VSAT – An Efficient, cost effective solution for connectivity for the educational Institute
A Case Study

A Thesis

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requirement for the award of the degree of

Masters of Engineering in
Electronics and Communication Department

Under the Guidance of: **Submitted by:**

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<u>CERTIFICATE</u>

I here by certify that the thesis report entitled **"** VSAT – An Efficient, cost effective solution for connectivity for the educational Institute A Case Study**"** for the requirement of the Masters of Engineering in Electronics and Communication is an authentic record of my own work carried out in the supervision of **Mr. Rajesh Khanna, Astt. Professor , and Dr. P.K.Bansal Professor & Head E&CED**,T.I.E.T Patiala.
This is to be certifying that above statement made by Mr.Sanjay Batish is correct to the best of my knowledge.

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1. Introduction:

Information technology is an amalgam of some wonderful inventions of the 20^{th} century in electronics and communication. During a very short span of time it has acquired an important place in almost all aspects of human life and particularly in the field of education. The steps taken facilitates in providing effective education in almost all disciplines and particularly for the technical education, to use newer technologies so as to ensure better technical education to all. One such solution is the use of Internet. But as the Internet traffic continues to grow at exponential rates worldwide, Internet services providers (ISP's) everywhere are faced with the challenge of keeping up with demand for network bandwidth and developing creative solutions for squeezing more use out of existing bandwidth. Especially in the developing countries like India where bandwidth requirements are more stringent, such solutions become all the more relevant. Satellite-based Internet connections are one of those solutions. VSAT is one such satellite-based service. VSAT is not new. [1]. In remote and rural areas, where there is little or no terrestrial communications infrastructure, can VSAT platforms prove their value? Making a phone call, surfing the Internet or receiving a fax are everyday functions of life token for granted -- by only 50 per cent of the world's population. For the other half, access to communication systems is far more elusive. The cost and infrastructure build-out needed to link a remote field office of 20 people or a rural community with 100 inhabitants through terrestrial solutions is often too high for operators or governments to undertake. It is in these situations that VSAT platforms -- communication services delivered via satellite-based very small aperture terminals [VSATs] -- have the potential to take center stage. In this thesis we have consider the case study of the complete working of VSAT is given and the performance evaluation of VSAT with leased lines is presented. The usage of VSAT in educational and rural is discussed. It is shown that VSAT provides a cost effective solution for broadband connectivity.

1.1 VSAT

VSAT stands for “Very Small Aperture Terminal” and refers to receive/transmit terminals installed at dispersed sites connecting to a central hub via satellite using small diameter antenna dishes (0.6 to 3.8 meter). VSAT networks may transmit voice, data, fax, or video conferencing. The emergence of the VSAT in the 1980s marked the beginning of a new era in satellite communications. A VSAT network consists of:

(i) Several hundred to several thousand VSAT remote sites with small antennas.

(ii) A large central earth station called a hub, which includes a large antenna and enables the connection of all the VSATs in the network.

(iii) Satellite transponder capacity.

A VSAT remote site includes an indoor unit, an outdoor unit and a small antenna. The indoor unit usually fits on a desktop (much like a modem) and contains the circuitry that activates the communications link between the user's equipment and the satellite. The outdoor unit is electronic equipment that transmits and receives signals to and from the satellite transponder, and is installed on a small antenna about 0.9 to 1.8 meters that can be mounted on an end-user's roof, ground, or wall.A question arises that why we should go for Satellite Communication when others mediums are available for communication. The satellite communication offers following advantages as compared to other channels.

- When the infrastructure does not provide communication ability to sites (high cost, long distance)
- When working in rugged terrain
- When there is a need in privately controlled system
- When you need to communicate with hundreds and thousands of sites
- When the type of traffic lends itself to satellite communication

VSAT (Very Small Aperture Terminal) is the common trade name for networks, private or public, which facilitates network's node-to-node connectivity, networking and network management. It is a kind of wide area network integrating the technology of satellite, telecom, computer as well as Internet, and allows for the use of small fixed antennas in providing highly reliable communication. VSAT networks further offer several advantages compared to ground-based communications networks:

- Ubiquitous service, providing equal access to bandwidth across large geographic regions;
- Independence from traditional, terrestrial-based infrastructures;
- High data transmission speeds;
- Fixed transmission costs, insensitive to distance or the number of receiving stations;
- Rapid and cost-effective deployment in geographically isolated regions and developing countries;
- Enhanced network visibility and management;

- Reliability.

1.2 WORKING OF VSAT

A VSAT network consists of a satellite, a central hub with an antenna of between 4.5 to 11 meters, and a network of several hundred to several thousand VSAT terminals with smaller antennas (usually 0.9 to 1.8 meter). From a communications perspective, there are two segments of the communication process: the earth segment, which consists of equipment at the hub and equipment at the remote locations, and the space segment, which is the link to and from the satellite. In the sky, the satellite serves essentially as a radio-frequency repeater. VSATs configured to communicate with each other (e.g., corporate headquarters and a branch office) send information to the satellite receiver on a given frequency. The satellite receives this information, amplifies it, and transmits it on a different frequency. The bandwidth is shared between the members of a given network, and is managed to provide each location with adequate transmission capacity and a set response time.

1.3 ARCHITECTURE OF VSAT

VSAT Terminal Equipment consists of two units - one placed outdoors for a line-of-sight to the satellite and one placed indoors to interface with the user's communications device (e.g. data terminal equipment). The outdoor unit consists of small antenna and electronic equipment for signal reception and transmission. The indoor unit is a small desktop box that contains the receiver and transmitter boards and an interface to the user's equipment.

A typical VSAT site consists of a parabolic-shaped antenna mounted on the roof of a building, connected by a cable to a chassis inside the building. Operators install these antennas at customer sites and buy transmission capacity on satellites. It contains a modem for translating satellite transmissions back into data (and vice versa) and terrestrial interfaces for connecting customer equipment. A block diagram of a complete VSAT link is shown in figure 1.

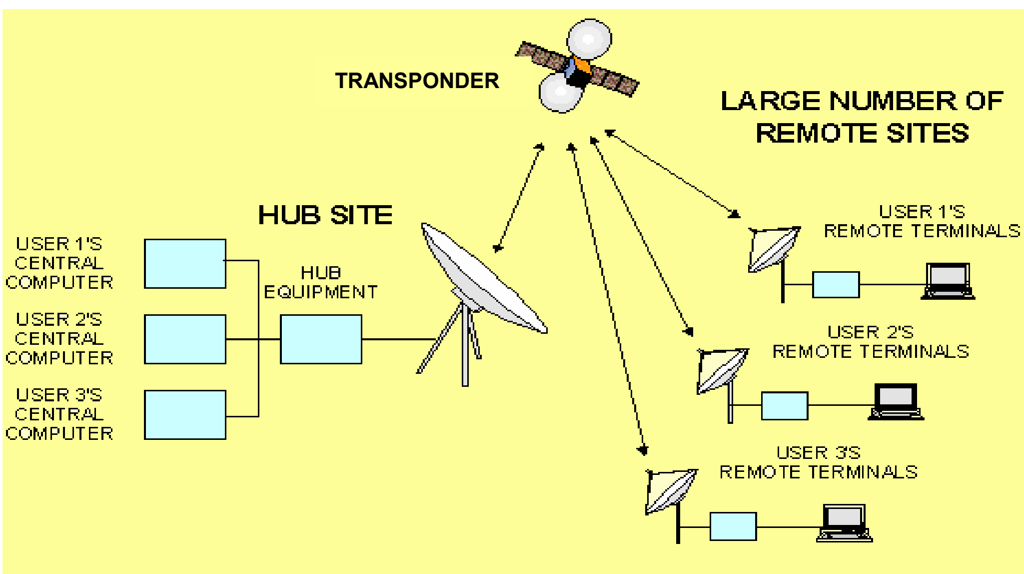


Figure. 1

1.4 Basic multiple access and modulation schemes

Effective and efficient satellite communications depends on the type of modulation and multiple access used by transmitting user terminals and earth stations. The staunch support by suppliers of their particular approach often produces interesting and confusing debate within the technical community. Mirroring the dialog of the digital mobile (cellular) standards, satellite multiple access techniques run the gamut of time division, frequency division and code division approaches. Figure 3 shows how these techniques occupy the two key dimensions of satellite capacity: frequency spectrum and time. Evaluation of these systems is ongoing, and each can demonstrate satisfactory operation in a live network. Any of the three can be made to work; however, it is likely that one or two may be superior for a specific defined application. Beyond the theory, it is the product design and protocol operation that matter as to how well the multiple access system delivers information in an effective and manageable way.

Figure 2. Illustration of the time and frequency utilization of basic multiple access techniques, indicating how four earth stations would share the overall channel bandwidth.

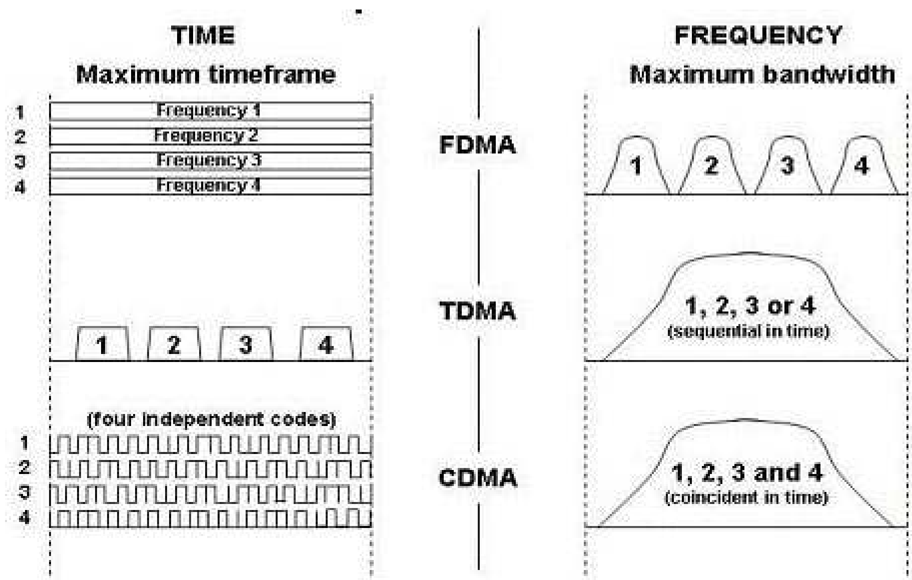


Figure :2

The primary modulation method in use over satellites is phase shift keying (PSK). Adopted by satellite engineers in the 1960s, PSK has found its way into all wireless systems as it is nearly optimum with regard to the use of bandwidth and power. Variants like minimum shift keying (MSK) and Gaussian MSK (GMSK) that are applied in different situations, and some have gained in popularity due to increased importance of using low-power transmitters on the ground.

Figure 3. Performance characteristics of current forward error correction techniques, provided for comparison purposes only.

