Use of a common pool helps to accommodate changing traffic conditions, without having to change the pool partitioning. With this flexible approach, the pool can be configured to meet current system needs.

Common Signaling Channels

DAMA-10000 uses multiple Common Signaling Channels (CSC) for control transmissions between the NCT and the RTs for the purpose of network establishment, network control, status reports and circuit establishment. The system is designed with an expandable architecture, where CSC channels can be added as the system population grows. Parallel, low rate CSC channels are ideal for several reasons:

- Minimize RF power usage at the remote VSATs
- Minimal bandwidth overhead required for each CSC channel
- Parallel CSC structure is easy to expand as networks grow
- Separate CSCs can be setup for each subnetwork

Dynamic Link Power Control (Option)

With the DAMA-10000 system, link quality is monitored on the common signaling channels to enable real-time power control. Since the link is dynamically adjusted, the system can operate with less link margin for more efficient satellite resource utilization.

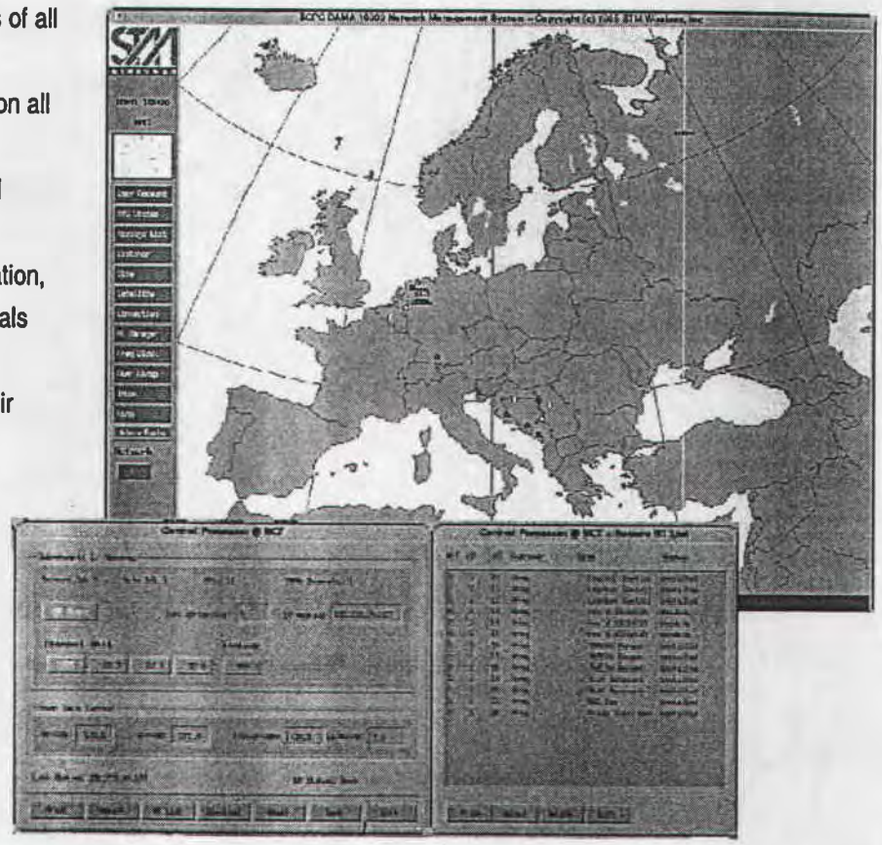
Network Management System

STM's NMS is one of the most powerful, sophisticated and user-friendly network management systems in the industry. Every remote terminal and NCT communications parameter can be controlled and monitored from one central NMS work station. The NMS contains a comprehensive set of tools for maintaining the network, providing total network operation visibility and network control. Records containing traffic information are backed up on disk by the NMS as soon as each individual record is received, so that all data in memory is saved. The basic configuration for the NMS consists of a graphical user interface workstation that is locally connected to the Network Control Terminal (NCT).

NMS OPERATOR INTERFACE gives centralized network management and control of the entire network through a single Graphical User Interface. When the NMS is powered up, a customized color map showing the entire network is displayed as the main screen. This identifies the NCT and each remote terminal location and displays their status in real-time. The map screen provides entries to other NMS functions via simple point-and-click mouse operations. These entries are shown in the form of menus or buttons from which the operator can select the desired operation. All messages and alarms generated by the system are displayed at the operator console in English language and in color coded graphical format. The messages are time stamped and stored in the network database for future retrieval. A hard copy of the system messages is also available.

INFORMATION DATABASE gives the operator of the NMS full control of virtually all the system parameters ranging from the customer name at each site, to the data rate of any port in the network. All the configuration parameters required for the proper operation of the terminal are entered in the database configuration of the NMS. The following NMS parameters can be configured by the network operator:

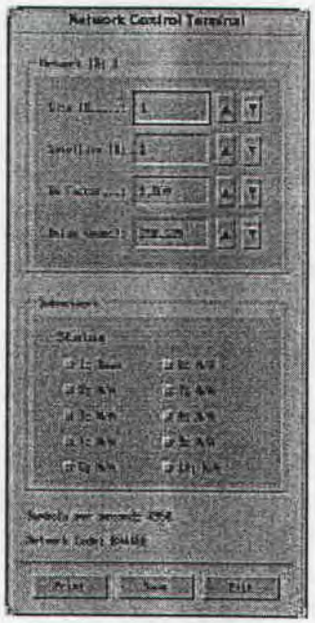
DAMA-10000 Network Management System



- Customer records which contain profiles of all subscribers.
- Satellite records containing information on all satellites accessible by the network.
- Site records containing the geographical locations of all the sites in the network.
- Terminal records with configuration, location, and phone number of all network terminals
- Module/port definitions of each terminal.
- Network operator records containing their profiles and access privileges.

SOFTWARE DOWNLOAD. Remote terminal operating parameters and software can be changed under control of the hub. Port configuration parameters, as well as the executable codes for the remote terminals, can be downloaded from the NMS without impact on the rest of the hub operations.

REMOTE MANAGEMENT TERMINALS can be installed at remote sites to provide additional system control flexibility. Depending on how the primary and remote sites are configured, each site is capable of monitoring and controlling all or part of the network.



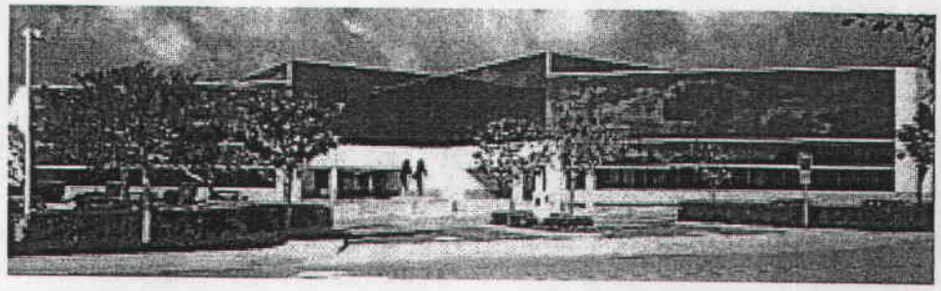
Applications

- Public Telephone Networks
- Private Corporate Networks
- Rural Telephony
- ISDN Network Extension
- Cellular Telephony Backbone
- Video Conferencing

The DAMA-10000 is ideal for new network development or as an upgrade to an existing SCPC system. The flexible expansion capability of the system allows your network to grow gracefully as demand increases without requiring major new investments.

The Company

STM Wireless, Inc. is a leading manufacturer of satellite and wireless radio communication products using VSATs (Very Small Aperture Terminals), transceivers, modems and other networking equipment. STM products are designed to support data, fax, voice and video networks requiring cost-effective connections between geographically dispersed locations. The company's proprietary equipment and software are employed by business, government agencies and telephone companies in Europe, the Americas and Asia. The company also provides full turnkey system integration services and shared hub services.



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DAMA-10000 4-Channel Unit

4-Channel Unit

Introduction

The STM Wireless DAMA-10000 system is a full mesh, single hop satellite transmission network which allows direct connection between any two ports in the network. It provides real-time Demand Assigned Multiple Access (DAMA) communications solutions. The 4-Channel Unit is the base indoor unit for all remote terminals in the DAMA-10000 satellite network.

Features

- Highest Industry Data Rate
- High Quality Voice/Fax Communications
- Video Conferencing
- Flexible System Architecture

Control Processor

Embedded in the 4-Channel Unit is a Control Processor which carries out multiple functions in the DAMA-10000 network. It acts as the control element in the 4-Channel Unit for all inserted modules and provides access to external interfaces. The Control Processor functions as the DAMA modem for all Common Signaling Channel (CSC) processing functions at the remote terminal. It is equipped with multiple interfaces to support operator control consoles, diagnostic terminals and provide control of external equipment such as INTELSAT modems. When the 4-Channel Unit is configured as the Network Control Terminal (NCT), the Control Processor functions as the common signaling source. When combined with Control Demodulator Module (CDM), the Control Processor provides all signal generation, modulation, demodulation and message recovery functions for the Common Signaling Channel.

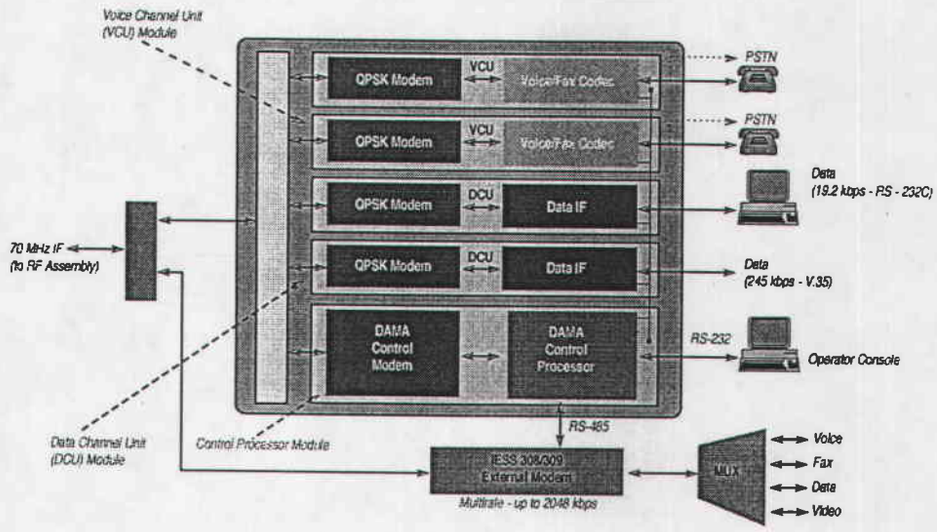
The 4-Channel Unit has an internal Control and Signaling Bus which connects the Control Processor with all Channel Unit slots. Control and monitoring functions provided by this bus include:

- Signaling information (e.g. off-hook, dial digits, etc.) which is passed from the Channel Unit to the Control Processor to enable call request processing;
- Channel setup and configuration information which is passed from the Control Processor to the appropriate Channel Unit on call setup;
- Status such as received Eb/No, carrier lock detect and on-line fault information which is available to the Control Processor upon request.

The 4-Channel Unit has embedded 70 MHz IF splitting and combining functions so that the output power for each channel unit can be set independently by the Control Processor. This can be:

- Open loop to power balance multiple channel units operating at different data rates
- Closed loop under the control of the Network Management System (NMS) via commands sent on the DAMA Common Signaling Channel.

4 - Channel Unit Configuration



An RS 485 port is used to control external equipment, either to enhance the capability of the terminal, or to allow it to operate in an open-architecture environment. In the baseline configuration, this port and the accompanying software drivers are designed to monitor and control high speed modems operating above 384 Kbps. Additional software drivers can be added to enable monitor and control of a full range of selected equipment including 308/309 INTELSAT modems, video modems, etc. With this port the 4-Channel Unit can be used to bring demand-assigned operation to any existing SCPC network and/or equipment.

Flexible System Architecture

The standard remote terminal consists of a single 4-Channel Unit which can be equipped with up to four independent modules. These can be a mixture of Voice/Fax and Data Channel Units:

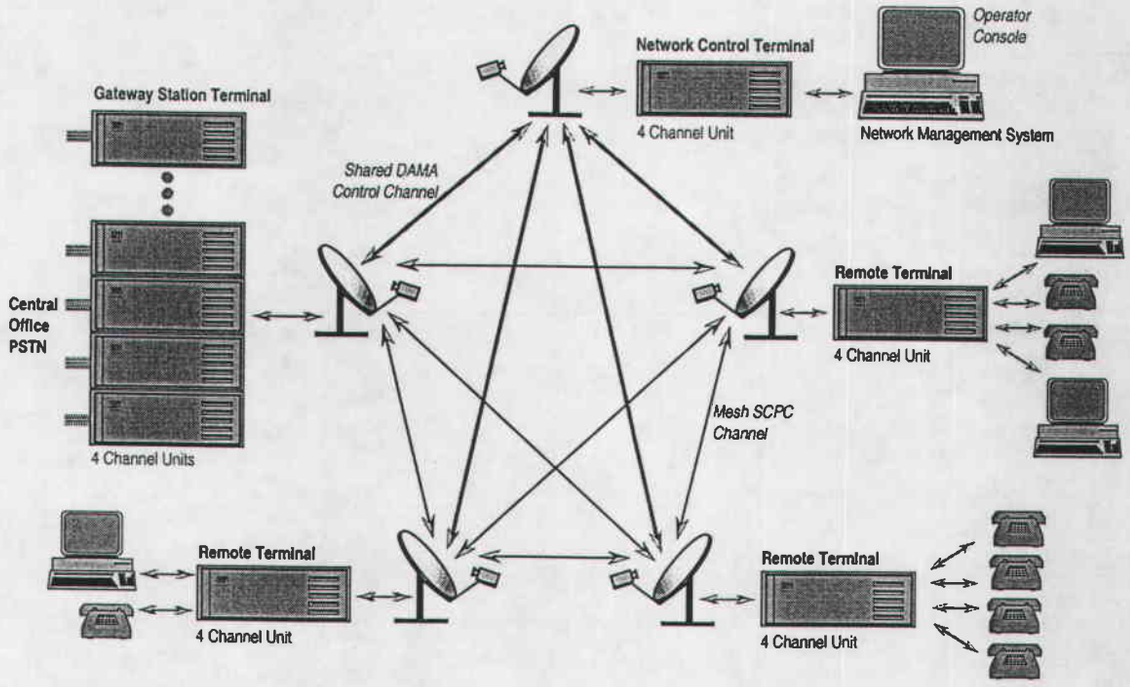
- Voice Channel Unit (VCU). Provides variable voice digitization at 4.8, 8 and 16 Kbps and facsimile with Group III compatibility
- Data Channel Unit (DCU). Operates with data rates up to 384 Kbps. (Higher data rates can be supported by addition of an external modem controlled by the terminal).

All remote terminals can have multiple 4-Channel Units daisy-chained to provide additional capacity as required. Rack mountable units are also available for gateway applications. Any 4-Channel Unit can be configured as the NCT by addition of a plug-in Control Demodulator Module and the Network Management System.

The DAMA-10000 VCU and DCU modules are designed with a common modem and IF section which have the following features:

- 70 MHz IF with 40 MHz tunability (50 to 90 MHz)
- < 1 kHz step size. Local control can provide tuning resolution to < 1 Hz
- Highly accurate, all digital pulse shaping and data detection processed to enable close channel spacing and allow adjacent channel operation with non-mesh VSAT services.

DAMA-10000 Network Architecture



Control Demodulator

To utilize a 4-Channel Unit as the NCT, a Control Demodulator Module is inserted into one of its four expansion slots and it is locally connected with the Network Management System. The CDM provides the necessary demodulation of the inbound TDMA portion of the dedicated Common Signaling Channel for the NMS. Up to four CDMs can be inserted into the expansion slots of a 4-Channel Unit as the network grows or for networks with high volume traffic. 4-Channel Units with additional CDMs can be daisy-chained to accommodate even larger networks.

Advanced Technology

The DAMA-10000 uses Digital Signal Processing (DSP) technologies to improve stability and performance while reducing costs. Direct Digital Synthesis is employed for better overall frequency control. Programmable Gate Arrays are used for direct digital modulation and demodulation, providing improved signal conversion performance.

RF Equipment

The DAMA-10000 4-Channel Unit is designed to operate with outdoor RF equipment at extended C-Band, C-band or Ku-band frequencies. The power of the transceiver and the size of the antenna are determined by the satellite chosen and the maximum throughput required.

Remote Monitor and Control

A powerful Network Management System (NMS) is located at the Network Control Terminal. The NMS contains a comprehensive set of tools for maintaining the network providing total operation visibility and control.

Specifications

Transmit	
IF Frequency	70 MHz ± 18 MHz
Step Size	< 1 Hz
Frequency Stability (0° to +50°)	< 1 Hz
IF Output Power	-35 dBm to -20 dBm in 1 dB steps
Phase Noise	Meets INTELSAT IESS 308/309
Spurious	< -50 dBc @ 4 KHz BW
TX Control	Individual ON/OFF control for each channel
Receive	
Frequency	70 MHz ± 18 MHz
Step Size	< 1 Hz
Input Power Level	-50 to -30 dBm
Composite Power Level	-5 dBm
Control Processor	
Operating Frequency	52 to 88 MHz
Outbound TDM Channel	
Data Rate	9.6 Kbps
Modulation	BPSK
Coding	r = 1/2, k = 7
Scrambling	V.35
Inbound TDMA Channel	
Data Rate	9.6 Kbps
Modulation	BPSK
Coding	r = 1/2, k = 7
Interfaces	
Monitor & Control	RS-232
External Modem Control	RS-485
LAN	Ethernet (BNC)
Mechanical	
Height.	6.96 in. (177 mm)
Width	17.00 in. (432 mm)
Depth	17.75 in. (451 mm)
Prime Power and Environmental	
Input Voltage	48 VDC or 90-264 VAC, 50/60 Hz
Power Consumption	46 Watts (Basic Unit) (40 Watts nominal per additional Channel Unit)
Operating Temperature	0° to 50°C
Operating Humidity	10% to 90%, noncondensing
Altitude	Up to 10,000 feet
Storage Temperature	-20° to 60° C
Storage Humidity	5% to 95%, noncondensing

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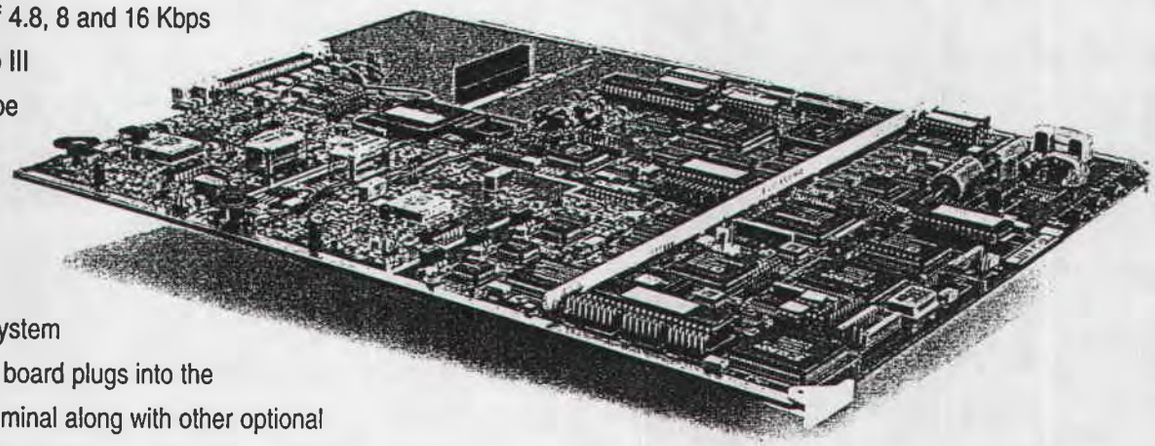
DAMA-10000 Voice Channel Unit

Introduction

The DAMA-10000 Voice Channel Unit (VCU) integrates a VOICE/FAX codec and selectable BPSK or QPSK modem functions into a single full capability voice module. It has built-in echo cancellation, on-board discrete fax modem and full 2-wire and 4-wire interfaces. The VCU provides variable voice digitization rates of 4.8, 8 and 16 Kbps and facsimile with Group III compatibility which can be selected either locally by the Control Processor module or remotely under Network Management System (NMS) control. The VCU board plugs into the DAMA-10000 remote terminal along with other optional expansion boards. Up to four expansion boards can be operated simultaneously in one 4-Channel Unit.



Features

- Supports Standard Trunk Signaling
- Supports Rotary Pulse and Touch Tone Dialing
- Supports R1 and R2 Signaling
- Full CCITT Group III Fax Capability
- Built-in Echo Cancellation
- Monitor, Control and Diagnostics Via the NMS

Advanced Technology

The latest advancement in digital voice compression algorithms are incorporated into the VCU. Advanced Multi-Band Excitation (AMBE) is used for the 4.8 Kbps voice compression. For 8- and 16-Kbps, ITU G.729 and G.728 are used respectively. The result is significantly improved voice quality, even at 4.8 Kbps with a Mean Opinion Score up to 3.5 providing superior speech intelligibility.

Interfaces and Signaling

The basic Voice Channel Unit supports standard 2 and 4-wire E&M (Types I-V), and OPX signaling interfaces. Dial Pulse, DTMF and MFC are recognized by the VCU. Group III facsimile and R1 and R2 signaling are also supported. Also available is in-band data capability which allows for detection and transmission of synchronous data.

Remote Monitor and Control

A powerful Network Management System (NMS) is located at the Network Control Terminal. The NMS contains a comprehensive set of tools for maintaining the network providing total operation visibility and control.