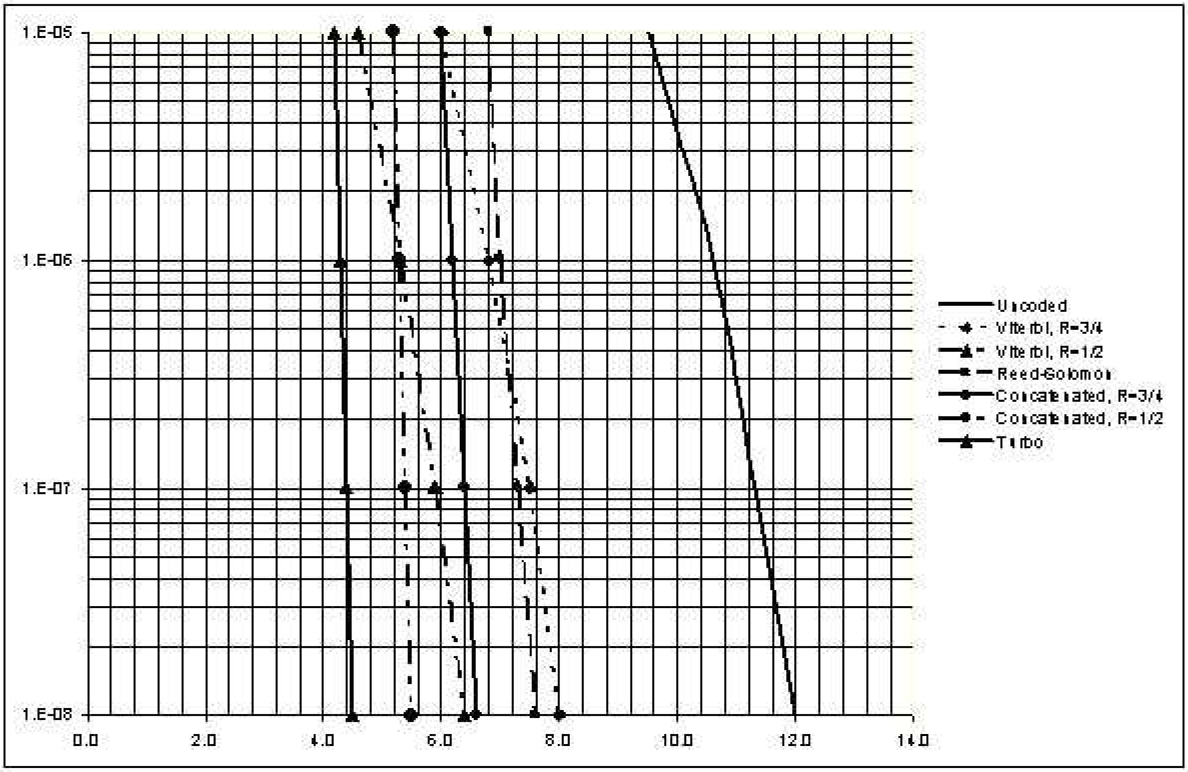


Figure 3

1.5 Comparing Technical Performance

A global comparison of technology and its implementation by developers and manufacturers is probably impractical. However, if the basic requirements for the network are known, it is possible to narrow the possibilities and make choices of equipment and operating parameters. Most generalized comparisons resort to the basic linear equations for the wireless line-of-sight path, e.g.,

$$C = P_t G_t G_r \left(\frac{\lambda}{4\pi R_0} \right)^2$$

where C is the received carrier power, P_t is the transmitter output power, G_t is the transmit gain, G_r is the receive gain, and R_0 is the range from the transmitting antenna to the receiving antenna. From the basic geometry of the geostationary orbit, the line-of-site path length (R_0) can be estimated from:

$$R_0 = 42643.4 \times 10^3 \sqrt{1 - 0.29577 \cos\varphi \cos\delta}$$

where ☐ is the latitude and ☐ is the longitude of the earth station relative to that of the satellite.

The measure of link performance, C/N, is computed as the ratio of C to the noise (N) in the signal RF bandwidth (B). For pure thermal noise as produced within the receiving earth station,

$$N = kTB$$

where k is Boltzmann's constant and T is the equivalent noise temperature of the receiving system (composed of contributions from the antenna, coupling loss and low noise amplifier).

Conversion to E_b/N_0 amounts to multiplying the C/N by the ratio of the information bit rate to the bandwidth, B.

This simple calculation is not sufficient to account for a variety of other noise sources and impairments that significantly affect the satellite channel. These include:

- Uplink noise, which is computed in the same manner as above;
- Propagation effects due to the various layers of the atmosphere, particularly absorption by clear air and rain (which introduces substantial power loss at frequencies above about 10 GHz), and scintillation fading due to the troposphere and ionosphere;
- Transponder intermodulation distortion, which may add noise products into the spectrum of the carrier;
- Interference from cross polarized signals on the same satellite (XPOL) and from adjacent satellites (ASI)
- Direct distortion to the signal as it passes through the uplink earth station, satellite transponder, and receiving earth station;

the principal impact is called intersymbol interference (ISI), an impairmentwhich causes the required E_b/N_o to increase for the same probability of bit error.

Satellite communications engineers most often use the link budget to identify and combine the various gains, losses and margins in the uplink and downlink path. The practice of link budget formulation involves both science and art. Individuals who routinely compile them have their own unique formats, typically embodied in personalized Microsoft Excel spreadsheets. There are a myriad of calculations and assumptions for individual entries, and engineers typically include margins anywhere in the range of 0.5 to 3 dB to cover factors not known with sufficient accuracy.

2.1 VSAT Access

The primary objective and advantage of these networks is to maximise the usage of common satellite and other resources amongst all VSAT sites.

The method by which these networks optimise the use of satellite capacity, and spectrum utilisation in a flexible and cost-effective manner are referred to as satellite access schemes. VSAT networks are available in various shapes and sizes ranging from **point-to-point**, **point-to-multipoint**, and **on demand.**

2.1 Single Channel Per Carrier (SCPC)

SCPC is a point-to-point technology, making it the VSAT equivalent to conventional leased lines. SCPC is used for economical distribution of broadcast data, digital audio and video materials, as well as for full-duplex or two-way data, audio or video communications. In an SCPC system, user data is transmitted to the satellite continuously on a single satellite carrier. The satellite signal is received at a single location, in the case of a point-to-point system, or at many locations in a broadcast application, providing hubless connectivity among multiple sites. As a leased-line equivalent, SCPC can deliver dedicated bandwidth of up to 2 Mbit/s.

Examples of SCPC VSAT Applications:-

1) High Speed
2) Credit authorizations
3) Replacement of terrestrial circuits
4) PABX extensions
5) Backup circuits for redundancy or diversity
6) Inventory management
7) Supports true multimedia capabilities--voice, data, fax and e-mail
8) Access to remote locations where high-speed terrestrial digital connectivity is not available .

2.2 Point to Multi point

VSAT network architecture is the Time Division Multiplex/Time Division Multiple Access network, used around the world for low speed (300 bps - 19,200 bps) data communications such as credit card processing and verification, point-of-sale inventory control, and general business data connectivity. With TDMA networks, numerous remote sites communicate with one central hub--a design that's similar to packet-switched networks.

A typical TDMA network employs a large satellite hub system that manages all network terminal access and routing. Data is transmitted to and from the hub in short bursts on satellite channels that are shared with 30 to 40 other terminals (depending upon network loading parameters). The hub communicates with these VSAT terminals over a higher-speed "outbound" TDM satellite carrier. The terminals transmit back to the hub on their assigned "inbound" carriers using TDM protocols. This combination allows a certain number of slots in time each second that each terminal can transmit data, and can dynamically assign more or less time to terminals based upon their individual requirements. With this type of assignment, maximum network efficiency and throughput is maintained. The antennas are Sub-Meter to 2.4 meter in size depending upon locations.
Most domestic offerings are based on TDMA, although some domestic operators offer point-to-point SCPC links as well.

2.3 TDMA (Time Division Multiple Access)

In a TDMA network, all VSATs share satellite resource on a time slot basis. Remote VSATs use TDMA channels or in-routes for communicating with the hub. There are several in-routes associated with one out-route. Several VSATs share one in-route thereby sharing the bandwidth.

Typical in-routes operate at 64 or 128 Kbps. Generally systems with star topology use a Time Division Multiplexed/ Time Division Multiple Access (TDM/TDMA) transmission technique. Critical to all TDMA schemes is the function of clock synchronisation which is performed by the TDMA hub or Master Earth Station.

2.4 Fixed Assigned TDMA

The VSATs may access the inroute on a fixed assigned TDMA mode, wherein each VSAT is allocated a specific time slot or slots. Slotted ALOHA - In this case each VSAT can access any slot at any time with the remote sites randomly transmitting messages on the inbound transmission path. Most of the time this allows messages an instant access to the in-route data stream making it to be the fastest method of transmitting messages to the hub.

However, when two or more sites transmit packets simultaneously a collision occurs where the hub station will not receive any of the affected packets. On detecting a collision, remote sites undergo a random transmission delay and re-transmit the packet in another time-slot before the transaction is complete.

Slotted ALOHA helps in most efficient use of bandwidth in situations where multiple sites are randomly transmitting short bursty messages back to the hub. TDMA networks are ideally suited for medium to large networks with medium data rates. Dynamic Reservation - As an intermediate refinement, techniques have been developed to toggle the operation of a VSAT from a Slotted ALOHA mode to a Fixed Assigned mode. This is referred to as Dynamic Reservation. As the traffic grows, the VSAT senses the same and switches over to a fixed assigned TDMA mode, wherein it has an assured amount of slots. This switchover between Slotted Aloha and Fixed Assigned TDMA is done dynamically dependent on the traffic profile. This allows optimum usage of satellite resources.

2.5 FDMA (Frequency Division Multiple Access)

Here all VSATs share the satellite resource on the frequency domain only. Typically implemented in a mesh or single satellite-hop topology, FDMA has the following variants.

2.6 PAMA (Pre Assigned Multiple Access)

It implies that the VSATs are pre-allocated a designated frequency. Equivalent of the terrestrial leased line solutions, PAMA solutions use the satellite resources constantly. Consequently there is no call up delay which makes them most suited for interactive data applications or high traffic volumes . As such PAMA connects high data traffic sites within an organisation. SCPC (Single Channel Per Carrier) refers to the usage of a single satellite carrier for carrying a single channel of user traffic.

The frequency is allocated on a pre-assigned basis in case of SCPC VSAT's. The term SCPC VSAT is often used interchangeably with PAMA VSAT. Thus a permanently assigned frequency channel provides dedicated bandwidth, through which you can send data, voice or video. This illustrates the concept of Dedicated Resource in Shared Environment. Here the frequency channel is dedicated to you but the basic Satellite resource is shared by many.

Now the assigned frequency carrier in PAMA can either be used for voice or for data. But what if you want to use one carrier for data and voice. Of course this is possible. How ever it calls for the use of a call of device called Voice Data Multiplexer (VDM) which combines or aggregates several data and voice channels into one trunk line which in turn is interfaced to the VSAT equipment.

2.7 DAMA (Demand Assigned Multiple Access)

Network uses a pool of satellite channels, which are available for use by any station in that network. On demand a pair of available channels are assigned so that a call can be established. Once the call is completed, the channels are returned to the pool for an assignment to another call. Since the satellite resource is used only in proportion to the active circuits and their holding times, this is ideally suited for voice traffic and data traffic in batch mode. DAMA offers point to point voice, fax, and data requirements and supports video conferencing.

2.8 CDMA (Code Division Multiple Access)

Under this a central network monitoring system allocates a unique code to each of the VSATs enabling multiple VSATs to transmit simultaneously and share a common frequency band. The data signal is combined with a high bit rate code signal which is independent of the data. Reception at the end of the link is accomplished by mixing the incoming composite data/code signal with a locally generated and correctly synchronised replica of the code.

Since this network requires that the central NMS co-ordinates code management and clock synchronisation of all remote VSATs, Star is by default the best topology. Although this is ideally suited for very large networks with low data requirements there are practical restrictions in the use of spread spectrum.

Frequency Band	**Uplink (GHz)**	**Downlink (GHz)**
C Band	5.925 to 6.425	3.700 to 4.200
Extended C-Band	6.725 to 7.025	4.500 to 4.800
Ku Band	14.000 to 14.500	10.950 to 11.700

Frequency Band Table 1

- The Ku- Band has higher frequency, hence smaller antenna sizes
- Susceptible to rain outages making it unsuitable for use in South East Asian regions.
- Indian service providers hire space segment only on the INSAT series and operate in Ext-C band only.
- Ext-C band is available only on the INSAT series of satellites and is not a standard band available internationally

3.1 SATELLITE TRANSPONDER

The satellite contains a number of transponders, or repeaters. These transponders perform the following functions:

- Signal Reception - it receives the signal up linked by a VSAT and/or hub
- Frequency Translation - the frequency of the received signal is translated to a different frequency, known as the downlink frequency. The frequency translation ensures that there is no positive feedback and also avoid interference related issues.
- Amplification - the transponder also amplifies the downlink signal.

Typically a satellite has 500 MHz bandwidth that is split into 12–14 transponders, each having a bandwidth of 36 MHz. Two transponders can use different polarization, so that they can use the same frequency range without interference. A satellite transponder as shown in figure 2 is a combination receiver, frequency converter, and transmitter package. It is a physical part of a communications satellite.

Communications satellites typically have 12 to 24 onboard transponders. It is made of

(i) Low noise amplifier (LNA): amplifies the uplink signal
(ii) Frequency Converter: Converts the incoming signal to the downlink frequency. The uplink and downlink signal must be differ to avoid conflicts with each other.
(iii) High Power Amplifier (HPA): amplifies the signal to be rebroadcast
(iv) Interconnections cables.

The VSAT Extended C-Band is a high performance, low cost RF transceiver system designed for two-way satellite communication with high-speed transmission capability suitable for both telephone and high speed Data Communication. ODU can be operated with different modulation format like BPSK, QPSK and FM. Additional features like low phase noise and low spurious make it suitable for both Single Carrier Per Channel (SCPC) or Multi Channel Per Carrier (MCPC) transmission applications. Further more, the ODU has built-in micro phonic prevention feature.

Figure 7 shows typical block diagram of the ODU in VSAT applications. The system consists of two main chains, namely transmit and receive chain. The Receive chain consists of LNA and down-conversion path in RFT. it receives a signal carrier ranging from 4.5 GHz to 4.8 GHz , down converts to 70 MHz IF signal for the ODU to demodulate.

Conversely, the transmit chain consist of double up-conversion and the amplification in the RFT. A 70 MHz IF modulated signal from the IDU is sent to the RFT for double up conversion and amplification to the frequencies between 6.725 GHz to 7.025GHz. For the different power requirements, different RFT rating are available in the determining the transmitting power of the up link signal.

The ODU is designed as such as for the easy system integration and maintenance. The LNA is flanged mounted to the OMT of the dish antenna. The RFT is designed to be mounted under the antenna whilst the SSPA is mounted on the pole connecting to the OMT. Fig 7 shows the integration diagram of the ODU system mounting on the antenna. The Extended C-Band ODU is designed for the out door environment.

3.1.1 Transponder

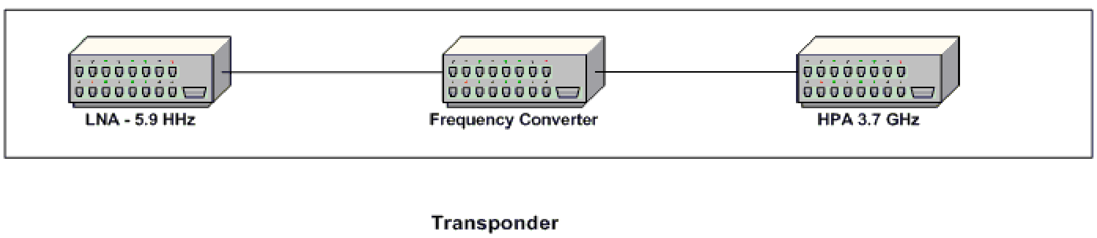


Figure.4

3.2 Earth Station (HUB)

The hub station is usually a relatively large, high performance earth station with an antenna diameter of anything between 6 and 11m. The hub consists of a control center, which manages the network as well as microwave equipment, including an outdoor antenna, for the transmission and reception of signals. A substantial amount of interfacing equipment necessary to support the wide range of terrestrial interfaces required at the hub completes the installation. This equipment is usually mounted in several racks. A block diagram of hub stage is shown in figure 5.

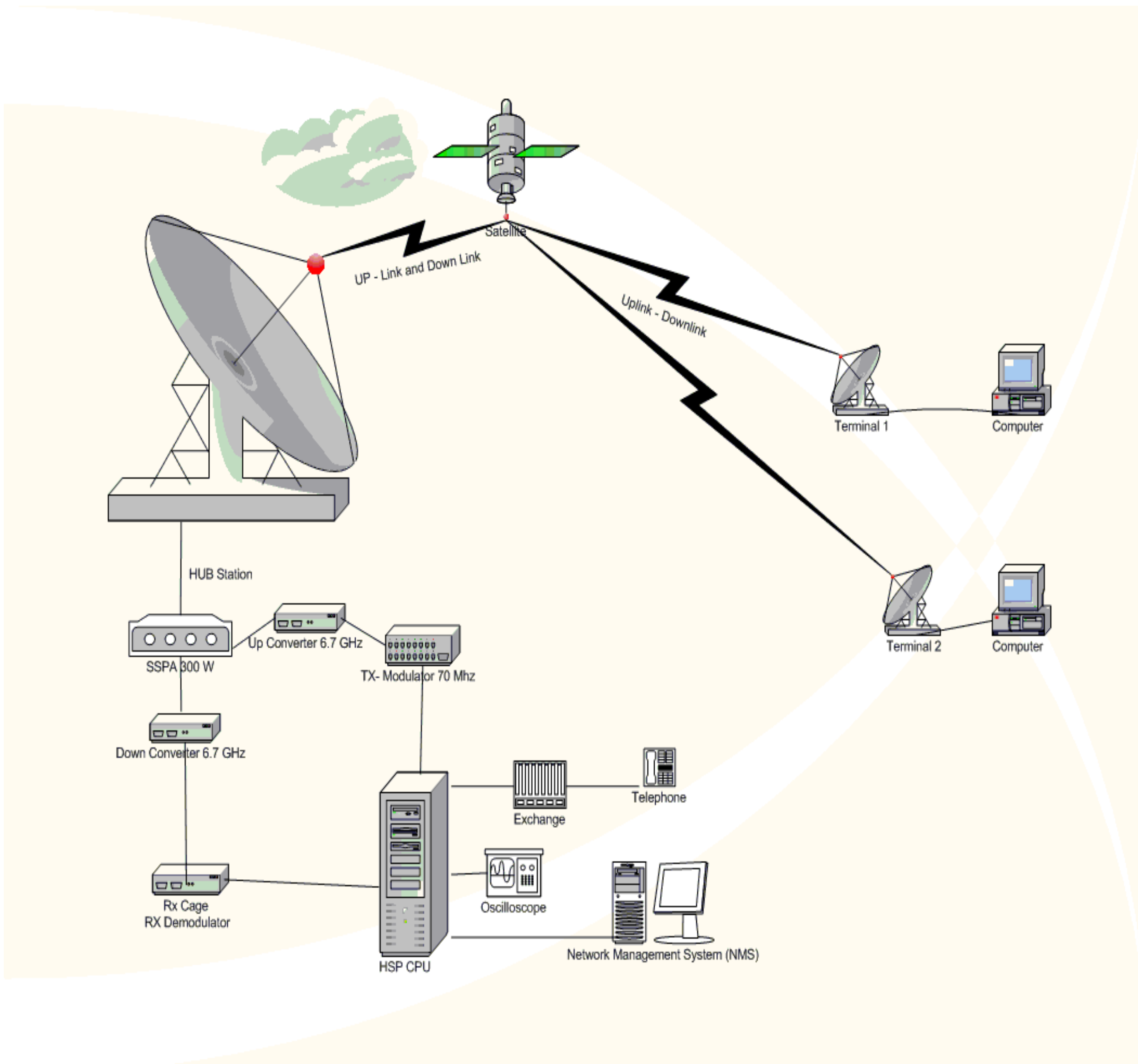


Figure 5

3.2.1 Various Earth Station Equipments

The hub stage consists of following equipments

a) Solid state power amplifier (SSPA): 300 W, Base band equipment Hub satellite processor (HSP) , Network Management system (NMS) ,Gateway to PSTN

b) Hub satellite processor (HSP): CPU cage, modulator (satellite transmitter), receiver cage and power splitter.

c) Hub Voice Processor (HVP: PSTN Gateway): Hub Voice processor digitized the voice, organize it in packets and send it to HSP to be transmitted

3.2.1 Subsystems of Earth Station (HUB) The hub station consists of several main subsystems; except for the antenna these are usually fully redundant with automatic switchover in the event of failure:

- A switch (generally a packet switch) which controls routing between host ports and the modulator and demodulator ports, as well as adding and reading header address information, which controls routing to and from individual IDUs.
- One or more modulators that modulate the outbound carriers with the TDM stream generated by the switch (each outbound carrier has a dedicated modulator)

- A bank of demodulators that receive the inbound carriers and extract the data packets and feed them to the switch.