Specifications

General/Modem

Operating Frequency Range	70 ± 18 MHz
Step Size	< 1 kHz
Settling Time	< 250 msec
Demodulator Input Level	-30 to -50 dBm, -5 dBm composite
Modulator Output Level Control	16 dB in 1 dB steps
Modulation	BPSK/QPSK
Forward Error Correction	Convolutional encoding/ Viterbi decoding r = 1/2 or 3/4
Data Scrambling/Descrambling	V.35 or none
Phase Noise	Meets IESS 308/309
Spurious	< -55 dBc @ 4 kHz bandwidth

Voice/Fax

Compression	4.8 Kbps AMBE 8.0 Kbps G.729 16.0 Kbps G.728
Telephone Interface	4-wire E&M (Types I-V) 2-wire Loop Start (OPX) Connector: RJ-45
Signaling	DTMF, R1 and R2
Echo Cancellation	CCITT G.165
FAX Interface	CCITT Group III T.4, T.30
Impedance	600Ω
Longitudinal Balance	> 60 dB
Audio Bandwidth	300 Hz to 2900 Hz
Idle Channel Noise	< 20 dBnrc
Tx/Rx Level	-24 to +6 dBm

Other

Power Consumption	40 Watts nominal
Operating Temperature	0° to 45° C Ambient
LED Indicators	Tx Enable, Receive Sync. Summary Fault

Controlled & Monitored Parameters

Transmit Frequency	Received Frequency
Data Rate	Encoding/Decoding Select
Scrambling ON/OFF	Received Eb/No

STM WIRELESS

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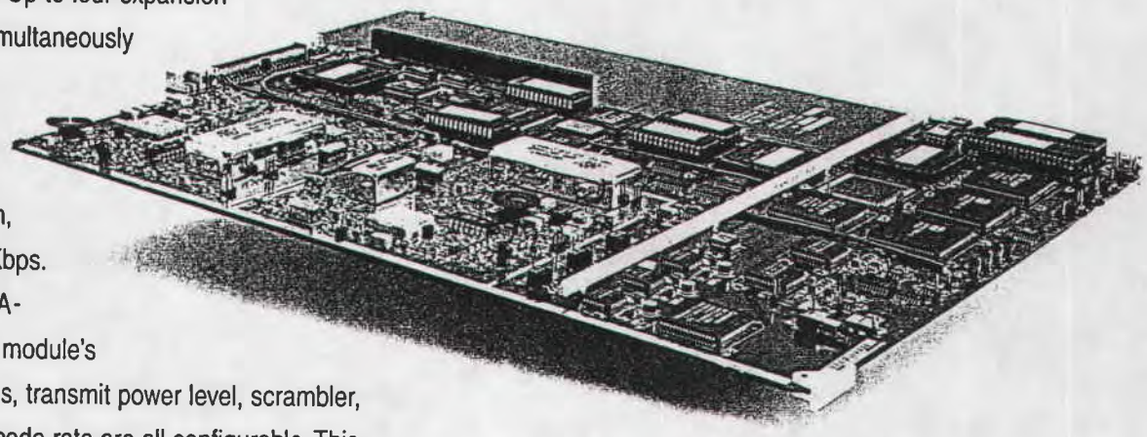
DAMA-10000 Data Channel Unit

Introduction

The DAMA-10000 Data Channel Unit (DCU) is an advanced, variable rate modem specifically designed for bit transparent, bandwidth-on-demand applications. This digital modem provides excellent flexibility and reliability with no user adjustments required. The DCU is a single module which plugs into the DAMA-10000 remote terminal along with other optional expansion boards. Up to four expansion boards can be operated simultaneously in one 4-Channel Unit.



The DCU supports both BPSK and QPSK operation, with data rates up to 384 Kbps. When inserted into a DAMA-10000 4-Channel Unit, the module's transmit/receive frequencies, transmit power level, scrambler, data rate, modulation and code rate are all configurable. This is done either locally by the Control Processor module or remotely under Network Management System (NMS) control.

Features

- Variable Data Rates up to 384 Kbps
- Selectable Modulation Techniques and Forward Error Correction (FEC) Rates
- Supports Industry Standard Interfaces
- Monitor, Control and Diagnostics Via the NMS

Advanced Technology

The DCU design integrates the latest digital signal processing technology to reduce modem size and cost while providing superb performance and capability. The DCU incorporates digital data filters for both modulation and demodulation functions giving accurate signal generation and low loss performance. The unit incorporates Direct-Digital Synthesis (DDS) technology to ensure accurate frequency control. As with the DAMA-10000 Control Processor and VCU modules, the DCU transmit and receive frequencies can be locally controlled to better than 1 Hz accuracy. It meets INTELSAT phase noise and spurious requirements.

Interfaces and Signaling

The DCU is designed to operate with a group of baseband interface modules and an optional elastic buffer module. Both synchronous and asynchronous modes required for the DAMA-10000 network are supported. The DCU modules are configurable as RS-442/449, RS-232C and V.35 interfaces. Signaling information from the various port configurations are routed from the DCU to the Control Processor to enable full bandwidth on demand capability.

Remote Monitor and Control

A powerful Network Management System (NMS) is located at the Network Control Terminal. The NMS contains a comprehensive set of tools for maintaining the network providing total operation visibility and control.

Specifications

General

Operating Frequency	70 ± 18 MHz
Step Size	< 1 kHz
Digital Interface	Selectable: RS-422/449, V.35 RS-232C, TCP/IP, X.25, SDLC
Data Rate	up to 384 Kbps
Modulation	Selectable BPSK/QPSK
Spectral Mask	Per INTELSAT IESS 308 and 309
Forward Error Correction	1/2 or 3/4
Encoding/Decoding	Convolutional/Viterbi
Data Scrambling/Descrambling	V.35 or none
Phase Noise	Meets INTELSAT IESS-308
Power Consumption	40 Watts Nominal

Modulation

Spurious	< -50 dBc at 4 kHz Bandwidth
Output Power Control	16 dB in 1 dB Steps
Data Clock Source	Internal or External, Selectable

Demodulator

Input Level	-30 to -55 dBm
Maximum Composite	-5 dBm

Signals Monitored and Controlled

Tx & Rx Frequency	Tax On/Off
Data Rate	Scrambler On/Off
Bit Error Rate	Acquisition Rate
Eb/No	Tx/Rx Clock Source
Received Signal Level	Operating Mode

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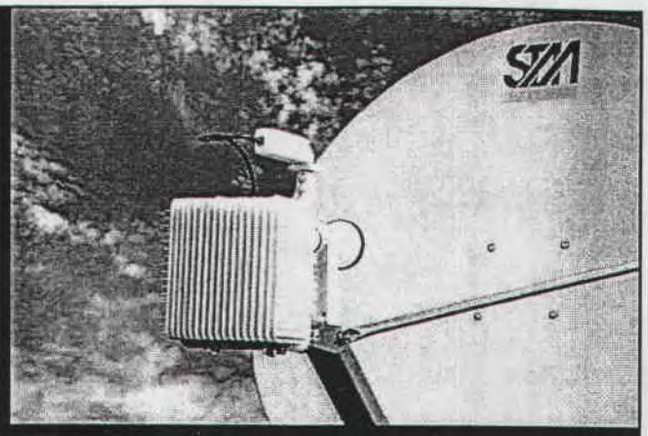
Annex B.2 STM Wireless VSAT Equipment

B.2.2 STM Subscriber Earth Station

Subscriber Earth Station



The Subscriber Earth Station provides voice, fax and data services to remote areas by satellite. It combines powerful call routing and network management features into a small, easy-to-install terminal tailored for solar power. It is a cost-effective solution for remote Public Calling Offices and Payphone applications.

STM WIRELESS

The Subscriber Earth Station (SES) is STM's telephony product designed to provide reliable, affordable, on-demand telecommunications service in underserved and remote areas. SES is a small, light-weight and extremely low cost, ultra-small aperture terminal which is ideally suited for areas where telecommunications service is unavailable, unreliable, or simply too expensive. Since it is satellite based, an SES terminal can be quickly installed virtually anywhere to allow immediate access to the SES network and the public switched telephone network (PSTN). SES uses STM's state-of-the-art DAMA-10000 Network System, which maximizes the use of available satellite capacity and minimizes operational costs. SES provides excellent telecommunications service with high quality voice and industry standard interfaces.

Features

- Single or Optional Dual Channel System
- High Quality Voice, Data and Fax
- Ruggedized, Fully Integrated Terminal
- On-Demand Bandwidth - DAMA
- Integrated Network Management System
- PSTN Signaling, Call Routing and Payphone Support
- Low Power Consumption

SES Architecture

The SES terminal provides single line or optional dual line connectivity of voice, fax, and In-Band data calls between gateways and other subscribers. The terminal uses a full-mesh bandwidth-on-demand technique to provide network flexibility and optimal use of network resources. TDM/TDMA techniques are used for call processing, assignment and network management purposes.

The SES network consists of a Network Control Center (NCC), one or more access gateways, and up to thousands of remote SES terminals.

Network Control Center (NCC)

The NCC is the single focal point for system level control. The NCC provides centralized management and control functions for establishing the DAMA connections; it maintains a database of network performance; and it stores call detail record information. The NCC provides over the air software downloading with no on-site adjustments or calibrations required. The NCC also performs the switching and routing functions for the SES terminals and one or more PSTN access gateways.

PSTN Access Gateway

The network operator has the flexibility to support a single gateway or multiple gateways. Multiple gateways allow the operator to put gateways in different area codes, reducing the number of back haul connections and simplifying PSTN routing of incoming and outgoing calls.

High Quality Voice, Data and Fax

The SES features a proven, high quality digital vocoder with built-in error correction algorithms for high quality operation even under high bit error rate conditions. The vocoder compression complies with CCITT Recommendations. The SES supports up to 14.4 Kbps Group III fax and up to 14.4 Kbps In-Band data with a standard dial-up modem.

Integrated Ultra Small Terminal

STM's unique integrated Ultra Small Terminal design is ideal for rural telephony applications. The SES is specifically designed to reduce equipment costs by minimizing size, weight, and power consumption. The SES has the RF and terminal electronics housed in a small, low-cost, weatherproof package. This efficient design requires minimal interconnections and cabling to further reduce cost and simplify terminal installation. The SES terminal consists of two elements: a small, offset-fed antenna and a ruggedized transceiver terminal mounted on the antenna. The terminal provides all RF, inbound/outbound modulation, terminal control, voice compression and a 2-wire interface for connection to telephone equipment.

Designed for remote locations where solar and battery power are required, the SES supports real-time shutdown of unused circuits to reduce power requirements. Even while the SES is on-line, unused circuitry (e.g., majority of the transmit and voice circuitry) is automatically disabled to conserve battery power. The SES uses full power only during transmission of voice communications.

On Demand Bandwidth DAMA

In a DAMA system, the network allocates transmit and receive frequency pairs to each call from a pool of frequency channels on a demand-assigned basis. When a caller at a remote terminal requests service (e.g., picks up the telephone to make a call), the request is made to the NCC over the shared DAMA common signaling channel. The NCC determines whether the call is valid and then establishes the channel between the SES and the called number. When the call is completed, the NCC releases the call and returns the freed bandwidth to the DAMA frequency pool. By using a DAMA system, a single transponder can support several thousand subscribers.

Industry Standard Interfaces and Switching

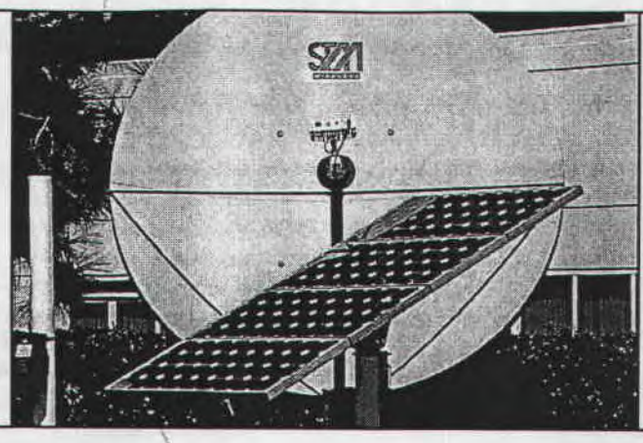
The SES system provides standard telephony 2-wire loop start interfaces for direct connection to standard telephone set equipment. Both Battery Reversal and 12- and 16-KHz metering pulses are supported for call accounting. The SES system uses simple phone number identification based on the call origination and/or destination. This means that the SES network can follow established numbering and routing schemes.

Use of Dual-Line Terminal

The SES supports two lines by combining two calls to the same PSTN access gateway. An STM proprietary technique allows two standard G.729 or AMBE calls to share a common connection in a DAMA mode. When a call is placed, the channel is allocated. When both calls are released, the channel is returned to the DAMA frequency pool.

Integrated Network Management System

STM's NMS is one of the most powerful, sophisticated, yet user-friendly network management systems in the industry. The NMS contains a comprehensive set of tools for providing network control, visibility of network operations, and call accounting.

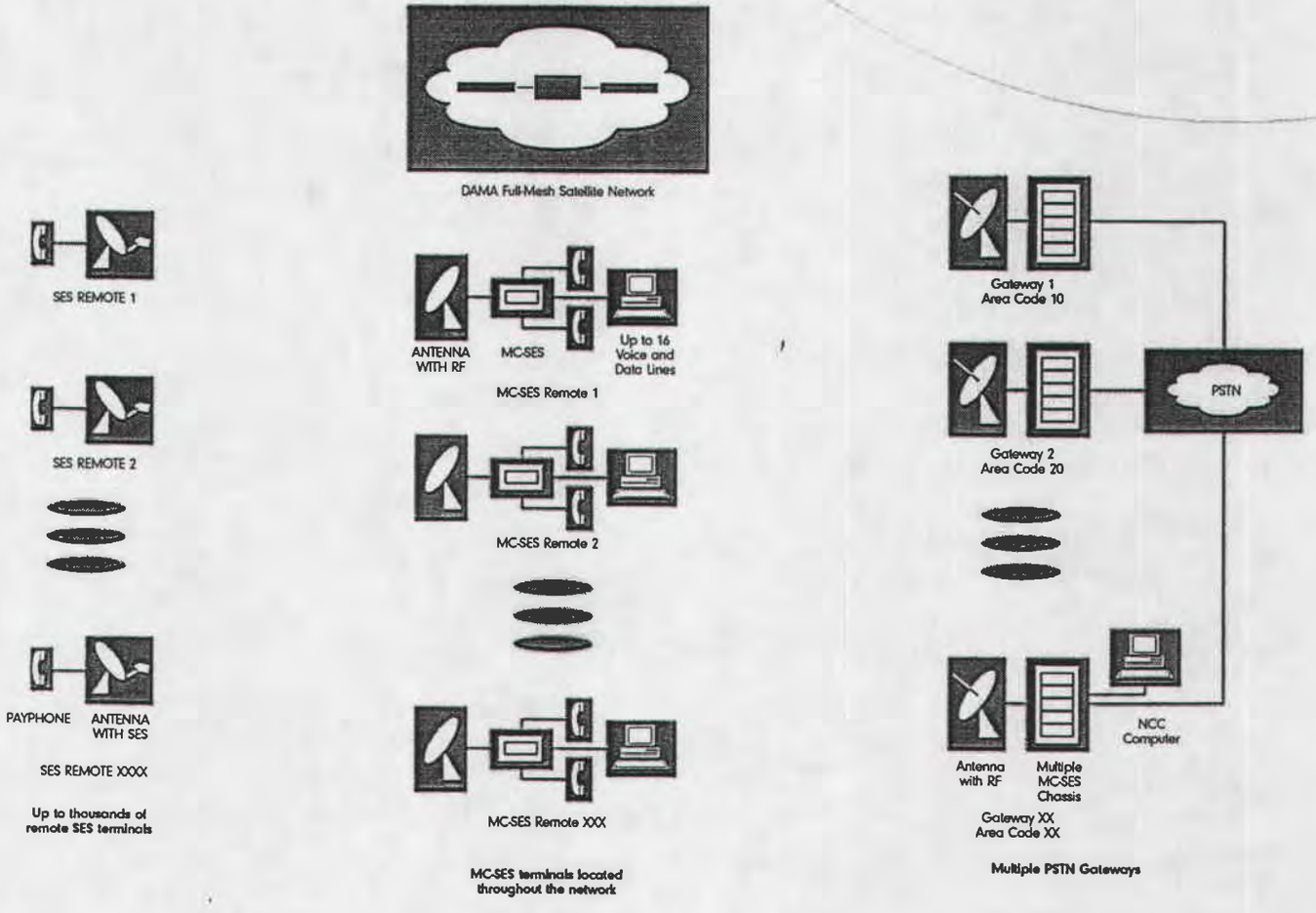


The SES provides high-quality, reliable communications tailored for solar power.

Network Control - The SES network operator has full ability to control the communications parameters of each terminal and allocate satellite resources. The SES has enhanced switching and routing capability, allowing an unrestricted numbering plan, multiple user sub-networks, and automatic circuit rerouting.

Operation Visibility - The NMS provides a simple Graphical User Interface. The NMS operator has the ability to monitor every SES communications parameter and terminal status. The NMS also provides routine system upgrades online through the network, eliminating the need for site visits.

Call Accounting - Built-in database software provides full call accounting, terminal, and network status, allowing the NMS to supply billing information to operator-specific billing systems.



The Subscriber Earth Station provides remote subscribers with PSTN access by satellite. A typical SES satellite network can comprise thousands of SES terminals, located throughout a region or country. A sister product, the Multi-channel Subscriber Earth Station, provides the equipment at the Gateways to the PSTN. The NCC can be located at any gateway. Moreover, the NCC can be installed at its own independent site, such as a Network Operations Center.

Subscriber Earth Station

Specifications

RF & Modem Parameters:	
Frequencies	
INSAT C-Band	Tx: 6.725 to 7.025 GHz, Rx: 4.5 to 4.8 GHz
C-Band	Tx: 5.850 to 6.425 GHz, Rx: 3.625 to 4.2 GHz
Ku-Band	Tx: 14.0 to 14.5 GHz, Rx: 10.95 to 12.75GHz
Output Power	
C-Band and INSAT C-Band	1 Watt or 2 Watts
Ku-Band	1 Watt
Satellite Modem	
Multiple Access	FDMA-DAMA
Dual Channel Mode	FDMA-DAMA-MCPC
Tuning Steps	1 Khz
Frequency Stability	<0.3 ppm
Power Stability	± 1dB
Voice Processing:	
Voice Compression	4.8 Kbps AMBE 8 Kbps G.729 16 Kbps G.728
Modulation	DQPSK
FEC	½
Echo Cancellation	ITU G.165
Dialing	DTMF or Pulse
Fax	Group III 14.4 Kbps
Data	14.4 Kbps V.32
Telephony Interfaces	2-Wire Loop Start
Satellite Network Control	TDM/TDMA at 9.6 Kbps
Power:	
Standard	-48 VDC for Battery and Solar Powered Operation
Optional	110/220, 50/60 Hz VAC ±5%
Consumption	35 Watts Idle, 40 Watts Active
Protection	Fuse protected
Environmental:	
Temperature	Operating -30° to 60° C, Storage -40° to 70° C
Relative Humidity	Up to 100%
Altitude	5000 meters
Dimensions	9.614 x 9.614 x 4.346 inches
Weight	11.50 lbs.

STM WIRELESS
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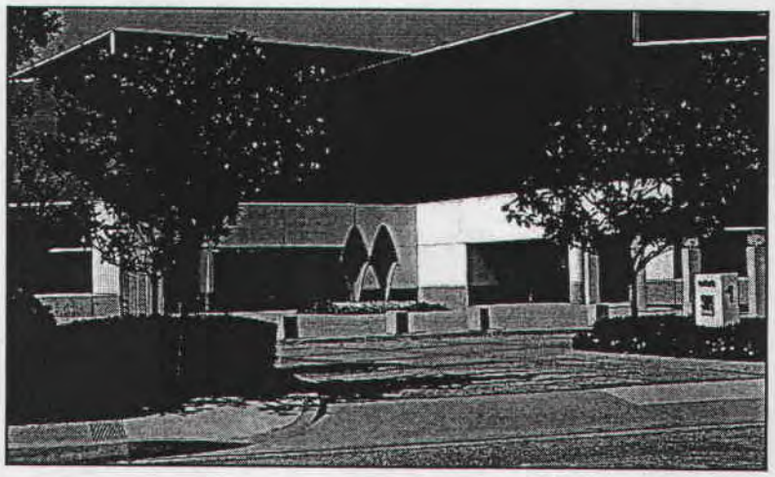
www.stmi.com

STM: EXPERIENCE WITH INNOVATION.

- Founded in 1982.
- Established customers throughout the world.
- Extensive rural telephony experience.
- Feature-rich, cost-effective solutions.



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Multi-Channel Subscriber Earth Station 2000

The Multi-channel Subscriber Earth Station 2000 provides multiple voice, fax, and data service channels to remote areas by satellite. It combines powerful call routing, network management, and highly efficient satellite transponder access. It is ideal for voice and data applications at sites with demanding service requirements.

STM WIRELESS

The Multi-Channel Subscriber Earth Station 2000 (MC-SES) provides up to 16 telephony voice and data channels in a single rack-mount chassis. The MC-SES is ideally suited for national phone network access gateways, rural exchanges, and remote cellular systems. Since it is satellite based, an MC-SES terminal can be quickly installed, providing immediate access to the public switched telephone network (PSTN) at remote locations. The MC-SES uses STM's state-of-the-art DAMA-10000 Network System, which maximizes the use of available satellite capacity and minimizes operational costs. MC-SES provides excellent telecommunications service with high quality voice and industry standard interfaces.

Features

- 1 to16 Channels per Chassis.
  Chassis can be combined for more channels per site
- Built-In G.703 E1 Interface
- High Quality Voice, Data, and Fax
- Modular Expansion with Support for Multiple E1s Per System
- On-Demand Bandwidth – Full Mesh DAMA
- Multiple PSTN Gateways
- Integrated Network Management System
- PSTN Signaling, Numbering Plan, and Payphone Support
- Support for Data at 64 Kbps up to 2 Mbps
- Low Cost Installation and Operation

MC-SES Architecture

The MC-SES completes the evolution of the STM Wireless family of Demand Assigned Multiple Access (DAMA) products. It provides a DAMA Single Channel Per Carrier (SCPC) system for voice, fax, data, and broadband applications. The STM Wireless DAMA system architecture has the flexibility to support a single gateway or multiple gateways. This allows the operator to put gateways in different area codes, reducing the number of back haul connections and simplifying the PSTN routing of incoming and outgoing calls. Each gateway is supported via the MC-SES system, under control of the Network Control Center. Furthermore, the architecture enables one network to support voice, data, and broadband traffic concurrently.

Network Control Center (NCC)

The NCC is the single focal point for system-level control. The NCC provides centralized management and control functions for establishing the DAMA connections and maintains a database of network status, performance, and call detail record information. The NCC provides over-the-air software downloading to remote MC-SES terminals, with no on-site adjustments or calibrations required. The NCC also performs the switching and routing functions for the remote terminals and one or more PSTN access gateways.