- An **RFT** (radio frequency terminal), which contains:

- The transmit subsystem containing up converters which change the 70 or 140 MHz IF to the required transmit frequency before feeding it to the High Power Amplifier (HPA). If the hub only uses a single carrier for data it is possible to use a solid-state power amplifier (SSPA), otherwise a more powerful Traveling Wave Tube Amplifier (TWT) must generally be used. Up-link power control is often provided so that the power transmitted by the hub can be increased to compensate for high link attenuation due to precipitation in bad weather.

- The receive subsystem consisting of a Low Noise Amplifier (LNA) with a noise temperature usually between 150 and 175° K (Ku band) and a down converter to change the received frequency to the IF frequency (70 or 140 MHz).

- The antenna subsystem consisting of a large antenna (6 to 11 m in diameter) on a mount with a tracking system which allows the antenna to follow the satellite as it moves very slightly in the sky. A feed horn is fitted at the focus of the dish to collect the received signals from the antenna and to feed the transmit signals to it.

- A NCC (network control center) that controls and monitors the operation of the hub and the IDUs in the network.

- The primary power subsystem, which guarantees the quality and continuity of the power supply for the hub. It typically contains power switching, an uninterruptible power supply with a large battery bank and a diesel generator.

The hub is usually very expensive, costing typically between 0.5 million Euro to 2 million Euro, depending on the configuration and manufacturer. This cost excludes the price of the RFT, antenna and civil works.

3.3 Network Management Systems (NMS): PC based Windows NT platform, real window application, client-server architecture and TCP/IP connectivity with HSPs

- Addition and deletion of system element
- Remote configuration
- Firmware download to remote site
- Transponder frequency control
- Numbering plan
- Billing data base
- System performance
- Real time traffic
- Real time traffic of all the sites
- Hub redundancy control
- Geographical and logical network presentation
- Spontaneous reporting
- Remote site control
- Hub conditions
- Complete trace of events
- Static's

- Call details records (CDRs)
- Distance and international charges

3.4 Typical VSAT network configurations

VSAT networks can be arranged in point-to-point, star, mesh, star/mesh, and broadcast configurations as shown in figure 6. The preferred arrangement depends on the kind of information flow the network will service.

3.5 Network Topologies shown in figure 6

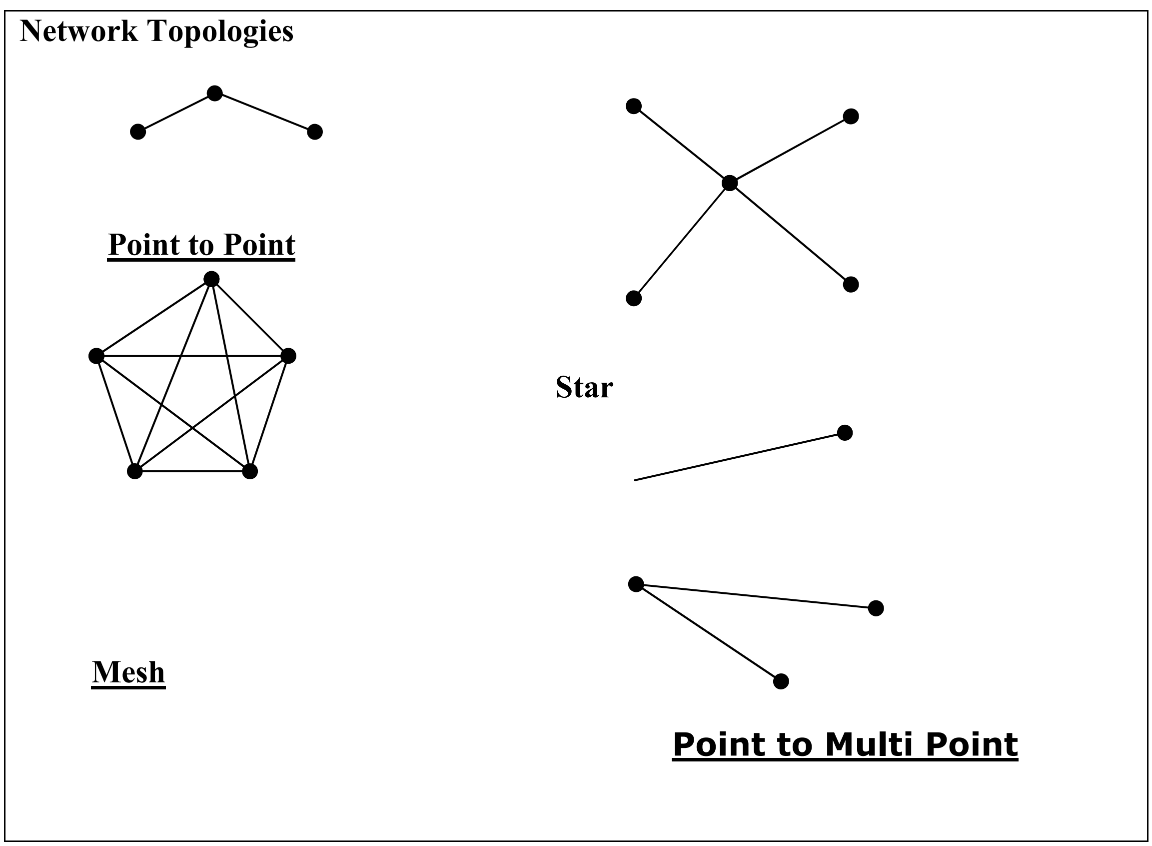


Figure.6

3.5.1 Star Topology

The most popular of these is Star topology. Here we have a big, central earthstation known as the hub. Generally the hub antenna is in the range of 6-11metre in diameter. This hub station controls, monitors and communicates with a large number of dispersed VSATs. Since all VSATs communicate with the central hub station only, this network is more suitable for centralized data applications.

3.5.2 Mesh Topology

In a mesh topology, a group of VSATs communicate directly with any other VSAT in the network without going through a central hub. A hub station in a mesh network performs only the monitoring and control functions. These networks are more suitable for telephony applications. These have also been adopted to deploy point-to-point high speed links.

However, in actual practice, a number of requirements are catered to by a hybrid network topology.

4.0 Remote VSAT:

Remote terminals usually support a wide range of common electrical interfaces such as RS-232, RS-422, V.35, as well as voice and TV. Several common protocols are also generally supported including SDLC, 3270 bisync, X.25, asynchronous and Ethernet. Asynchronous data rates are typically available up to 9.6 kb/s. Synchronous data rates between 1.2 and 32 or 64 kb/s are also generally available.

Remote terminals have now become very reliable, with MTBFs of typically 25000 hours. Link availability is also usually designed to be high, with an end-to-end availability of better than 99.7% being quite common. The prices of a remote terminal, like that of a hub station, can vary a great deal, but typical prices are in the range 3 to 8 KEuro (for a complete installation consisting of antenna, mount, ODU and IDU). A typical remote terminal is shown in figure 7.

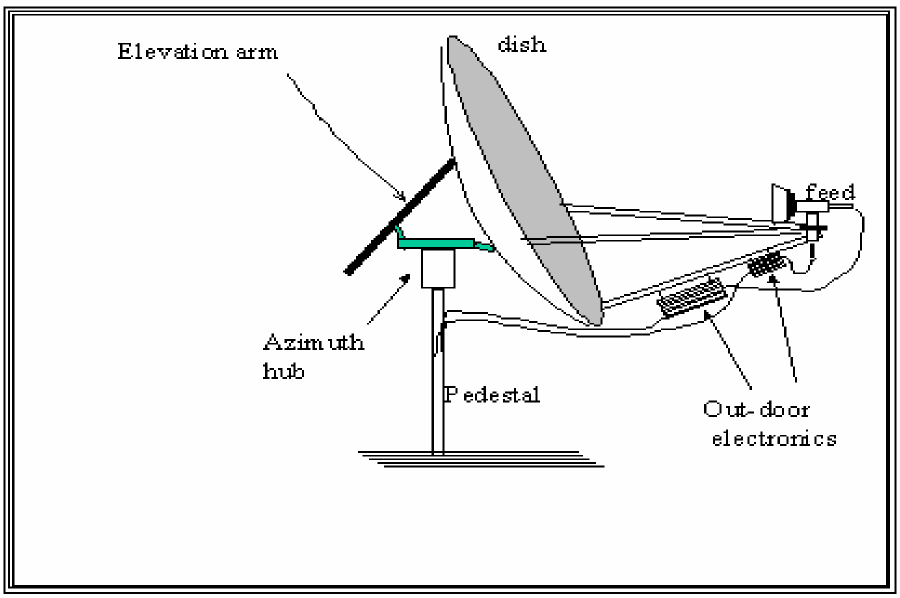


Figure 7

4.1.1 Equipments at Remote End terminals

- A dish antenna, generally 0.55 to 2.4 m in diameter (though larger dishes are sometimes required), which can be wall, roof or ground mounted.

- The antennas are usually offset-fed parabolic dishes, although larger dishes tend to be center-fed. Recently, to gain higher performance (in particular side lobe performance) dual reflector, Gregorian designs have started to become common. Several different materials are used for the dishes with spun aluminum, steel, fiberglass and reinforced plastic being the most popular.

- An outdoor unit, which contains the microwave electronics for the terminal. This is usually the size of a shoebox, but it may be much smaller. If the **ODU** is large it is normally supported on the antenna mount behind the dish. Smaller ODUs can be attached directly to the rear of the feed assembly in front of the dish.

- The outdoor unit is usually all solid state with GaAs FETs used in the Low Noise Receiver and the High Power Amplifier. LNA noise temperatures are typically in the range 190 - 225° K (Ku band) and HPA output powers are usually in the range 0.1 - 6 W (Ku band).

4.2 Transceiver: Functional Description

The main function of the Extended C-Band ODU is to up convert the IF 70 MHz input from the modulator to an RF signal (6.725 GHz to 7.025 GHZ) for Transmission via an antenna, and to down convert the RF signal (4.500 GHz to 4.800 GHz) to an IF signal (70MHz) for the demodulator.

The Extended C-Band ODU is available with different options i.e 2W, 5W, 10W, 20W. See Table 2 for the list of output power rating versus gain.

Output power rating (W)	**P 1dB (dBm)**	**Gain (dB) min**

2	33	58
5	37	62
10	40	65
20	43	68

Table 2

4.3 Five Modules with ODU

There are four modules with in the ODU namely ,Down Converter up Converter, amplifier and power supply.

4.3.1 UP Converter :

This Module is a dual up conversion unit. The IF transimit signal from the modem of the IDU system enters the IF input terminal of the RFT at the frequency of 70 MHz ± 18 MHz.

In the first up converter, it mixes wit an LO signal to produce an L-Band signal. After passing through a bandpass filter (to reject the LO and harmonics), the signal is mixed in the second up-converter with an agile LO signal resulting in the desired RF frequency in the Extended in the C-Band. The RF signal is than amplified by the solid state power amplifier.