High Quality Voice, Data, and Fax

The MC-SES features a proven, high quality digital vocoder with built-in error correction algorithms for high quality operation even under high bit error rate conditions. The vocoder compression complies with CCITT Recommendations. The MC-SES supports data rates up to 14.4 Kbps for Group III fax and up to 14.4 Kbps for dial-up modem data.

The optional MC-SES data capability supports from 1 to 16 channels at 64 Kbps. Broadband channels are also supported up to 2 Mbps. The data can be provided on the G.703 E1 interface or via an Ethernet LAN router internal to the MC-SES.

PSTN Access Gateway

In many satellite networks, the connection to the PSTN requires several individual pieces of equipment, in multiple racks, to provide capacity for a single E1 interface. The STM Wireless MC-SES allows the installation of several E1s of traffic capacity in a single standard rack. Furthermore, the MC-SES system provides a standard telephony G.703 E1 interface, including the necessary signaling for direct connection to standard telephone switching equipment. No additional interface equipment is necessary. The basic chassis provides 16 channels.The combination of two chassis provides an E1 interface (30 voice channels).

Broadband Data

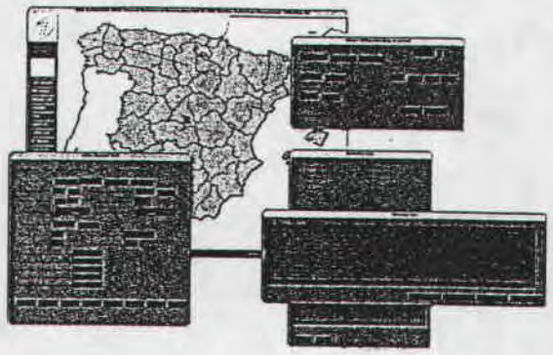
The MC-SES system can be configured to support either voice or 64 Kbps data. If data is required at higher rates, the MC-SES uses the STM Wireless Data Channel Unit, capable of supporting data rates up to 2 Mbps. The Data Channel Unit also supports the Application Interface Card (AIC), which provides IP routing and TCP satellite acceleration.

Demand Assigned Multiple Access (DAMA)

In a DAMA system, the network allocates transmit and receive frequency pairs to each call from a pool of frequency channels on a demand-assigned basis. When a caller at a remote terminal requests service (e.g., picks up the telephone to make a call), the request is made to the NCC over the shared DAMA common signaling channel. The NCC determines if the call is valid and then establishes the channel between the DAMA system and the called number. When the call is completed, the NCC returns the bandwidth to the DAMA frequency pool for reuse. By using a DAMA system, a single transponder can support several thousand subscribers.

Integrated Network Management System (NMS)

STM's NMS is one of the most powerful, sophisticated, user-friendly network management systems in the industry. The NMS contains a comprehensive set of tools for providing network control, network visibility, and call accounting.

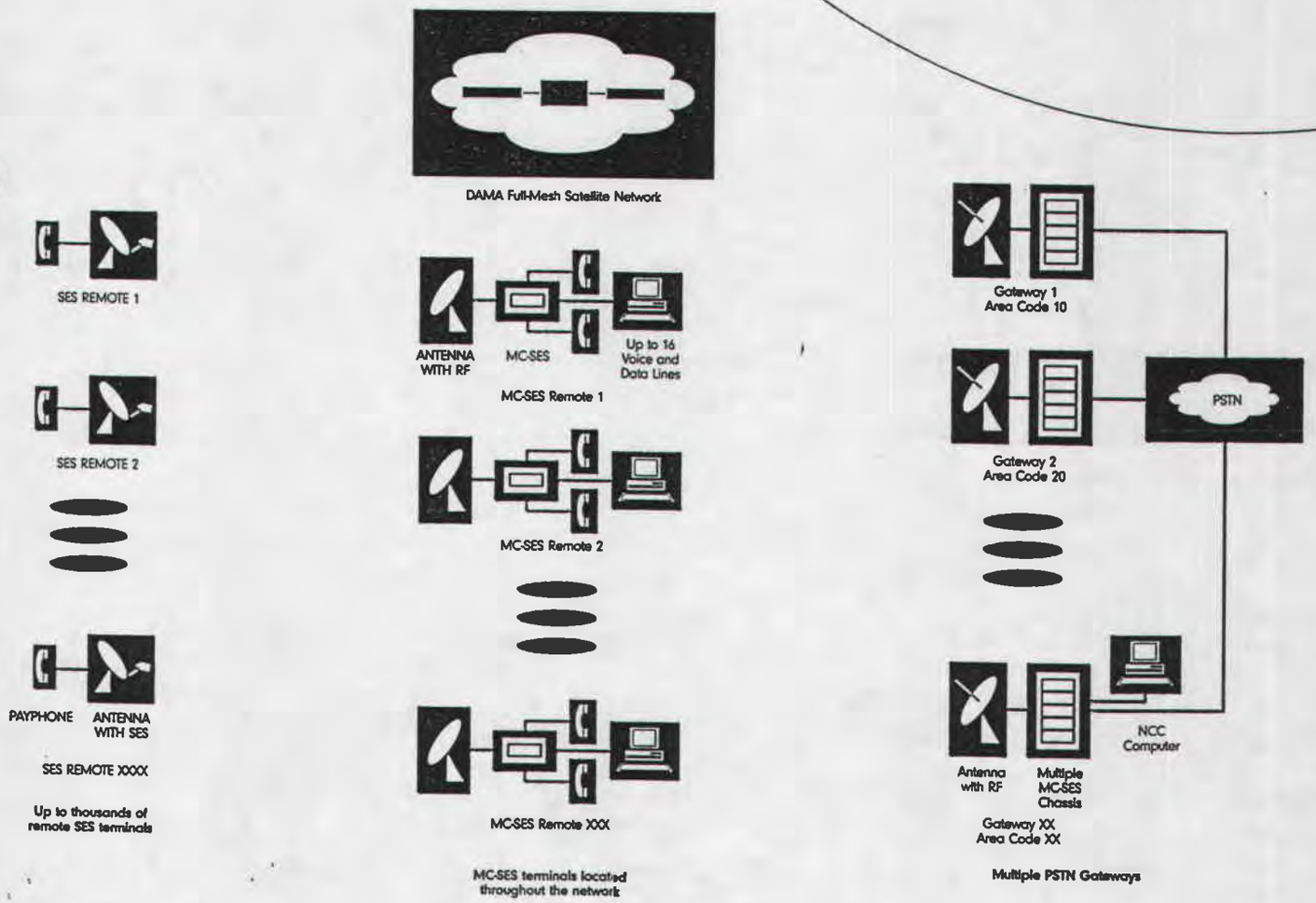


The Graphical User Interface of the NMS provides comprehensive network monitor and control in a user-friendly format.

Network Control – The MC-SES network operator has full control of the communications parameters of each terminal and allocated satellite resources. The MC-SES has enhanced switching and routing capability, enabling unrestricted numbering plans, multiple user sub-networks, and automatic circuit rerouting.

Operation Visibility – The NMS provides a simple Graphical User Interface. The NMS operator has the ability to monitor every individual MC-SES communications parameter and the capability to provide routine system upgrades online through the network, eliminating the need for site visits.

Call Accounting – Built-in database software provides full call accounting, terminal, and network status, allowing the NMS to supply billing information to operator specific billing systems.



The Multi-channel Subscriber Earth Station (MC-SES) provides remote subscribers, located throughout a region or country, with multiple voice and data lines for PSTN access. The MC-SES also provides the satellite network equipment at PSTN Gateways. The MC-SES seamlessly integrates with STM's Subscriber Earth Station terminal to provide a complete DAMA Full-mesh satellite network. Moreover, the NCC can be installed at its own independent site, such as a Network Operations Center.

Multi-Channel Subscriber Earth Station 2000

Specifications

Number of Satellite Channels Configurable from 1 to 16 per chassis.
Two Chassis combine to form an E1 interface.

Operating Frequency	52 MHz to 88 MHz
Modulation (Satellite)	BPSK/QPSK
FEC Coding (Satellite)	Rate 1/2 and 3/4 (k=7, convolutional encoding), Viterbi decoding
Data Scrambling (Satellite)	V.35
Voice Compression	4.8 Kbps AMBE 8 Kbps G.729 16 Kbps G.728
Voice Processing	90 msec
Echo Cancellation	ITU G.165
Dialing	R2 Signaling, DTMF
Fax	14.4 Kbps Group III
In-Band Voice Data	14.4 Kbps V.32
Data	9.6 Kbps to 2 Mbps
Optional Data Routing	IP Routing and TCP Acceleration
User Interfaces	Voice or Data: G.703 E1 - 64 kbps A-Law PCM or 64 Kbps Data Optional 2-Wire Loop Start Payphone Support: 12 kHz, 16 kHz, and Battery Reversal Optional Data: 9.6 Kbps to 2 Mbps Ethernet
Satellite Network Control	TDM/TDMA at 9.6 Kbps
Input power	1) -48 VDC 2) 90-132/180-264, 50/60 Hz VAC 3) < 135 Watts Full Configuration
Operating temperature range	-30°C to 55°C
Operating humidity range	Up to 95%, non condensing
Dimensions	Height: 5.25" (3U) (133mm) Width: 17" (432mm) (With Slides 19" rack mount) Depth: 17" (432mm)

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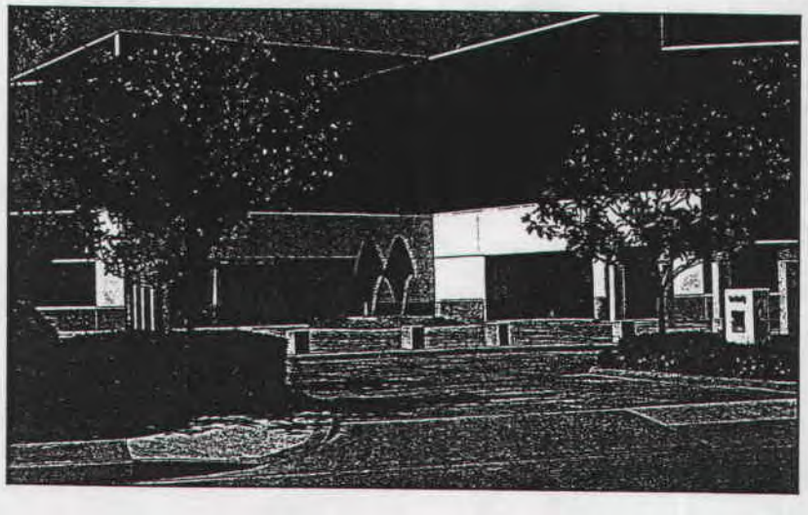

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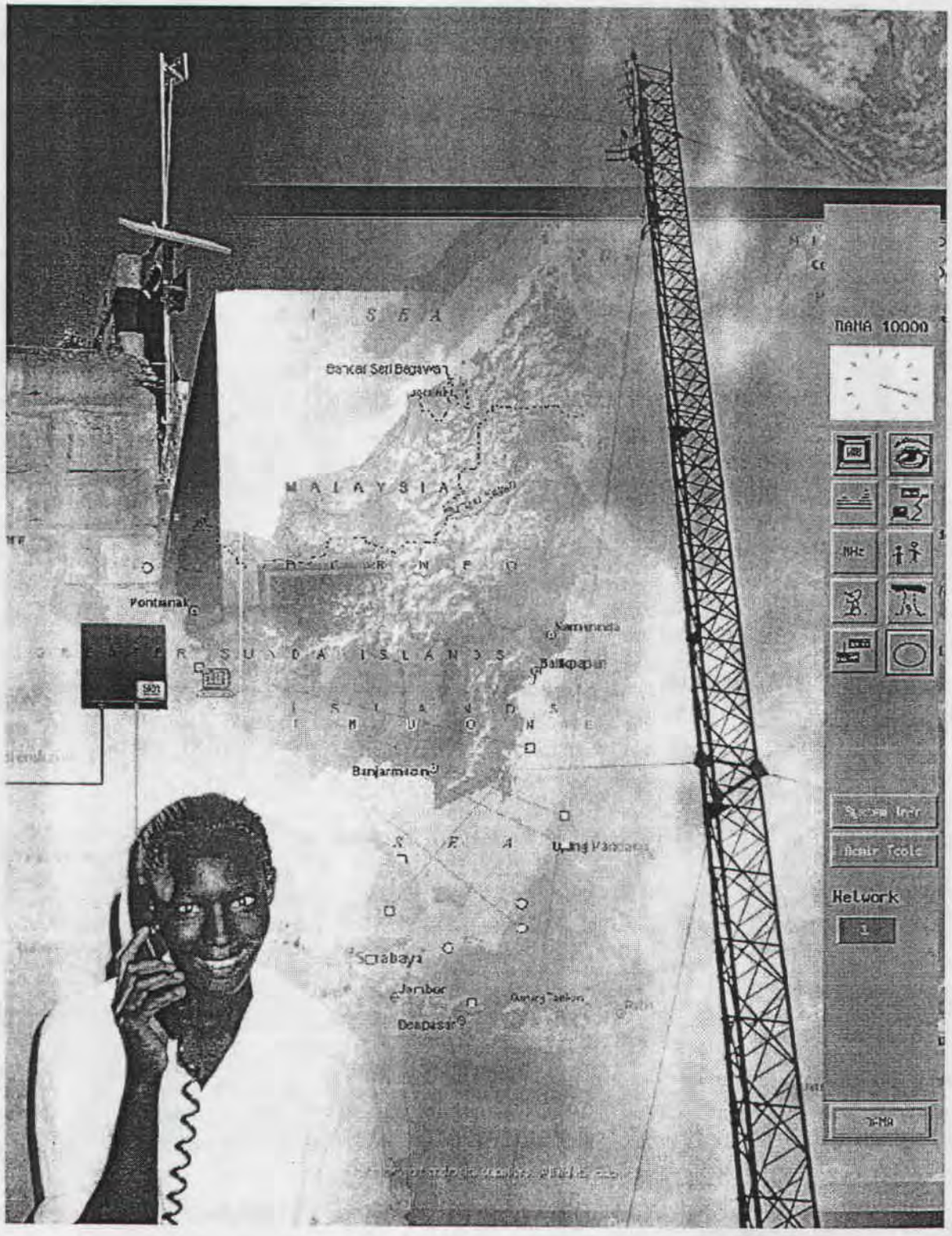
Annex B.2 STM Wireless VSAT Equipment

B.2.3 STM Space Loop

SpaceLoop

Utilizing DAMA satellite technology fully integrated with Wireless Local Loop, the SpaceLoop Wireless Communication Solution is a complete turnkey system that specially addresses rural telephony issues. SpaceLoop system is cost-effective even for as few as 20 subscribers per cell or less than 1 subscriber per square kilometer.



Introduction

The wireless air interface for the WLL segment is based on the Digital European Cordless Telephone standard (DECT). DECT offers a simple air interface to help reduce the cost of the subscriber and base radio equipment, while providing toll quality voice for the local loop.

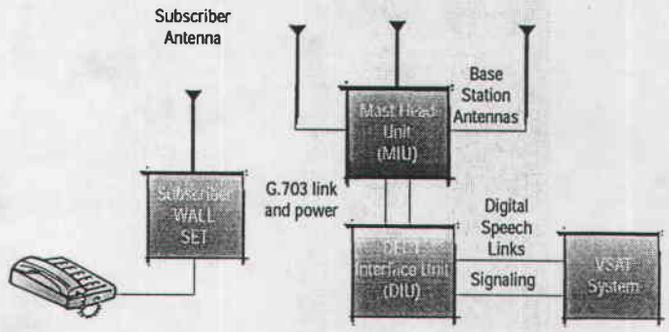
SpaceLoop functions as a local exchange, providing complete local call control. Local calls are handled without the need to access the PSTN and without wasting satellite resources. Subscriber numbering plans and calling features are fully integrated into the Public Switched Telephone Network via multiple Gateways.

A key component for a profitable telephony solution is to accurately maintain a Call Detailed Record (CDR) for all calls that take place in that network. SpaceLoop provides flexible charging methods, and CDR's are generated for intra-cell, inter-cell and long distance calls.

The SpaceLoop WLL Terminal Description

The DECT Interface Unit (DIU) performs switching, controls the Mast Head Unit (STM's DECT Base Station) and interfaces with the VSAT System. It processes all the incoming and outgoing calls to and from the WLL subscribers it serves. The DIU provides call control, power to its assigned Mast Head Unit (Base Station), voice coding, call set-up and teardown and billing data.

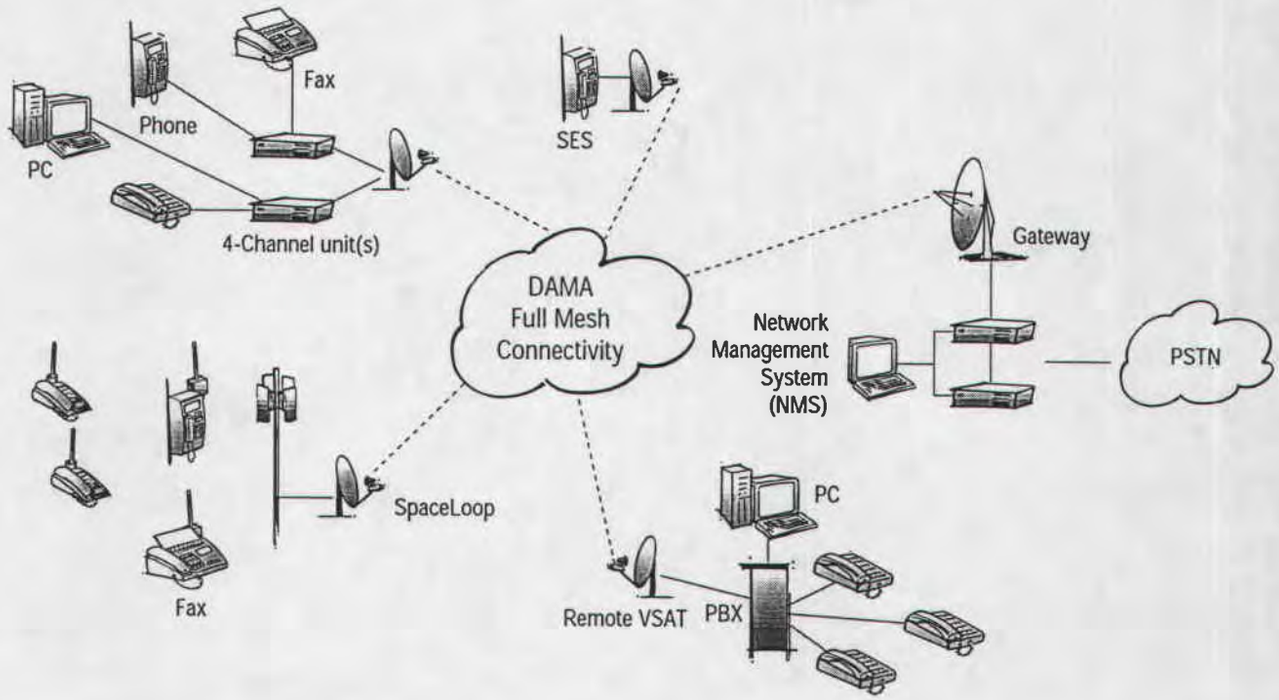
The Mast Head Unit (MHU) is a small, weather-tight rectangular unit. Its compact size allows for unobtrusive interior installations. Its rugged construction and broad temperature and humidity operating ranges make it equally suitable for exterior installations on buildings and antenna masts. Each radio within the MHU provides up to 6 simultaneous, two-way telephone conversations. The coverage radius depends on the propagation environment and antenna gain values. With a line-of-sight link and high-gain, directional antennas, this radius can reach ranges of three to five kilometers.



DECT WLL System Architecture

The MHU contains three DECT radios and base-band controllers. The radios are connected to antennas that provide coverage in three sectors, each with space diversity. The sectors may be allowed to overlap (e.g. to cover a community from an edge or corner rather than its center). STM provides a wide range of choices for antennas.

The Subscriber WALL SET is a small rectangular unit designed for either indoor or outdoor installation. STM offers a range of antenna options to best match cost and performance with the installation requirements. Low loss coaxial cable connects the antenna to the WALL SET. The WALL SET features an internal battery with up to 24-hours of standby time to continue service in the event of a power failure. Its energy efficient design makes it suitable for either solar or commercial power. The WALL SET provides a telephone connector for a standard telephone, payphone, fax machine or modem.



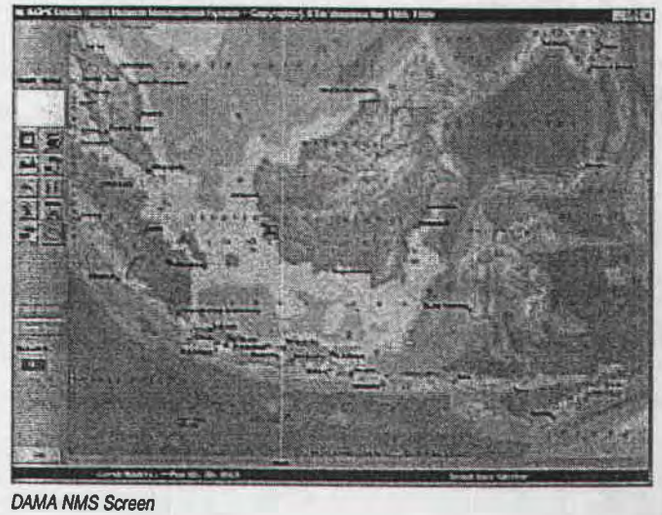
SpaceLoop integrates with STM's full spectrum of communication solutions

PSTN Interface via Satellite

STM features its DAMA-10000 4-Channel Chassis and associated Network Management System (NMS) as the full mesh, single-hop satellite system that connects the local DECT WLL subsystem with both the PSTN and with other DECT WLL subsystem locations. The System offers powerful, flexible switching and signaling options that enable the satellite link to integrate seamlessly between the DECT WLL subsystem and the PSTN. The NMS enables the network operator to completely control the access of an individual WLL subscriber to both the PSTN and other DECT WLL subsystems.

Network Management System (NMS)

The NMS features an Intuitive Graphical User Interface (GUI) for simple point-and-click operation. It provides monitor and control for the entire system, and it is generally located at one of the Gateways. SpaceLoop is fully integrated into the same DAMA NMS that controls the regular full mesh DAMA VSAT Network. This integration provides centralized system and fault control, monitoring, user administration, maintenance, and billing data collection for the WLL users. The NMS offers features that can analyze the dialed digits of a call and route the subscriber traffic in a manner to use both satellite and PSTN resources most efficiently.



DAMA NMS Screen

Annex B

B.3 Gilat VSAT Equipment

Rural Telephony Market

In rapidly developing countries, reliable telecommunications have rightly been given the highest priority in infrastructure planning. Governments are attempting to provide people in all areas of their countries (however remote) with basic communications.

This has been difficult to accomplish in particularly harsh environments such as the mountains of Chile or the scattered islands of Indonesia. But in both these countries, forward-looking governments and their regulatory agencies have allowed and even encouraged the deployment of VSAT networks for public telephony. The result? Large populations of rural users that used to be miles from a telephone are making phone calls on a daily basis, from a Public Call Office (PCO), and at a cost that they can afford. Meanwhile, their telephony operator is getting a return on investment that would be impossible with other technologies. And since data communications runs over the VSAT network with the same ease as voice, fax machines are also hooked up to the network and it is expected that Internet-access is not far behind.

In some countries, the existing telephone network just needs to be expanded a bit. Private users as well as government offices, military outposts, post offices and hospitals want to be able to rely on the fact that when they lift the handset they'll get connected within minutes rather than hours. And when they get connected, they want to hear the person on the other end of the line.

VSAT networks are being implemented to interface transparently with the existing analog network. Ethiopia, Kazakhstan and Russia have commissioned such networks, allowing these countries to quickly provide new and improved lines in their urban and semi-urban regions. Subscribers include local factories and shop owners, mining operations and international organizations. Click on DialAway or FaraWay for product information.

Efficient FTDMA DAMA-Enhanced Operation

Satellite space segment is the most costly ongoing resource in VSAT network operation. In order to use it efficiently most VSAT-based rural telephony networks use DAMA (Demand Assigned Multiple Access). In DAMA, a telephone set isn't "on-line" until a user makes a telephone call. If there is a channel available the call goes through. If not the user gets a busy signal. The service provider decides how many simultaneous telephone calls will go through the network. Usually that decision is based on experience as to local user demand. However, if the initial assessment is too small for a rapidly growing network, the space segment can be increased and shared evenly by all the users.

FTDMA is an enhancement of old-fashioned SCPC DAMA. Rather than sharing the satellite space segment based only on the carrier's frequency (Single Channel Per Carrier), new technology allows the division of each carrier into many time slots. This allows users to share even the carrier itself, thus increasing network capacity and reducing costs at the network terminal. Furthermore, operators enjoy greater flexibility in adjusting the network to user demand. Click on FaraWay or DialAway to find out how Gilat's products work.

Integrated WLL / Satellite Solution

An innovative solution is required to provide a telephony infrastructure for widely dispersed population centers. By integrating WLL or Cellular access with a VSAT's highly efficient switch and long distance transmission, remote population centers can enjoy robust communications and distant-independent connection to the PSTN.

A single NMS PC-based platform is utilized for both the WLL and the VSAT combined networks. The NMS allows remote status monitoring and controlling of all elements from one central location. Moreover, the NMS provides over-the-air maintenance and an optionally enhanced capability to control and monitor the auxiliary equipment (e.g. solar panel). Utilization of DAMA for both the WLL and the VSAT enables efficient and complete end-to-end bandwidth utilization. WLL Intra-Call features enhance the network bandwidth utilization by providing local switching capability within the cells, without the need to consume satellite resources. See the FaraWay data sheet for further information.

Annex B.3 Gilat VSAT Equipment

B.3.1 Gilat DialAw@y IP

Gilat

DialAw@y® IP

Satellite-Based Network for Public Telephony and Internet Access

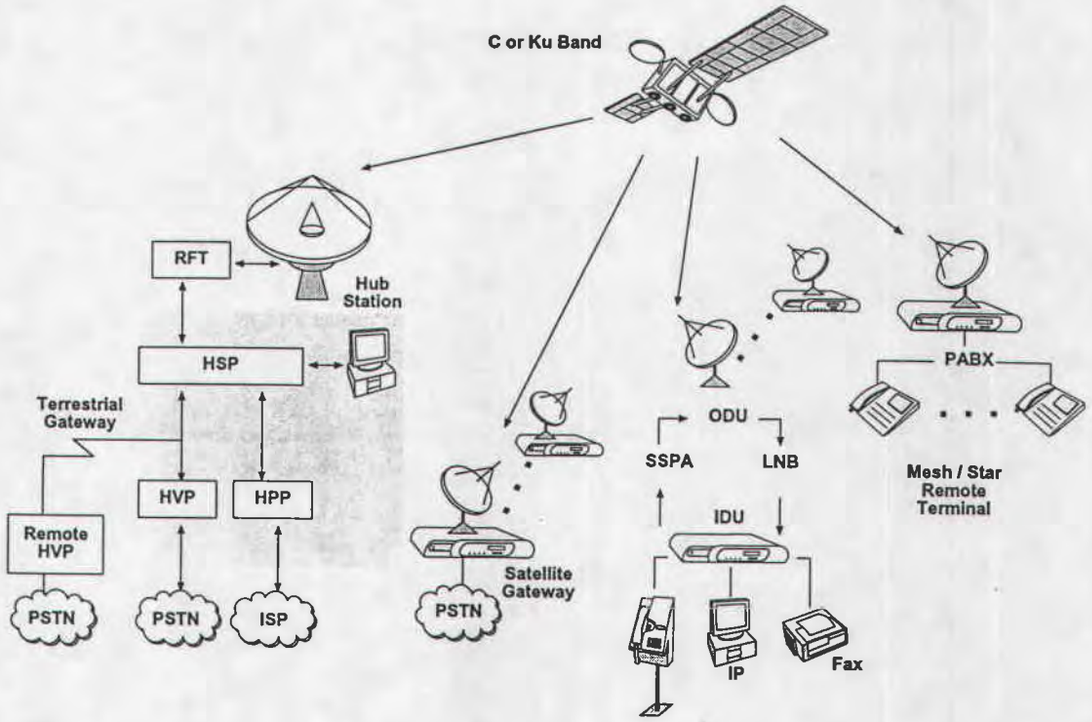
Gilat's DialAw@y IP VSAT network is a low-cost public telephony and Internet solution that provides voice, fax and Internet services via satellite. Each unit supports up to 3 telephone channels and an Ethernet port for PC connection.

Delivering toll-quality voice and IP transmission, DialAw@y IP is the reliable solution for communities and businesses in areas where PSTN and Internet services are unavailable, overloaded or too expensive.

Quick to install and easy to manage, the network is ideal for the fulfillment of Universal Service Obligations (USO) and replacing outdated infrastructure. Services such as Payphones, Public Call Offices (PCO), and Small Office / Home Office (SOHO) connectivity can be established in any location.

DialAw@y IP features:

- *Toll-quality full duplex voice*
- *High speed Internet-access*
- *Payphone support*
- *Group 3 fax relay*
- *Voice band data*
- *Full mesh or star topology*
- *Multiple PSTN gateways*
- *Conventional numbering plan*
- *Remote control and monitoring*
- *Ultra-low power consumption*
- *Superior reliability*
- *Low-cost installation and operation*
- *Rapid deployment*



Architecture

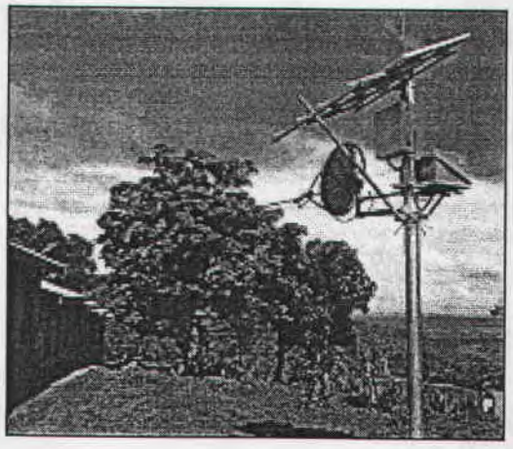
A DialAw@y IP network consists of a central hub, multiple PSTN gateways, satellite channels and remote terminals (VSATs). A **remote terminal** consists of a small outdoor antenna (typically 0.55 to 1.2 meters), an Outdoor Unit (ODU) and an Indoor Unit (IDU). The **hub** consists of an RFT and baseband equipment. The baseband includes a Hub Satellite Processor (HSP), a Hub Voice Processor (HVP), a Hub Protocol Processor (HPP) and a Network Management System (NMS).

Each HVP can be connected directly to the PSTN using a digital E1 line. The HPP is used to interface with the Internet Service Provider (ISP). The hub design permits easy scalability and incorporation of new features.

DialAw@y IP's **Network Management System** enables the hub operator to monitor and control the remote terminals, and to gather call data records from the sites for billing operations. Client - Server architecture enables remote NMS capability.

PSTN gateways are remote terminals that serve a different function. They establish digital E1 connectivity with several central offices in various locations. There are two options available. Satellite gateways, which utilize satellite channels, and terrestrial gateways, which carry compressed voice data over terrestrial leased lines.

Voice/Fax/Data Transmission

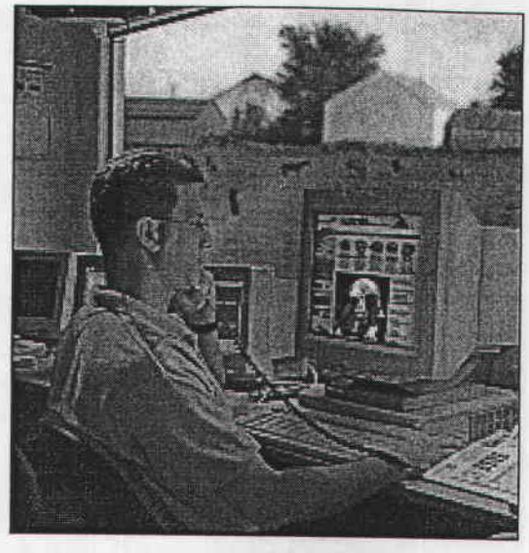


DialAw@y IP's minimal power requirement is ideal for solar operation

With DialAw@y IP, the analog voice input is digitized and compressed to 4.8 or 6.4 kbps. The compressed voice is packetized and transmitted to the hub or to another remote terminal via the satellite. At the destination, a voice/ fax/ data card decodes the incoming voice packets into digitized voice, which is then reconverted into analog form. The voice/ fax/ data channel is configured for voice mode by default. When a Group 3 fax transmission is detected, the channel automatically switches to fax mode. Upon completion of the fax message, the channel automatically returns to voice mode.

Internet Access

The DialAw@y IP provides two-way always-on asymmetric IP routing. The IP data is time-multiplexed with the telephony data, enabling simultaneous telephone calls and Internet browsing. Internet access is carried out without occupying a telephone line. The hub transmits a high-speed outbound carrier of up to 8 Mbps containing IP data. The VSATs transmit an inbound carrier of up to 153.6 kbps. The VSAT acts as a router, enabling the connection of more than one PC. An Ethernet LAN port at the VSAT is used for PC connection (RJ-45). Internet-enabling technologies such as TCP spoofing and Internet Page Acceleration are incorporated to ensure a superior user experience.



Features

- *Toll-quality full duplex voice*

  A toll-quality G.723.1 voice compression algorithm is used at 6.4 kbps. It has a Mean Opinion Score (MOS) voice quality rating of 3.9, better than the G.726 32- kbps ADPCM. The algorithm is language-independent and passes in-band DTMF as well as other voice band tones. Every voice connection is full duplex.

- *High speed Internet-access*

  Internet-access services such as web browsing, e-mail, and e-commerce can be delivered to the Public Call Office, or private office, via an ISP connection at the hub.

- *Payphone support*

  Flexible adjustment to various payphones. 16/12 kHz or reverse polarity metering pulse is supported.

- *Group 3 fax relay*

  Fully supported at 4.8 kbps, with automatic voice/fax mode switching.

- *Voice band data*

  Fully supported at 2.4 kbps with automatic voice/data mode switching.

- *Full mesh or star topology*

  Full-mesh single hop communication between VSATs is available using a mesh connectivity plug-in card. Star topology further reduces operators' costs.

- *Multiple PSTN gateways*

  Call routing can be carried out to several PSTN locations using digital E1 satellite or terrestrial Gateways.

- *Conventional numbering plan*

  Destination numbers for incoming and outgoing calls are manipulated by the system to conform to PSTN conventions.

- *Remote control and monitoring*

  The Network Management System controls and monitors all parameters of the VSAT remote terminals via the satellite link such as:
  - Updates VSAT parameters and software
  - Gathers call data records for billing
  - Enables/disables remote units

- *Ultra-low power consumption*

  Requiring very low power, DialAw@y IP is an excellent solution for remote areas where no power is available and solar panels are used.

- *Superior reliability*

  - Industry leader in MTBF
  - Unique immunity to interference and data interception

- *Low-cost installation and operation*

  DialAw@y IP is the cost leader among all satellite-based telephony solutions.

- *Rapid deployment*

  Compact design allows a single team to install up to three remote sites per day.

DialAw@y® IP

Gilat

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Technical Specifications

Network	*Type*	DAMA mesh or star
	Frequency Range	Rx / Tx
	Ku-band:	10.95 – 11.70 GHz / 14.00 – 14.50 GHz
		11.70 – 12.20 GHz
		12.25 – 12.75 GHz
	C-band:	3.62 – 4.20 GHz / 5.850 – 6.425 GHz
	Extended C-band:	4.50 – 4.80 GHz / 7.625 – 7.025 GHz
	BER Performance	Better than 10^{-7}
	Voice Compression	ITU G.723.1, 6.4 or 4.8 kbps
	Echo Canceller	ITU G.165
	Group 3 Fax Relay Speed	Up to 4.8 kbps
	Data	Voice band data up to 2.4 kbps
	Protocols	IP Routing
Hub Station		
	User Ports	
	Voice Interfaces:	E1 (G.703), FXO, FXS
	Voice Signaling:	MFC R2
	Ethernet LAN:	10 base T
	Outbound Carrier	Statistical Time Division Multiplexing (STDM)
	Number of Carriers:	Configurable
	Bit Rate:	64 Kbps to 8 Mbps
	Error Correction:	Convolutional or Concatenated, Viterbi
	Modulator	
	Modulation:	QPSK,BPSK
	IF Output:	70 ± 18 MHz or 140 ± 36 MHz, 1 kHz increments
	Network Management	PC-based Windows NT server with object-oriented graphical user interface
Gateway		
	Voice Interface	E1 (G.703), MFC R2
Remote Terminal		
	Inbound Carrier	Proprietary combined TDMA and FDMA
	Bit Rate:	9.6, 19.2, 38.4, 76.8, 153.6 kbps, software configurable
	Modulation:	MSK, DPSK
	Outdoor Unit	
	Antenna Size (typical):	Ku-band: 0.55m to 1.20m; C-band: 1.80m to 2.40m
	LNB Type:	Standard TVRO
	Up-Converter:	Proprietary SSPA
	Operating Temperature:	-40° to +60°C
	Humidity:	Up to 100%
	Indoor Unit	
	Number of Voice Interfaces:	up to 3
	Voice Interface:	2-wire FXS, 4-wire E&M (optional)
	Ethernet LAN:	10 base T, USB
	Payphone Support:	Metering pulses at 16/12 kHz or reverse polarity
	Operating Voltage:	AC: Autorange 100 - 240V or DC: 12V, 24V, 48V.
	Power Consumption:	Less than 25W
	Dimensions:	6 cm (h) x 40 cm (w) x 34 cm (d)
	Weight:	3.9 kg
	Operating Temperature:	-10° to 60°C (weatherized version optional)
	Humidity:	Up to 95%, non-condensing

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Annex B.3 Gilat VSAT Equipment

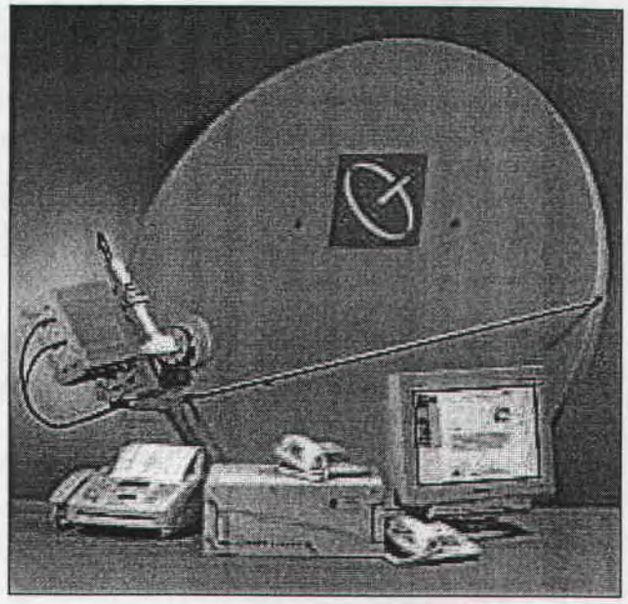
B.3.2 Gilat FaraWay VSAT

Gilat

FaraWay™ VSAT

Satellite-based voice and data network

FaraWay VSAT is a communication network that provides on-demand voice, fax and data services to remote locations via satellite. It employs a full-mesh, DAMA network architecture that maximizes the use of available space and ground-based resources.



FaraWay VSAT offers a cost-effective solution for areas where telephone and data services are unavailable, unreliable or too expensive. It satisfies the exacting standards of PSTN and private network operators for voice encoding, data links, signaling, call accounting and maintenance.

FaraWay VSAT features:

- *Full Mesh*
- *DAMA*
- *Toll-quality voice*
- *High-speed data links on demand*
- *Single modem/single carrier operation*
- *Industry standard implementation*
- *Group 3 fax and voice band data*
- *Switching and numbering capabilities*
- *PSTN interfaces and signaling support*
- *Call accounting*
- *Very low power consumption*
- *Extremely low space segment utilization*
- *Easy expansion*
- *Fully intergrated ODU*

Applications

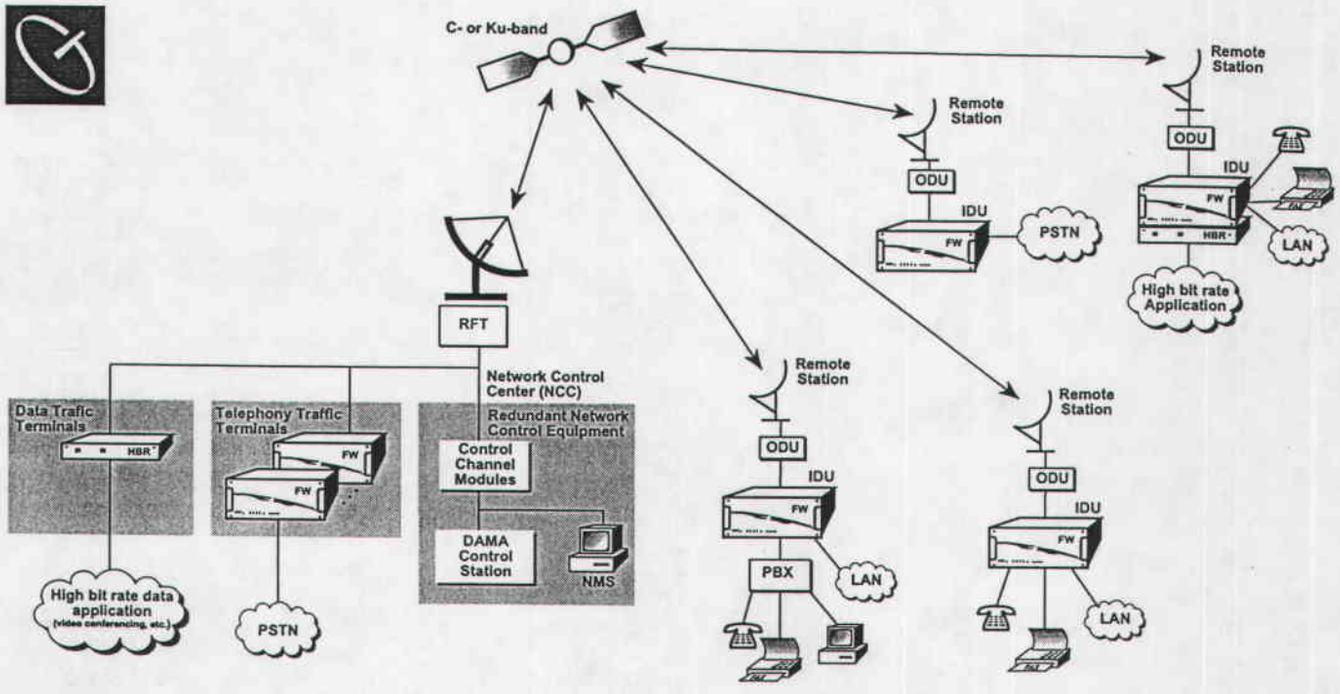
Corporate networks

FaraWay enables businesses to expand the reach of their corporate networks to remote areas. Since FaraWay is designed to provide multiple services utilizing a single platform, remote office users connected to the network can perform day-to-day business communications such as high-quality telephone calls and conferences, high-speed fax transmissions, personal computer connections to email and Internet, and more.

The remote offices can also have high-speed data connections to the company WAN or other computing services, or to video conference rooms. FaraWay was designed for flexible utilization of available satellite and remote resources for any type of on-demand voice or data service.

Satellite telephony

FaraWay enables telephony services of uncompromising quality to underserved regions. Services include telephone kiosks in villages, payphones in rural areas or full-scale town networks, each providing a transparent interface to the user. When cellular or wireless local loop service is provided to a particular zone, FaraWay can easily serve as the backbone to connect the wireless base stations to each other and to the PSTN. Where deregulation permits, connection can be made to any part of the PSTN. The full mesh capability of the network enables multiple connections to the PSTN, thus minimizing charges and decreasing the terrestrial overload. Also, the standards implemented over FaraWay ensure seamless integration with domestic regulations and international links.



Architecture

The network consists of a Network Control Center (NCC) and numerous remote terminals.

The NCC acts as an exchange for the user equipment connected to the network and performs switching functions based on an unrestricted numbering plan.

The NCC also operates the network automatically, carries out control and monitoring functions (such as DAMA and call processing), provides network usage reports, traffic statistics and billing data, and manages the satellite space segment. The remote station equipment includes an antenna, an Outdoor Unit (ODU) and an Indoor Unit (IDU). The ODU includes an SSPA, LNA, and up and down converters between the C, Ex-C or Ku-band RF and the required IF frequency.
The IDU includes a controller, a satellite modem and user interface cards.
It can also optionally include a fully integrated High Bit Rate (HBR) modem for very high bit rate applications (video conferencing etc.).