4.3.2 Down Converter :

This Module is a dual down conversion unit. The very weak incoming RF signal being received passes through a low noise amplifier and image reject filter to be down converted by an agile LO signal at Extended C-Band.

The Down converted signal is than filtered, amplified and sent for a second stage of down conversion , where it is mixed with 1.1125 GHz LO. The final result is an IF signal of 70 MHz ± 18 MHz. The IF signal is amplified and filtered before transimission to the demodulator of the IDU.

4.3.3 Power Supply :

The power supply is designed to supply DC power to the VSAT Extended C-Band ODU system. The power supply designed with a protective device to shut down the power supplied to the SSPA in case of any LO unlocked.This is prevent any corrupted signal from being transmitted out of the malfunctioned system. It is located within the RFT.

4.3.4 Monitor and Control:

The Monitor and Control function of the Extended C-Band ODU features both Local and Remote. In the local mode, user can monitor status o ODU from the LEDs , control frequency and gain adjustments using DIP switches.

4.4 UP/DOWN converter gain adjustment:

The gain of the up-down converter can be adjusted if desired. To do so, open the M&C window at the RFT, Locate the up and down gain switch.

The gain adjustment range for the both up and down converters are 20 dB minimums each.

Dip Switch setting Parameters as shown in the Table 3

Parameter	**Description**
A0 to A10	Frequency Selection
SPA	SSPA Switch On/Off
D1,D2,D4,D8,D16	D/C gain adjustment
U1,U2,U4,U8,U16	U/C gain adjustment
L/R	Local/Remote Switch (On/Off)

Table 3

4.5 Alarm and status of RFT :

The alarm using RED LEDs are located in the M&C access panel. With the red LED light up, it indicates an alarm condition. The status of the alarm are as shown in the Table 4

LED	**Colour**	**Description**
L1	Green	Power on
L2	Yellow	Local Mode
L3	Green	SSPA on
L4	RED	SSPA alarm
L5	RED	Upconverter alarm
L6	RED	Downconverter alarm
L7	RED	LNA alarm

Table 4

4.6 Gain Adjustment DIP Switch Setting:

DIP switches for selecting the U/C and D/C frequency channels. A "0" would means the DIPswitch is set to "ON" position while a "1" would mean that the DIP switch is set to "OFF" position. Table shows the tabulated gain selection table 5 using dipswitch setting.

U/C	**U16**	**U8**	**U4**	**U2**	**U1**
D/C	**D16**	**D8**	**D4**	**D2**	**D1**
Attenuation	**16**	**8**	**4**	**2**	**1**
0	1	1	1	1	1
1	1	1	1	1	1
2	1	1	1	0	0
3	1	1	1	0	1
4	1	1	0	1	0
5	1	1	0	1	1

6	1	1	0	0	0
7	1	0	0	0	1
8	1	0	1	1	0
9	1	0	1	1	1
10	1	0	1	0	0
11	1	0	1	0	1
12	1	0	0	1	0
13	1	0	0	1	1
14	1	0	0	0	0

4.7 Solid State Power Amplifier : (SSPA)

The signal from the up converter needs to be amplified to a suitable power level to reach the satellite. The required transmitter power depends on the VSAT network system design and the derivation of the suitable transmit power will not be discussed here. The solid state power amplifier (SSPA) provides the amplification as the final stage before transmission to the satellite via the antenna.

The SSPA receives the 6.725 GHz to 7.025 GHz transmit signal from the up converter. This transmit signal is sent to the RF section. The RF consist of Multiple gain stages that are based on the high performance microwave power GaAs FET designed to provide high gain, high power and low distortion for satellite communication application.

All the power GaAs FETs are housed in different partitions. These partitions will eliminate any interference from the DC section and prevent oscillation. The input and output of the SSPA are protected from any mismatch with internal isolators. However it is good to terminate RF during testing.

4.8 RF Functional description

The LNA receives very weak down link signal and amplifies it to the right level before sending it to RFT for frequency down conversion. The LNA uses HEMT (High electron Mobility Transistor) device to achieve low noise, high gain and low distortion application features.

5.0 Operating Parameters :

5.1 Transmit path specifications:

5.1.1 Input

Frequency Range	70 ± 18 MHz
Interface	N-type
Impendence	50 ohms

5.1.2 Output

Frequency Range	6.725 GHz to 7.025 GHz
Interface	N-type
Impendence	50 ohms

5.1.3 Gain

Gain Adjustment	31 dBm (1dB step)

5.1.4 Transceiver options

Output Power rating (W)	2	5	10	20
1 dB compression point	33	37	40	43
Total Transmission gain	58	62	65	68

5.2 Receiver Path specifications:

5.2.1 Input

Frequency Range	70 ± 18 MHz
Interface	N-type
Impendence	50 ohms

5.2.2 Output

Frequency Range	4.500 GHz to 4.800 GHz
Interface	N-type

Impendence	50 ohms
5.2.3 Gain	80 - 90 dBm
Gain Adjustment	31 dBm (1dB step)

5.3 LNA Specifications

(1) Frequency	4.500 to 4.800 GHz
(2) Gain	45 dBm
(3) Input VSWR	2.5
(4) Output VSWR	1.7

5.4 UP Converter Specification:

(1) Type	Double Conversion
(2) Output RF Frequency	6.725GHz to 7.025 GHz
(3) Input IF frequency	70 ± 18 MHz
(4) Conversion Gain	20 dBm

5.5 Down Converter Specification:

(1) Type	Double Conversion
(2) Output RF Frequency	4.5 GHz to 4.8 GHz
(3) Input IF frequency	70 ± 18 MHz
(4) Conversion Gain	40 dBm

5.6 SSPA Specification

(1) SSPA (2W)

Frequency	6.725 GHz to 7.025 MHz
Small signal gain	33 dB

SSPA (5W)

Frequency	6.725 GHz to 7.025 MHz
Small signal gain	37 dB

5.7 Electrical

Power Supply	190 – 240 VAC
Total Power Consumption	
2W ODU	50 VA
5W ODU	70 VA
10 W ODU	100 VA
20 W ODU	250 VA

5.8 Environment

Ambient Temperature	
Operating	- 20 to + 60 degree C
Stogare	- 40 tp + 85 degree C
Relative Humidity	
Operating	100%
Storage	100%

5.9 Interface

(1) AC IN

3 pin connector for ac power line. This is the AC power supply input for the VSAT Extended C Band ODU.

Pin A : Earth

Pin B : Live

Pin C : Netural

(2) IF IN

50 ohm N type jack. Connect to the indoor unit. This will accept the 70 MHZ signal from the indoor unit.

(3) IF OUT

50 ohm N type jack. Connect to the outdoor unit. It provide the 70 MHZ signal to the indoor unit.

(4) RF IN

50 ohm N type jack. Connect to the N type jack of LNA .

(5) RF OUT

50 ohm N type jack. Connect to the SSPA.

5.10 Indoor Unit

Indoor unit, which provides the modulation, demodulation, multiplexing, demultiplexing and synchronization with the rest of the network and supports the user interfaces. This box is usually about the size of a domestic video recorder.

6.0 Advantages of VSATs

If by now we believe that VSATs provide an edge over terrestrial lines only in cases where the land lines are difficult to install, say in the case of remote locations, then consider this. Close to 50 percent of the total VSAT population is installed in the US that also boasts of world's best terrestrial communications.

Networking of business activities, processes and divisions is essential to gain a competitive edge in any industry. VSATs are an ideal option for networking because they enable Enterprise Wide Networking with high reliability and a wide reach, which extends even to remote sites.

6.1 Last Mile Problem

Let us begin with the situation where you have reliable high-speed links between city exchanges for meeting your communication requirements. But before you begin to feel comfortable, connections from the nearest exchange to your company's office often fail. Consequently, stretching what is technically called the last mile problem into much longer distances. VSATs located at your premises guarantee seamless communication even across the last mile.

6.2 COMPARISION OF VSAT WITH LEASED LINE AND RADIO LINK

Since the beginning of the Internet, connections have steadily been improving, from 9600 baud to today's broadband connections of several mbps. New broadband technologies have recently come into being to satisfy people's demands for faster and faster connections. The three current available broadband technologies are leased line, radio link and satellite all of which have different advantages and disadvantages.

VSATs provides an edge over terrestrial lines only in cases where the land lines are difficult to install, say in the case of remote locations. Close to 50 percent of the total VSAT population is installed in the US that also boasts of world's best terrestrial communications. VSATs are an ideal option for networking because they enable Enterprise Wide Networking with high reliability and a wide reach, which extends even to remote sites. The few advantages of VSAT are discussed below.

The comparison of VSAT link with, Twisted cable, Coaxial cable, Microwave link on the basis of various parameters is shown below in Table 5

Criteria/Media	Twisted	Coaxial	Microwave	Satellite
Cost	Lowest	Fair	High	High
Speed	Lowest	Fair	High	High
Availability	Good	Good	Good	V. Good
Expandability	Fair	Good (local)	Good	Excellent
Errors	Fair	Good	Fair	Fair
Security	Fair	Fair	Poor	Fair
Distance	Good	Poor	Good	V.Good
Environment	Fair	Good	Fair	V.Good
Uptime	75%	80% – 85%	97%	99%

Table 5: Comparison between Line, Microwave and VSAT

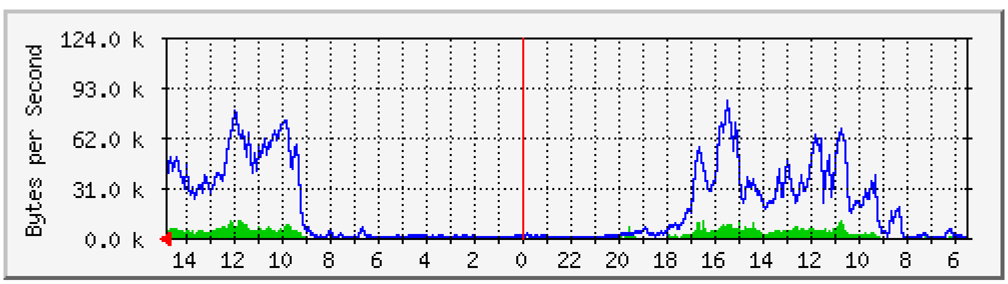
6.2.1 Local Loop Problem & Reliability

Let us begin with the situation where you have reliable high-speed links between city exchanges for meeting your communication requirements. Communications from point A to point B over long distances using terrestrial technology must, of necessity, involve multiple transmission media, connected by multiple switching elements, operating in multiple political jurisdictions. Add to this the multiplying factor induced by multipoint conferences, and the number of potential sources of interruption increases rapidly. In a satellite-based network, the entire service is provided by a single entity, thereby minimizing the number of potential failure modes. VSATs located at your premises guarantee seamless communication even across the last mile Uptime of up to 99.5 percent is achievable on a

VSAT network. This is significantly higher than the typical leased line uptime of approximately 80 to 85 percent.

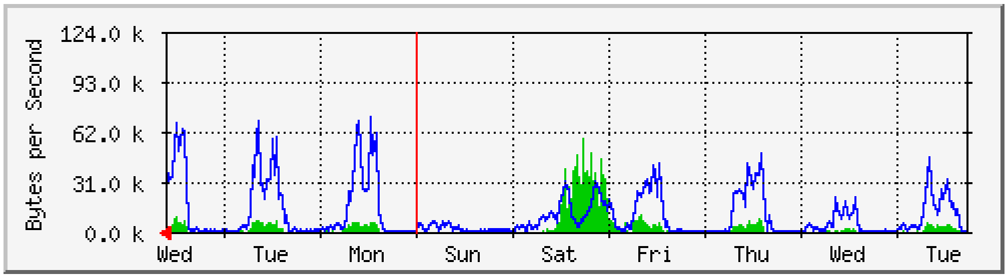
A typical statistics of VSAT link are shown in figure 8. These statistics are last updated Wednesday, 1 January 2003 at 14:52, up for 51 days, 4:58:33. As it can be seen from these graphs the system was not down for the last 51 days. It shows that VSAT link is free from above mentioned problem i.e Local Loop.

`Daily' Graph (5 Minute Average)



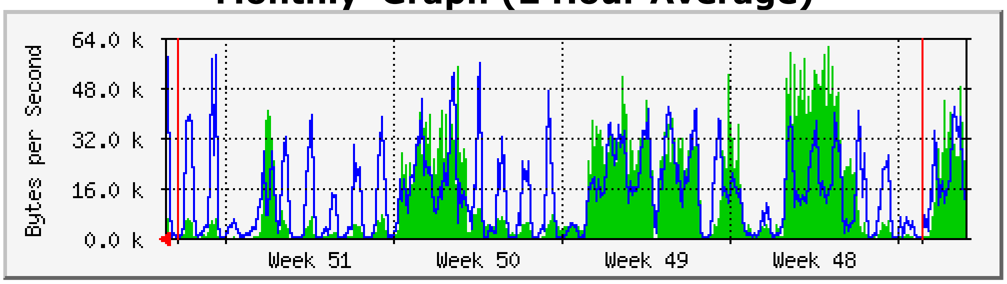
Max In:	12.2 kB/s (9.8%)	Average In:	2863.0 B/s (2.3%)	Current In:	5831.0 B/s (4.7%)
Max Out:	85.5 kB/s (69.0%)	Average Out:	18.9 kB/s (15.2%)	Current Out:	35.2 kB/s (28.4%)

`Weekly' Graph (30 Minute Average)



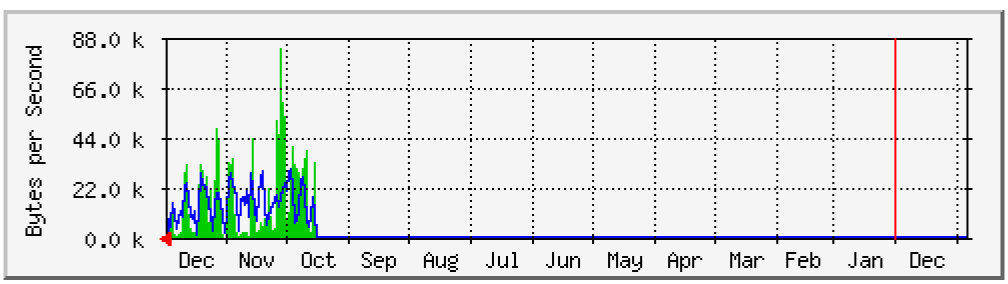
Max In:	59.5 kB/s (48.0%)	Average In:	3967.0 B/s (3.2%)	Current In:	5994.0 B/s (4.8%)
Max Out:	71.3 kB/s (57.5%)	Average Out:	11.1 kB/s (8.9%)	Current Out:	41.8 kB/s (33.7%)

`Monthly' Graph (2 Hour Average)



Max In:	62.1 kB/s (50.0%)	Average In:	14.5 kB/s (11.7%)	Current In:	7431.0 B/s (6.0%)
Max Out:	58.7 kB/s (47.3%)	Average Out:	14.1 kB/s (11.4%)	Current Out:	47.8 kB/s (38.6%)

`Yearly' Graph (1 Day Average)



Max In:	84.4 kB/s (68.1%)	Average In:	18.8 kB/s (15.1%)	Current In:	2466.0 B/s (2.0%)
Max Out:	30.2 kB/s (24.3%)	Average Out:	16.0 kB/s (12.9%)	Current Out:	15.6 kB/s (12.6%)

GREEN ### Incoming Traffic in Bytes per Second

BLUE ### Outgoing Traffic in Bytes per Second

Figure 8 : Traffic analysis of VSAT link using MRTG

6.2.2 Reach

You must be well aware of the limitations faced by terrestrial lines in reaching remote and other difficult locations. In our country, we have a plethora of such sites. VSATs, on the other hand, offer you unrestricted and unlimited reach due the inherent distance insensitive nature of satellite communications.

6.2.3 Reliability

Uptime of up to 99.5 percent is achievable on a VSAT network. This is significantly higher than the typical leased line uptime of approximately 80 to 85 percent. As most of the service providers are in the private domain, service is prompt and efficient.

6.2.4 Flexibility

VSAT networks offer enormous scalability. This feature factors in changes in the education environment and traffic loads that can be easily accommodated on a technology migration path. Additional VSATs can be rapidly installed to support the network expansion to any site, no matter however remote.

6.2.5 Time

VSAT deployment takes no more than a week due the easy availability as compared to 4 to 6 months for leased lines. No govt. permission is required for the same.

6.2.5 Network Management

Network monitoring and control of the entire VSAT network is much simpler than a network of leased lines, involving multiple carriers at multiple locations. A much smaller number of elements need to be monitored in the case of a VSAT network.

6.2.6 Maintenance

A single point contact for operation, maintenance, rapid fault isolation and trouble-shooting makes things very simple for a client, using VSAT services. VSATs also enjoy a low mean time to repair (MTTR) of a few hours, which extends up to a few days in the case of leased lines. Essentially, lesser elements imply lower MTTR.

Maintenance contains (a) Gain (b) Water Leakage protection

For Gain:

At Indoor

(1) Confirm the demodulator is Locked the receiver signal (by looking at the dempdulator Lock's LED)

(2) Record down the modems configuration (especially the transmit and receive frequency, power and BER reading from the modem.

(3) Check the programmed transmit IF frequency is same as recorded in the SETUP record for this station.

(4) If the frequency is different, over write the reading on the record by the current setting.

(5) Turn on the pure carrier of the modem.

(6) Turn Off the power.

At Outdoor

i. Mark IF cable which is connected to the IF IN of the RFT as transmit (eg : by tapping a red tape).
ii. Disconnect the IF IN and IF OUT connector from RFT
iii. Turn On the ODU Power.
iv. Connect the spectrum analyzer to the transmit IF cable and compare the output from ther modem.

Water Leakage Protection:

(1) Apply MS4 silicon compound on the RFT and M&C window.
(2) Screw can be tightned of M&C.
(3) Sealing : Seal up all the connectors and important joints.

6.2.7 Cost

A comparison of costs between a VSAT network and a leased line network reveals that a VSAT network offers significant savings over a two to three years timeframe. This does not take into account the cost of downtime, inclusion of which would result in the VSAT network being much more cost - effective. Pay-by-mile concept in case of leased line sends the costs spiraling upwards. More, so if the locations to be linked are dispersed all over the country. Compare this to VSATs where the distance has nothing to do with the cost. Additionally, in case of VSATs, the service charges depend on the bandwidth, which is allocated to your network in line with your requirements. Whereas with leased line one can get a dedicated circuit in multiples of 64Kbps, whether you need that amount of bandwidth or not.

6.3 Features & Applications:

- ✓ Public network
- ✓ Private user
- ✓ Standalone phone
- ✓ Built-in echo chancellor
- ✓ Voice activity detection
- ✓ Remote voice level adjustment
- ✓ Group 3 fax relay up to 4.8 KBPS
- ✓ Fax uses the same interface
- ✓ Low power consumption (< 30 w)
- ✓ Less failure , low cost
- ✓ Quick installation
- ✓ Field proven reliability
- ✓ Wide operating temperature range
- ✓ business networks for hotel reservations, banking, retailing and news distribution
- ✓ internet and intranets
- ✓ specialized networks for international organizations
- ✓ wideband mobile and off-shore communications
- ✓ remote/rural public telecommunications
- ✓ telemedicine and distance learning.
- ✓ environmental monitoring
- ✓ research and education

Breaking through the barrier of time, space and faculties, Manipal IT Education provides VSAT satellite Technology, an interactive distance learning solutions.

To ovecome the huge shortage of of good teachers at various study centers for advanced IT subjects and to ensure minimum quality teaching we are providing interactive classes through VSAT.

VSAT are small, software-driven earth satellites, used for the reliable transmission of data, video, or voice. It can be simply plugged into an existing terminal equipment and requires no staff or additional technology to operate. It covers the entire spectrum of interactive distance learning from Synchronous to Asynchronous, class romm to desktop PC based solutions and is high quality video over IP networks. VSAT provides virtually error-free digital data communications with 99.9% network reliability.

A studio has been established in Manipal having the most modern video, audio, broadcasting systems including three sets of studios cameras videomixer, editing equipment, interactive software systems thus creating a virtual classroom.

The classes will be taken by the well-trained teachers in a well equipped studio. Students are able to hear the teacher ask, answer questions and communicate with the other students in real time, on his own PC or on a T.V screen in a class. The students can answer the instructor by email or by voice-mail or by text based chat.

Students can also access the training material, previously prepared and stored in the server. Students can use the wide variety of multimedia tools such as internet, music, digital video, animation and graphics.

It creates a **unique interactive** environment enabling teacher-led training to unlimited number of students in different study centres and geographically dispersed sites. It is specially suited for Information technology in software training.

6.4 VSAT IN TECHNICAL EDUCATION

The increasing demand for technical education and the revolution in information technology provide an opportunity to change the curricula and delivery system of technical education so as to provide prospective engineers an edge to successfully face the challenge in globally competitive setting. Therefore, technical education and IT has to develop a mutually supportive relationship for achieving excellence .

We are using multi-technologies in imparting technical education. At the one end, some premier institutions are having access to all facilities in terms of educational technology such as multimedia system, LAN, WAN, and World Wide Web on the other hand a large number of technical institutes are still depending only on stereotyped lecture method in imparting knowledge. Therefore the existence of technology gap provides an opportunity to use IT supported education technologies for better delivery of education, easier access to a number of knowledge sources, sharing through networks and quality distance learning in technical education. Let's see how the VSAT can provide distance-learning solution?