FaraWay architecture is based on multi-carrier TDMA, combining the benefits of FDMA and TDMA. Each remote station transmits a single carrier with several channels, enabling multi-channel operation without costly ODU back-off.

Features

- *Full Mesh*

  FaraWay employs a full mesh network architecture, enabling single hop VSAT to VSAT voice and data calls, minimizing delay and allowing for routing calls through the optimal PSTN gateway.

- *DAMA*

  Demand Assigned Multiple Access operation is used by FaraWay to assign satellite circuits upon demand, thus ensuring efficient use of satellite circuits according to actual user needs.

- *Toll-quality voice*

  FaraWay employs toll-quality voice compression at rates of 16 or 8 kbps, in compliance with ITU recommendations G.728 and G.729A respectively. It is also in compliance with echo cancellation ITU recommendation G.165.

- *High-speed data links on demand*

  High-speed data links can be established on a permanent basis or on demand, in full mesh configuration. The data links can be synchronous or asynchronous, at any rate up to 128 kbps using a FaraWay

IDU, or up to 2 Mbps using the fully integrated HBR modem. These connections can be established on demand (using V.25 bis or other dialing protocols as an option), utilizing the same space segment as the rest of the network. All the data rates, types and interfaces are supported at each port and are configurable via software.

- *Single modem/single carrier operation*

  The FaraWay IDU can support 2-8 voice or data channels per single modem, a configuration typical of thin-route applications. A single modem transmits a single carrier so no backoff is required, and a low-power ODU can be used, which results in additional cost savings and simplicity.

- *Industry standards implementation*

  FaraWay supports a wide range of industry-approved standards for telephony, data, voice compression, RF and more. These standards ensure a smooth interface with most existing user equipment, keeping the implementation and integration cost to a minimum.

- *Group 3 fax and voice band data*

  Group III fax and voice band data are supported over the voice ports with no add-ons or modification required.

- *Switching and numbering capabilities*

  FaraWay offers an unrestricted numbering plan, multiple-user sub-networks, automatic circuit re-routing and assignment of hot lines. Built-in telephone exchange software transforms the network into a sophisticated switch which allows the operator to bill users on a per-use basis.

- *PSTN interfaces and signaling support*

  FaraWay wide implementation of international standards ensures connectivity to almost any existing PSTN equipment, without the degradation often caused by external adapters. FaraWay also offers a full support of standard telephony signaling protocols, as well as solutions tailored to the requirements of a specific region.

- *Call accounting*

  All call record data are automatically collected in the NMS for archiving in a simple ASCII format capable of being read by any off-the-shelf biling software.

- *Very low power consumption*

  FaraWay's very low power consumption is a major advantage where power is not available, resulting in savings on solar panels, batteries, UPS etc.

- *Extremely low space segment utilization*

  By utilizing the unique MCPC FTDMA access scheme and its ITU approved compression rates of 8 and 16 kbps, FaraWay offers the best space segment utilization, using 9.2 KHz of bandwidth per channel (compared to a typical 22.5 kHz in other SCPC systems). This will enable the network operator to conduct more traffic on the same space segment, generating up to double the revenues.

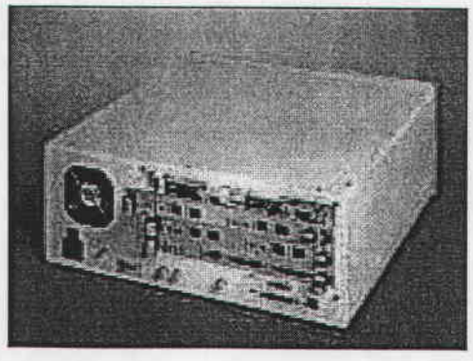
- *Easy expansion*

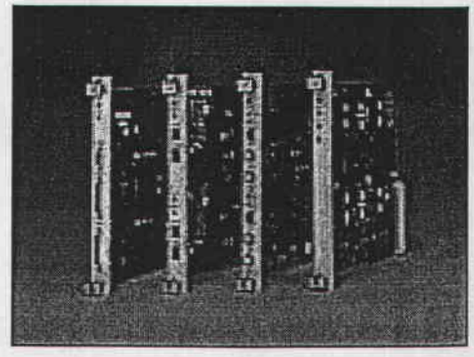
  The network can begin small, without a hub, and then grow to thousands of remote sites. Similarliy, a site can begin with only 2 channels and then grow without any costly RF or power changes.

- *Fully integrated ODU*

  Gilat offers a full line of fully integrated ODUs supporting FaraWay, which are controled through the FaraWay IDU, or remotely via the FaraWay hub, thus lowering costs and eliminating the need for additional indoor control equipment.

FaraWay back panel and interface modules





FaraWay™ VSAT

Gilat

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Technical Specifications

Network		
	Architecture	DAMA FTDMA, full mesh, single hop
	Capacity	Up to 8,000 remote stations Up to 30,000 calls per hour
	Frequency Bands	Ku-band, C-band, Extended C-band
	Modulation	QPSK
	Forward Error Correction	3/4
	BER Performance (FEC 3/4)	10^{-6} (E_b/N_0 = 7.2 dB) 10^{-4} (E_b/N_0 = 6.0 dB)
	IF Frequency	70 ± 18 MHz
Telephony Interfaces		FXS and FXO 4-wire E&M types I-V E1/T1
Payphone Support		12/16 KHz metering pulses, or reverse polarity
Data interfaces		RS-232/RS-530 synch and asynch internally, and Ethernet (RJ-45), V.35, G.703, RS-422 externally
Signaling Standards		DTMF Decadic (pulse) R1, R2 (option) China #1 (option) Other standards are available
Voice		
	Voice Encoding	ITU G.728, 16 kbps LD-CELP ITU G.729A, 8 kbps
	Echo Cancelling	ITU G.165
Facsimile		Group 3, up to 9.6 kbps over voice ports
Data		V.32 voice-band data up to 9.6 kbps over voice ports Up to 128 kbps internally, and up to 2 Mbps, using a fully integrated HBR modem. On demand data, utilizing V.25 bis or other dialing protocols (option)
Network Control Center (NCC)		NMS - Windows NT Workstation Fully redundant DAMA controller Fully redundant control modules
Remote Terminal		
	Outdoor Unit (ODU)	
	Antenna Size:	From 1.2m and larger
	Operating Temperature:	-40° to +60°C
	Humidity:	Weatherproof
	Indoor Unit (IDU)	
	Number of Ports:	1 to 8 per chassis; chassis are stackable
	Operating Voltage:	AC: 120/220V, 50/60 Hz DC: -48V (up to -72V optional)
	Power Consumption:	30 to 50W per chassis, depending on number of ports
	Typical Site Power Consumption:	130W for 8 channels (IDU+ODU)
	Dimensions:	17.7 cm (h) x 43.7 cm (w) x 42.7 cm (d)
	Weight:	8.5 kg
	Operating Temperature:	0° to 50°C

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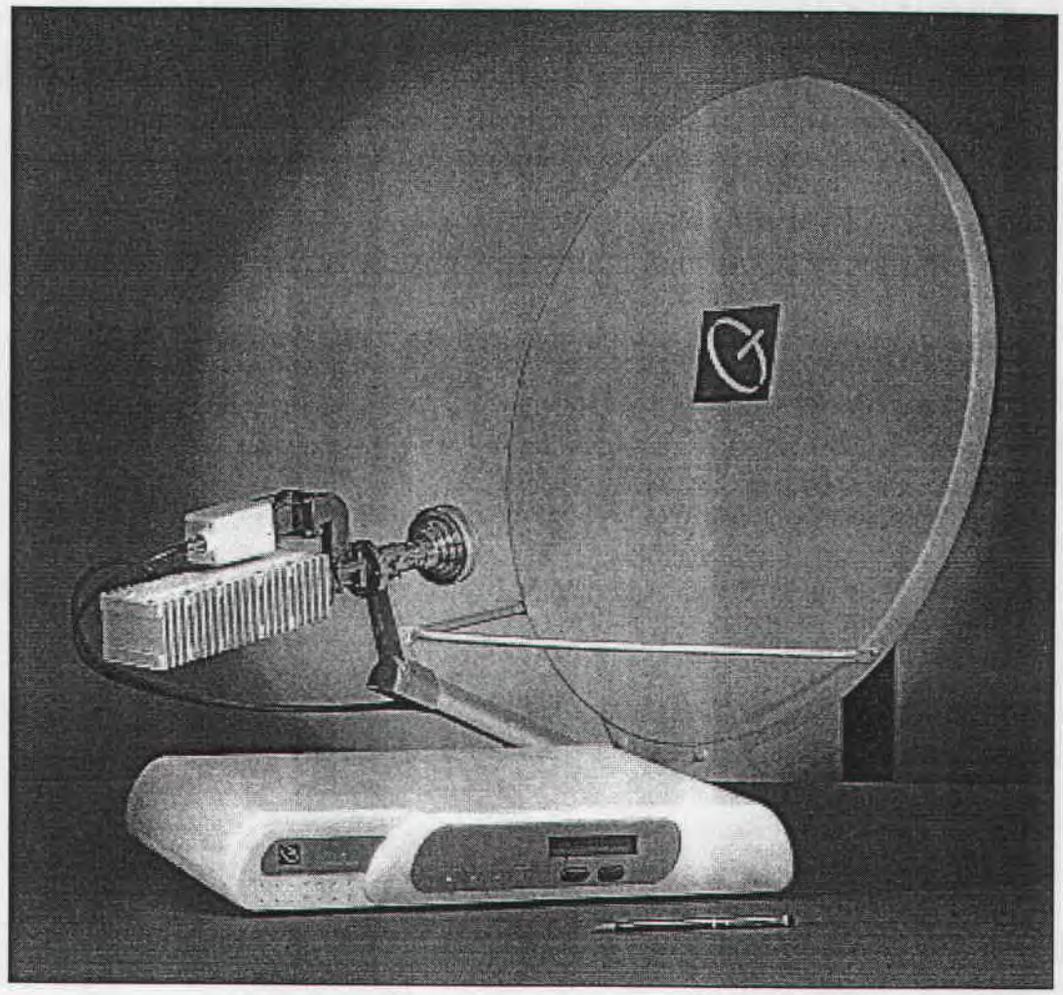
Annex B.3 Gilat VSAT Equipment

B.3.3 Gilat Skystar Advantage

Gilat

Skystar Advantage™

Satellite-based VSAT network for data communications



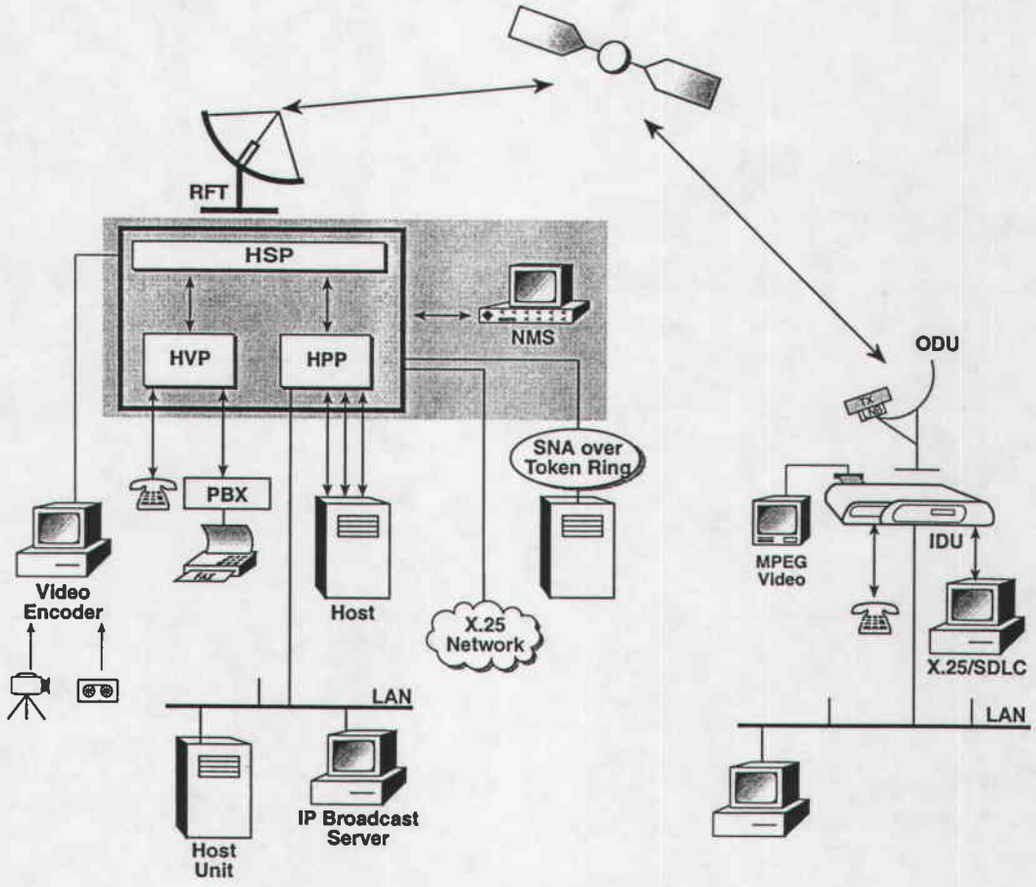
Skystar Advantage™ is a private VSAT network designed for data, multimedia and voice applications, providing highly reliable communication between a central hub and almost any number – tens or thousands – of geographically dispersed sites.

Skystar Advantage is a versatile and modular VSAT product that integrates the features of several different applications into a single platform. The same network can be used for interactive data, voice and paging, as well as for broadcasting multimedia over IP. Its modular 3-slot plug-in card architecture enables customization for each remote site.

A unique patented satellite access scheme, ASIC-based receiver, powerful integrated communications controller, small antenna and modular design result in outstanding network performance and make the system reliable, efficient and affordable.

Skystar Advantage offers:

- *Concurrent protocol support*
- *Multicast service*
- *Integrated voice/fax capabilities*
- *Efficient space segment utilization*
- *Superior reliability*
- *Rapid deployment*
- *Low power consumption*



Architecture

The Skystar Advantage network consists of a hub, satellite channel and remote VSATs. The hub consists of an RF terminal (RFT) and baseband equipment. The baseband includes a Hub Satellite Processor (HSP) to control the satellite transmission, a Hub Protocol Processor (HPP) to interface with the customer's data equipment, an optional Hub Voice Processor (HVP) for voice interfaces, and an optional video encoder.

An advanced, user-friendly Network Management System (NMS) provides centralized monitoring and control, statistics, alarms and events, network configuration and report generation.

A remote terminal consists of a small outdoor antenna (typically 0.55 to 1.2 meters), an Outdoor Unit (ODU) and an Indoor Unit (IDU).

In contrast to other VSAT networks, the hub architecture features internal hub switching for remote-to-remote circuit connectivity.

Applications

Skystar Advantage applications include:

- *PoS transactions*
- *Credit/debit/check authorization*
- *Inventory control*
- *Banking and ATM transactions*
- *Reservation systems*
- *Lottery transactions*
- *Paging*
- *Stock market and financial transactions*
- *Distance learning/training*
- *Multimedia (video and audio) multicast*
- *Reliable software distribution*
- *Internet/Intranet access*
- *SCADA*
- *Voice/Fax*
- *Remote video monitoring*

Skystar Advantage™

Gilat

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Technical Specifications

Network		
	Architecture	Interactive, star configuration
	Capacity	Up to 34,000 VSATs
	Protocols Supported	X.25, Async (X.3/X.28/X.29), SDLC, TCP/IP and more
	Rx Frequency Range	Ku-band, C-band, Extended C-band
Hub Station		
	User Ports	
	Interface:	RS-232, RS-422, V.35, Token Ring or Ethernet
	Port Designation:	DCE or DTE
	Information Bit Rate:	110 bps to 512 kbps (on serial ports)
	Data Format:	Synchronous or asynchronous
	Outbound Carrier	Statistical multiplexing
	Number of Carriers:	Configurable
	Bit Rate:	64 kbps to 6 Mbps, software configurable
	Error Correction:	Concatenated Viterbi and Reed Solomon
	BER Performance	Better than 10^{-12}
	Modulator	
	Modulation Scheme:	BPSK or QPSK
	IF Output:	70 ± 18 MHz or 140 ± 36 MHz, 1kHz increments
	Network Management Platform	SUN workstation with object oriented graphical user interface
Remote Terminal		
	Inbound Carrier	Proprietary combined TDMA and FDMA (FTDMA)
	Bit Rate:	9.6, 19.2, 38.4, 76.8 and 153.6 kbps, software configurable Optional dual bit rate
	Outdoor Unit	
	Antenna Size (Typical):	Ku-band: 0.55 to 1.20 m C-band: 1.80m
	SSPA Power	Ku-band: 0.5, 1 and, 2w C, Ext.C-band: 2 watt
	LNB Type:	Standard TVRO type
	Up-Converter:	Compact
	Operating Temperature:	-40° to +60°C
	Humidity:	Up to 100%
	Indoor Unit	
	Basic Unit Ports:	2 serial ports plus Ethernet
	Additional Expansion Cards	4 serial ports, Token Ring, voice, video and customized cards, field upgradeable
	Port Designation:	Software configurable DCE or DTE
	Port Information Bit Rate:	50 bps to 128 kbps
	Interface: (others available on demand)	Serial: RS-232, X.21 Token Ring: UTP RJ45, STP DB9 Ethernet: 10BaseT Voice: 2-wire FXS RJ11 Video: BNC for composite video, S-video (Mini DIN) Audio: 3.5mm mini jack
	Operating Voltage:	AC: Autorange 100-240V or DC: 24V, 48V, 12V (optional)
	Power Consumption:	Less than 25W, including ODU
	Dimensions:	6 cm (h) x 40 cm (w) x 34 cm (d)
	Weight:	3.9 kg
	Operating Temperature:	-10° to 60°C (weatherized version optional)
	Humidity:	Up to 95%, non-condensing

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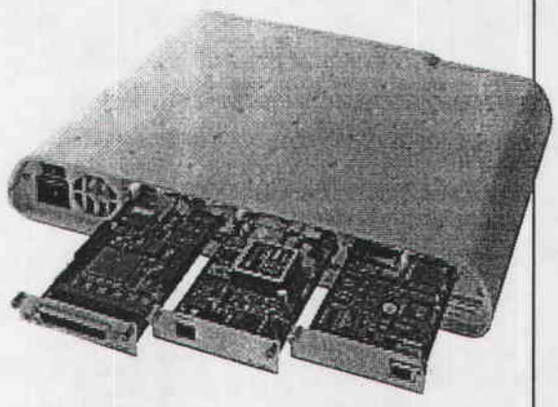
Flexible Modular VSAT

Skystar Advantage offers intrinsic modular flexibility. The IDU comes with three slots for plug-in cards. This design enables field upgradeability by the addition of optional plug-and-play like cards to support a variety of interfaces and applications. At each remote site the plug-in cards are simply inserted into slots in the VSAT back panel, without having to remove the cover. In a dynamic high-tech environment, application requirements change rapidly. The "plug-and-play" concept enables affordable and quickly implemented solutions by adding new plug-in cards as new applications are required.



Satellite Access

Skystar Advantage uses a proprietary two-dimensional access scheme. This enables the use of low-cost ODU hardware, saves on space segment and allows the VSAT network to handle momentary peak traffic loads without any significant degradation in response time. The network is immune to outages caused by frequency interference and offers intrinsic security capabilities. The unique FTDMA scheme provides no back-off in time for retransmissions and consistent utilization of the entire bandwidth by all remote sites. The access scheme provides superior network throughput stability and load balancing.

Features

- *Concurrent protocol support*

  Skystar Advantage can be configured to implement different protocols concurrently. It can simultaneously support SDLC, X.25, TCP/IP including IP routing, voice, MPEG1 and MPEG2 video and more.

- *Multicast service*

  IP multicast delivers information to a large number of recipients simultaneously. Implementing IP multicast via satellite as an added value overlay to interactive data networks provides a single-tier architecture for multicast applications. Multicast applications include the transmission of live video/audio streams of news and entertainment, multimedia corporate training, database replication, software update distribution and dissemination of financial data. Skystar Advantage's powerful outbound capability, up to 6 Mbps, enables simultaneous use of multiple applications.

Video/audio transmission via Skystar Advantage

- *Integrated voice/fax capabilities*

  Plug-in voice cards at the remote VSATs and dedicated interfaces at the hub facilitate transparent telephone line services to VSAT users.

- *Efficient space segment utilization*

  Superior utilization of space segment allows for high network throughput per bandwidth. MSK modulation results in efficient inbound channel spacing. Low satellite power utilization is achieved by outbound concatenated coding.

- *Superior reliability*

  - Market leader in MTBF
  - Dial backup support
  - Unique immunity to carrier interference and data interception
  - Software stored in FLASH memory for improved performance

- *Rapid deployment*

  Compact design enables quick installation of individual sites and rapid deployment of large networks.

- *Low power consumption*

  With less than 25w, Skystar Advantage offers substantial savings with regards to UPS, battery or solar panel cost. This minimal power consumption makes it ideal for SCADA and any other outdoor use.

Angola Cabinda Province VSAT Network
Annex C
Power Brochures

C.0 Power Brochures

Brochures are included for the following alternative energy sources:

VSAT Solar Power Panels.
Wind Turbines
Power Turbines

Additional technical information will be forthcoming during the Phase II Effort.

TOTAL

PHOTOWATT INTERNATIONAL S.A.

PHOTOVOLTAIC MODULES

PWX 500*

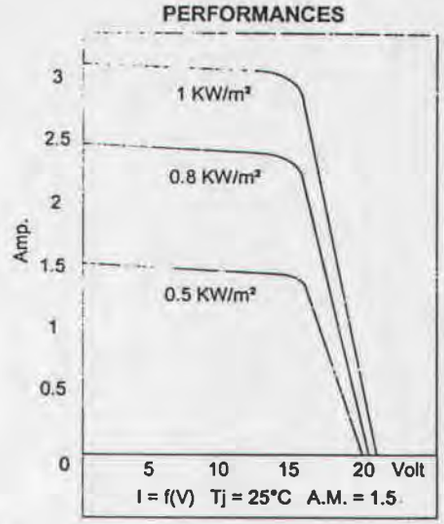
Photovoltaic module
49 Watts 12 Volts
Bi-glass series, Polycristallin
With or without frame

* Photowatt Int. ™

DESCRIPTION

Photovoltaic cell : high efficiency silicon. Performance stability.
Optimized contact grids and anti -reflective coating.
Front face : tempered glass, low iron content for high light transmission. Self cleaning under wet conditions.
Encapsulating material : high temperature, polymerized layers, low hygroscopy, UV stabilized (for stable light transmission).
Back face in tempered glass ensuring protection of cells connections : watertight and high mechanical resistance (shocks, scratchings).
Bi-glass encapsulation, resisting high thermal cycles (prevents decomposition of layers).
Frame-cell distance optimized to minimize shading on the active surface at the beginning and end of day.

PERFORMANCES



CHARACTERISTICS

Cell temperature (°C)	25	45	60
Maximum power (W)	49	44.8	41.5
Voltage at Pmax. (V)	17	15.44	14.27
Current at P max. (A)	2.88	2.9	2.91
Short circuit current (A)	3.15	3.17	3.18
Open circuit voltage (V)	21.6	20	18.86

Typical data at 1 KW/m², AM 1.5

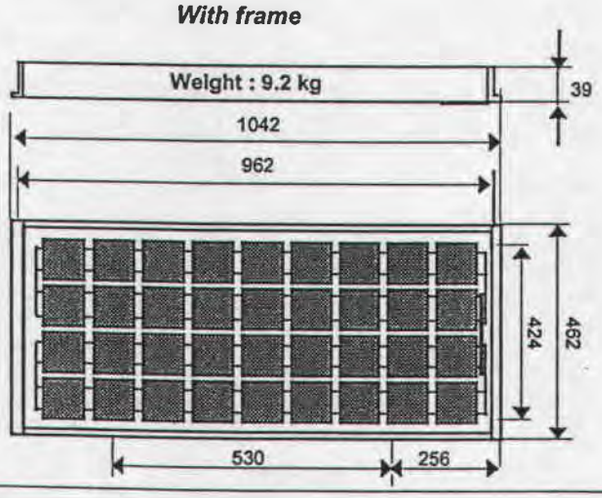
French norms NFC 57100, American specifications of the DOE by J. PL and recommandations by ISPRA.

CONDITIONS OF USE

Temperature : - 40 to + 85 °C.
Storage temperature : - 40 to + 85 °C.
Relative humidity : 0 to 100%.

DIMENSIONS

With frame



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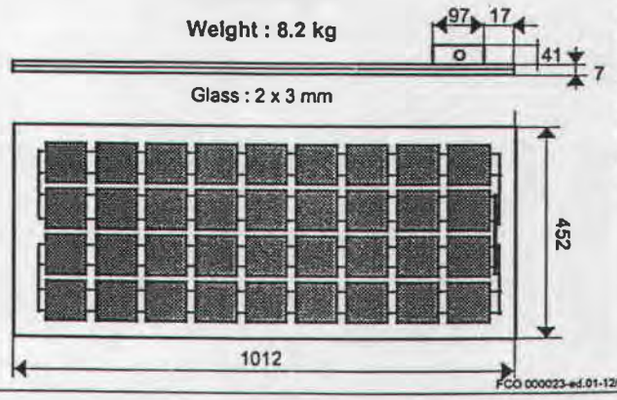

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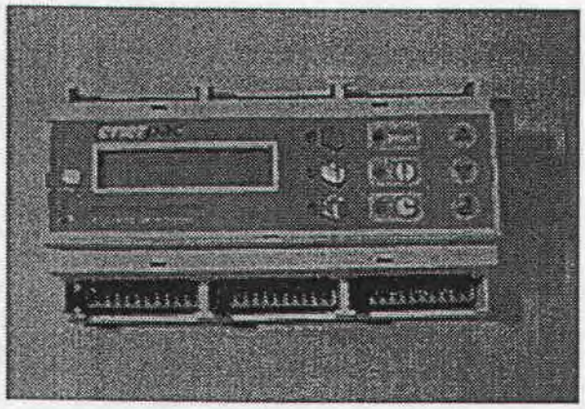
enerpac®



Regulator - data logger

The *enerpac*® regulator-data logger has been designed to manage photovoltaic systems. It allows precise of complex photovoltaic generators (hybrid systems with AC and DC power : aerogenerator, generating set, battery charger...). Moreover, the *enerpac*® performs diagnostics of the installation and detailed analysis conforming to the Quality charter of ADEME /EDF and the guidelines laid down by the E.E.C. (DGXVII). Finally, it has a photovoltaic regulation function, for the management of energy, in a compact and effective format.

❖ Main functions

Measures

Direct measures :

* Solar panel DC, use of the system, inverter, generating set charger and auxiliary charger
* Solar panel DC voltage, battery and use
* Sunniness
* Temperatures
* Wind speed
* Inverter output power (AC load)
* Generating set charger output power (AC load)

Calculated measures :

* Day irradiation
* Photovoltaic array power
* Energy consumed in DC load
* Inverter input power
* Auxiliary charger output power
* Generating set charger output power

Display of direct and calculated measures

Data logging

* Daily logging of all the measured and calculated data (total, minima, maximal) as well as the alarms.
* Data memory capacity of over 2 years
* Detailed logging of all the measured and calculated data at 10 minute intervals over the last 30 day period

Remote control

* Automatic alarm emission to PC
* Display of the nature of the failure by push button
* Signalling with red flashing LED and working a dry contact (RA relay)

Regulation

* Automatic control of the battery charge by cutting off the current from the photovoltaic panels (RC relay)
* Automatic limitation of the battery discharge level by cutting off the appliances (RD relay)
* Periodic boost charge of the battery
* Dual charge reset :
  - after a delay time
  - with a voltage threshold
* High and low level battery voltage (RH and RL relay)
* Setting of regulation threshold by means of the keyboard
* Visualisation of the level of the battery on the front

Driving

- Control of the start and stop of the generating set from a battery voltage threshold or from a clock (RG relay)
* Control of a timer relay from a clock (RT relay)

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❖ Technical specifications

Description

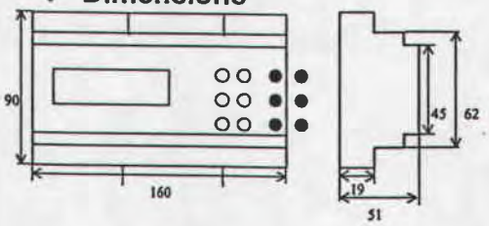
- Inputs via 11 analog channels :
- 3 DC voltage channels Va, Vs, Vl
- 5 DC channels Ia, Il, Iii, Ibu, Iau
- 1 calibrated cell Gi
- 2 0/5V channels for anemometer and suncash (Ve1 Ve2)
- 1 analog input 0/5V for external driving
- 2 temperature inputs T1 and T2
- 4 impulse inputs DI1and DI4
- 6 digital inputs DI5 and DI10
- 1 series interface RS485 to communicate with a deported visualisation
- 1 series interface RS232 to communicate with a external peripheral
- 1 series interface RS232 for modems or satellite
- 1 series interface RS232 on the front to connect a local PC
- 1 LCD displayed 2 lines * 16 letters
- 6 push buttons
- 6 status LED's
- 1 buzzer for the alarms and keyboard functions
- 1 real time clock to date events
- 7 outputs with dry contact (COM, NO, NC).
- 1 memory of 1 M for data
- 1 memory of 128 K for the software
- 1 processor of 16 bits at 16 MHz

Specifications

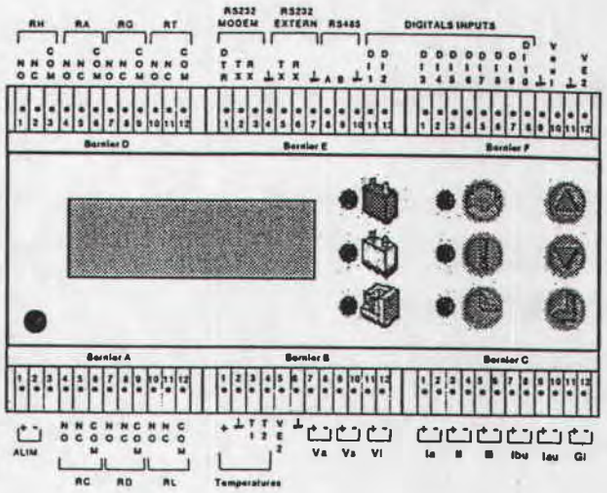
- Supply : 9 to 68V en standard (option : 70to 5000V)
- 4 serial port links : RS232, RS485
- LCD displayed 2 * 16 letters
- Operating temperature : -10 à + 70°C
- Humidity : > 95% RH.
- Conformity to EMC generic norms : EN50081-2 (emitting) and EN50082-2 (immunity)
- Lightning protection (supply ± 2kV ; E/S ± 1kV)
- Resolution : 10bits – precision ± 0,5%
- Negative or positive polarity to the mass
- Unstichable without intervention on the wiring
- Attachment : symmetrical DIN rail
- Consumption:

	12V	24V	48V
Unload (without I/O)	33 mA	17 mA	15 mA
Inload : active I/O	75 mA	54 mA	62 mA

❖ Dimensions

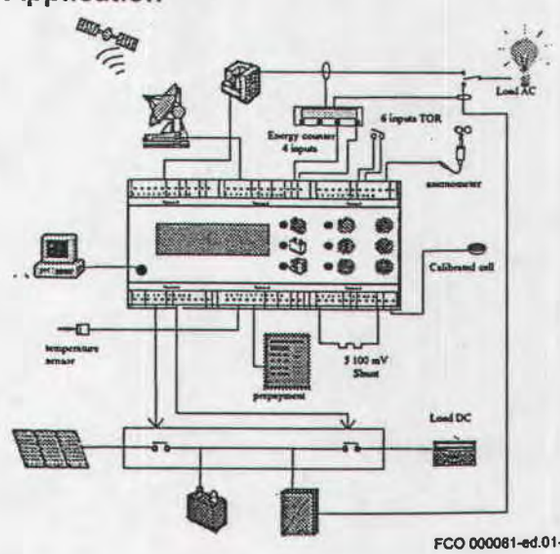


Presentation



ALIM : 9 to 68 V supply input
RC, RD: Control of the charge relay and limitation of the discharge relay
RH, RL: high and low battery threshold relay
RG : Generating set control relay
RA : Alarm relay
RT : Remote control relay
T1, T2 : Temperature 1 and 2 (battery et other).
Va, Vs, Vl : Voltage of solar panels , battery, and use.
Ia, Il, Iii, Ibu, Iau : Current of solar panels, use, inverter, charger and auxiliary (shunt 100 mV)
Gi : Calibrated cell
VE1 : 0/5 V analog input or suncash input
VE2 : 0/5 V analog input or anemometer input
Vout : 0/5 V analog output
DI1 to DI4 : Impulse inputs (energy meter), alarm or status digital inputs
DI5 to DI10 : Alarm and status digital inputs

❖ Application



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Operation and Maintenance Costs for Wind Turbines

Modern wind turbines are designed to work for some 120 000 hours of operation throughout their design lifetime of 20 years. That is far more than an automobile engine which will generally last for some 4 000 to 6 000 hours.

Operation and Maintenance Costs

Experience shows that maintenance cost are generally very low while the turbines are brand new, but they increase somewhat as the turbine ages.

Studies done on the 5000 Danish wind turbines installed in Denmark since 1975 show that newer generations of turbines have relatively lower repair and maintenance costs that the older generations. (The studies compare turbines which are the same **age**, but which belong to different **generations**).

Older Danish wind turbines (25-150 kW) have annual maintenance costs with an average of around 3 per cent of the original turbine investment. Newer turbines are on average substantially larger, which would tend to lower maintenance costs per kW installed power (you do not need to service a large, modern machine more often than a small one). For newer machines the estimates range around 1.5 to 2 per cent per year of the original turbine investment.

Most of maintenance cost is a fixed amount per year for the regular service of the turbines, but some people prefer to use a fixed amount per kWh of output in their calculations, usually around 0.01 USD/kWh. The reasoning behind this method is that tear and wear on the turbine generally increases with increasing production.

Economies of Scale

Other than the economies of scale which vary with the size of the turbine, mentioned above, there may be economies of scale in the operation of wind parks rather than individual turbines. These economies are related to the semi-annual maintenance visits, surveillance and administration, etc.

Turbine Reinvestment (Refurbishment, Major Overhauls)

Wind - battery systems: Small wind-battery systems are simple to install and provide an effective source of power for applications such as boats, caravans and outbuildings. These use low voltage DC lights and appliances. Larger systems can provide power for example to a house and typically include an inverter to provide AC "mains" from the battery.

The wind turbine and battery should be chosen carefully. The size and type of machine will depend very much upon location and load demands, but must also be matched to the battery it is charging. The battery must be large enough to provide sufficient storage but not oversized such that the generator cannot cycle it sufficiently.

Other system components are similarly critical. To prevent damage from overcharging, the turbine should be connected to the battery via a regulator. An ammeter is a valuable tool that will show at a glance how well the turbine is performing. A voltmeter connected across the battery will provide information as to the battery's state of charge. All circuits should be fused and adequate cabling should be used throughout to minimise wiring losses.

Other systems: Wind power, from larger machines, can be used for heating. Any power generated is fed directly to immersion or storage heaters. While simple, such schemes are often effective as the wind usually blows when the heat is needed most.

Wind generators can also be simply integrated into hydro or photovoltaic systems. Wind power ideally complements solar power, the two sources providing a seasonal continuity of supply. Hybrid schemes using a diesel generator or grid-connected schemes are other common uses

main menu

Careful system design will give a safe and reliable electricity supply. *SUNDOG* specialises in the design, supply and installation of renewable energy systems and can provide a system tailored to your individual needs.

Some wind turbine components are more subject to tear and wear than others. This is particularly true for rotor blades and gearboxes.

Wind turbine owners who see that their turbine is close the end of their technical design lifetime may find it advantageous to increase the lifetime of the turbine by doing a major overhaul of the turbine, e.g. by replacing the rotor blades.

The price of a new set of rotor blades, a gearbox, or a generator is usually in the order of magnitude of 15-20 per cent of the price of the turbine.

Project Lifetime, Design Lifetime

The components of Danish wind turbines are designed to last 20 years. It would, of course, be possible to design certain components to last much longer, but it would really be a waste, if other major components were to fail earlier.

The 20 year design lifetime is a useful economic compromise which is used to guide engineers who develop components for the turbines. Their calculations have to prove that their components have a very small probability of failure before 20 years have elapsed.

The actual lifetime of a wind turbine depends both on the quality of the turbine and the local climatic conditions, e.g. the amount of turbulence at the site, as explained in the page on turbine design and fatigue loads.

Offshore turbines may e.g. last longer, due to low turbulence at sea. This may in turn lower costs, as shown in the graph on the page on the Economics of Offshore Wind Turbines.

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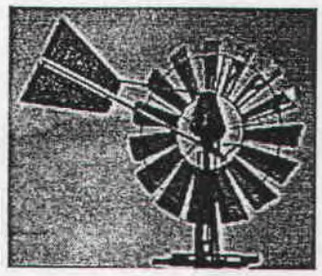
Wind Turbine Design: Basic Load Considerations



Water pumping windmill, South Australia, Photograph © 1997 Soren Krohn

Whether you are building wind turbines or helicopters, you have to take the strength, the dynamic behaviour, and the fatigue properties of your materials and the entire assembly into consideration.

Extreme Loads (Forces)

Comodoro Rivadavia, Argentina (NEG Micon 750 kW turbines) Photograph © 1998 Soren Krohn

Wind turbines are built to catch the wind's kinetic (motion) energy. You may therefore wonder why modern wind turbines are not built with a lot of rotor blades, like the old "American" windmills you have seen in the Western movies.

Turbines with **many** blades or very **wide** blades, i.e. turbines with a very **solid** rotor, however, will be subject to very large forces, when the wind blows at a hurricane speed. (Remember, that the energy content of the wind varies with the **third** power (the cube) of the wind speed).

Wind turbine manufacturers have to certify that their turbines are built, so that they can withstand **extreme winds** which occur, say, during 10 minutes once every 50 years.

To limit the influence of the extreme winds turbine manufacturers therefore generally prefer to build turbines with a few, long, narrow blades.

In order to make up for the narrowness of the blades facing the wind, turbine manufacturers prefer to let the turbines rotate relatively quickly.

Fatigue Loads (Forces)

Wind turbines are subject to fluctuating winds, and hence fluctuating forces. This is particularly the case if they are located in a very turbulent wind climate.

Components which are subject to repeated bending, such as rotor blades, may eventually develop cracks which ultimately may make the component break. A historical example is the huge German Growian machine (100 m rotor diameter) which had to be taken out of service after less than three weeks of operation. Metal **fatigue** is a well known problem in many industries. Metal is therefore generally not favoured as a material for rotor blades.

When designing a wind turbine it is extremely important to calculate in advance how the different components will vibrate, both individually, and jointly. It is also important to calculate the forces involved in each bending or stretching of a component.

This is the subject of **structural dynamics**, where physicists have developed mathematical computer models that analyse the behaviour of an entire wind turbine.

These models are used by wind turbine manufacturers to design their machines safely.

Structural Dynamics: An Example *)

A 50 metre tall wind turbine tower will have a tendency to swing back and forth, say, every three seconds. The frequency with which the tower oscillates back and forth is also known as the **eigenfrequency** of the tower. The eigenfrequency depends on both the height of the tower, the thickness of its walls, the type of steel, and the weight of the nacelle and rotor.

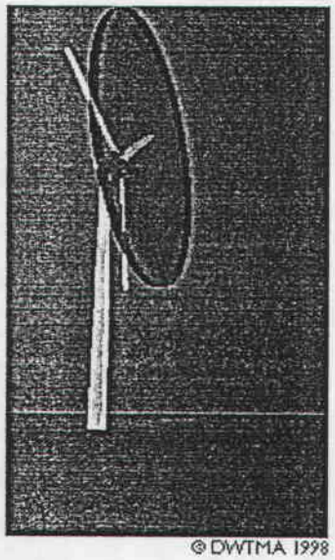
Now, each time a rotor blade passes the wind shade of the tower, the rotor will push slightly less against the tower.

If the rotor turns with a rotational speed such that a rotor blade passes the tower each time the tower is in one of its extreme positions, then the rotor blade may either **dampen** or **amplify** (reinforce) the oscillations of the tower.

The rotor blades themselves are also flexible, and may have a tendency to vibrate, say, once per second. As you can see, it is very important to know the eigenfreqencies of each component in order to design a safe turbine that does not oscillate out of control.

*) A very dramatic example of structural dynamic forces at work under influence of the wind (undampened torsion oscillations) is the famous crash of the Tacoma Bridge. You may find a short movie clip (700 K) on the disaster on the Internet.

The Energy in the Wind: Air Density and Rotor Area



© DWTMA 1998

A wind turbine obtains its power input by converting the force of the wind into a **torque** (turning force) acting on the rotor blades. The amount of energy which the wind transfers to the rotor depends on the density of the air, the rotor area, and the wind speed.

The cartoon shows how a cylindrical slice of air 1 metre thick moves through the 1,500 m^2 rotor of a typical 600 kilowatt wind turbine.

With a 43 metre rotor diameter each cylinder actually weighs 1.9 tonnes, i.e. 1,500 times 1.25 kilogrammes.

Density of Air

The kinetic energy of a moving body is proportional to its mass (or weight). The kinetic energy in the wind thus depends on the density of the air, i.e. its mass per unit of volume.

In other words, the "heavier" the air, the more energy is received by the turbine.

At normal atmospheric pressure and at 15° Celsius air weighs some 1.225 kilogrammes per cubic metre, but the density decreases slightly with increasing humidity.

Also, the air is denser when it is cold than when it is warm. At high altitudes, (in mountains) the air pressure is lower, and the air is less dense.

Rotor Area

A typical 600 kW wind turbine has a rotor diameter of 43-44 metres, i.e. a rotor area of some 1,500 square metres. The rotor area determines how much energy a wind turbine is able to harvest from the wind.

Since the rotor area increases with the **square** of the rotor diameter, a turbine which is twice as large will receive $2^2 = 2 \times 2 =$ **four** times as much energy. The page

on the size of wind turbines gives you more details.

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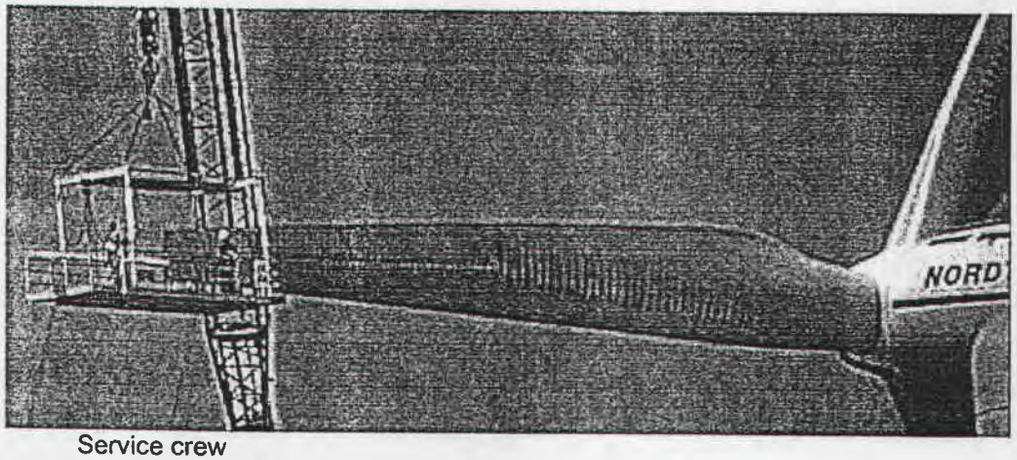
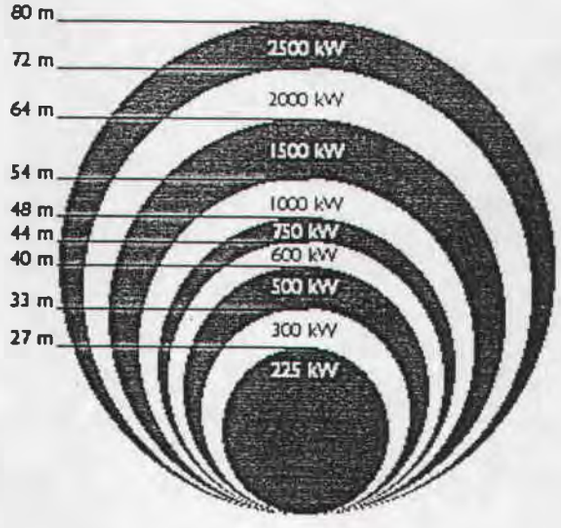
Size of Wind Turbines



Service crew working on a 32 m rotor blade on a 1.5 MW wind turbine

Photograph © 2000 Christian Kjaer

Power Output Increases with the Swept Rotor Area



When a farmer tells you how much land he is farming, he will usually state an area in terms of hectares or acres. With a wind turbine it is much the same story, though doing wind farming we farm a **vertical** area instead of a **horizontal** one.