6.4.1 Distance Learning Solutions

The essential challenge of distance learning is overcoming distance. Educators are now relying on a variety of technologies, online and off, to break down classroom walls. According to Chris Olmegren, the director of distance learning at the University of

Wisconsin, the buzzwords are "hybrid technology." As the Internet's technical ability (that is, bandwidth) increases, she said, "We hope to use the World Wide Web as a full multimedia transmission network." The distance learning activity can be of two types

(i) Distance Learning Online
(ii) Distance Learning Offline

4.2.1 Distance Learning Online

Online learning falls into two categories -- synchronous, meaning students "attend" lectures or chat rooms at the same time, or asynchronous, meaning they do coursework on their own schedules. e-mail: Professors and students send messages back and forth using electronic mail.

- Chat: Class discussions and individual student-teacher meetings are held in "real-time" chat; but keeping up a linear conversation is difficult because the dialogue doesn't appear on the screen sequentially.
- Message boards: Professors use moderated topic boards, like those on the Usenet news groups, to carry on extended class discussions.
- Web sites: Using a password, students access a class site that contains elements like syllabuses, notes, related links and assignments.
- Streaming audio and video: Simulcasts of a professor's lectures can be sent live or recorded in "real time" (meaning no downloading) to a student's personal computer.

4.2.2 Distance Learning Off Line

- Disks: CD-ROM's and other software carry class material like special exercises and textbooks.
- Two-way video conferencing: Video is sent over an ISDN phone line between a broadcasting station (where the professor is) and a remote location, like a library or a conference room (for students). Questions are asked by telephone. Audio conferencing: Voice-activated conferencing is similar to speakerphone methods corporations' use.
- One-way video broadcasting: In one of the first technological forms of distance learning, classes are sent live or recorded via local television broadcasts, or by satellite or microwave.
- Snail mail: Videos, cassettes or paper arrive by mail.
- Face to face: Students sometimes meet on campus or with tutors at special centers. Tests are, by necessity, open book or proctored.

Breaking through the barrier of time, space and faculties, VSAT satellite Technology, provides an interactive distance learning solutions for both on line as well as off line distance learning education. To overcome the huge shortage of good teachers at various study centers for advanced communication and computer subjects and to ensure minimum quality teaching we can provide interactive classes through VSAT.

VSAT software-driven earth satellites, used for the reliable transmission of data, video, or voice can be simply plugged into existing terminal equipment and requires no staff or additional technology to operate. It covers the entire spectrum of interactive distance learning from Synchronous to Asynchronous, classroom to desktop PC based solutions and is high quality video over IP networks.

VSAT provides virtually error-free digital data communications with 99.9% network reliability.

For implementing distance-learning solution through satellite a studio has to be established in the institute having the most modern video, audio, broadcasting systems including sets of studios cameras video mixer, editing equipment, interactive software systems thus creating a virtual classroom.

The well-trained teachers will take the classes in a well-equipped studio. Students are able to hear the teacher ask, answer questions and communicate with the other students in real time, on his own PC or on a T.V screen in a class. The students can answer the instructor by email or by voice-mail or by text based chat.

Students can also access the training material, previously prepared and stored in the server. Students can use the wide variety of multimedia tools such as Internet, music, digital video, animation and graphics.

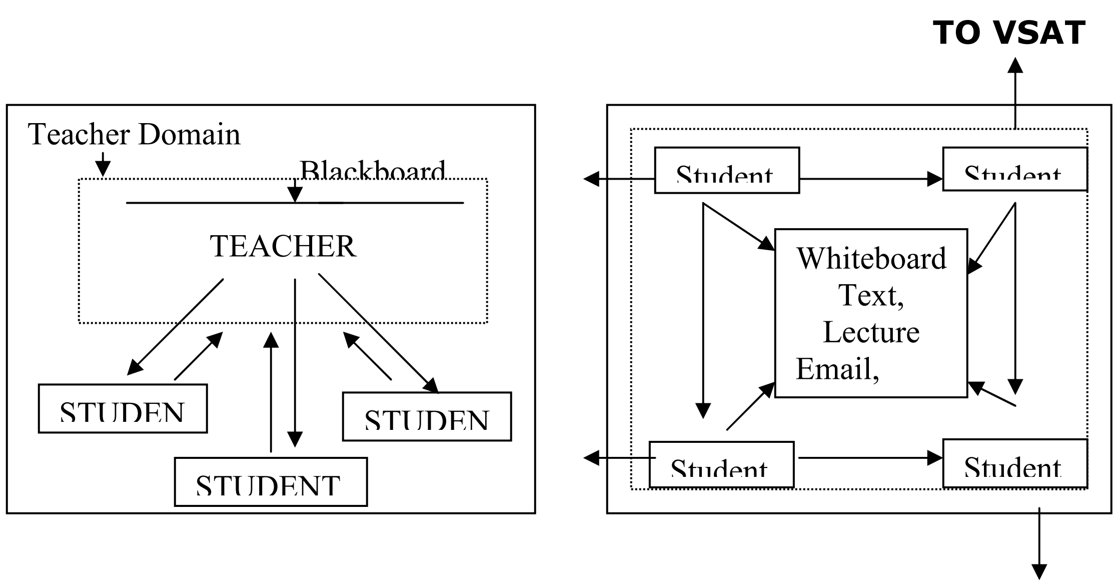
It creates a **unique interactive** environment enabling teacher-led training to unlimited number of students in different study centers and geographically dispersed sites.

Example of Interactive Classroom For DSP/Communication Courses

Hüseyin Abut, School of Applied Science, NTU, Singapore and Yusuf, San Diego State University, San Diego have presented a new classroom environment to conduct digital signal processing and communication systems courses as

shown in figure9. Key features of the model are the collaborating instructor, embracing students and a smart classroom.

This classroom shall be equipped with a "Whiteboard" and advanced telecommunication networks, electronic textbook, and other resources, World Wide Web (WWW), Matlab, and other on-line tools. The underlying assumptions of the educational process are team building instead of independent learning, collaborating/supervising instructor, lateral curriculum instead of a vertical curriculum, and idea-to-product design concept. They have presented a sample lecture in the proposed interactive classroom, where the concept of eye diagrams in regenerative repeaters will be presented from the first author's text using Matlab and WWW. As you have to be connected to the WWW it requires a broadband connection, which is possible through VSAT.



OLD CLASS ROOM MODERN CLASS ROOM

Figure9 Old Class room Vs. Modern Class room

4.3 Rural Education

VSAT can be the medium of choice in rural and isolated areas because satellite networks have the various advantages mentioned above . At last, low-income, remote community may end their isolation through satellite-based solutions that may be cost-effective and provide a reliable flow of education materials, teacher training, and communications. With the advent of VSAT two-way satellite broadband networks are now possible with upload speeds of kbps touted, and 24-hour always-on connections, it appeared that real broadband speed and functionality were finally available to satellite users (see Fig. 10).

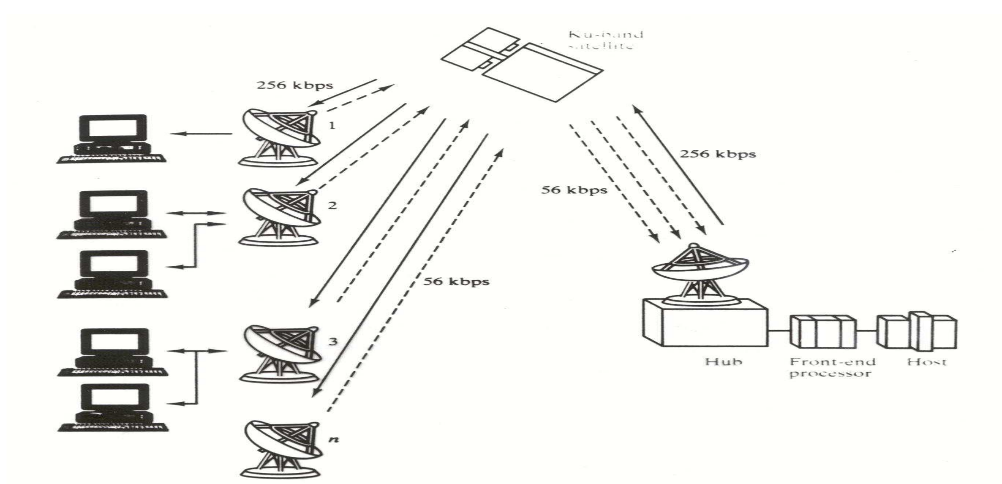


Figure 4: A two way broadband network for rural education

6.6 Videoconferencing Networks

Videoconferencing networks can be implemented using satellite or terrestrial. Videoconferencing can be implemented in four modes.

6.6.1 **Broadcast**: One site transmitting video/audio to a number of other sites. No return video or audio.

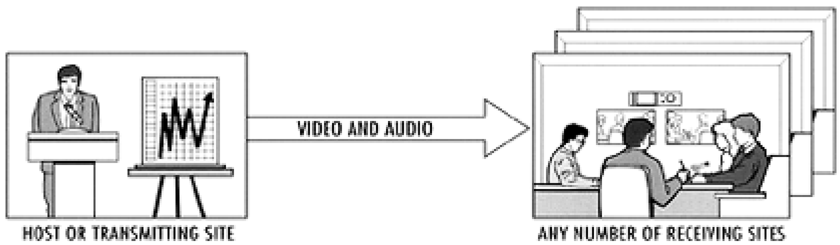


Figure.11 Broadcast

6.6.2 **Two Way**: Two sites in a video/audio full-duplex conference.

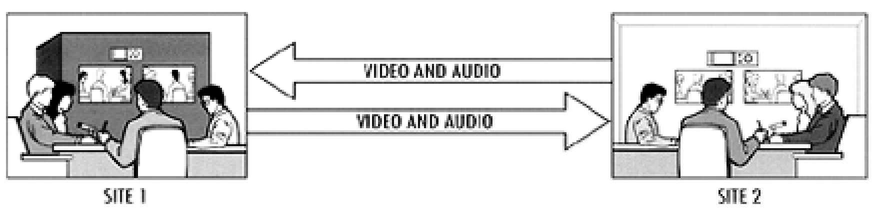


Figure 12. Two-Way

6.6.3 **N Way (Broadcast with audio return):** One site transmitting video/audio to other sites, and those other sites transmitting audio only. All sites hear each other at all times. The video/audio transmit site can be dynamically changed while conference is in progress by the push of a button.