The area of the disc covered by the rotor, (and wind speeds, of course), determines how much energy we can harvest in a year.

The picture gives you an idea of the normal rotor sizes of wind turbines: A typical turbine with a 600 kW electrical generator will typically have a rotor diameter of some 44 metres (144 ft.). If you double the rotor diameter, you get an **area** which is **four** times larger (two squared). This means that you also get **four** times as much power output from the rotor.

Rotor diameters may vary somewhat from the figures given above, because many manufacturers optimise their machines to local wind conditions: A larger generator, of course, requires more power (i.e. strong winds) to turn at all. So if you install a wind turbine in a low wind area you will actually maximise annual output by using a fairly **small generator** for a given rotor size (or a **larger rotor size** for a given generator) For a 600 kW machine rotor diameters may vary from 39 to 48 m (128 to 157 ft.) The reason why you may get more output from a relatively smaller generator in a low wind area is that the turbine will be running more hours during the year.

Reasons for Choosing Large Turbines

1. There are **economies of scale** in wind turbines, i.e. larger machines are usually able to deliver electricity at a lower cost than smaller machines. The reason is that the cost of foundations, road building, electrical grid connection, plus a number of components in the turbine (the electronic control system etc.), are somewhat independent of the size of the machine.
2. **Larger machines are particularly well suited for offshore wind power**. The cost of foundations does not rise in proportion to the size of the machine, and maintenance costs are largely independent of the size of the machine.
3. In areas where it is difficult to find sites for more than a single turbine, **a large turbine with a tall tower uses the existing wind resource more efficiently**.

You may take a look at some megawatt-sized wind turbines in the picture gallery.

Reasons for Choosing Smaller Turbines

1. The **local electrical grid may be too weak** to handle the electricity output from a large machine. This may be the case in remote parts of the electrical grid with low population density and little electricity consumption in the area.
2. There is **less fluctuation in the electricity output from a wind park** consisting of a number of smaller machines, since wind fluctuations occur randomly, and therefore tend to cancel out. Again, smaller machines may be an advantage in a weak electrical grid.
3. The **cost of using large cranes**, and building a

road strong enough to carry the turbine components may make smaller machines more economic in some areas.

4. Several smaller machines **spread the risk** in case of temporary machine failure, e.g. due to lightning strikes.
5. **aesthetical landscape considerations** may sometimes dictate the use of smaller machines. Large machines, however, will usually have a much lower rotational speed, which means that one large machine really does not attract as much attention as many small, fast moving rotors. (See the section on wind turbines in the landscape).

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http://www.windpower.dk/tour/wtrb/size.htm

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Megawatt-Sized Wind Turbines

To get the best quality, set your monitor to thousands of colours or better when viewing these pictures.

Nordtank 1500

The prototype of the NEG Micon 1500 kW Turbine (35K JPEG) was commissioned in September 1995.

The original model had a 60 metre rotor diameter and two 750 kW generators operating in parallel.

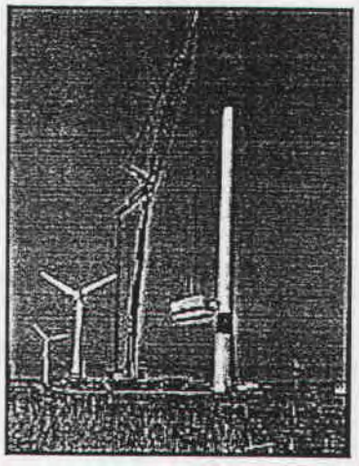
The most recent version is a 1,500/750 kW model (with two 750 kW generators) with a 64 metre rotor diameter.

The photograph was taken at the Tjaereborg site in the Western part of Denmark near the city of Esbjerg.

(Photograph © 1995 NEG Micon A/S 1996)

The Tjaereborg test site for megawatt turbines is located in Western Denmark near the city of Esbjerg

Vestas 1.5 MW



The prototype of the Vestas 1500 kW Turbine (51K JPEG) was commissioned in 1996.

The original model had a 63 metre rotor diameter and a 1,500 kW generator.

The most recent version has a 68 metre rotor diameter and a dual 1650/300 kW generator.

The picture shows the nacelle being hoisted by a crane.

In the background to the left you may see the ELSAM 2 MW test turbine (on a concrete tower), and the NEG Micon 1500 kW a bit farther in the background. At the far left you can catch a glimpse of a Bonus 750 kW turbine (the most recent version is a 1 MW turbine).

(Photograph © 1996 Vestas Wind Systems A/S 1996)

The Future for Megawatt-Sized Turbines

600 and 750 kW machines continue to be the "working horses" of the industry at present, but the megawatt-market took off in 1998.

Megawatt-sized machines will be ideal for offshore applications, and for areas where space for siting is scarce, so that a megawatt machine will exploit the local wind resources better.

Pictures

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Updated 26 September 2000

http://www.windpower.dk/pictures/mega.htm

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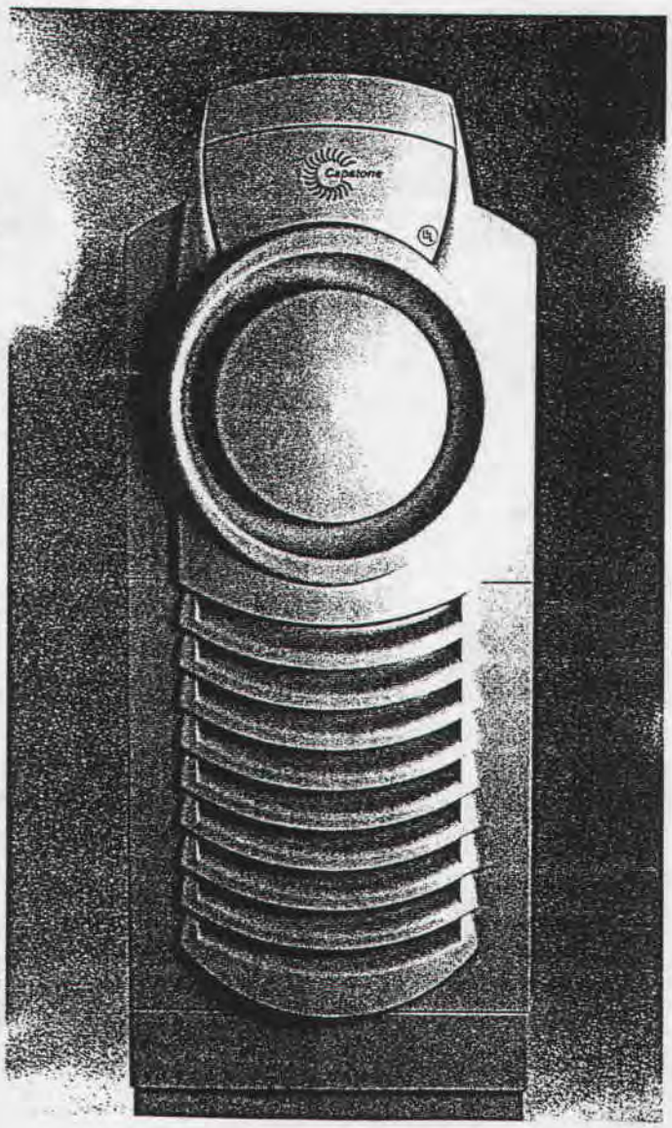
CAPSTONE MICROTURBINE™

PRODUCT INTRODUCTION. Capstone Turbine Corporation's commercial launch of the Model 330 MicroTurbine generator in December 1998 introduced a powerful new technology. The core of the microturbine is the high-speed compressor-turbine section, which rotates at 96,000 rpm. On the same shaft is a high-speed generator that uses permanent magnets. Air bearings and air cooling contribute to a long life that is virtually maintenance-free. The high-speed generator delivers high frequency power of 1600 Hz. Solid state digital power electronics convert the power to 400-480 VAC @ 50/60 Hz.

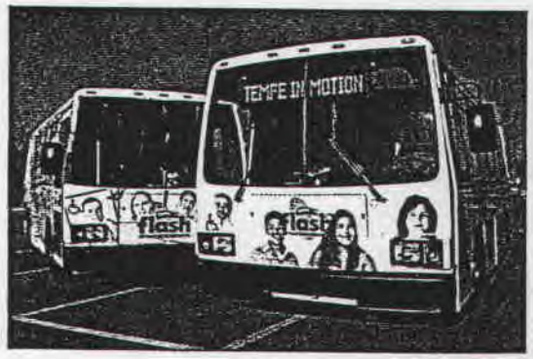


EMISSIONS. Capstone MicroTurbines offer very low emissions -- among the lowest produced from fossil fuel combustion systems. Microturbines are also smaller, lighter, and operate with no vibration and less noise than reciprocating engines.

	NOx(ppm)
Reciprocating Engines (500 kW)	2,100
Gas Turbines (4.5 MW)	25
Coal Fired Steam (500 MW)	200
Capstone MicroTurbine™ (natural gas)	**<9**

Source: Cambridge Energy Research Associates

APPLICATIONS. One application of great interest is the **hybrid electric vehicle (HEV)**. Using a Capstone MicroTurbine as an on-board battery charger, the prototype CARTA 714 HEV bus in Chattanooga has logged 30,000 miles since 1997 with no breakdowns. The only maintenance: an air filter change. The bus generates less than 1/25th of the emissions of a diesel bus. Production hybrids are now entering service in Tempe, Los Angeles, Atlanta and other urban centers.



In small-scale **cogeneration** applications, the microturbine's exhaust heat can be used for water and air heating, absorption cooling, dehumidification, food processing, even award-winning greenhouse applications. Efficiencies reach 80% using these systems.

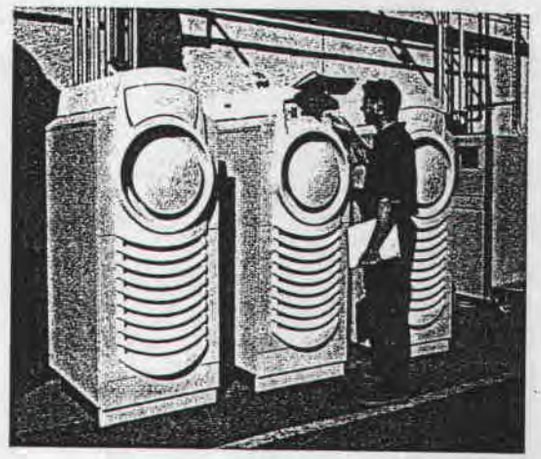
Power when and where you need it. Clean and simple.

The benefits of the MicroTurbine are also being proven in the **resource recovery** market. In oil and gas fields, a special version of the Model 330 can handle up to 7% H_2S "sour" gas. Coal bed methane and low-Btu landfill gas and digester gas applications are also in operation.

The global technological economy, including the internet, has created a huge growth market for **power reliability and quality**. Microturbines combined with power storage provide new capabilities for secure, onsite delivery of reliable, high quality electric power.

The Capstone MicroTurbine shows great promise as a low-cost alternative to expensive transmission and distribution (T&D) upgrades. Why tear up streets to install additional capacity as business expands? **T&D deferral** is now practical on cost, emissions and maintenance levels.

A deregulated electricity market will bring more price volatility as well as more price differentiation for time of use. Capstone MicroTurbines mitigate such risks through **peak-shaving** applications. The economics get even better when combining peak-shaving and **standby** functions.



VISION. Distributed generation is a paradigm shift -- from an infrastructure of only large centralized plants to a more flexible way of delivering power. The new electric network works with the grid to connect customers to plants of all sizes and to small onsite generators. Distributed generation offers control, cost-effectiveness and responsiveness.

Dr. Åke Almgren President & CEO

Capstone

CAPSTONE TURBINE CORPORATION

21211 Nordhoff Street • Chatsworth, CA 91311
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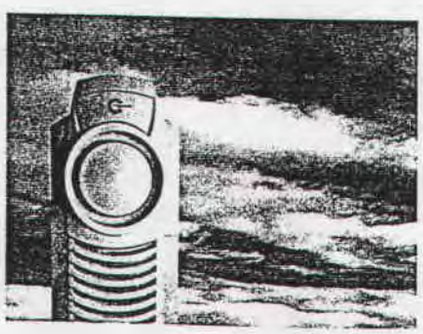

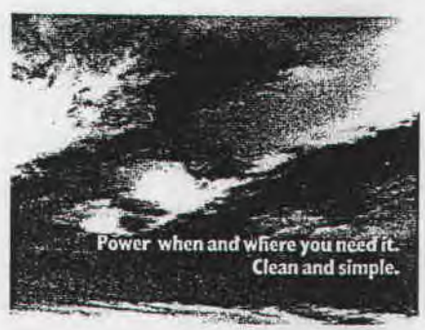

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Angola Cabinda Province VSAT Network
Annex D
List of Acronyms

List of Acronyms

BER	Bit Error Rate. The ratio of error bits to the total number of bits transmitted.
Class V	A type of circuit switch used in a local telephone end office. It provides end-customer services, such as call waiting and call forwarding.
CCITT	In English means the Consultative Committee on International Telegraphy and telephony. The CCITT is now known as the ITU-T (International Telecommunications Union-Telecommunications Services Sector), based in Geneva, Switzerland.
CCIR	Comite Consultatif International des Radiocommunications. The agency responsible for the international use of the radio spectrum. It is now known as the International Telecommunications Union-Radio (ITU-R).
CDMA	Code Division Multiple Access, also known as Spread Spectrum, is a name for a form of digital, spread spectrum cellular phone service that assigns a code to all speech bits, sends a scrambled transmission of the encoded speech over the air and reassembles the speech to its original format.
DAMA	Demand Assigned Multiple Access. A way of sharing a channel's capacity by assigning capacity on demand to an idle channel or an unused time slot.
E-1	The European equivalent of the North American 1.544Mbps T-1, except that E-1 carries information at the rate of 2.048Mbps. It is designed to carry 32 digital channels at 64Kbps.
FEC	Forward Error Correction. A technique used by a receiver for correcting errors incurred in transmission over a communications channel without requiring retransmission of any information by the transmitter.
FDMA	Frequency Division Multiple Access. One of several technologies used to separate multiple transmissions over a finite frequency allocation.
GSM	Global System for Mobile Communications. It is the standard digital cellular phone service you will find in Europe, Japan, Australia, and elsewhere—a total of 85 countries around the world.
HF	High Frequency. Portion of the electromagnetic spectrum, typically used in short-wave radio applications; frequencies approximately in the DMHz to 30MHz range.

HPA	High Power Amplifier.
ICO	The ICO system consists of a space segment and a dedicated ground network. The company's goal is to use its system to provide global IP services, including Internet connectivity, data, voice and fax. The system operates in both circuit-switched mode, based on the GSM standard, and in packet-switched and Internet protocol mode.
IF	Intermediate Frequency. A microwave frequency that has been reduced from its native frequency, so that it can be processed. This is necessary because a microwave cannot be fully processed in its native frequency.
IFL	Interfacility Link. This refers to the cables that connect the outdoor unit (ODU) to the indoor unit.
IMP	Intermodulation Products. The production, in a nonlinear element of a system, of frequencies corresponding to the sum and difference frequencies of the fundamentals and integral multiples (harmonics) of the component frequencies that are transmitted through the element.
INTELSAT	International Telecommunications Satellite organization. A worldwide consortium of national satellite communications organizations. INTELSAT owns and operates the world's most extensive global communications satellite system.
Iridium	The name for Motorola's incredibly ambitious satellite project "to bring personal communications to every square inch of the earth". According to Motorola, "for the first time, anyone, anywhere, at any time can communicate via voice, fax, or data".
LEO	Low Earth Orbit satellites. A group of these satellites is known as a "constellation". To establish a connection, you gain access to one of these satellites much as you gain access to a cell site in close proximity in the case of cellular telephony. Satellites that are not stationary from a fixed point on earth and have the lowest orbit of all communication satellites. Must either be tracked or use a frequency band and access methodology that allows access to the satellite with a non-directional antenna. Most handset-to-satellite systems are based on LEO satellites using L-Band.
LNB	Low Noise Block Downconverter. A combination Low Noise Amplifier and downconverter built into one device attached to the feed.
LOS	Line of sight.

MMDS	Microwave Multi-point Distribution System. It is a way of distributing cable television signals, through microwave, from a single transmission point to multiple receiving points.
OC-12	Optical Carrier-level 12. SONET channel of 622.08Mbps.
OC-48	Optical Carrier-level 48. SONET channel of 2.488Gbps.
ODU	Out Door Unit.
PBX	Private Branch Exchange. A private branch exchange. A PBX is a small version of the phone company's larger central switching office.
QPSK	Quadrature Phase Shift Keying. A compression technique used in modems and in wireless networks, such as CDMA.
RF	Radio Frequency. Electromagnetic waves operating between 10KHz and 3MHz propagated without guide (wire or cable) in free space.
SCPC	Single Channel Per Carrier. A technique used in analog satellite and certain other radio systems. SCPC supports one transmission per frequency channel.
Soft Switch	A type of switch developed in the late 1990s as a replacement for the CO (Central Office) circuit switches used in the traditional PSTN (Public Switched Telephone Network).
SONET	Synchronous Optical Network. A family of fiber optic transmission rates from 51.84 million bits per second to 39.812 gigabits per second, created to provide the flexibility needed to transport many digital signals with different capacities, and to provide a design standard for manufacturers.
SSPA	Solid State Power Amplifier. A VSLI solid state device that is gradually replacing Traveling Wave Tubes in satellite communications systems because they are lighter weight and are more reliable.
TDM	Time Division Multiplex. A technique for transmitting a number of separate voice and/or video signals simultaneously over one communications medium by interleaving a piece of each signal one after another.
TDMA	Time Division Multiple Access. TDMA is used to allocate a discrete amount of frequency bandwidth to each user, in order to permit many simultaneous conversations. See TDM.
TDM/TDMA	See TDM and TDMA.

3G Specifications	Third Generation Mobile System. An ITU-T discussion over a proposed worldwide cellular phone GSM standard.
TWTA	Traveling Wave Tube Amplifier.
UHF	Ultra High Frequency. Portion of the electromagnetic spectrum ranging from about 300MHz to about 3GHz.
VF	Voice Frequency.
VHF	Very High Frequency. Portion of the electromagnetic spectrum with frequencies between about 30MHz and 300MHz.
VoIP	Voice over IP. The technology used to transmit voice conversations over a data network using the Internet Protocol.
VOX	Voice Operated Carriers. A voice-operated relay circuit that permits the equivalent of push-to-talk operation of a transmitter by the operator.
VSAT	Very Small Aperture Terminal. A relatively small satellite antenna, typically 1.5 to 3.0 meters in diameter, used for satellite-based point-to-multipoint data communications applications.

Angola Cabinda Province VSAT Network

Annex E
Site Survey

1.0 Introduction

The following survey report will function as the foundation for Phase I of the feasibility study. Of primary importance, will be what exits versus what is planned to meet the telecommunications needs in Cabinda.

Trip to Cabinda: Saturday 21 October John Lonergan traveled to the town of Cabinda via SONEGAL Air Charter. Carroll Henry and members of his staff met us at Cabinda Airport. He briefed us on security and the does and don'ts while in Cabinda. He also introduced us to Eng. Joao Atonso, the AT engineer in charge of this study. Joao was most informative and became my comrade for the next five days.

2.0 Site Visits

Cacongo: A visit was undertaken to the transmission facility at the Cacongo Site on Sunday 22 October. This site is ideal for cellular transmission having a 100 m guyed tower on the top of an 800-m hill. From the hill top site cellular transmission can be extended to the Brazzaville border in the town of Chicamba in the north and possibly as Far East as the town of Dinge on the road to Buco Zau.

Cable will be extended down the hill via buried plant to the existing telephone building in the town of Cacongo. A new earth station is planned for the hill top site.

Unfortunately trips to the Municipalities of Belieze, Buco-Zau and Landana were prohibited without Military or Police Escort.

Malembo Town: On Monday, 23 October, we visited the proposed new earth station site in the town of Malembo. A satellite ground station is now proposed adjacent to the Women's College in Malembo. This school trains young ladies in developing Handy Crafts for both the existing and the future Tourist Trade.

A concrete foundation was being installed to for the emplacement of a 3.8-M antenna. This system employing the Hughes Telephony system will provide voice and e-mail service to both the college and the town of Malembo.

Latter that afternoon a visit was made to two of the banks in Cabinda. Each have a Hughes Personnel Terminal operational for data service. The branch mangers were both hoping for something better for the long haul communications with Luanda.

Chevron Facility: On Tuesday, 23 October, we visited the Chevron Communications Complex at Malembo. Of primary importance was using the Chevron transmitting tower to broadcast the cellular signals back to Cabinda, east to the Brazzaville Border and north to the town of Malembo.

The Chevron communications personnel felt that their would be no problem in putting additional AT Base station channels that will be collocated in their communications complex. They did however raise the issue of having AT's handheld cellular units on their rigs. The Chevron Safety Department has to approve the handsets before they can be used on the off shore rigs and in the refineries.

A presentation was also made to the Facilities Staff of Chevron headed by Mr. Carroll Henry. Mr. Henry is the coordinator for this project and he and his staff have done an excellent job in supporting us during this survey.

Angola Telecom Facilities: On Wednesday, 25 October, a tour was undertaken with Eng. Jao Atonso and Mr. Lonergan at the new exchange building in Cabinda. I was shown the new cellular equipment manufactured by Motorola and the existing Hughes Satellite Equipment that will function as the Gateway

Station for Cabinda Province. Concerning the former, cellular service was first offered to the Cabinda Community on Monday, 23 October.

I also reviewed the existing LOS links by Harris Farinan, the new Alcatel, S-12, Class V Central Office and the control, monitoring and the billing system for the same. I was impressed with the cleanliness and the efficiency associated with the MDF management. All cabling and cross connects were undertaken professionally.

Later in the day I was driven south to the border town of Lema with the Congo. This town will initially be served via the Cabinda Cell site. Plans in the future call for a transmitting tower than can broadcast across the Congo River to the town of Soya the northernmost town in the Angolan Province of Zaire on the Congo River.

I was also impressed with the power system, i.e. the –48vdc battery plant and comparable rectifier and charger system for the other electronic equipment. It should be noted that the Cabinda Exchange was one of the best managed and equipped that I have visited in all of Africa.

Meeting –The Mitchell Group: Discussions were held with key personnel of the Mitchell Group on Thursday, 26 October. This company is undertaking a major power study in the province. They have a team of engineers in Cabinda with their primary objective being to determine how to provide Power throughout the Province. Like ETS, the Mitchell study is TDA funded with support from the Chevron staff at Malembo. It is imperative that a meeting on their findings is held in DC sometime early December. Their recommendations and timing to implement can assist in solving the telecommunications power problem at specific locations.

3.0 Conclusions

Unfortunately, a complete and accurate inventory is not possible due to civil unrest in the area. The above information and requirements noted by the customer were deemed sufficient to complete an accurate design effort.

CABINDA TELECOMMUNICATIONS FEASIBILITY STUDY PHASE II REPORT

15 JANUARY 2002

ETS

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1.0 Introduction

Phase II addresses the communications needs for the Province of Cabinda. Considerations were given to the optimum satellite system, a state-of-the-art rural radio network and the all important power subsystems.

The type of transmission equipment selected by ETS is presented in Section 2.0. The reasons and the utility to Angola Telecom based on this decision are also included in this section.

This report is supplemented with the equipment designed and purchased for Angola Telecom by the Governor of Cabinda. Discussions on the design and the type of equipment that was provided by the Governor is contained within Section 3.0 of this report.

The design presented in the Phase I Report was accepted by Angola Telecom with no changes requested. As a result, no new design information is presented here and no further discussion of the soft-switch design will be included at this time.

Section 4.0 contains a series of recommendations. These suggestions are derivatives of the TDA Study Contract by ETS's technical staff.

Please note that this final report is a supplement to the Phase I report which was submitted by ETS this past spring. A summary is presented at the conclusion of this report to address contractual specifications.

It is suggested that Angola Telecom consider these recommendations and plan to implement similar telecommunication networks within the other provinces of Angola.

2.0 Selection of the Transmission Medium

Careful consideration was given to the type of communications network to be provided for Cabinda Province. Emphasis was placed primarily on the transmission medium. It was decided after careful study and inspection of the existing topology in Angola that satellite communications would be the ideal short-term solution for communications throughout the province and more specifically to the towns and the municipalities in Cabinda.

It should also be noted that Angola Telecom was procuring a ten-station satellite network that would enable subscribers to call the Gateway Station in Cabinda City and the nation's capital in Luanda. This procurement was undertaken prior to the award of the TDA Study Contract with ETS.

The Gilat Equipment and the ground station equipment manufactured by STM were considered in the basic network design. The former equipment was too expensive based on both a channelization factor and a remote station basis. The latter equipment manufactured by STM, was less expensive than Hughes and had the majority of the technical features in the TES family of equipment. Unfortunately, the STM Equipment would have called for a new hub station in both Luanda and Cabinda City. This additional expense would have negated any of the cost savings realized on subsequent remote station procurements.

Of equal importance was the experience factor attained by the Angola Telecom Operations Personnel. Angola Telecom Engineers and installers were experienced with the Hughes Equipment at the Luanda Station and the Cabinda Gateway Stations. These Telecom Personnel understood

the operations of the TES Equipment and were developing a degree of competence in maintaining this equipment throughout Angola.

Other factors that were an integral part of this decision making process were the Training Course, the logistic aspect and the utilization of the Control & Monitoring Computer at the Angola Hub Station in Luanda.

Hughes conducts an excellent training course. Prior to this contract, other Angolan Telecom Engineers have been sent to Gaithersburg, Maryland for the Hughes Training Course. These students highly recommended the Hughes Curriculum Vitae.

Commonality of Equipment is essential to the logistic aspect of any Telephone Operating Company. Sparing only from one source for the channel cards, DAMA Modems and the operational computer will result in large savings for Angola Telecom in the future.

Angola Telecom also wanted to upgrade their C&M Computer at the Luanda Hub Station. An additional equipment supplier would have necessitated new redundant computers for the other manufacturer besides providing a new unit for the existing Hughes equipment.

In the future, satellite network was planned to be extended to the other Provinces of Angola. Consequently, after much soul searching by ETS Engineers and Designers, it was decided to recommend the expansion of the existing Hughes TES system throughout the Province.

3.0 New Equipment

New Hughes SCPC DAMA equipment was purchased under a separate contract via the Governor of Cabinda. This equipment will be used to augment the existing network in Cabinda. The equipment is part of the Hughes Network Systems (HNS) TES (Telephony Earth Station) Quantum – Quantum-Direct product line. Thirty-two Channel Unit cards were procured, including the main voice channel DAMA board, a Fax Interface Module (FIM) data-card and a two-wire telephone interface data-card. The two data-cards plug directly into the Channel Unit card. A quantity of two of Hughes 14 slot DAMA chassis and one of the Hughes four slot chassis were provided. This equipment is fully compatible with the equipment in the existing operational VSAT system in Cabinda Province. This additional equipment will allow Angola Telecom to expand up to three or more additional nodes in the existing satellite network.

The new equipment includes one IF Distribution Kit. This kit contains components necessary for the connection of several DAMA chassis to transmit and receive IF (Intermediate Frequency) lines. If Angola Telecom intends to install both of the new 14 slot DAMA chassis and the new 4 slot DAMA chassis at a single site, such as the Luanda Hub or the Cabinda Gateway, this kit will provide the means for said type of connection.

A new Network Control System (NCS) will provide the means to control and configure the entire VSAT network. The NCS is also used for control of the Demand Assigned Multiple Access (DAMA) functionality of the network. The existing NCS is not redundant. Loss of the NCS will force operation of the system into a pre-assigned mode of operation.

It should be noted that additional equipment was purchased in order to make the existing NCS at Luanda redundant. Initially, a second NCS computer system was ordered to serve as a backup to the NCS computer already operational at the Luanda Hub Station. Unfortunately, the computer technology is advancing at a rapid pace, and since the original equipment was purchased, there have been large enhancements in the design of computer capacity and capability. Consequently, Hughes now uses a newer version of the NCS computer. Hughes was concerned that the differences between the new version of the NCS computer system and the old version would be too great to allow them to backup each other. The task of making the two different computers to effectively work together would be extremely difficult. Hughes determined that it would be more economical to provide two new identical NCS computer systems that would be fully compatible with each other. **They did this for Angola Telecom at no extra charge. (Two complete NCS computer systems were shipped with the TES Equipment in late September via ocean to the port of Malongo.)**

Each new NCS computer system, provided, will include the following hardware:

- Compaq computer D10 workstation
- 21 inch color monitor
- Wide carriage 24 wire dot matrix printer
- 16 port 10Base-T hub
- Ethernet terminal server
- Associated cables and software

Hughes will provide field personnel to install and check out this equipment at the Luanda Hub Station. ETS will also provide personnel to assist Angola Telecom with the installation of the remote equipment in Cabinda.

TES training at the Hughes facility in Gaithersburg, Maryland in the USA was also purchased and provided under the TDP contract. This training was for one person. The duration of the training was for four and a half weeks. The courses provided were:

System Architecture	3 days
Remote Installation	5 days
Network Operations & Configuration	10 days
Network Engineering & Management	5 days

The schedule for these courses ran concurrently from 10 October 2001 through 9 November 2001.

The existing VSAT DAMA network in Cabinda consists of 12 nodes. Originally, these included a hub in Luanda, a gateway in Cabinda City, and ten remote sites in Cabinda Province. Six of the remote sites had eight voice channels each and four sites had four voice channels each. The Cabinda City gateway was equipped with 64 voice channels. It is our understanding that for security reasons, some of the sites have been moved to other locations and some of the equipment has been reassigned. The Luanda hub has a 15-meter antenna with a 125-Watt and a 1 kW High Power Amplifier (HPA). The Gateway in Cabinda City is equipped with a 3.8-meter antenna and a 40 W HPA. The remotes all have 3.8-meter antennas and 20 W HPA's. The network has the capability of full mesh connectivity. If the NCS is configured appropriately, each site can communicate with any of the other sites. The 3.8-meter antennas are large enough to allow direct links through the satellite between remote sites with a unity power/bandwidth ratio. This power/bandwidth ratio is the ratio of

the fraction of available satellite transponder power required by a carrier to the fraction of the available bandwidth required by a carrier.

The new equipment can be used to increase channel capacity of the Cabinda Province VSAT network in several ways. In one scenario, both of the new 14 channel DAMA chassis and the 4 channel DAMA chassis could be installed at the Luanda hub. This would allow an additional 32 voice channels into Luanda. Due to the DAMA mesh connectivity, these additional voice channels could come from any number of remotes and Cabinda City, in changing combinations as instantaneous traffic patterns dictate. If all of the new DAMA chassis are installed at a single site, the IF kit would be used to connect the additional chassis to the IF network of the Luanda earth station.

In a second scenario, all of the new DAMA chassis could be installed at the Cabinda City gateway site, increasing its voice channel capacity to Luanda and remotes by 32 channels. With the existing network, the Cabinda City site can receive 64 simultaneous channels from the remotes and Luanda. The additional chassis would increase this capacity to 96 simultaneous voice channels.

In a third scenario, the distribution of the new DAMA chassis could be split up, installing one of the 14 channel DAMA chassis at Luanda site, one at the Cabinda City site, and then install the 4 channel DAMA chassis at one of the remotes. This would increase the instantaneous capacity of Luanda and Cabinda City each by 14 channels and increase the instantaneous capacity of one remote by four voice channels.

A fourth possible use of the new DAMA chassis would be to replace 4 channel chassis with 14 channel DAMA chassis at two of the remote locations. This would increase the capacity of those two sites to 14 channels each. Then due to the mesh DAMA SCPC nature of this network, these channels can be assigned as needed to any of the other remote sites and/or Cabinda City and Luanda. The replaced 4 channel chassis and the new 4 channel chassis could be reassigned to three other remote sites, thereby increasing their capacity. In this scenario, the capacity of five remote sites would be expanded.

There are other network scenarios. Fortunately the decisions on channelization and equipment placements are in the hands of a capable systems engineer at Angola Telecom, Eng. Joao Afonso Pemba. Eng. Pemba has been trained at the Hughes Facility and with his previous experience, has the expertise to make the right or the optimum decision for Angola Telecom.

4.0 Recommendations

The ETS Technical Staff evaluated the existing and planned telecommunications network for the province of Angola. We were given "Carte Blanc" by Angola Telecom and the TDA Office in determining the ideal solutions for Angola Telecom. Utility to Telecom, Optimization of Existing Assets, Costs and Operational Expense formed the foundation in our selection process.

Our primary suggestions and or recommendations for the short range and over the next twenty-four months are as follows.

Microwave Extension: We suggest that the existing Farinon Microwave link be extended North from the mountain top terminal at Cacongo to the city of Chicamba and east from Cacongo to the town of Dinge. The AMPS cellular will be the primary users on these Line of Site extensions.

During the next twenty-four months extend the LOS to both the borders of Congo Brazzaville and the Congo.

Cellular Expansion: Extend the existing AMPS cellular system to Cacongo and then on to the towns of Chicamba and Dinge. During calendar year 2002 and 2003 with the additional microwave extensions to the borders of the Congo's, install the AMPS System over the LOS for coverage on these major transport routes.

In the future (next 24 months) provide coverage via the new CDMA network now scheduled for operation in mid 2002.

Power Systems: Provide solar panels to energize the remote earth stations. From Angola Telecom provide, at a price, a solar panel assembly coupled to a 12 V car battery which could be used to recharge hand Held Radios. This will enable remote subscribers to have the ability to recharge their Hand Held Units.

Consider in the future the use of both gas turbines and windmill generation. The former would be ideal considering the Malongo Production Facilities. For the latter, enough wind energy exists through most of the year to produce 2.5 KWH per generation facility.

Remote Ground Stations: Go with the Hughes family of equipment. Procure an additional ten to fifteen low-density terminals that can be used by the lumber and the agriculture community and fixed station subscribers in Cabinda Province. Like the majority of the other remote stations, these terminals can be energized via solar power.

5.0 Contract Enhancements

5.1 General

A number of important factors were considered in the selection of the ideal communications network for the province of Cabinda. Of major importance is the optimization and utilization of existing assets of Angola Telecom.

Some of the key factors or reasons why ETS recommended the expansion of the existing Hughes Ground Station Equipment and the limitations on network expansion are as follows.

AA Site Accessibility:

Unfortunately the problem with Terrorists located north and north east of Cabinda City precluded the undertaking of a comprehensive site surveys to the towns of Chicamba and Miconje on the Congo Brazzaville Borders in the fall of 2000. A trip to the Congo border in the south i.e. the town of Lema was also prohibited.

The spring trip in April resulted in more travel restrictions. The road to the Chevron Complex in Malembo was closed due to terrorists. Travel to the Oil Complex by foreign nationals was only permitted via helicopter.

The travel restrictions prohibited a complete accounting of the telecommunications equipment, however a partial accounting was completed and included in the Phase I report under Annex E. This information was sufficient to facilitate the design effort.

BB ETS & SuperTel

During the late fall of 2000, ETS was acquired in its entirety by SuperTel networks. The TDA Study was in the implementation phase prior to this acquisition. Consequently, for simplicity sake and throughout the remainder of this document, the implement of the TDA study will still be referred to as ETS. We sincerely hope that this naming used throughout will not lead to confusion on the part of the reviewer of this document.

CC Phraseology

Perhaps in some instances there is confusion on the technical terminology used. Throughout this document, ETS was tasked with the translation of the basic document into European Portuguese and not the dialect more commonly used here in the States of Brazilian Portuguese. Consequently the verbiage used in some instances is more European than American.

DD In Country Availability of Documentation

Unfortunately, the documentation on what Telecom equipment exists in Cabinda and in Cabinda City is negligible. The Chief Engineer of Angola Telecom in Cabinda City is attempting to rectify this important telco-operating requirement. This did not effect the design effort.

This same scenario applies to traffic information and management. New systems being installed in the switching, cellular and the satellite arena are being documented via viable record keeping functions.

EE Power Systems.

Key to Telecom operation throughout the province. A TDA study has been undertaken to provide power throughout the province. This study should be near conclusion and has been implemented by a D.C. Consulting firm that specializes in Power distribution networks. The ETS recommendations would be to extend the existing high voltage systems to the borders of the Congo and Brazzaville. The ideal and most economical solution would be to extend the natural gas along the main highways to the border towns. Natural gas could then energize the villages along the routes to the border.

Unfortunately without power, no communications and no cellular system extension can be provided except at exorbitant costs. Solar power is too expensive for cellular base station applications. Power however, must be provided to the remote locations so that rural subscribers can energize and utilize their hand held units.

FF Network Design

An ideal network design employing ground stations was presented within the Phase I Report. Unfortunately unrest in the rural cities have prohibited the implementation of ground station and cellular communications to many of these rural towns.

These rural villages are dependent on power to energize the new ground station and cellular equipment and security provided by the Angolan National Police. In many cases one or both of these assets do not exist. Hence the new changes into remote areas that have adequate protection and a viable power supply.

GG Ground Station Power.

Solar cells can be provided economically for the low-density satellite stations, i.e. 2 or less channels. Solar does not exist for a supplemental PABX, Switch or Cellular system at these remote locations. Eight or more satellite channels also makes solar prohibitive from a power drainage standpoint.

5.2 Phase I Aspects

This part of the report addresses the primary tasks undertaken by ETS under Phase I of the TDA Contract. Information contained within the existing Phase I Report is reference and or supplemented herein.

5.2.1 Tasks For Government User Traffic

The first four items of the Government User Traffic are addressed within the Phase I Report, Annex A.3. Unfortunately due to local terrorists, border and custom functions could not be adequately addressed. Discussions on the remote communications needs were undertaken with the Customs Group at Cabinda Airport and with the local military in Cabinda City. Other than having the need for remote communications to their provincial headquarters, neither group could determine or estimate their telecommunications and data requirements.

5.2.2 Tasks For Non-Government Users.

An effort was made by the ETS technical staff to address the non-government user traffic within the province. These traffic estimates are presented within Annex A.4 of the Phase I Report.

Cellular radio has recently been introduced in the Province. This new system is analog using the Motorola Amps family of Equipment. Plans in the future call for a digital system employing CDMA technology manufactured by AT&T or Qualcom. This latter transmission technique will be the primary carrier for Internet traffic within Cabinda City now scheduled for late 2003.

The weakness in the cellular approach is its extension from Cabinda city. There is little or no power systems to support the base station requirements.

5.2.3 Design an Idealized Telecom System for Cabinda Province

ETS postulated a basic network design for the Cabinda Telecom network. The foundation for this design is found within Annex A of the Phase I report. The ideal approach is satellite communications to the rural villages supplemented with cellular base stations for local distribution radio. The size of the latter is dependent on the number of subscribers potentially available at the remote towns or villages within the province.

5.2.3.1 Traffic Models for Government and Non-Government users.

The traffic models are presented in Annex A.3 and A.4 of the Phase I report. Note these were developed for both Government and Non-Government users.

5.2.3.2 Rural Telecommunications and Party Lines.

Single party lines can be used at those locations in which the specific town or village is being covered via other base station sites for the AMPS or CDMA Cellular Transmission.

It should also be noted that any remote cellular subscriber will have access locally to all other subscribers within its town or village. Also to all telco subscribers in Cabinda City, the same for greater Luanda and the rest of Angola, and the international medium, be it regional in Africa or any of the other international subscribers worldwide.

The system is considered part of the overall design and is covered in the Phase I report, Sections 3.0 and 4.0 and in the Phase II report, Section 4.0.

5.2.3.3 Use of Existing Inventories.

The foundation for the Cabinda system design was utilizing the Hughes TES equipment. Ads stated throughout the Phase I and Phase II reports the most optimum approach for Angola Telecom was to expand the Hughes TES family of equipment throughout the Cabinda Province.

This is covered in the Phase II report, Section 2.0. It has been determined that the best and most cost-effective solution would be to build upon the existing installations.

5.2.3.4 New Wireless Technology and VSATs.

This is the ETS and the Angola Telecom approach to both rural and cellular communications. VSAT technology coupled with cellular radio is discussed throughout the Phase I and Phase II reports.

The Phase I report discusses the various technologies that are available.

5.2.3.5 Regional Assessments and Standards.

The applicable standards are addressed in the Phase I report, Section 3.0. and in the Phase II report, Section 2.0 and 3.0. These sections cover standards used for the design and implementation of the installations. The new Hughes TES equipment complies with these standards. The compatibility of equipment issue is avoided by the use of equipment by the same manufacturer.

5.2.3.6 Environmental Impact.

ETS evaluated the weather and environmental conditions in Cabinda Province before concurring with the Hughes TES design. Consideration in our basic design is delineated in Annex A under Rain Fade Margins for satellite operations within Cabinda Province.

The environmental impact of this project is minimal and is addressed in the Phase I report, Annex A.1.3.2.

5.3 Phase II Contractual Points

The following paragraphs address the specific requirements specified within Annex I, Terms of Reference of the Contract. The following paragraphs compliment the existing Phase I & II Reports.

5.3.1 Phase II Pilot Validation Project for Phase I

During the first (Nov 00) and second (Apr. 01) trips by ETS to Cabinda Province it was jointly decided to utilize the existing Hughes Network as the foundation of our network design. This universal decision arrived at jointly during meetings with the customer Angola Telecom, Chevron the Project Coordinator, TDA the U.S. Government Administrator and ETS was based primarily on paragraph 3c of the contract. This states that "The use of applicable existing inventories is useable, technically and economically viable."

Cabinda had two operational systems implemented by Hughes. The first was the Hughes PES system that provided low rate data service to the banks throughout the province. The second was the TES System presently operational by Angola Telecom that provide voice and data from Cabinda City to the capital, Luanda. Consequently, the optimum solution was to expand the existing Hughes TES network rather than implementing a new equipment provider such as STM. The latter would have necessitated a new hub station at Luanda and a mini hub or gateway station in Cabinda City to carry traffic throughout the province.

Logistics, training of local personnel, the Hughes Technical Support Team and the utility to the end user Angola Telecom also substantiated the selection of the TES family of equipment.

5.3.2 Development of A Procurement Specification:

After discussions with Angola Telecom detailed procurement specifications for the Hughes Equipment were not required. Angola Telecom has these procurement specifications and their implementation would have necessitated translating these documents into the Portuguese Language. (Hughes which has systems operational in two of the other provinces of Cabinda along with the Federal Territory have not translated any of their documents into Portuguese)

From a network design standpoint, ETS has undertaken the required system and traffic calculations, which form the foundation for the in-country design and procurement activity. These network calculations are portrayed within Annex A.3 and A.4 of the Phase I Report.

5.3.3 Assist Cabinda During the Installation Phase

ETS has provided a field engineer to assist Angola Telecom with the installation and testing of the new earth station equipment. Our field engineer has experience in working in Angola, is very familiar with the Hughes TES Equipment and is highly respected by Angola Telecom Technical Personnel.

5.3.4 Develop a Training Plan

Key Angola Telecom Personnel have been trained on the Hughes family of equipment in both Luanda and in Cabinda. To enhance the training associated with this TDA contract; ETS has paid for the training of Eng. Pemba at the Hughes Facility in Gaithersburg, Maryland. Eng. Pemba has been the first Angolan Telecom Engineer to attend this comprehensive training course in the States. Eng. Pemba attended the complete Hughes Training that lasted more than five weeks during the fall of 2001. With his curriculum vitae, Eng. Pemba will be able to train his local staff in the installation, testing and the operation of the Hughes Ground Station Equipment.

Training of local Telecom personnel will result in minimal western world assistance. Angola Engineers will be able to undertake the majority of over 98% of the maintenance aspects on the new Hughes Equipment.

5.3.5 Access the Performance of the Project

Our customer Angola Telecom was pleased with the resultants provided by ETS on the Cabinda Study Program. The project coordination group, Chevron Malongo also appeared to be pleased. The Governor of Cabinda along with key personnel at the U.S. Embassy in Luanda also voiced their approval. We recommend that discussions be undertaken with each of said organizations to substantiate this premise.

5.3.6 Development of a Procurement Specification

The Hughes TES Equipment was recommended and procured to compliment the existing plant in place throughout Cabinda Province. Please refer to Par. 5.3.2 above for additional details.