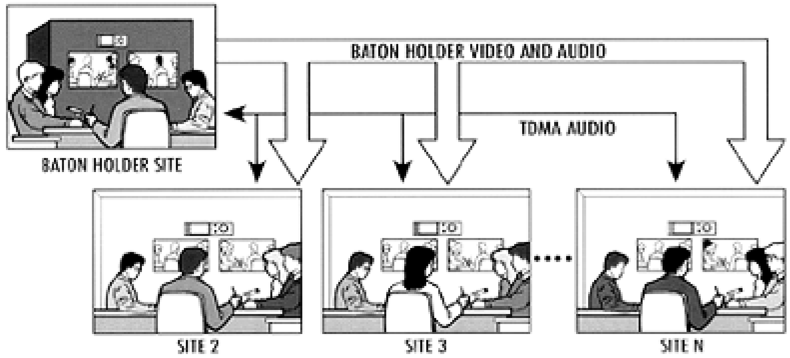


Figure 13 N Way (Broadcast with audio return)

6.6.4 **2+N Way (Multipoint)**: One site (Instructor/Baton Holder) transmitting video/audio to other sites while receiving video/audio from one of the other sites (selectable by that site) while also receiving audio from all other sites. All sites hear each other at all times. The video/audio transmit sites can be dynamically changed while conference is in progress by a push of a button.

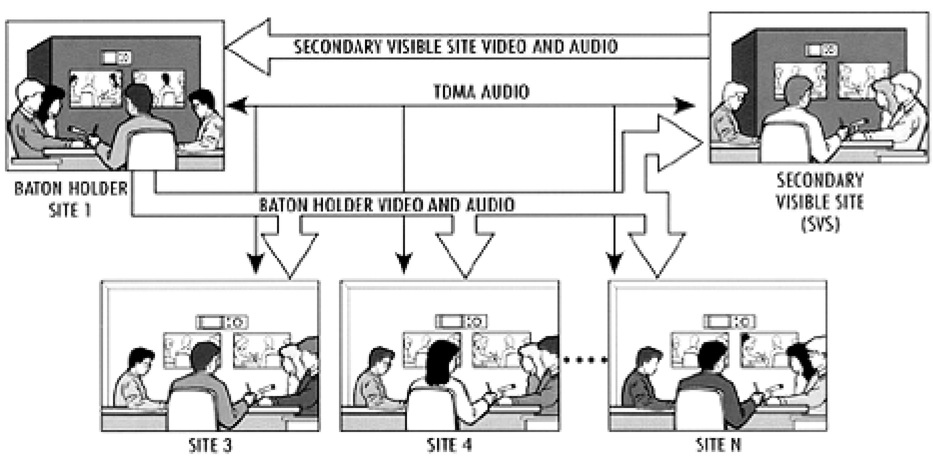


Figure 14 2+N Way (Multipoint)

Satellite technology furnishes the natural medium for multipoint videoconferencing. It is superior to terrestrial equivalents in all the attributes that differentiate the two technologies as mentioned above.

The VSAT based teleconferencing system provides high-quality video conferencing via satellite allowing point-to-point as well as multipoint conferencing modes. It provides four conferencing modes. Because satellite transmission is broadcast in nature, the transmission costs stay the same no matter how great the distance between locations, how many sites in a multipoint conference, how many sites in the network. Satellite technology also provides the capability for video conferencing to any location independent of the existing terrestrial infrastructure making a rural location just as accessible as any urban location.

7.0 Case study of an educational institute for finding cost effective solution for broadband connectivity.

When it comes down to cost, making general comparisons between VSAT services and their terrestrial equivalents is almost impossible. Charges for terrestrial services are nearly always distance-dependent, while VSAT connections cost the same whether sites are 1 or 1,000 miles apart. And with most VSAT services, the cost per connection comes down considerably when a customer adds users

Below we present an actual comparison of VSAT with lease line and radio link connectivity when they were implemented in an educational institute. The cost of VSAT is less than both the others and it is much effective and better service for the Internet connectivity.

7.1 VSAT Tariff:

The basic cost structure of VSAT is shown in Table 6.

Basic Equipment Price: **3.0 Lac**

Installation and Warranty support charges:	**15,000**
Connectivity Charges:	**1.20 Lac**

Table6: Cost structure of VSAT

7.2 LEASE LINES Tariff

For leased lines the annual tariff is shown in table 7

Sr.No	Speed	Registration Charge (in Rs.)	Installation Charge (Rs. in Lakhs)	Annual tariff (Rs in Lakhs) for different centres as detailed below in the table		
				A	B	C
1	64 kbps	10,000	1.25	2.3	4.1	6.8
2	128 kbps	10,000	1.25	4.2	7.4	12.3
3	192 kbps	10,000	1.25	5.9	10.2	17
4	256 kbps	10,000	1.25	7.3	12.7	21.1
5	384 kbps	10,000	1.25	9.4	16.4	27.3
6	512 kbps	10,000	1.25	11.4	19.6	32.7
7	768kbps	10,000	1.25	15.1	26.2	43.6
8	1 Mbps	10,000	1.25	18.9	32.7	54.5
9	2 Mbps	10,000	1.25	26.0	45.0	75.0

Table 7: Cost structure of Leased Line

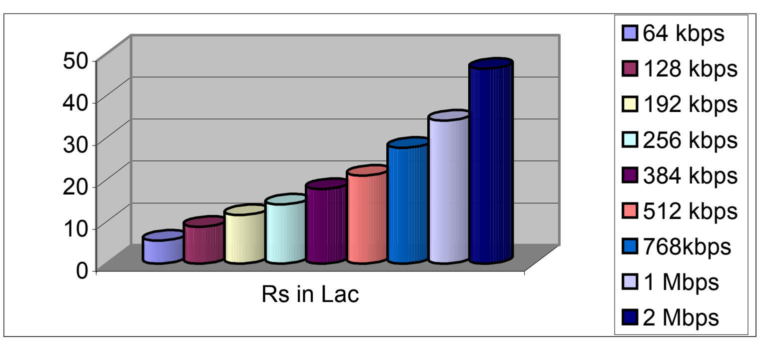


Figure 15: Cost structure of Leased Line

These rental rates are annual and applicable to all classes of subscribers uniformly **except press/news agencies**. The charges for high-speed data circuits used by press/news agencies for propagation of news shall be 1/3 rd of normal charges of the respective leased circuit. This concessional tariff will not extend to circuits hired for transmission of commercial data to commercial institutions likes banks; videotext/news scan and stock scan services etc. The tariff for connectivity of leased line and radio link is given in figure 16.

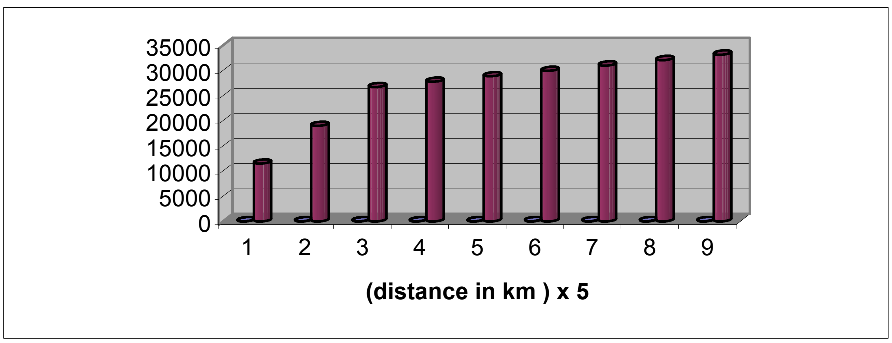


Figure 16: Tariff for leased line and radio link

7.3 Comparison between the rates of Leased Line, Radio Link and VSAT

The cost analysis of all the three links is shown in table 8 and figure7

S.No	**Cost Analysis**	**Leased lines**	**Radio Link**	**VSAT Link**
1.	One time cost Installation includes Hardware Cost	1.35 Lac	1.0 Lac	3.15 Lac
2.	Monthly/Annually Cost	4.1 Lac	4.0 Lac	1.2 Lac

3.	**Total**	**5.45 Lac**	**5.0 Lac**	**4.25 Lac**

Table 8

For radio link of 64 kbps, installation charge will be Rs.3 lakh that includes the Radio link provided by VSNL. For speeds higher than 64 kbps, the installation charge will be actual cost of Radio link based on last purchase price plus Rs 1.0.lakh. If customer can arrange the Radio Link of his or her own, VSNL will charge only Rs.1 lakh as installation charge. Annual WPC charges & O&M Charges for Radio Link will be extra and will be notified soon. Till that time customer may provide an undertaking to pay the charges to be decided by VSNL.

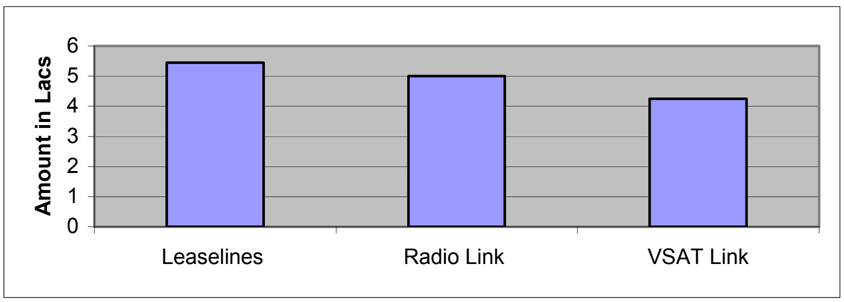


Figure 7: Graph Showing the Rates for 64 Kbps Solutions

Below we present an actual comparison of VSAT with lease line and radio link connectivity when they were implemented in an educational institute. The cost of VSAT is less than both the others and it is much effective and better service for the Internet connectivity.

8.0 CONCLUSION

VSAT is a mature and viable business-friendly technology. It is reliable, and can be easily and quickly deployed even in the remotest of places. Many businesses opt to invest in VSAT so as to solve their communications and Information Technology problems and thereafter get on with "the business of doing their core business" unencumbered by non-responsive and antiquated telephone companies

The VSAT industry is a major link in the worldwide chain of communication networks. As countries deregulate their telecommunications infrastructure and competition brings prices down, services and costs should improve, which should mean an improvement in world telecommunications. Internal networks will continue to expand and develop, as VSAT technology improves and becomes less costly, especially for the consumer market. Business-related Intranets will continue to expand in world markets, while governments and private industry will pay special attention to VSAT-linked Intranets that will enhance development

9.0 FUTURE TRENDS

With deregulation the new norm in Europe, industry experts believe that the VSAT market will improve due to increased demand for voice, data and multimedia applications. The director general of Intelsat, Irv Goldstein, predicts that VSAT networks will see increased demand for newer applications, such as Internet and multimedia. Other regions expected to see growth in the coming years include the Asia-Pacific, Latin American, African, especially South Africa, Russia and the former Soviet Union. As economies grow, telecommunications regulations are relaxed, and demand for satellite services increases.

The VSAT market faces a challenge in coming years from its primary competitor, the terrestrial wireline and wireless networks operated principally by the telephone industry. VSATs have enjoyed various advantages up until now over terrestrial information systems, with lower terrestrial costs, increased bandwidth and coverage and improved service. VSATs will have greater competition, as deregulation in Western Europe, for instance, will force VSAT operators to lower their prices to earn and maintain market share, while improving service.

VSATs have traditionally served large companies and governments. Now providers such as Gilat are beginning to focus on the home consumer market.

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